ISSN 0375-7846

The North West Geologist

Published under the auspices of
THE LIVERPOOL GEOLOGICAL SOCIETY,
THE MANCHESTER GEOLOGICAL ASSOCIATION and
THE LANCASHIRE GROUP OF THE GEOLOGISTS' ASSOCIATION
Number 8

THE NORTH WEST GEOLOGIST
(Formerly THE AMATEUR GEOLOGIST)

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Editorial

Once again we begin our editorial on a sad note in reporting the recent death of former MGA President, Professor Ansel Dunham. This famous son of a famous father was known to many in our region during his time on the teaching staff of The University of Manchester in the 1970's. We are grateful to Norma Rothwell for writing the obituary published in this volume and send our sincere condolences to Sir Kingsley and Lady Dunham.

This issue, purely coincidentally, has something of a thematic nature, concentrating on things Triassic. David Thompson takes a historical look at various issues of Triassic stratigraphy and palaeontology, Tony Morgan's list of Merseyside RIGS sites is by definition largely concerned with the Trias, our Book Review celebrates Geoff Tresise's definitive work on *Chirotherium*, and even Carboniferous corals crop up in Triassic conglomerates ! Thankfully Harry Holliday's anecdotal piece reminds us that the northwest does have some Palaeozoic !

As always we are very grateful to all contributors to this edition, but would like to encourage more of you to send us copy - serious papers, shorter articles, book reviews, field trip reports, letters, cartoons etc. - do not be afraid to put pen to paper !

John R Nudds (MGA)   N.C. Hunt (LGS) Alistair Bowden (LGGA)
Spring 1998

Notes for Authors

Articles and suggestions for future issues are always most welcome and should be sent to either Dr John R Nudds, Manchester University Museum, Oxford Road, Manchester M13 9PL, N.C. Hunt, Department of Earth Sciences, The University, Liverpool L69 2BX, or Alistair Bowden, Clitheroe Castle Museum, Castle Hill, Clitheroe, BB7 1BA. Articles should preferably be presented on disk, if possible in **Wordperfect** (Windows or DOS), and may be up to 3,000 words in length. Figures should be designed for reduction to fit a maximum frame size of 180mm x 125mm.

Back numbers of The Amateur Geologist and The North West Geologist

Limited stocks of most previous issues are held in Manchester and Liverpool and copies can be obtained by application to the editors.

Officers and Committee Members for the Session 1996/97.

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IN BRIEF....

Lottery problems for Manchester Museum

In the last issue we reported on the Heritage Lottery Fund award of £12 million to The Manchester Museum on condition that it was able to raise sufficient partnership funding. As with many other lottery approved schemes this is proving to be difficult as rivals in the heritage sector compete for the same limited grants. The anticipated European funding, which would have provided the final £2.5 million of partnership funding required, was awarded instead to other schemes in the north-west, leaving Manchester Museum's plans in some jeopardy. A decision should be made by mid-summer and it may be that a less ambitious scheme will evolve. Academic staff at the Museum may not be too unhappy with this - many have expressed concern over the welfare of the collections during the massive upheaval that is planned. For example the new Earth Sciences Collection Centre, which MGA members will fondly remember opening in 1992, is to be largely dismantled. We await news with eager anticipation....

Latest BGS publications

Readers will be pleased to hear that the British Geological Survey sheet memoir, *Geology of the country around Snowdon*, has just been published to accompany the 1:50,000 Snowdon map (Sheet 119) which appeared last year. The memoir describes the geology of the Snowdon area in the heart of the Snowdonia National Park and can be obtained from the BGS Sales Desk at a cost of £45.00. Other recent 1:50,000 maps of potential interest to workers in the north-west include Kirkby Stephen (Sheet 40), Richmond (Sheet 41) and Hawes (Sheet 50), which are available flat or folded at £9.95.

Lindow Moss in the news again

Lindow Moss, to the west of Wilmslow in Cheshire, the site of the world-famous discovery of Lindow Man, is to undergo an increase in its peat extraction operation. Croghan Hill Horticulture have asked for a review of permissions on five extraction areas. Cheshire County Council requested more information than was given in the original application in April 1997 and a hydrological report from Sheffield University has convinced the authority that a four-fold increase in current extraction to $60{,}000m^3$ is in order. The applicants have agreed to allow access to the site for archaeological recording should further bog bodies or other evidence be revealed.

OBITUARY

Ansel Charles Dunham

Many members will have read the news of the recent death of a former President of the MGA, Professor Ansel Dunham, with great sadness.

Recently at the University of Leicester, moving there from the University of Hull, Ansel was for many years in the 1960's and 1970's a member of the academic staff of The University of Manchester. During those years he was an enthusiastic member of the MGA and a distinguished president.

He was also an Associate Lecturer of the Open University and in 1974 had the very doubtful pleasure of starting me on my geological studies.

Ansel was a delightful person, kind, considerate and with a great ability to communicate his knowledge and love of Earth Sciences. When asked what it took to be a good geologist his reply was, "Look at lots of rocks". Wise council indeed.

A true gentleman, he will be very much missed by all who knew him. Our sincere sympathy goes to his widow, Helen, all his family, and especially to his parents, Sir Kingsley and Lady Dunham.

(Norma Rothwell)

PROCEEDINGS OF THE LANCASHIRE GROUP OF THE GEOLOGISTS' ASSOCIATION 1996/97 SESSION

1996

Apr. 13	Field trip to Anglezarke led by members of the group.
May 11	Field trip to the Vale of Chipping led by Mike Gosling.
May 29	Field trip to Hall Hill Quarry led by Alistair Bowden.
Jun. 15	Field trip to the North Pennine Orefield led by Rod Ireland.
Jul. 18	Field trip to Boulby Potash Mine led by Peter Edey.
Jul. 20	Field trip to Triassic exposures in West Lancashire led by Steve Hewitt.
Sep. 27	*The geology and history of lead/zinc mining in the northern Pennines* by Rod Ireland.
Sep. 28	Field trip to Cartmel led by Murray Mitchell.
Oct. 25	*The geology of the A66 road improvement scheme* by Mr D.J. O'Farrell.
Nov. 29	*Coastal rock weathering and erosion* by Professor D. Motteshead.

1997

Jan. 17	Annual Dinner.
Jan. 31	*Butchers and weavers in the fossil record* by Dr Paul Selden.
Feb. 28	*Have hammer, will travel!* by Dr D. Watkine.
Mar. 21	*The volcanoes of Hawaii* by Mike Gosling.

THE BACKGROUND TO THE FINDING OF FOOTPRINTS AND OTHER TRACE FOSSILS OF ?SCYTHIAN, ?ANISIAN AGE IN THE SHERWOOD SANDSTONE GROUP (TRIASSIC) AT HILBRE, WIRRAL, EAST IRISH SEA BASIN

by David B.Thompson

INTRODUCTION

"This is the world's limit we have come to; this is the Scythian country, an untrodden desolation." Aeschylus writing in *Prometheus Bound*.

The finding of a new and substantial Triassic footprint locality in the Liverpool area, the first since the turn of the century, is a most exciting prospect. The credit for the newest finds lies largely with the Ranger Service of the Wirral Metropolitan Borough Council and particularly with Vicky Seagar (Hilbre Ranger) and with Mike King (a doctoral student of Dr Mike Benton of Bristol University).

The first published record of the find was released in an obscure report of the Hilbre Bird Observatory (Bell 1992): "In late February, 1990, Force 11-12 north-westerly winds coincided with spring tides, dislodging and shattering large slabs of the sandstone bedrock on the western side of Hilbre. Some of the broken rock, cast up at the south end of the island, was examined independently by two observatory members: immediately after the event, J.C.G [John Gittins] recognised fossilised mudcracks in one of the slabs, formed and preserved when the rock material was being laid down; subsequently after several examinations, during a close inspection by A.A.B. [Tony Bell] in July 1991, two or three obscure footprints were apparent amongst the mudcracks on one of the slabs, and were photographed *in situ*".

Soon after July 1991 the specimen bearing the first footprints was removed from Hilbre Island by the agreement of the three rangers and from 1992-3 was kept at the Thurstaston Visitors' Centre awaiting conservation measures. Since then the original slab and many others have been registered in the collections of the National Museums and Galleries on Merseyside.

The original footprint slab, 83 x 67 cm of medium-grained sandstone, exhibits extensive mudcrack casts. It was inspected on site by Dr Geoffrey Tresise (Former Curator of Earth and Physical Sciences at National Museums and Galleries on Merseyside). In his subsequent report in December 1992

(Tresise 1992), he recognised a track with three footprints which, "were generally similar to, but smaller than *Chirotherium*" in the well known Storeton quarries where they have been frequently discovered between the years 1838 and 1930 (Tresise 1989b). Perhaps following the Geological Survey map and memoir (Wedd *et al.* 1923), he noted that the slabs came from an horizon in the Chester Pebble Beds Formation (Warrington *et al.* 1980), formerly the "Bunter Pebble Beds", Lower Triassic in age, c. 245 million years old (Harland *et al.* 1990). He suggested therefore that they were apparently older than the prints from Storeton and other related places (e.g. Runcorn) (Beasley 1896, Maidwell 1914, Tresise 1993a,b) which are in the largely fluvial Helsby Sandstone Formation c. 242 m.y. (Thompson 1970a,b; Warrington *et al.* 1980). He remarked also on the presence of ripple marks and "worm casts". He concluded that the footprints could not be assigned to an ichnotaxon because of poor preservation.

Against a background of very active hydrocarbon exploration and exploitation offshore (Haigh *et al.* 1997; Yaliz 1997), these chance finds, and others which followed at the same place, eventually offered an opportunity to identify a new assemblage of trace fossils and possibly to solve a long-standing stratigraphical problem in the area: the likely horizon in the Triassic System of the rock formation to which the fossils belonged. The first stage of this work is now near completion (King & Thompson in prep.), and it is appropriate that a historical appreciation of these events and their context is presented here which, the author hopes, will interest both local amateurs and professionals alike. Not for want of a reason did Professor H.H. Read dub the members of the Liverpool Society a "Triassic audience"!

THE HISTORICAL CONTEXT OF THE STRATIGRAPHICAL PROBLEM

The location of the footprints (Figs 1, 2) was at NGR SJ 186876 on Hilbre, 1.5 km west of Hilbre Point, at the northwest tip of the Wirral. The rock succession here dips 6-10 degrees to northeast and strikes northwest to southeast. It is continued in Little Hilbre Island (=Middle Island=Middle Eye). It is separated by north-south faults from rocks of a different horizon in the Lower Trias on Little Eye and Tanskey Rocks to the southeast. The successions at Hilbre Point and Redstones Rocks (SJ 2088), separated by a fault and hence of different stratigraphic horizons, have been compared to those on Hilbre itself, albeit necessitating a fault, here named the West Kirby Beach Fault, to be hypothesised between the two areas ever since Hull's geological map and section (1855a & b) and Morton's account of the area (1856).

PROCEEDINGS OF THE MANCHESTER GEOLOGICAL ASSOCIATION 1996/97 SESSION

1996	
Apr. 26	Annual Dinner at Harwood Rooms, UMIST. Guest of Honour: Dr Fred Broadhurst.
May 18	Field trip to Goyt's Moss led by Michael Eagar.
Jun. 16	Field trip to Western Pennines led by Wishart Mitchell.
Jul. 14	Field trip to Lud's Church and Roach End led by Don Steward.
Aug. 14	Field trip to Meadowbank Salt Mine, Cheshire led by Betty Knight.
Sep. 11	Members' "Twelve Best Slides" Evening.
Sep. 15	Field trip to Furness Peninsula led by Derek Leviston.
Sep. 25	*Conversazione* at The Manchester Museum.
Sep. 28	Field trip to Oldham led by Fred Broadhurst & Bill Hotchkiss.
Oct. 9	*Sediment management to optimise water quality in the Manchester Ship Canal* by Dr S Boult.
Nov. 13	*Plate tectonics in the Archaean - a sceptic's view* by Professor R.G.Park.
Dec. 11	*Volcanic eruptions in atmosphere free bodies* by Dr L. Wilson.
1997	
Jan. 8	*Tracking dinosaur footprints* by Dr M. Romano.
Feb. 12	Annual General Meeting and Presidential Address by Dr John Nudds - *The way that I went: a geology of Ireland*.
Mar. 12	Short talks by Tony Browne, Mary Howie & Christine Arkwright.

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Membership on 30 September 1997:

201 Ordinary members, 31 Student members, 6 Honorary members, 3 Life members. Total = 241.

The Liverpool Geological Society Prizes for General Excellence were awarded as follows:

The University of Liverpool	- Geology: Jonathan David Hall Nicholas Erik Timms - Geophysics: Nigel John Cassidy - Geology & Physical Geography: Tom Bradwell
John Moores University	- Earth Science: Paul Leicester and Nicholas Midgley

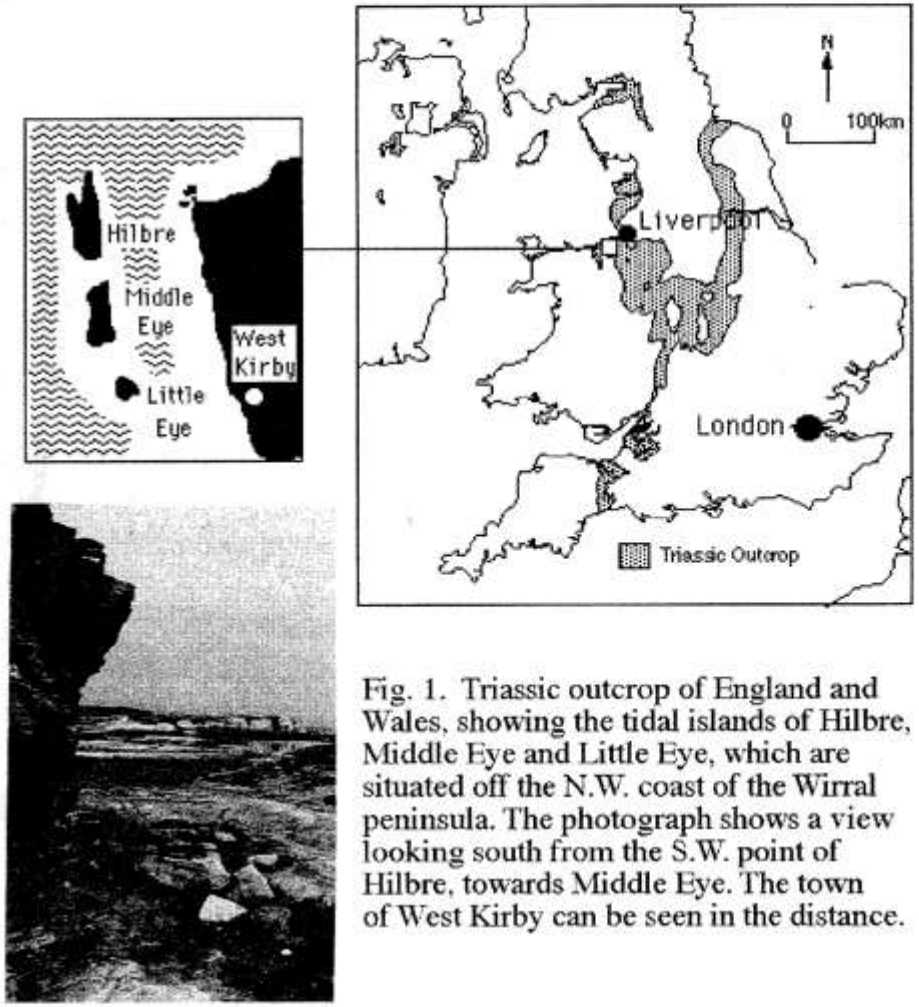

Fig. 1. Triassic outcrop of England and Wales, showing the tidal islands of Hilbre, Middle Eye and Little Eye, which are situated off the N.W. coast of the Wirral peninsula. The photograph shows a view looking south from the S.W. point of Hilbre, towards Middle Eye. The town of West Kirby can be seen in the distance.

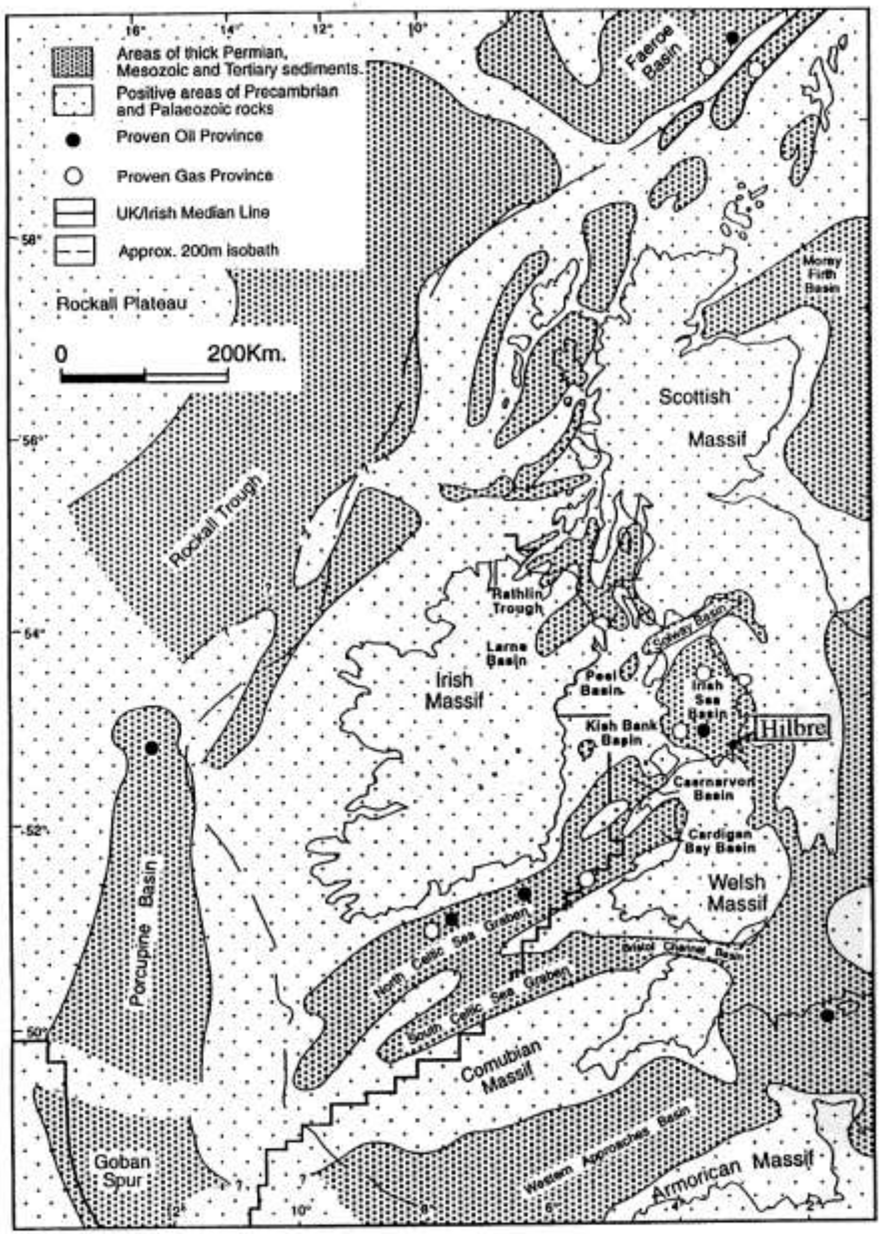

Figure 2. The Triassic footprint localities of Merseyside in relation to the Permo-Jurassic basins of the British Isles (after Maddox *et al.* 1997, fig. 1, p. 96, through the kind permission of The Geological Society of London). The position of Hilbre is boxed.

Mar. 18	The Distinguished Visitor's Address by Professor Peter Wheeler - *Ruling reptiles or chickens from Hell: What were the dinosaurs ?*
Mar. 21/23	Field trip to Southern Uplands of Scotland led by Charles Underwood.
Apr. 20	Field trip to Great Orme and Copper Mine led by D.A. Jenkins and C. Rowley.
May 10	Field trip to Dudley Museum and Wren's Nest led by Colin Reid.
Jun. 7	Field trip to the Hematite mines of the western Lake District led by Mervyn Dodd and David Kelly.

Officers and Members of Council for the Session 1996/7 and Trustees 1995/98:

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PROCEEDINGS OF THE LIVERPOOL GEOLOGICAL SOCIETY

1996/97 SESSION

1996

Oct. 8	The Presidential Address by Chris Hunt - *Aggregate Properties: Isle of man case study.*
Oct. 29	*The recognition of rising and falling sea levels in the geological record (with examples from the Carboniferous)* by Sarah Davies.
Nov. 12	*Spinning compasses - the Earth's magnetic field, past and present* by Graham Sherwood.
Nov. 23	Practical Session at Liverpool Museum on *An introduction to the identification of fossils* with Wendy Simkiss and Tony Morgan.
Dec. 3	The Distinguished Member's Address by Professor Michael Hambrey - *The stability of the Antarctic Ice Sheet during the Tertiary Period.*

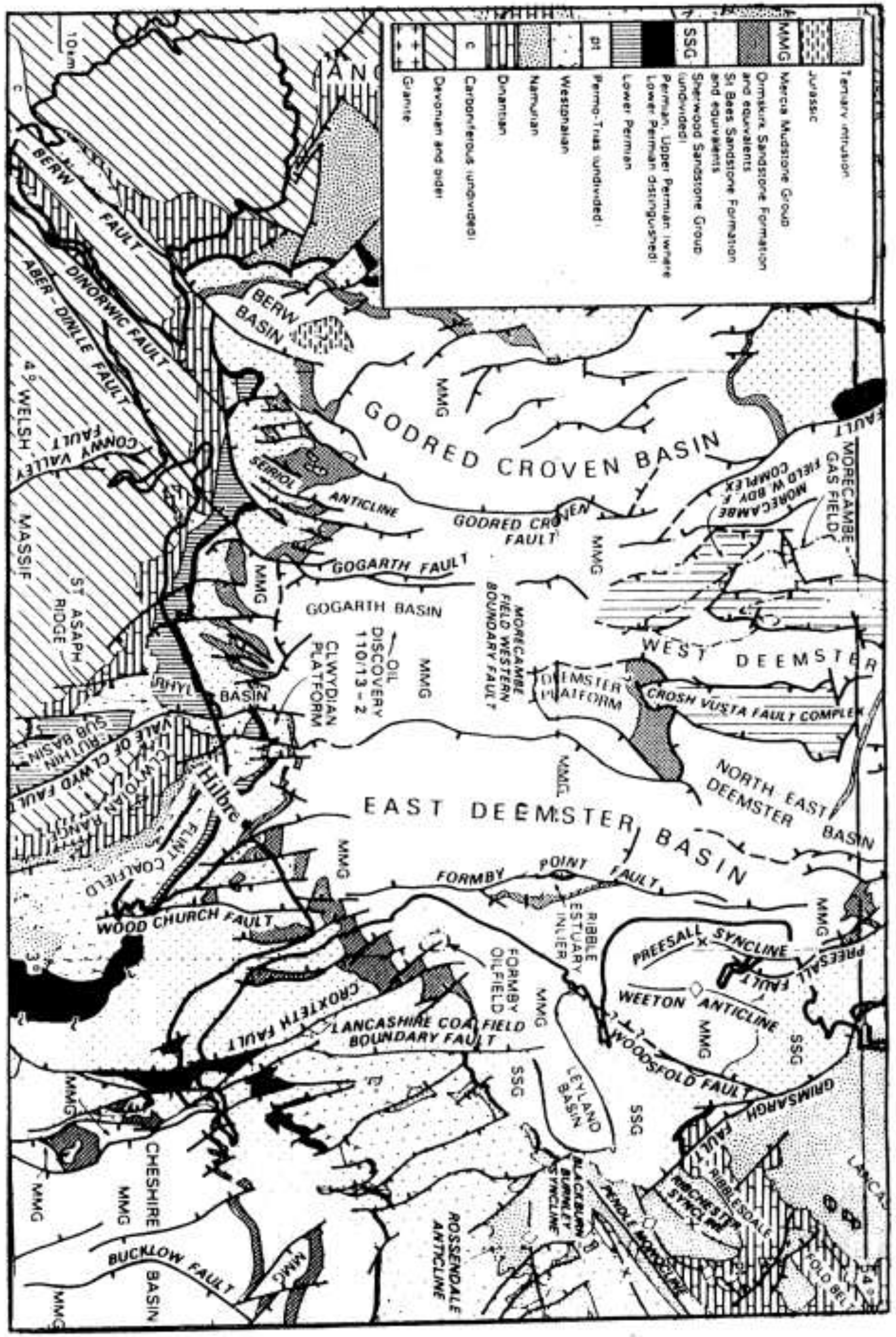
1997

Jan. 14	*Hydrothermal exploration on the Mid-Atlantic Ridge* by Lindsay Parson.
Jan. 28	Practical Session at Liverpool John Moores University on *A practical introduction to trace fossils and ancient marine environments* with Joe Crossley.
Feb. 4	*Early life from the Late Precambrian/Cambrian* by Peter Crimes.
Feb. 7	The Society Dinner at Jenny's Seafood Restaurant, Liverpool.
Feb. 25	*Water as a resource and a hazard* by Frank Nicholson.
Mar. 8	Field trip to The River Dee Catchment led by Frank Nicholson.

No footprints or other trace fossils have been reported previously from the islands in the Dee Estuary, but large and small footprints, mudcracks and rainpittings, associated with thin mudstone intercalations in sandstone building stone quarries (now known to be of Anisian, Middle Triassic age) (Benton *et al.* 1994) had been first found at Storeton, in the general Liverpool area, in 1838. These features created enormous public and scientific interest (see Tresise for the full stories: 1989a,b; 1991a,b; 1993a,b; 1994, 1997) which was only increased by other finds at Rathbone Street (Liverpool) (1840), Weston (Runcorn) (1846) and Flaybrick Hill (Birkenhead) (1848). The larger prints were soon associated with finds which had been made in 1833 in what are now known to be Middle Triassic Sandstones at Hessburg, Germany. The latter were given the name *Chirotherium* (=hand animal), whilst the smaller prints were eventually named *Rhynchosauroides* from their presumed relationship with a lizard-like animal *Rhynchosaurus articeps* Owen. Bones of the latter had been found two years after its presumed footprints (Ward 1840) in the Grinshill Quarries in North Shropshire (in the south of the Cheshire Basin). The presence of the many other types of trace fossil which are present on the slabs from the general Liverpool area, and which would contribute greatly to our understanding of the palaeoenvironment of the times, have been inconveniently ignored right up until the present day.

Formerly the beds on all the Hilbre islands (Middle Island, Little Eye, Tanskey Rocks, Caldy Rocks etc.) were considered to belong loosely to the Cheshire Basin (Hull 1869; Thompson 1970a), but modern hydrocarbon exploration offshore has assigned them to the East Irish Sea Basin (EISB) and to a sub-basin, the East Deemster Basin, of that general area (Jackson *et al.* 1987; Jackson & Mulholland 1993; Jackson *et al.* 1995; see Fig. 3). This sub-basin is bounded on the east by the north-south Formby Point-Woodchurch Faults downthrowing west, and on the west by an unnamed north-south fault some 20 km westwards. It terminates southwards on the Lleyn Peninsula-Rossendale basement ridge. A seismic section across the sub-basin is given in Jackson & Mulholland (1993, fig. 3b). North-south faults of modest throws are easily seen or inferred both on the Wirral and in small parallel fractures and channels which cross the Hilbre Point-Redstones and the Hilbre islands area. Indeed, one small north-south fault terminates the footprint locality itself on its northwest side.

The stratigraphic problem associated with the outcrops of Hilbre and Wirral is longstanding. In 1854 the Geological Survey of Great Britain, in the form of Edward Hull, was completing the mapping of the Carboniferous and Permo-Triassic basins on horseback. The Survey heralded its work by presenting the then new, but now Old Series, one-inch geological map 79 of the



DIRECTORY OF BRITISH

GEOLOGICAL MUSEUMS

Published by The Geological Society

This handy A5 Directory includes details of all major geological museums in the British Isles and lists contact names, 'phone numbers, opening times, admission charges, as well as details of major collections, gallery displays, research facilities and publications.

Compiled by Dr John Nudds for The Geological Curators' Group and published in 1994, it is now available at the specially reduced price of £10.00 to subscribers to *The North West Geologist*.

Please send cheques (payable to "Dr J.R.Nudds") to Manchester University Museum, Oxford Road, MANCHESTER M13 9PL.

BOOK REVIEW

The tracks of Triassic vertebrates. Fossil evidence from north-west England. Geoffrey Tresise with William A.S. Sarjeant. 1998. The Stationery Office. ISBN 0 11 290498 X. £65.00 (or £29.75 from Liverpool Museum Bookshop), 204pp.

Large vertebrate footprints from the Triassic Period were first found in Germany in the 1830s. Hundreds of subsequent finds in North West England were to attract the attention of early gentlemen geologists. The times of these Victorian scientists is brought to life by this book with skilful reference to hitherto unpublished accounts and illustrations.

This lavishly illustrated book then conducts the reader through a comprehensive history of these fossil footprints from the early attempts to reconstruct an animal without skeletal remains, through over a century of commentary on the tracks and trails via the leading role of eminent local scientists such as ichnologist Henry Beasley, to the present day level of understanding and interpretation and recent finds on Hilbre Island. Beasley's extensive photographic archive is fully inventoried and generously illustrated (Appendix 1).

The contribution of local museums to the story is significant and also members of local societies will be interested in the roles played by their groups in this fascinating story. Chapter 9: George Morton and the Liverpool Geological Society is of particular interest.

The title gives an immediate impression of a very specialised topic, but this book is as much a commentary on local history as it is a geology reference on its much older topic and will appeal to a wide audience. The cover price of £65 unfortunately places the book in the category purchased largely by libraries and academic institutions, but the special price of £29.75 from the Liverpool Museum bookshop should ensure that it appeals to a larger market.

The authors are congratulated for assembling this important record of *Chirotherium*, which is a significant milestone in the history of local geology.

(Chris Hunt)

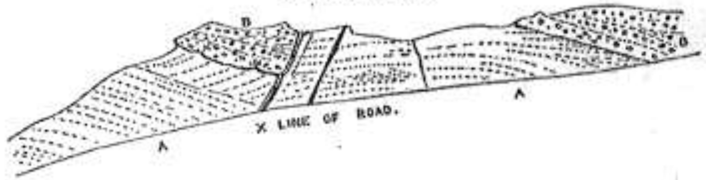
Figure 3. The structure and solid geology of the southeast part of the East Irish Sea Basin to show the assignment of the Hilbre islands to the Ormskirk Sandstone Formation (=both the Helsby Sandstone and the Tarporley Siltstone formations) and Hilbre Point to the St Bees Sandstone Formation, all in the East Deemster Sub-basin (after Jackson & Mulholland 1993, fig. 2, through the kind permission of The Geological Society of London).

Figure 4 (overleaf).
A. The Old Series Geological Map of Hull 1855 in the area of northwest Wirral. F1 = The Lower Soft Red Sandstone (later confirmed by Hull 1860 as the Bunter Lower Red and Mottled Sandstone); F2 = Pebble Beds (The Bunter Pebble beds); F3 = Upper Soft Red Sandstone (The Bunter Upper Red and Mottled Sandstone); F4 = The Lower Keuper Sandstone (not identified on the map of 1855); F5 = Waterstones and White Sandstone (The Keuper Waterstones); F6 = Red Marl (The Keuper Marl with beds of Upper Keuper Sandstone). (With acknowledgments to the Director of the British Geological Survey.)

B. A geological section along the northern side of the main road 1 km east of West Kirby (from Hull 1869, p. 57, fig. 31). According to modern mapping, based on Rice (1939), the lowest rock units would be the Thurstaston Soft Sandstone Member, succeeded by the Delamere Pebbly Sandstone Member, with both belonging to the Helsby Sandstone Formation of Anisian, Middle Triassic age (Thompson 1970a, 1984).

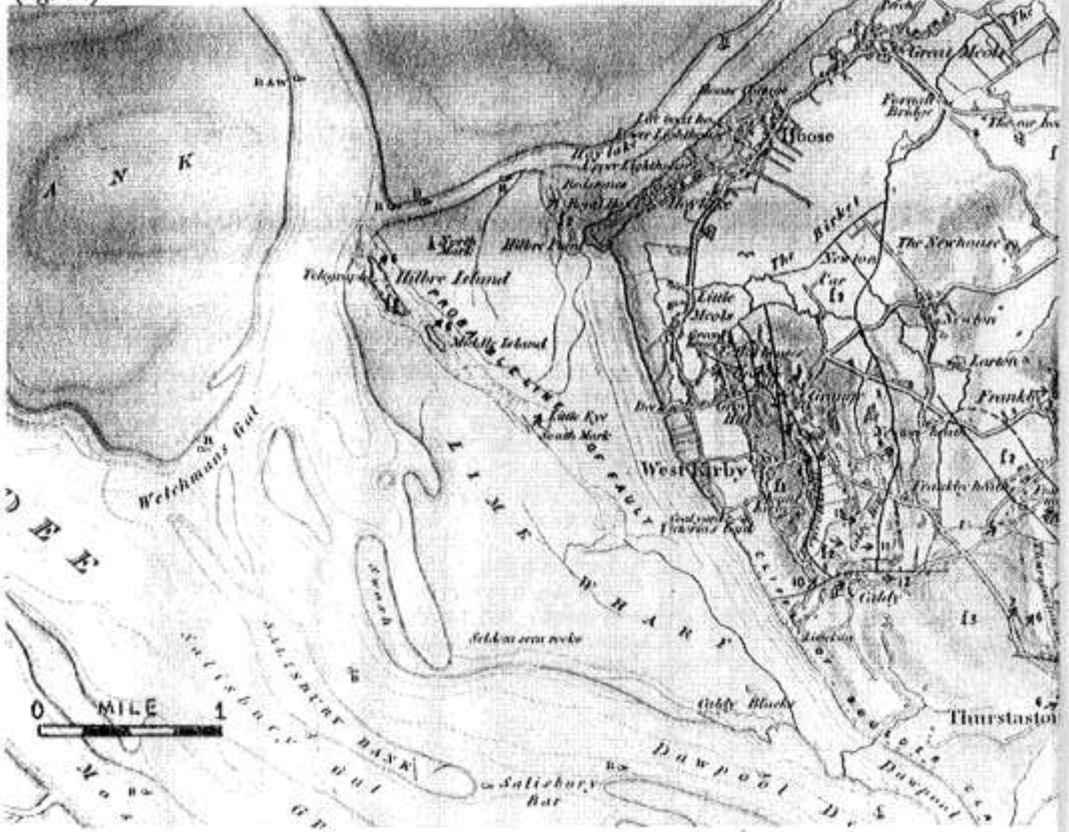
At West Kirby the Conglomerate beds form an escarpment, rising about 200 feet above the sea. The beds which contain pebbles are very hard, and are separated by two interstratifications of soft red sandstone. At the line of junction the surface of the Lower Mottled Sandstone is often deeply eroded, as in the section from which the following sketch is taken (fig. 31).

GRANGE HILL.



A. Lower Red and Mottled Sandstone. B. Pebble Beds × Fault.

At Hilbre Point, near Hoylake, a spur, or reef, of sandstone belonging to the Conglomerate series, strikes northward into the sea, with an easterly dip. It is highly probable that the eastern edge is a line of fault, perhaps a continuation of that represented in the above woodcut (fig. 31).



observed on Wether Edge and on the ridge beyond Swinden Water. Once explained as glacial overflow channels, these features are now accepted as of sub-glacial origin.

The excursion concluded at Hurstwood Reservoir (SD 887315), where exposures of the Old Lawrence Rock showed evidence of past quarrying. The reservoir dam, constructed in the 1920's was unfortunately discovered later to have been built over an unsuspected fault, and a great amount of concrete was required for its completion. Periodic measurements of movement on the fault are still made by checking the alignment of a series of concrete emplacements set in the top of the retaining wall.

(Norman Catlow)

produced in late medieval times by the extraction of limestone boulders from the high level marginal till. A fine example of an old lime-kiln remains, constructed from gritstone boulders.

From here, we moved along the old packhorse track towards Gorple Gap, with a good view of Black Hameldon. This hill was a nunatak in the last phase of the last glaciation, and has no drift deposits above 1500ft. The drift limit is progressively higher to the north and lower to the south, and a line projected through these heights would intersect ground level at the end moraine at Chelford in the Cheshire plain. The 1500ft level could mark the limit of dirty ice, clean ice above this would have left no deposit.

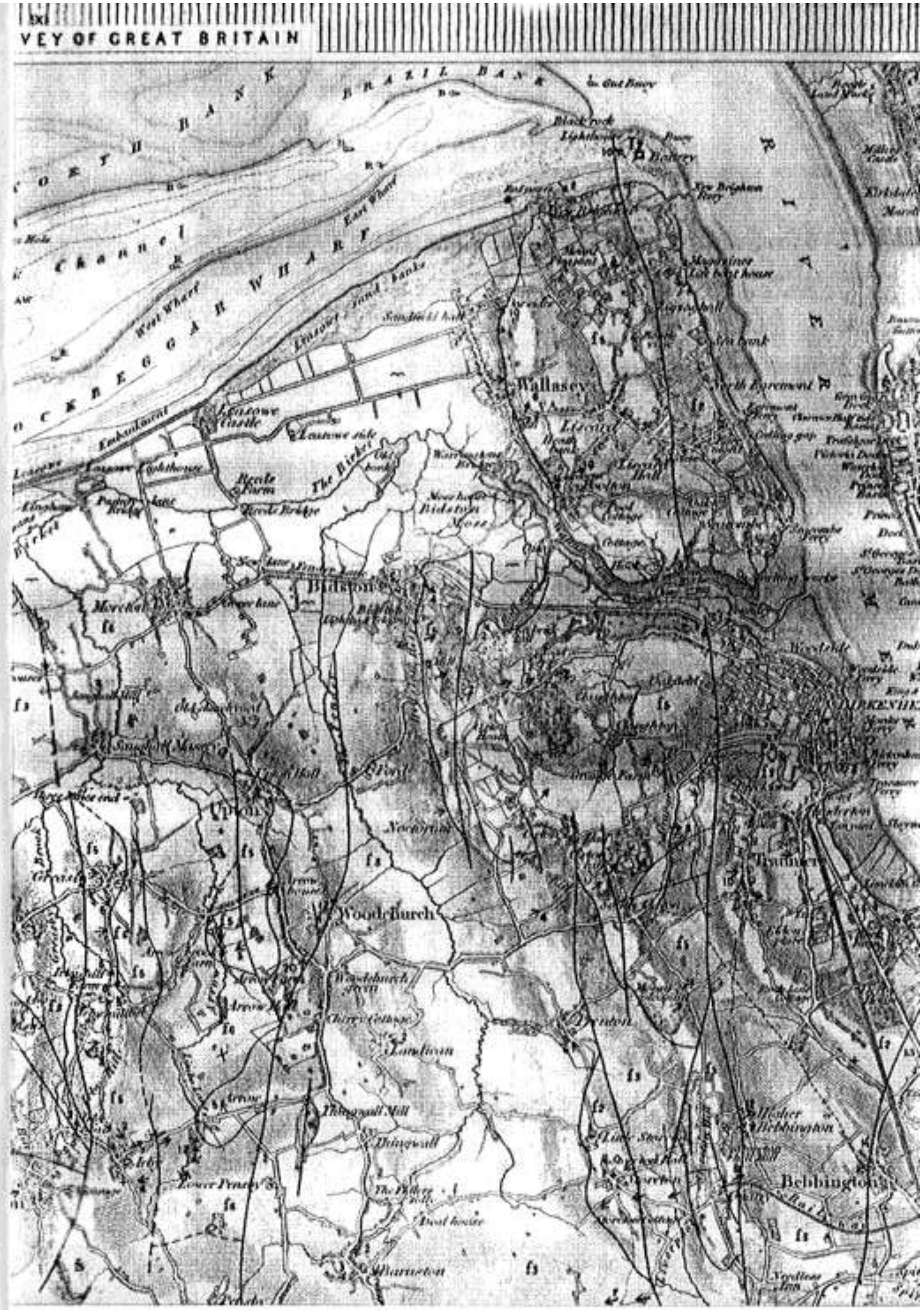
At Harestones, a prominent outcrop of the Kinderscout Grit, a coarse grained arkose, forming the core of the Hameldon Anticline (which is the central Pennine anticline and, appropriately, the Lancashire/Yorkshire border), was a wonderful example of a mill wheel, carved *in situ* from a block of gritstone, and then abandoned. Sadly it had been vandalised be some passing graffiti artist intent on demonstrating a breadth of intellect marginally superior to that of his aerosol spray can.

We halted for lunch at Gorple Rocks (SD 920320), an outcrop of cross-stratified Kinderscout Grit with a gentle easterly dip. The Gorple Reservoir below this point rests on the shales which underlie the Kinderscout Grit. Above the reservoir, the prominent outcrop of Mystery Buttress could be seen, topped by a perched block. This block rests on pebbles, not on glacial drift, and is taken as evidence in favour of the clean ice argument mentioned above.

Along the Gorple Road leading back to Hurstwood, first-order rock exposures in the core of the Pennine anticline were observed. These rocks are heavily frost shattered, having been subjected to stretching and fissuring whilst being upfolded.

In Rams Clough (SD 912321) at Gorple Gate an exposure of westerly dipping shales was seen outcropping above the Kinderscout Grit. Diligent exploration of this outcrop produced abundant specimens of *Dunbarella* and *Bilinguites gracile* (formely, *Reticuloceras gracile*) from a highly fossiliferous marine band.

A short detour took us to Wether Edge (SD 904325), crossing a small outcrop of the Rough Rock (top of the Millstone Grit series) on the way. From the viewpoint we looked down into the Swinden Valley, with Pendle and Pen-y-Ghent in the background. Fine examples of "severed spur"-type channels were



Wirral and Liverpool (Hull 1855a) (Fig. 4A), and a specially levelled geological section from Little Eye across the Wirral Peninsula published much later (Hull 1865 a & b), to the meeting of the British Association for the Advancement of Science (BAAS) at Liverpool (Morton 1856).

The story of the mapping of the area is of considerable interest and is much concerned with the interactions of many distinguished geologists of the day. Edward Hull (1829-1917)(Fig. 5A) had been born and educated in Ireland and had gained an engineering diploma in 1849, followed by a degree in geology in 1850. The latter was the direct result of being fascinated by Thomas Oldham's lectures at Trinity College Dublin (Hull 1910; Herries-Davies 1983; 1995). There being no employment for a would-be railway engineer, he followed Oldham's advice and enlisted Roderick Murchison's familial support (Hull's sister was married to Murchison's cousin) to approach Henry de la Beche (1796-1855; FRS 1819), Director of the Geological Survey, for a job. More than a touch of nepotism creeps in here and it is entirely consistent with Hull's and Murchison's overall personalities (see Hull 1910, Stafford 1989)! De la Beche appointed Hull as a Temporary Assistant Geologist to the Survey in 1850, whereupon he was trained by Joseph Beete Jukes (1811-1869; FRS 1853) in North Wales. The training included the making of six-inch to the mile horizontal geological sections using a chain and theodolite. The Old Series geological section lines for the west of the Dee Estuary were first published in June 1850. Subsequently Hull set off to map the Carboniferous and Permo-Triassic basins of England starting in Warwickshire, Worcestershire, Gloucestershire and south Staffordshire before moving northwards. By 1854 he had mapped parts of Cheshire including sheet 79 containing the Wirral (Morton 1856, p.71) and had drawn a geological section across it. He was thus able to present the Survey's interim stratigraphic conclusions to the BAAS meeting at Liverpool in that same year, and the Old Series geological map of the Wirral and Liverpool was issued in February 1855 (Hull 1855a).

Initially Hull had displayed an acceptable standard of work as a surveyor, but he soon became increasingly slipshod. By the time the rocks of the Hilbre islands and Hilbre Point were assigned to the "Bunter" Pebble Beds (following Adam Sedgwick's (1826) introduction of the German classification of the Triassic rocks to the British Isles), de la Beche was instructing Andrew Ramsay (1814-1891; FRS 1843), his local Director, to secure Hull's resignation (Herries-Davies 1983, p.199). The kindly Ramsay demurred, but successive inspections revealed little improvement; indeed careless editing of memoirs was being added to the list of Hull's weaknesses. Little wonder therefore that Hull was passed over for promotion and tenure between 1850 and 1859, despite the fact that Murchison (1792-1871; FRS 1826), whose appointment at an advanced

LGGA FIELD TRIP TO HURSTWOOD, NEAR BURNLEY (19th APRIL 1997)

Leader: I.A. Williamson

The day began with a short historical tour of the ancient hamlet of Hurstwood (SD 881335), which contains a wealth of late Elizabethan houses built of locally obtained stone, and roofed with the flaggy sandstones of the Old Lawrence Rock. The characteristic low-pitch of the roofs hereabouts is a direct result of the unavoidable weight of this material.

Several notable buildings were pointed out, among them: Hurstwood Hall with its mullioned windows, built by Townley in the 1540's; the reputed house of the Elizabethan poet Edmund Spencer; the dwelling place of the sister of Ernest Shackleton, the polar explorer; and Tattersall's Tenements, the origin of the famous Tattersall family of horse racing fame.

We moved on along the post-glacial gorge of the River Brun, which is cut into the thick bedded Dandy Rock, with the Dandy Mine above it. The pre-glacial valley of the River Brun is now infilled with glacial drift (70ft of boulder clay were proved in the boreholes for coal). The river later cut a deep gorge through the bedrock to form the narrow Rock Glen, later widened by mid-19th Century quarrying, probably for Victorian buildings in Hurstwood and Worsthorne.

At the head of the gorge, at Hey Laithe, we crossed the Worsthorne Fault (throw 500ft) and paused for a short talk on coal mining activity in the area. The Arley Mine which was worked here has all been mined out, but massive reserves remain in the Union Mine. Problems of high sulphur content, however, and the danger of draining the overlying aquifer mean that these reserves will probably never be recovered. The possibility of methane drainage was discussed, but the relatively shallow depth of the coal means that much of the methane is already lost.

We proceeded up the valley to Cant Clough reservoir, built from stone quarried nearby. Here could be seen the track of Union Mine indicated by a notch in the hillside where differential erosion of the soft coal and the hard bedrock had picked it out. The remains of the Union Mine workings were marked by a stream of ochreous water issuing from the ground.

Above Cant Clough Reservoir we passed through a field of hushings,

MUSEUMS ROUNDUP

Clitheroe Castle Museum

Documentation work has continued at a pace. We now have three regular volunteers, Norman Catlow, Geoff Sullivan and Catherine Jopson, who have worked wonders on the collections. The minerals, igneous, sedimentary and metamorphic rocks are all now on the computer and re-stored in a highly accessible order. This makes it easy to search for complex groups of specimens and then find them in the stores, as intimately associated specimens should be together. This work is slow and the advanced stage that we have reached so quickly is a credit to the hard work of our volunteers. Work in future will concentrate on the fossil collection which may take some years to complete.

The Earth Science education package that we offer is now honed to perfection. The primary school market is now more difficult to capture with the specific attainment targets of National Curriculum, but with some attention to detail, it is possible to produce activities carefully tailored to attract school groups by the bus load. The ROX Project developed at Clitheroe is made up of three parts: ROX 1 is an introductory pack of teachers' notes and childrens' exercises so that groups are prepared prior to the museum visit; ROX 2 is an intensive session at the museum with an activity session and a detailed worksheet for the galleries; ROX 3 is a loan box which is taken to schools and contains exercises, based upon specimens, videos and books, which build upon topics introduced previously.

The Activity Weekend held last July was as busy as ever. Military history, spinning, Victorian washing day, printing, natural history, childrens' activity area, minerals, coral sectioning and gold panning were amongst the themes covered by over thirty volunteers. It was the museum's busiest weekend and staff and visitors had an intensive, tiring yet enjoyable time, I hope !

I will finish by inviting anyone with spare time that they would like to put to constructive use, to join our merry band of volunteers every Wednesday. Not only is this very satisfying work, but it must also be quite fun as I have heard much laughter emanating from the stores in recent months !

(Alistair Bowden)

age had been greeted by acclamation in parliament, was now Director General of the Survey (from 1855). (Note the military metaphor, connotation and rank; Murchison, formerly only a junior officer, was now at the head of a geological army which was to pursue campaigns and conquer ground in rugged terrain in the face of an implacable opponent, Nature itself, not to mention any number of perceived intellectual enemies).

In a context of renewed expansion of the Survey in order to pursue applied ends, notably the delineation of the coal reserves of the British Isles, Hull was eventually given tenure and promoted to Geologist in 1859. Hence the maps and memoirs for the Wigan, Prescot, Oldham-Manchester and Altrincham areas (Hull 1860b,c,d; 1861) were drafted and the local geology described briefly. On the slightly more positive side, throughout his life (which included his election to FRS in 1867 and his very capable Directorship of the Survey in Ireland from 1869 to 1891), Hull developed a penchant for constructing sweeping generalisations: inventing stratigraphic classifications (Table 1), palaeoenvironmental diagrams (Fig. 8) and palaeogeographies of far-ranging application. As Herries-Davies (1983, p.200) states, "sometimes a breathtaking naivety led him to adopt simplistic solutions to problems that really possessed great complexity". With hindsight we now know that the problem of correlating the rock formations and interpreting the aeolian, fluvial and evaporitic palaeoenvironments of the Permo-Triassic rocks were of this kind. Remember, however, that only recently have historians of the geological sciences been professional enough to caution us against evaluating old hypotheses and classifications outside the historical context in which they were created and discussed.

It was against this background that the classification of the deposits hitherto merely known as the New Red Sandstones (Table 1) was first attempted. The scheme is likely to have been proposed orally at the BAAS at Liverpool in 1854 (Morton 1856), but it was only set down in full at the meeting of the peripatetic Manchester Geological Society, of which Hull was a Vice-President, in the rooms of the Natural History Society Museum[1] in Peter Street, Manchester, in December 1859 (Hull 1860a) (Fig. 5B). Hull's classification was thereafter adopted and applied unswervingly (and often uncritically) by members of the Survey in its memoirs (including the Liverpool Memoir; Wedd *et al.* 1923) from 1860 until it was replaced by the scheme of Warrington *et al.* only in 1980! Herein, therefore, lay part of the problem of assigning proper ages and correlating isolated outcrops of rock at Hilbre,

[1] This Museum was the forerunner of the present Manchester University Museum.

Table 1. The Geological Survey's new classification of the rocks of the Trias or New Red Sandstones as formally pronounced by Edward Hull at the meeting of the Manchester Geological Society on Tuesday 20th December 1859 in the rooms of the Museum of the Natural History Society, Peter Street, Manchester (after Hull 1860, p. 23).

FORMATION	DIVISION	SUBDIVISION
Trias		1. Red Marl, with beds of Upper Keuper Sandstone
or	Keuper	2. Lower Keuper Sandstone or Watersones, with a base of breccia or conglomerate.
New		1. Upper Red and Mottled Sandstone
Red	Bunter	2. Pebble Beds
Sandstone		3. Lower Red and Mottled Sandstone
(Permian)*		1*. Soft Red Sandstone of Collyhurst (overlain by thin limestones in which E.W. Binney had found fossils)
(Permian?)*		1*. (The Upper Carboniferous Red Sandstones and Mudstones like the Keele Sandstones were then regarded by Hull as Permian in age).
(Carboniferous)*		2*. Productive Coal Measures

* These definitions and descriptions were not included in Hull's Table in his 1860 paper, p. 23; they have been added in order to clarify the stratigraphic succession of those times.

CONSERVATION CORNER

Lancashire RIGS (Alistair Bowden)

This has been a most unusual year. After completing our first round of site designation, the group has taken a new direction. We are developing a Heritage Lottery Fund bid to move the group from a passive, reactive position, into one in which we actively develop links with planning authorities, education, local geology groups, other conservation groups and industry to accomplish all our aims. This is a long process involving a great deal of preparation, but we ultimately hope to employ two part-time members of staff to support a more professional group to develop the protection and interpretation of Lancashire's Earth Heritage.

Greater Manchester RIGS (Simon Riley)

Our major drive this last year has been site recording which has progressed well. The eight districts of Greater Manchester originally selected for the survey (comprising of over 70 sites) are virtually complete. Our thanks to all those who have helped with the site surveys and by way of a gentle reminder, I would be grateful if any completed recording forms could be returned as soon as possible.

We are now in the process of broadening the survey area for Greater Manchester to include the districts of Stockport, Tameside and Trafford (originally taken on by Cheshire RIGS). A provisional list of potential sites has been drawn up for these districts. Any additional information on potential RIGS sites in these areas would be particularly welcomed. As ever there is no shortage of work and any offers of help will be gratefully received. Contact Simon Riley, Manchester University Museum, Oxford Road, Manchester M13 9PL (Tel. 0161 275 2636; Fax 0161 275 2676; e-mail simon.riley@man.ac.uk).

Staffordshire RIGS

For information contact Sue Lawley at the Staffs Wildlife Trust, Coutts House, Sandon (Tel. 01889 508534).

Now, all the waters that had percolated down through the rock and through the upper mine workings to this low point could now run away in its subterranean channel to Alston and its meeting with the River South Tyne. The final leg up to Middleclough Burn was never started, for very little had been learned in this mammoth, deep-driven tunnel. After 1900 the Vielle Montagne Zinc Company extended the Nent Force Level up to an underground shaft in Ramp Gill Mine called the Low Whimsey Shaft (see no 10, Figs 1, 2).

The last manager at Nenthead, Mr Amos Treloar, told the author personally that the length between the Wellgill Shaft and Brewery Shaft gave him much trouble in his time at Ramp Gill Mine. In exploring those higher measures on the drive to Brewery Shaft, the rock driven through was of poor strength and quite unstable at times. Mostly shale, Amos kept having to detail men to clean out this stretch after falls, for these falls could never be allowed to impede the flow of water from Brewery Shaft. In desperation they ordered a quantity of bricks, and then turning themselves into "brickies", began to lay these along the sides in the unstable places. Realising that there were not sufficient bricks for all the bad ground, Amos let on an idea that was to save the day, for the waterway is still open after all these years. They laid the bricks corner to corner, but leaving gaps in between the bricks, so that more wall can be faced with fewer bricks.

The Nent Force Level was not a great success; it did not find any new reserves at depth and so the only good that came from it was the spillway for water, which was at a much lower level than the River Nent. Water power was harnessed after 1903 and then this spillway became a real asset because of the extra head of usable water to power the pelton wheels and compressors in the chamber below the Brewery Shaft (Holliday 1997).

REFERENCES

HOLLIDAY, H. (1997). Power for free - the Nenthead hydraulic compressors. *The North West Geologist* **No. 7**, 48-55.

Figure 5 (overleaf).

A. Edward Hull (1829-1917; FRS 1867), a modestly successful geologist with the Geological Survey of England and Wales, and later Scotland, but a very successful Director of the Geological Survey of Ireland 1869-1891. (From Hull 1910.)

B. *The Transactions of the Manchester Geological Society* 1860, related to the December meeting of 1859, at which Edward Hull, as a Vice-President, was invited to introduce formally the Geological Survey's new classification of the Triassic rocks of the Central Counties (and in effect the rest of the British Isles). This illustrates Hull's penchant for "squeezing the evidence" and constructing wide-ranging, oversimple generalisations of doubtful value (see also Fig. 8).

Manchester Geological Society.

Vol. 2.] DECEMBER, 1859. [Part 3.

The monthly meeting of the members of the Manchester Geological Society was held on Tuesday, 20th December, 1859, at the rooms of the Natural History Society, Museum, Peter Street. Sir James Kay-Shuttleworth, Bart., F.G.S., president of the society, occupied the chair. There were present Mr. W. E. Binney, F.R.S., F.G.S.; Mr Joseph Dickinson, F.G.S.; Mr. Thomas Wynne, F.G.S.; Mr. John Atkinson, Mr. A. Knowles, and many other members.

The PRESIDENT said this was the first time he had occupied this position, which he felt he owed rather to the kindness of the members than to any merits of his own, or to his acquaintance with the geology of this district. As far as his humble position in the county would permit, he should be extremely happy if he could afford any facilities to the Geological Society of Manchester, by aiding the members to pursue their inquiries in his neighbourhood. Personal hospitalities, and such as he hoped to procure from gentlemen in the vicinity, access to their mining surveys, and other means for geological investigation, with any other facilities at his command, he should do all he could to place most heartily at the disposal of the society.

Mr. BINNEY said it was one of the objects of this society to hold such meetings in different towns of Lancashire. Some years ago they had a very interesting meeting at Wigan, and he thought it was very desirable they should have a meeting either at Burnley or Accrington. He was sure there were many intelligent engineers and practical geologists in the neighbourhood, who would take great interest in their proceedings. He could speak from his own knowledge that there was amongst the working men of that district a spirit of inquiry and industry in collecting fossils, such as he had met with in no other part of Lancashire. He was remarkably pleased with the collections he saw at Burnley. The collection of fish was the best he had seen in the country; and the collection of fossil plants was an admirable one, and did great credit to the

No.	Shaft name	Feet from Portal	Depth of Shaft	Height at Shaft top
1.	Jockey Shaft	485'	40'	930'OD
2.	Gossip Gate Shaft	1,875'	62'	952'OD
3.	High Nent Force Shaft	4,520'	147'	1,037'OD
4.	Water Greens Shaft	7,020'	175'	1,065'OD
5.	Foreshield Shaft	9,325'	215'	1,105'OD
6.	Lovelady Shield Shaft	12,825'	241'	1,131'OD
7.	Nentberry Haggs Shaft	17,700'	360'	1,250'OD
8.	Wellgill Shaft	22,260'	213'	1,273'OD
9.	Brewery Shaft	26,125'	422'	-
10.	Low Whimsey Shaft (an underground shaft at Rampgill Mine).	-	328' (Rampgil l Horse Level)	-

Table 1. The shafts along the Nent Force Level

drive. A waterblast consists of a wooden pipe, square in section that is run down the side of a shaft with a stream of water channelled in the top. In falling by gravity, air is induced to enter this box with the falling water and is thus forced down to the shaft bottom and if necessary along the passages. The water runs away via a cistern, but the air is forced along the pipe until it reaches the working face where it clears the gases from blasting and dispels the dust.

In the 1830's the disadvantages of wooden pipes from the point of leaking and rotting were well known, and after considering other materials, for example tin and iron, which had their own weaknesses in highly mineralised waters, Mr Thomas Dickinson, the agent and Moor Master at the time, decided to use lead pipes. Whether or not this was a success the author is unaware, but he must have had faith in this material for he fitted up the Nentberry Haggs Shaft with a lead pipe 1,800 feet long to ventilate the next length of passage. This shaft, the largest of the nine along the whole length (see no 7, Figs 1, 2), was actually sunk before the level had reached that point; this allowed a breathing space before the break through to allow machinery and water wheels to be in place ready for the next level. One water wheel was used for pumping out water and the other was used for hoisting materials, and possibly men, up and down the shaft.

However, Haggs Engine Shaft was the jumping off place for another change of plan. Lack of success in the search for deep ore reserves forced them to think again and so from this shaft onwards the deep drive was discontinued and instead they continued at a higher level. The rest of the drive, because boats were not to be used, could become a smaller, more normal sized passage, so progress came quicker in this final stretch. This drive onwards was at 145 feet higher, i.e. about 1,035 OD, or 215 feet down from the surface. The shaft from the surface down to the new drive was 10 feet in diameter, but below the new drive was only 7 feet, for it was only used for the falling water.

Today the lower part of this shaft is much affected by this water; sharp flutes are formed in the limestone, and near the bottom large numbers of timbers have fallen out of the upper works and block the way into the level.

The next shaft, Wellgill (see no 8, Figs 1, 2), near to the village of Nenthead, was reached in 1842, 66 years after it was begun, and the distance to this point is 4.25 miles (6.8 km); this equates to 22,260 feet from the entrance in Alston. By 1856 the Nent Force Level had reached Ramp Gill Mine and was connected to the Brewery Shaft (see no 9, Figs 1, 2); this point is 26,125 feet from Alston and had taken 79 years to drive (Table 1).

working men who contributed them. He had not seen throughout the United Kingdom such industry and intelligence in collecting fossils, and it would give him great pleasure to revisit Burnley.

The PRESIDENT repeated his offer of the hospitalities of Gawthorpe Hall, and suggested a desirable course of explorations under Mr. Binney's guidance, extending over the best part of two days. Such a meeting would be exceedingly encouraging to the working men of his district, would give a new stimulus to their observations and investigations, open the sources of information contained in the mining district, and have a considerable influence on the question of structural geology, to which Mr. Binney and other eminent geologists were giving increased attention.

A discussion ensued as to the best time and locality for the excursion, and it was understood that it should take place as early as convenient, the details of arrangement being left with the President, Mr. Binney, Mr. Dickinson, and other members of the council.

Mr. EDWARD HULL, B.A., F.G.S., of the Geological Survey of Great Britain, was requested by the President to read his paper.

ON THE NEW SUBDIVISIONS OF THE TRIASSIC ROCKS OF THE CENTRAL COUNTIES.

BY

EDWARD HULL, A.B., F.G.S.

Of the Geological Survey of Great Britain.

IT is not my intention in this communication to tread in the steps of those Lancashire Geologists, who have already very faithfully described the distribution of the Permian and Triassic rocks of Cheshire and Lancashire. Mr. Ormerod,* in his well-known Memoir, published by the Geological Society of London, has traced the range of the Keuper and Bunter Divisions, from the skirts of the Lancashire and North Staffordshire coalfield on the north and east, to the ranges of Peckforton and Delamere Forest on the west. Mr. Binney,† in several contributions to this and other scientific societies, has described these and the subordinate Permian and Carboniferous rocks in great detail; and I here take the opportunity of acknowledging the essential service to myself which his Memoirs have proved, in the prosecution of the Geological Survey of this district.

* *Journ. Geol. Soc.* London. Vol. iv.

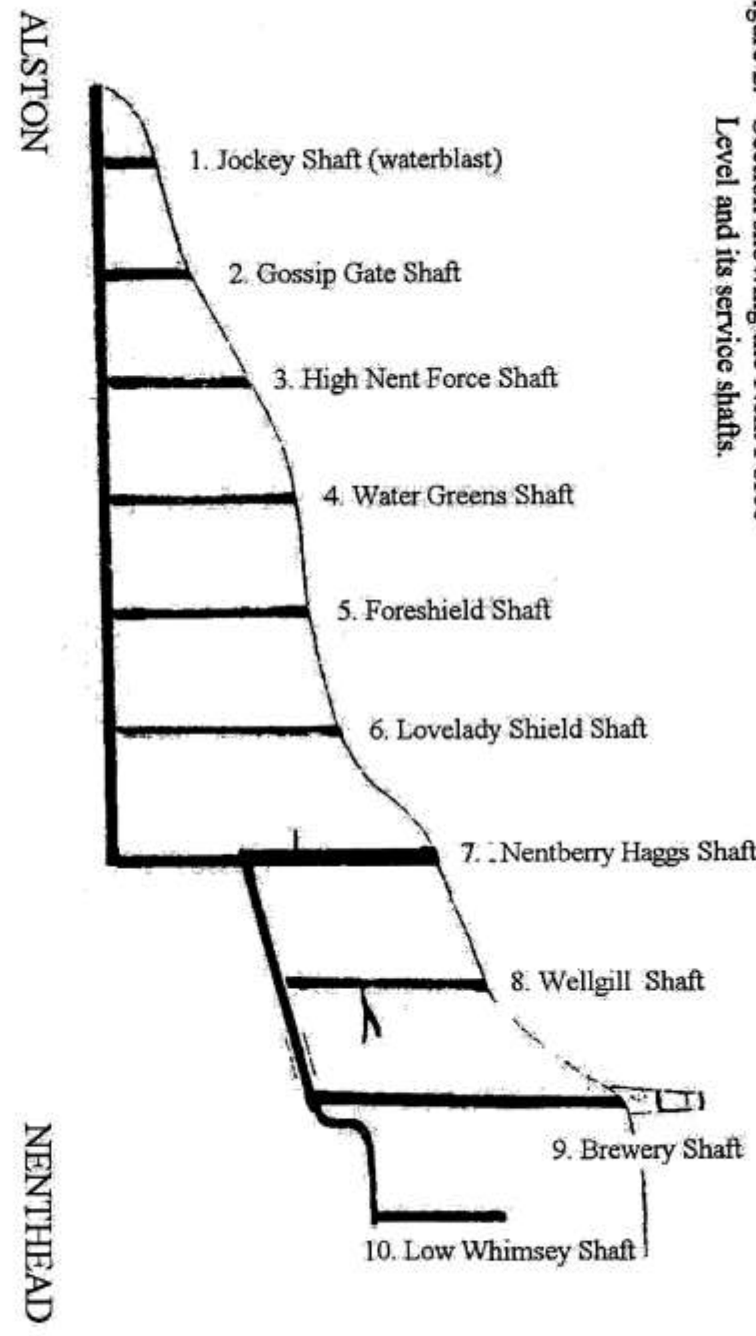
† *Trans. Geol. Soc.* Manchester. Vol. i.—Also *Mem. Lit. and Phil. Soc.* Manchester. Vol. xii.—And *Quart. Jour. Geol. Soc.* London. Vol. ii.—See also Mr. Rawlinson.—*Ibid.* vol. ix.

Middle Island, Little Eye, Tanskey Rocks, Caldy Backs, Hilbre Point, Grange Hill, Caldy Hill, Thurstaston etc. Hull's solutions (Fig. 4) do not bear modern scrutiny. For example the rocks of the Grange Hill roadcut, southeast of West Kirby (Fig. 4B), now regarded as the top of the largely aeolian Thurstaston Sandstone Member overlain erosively by the fluvial Delamere Pebbly Sandstone Member of the Helsby Sandstone Formation (Middle Triassic) (Rice 1939a, Thompson 1970a, Benton *et al.* 1994) was ascribed to the "Bunter Lower Mottled Sandstone" (?Permian) overlain by the "Bunter Pebble Beds" (Lower Triassic).

One George Highfield Morton (1826-1900) was present at the BAAS meeting in 1854. Then a painter and decorator educated at the Liverpool Mechanics' Institute, he was soon to be turned into a lecturer in geology at Queen's College (an evening college and an arm of the Liverpool Institute and London University) (Hewitt 1910). Thus he was inspired to investigate the local Triassic rocks from that time onwards. There being no prestigious geological society in the town until 1859, he presented his first paper to the Liverpool Literary and Philosophical Society in 1856. This paper related to the subdivisions he recognised in the New Red Sandstone, all illustrated by geological sections which he had drawn up himself. No doubt relying greatly on the oral presentations of Hull in 1854 and the Survey map of 1855, he nevertheless revealed a considerable acquaintance with the Hilbre islands:

> "Rather more than a mile from the eastern shore of the Dee there is a small island, or rather point of rock, this is near the western extremity of the section; at no remote period it must have formed a part of Hilbre. Altogether there are three islands connected by rocks only covered at high water. They are all composed of the "coarse red sandstone and conglomerate" of the bunter formation. It dips to the N.E. at an angle of six degrees. On the S.W. of the two larger islands a true conglomerate crops out at the base of the cliffs. It is composed of fragments of white sandstone, probably derived from the upper coal measures at no great distance, for they are sharp and angular. There are also quartz pebbles imperfectly rounded, but of these and other primitive rocks there are comparatively few. The base is a yellow sandstone reposing upon a band of arenaceous clay*. The superincumbent beds are generally deeply tinged with per-oxide of iron, but in many places it changes both horizontally and vertically into a light brown or yellowish sandstone with quartz pebbles. The conglomerate of Hilbre has not been identified in any other position; it probably belongs to the base of the sub-division, but thins out to the east. A fault (No.1 in horizontal section) must of necessity exist in the bed of the Dee, between the islands

Figure 2. Section showing the Nent Force Level and its service shafts.



and the Cheshire shore, for the "lower soft red and variegated sandstone" is thrown up and can be observed in many sections about West Kirby**. It consists of a very soft red sandstone, so friable that it cannot be used as a building stone: there are not any clay partings, but joints cross it in many directions.

* This horizon is believed to be that of the present footprint finds.

** These outcrops are now referred to the Wilmslow Sandstone Formation and the Thurstaston Member of the Helsby Sandstone Formation rather than the Lower Mottled Sandstone (now known as the Kinnerton Sandstone Formation with a type section at NGR SJ 328604; see Thompson 1984).

By 1863 Morton had worked diligently on the local geology and it was in this context that he advertised a section of strata from Hilbre to Huyton in the Proceedings of the newly founded Liverpool Geological Society (Morton 1863a) (Fig. 6). He also provided a description of the rocks of the Hilbre islands in the first edition of his book on the Geology of Liverpool (Morton 1863b, p.32). By 1865 the Survey had at last published the specially constructed 1:10,560 (six inches to the mile) horizontal section from Little Eye to Horwich Moor (Hull 1865a & b) the basis of which had been exhibited in 1854. This was even more belatedly followed by the explanatory memoir of the geology of all the Permo-Triassic basins of the Midland Counties at a time when Hull was starting his Directorship of the Irish Geological Survey (Hull 1869). In this work Hull provided a woodcut of the position of the Breccia Bed on Middle Island (p.57) and described its fragments (said to be derived from the Carboniferous rocks in the vicinity of the North Wales coast) in some detail together with the incidence of the faulting across what we now describe as the footprint locality. In all these papers the beds were assigned to the "Bunter" Pebble Beds (BPB) of the Midland Counties. This opinion was therefore repeated in 1891 in Morton's second edition of his book. He suggested (1891, p.81-2) that the Lower Pebble Beds occurred at Hilbre itself. Outline rock successions were provided for the southeast of Hilbre (Morton 1891, p.89), Little Eye (*ibid.*) and Hilbre Point (*ibid.* p.93).

Possible dissent from this view of the age of the succession first came from Thomas Mellard Reade (1832-1909) (architect, surveyor and civil engineer, a very distinguished local and internationally accredited geologist) as a result of the first of many field visits by the typically victorian, highly active and inquiring Liverpool Geological Society in June 1887. He preferred (1888, p.389-90; 1892, p.386) to equate the rocks on Hilbre, and particularly the Breccia Bed, to the basal Lower Keuper Sandstones (LKS) of Hull's scheme,

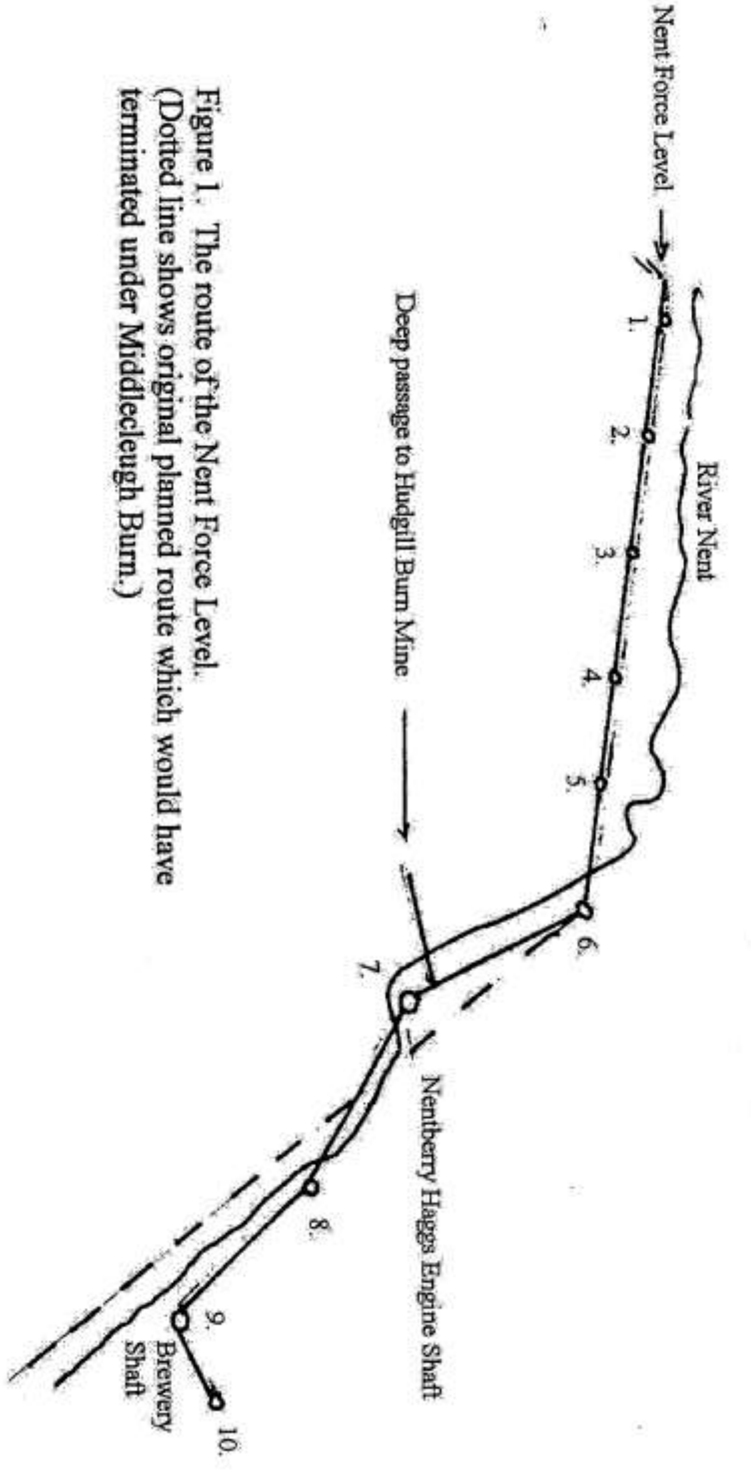


Figure 1. The route of the Nent Force Level.
(Dotted line shows original planned route which would have terminated under Middlecleugh Burn.)

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Figure 6. George Highfield Morton's advertisement for his "Section of the Strata from Hilbre to Huyton" on a scale 1:126,720 (from the *Proceedings of the Liverpool Geological Society* 1, 1863). This section was eminently comparable with that produced by the chain and theodolite transect (on a scale 1:10,560; six inches to the mile) from Little Eye to Horwich Moor by Edward Hull of the Geological Survey. The latter was constructed prior to the British Association meeting at Liverpool in 1854, but was published only in 1865.

project where he did flow meter tests in order to confirm that there was going to be sufficient flow out of the coal mines and if it was going to be adequate to fill up the canals above ground as well ! Smeaton, as arbitrator, would have been allowed to see much, if not all of this project, and would have understood just how it all worked, for off he went back to Alston Moor and within a few years had started to build his own underground canal to his mines.

In 1777 a second alteration was made to the original plans by altering the dimensions of the tunnel, from a normal sized passage to a large one, nine feet by nine feet. These dimensions clearly came from his work for the Duke of Bridgwater, the increased size allowing two boats to pass one another, one full of spoil and the other returning empty, to save winding it up shafts along the line of the valley. A dam would be placed at the entrance to the Nent Force Level to keep the water depth constant at four feet. Many of the original intentions were altered or never carried out because John Smeaton did not live to see it through. In the coal mines at Worsley, seam after seam was tapped and then opened up for profit as the Duke's underground canal moved forward into new ground. At Alston, however, no money was ever made by the drive forward, though the plan for a deep drive was a good sound idea that failed to find any new ore, and so it just became a never ending battle against hard rock that seemed to go on for ever as far as the tunnellers were concerned.

In later years boats took trippers up into the level for boat rides. These boats were pulled in against the current by means of wood or metal rods that had been set in the wall at a suitable height above the water. The boatmen of this time, about 1830, in grasping these projections, man-handled the boats along, the passengers being mainly the young. It was said that at one mile in it was still possible to look back all the way to daylight and the entrance looked just like a bright star ! The drill bits, sticks and jumpers that projected from the wall were hardly likely to have been in the original plan as a motive power for the boats, either full or empty, loaded or unloaded. Perhaps a single boat width level with passing places would have been easier made for it was 4.95 miles (7.95 km) to Brewery Shaft. But it was their size, nine feet square, that made it such hard work and the tunnelling went on for about 79 years. Fathers started it and it was their great-grandchildren that completed the level ! No fewer than nine air shafts came up to the surface along its course and the final length was completed to an internal shaft in Ramp Gill Mine in the early part of this century.

The very first shaft, Jockey's Shaft (see no 1, Figs 1, 2), was said to be a waterblast shaft, only 40 feet deep, but at 485 feet in from the portal; a water blast would have been sorely needed for the first and second shafts on the for "t'owd man" and his work was always present and he was spoken of with much reverence. At some date one Joseph Winskill, who was a miner himself, accidentally broke into and re-entered an old level or drift up on the Browngill vein. He found there ancient tools and some old coins from a previous age; it is said that those coins date from the time of King William Rufus (1087-1100), proving the antiquity of these ancient galleries.

The early mines would have consisted of small passages of a simple layout, or mere scratchings along the backs of the veins, and perhaps a few shallow shafts. By the year 1700 in the quest for more ore, many workings were pushing downward so fast that the depth reached was fast approaching the level of the valley floor, or even worse, the level of the local rivers. When these are reached no more will the adits be self draining. Anything to be mined below this depth will be at or under the water table, so to mine there water will have to be wound or pumped, a time consuming operation for horse or man. After 1856 a plan was in operation to encourage the miners to seek for lead ore below the free draining level, i.e. below the lowest adit, and adjustments were made to the duty owed if these ventures were accepted. By the year 1863 the general duty was reduced to only one ninth as a further encouragement.

The two receivers for the Greenwich Hospital, who owned the mineral rights, were Richard Walton and the engineer John Smeaton. During the year 1775 they made a report to the commissioners of the Hospital proposing the driving of a level for drainage from the River Nent at Alston to the mines above Nenthead. The purpose was to de-water the existing mines and their mineral veins and to explore at depth those known and yet unknown mineral veins. In effect this level, to be called The Nent Force Level, was to lower the natural water level along the Nent Valley; the depression caused would effect this water level for some distance either side as well, though it would take many years work before this adit took water underground from the Nenthead mines, and unkind people called the level, "Smeaton's Folly" for it found no new ore.

The original plan was to drive a perfectly straight leg as far as Lovelady Shield Shaft (see no 6, Figs 1, 2), then a slight turn for a second straight leg to a point near to Middleclough Burn at NY 790425, but for some reason the plan was changed for this second part now runs under the river and below the valley bottom. Later on a second alteration came about due to the news of the success of the Duke of Bridgwater's tunnel on the canal at Worsley. Here a canal was taken completely underground into the mines to the very source of the coal, which was then floated out on special boats built for the purpose. John Smeaton had been called down to Worsley to act as arbitrator on this canal

a significantly higher horizon than the BPB. He traced these rocks from Hilbre up to, but not including, Little Eye. This possible paradox caught the keen eye of Henry Charles Beasley (1836-1919), a bookmaker by profession, who was much later to become the foremost British expert on Triassic vertebrate and invertebrate trace fossils (ichnology). In one of his earliest papers, on the base of the "Keuper" in North Wirral (1891, p.256), Beasley noted that the latest Survey map (of a date and edition which has not yet been identified by the present author) placed the adjacent Redstones area, immediately north of Hilbre Point (Fig. 1), in the "Keuper" group of rocks, i.e. those which immediately succeeded the "Bunter" group. In Beasley's view this was greatly mistaken, and perhaps a Survey drafting error, since he claimed that the rocks there resembled the "Bunter" Pebble Beds at Burton Point in the south of the Wirral, where there was absolutely no doubt of their stratigraphic position. Perhaps significantly for the possible correlation of the Breccia beds present at Hilbre and Hilbre Point (less than 0.25km to the east on the mainland), Morton (1891, p. 93) recorded "annelid tracks" in the BPB at the latter place, but this did not result in any comparisons being made with sections higher in the Trias of the Wirral where comparable trace fossils had been briefly recorded (e.g. at Storeton; Morton 1863b).

No doubt this local stratigraphic problem was discussed on the many further excursions to the Hilbre islands and Hilbre Point led by members of the Liverpool Geological Society. Often, in the best interdisciplinary traditions, these were organised in co-operation with the Liverpool and Manchester Biological Associations (Beasley 1892, 1913; Anon 1896; 1900; Herdman 1904, 1905, 1907, 1909; Whitehead 1910, 1912, Jones 1916). The awareness of this ongoing puzzle is revealed in 1901 in a letter (courtesy of Dr Geoffrey Tresise) from Henry Beasley to Mellard Reade (H.C. Beasley to T.M. Reade 3 August 1901). It states, "the Survey and Mr Morton considered the whole, I think, Bunter Pebble Beds. You, if I remember rightly, were inclined to think them Keuper. But I do not think Mr Watts would trouble going into that question in his note - but say merely 'the Bunter of the Survey'". (William Whitehead Watts, 1860-1947, was at that time Assistant to Professor Charles Lapworth at Mason's College, soon to become Birmingham University, and was later Professor at Imperial College). So far Watts' intended publication has not been located.

Somewhat later, two local geologists (Travis & Greenwood 1911; Greenwood & Travis 1915) were willing to assign the rocks of Hilbre to the BPB when they employed up-and-coming microscopical and heavy mineral techniques and reported a horizon with 8.65% heavy minerals (the highest in the area). A year later however, they (particularly HWG; Greenwood 1916, p.233) were sure that, through further studies using the same techniques, the rocks beginning with the breccia bed were equivalent to the LKS Basement Beds elsewhere in the Wirral and were derived from a fresh igneous granitoid provenance. This left the beds below, including our footprint beds, in the Bunter Upper Mottled Sandstones (BUMS), which were said to be derived from previous sedimentary rocks.

By this time, in 1913, William C. Simmonds (b.1888) of the Survey, working under George W. Lamplugh (1859-1926; FRS 1905), District Geologist, had mapped the area on the six-inch scale, and had contributed to the writing of the Liverpool Memoir (Wedd *et al.* 1923) which pronounced (p. 72, 76) that the assigning of the rocks on all the Hilbre islands to any formation but the BPB was untenable. The field maps and subsequent hand-composed standards have been examined at BGS Keyworth and reveal an enormous amount of detail which has been necessarily summarised to fit the one-inch map, the only official New Series 1:63360 map of the Liverpool area to date. All outcrops on the islands and at Hilbre Point were assigned to "f2" on the official Survey maps and were appropriately coloured yellow. An outline succession was provided for "Little Hilbre Island" (=Middle Island) (*ibid.*, p.76). Subsequently T.A. Jones provided detailed notes on the petrographic nature of the pebbles in the Middle Bunter Sandstones and the derived fossils therein (one Ordovician quartzite with *Orthis*; an Upper Silurian *Platyschisma*; Carboniferous sponge spicules, chert with crinoids and radiolaria, and a coral, but did not always distinguish between material stemming from the Midlands or the English Channel) (Jones 1920a, p.281-308). Jones' further work on the Keuper Basement Beds (1926) did not settle any issues except the re-ascription of the provenance of the rocks in an igneous granitoid area. Nearly 50 years later Davies (1961) described the presence of a small derived ?Upper Valentian *Parmorthis* brachiopod in a pebble of reddish shale and a further Carboniferous coral in a bed c.1m above the Breccia Bed (which lies c.5m above the footprint bed).

Meanwhile, in the 1920s through to the Second World War, the Hilbre islands and the Northwest Wirral continued to be a favourite area for separate and joint field excursions led for the local society (Spence 1920; Hewitt 1920; Anon 1921; Jones 1922, 1931, 1932, 1937, 1938, 1946, 1947; Whitehead 1925, 1927; Jones & H.H. Read 1935; Rice 1939; Schofield 1941-2; Harris 1943-4) alas without any detailed records of the finds which were made or the discussions that took place. All that was reported concerned the mapping and descriptions of R.C. Rice (1939a) who equated the Redstones area with the BPB of Hilbre itself and the coarsest sandstone rocks of the Hilbre Point area with the Breccia Bed horizon of Hilbre.

THE NENT FORCE LEVEL

by Harry Holliday

Alston Moor consists of about 45 square miles of once mineralised and desirable lead mine land that in ancient times was well wooded and covered in trees. The proof of this can still be found today in some of the boggy ground that remains on the higher tops of the district. During the heyday of the mines, most of the trees were cut down to use for timbering in the mines (called pitwork locally) and were also used to burn during smelting of the metals when this was done locally. By Royal decree any miners who worked veins containing silver ore could claim a right to take any wood that was near by and convenient to his mine, to use for smelting the ore.

The Moor is described today as a bleak, wet, peaty moor with little vegetation growing on it, for those ancient forests never regenerated. The mineral veins are situated over most parts of this moor and in the early days any levels would have been driven well above the level of the rivers or indeed the valley floor. In order to counteract any water problems within the mine, early passage ways would have been driven upwards at a slight angle to ensure that they were self-draining. (Such passages are now called adits, from the latin *aditus*, meaning an entry or approach.)

At the lower end of the Vale of Nent are some fine waterfalls and the limestone band that the water tumbles over is the Scar Limestone, the second thickest cyclothem limestone in the northern Pennines after the Great Limestone. Near to these falls is an important portal that now has a direct connection to the Nenthead lead/zinc mines five miles away.

Whether the Roman legions or their slaves ever mined these minerals on Alston Moor may never be proved. Galena has been found in the ruins of the roman fort, less than two miles from Alston, now called Whitley Castle, and though this cannot be proved to have come off Alston Moor, many factors suggest that it might have done. However, proof does exist for mining in this region during the 12th century, for at about 1133 King Henry received £5,000 per year for the silver from mines said to be near Carlisle. Although the names of the mines were not stated it is thought that they were on Alston Moor.

Nenthead, the village, was not in existence until the early 19th century when the mine owners built it for their workers and their families. Such mining circles always talk of the "old men" who mined in previous centuries; respect

THE DINGLE, LLOYD ROAD, NEWTON-LE-WILLOWS. SJ 56699517
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Disused quarry and stream section, 15m long by 3m high, showing a variety of sedimentary structures, including cross and parallel bedding, channelling and erosional features.

WARGRAVE QUARRY, CANAL TOWPATH, WARGRAVE, NEWTON LE WILLOWS. SJ 578945
TRIASSIC, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Quarry showing sandstones with cross-bedding and erosional surfaces. Some beds yield pebbles of pale coloured quartzites. Site valuable for teaching at National Curriculum level.

WINDLEHURST QUARRY, HARD LANE, WINDLEHURST, ST HELENS. SJ 50349693
CARBONIFEROUS (UPPER), Silesian, Westphalian A, Lower Coal Measures, Old Lawrence Rock.
3m by 15m section of yellow sandstone in an old building stone quarry. It is the only site in the area to expose the Old Lawrence Rock.

CONCLUSION

Full information on the sites is held at Liverpool Museum as part of the National Scheme for Geological Site Documentation (NSGSD). Copies of site information for Knowsley, Sefton and St Helens are also kept at the offices of the Joint Countryside Advisory Service (JCAS) in Maghull. Each local authority has a full list of sites for its own area. All sites within the Merseyside RIGS group area will be re-surveyed within the next two years as a review of the local Unitary Development Plans.

The group is aware that the information recorded may not be complete. Anyone who can suggest additions, deletions or corrections should contact the Merseyside RIGS group c/o Tony Morgan, Liverpool Museum, William Brown Street, LIVERPOOL L3 8EN (Telephone: 0151 478 4286).

Alas no footprint beds had been discovered on any of the Hilbre islands before, or since, the turn of the century, despite the efforts of Henry Beasley, Joseph Lomas (1860-1908; chief science demonstrator of the Liverpool School Board) and Frederick Maidwell (1872-1921; a handicraft instructor). These stalwarts had been closely associated with classifying and reporting on the finding of Chirotheroid, Rhynchosauroid and Chelonoid footprints from the Storeton-Runcorn-Lymm and general Liverpool areas (Tresise 1997).

Since 1939-45 interest in these local rocks has languished save for attempts by Thompson (1969; 1970a,b; 1984), Steel & Thompson (1983), Oxnevad (1990) and Herries (1992) to define lithofacies, correlate them across the north of the Cheshire Basin to Liverpool and the Wirral, define new formations/members and interpret the BPB, BUMS and LKS in modern environmental terms. These interpretations relate to fluvial and aeolian processes and settings. Thus was the LKS divided into the Thurstaston Soft Sandstone Member (formed largely of transverse barchanoid dunes, reversing dunes and interdunes), the Delamere Pebbly Sandstone Member (largely braided rivers) and the Frodsham Soft Sandstone Member (transverse barchanoid dune ridges, sometimes blown out to form dome-shaped dunes and interdunes). These three members were soon assigned to the Helsby Sandstone Formation of Scythian age by Warrington *et al.* (1980) and they have since been shifted from the Lower Trias to the Middle Trias (Anisian) by Benton *et al.* (1994).

Coincidentally, enthusiasm for Triassic stratigraphy was revived somewhat as a result of successful hydrocarbon exploration in Morecambe Bay by British Gas starting in 1969. This was led by Dr Vic. Colter, a Manchester University graduate no less! At first, alas, the results of downhole wireline logging of the lower Triassic reservoir sandstones were said to be compatible with the three-fold classification of the LKS (now the Helsby Sandstone Formation) in Cheshire (Colter & Barr 1975). Thus the rocks of the Morecambe Bay gasfield (on stream in 1985 as a winter back-up facility, now a mainstream source of supply) were referred to the Thurstaston, Delamere and Frodsham members, despite the fact that the percentages of their successions in terms of fluvial-aeolian interpretations were widely different from those originally defined in northwest Cheshire. With hindsight, it can be seen that these early correlations hampered rather than improved understanding of the complex interplay of fluvial, aeolian and tectonic processes in the Cheshire and EISB basins.

The early work was soon augmented by more sophisticated data gathering and analysis (Ebbern 1981; Bushell 1986; Macchi 1990; Meadows 1991; Stuart & Cowan 1991; Evans *et al.* 1993; Stuart 1993; Williams & Eaton 1993).

Gradually it became apparent that there are Carboniferous source rocks, notably the Holywell Shale (Namurian E1-G1 in age) (Armstrong *et al.* 1997), beneath much of the southern part of the Irish Sea Basins (Fraser & Gawthorpe 1990; Hollywood & Whorlow 1993). Maturation, migration and trapping of oil and gas is likely to have taken place between 200 and 60 million years ago in more areas than those of the original discoveries of British Gas in the Morecambe fields (1969) and Hamilton Brothers (1992). The new fields so far discovered are designated as the Douglas and Lennox Oilfields, and the Hamilton gasfields, to the north of the North Wales coast and west of Formby Point (Fig. 7) (Yaliz 1997; Haigh *et al.* 1997). All this work resulted in the much more careful description and analysis of the reservoir successions in terms of fluvial, aeolian and tectonic events. In the EISB the equivalent of the Helsby Sandstone and the Tarporley Siltstone Formations combined eventually became known as the Ormskirk Sandstone Formation. This formation lies immediately below the Mercia Mudstones (Anisian-Norian) which form a regional cap to many potential trap structures (see Jackson & Mulholland 1993; Cowan *et al.* 1993; Knipe *et al.* 1993; Hardman *et al.* 1993). Having a precise stratigraphy and a detailed sedimentological description and interpretation has at last been seen to be of great economic importance. Perversely, but engagingly, oil company geologists find it to be practical and convenient to refer to the reservoir rocks of these oil and gas fields in terms of the Thurstaston, Delamere and Frodsham Sandstone members (Yaliz 1997; Haigh *et al.* 1997), well beyond the confines of the Cheshire Basin proper, to which they should be strictly restricted.

Since these happenings and the onset of investigations at the footprint locality at Hilbre, the British Geological Survey have introduced an intriguing development (Jackson & Mulholland 1993; BGS 1994; Jackson *et al.* 1995), the depiction of the area from Hilbre itself to Tanskey Rocks as part of the Ormskirk Sandstone Formation (OSF) of the EISB rather than the BPB, whilst that of Hilbre Point-Redstones is mapped as part of the St Bees Sandstone Formation (SBSF), the equivalent of the Chester Pebble Beds and Wilmslow formations (see Fig. 3); in both cases without written explanation.

Upon being queried by letter in 1994 as to the basis of this abandonment of conventional views nearly 150 years old, Drs Jackson and Mulholland, formerly of the Hydrocarbons Unit, Edinburgh, were kind enough to explain their decision at great length in a personal communication (Jackson, August 1994) and a telephone conversation (Mulholland, September 1994). In compiling their maps they had to weigh and marry together information from three sources: (i) literature relating to land geology since 1913; (ii) the solid geology beneath the coastal mudflats extrapolated from the land geology; (iii) the offshore solid geology compiled from drill records (somewhat scant) and

occasional pebbles, to sands with gravel. The pebbles include various erratics.

CRANK CAVERNS, RAINFORD OLD DELPH QUARRY, CRANK. SJ 51129953
CARBONIFEROUS (UPPER), Silesian, Westphalian A, Lower Coal Measures.
Disused quarry with tunnels and adits extending into hillside. The site exposes brown and yellow sandstones with a variety of sedimentary structures. High educational value.

CRONTON LANE (PUBLIC FOOTPATH), BLUNDELLS LANE, RAINHILL. SJ 485905
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Medium-coarse grained sandstone with angular to subrounded grains. Distinct bedded units up to 0.7m with cross lamination and ripples.

IBSTOCK QUARRY, CHESTER LANE, MARSHALLS CROSS, ST. HELENS. SJ 512919
CARBONIFEROUS (UPPER), Silesian, Westphalian B, Middle Coal Measures.
Disused brickworks. Sections show upper horizons of the Middle Coal Measures and show a marine band with *Lingula*. Faulting with a complex shatter zone 3m wide has been exposed.

SUTTON PARK, ROBINS LANE, PEASLEY CROSS, ST. HELENS. SJ 523936
PLEISTOCENE, Devensian.
A polished boulder of height 1.20m and width 2.92m. A rhyodacite with a glassy matrix and phenocrysts of highly kaolinised feldspar and quartz. Derived from the Borrowdale Volcanic Series as it resembles rhyodacites from Great Langdale.

SHAW STREET ERRATIC, SHAW STREET, ST. HELENS. SJ 515952
PLEISTOCENE, Devensian.
An Andesitic agglomerate from the Yewdale area of Cumbria, discovered at Crabfields, Cowley Hill in 1892.

TAYLOR PARK, GROSVENOR ROAD, WEST PARK, ST HELENS. SJ 49159472
TRIASSIC, Scythian, Sherwood Sandstone Group, Bunter Sandstone.
A quarry restored as a formal garden. Two main faces can be seen, showing medium grained, friable red sandstone. Cross-bedding can be seen.

PLEISTOCENE, Devensian.
Large gypsum boulder weighing around 18 tons. Found in boulder clay at Cooks Lane brickworks, Great Crosby in 1898, and erected at the junction of Liverpool Road and Islington. It was re-erected at its current site in 1926.

LYDIATE HALL QUARRY, LYDIATE HALL FARM, SOUTHPORT ROAD, LYDIATE. SD 36250537
TRIASSIC, Scythian, Sherwood Sandstone Group, Lower Keuper Sandstone (?Ormskirk Sandstone).
Disused building stone quarry exposing yellow, medium grained sandstone. Features seen include dip and strike, jointing and bedding planes.

RANGE LANE BLOWOUT, RANGE LANE, RAVEN MEOLS, FORMBY. SD 278054
HOLOCENE, Recent.
Large active dune blowout. The feature has considerable educational potential. Potentially one of the few sites on the Sefton coast where the natural development of a blowout from formation to eventual stabilisation could be followed.

THE DELL, LIVERPOOL ROAD NORTH, MAGHULL. SD 37420248
TRIASSIC, Scythian, Sherwood Sandstone Group, Bunter Sandstone.
20m long by 2m high exposure of medium grained red and brown sandstone. Bedding shows planar and cross-bedding. The latter shows younging by truncated tops and sloping foresets. Differential weathering has occurred along the base of the cross-bedding.

ST HELENS

BILLINGE QUARRY, BILLINGE. SD 527015
CARBONIFEROUS (UPPER), Westphalian, Lower Coal Measures, Crutchman Sandstone, [Langly Marine Band].
Fine-medium grained sandstones with siltstone, shale and thin coals. Several sedimentary structures can be seen. Sandstone beds up to 1.5m are seen. Part of an exposure to the north of the entrance can be reached from outside the boundary fence.

CARR MILL DAM, CARR MILL, ST. HELENS. SJ 52609835
PLEISTOCENE, Devensian.
Small cliff section approximately 5m high, showing good examples of glacial sands and gravels. These show variations in grading from sand, to sands with

seismic surveys (considerable but not publishable and hence not subject to public scrutiny).

Seismic evidence suggested that the rocks closest to Hilbre were unlikely to lie below the marker known as the Top Silicified Zone (controversially taken by BGS as the CPBF/WSF or OSF/SBSF junction, rather than within the WSF or SBSF as suggested by previous authors). Additionally the literature suggested that a zone Formby-Liverpool-Mid Wirral marked the furthest northwestward position of scattered pebbles rather than layered pebbles in the CPBF and the lower SBSF. The layers of close packed pebbles in parts of the Hilbre Breccia would be therefore anomalous if classified as CPBF or lower SBSF. Furthermore nearly all pebbles in the CPBF or SBSF are very rounded quartzitic (?Ordovician) and far travelled. The presence of closely packed largely angular sandstone pebbles (presumably Carboniferous) (fluvial) alternating with mottled poorly cemented units (?aeolian - their interpretation) were thought to relate better to descriptions of the Keuper Basement Beds of the LKS (Jones 1926) and modern descriptions of the Helsby Sandstone Formation, especially the Delamere Member (Thompson 1970a). They noted that certain previous authors (Mellard Reade 1888, 1892: Greenwood 1916) had suggested that the beds were "Keuper" in age. Contrary to their new mapping, they recognised that Rice (1939a) had drawn attention to the similarity of the angular clasts in the pebbly sandstones at Hilbre and Hilbre Point whilst placing the rocks in the BPB. Because quartz pebbles were more common at Hilbre Point, they felt that the classification of the rocks there as SBSF was quite secure. They noted that Jones (1920a p.282) implied that the Hilbre and Redstones/Hoylake exposures were atypical of the BPB because of the presence of baryte and this small point was also weighed in the scales.

On any interpretation, Jackson & Mulholland (1993) required some kind of geological fold and/or fault to separate the rocks of the Hilbre islands and Hilbre Point. They hypothesised either a NW-SE fault throwing down westwards (the solution finally adopted) or a fold pair (syncline on the west, anticline on the east). Fault solutions were considered which required the Neston/Wirral Colliery Fault to extend northwards to Hilbre, but change throw (as a scissor fault) as implied by Shackleton (1953) and Colter (1978). In the end, however, they terminated the Wirral Colliery Fault against the Woodchurch Fault and the West Kirby Beach Fault against the Caldy Grange Fault (Fig. 3).

PREVIOUS SEDIMENTOLOGICAL AND PALAEOENVIRONMENTAL INTERPRETATIONS

Early reports of the finding of footprints to the Liverpool Natural History Society (LNHS) were accompanied by surprisingly detailed environmental interpretations. President Francis Archer (1840) reviewed the first three years of the society 1836-1839 and described how workmen had at first ascribed the prints to the locomotion of antediluvian members of our race who, attempting to escape Noah's flood, had left their tracks upon the rocks, the smaller marks being made by the hands of the children involved (Tresise 1989b, p. 137). By June 1838, however, John Cunningham (1799-1873), a local architect and waterworks engineer, had visited Storeton quarry and immediately recognised the prints as those of the *Chirotherium* from the description of comparable finds by Kaup in 1835 in the Triassic rocks of Saxony. They had been popularised by Dr William Buckland's Bridgewater Treatise (1836). Cunningham reported to the LNHS on 3rd July 1838 and wrote a paper on the society's behalf which was read to the Geological Society of London (GSL) on 5th December 1838 by Buckland, then Reader in Mineralogy and Geology at Oxford and Fellow of Christ Church. It was made clear that "the clay beds upon which they (the footprints) rested must have been traversed by multitudes of animals". James Yates (1789-1871), born in Liverpool but residing in London, then read a second paper at this meeting concerning the *Chirotherium* and the web-footed animal mentioned by Buckland on behalf of Cunningham (Yates 1838). A third report, of two gigantic *Chirotherium* prints, was given by Sir Philip de Malpas Grey-Egerton MP (1806-1881) of Oulton Hall (Egerton 1838). The last mentioned prints may have come from the same horizon as that of the sandstone at Storeton (the LKS or the Helsby Sandstone Formation), or from the interbedded sandstones and mudstones of the Waterstones (now the Tarporley Siltstone Formation).

A new report by John Cunningham on three distinct horizons with "Fossil shower marks" in the rocks of Storeton was read to the LNHS on 5th February 1939 (Cunningham 1839a) and by Buckland to the GSL on 27th February (Cunningham 1839b). The rain pits were on the same seams of clay that preserved the footprints. Cunningham's interpretation was laughed at by many LNHS and GSL members, but he demonstrated his uniformitarian ideas by experiments which showed that soft clay exposed to large rain drops would develop pitting of exactly the same kind. The Proceedings of the GSL relating to this meeting record that, "the authors are of opinion, that each of the thin seams of clay... formed successively a dry surface, over which the *Cheirotherium* [sic] and other animals walked, leaving impressions of their footsteps; and that each layer was submerged by a depression of the surface"

SEFTON

AINSDALE HILLS, AINSDALE-ON-SEA, AINSDALE. SD 295116
HOLOCENE, Recent.
Classic dune morphology with parabolic dunes and slacks.

AINSDALE SANDS, AINSDALE-ON-SEA, AINSDALE. SD 285114
HOLOCENE, Recent.
Depositional coastline with beach ridge and runnel systems.

ALT ESTUARY, HIGHTOWN. SD 295029
HOLOCENE, Flandrian, Downholland Silt and Peat.
Exposures of post glacial deposits, including Downholland Silts and peat with a submerged forest. Western part of the exposure is on Altcar Rifle Range (controlled entry). Good educational value for GCSE, A level, degree level and research.

ALT ESTUARY FORESHORE, HIGHTOWN. SD 295029
HOLOCENE, Recent.
Dune slack area with vegetated, stable dunes. On the coast, undermining by the high tide exposes sections and also creates incipient blow-outs. A variety of beach features are seen at low tide such as ripples, current lineation and feeding trails.

FLEA MOSS WOOD, MOSS LANE, LITTLE CROSBY. SD 312026
HOLOCENE, Recent.
Relict dunes. Examples of bog oak ploughed from the underlying peat can be found.

FORMBY FORESHORE, MAD WHARF, FORMBY. SD 270083
HOLOCENE, Downholland Silt.
Deposits of silts and clays can be seen on the foreshore about 200m from the dunes. Trace fossils include footprints of hominids, birds and mammals (deer and cattle). Plant material is also seen. The footprints may indicate early evidence of animal husbandry.

FORMBY POINT, WICKS LANE, FORMBY. SD 270072
HOLOCENE, Recent.
Transgressive dune sheet. Tongues of sand on eroding coast.

GREAT CROSBY BOULDER, CORONATION PARK, CORONATION ROAD, CROSBY. SJ 318996 terminus of the Liverpool and Manchester Railway, the site has great importance as an industrial archaeological site.

WAVERTREE. LIBRARY ERRATIC, WAVERTREE. LIBRARY, PICTON ROAD, WAVERTREE. SJ 387896
PLEISTOCENE, Devensian.
A block of Andesitic volcanic agglomerate from the Borrowdale Volcanic Series of Cumbria. It has a fine-grained, grey-green groundmass containing larger fragments up to 3cm long. These fragments are angular and show fine layering.

WEST DERBY RAILWAY CUTTING, WEST DERBY, LIVERPOOL. SJ 395928
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Good example of local sandstone exhibiting massive, cross-bedded, cross-laminated and planar laminated units. The cutting is up to 7m deep in places. Good for introductory geology at GCSE and A level.

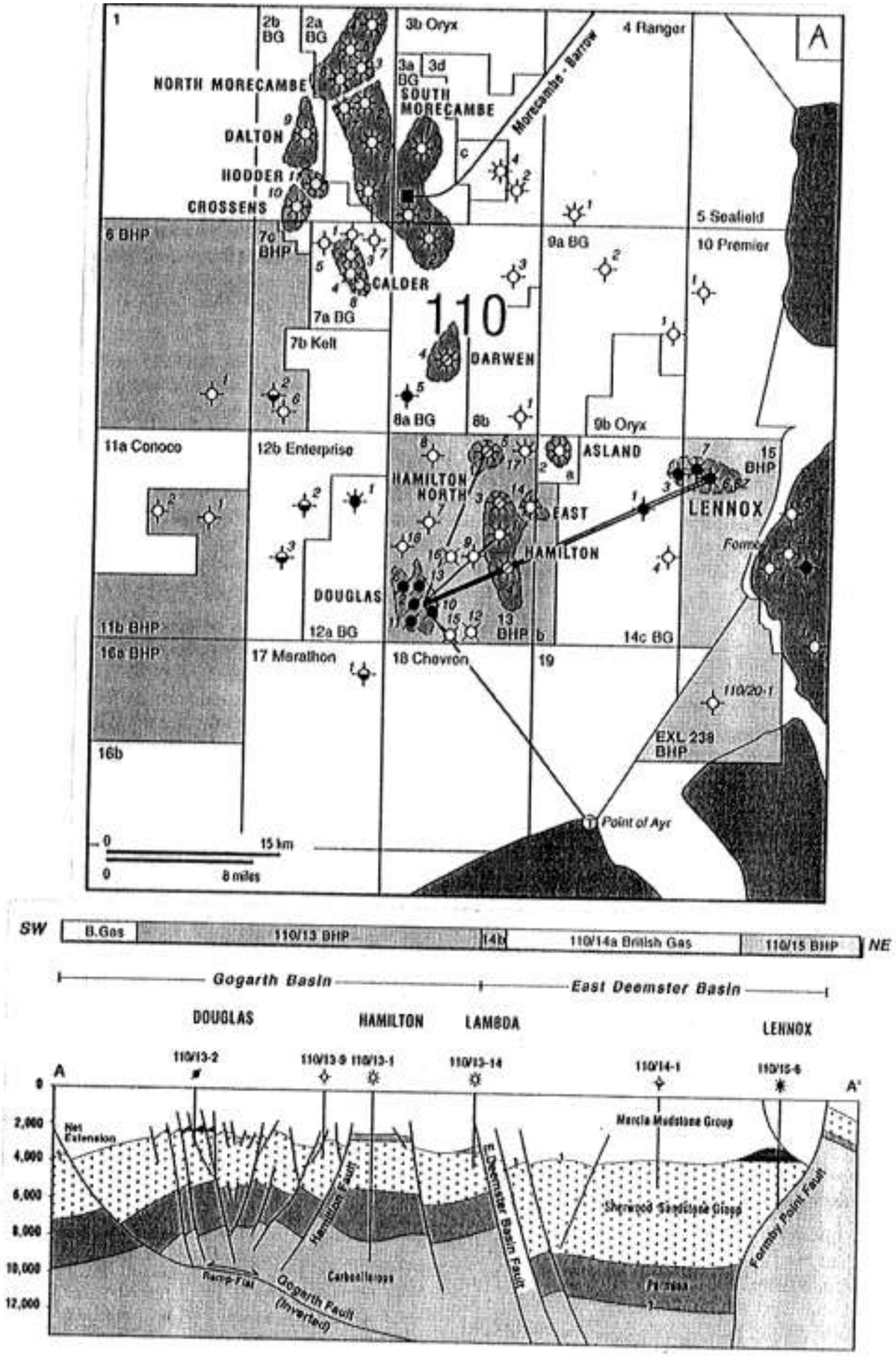
WHITLEY GARDENS (NORTH), SHAW STREET, LIVERPOOL. SJ 35739123
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Exposure of fine grained, red sandstone with lenses of yellow sandstone. Bedding is 8-40cm thick. Quartzite pebbles up to 8cm in diameter can be found.

WHITLEY GARDENS (SOUTH), SHAW STREET, LIVERPOOL. SJ 357912
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
8m wide section of red sandstone with cross bedding. Three small normal faults with 2-3 cm displacements can be seen in this section. Exposure is 3m in height at tallest part of the exposure.

WOOLTON QUARRY, WOOLTON, LIVERPOOL. SJ 420870
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
A former building-stone quarry with good exposures of the Chester Pebble Bed Formation. High educational value. Rock faces are visible each side of Mill Stile footpath. Housing occupies quarry floor so some exposures are inaccessible.

(Tresise 1991a,p. 228). In his Liverpool presentation, Cunningham suggested that the clay seams were laid down in "a great fresh water lake or the delta of an immense river" which periodically flooded the Storeton area. Tresise (1991a, p. 225-6) notes that in a letter dated 1858, Cunningham had maintained in 1839 that, "the impressions, i.e. the indentations made by the animals must have been filled up with wind-drifted sand, whereas he (Buckland) stood out for water transport". Indeed in the paper to the GSL (Cunningham 1839b), Buckland had spoken of, "the rise and fall of the tides over extensive sandbanks, the surface of which was between the level of high and low water", an interpretation which Cunningham had not sanctioned. Soon after these meetings further footprints were discovered in the quarry at Rathbone Street, Liverpool, in 1840, and at many other places in the general area.

Subsequently, the description of the sediments and their detailed succession was at first crude (Morton 1856, 1863b, 1891; Mellard Reade 1892; Wedd *et al.*, 1923) and only modest improvements were brought about by the employment of new techniques like microscopy, heavy mineral counts (Travis & Greenwood 1911) or the study of pebble provenance (Morton 1891; Wedd *et al.* 1923; Jones 1920a,b). Early authors referred the sediments broadly to origins in tidal basins, straits and shorelines (Hull 1860 see Fig. 8A, 1869; Mellard Reade 1889), but later more helpful uniformitarian comparisons were made with continental fluvial-aeolian processes and environments (Hewitt 1893; 1911) and deserts (Beasley 1891, Lomas 1907, Spicer 1912, Holland 1912, Whitehead 1916). Sedimentary structures were somewhat casually described, even by Rice (1939a,b), who did, however, distinguish that the palaeocurrents for the BPB and LKS were towards the northwest. Modern identification of basin-wide types of rock which might relate to particular processes, palaeocurrents and environments of deposition were eventually offered by Fitch *et al.* (1966), Thompson (1969; 1970a,b; 1984), Steel & Thompson (1983) and Earp & Taylor (1986) in respect of the BPB being deposited by high discharge, sandy-gravelly braided streams and the BUMS by moderate discharge more sandy-muddy braided streams whose courses ran dry and gave way to intermittent aeolian transport and deposition in transverse barchanoid ridges separated by flat-bedded interdune sheets. The LKS was interpreted as the result of further sandy gravelly braided fluvial flow of slightly increasing sinuosity upwards (at least in the Alderley area), interspaced with riverplain aeolian dunes and sheets (Thompson 1970a, b; 1984) which at least once became basin-wide sand sea (erg) in late Helsby Sandstone times when the spectacular Frodsham Sandstone Member was laid down (Thompson 1969). Descriptions of the structures, processes of origin, environments and palaeogeography of the Ormskirk Sandstone Formation in the EISB, in terms of alternating fluvial and aeolian processes at times when there were fluctuating



SPEKE SHORE, MERSEY WAY FOOTPATH, SPEKE. SJ 408828
PLEISTOCENE, Devensian. HOLOCENE, Shirdley Hill Sands.
Cliffs from old Liverpool airport (SJ 408828) to Hale Heath (SJ 456821) consisting of Boulder Clay and deposits of Shirdley Hill Sands. The cliffs are a habitat for a range of locally rare plants.

ST. ANNE STREET UNDERPASS, ST. ANNE STREET, ISLINGTON, LIVERPOOL. SJ 351911
TRIASSIC, Scythian, Sherwood Sandstone Group, Helsby Sandstone Formation.
10m long x 2m high exposure of a fine-medium grained yellow sandstone. The best section is seen at the north end, although this is weathered.

ST. GEORGE'S HILL, NETHERFIELD ROAD SOUTH, EVERTON. SJ 356920
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed formation.
Numerous exposures of fine-medium grained red and brown sandstones. Good examples of normal faults, slickensides and associated mineralisation. Good examples of bedding and cross-bedding.

ST. JAMES CEMETERY, ANGLICAN CATHEDRAL, LIVERPOOL. SJ 354893
TRIASSIC, Scythian, Helsby Sandstone Formation, Anisian, Mercia Mudstone Group, Tarporley Siltstone Formation.
Former quarry with an exposure of thinly bedded, brown and grey mudstones from which a rich microflora has been recorded. The north entrance to cemetery passes though yellow sandstone showing cross-bedding.

THE GROUNDS, CHILDWALL WOODS, CHILDWALL PARK AVENUE, CHILDWALL. SJ 413887
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Sections through the carriage drive and in the Grotto showing thickly bedded red sandstone, with pebbles of varying sizes scattered throughout. Faint cross-bedding and small faults can be seen in the driveway.

WAPPING RAILWAY CUTTING, CHATSWORTH STREET, EDGE HILL. SJ 369898
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Cutting through sandstones of the Chester Pebble Bed Formation. The original

OLIVE MOUNT CUTTING, SANDOWN PARK, WAVERTREE, LIVERPOOL. SJ 39709025
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Dull red or brown sandstone. The individual bands are separated at about 6m intervals by thin seams of red and grey shale. Quartzite pebbles are numerous in the sandstones.

QUEENS WALK, ANGLICAN CATHEDRAL, LIVERPOOL. SJ 353894
TRIASSIC, Scythian, Sherwood Sandstone Group, Helsby Sandstone Formation.
Friable, medium grained, yellow sandstone. Faint cross-bedding can be seen. Small mineralised joints can be seen on the west side of the exposure.

REYNOLDS PARK QUARRY, WOOLTON. HILL ROAD, WOOLTON. SJ 421876
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Sandstone quarry, formerly part of Reynolds Park. Steep, high faces on north and west sides of quarry. The South and east faces are lower and less steep. Some bedding can be seen on the north face from outside the quarry boundary.

RICE LANE FLYOVER, RICE LANE, WALTON. SJ 35869496
TRIASSIC, Scythian, Sherwood Sandstone Group, Bunter Pebble Beds.
20m exposure of fine grained, friable, red sandstone exposed in underpass. Units are 30-60cm thick. Cross bedding can be seen. Pebbles are abundant in this exposure.

RIVERSIDE GARDENS, RIVERSIDE DRIVE, DINGLE. SJ 362868
TRIASSIC, Scythian, Sherwood Sandstone Group, Wilmslow Sandstone Formation.
Section approximately 50m long by 4m high showing pale red sandstone, interbedded with thin bands of yellow sandstone. Cross bedding is clear in some. This site is the old cliff line of Dingle Point.

SEFTON PARK ERRATIC, DEER PARK, SEFTON PARK, LIVERPOOL. SJ 378873
PLEISTOCENE, Devensian.
Erratic boulder from the Borrowdale Volcanic Series. A fine grained, grey, glassy rock with weathered phenocrysts of feldspar and dark mafic minerals. Length 130cm; height 80cm; width 50cm.

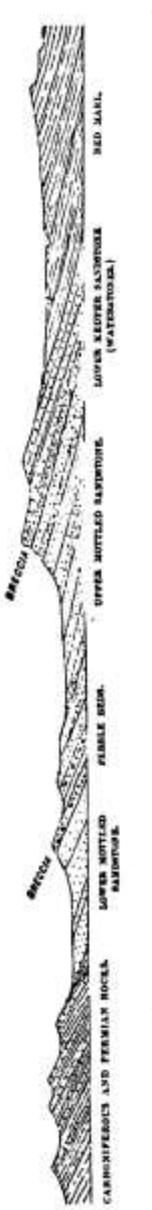
Figure 7.
A. The new offshore gas and oilfields of the East Irish Sea Basin (after Haigh *et al.* 1997, fig. 1, through the kind permission of The Geological Society of London) in relation to the positions of the Hilbre islands.

B. A geological cross-section of the Douglas and Lennox Oilfields and the Hamilton Gasfield (after Yaliz 1997, fig. 4) to show the Ormskirk Sandstone Formation as the reservoir rock at the top of the Sherwood Sandstone Group beneath caprocks of the Mercia Mudstone Group.

Figure 8 (overleaf).
A. Edward Hull's palaeoenvironmental diagram of the marine and tidal origins of the New Red Sandstone rocks of the Cheshire Basin (and other basins) (from Hull 1860, between pp. 22 & 23). This is another example of Hull's willingness to construct sweeping generalisations which oversimplify and are readily understood.

B. A modern interpretation of the palaeoenvironment of the Ormskirk Sandstone Formation (after Meadows & Beach 1993, fig. 8, through the kind permission of The Geological Society of London). Left diagram: schematic palaeogeography for the lower part of the Ormskirk Sandstone Formation based on facies identified in wells and seismic characteristics. Right diagram: schematic palaeogeography for the upper part of the Ormskirk Sandstone Formation based on facies identified in wells and seismic characteristics.

IDEAL SECTION OF THE TRIAS OF CHESHIRE.



IDEAL RESTORATION of the relative position of land and sea during the commencement of the Keuper period, showing how the breccia at the base of the Lower Keuper Sandstone was formed along the old sea coast.

X—Gravel beach forming along the coast, and spread out over the surface of the Bunter Sandstone. This gravel is now the basement breccia of the Lower Keuper Sandstone.

Z—Gravel beach, now forming the base of the Pebble bed of the Bunter, once accumulated round a coast in a similar manner to the breccia of the Keuper Sandstone (X).

1—Upper Mottled Sandstone (Bunter). 2—Pebble beds (Bunter). 3—Lower Mottled Sandstone (Bunter).

Where banks are eroded Boulder Clay and Shirdley Hill Sands can be seen.

HERCULANEUM ROAD, DINGLE, LIVERPOOL. SJ 355876
TRIASSIC, Scythian, Sherwood Sandstone Group, Helsby Sandstone Formation.
Three dimensional exposure with a maximum thickness of 4m. It is composed of a fine-medium grained, red and yellow sandstone. The units are arranged as three cross bed sets that are faulted and jointed. There are small re-activation surfaces.

LIME STREET RAILWAY CUTTING, LIME STREET STATION, LIVERPOOL. SJ 352905
TRIASSIC, Scythian, Sherwood Sandstone Group, Helsby Sandstone Formation, Wilmslow Sandstone Formation, Chester Pebble Bed Formation.
Very large scale sections through yellow and red sandstones with occasional shale partings. Several faults cut the section along it 2,100m length. Large scale cross-bedding can also be seen. Some sections can be seen from the ends of platforms.

METROPOLITAN CATHOLIC CATHEDRAL, BROWNLOW HILL, LIVERPOOL. SJ 35679028
TRIASSIC, Scythian, Sherwood Sandstone Group, Helsby Sandstone Formation.
Excavation at the north-west corner of the crypt exposes two sections of a soft, friable, medium grained, yellow sandstone. It is well sorted with rounded grains. Upper layers show cross-bedding.

NETHERFIELD ROAD NORTH, EVERTON. SJ 35229302
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Medium-coarse grained red sandstone with pebbles in a 0.5m high by 4.4m long section south-east of junction with Everton Valley. Vertical (west) face shows cross-bedding and quarrying marks.

NOTRE DAME HIGH SCHOOL, EVERTON VALLEY, EVERTON. SJ 355930
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Large exposure of sandstone on east side of playground. Bedding can be seen. Prior permission to visit site must be obtained.

LIVERPOOL

COLLEGE STREET NORTH, SHAW STREET, LIVERPOOL. SJ 35749115
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Cutting showing a 50m long section of fine grained, friable red sandstone with occasional lenses of pale yellow sandstone. Cross bedding can be seen, with occasional herringbone cross bedding. Five small normal faults can be seen.

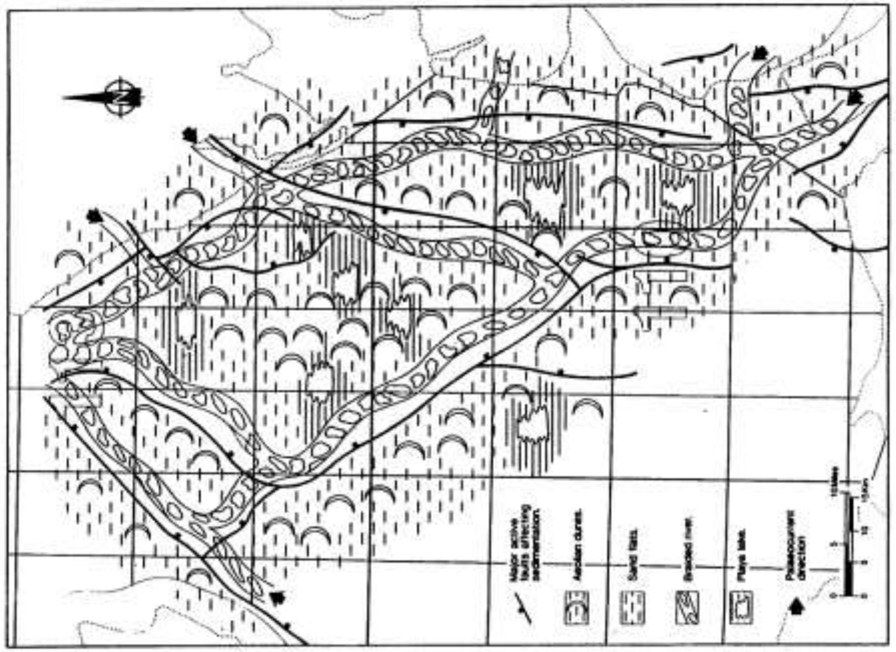
EVERTON GAOL, NETHERFIELD ROAD SOUTH, EVERTON. SJ 355916
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
3m wide x 1m high exposure of fine-medium grained red sandstone. Northern 60cm shows interbedded pale brown banding.

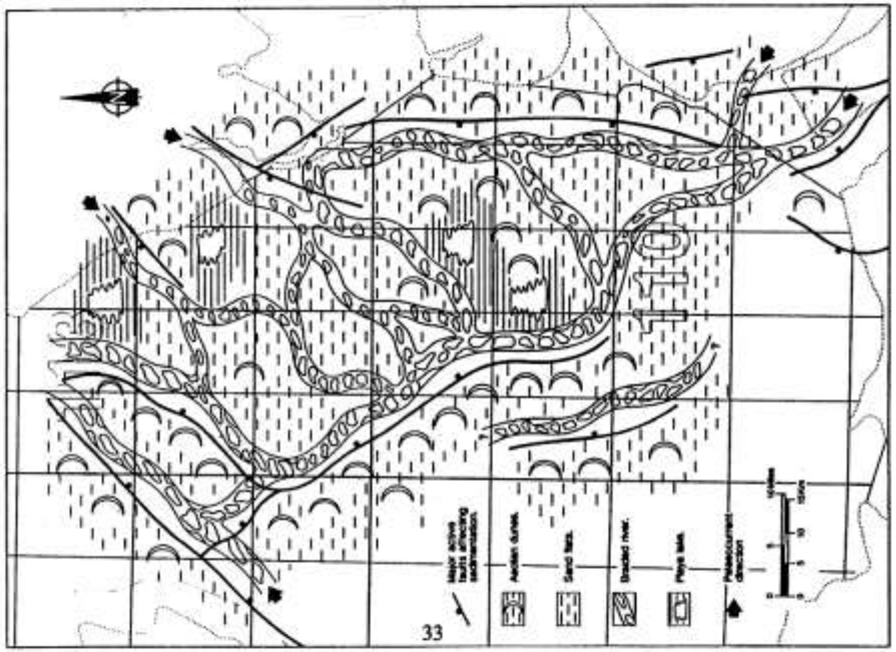
EVERTON PARK (NORTH), NETHERFIELD ROAD SOUTH, EVERTON. SJ 355920
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed formation.
20m long x 1.5m high exposure of fine-medium grained red sandstone. Bedded units approximately 50cm thick can be seen.

EVERTON PARK (SOUTH), NETHERFIELD ROAD SOUTH, EVERTON. SJ 355917
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Section through medium grained red sandstones with interbedded bands of pale brown and yellow medium grained sandstones. Cross-bedding can be seen. Size of outcrop 20m long x 9m high.

EVERTON QUARRY, MARK STREET, EVERTON. VALLEY, EVERTON. SJ 354930
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
South and east walls of a former sandstone quarry showing fine to medium grained, red sandstone. Units >1m thick, interbedded with thin bands of soft, yellow sandstone and occasional clay layers.

FAZAKERLEY BROOK, HAWKSMOOR ROAD, FAZAKERLEY, LIVERPOOL. SJ 390968
PLEISTOCENE, Devensian. HOLOCENE, Shirdley Hill Sands.
Stream section showing fluvial processes including bank erosion and meanders.





water tables, have recently been offered by Thompson (1984), Cowan (1993), Macchi (1990), Meadows (1991), Meadows & Beach (1993a,b), Cowan *et al.* (1993) and Thompson & Meadows (1997). In the times of the succeeding Tarporley Siltstone Formation (formerly the Waterstones and a rock formation which has been totally eroded away in the Hilbre area), sea levels rose and marine waters episodically entered the EISB and the CB, the rivers became estuarine, and current, wave and desiccation processes became the norm, in part on intertidal sand and mud flats (Ireland *et al.* 1978).

Long ago large and small sedimentary cycles were recognised within and between the rock formations of these Triassic rocks. At the time, they were referred loosely to climatic and/or tectonic origins (Thompson 1966;, 1970b, p.209-211; Steel & Thompson 1983). Related to this, the recognition of palaeomonsoonal conditions in Permo-Triassic rocks was contemplated as a possibility (Thompson 1966, p.316-33; Oxnevad 1991, p.138-47). Since then, the presence of these cycles in monsoonal latitudes has been increasingly interpreted by Clemmensen *et al.* (1994) and Herries & Cowan (1997) in terms of Milankovitch-type stacked precession cycles (generated over 23,000 years in the case of the 2-10m thick drying-upward cycles) and eccentricity cycles (generated over 100,000 or 400,000 years for various larger drying-upward cycles).

The study of the trace fossils which relate to our story, especially with respect to the footprints of *Chirotherium* and *Rhynchosauroides*, is longstanding (Beasley 1891, 1897; Lomas 1904-10; Maidwell 1914; Tresise 1989a,b, 1991a,b, 1993a,b, 1994, 1997). Less remarked upon, and certainly not accurately, are the many records in the Liverpool area of worm "tracks" or "casts" e.g. by Morton (1891) at Hilbre Point, or "crustacean" tracks at Irby (Schofield 1906). It is well known that the footprint slabs from the LKS in many museums contain current and wave ripple marks and hosts of distinguishable trace fossil species whose existence and importance has been largely ignored until recently (but see Beasley 1908 pl. 5, fig. 2 for a trackway now described by Pollard (1985) as *Acripes {Merostomichnites} triassicus*, the trace of a notostracan branchiopod with several pairs of walking limbs like the present *Triops*). In the present study at Hilbre as many as 15 horizons of bioturbation, horizontal and vertical burrowing, and a hundred or so slabs with identifiable *Skolithos*, *Planolites*, *Scoyenia* and the like, have been found in a small part of the succession exposed close to the footprint beds on Hilbre itself. The presence of the non-marine, freshwater aquatic marginal *Scoyenia* association is well established (Dr J.E. Pollard pers. comm. 1994). These discoveries complement those of the non-marine (*Scoyenia*) and intertidal

PEX HILL QUARRY, PEX HILL, CRONTON. SJ 500887
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Disused sandstone quarry and exposures in adjoining lanes in a country park. Good examples of pebble bands, bedding and cross bedding. The site shows the relationship between geology and topography very well. The area is also of botanic, ornithological and historic interest. Good educational site.

SCOTCHBARN LANE CUTTING, SCOTCHBARN LANE, PRESCOT. SJ 474925
CARBONIFEROUS (UPPER), Silesian, Westphalian C. PERMO-TRIASSIC, [Lower Bunter Sandstone].
Rock exposed on both sides of railway. West of the railway bridge Triassic sandstones can be seen. East of the bridge a fault brings up 'Red Bed facies' of Westphalian C age.

STADT MOERS PARK, PARADISE LANE, WHISTON. SJ 466908
CARBONIFEROUS (UPPER), Silesian, Westphalian B, Middle Coal Measures.
A small exposure of shales with ironstone nodules can be seen on the north wall of this former quarry. The exposure shows thinly bedded shale, with occasional plant fragments.

STAND QUARRY, KNOWSLEY PARK, PRESCOT. SJ 454944
CARBONIFEROUS, (UPPER), Silesian, Westphalian A, Lower Coal Measures.
White-yellow massive current bedded sandstone capping small hills north and south of White Man's Dam. Exposure approximately 30m long x 6m high. Thickness of bedding ranges from 1cm to 30cm.

WARRINGTON ROAD CUTTING, WARRINGTON ROAD, PRESCOT. SJ 473924
CARBONIFEROUS (UPPER), Silesian, Westphalian B, Middle Coal Measures.
Exposures of sandstone are seen on both sides of this railway cutting. Bedding planes and jointing can be seen from the road bridge.

Measures.
4m high x 100m long cutting in fine-medium grained, pale sandstones with carbonaceous partings. Cross-bedding and a fault can be seen. No official public access, although frequently used by the public.

DELPH LANE QUARRY, DELPH LANE, WHISTON. SJ 48139213
TRIASSIC, Scythian, Sherwood Sandstone Group, Chester Pebble Bed Formation.
Former sandstone quarry. Very steep sides with one easy access point. Good examples of bedding planes. Cross bedding can be seen in the northern face of quarry.

HALSNEAD PARK QUARRY, HALSNEAD PARK, WINDY ARBOR, WHISTON. SJ 468897
CARBONIFEROUS (UPPER), Silesian, Westphalian C, Middle Coal Measures.
Quarry exposing yellow and brown sandstones with thinly bedded black shales. The sandstones are 1 - 1.5m thick and show a number of features including cross bedding and channel features.

HURST HOUSE QUARRY, THE HAZELS BUSINESS PARK, PRESCOT. SJ 455925
CARBONIFEROUS (UPPER), Silesian, Westphalian A, Lower Coal Measures.
60m long by 5m high exposure of flagstone, grit and coal. Bedding, dip and current ripples can be seen. Educational value at National Curriculum level upwards.

KIRKBY BROOK (LITTLE BROOK), VALLEY ROAD, WESTVALE, KIRKBY. SJ 405979
PLEISTOCENE, Devensian. HOLOCENE, Flandrian, Shirdley Hill Sands. HOLOCENE, Recent.
Meanders expose glacial, post-glacial and Recent sediments. Brown boulder clay is overlain by 2m of aeolian Shirdley Hill Sands with peat and soil horizons. The sands are covered by river alluvium with a variety of pebbles derived from the boulder clay.

KNOWSLEY PARK MOSS, KNOWSLEY PARK, PRESCOT. SJ 457966
HOLOCENE.
>3m of well-drained peat deposits on side of drainage ditch. Evidence of unhumified *Sphagnum* remains with a clear horizon visible. Palaeoecological interest. Suitable for degree level study.

(*Skolithos-Glossifungites-Diplocraterion*) trace fossil assemblages found in the overlying Tarporley Siltstone Formation which have already received careful attention (Ireland *et al.* 1978; Pollard 1981). They present important opportunities, in conjunction with a revision of the footprint beds on modern lines (currently being carried out by Mike King), for unravelling the story of the palaeoenvironments of the host formation. The arguments for placing the Hilbre footprint beds in the Anisian, Middle Triassic, Ormskirk (=Helsby) Sandstone Formation in the East Deemster sub-basin, and therefore making them broadly comparable with the occurrences in the Storeton and Runcorn Footprint Beds, rather than assigning them to the Scythian, Lower Triassic, Chester Pebble Bed or the Wilmslow Sandstone Formations, will necessarily have to be given in detail elsewhere (King & Thompson in prep.; King, Pollard & Thompson in prep.). Thus Aeschylus' percipient pronouncement that the Scythian country is an "untrodden desolation" is likely to be confirmed - with just a slim chance that he will be confounded by ongoing investigations.[2]

ACKNOWLEDGEMENTS

The author would like to thank Joe Crossley, Hon. Secretary, and the successive librarians of the Liverpool Geological Society for the prolonged loan of a full set of the *Proceedings* of that Society. He wishes also to thank Fred Broadhurst, Morven Simpson, John Pollard, Rod Ireland and Ron Steel for stimulating discussions over many years. More recently Geoffrey Tresise, formerly of the Liverpool Museum, Vicky Seagar, Hilbre Ranger, John Pollard and Mike King of Bristol University, have co-operated enthusiastically over the footprint studies. The help of John Rees and the Librarian of the British Geological Survey, Graham McKenna, in accessing archival material, has been very much appreciated. The editor of this journal, Dr John Nudds, has also been most co-operative. Finally, thanks are due to Richard Wallace and Gerry Nussbaum of the Classics Department, Keele University, for their recent explanation of the context of the introductory quotation which, it has to be confessed, has remained pinned enigmatically to the author's office noticeboard for well nigh 25 years and has never, until now, been used !

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[2] The introductory quotation is taken from the first two lines of *Prometheus Bound* by a Greek playwright (Aeschylus) who was writing in Athens in c. 470 BC. The words are spoken by Kratos (meaning roughly "Power") escorted by Bia ("Violence" or "Force") and are addressed to Hephaestus (God of the blacksmiths). Kratos and Bia are acting on behalf of Zeus (King of the Olympian Gods) in order to punish Prometheus (the man of foresight and civilization to come) by pinning him to a rock. The chances of the outcrop being a Permo-Triassic one are truly slim because, in those days, Scythia stretched from the River Danube to the Caucasus. The words were spoken merely to inform the audience of the context in which the succeeding drama was to take place.

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1913. Geological field slips for 1:10,560 geological maps of the Hilbre islands and the extreme northwest of the Wirral Peninsula encompassed by one inch sheet 96 of the New Series of the Geological Survey. Mapping by W.C. Simmonds, approved by G.W. Lamplugh on the 5th December 1913. Maps available in the archives of the British Geological Survey, Sir Kingsley Dunham Centre, Keyworth, Notinghamshire.

1913 and 1923. The hand-composed standard 1:10,560 geological map prepared by W.C. Simmonds and vetted by G.W. Lamplugh for the same areas. Maps are available as in the entry above.

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A PROVISIONAL LIST OF REGIONALLY IMPORTANT GEOLOGICAL/GEOMORPHOLOGICAL SITES ON MERSEYSIDE

by Tony Morgan

INTRODUCTION

This is a provisional list of "Regionally Important Geological and Geomorphological Sites" (RIGS) selected since 1992 by the Merseyside RIGS group. The group covers the unitary districts of Knowsley, Liverpool, Sefton and St Helens. Information on sites in the area was collected using recording forms devised by the group. The form prompts fieldworkers to collect information on the stratigraphy, rock type, Quaternary geology, sedimentary and tectonic structures, palaeontology, mineralogy, geomorphology and present day processes of a site. In addition to the geological and geomorphological aspects of a site, information on educational value, access, safety issues, site management and historic and cultural issues is noted. Square brackets [ ] indicate that there is some uncertainty about the formation or member in question.

The sites are here arranged in alphabetical order of district.

KNOWSLEY

COMMUNITY CENTRE DRIVEWAY, BLUEBELL LANE, HUYTON VILLAGE, LIVERPOOL. SJ 44249117
TRIASSIC, Scythian, Sherwood Sandstone Group, [Wilmslow Sandstone Formation].
Exposures of yellow and orange, friable sandstone on both sides of driveway.

COMMUNITY CENTRE GROUNDS, BLUEBELL LANE, HUYTON VILLAGE, LIVERPOOL. SJ 44239118
TRIASSIC, Scythian, Sherwood Sandstone Group, [Wilmslow Sandstone Formation].
Exposure of yellow and orange, friable sandstone. 4m wide x 1m high exposure. Bedding 10cm - 40cm thick.

CRONTON MINERAL LINE, WINDY ARBOR ROAD, WINDY ARBOR, WHISTON. SJ 465900
CARBONIFEROUS (UPPER), Silesian, Westphalian C, Middle Coal

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sediments of the Bulkeley Hill Sandstone Formation (and ? the Wilmslow Sandstone Formation) has been removed. How this could happen in an essentially extensional Mackenzie-type basin is not explained, and other hypotheses to account for the seismic results would be welcomed. The implication for the Alderley area is that the junction of the Engine Vein Conglomerate Member and the Wilmslow Sandstone Formation at Castle Rocks, Alderley, or alternatively the base of the Wood Mine Conglomerate Member (not well exposed at outcrop), is a line of major unconformity. Evans *et al.* (1993, p. 867) wrote that, "active faulting (in the Trias) is evidenced ...near Alderley, where ...(the) Engine Vein Conglomerate ...represents a localised alluvial fan developed along the Red Rock Fault scarp". These authors seem to require the pebbles of their alluvial fan to be derived from due east (where the Carboniferous Limestone would not have been exposed) rather than belonging to through rivers which traversed across basin after basin in the Midlands and eventually brought pebbles from the southwestern parts of the southern Pennines where Carboniferous Limestones are known to have been exposed and where Chester Pebble Beds with limestone clasts were also available to be eroded.

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In areas to the immediate east of the latitude of Alderley, in the western and central Pennines, the topographically higher outcrops of Carboniferous Limestones and Millstone Grits around Buxton and Castleton are not reddened. The Permo-Triassic cover, if ever present, is therefore believed to have lain at a higher topographic level; the limestones were not exposed and were not available to provide an exotic fauna; they were covered by Millstone Grits in Triassic times. It is possible that all these more northerly Pennine areas were once overlain by the Lower Triassic "Bunter Pebble Beds" from which reworked exotic pebbles could be derived second-hand to be deposited in the Helsby Sandstone Formation of Alderley, an hypothesis which goes back as far as Edward Hull (1860). Bear in mind, also, that the Southern Pennines, including the exposed limestones, were overlain in Miocene-Pliocene times by the Brassington Formation, now preserved providentially down solution hollows in the southern White Peak (Walsh *et al.* 1972). This formation, too, bears all the signs of being composed of sands and pebbles largely reworked from the "Bunter Pebble Beds".

In 1966 I reported cross-bed palaeocurrent data for 100m squares of the Helsby Sandstone Formation on a statistically controlled basis for the Engine Vein Conglomerates and the underlying Wilmslow Sandstone Formation at Alderley Edge. Having made correlations of the members of these formations across the Cheshire Basin (Thompson 1970), further comparable data were assembled and maps of palaeocurrents produced for the Permian and the Triassic of the entire basin (Thompson 1984, figs 7-11). The palaeocurrents for the Wilmslow Sandstone, partly (even largely) aeolian in its upper part, were directed towards the west-north-west, and were the result of an easterly (trade) wind; those of the pebbly, fluvial regime of the Helsby Sandstone were much more northwesterly and northerly directed. Thus, a derivation of the exotic fauna from the southeastern margins of the basin and the southwestern parts of the Pennines, where Carboniferous Limestone was exposed, is perfectly possible. A reworking of the early parts of the underlying Chester Pebble Beds Formation (e.g. in the Rushton Spencer-Rudyard Lake-Leek palaeovalley) is not ruled out, for pebble counts for such areas revealed the presence of many highly rounded (0.7) limestone pebbles which were closely packed and had undergone much pressure solution pitting (see Thompson 1984 for details of the Rushton area).

The whole matter of Anisian palaeocurrents and the derivation of the pebbles has been highlighted by the reporting of seismic work across the centre of the Cheshire Basin (Evans *et al.* 1993). The favoured interpretation of these lines involves the postulation of an angular unconformity at the base of the Helsby Sandstone under which as much as 1.1 km thickness of previous

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day outcrops of the Carboniferous Limestones, Millstone Grits and Coal Measure sandstones to varying degrees across wide areas of Derbyshire. These areas must now be considered as the possible sites of origin (provenance) of the exotic fauna which is found in the pebbles of the Helsby Sandstone Formation at Alderley Edge and adjacent places.

On the southeast margins of the Cheshire Basin, in the southwest Pennines, the Carboniferous Limestones of the Weaver Hills (and particularly of Cauldon Low where in the deep borehole reddening extends to 292m below the surface), the Dove Valley (SK 145567) and Alstonefield are all affected by red-staining (Aitkenhead *et al.* 1985, p.99; Chisholm *et al.* 1988, p.74-5). Further south, in the Ashbourne to Cheadle area, a rugged limestone palaeolandscape has been contoured (Chisholm *et al.* 1988, p.75, fig.20). Palaeocurrents with vector means trending between WNW and NNE across the southwest Palaeo-Pennines have been measured on cross-bedding in areas close to the outcrop of the present base of the Permo-Trias. It is clear that in those areas, limestones of Chadian age and upwards, and even small outcrops of Courceyan age (Morris 1970), were exposed in lower Triassic times when the Hawksmoor Sandstone Formation (= the"Bunter Pebble Beds" of old) was originating and incorporating pebbles (including first hand derived fossils of local origin). Such limestone outcrops could also give rise to the exotic fauna found in the Helsby Sandstone Formation of the Alderley area if the Hawksmoor Sandstone Formation itself was later eroded to yield second-hand derived fossils. Palaeocurrents for the overlying Hollington Sandstone Formation (believed to be of the same age as the Helsby Sandstone Formation) (*ibid.* p.74-75) are not very different from those of the underlying Hawksmoor Sandstone Formation, and it is possible that comparable limestone areas were still exposed on higher ground in Middle Triassic times so as to yield up derived fossil corals at first hand.

Further north and northwest in the Pennines, on the eastern margins of the Cheshire Basin, the middle and highest Millstone Grits and Coal Measure Sandstones are commonly reddened to considerable depths around Leek, Rudyard, Heaton, Rushton Spencer, Bosley and the Cloud, and a wide palaeovalley has been contoured (aligned NNW-SSE through Rudyard and Rushton Spencer) in which palaeocurrents flowing NNW have been measured (Chisholm in Chisholm *et al.* 1988, p.78, fig.22). North of Leek the Millstone Grits (Evans *et al.* 1968, p.57; Stevenson & Gaunt 1971 p.5, 181, 234-5, 344, 260-61) and Coal Measure Sandstones (Stevenson & Gaunt 1971, p.269, 276-7) of the western side of the Goyt Syncline are red-stained to considerable depths and it is inferred that the present topography in all these marginal areas is, in many places, not far from being an exhumed Permo-Triassic palaeolandscape.

The biostratigraphic information available at the time led Thompson (*ibid.*,p.271) to suppose that the latter two taxa were restricted to the Tournaisian Series (approximately equivalent to the Courceyan Stage), and thus he considered that they "could only be derived from the Midlands, South Midlands and areas on the north side of the south-west province", these being the nearest exposures of Tournaisian limestone, again as known at that time. There are two reasons, however, why we can now postulate a more local source. First, it is shown herein (Table 1) that all five taxa do range into the Visean, and secondly the record of the late Courceyan conodont *Scaliognathus anchoralis* by Morris (1970) from the lowest exposed limestones in the Weaver Hills, suggests that Tournaisian limestones were present much nearer that had been thought.

I suggest, therefore, that the most obvious derivation of the limestone pebbles within the Helsby Sandstone Formation at Alderely is from the adjacent Derbyshire massif, where Visean, and possibly also Tournaisian, shelf limestones would have been exposed. This is perfectly consistent with Triassic palaeocurrent directions shown by Thompson (1984; and other authors cited in the discussion below).

DISCUSSION

David Thompson writes:

The nature and origin of the likely areas of provenance of the exotic pebbles require considerable explanation and the mental construction of palaeogeological maps of the landscapes which prevailed at the beginning of both Permian and Triassic times. The degree of erosion and exposure to semi-arid soil-forming processes of the Carboniferous rock units which unconformably underlie the Permo-Triassic rocks is usually judged by circumstantial evidence of the areal distribution and the degree of red (hematite) staining of the Carboniferous subcrops. This reddening is the result of the oxidation of iron-bearing minerals (e.g. siderite $FeCO_3$, pyrite FeS_2 and chalcopyrite $CuFeS_2$ etc.) in the subcrop palaeosoil profiles and in the porous Carboniferous strata all the way down to the palaeo-watertables (which are inferred to have been very depressed in Permo-Triassic times). In Carboniferous Limestone areas reddening often lines "neptunean dykes" to great depths and in Millstone Grit and Coal Measure sandstones pore-linings of hematite are often deeply pervasive and developed to depths of as much as 100m. Such tell-tale reddening, indicative of the former presence of Permo-Triassic landscapes and cover rocks, are frequently observed to effect present-

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better placed in ***Amplexizaphrentis***. It first appears at the top of the Arundian Stage, has not been recorded from the Holkerian or Asbian, but is present again in early and late Brigantian strata (Mitchell 1989).

3) "*Lithostrotion* sp. or *Dibunophyllum* sp."
This is a species of either *Siphonodendron* or *Dibunophyllum*. The former genus ranges from the base of the Arundian into the Brigantian, whilst the latter is restricted to the Asbian and Brigantian stages.

4) "*Zaphrentis konincki* ? Edwards and Haime" (from Worms Hill, Styal)
This is now referred to *Sychnoelasma konincki* (Milne Edwards & Haime). It has a late Courceyan (*C. patulum* Biozone) to Arundian range (Mitchell 1989).

5) "*Caninia* sp." (from Kirkleyditch Quarry, Mottram St Andrews)
This can only be referred with any confidence to "Caniniid indet." as there are other similar genera, and as such has no stratigraphic value, occurring throughout the Lower Carboniferous.

SERIES	STAGE	1	2	3	4	5
VISEAN	Brigantian	|	|	| |		|
	Asbian	|		| |		|
	Holkerian	|		|		|
	Arundian	|	|	|	|	|
	Chadian				|	|
TOURNAISIAN	Courceyan				|	|

Table 1. Stratigraphic ranges of rugose coral species (1 to 5) described in text against the regional stages of the Lower Carboniferous.

POSSIBLE SOURCE AREAS

Apparently some of this material was of a fragile nature suggesting dissolution weathering *in situ* or a first-hand origin from an adjacent area rather than being derived second-hand (for example, from the underlying Chester Pebble Beds Formation) or from a more distant source.

A DERIVED CORAL FAUNA IN TRIASSIC SEDIMENTS AT ALDERLEY EDGE

by John R Nudds

INTRODUCTION

David Thompson (1966, p. 269), in his MSc thesis on the stratigraphy and sedimentology of the Permo-Triassic rocks of the Cheshire Basin, including the area around Alderley Edge, devoted a section to the derived fauna found within the conglomerates and pebbly sandstones of the Anisian (Middle Triassic) Lower Keuper Sandstone (now the Helsby Sandstone Formation). Much of this sparse fauna, in pebbles of rotted crinoidal limestone and chert, comprised rugose corals of Lower Carboniferous age. These corals were identified by Dr F.M. Taylor of Nottingham University who also gave the stratigraphic ranges of the species as understood at that time, and suggested possible source areas for these pebbles. In view of the current interest in Alderley Edge and the interdisciplinary research now being undertaken at The University of Manchester, it is appropriate to review this fauna in the light of current knowledge. Unfortunately it appears that the specimens are no longer extant, but it is still possible to bring the information up to date both taxonomically and stratigraphically.

SPECIES PRESENT AND STRATIGRAPHIC RANGES

Dr Taylor identified the following five taxa, all from the Engine Vein Conglomerate, the lowest member of the Helsby Sandstone Formation. The first three are from Alderley Edge itself, the latter two coming from adjacent areas as stated.

1) "*Lithostrotion martini* Edwards and Haime"
This is now referred to *Siphonodendron martini* (Milne Edwards & Haime). The ancestral species of the family Lithostrotionidae, it appears at the base of the Arundian Stage and extends into the early Brigantian. The type material of this long-ranging species was redescribed by Semenoff-Tian-Chansky & Nudds (1979).

2) "*Tropophyllites* (sic) *enniskellini* (sic) Easton (sic)"
This is now referred to *Amplexizaphrentis enniskilleni* (Milne Edwards & Haime). Padget (1952) referred the species to *Triplophyllites* Easton, but it is

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