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Editorial

My thanks to all those who sent articles to me, some of these were too late for inclusion in issue 12 so they appear in this issue. I am very grateful to Fred Owen from the Manchester Geological Association for his ability in finding material and also to those willing authors who have contributed. It is also good to see some new authors contributing as well as receiving high quality material from our regular authors. I have, however been surprised at the lack of response in finding a suitable image for the front cover. Fortunately, this year we have an excellent image from Dr Peter Rankilor showing a prime example of a local trace fossil. Once again I appeal for images of local geology. The subjects can be on any scale from microscopic to mountain-range sized, although the photograph size cannot (see authors' notes below) and can be any local rock, mineral, fossil and can include building stones, mine or quarry pictures, geological or geomorphologic features. The images can be modern or historical but must not infringe copyright laws.

Wendy Simkiss

Notes for Authors

Articles and suggestions for future issues are most welcome and should be sent to either Chris Hunt, Department of Earth Sciences, The University, Liverpool L69 2BX or Wendy Simkiss, Earth Sciences, World Museum Liverpool, William Brown Street, Liverpool, L3 8EN,
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Articles should preferably be presented on disk, if possible in MS Word, and may be up to 3,000 words in length. Figures should be designed for reduction to fit a maximum frame size of 180 mm by 125 mm. Cover pictures can either be either photographs or digital images and must include the name of the photographer or owner, the society to which they belong and information about the image including the location. The cover picture will be around 92mm by 72 mm and, if sent as a digital image must be at least 200 dpi.

NOTES ON THE GLACIAL ERRATIC CURRENTLY LOCATED WITHIN THE MANCHESTER UNIVERSITY QUADRANGLE

By Maria A. Gorick

The large glacial erratic which is currently located within the Manchester University quadrangle was discovered in 1888 (Reade, 1888; Roeder, 1890).

The boulder was found at a depth of 90 feet (27.4 metres) above sea level (Roeder 1890), when excavations were undertaken along Oxford Street to allow the construction of a sewer. The section of superficial deposits thus exposed, along with the discovery of the large boulder, seems to have been the cause of quite a flurry of activity among the local geological community. Several talks were given on the subject at meetings of the Manchester Geological Society and articles appeared in the *Transactions of the Manchester Geological Society* and the *Proceedings of the Liverpool Geological Society*. An article on the subject by Professor W. Boyd Dawkins appeared in the *Manchester Guardian* (2 March 1888).

At the time of discovery, the size of the boulder was measured as 9 feet 6 inches (2.9 metres) by 7 feet 4 inches (2.2 metres) by 5 feet 7 inches (1.7 metres) (Reade 1888), with a mass estimated to be somewhere in the region of 20 to 30 tons (20.3 to 30.5 tonnes) (Roeder, 1890).

Striations are visible on the exterior of the boulder which suggests it has been transported by ice. However, heavy weathering prevents any observations to be made regarding petrology. Fortunately, at the time of the rock's discovery, several samples were taken and thin sections made. In addition, part of the weathered surface was scrubbed away to allow a study to be conducted regarding rock type and composition.

Analysis of thin sections, specific gravity (calculated as 2.74) and composition (63.6% silica) (Kendall, 1890) determined the rock to be an andesite (Judd 1888). The rock itself has been altered and contains a large quantity of secondary epidote (Judd 1888) which has resulted from the saussuritization of plagioclase feldspars.

Those plagioclase feldspars that remain unaltered are zoned and contain many inclusions. The ferromagnesian minerals are so altered that they cannot be identified. However, the rock's texture and habit indicates that it was a pyroxene-andesite (Judd 1888).

Comparison of the characteristics of the rock with samples from Shoulthwaite, Cumberland (Kendall 1890) and Eycott Hill (Judd 1888), among others, led to the conclusion that the rock had originated in the Lake District (Judd 1888; Kendall 1890).

The north face of the boulder, as it is currently positioned in the quadrangle, is the surface upon which the boulder was resting when discovered with the south face being the upper surface (Kendall 1890; Roeder 1890). The roundness and smoothness of the upper part of the boulder contrasts with the angular, fractured lower part. A possible explanation for this is that the boulder was originally larger, and part of it has been broken off (Roeder 1890).

The south face of the boulder appears polished and striated. The striations upon the north face are deeper than those upon the south. Small grooves on the south face of the rock are associated with raised prominences which are a build up of weathered crust. The lee-side is to the south east and so movement must have come from the opposite direction. Similar prominences upon the northern face indicate direction from the east (Kendall 1890).

As the prominences are formed from the weathered crust, it appears that the crust developed before the rock was affected by ice. The edges of the scars upon the south west upper surface and north east side of the lower end have been rounded, probably by the ice which smoothed and polished the rock surface. Therefore it is likely that the rock suffered the scarring before glaciation occurred (Kendall 1890).

When the erratic was found in the Oxford Street section, it was noted that the long axis of the boulder lay in the same plane as the longitudinal striae (Roeder 1890). The gravel upon which the boulder rested was indented and yet it was observed that it had not been fractured or crushed (Kendall 1890; Roeder, 1890). A thin layer of finely laminated clay was sandwiched between the boulder and the gravel. The laminations were the result of compression due to the weight of the boulder. The gravel which lay beneath this clay layer was at a depth of three feet (91cm) beneath the main gravel bed (Kendall 1890). Taken together these observations suggest that the boulder was not dropped from the ice sheet, but was probably carried along the bottom of an iceberg. When the ice began to melt, the boulder, which was enclosed in clay, was gently deposited upon the surface of the gravel. The weight of the boulder caused it to sink beneath the gravel bed, pushing down the area of gravel and clay upon which it was initially deposited.

If new petrological observations were to be made regarding this andesite erratic, some of the weathered crust would have to be removed or the original samples and thin sections located and examined. Despite this, some of the boulder's history can be traced in its surface features. The effect of a blow has left its mark as angular fractures, visible on the lower half of the rock, and rounded scarring. The striations, raised prominences and fissures point to transportation by ice.

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MUSINGS ON A CYCAD

By Alan J. Bowden

Introduction

Cycas revoluta the so called 'Sago Palm' (although it is neither a palm nor producer of sago) is commonly found in florist shops, garden centres and landscape suppliers **(Figure 1).**

Figure 1. *Cycas revoluta,* commonly found in garden centres and florists. This is the most common cycad in cultivation although it is restricted to the southern tip of Japan, particularly the small islands off the mainland of Kyushu. The leaves of this plant were exported in large numbers to the USA as 'palm leaves' for use in Palm Sunday celebrations. The stems contain a lot of starch and, in times of famine, have been carefully prepared to break down the toxins and used as a food-stuff.

It is a living representative of a group of plants that exploited the seed bearing habit some 300 million years ago. There are about 190 living species of cycads, most of which are endangered within their habitats as a result of

human intervention. In this short article I will attempt to outline in general terms a few of the questions posed by the Cycadales (the order containing the cycads) from the Upper Palaeozoic through to the Mesozoic when they achieved their greatest diversity and global range. For a comprehensive treatment see Norstog & Nicholls (1997) and Watson & Cusack (2005) and the literature contained therein. Most of the genera encountered are known only from fragmentary fossils whereas living cycads have full taxonomic status.

A botanical interlude

The cycads are a small family of plants within the gymnosperms (non-flowering plants with 'naked' seeds), one of the two major seed-bearing plant groups which also contain the conifers. This is a term of convenience based upon a common reproductive character. The other group is known as the angiosperms (flowering plants). Gymnosperm seed ovules are unenclosed, relatively unprotected and directly exposed to pollen grains whilst the angiosperm ovules are enclosed within an ovary and never directly exposed to pollen grains. As cycads were amongst the earliest of seed bearing plants, it is possible that insect-pollination originated with them and their seed fern relatives long before the rise of flowering plants. Cycads are fascinating plants producing both male and female plants and cones (dioeceous), often of large size - a cone of the living Australian cycad *Lepidozamia peroffskyana* can weigh up to 40 kg.

Setting the scene

For many people cycads represents a link with the 'Age of Dinosaurs' as popularised in museum dioramas, artwork and popular literature associated with reconstructions of past Mesozoic environments. The Cycadales and their fossil contemporaries, the extinct Benettitales such as *Williamsonia,* and the Cycadeiodea and Ginkgoaeles have come to represent our view of the Mesozoic just as the lycopsids, ferns and pteridosperms of the Carboniferous

Coal Forests have dominated popular viewpoints of the Upper Palaeozoic. Cycads reached their peak in the Jurassic and early Cretaceous. Many living species share characteristics known from early forms of the group, with the Genus *Cycas* displaying possibly the most ancient lineage having characteristics that may be traced back into the early Permian (Artinskian age) of China 268 million years ago. This may have originated as a Gondwanan Cycadale and the modern genus retains some morphological and biochemical markers that may indicate that this group separated relatively early on from other cycad genera. However, some authors have argued that the genus *Cycas* is not as primitive as generally believed and may have evolved during the Cretaceous. Later, more modern, forms adapted to harsher and drier habitats appeared with the African *Encephalartos* species regarded by more than one worker as being possibly the most evolved in terms of adaptability, although these too seemed to be extant during the Upper Cretaceous.

Today, cycads occupy a wide range of habitats from tropical and subtropical forests, warm temperate regions, and open grasslands to rocky slopes and cliffs. Now they are restricted in the wild to latitudes extending from 35 degrees north to 35 degrees south. This latitudinal range mimics some of the environments to be found during the Mesozoic, typically where it was warm and humid as well as warm and dry. Most modern cycads do not like long freezing spells, although many such as *Cycas* and some *Macrozamia* and *Encephalartos* species are frost tolerant. However, this may not have been the case during the Mesozoic when they achieved a global distribution which matched the warmer climatic conditions found during that era.

The problem of form genera

One of the main taxonomic problems facing palaeobotanists lies in the recognition of plant genera and species. Due to the highly fragmentary nature of much of the fossil material, it is very difficult to reconstruct fossil forms with any high degree of certainty. Hence, the erection of form genera to which

fragmentary material is assigned. For example large fern like fronds of the Carboniferous Medullosan pteridosperms *Neuropteris* and *Alethopteris* are recognised as form genera, the complete plant being unknown. Seeds of the Medullosaceae look very similar to the seeds of both living and fossil cycads and are assigned to form genera such as *Trigonocarpus*, and *Pachytesta* **(Figure 2)**. Sometimes it is possible to link up these fragments to build up a picture of the complete plant. A cycad example from the Rhaetic of Sweden is *Bjuvia simplex*. This is known from a megasporophyll, *Palaeocycas integer*, which was associated with a simple form of leaf (*Bjuvia simplex*) on the basis of cuticular and epidermal structure. The stem is unknown but was inferred for the reconstruction **Figure 3**. The erection of form genera represents what Harris (1961) called "broken knowledge" in as much that there is information about a large number of separate bits of plants to which names have been assigned, the overriding aim of the palaeobotanist being to reconstruct the morphology of the plant from these disparate elements. A recent revision of the International Code of Botanical Nomenclature (the 2001 'St Louis Code') has dropped the term form genera in favour of morphogenera. The technical advantage of this is that form genera could not be assigned to a family whereas morphogenera can (Cleal, personal communication).

The effects of taphonomy

The botanist and palaeobotanist John Lindley (1799-1865) conducted one of the first experiments in differential preservation of plant material. He immersed 177 species of plants in a tank of water which he kept topped up for two years. At the end of this period it was drained out and the remains analysed. He found that cycads and conifers were the most recognisable elements of the surviving flora with fruiting structures on non flowering plants breaking down more rapidly than leaves and stems in an aquatic environment. This early experiment in taphonomy was written up in volume III of Lindley and Hutton's Fossil Flora. With fossil bearing sites of the early Mesozoic being of limited extent, our knowledge of the development of the Cycadales is constrained by the palaeoenvironment, taphonomic processes and lithology.

Taphonomic processes may influence the comparative fossil abundance of Cycadales and the Benettitales. Apart from leaves and, in rare instances,

Figure 2. **From left to right, seeds of Pteridosperms (seed ferns) an indeterminate form (Higgins ZG) and Trigonocarpus (Higgins ZC), seeds of the modern cycads *Macrozamia moorei* (Liv 2004.35.2) and *Lepidozamia peroffskyana* (Liv 2004.35.1).**

Figure 3. *Bjuvia simplex* from the Rhaetic of Sweden, reconstruction after Florin and redrawn by Gausen.

Figure 4. *Leptocycas gracilis* reconstruction after Delevorys and Hope (1971).

stems, cycads do not appear to preserve as well as members of the Bennettitales. These appear to be more common as fossils but they may reflect the effects of differential preservation rather than an endemic distribution of genera. A further complication is the requirement that reasonable preservation is necessary to distinguish between the two groups of plants based upon cuticle analysis and venation.

An exception to this is a cycad found in the Upper Trias of North America. The genus *Leptocycas gracilis* is known from leaf fragments, stem material and cone fragments in association. Reconstruction of this species indicates that the Mesozoic cycads probably had more slender stems than those found in modern genera (Delevorys & Hope, 1971) **Figure 4**. Other fragmentary Triassic fossils also indicate that the earlier cycads may have been of smaller stature than later Mesozoic genera.

Searching for Palaeozoic ancestors

The spread of cycads seemed to have occurred during the existence of the super continent known as Pangea which had largely assembled by the Triassic **(Figure 5)**. Prior to this, Permian Gondwanan forms evolved, possibly from a Pennsylvanian ancestor. Is this an evolutionary response to the drying out of the environment from Late Pennsylvanian times to the early Permian? It is tempting to suggest that this may be the case; however, the fossil evidence is too scarce to make sweeping assumptions. Leary (1990) suggests that one of the possible precursor forms is *Lesleya*. This genus has been listed under the Cycadaceae by Cleal (1993) and is known from the Lower Pennsylvanian strata of Western Illinois. This reinforces a view held by Mamay (1976) that the cycads originated from entire-leaved Pteridosperm (seed-fern) genera as far back as the Lower Carboniferous, although not all workers are in agreement with this idea. Mamay (1976) suggests that cycad leaves were originally simple with the pinnate compound leaves being produced by progressive marginal incisions which eventually gave rise to the *Cycas* type of leaf pattern. However, Delevoryas (1982) put forward an alternative suggestion that it was just as easy for cycad leaf forms to evolve from any of the Palaeozoic seed-fern pinnate leaved genera. Certainly by the Triassic the surviving fragmentary leaf material indicates that both simple and pinnate forms existed in the flora.

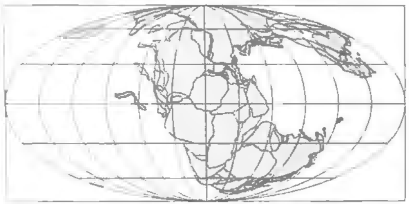

Figure 5. The super continent Pangea in the early Triassic. Computer generated map, Mollweide projection, derived from Schettino & Scotese 2000.

Further support for the early evolution of cycads is given by the discovery and description of the megasporophylls known as *Phasmatocycas kansana* and *Archaeocycas whitei* recorded from the Lower Permian rocks of Kansas and Texas. Mamay has suggested that these evolved via Carboniferous pteridosperms, an idea which has been supported by modern cladistic studies (Watson and Cusack, 2005). Leary's suggestion that plants such as those represented by *Lesleya* (which predates both *Phasmatocycas* and *Archaeocycas* by some 35 million years) could act as a precursor to these form genera is attractive as it presents one potential evolutionary pathway. The fossil reproductive material *Crossozamia*, as defined by Gao and Thomas (1989), represents a form genus that appears to have strong *Cycas* like affinities. Superficially the megasporophylls look remarkably like those found on *Cycas revoluta*. Other form genera linked to *Crossozamia* are the leaves *Taenopteris*, *Yuania* and *Tianbaolina*. Gao and Thomas suggest that *Yuania*

Figure 6. The leaf *Nilssonia compta* from the Yorkshire Deltaic series (Liv 60.64.AJK).

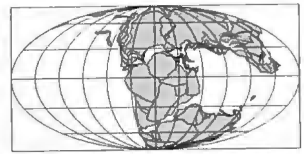

Figure 7. The break-up of Pangea during the late Jurassic. Computer generated map, Mollweide projection, derived from Schettino & Scotese 2000.

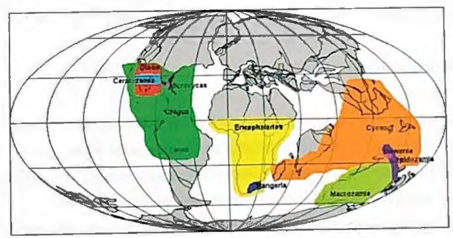

Figure 8 Pangea, Gondwana and Laurasia at the end of the Cretaceous with modern cycad genera superimposed. Computer generated map, Mollweide projection, derived from Schettino & Scotese 2000.

are juvenile leaves whilst *Tianbaolina* are fully expanded adult leaves. If these form genera do have true *Cycas* affinities then they are very important with respect to Cycas and its place in cycad evolutionary history.

By the Jurassic, Cycadalean evolution may have been largely completed and the fossil evidence is more plentiful. Most of the Jurassic fossils attributed to cycads consist of leaf form genera such as *Nilssonia, Ctenis* and *Pseudoctenis.* Finding vegetative parts in association is difficult and the work of Thomas and Harris (1960) in the Yorkshire Deltaic Series was particularly noteworthy in linking disparate vegetative and reproductive structures to a single plent. A cycad example of Aaelian age from the Middle Jurassic Ravenscar Group sediments of Yorkshire is known from fragments of the female cones *Beania gracilis* Carruthers, male cones *Androstrobus manis* Harris, scale leaves *Deltolepis crepidata* Harris and leaves *Nilssonia compta* (Phillips, **Figure 6**). By careful analysis of the association of these fossils Thomas and Harris were able to demonstrate that these individual fossils appear to represent parts of the same Cycad species which may be very distantly related to the extant South American *Zamia* or Central American/Mexican *Dioone* species. It is interesting to note that the deposits in which these fossils were found were largely fluviatile and deltaic sediments laid down during the subsiding Cleveland Basin. For further information on the Mesozoic flora the interested reader is encouraged to refer to the works by Norstag & Nicholls (1997) and Watson & Cusack (2005).

Tectonics and cycad distribution

The existence of Pangee allowed for the migration of plants and animals across a wide region, aiding diversity of the fauna and flora after the Permo-Trias extinction event. Tectonic movements began to break up this land mass with the first rifting episode occurring during the Middle Jurassic, approximately 180 Ma. Here, igneous activity occurred along the east coast of North America and the northwest coast of Africa. The Central Atlantic Ocean began to open up and the North American part of Laurasia started a slow drift away northward whilst Eurasia began a southerly drift. As the

Jurassic period drew to a close the Tethys seaway opened up a corridor from the present position of the Caribbean through to the Straits of Gibralter, then continuing south between Arabia and the Near East towards the South Polar sea **(Figure 7)**. Extensive volcanic activity along the adjacent margins of east Africa, Antarctica and Madagascar initiated the formation of the western Indian Ocean. Whilst this took place the global distribution of the Cycadales was permanently sundered so that generic and species specialisation began to take place within much reduced regional and latitudinal ranges. As the Central Atlantic Ocean continued to open during the Mesozoic, the Laurasian continental block rotated clockwise so that the warm Tethyan Sea that had separated Laurasia from an increasingly fragmenting southern Gondwanan continent started to close. Cycads were present on both continental blocks and modern distributions of cycad genera may be traced back to that time some 150 million years ago. The living Indo-Austrelian and African cycad floras may be representative of those formerly of Gondwanan origin. Within Australia there are three endemic genera, *Macrozamia, Bowenia* and *Lepidozamia*. The African continent has two endemic cycad genera namely *Stangeria* and *Encephalartos. Cycas* appears in the Indo-Australian region but it may be originally of Laurasian origin. Relict Laurasian cycad floras are found in the Pan-American region and are represented by *Ceratozamia, Dioon, Microcycas* and *Zamia.* Paradoxically, although originally part of Gondwana, South America has not retained any of the Gondwanan cycad flores. Instead Laurasian forms have inhabited that region.

Certainly by the Late Cretaceous most, if not all, of the extant cycad genera had evolved which suggests that there has been very limited post Mesozoic evolution of the group **(Figure 8)**. The Upper Cretaceous was a time of increasing environmental stress with the flood basalt eruptions that formed the Deccan Traps, changes in oceanic circulation occurring as a result of the break-up of Gondwana and Laurasia, dropping sea levels and cooling deep ocean water, increasingly seasonal global climates as a result of mountain building in the Americas, Europe and Asia with corresponding changing global wind patterns. Finally at least three major asteroidal/cometary impacts caused significant disruption of the already stressed biosphere, the largest of which is held by some to be the causal element for the K/T extinction event – a view not held by this author, despite his background interests in meteoritics. Survival in this environment was restricted to those who were able to adapt most readily to the changing conditions. The Bennettitales such as the tall arborescent Williamsonias and the squat Cycadeiodeae became extinct with the Cycadales re-establishing their ranges in a changed world. Why did the other groups die out? Was it merely chance, a loss of dinosaurian grazers and other vectors such as specialised insect pollinators or some other biological or environmental factor not yet recognised? Alone out of the Mesozoic Gymnosperms under discussion the Cycadales and the Ginkgoales survived the K/T boundary

Research into modern and fossil cycad distribution patterns implies that floral migration may have occurred from eastern Gondwana (today's Argentina), through to North America, England and Sweden (Laurasian block) via Antarctica. However, so called plant migration patterns could be misleading and it may be more likely that modern distribution patterns result from adaptation and survival mechanisms. As an example, the modern cycad *Stangeria eriopus* is known from a single species living in the coastal belt of eastern South Africa. This unusual cycad has leathery fern like leaves and for many years was thought to be a fern and included in the fern genus *Lomaria* as *Lomaria eriopus* until a specimen grown in captivity developed a cone typical of cycads. Ancestral forms of this cycad have been recorded as fossils from Argentina and the fossil cycad cone *Andostrobus zamioides* found in the Middle Jurassic sediments of Yorkshire appears to be related. *Stangeria* like relatives have also been found in Europe as leaves of *Eostangeria saxonica* from the Middle Eocene of Germany and *Eostangeria ruzinciniana* from the Middle Miocene of Bulgaria. Are these form genera really related or examples of concurrent evolution? An alternative view point to the migration theory is that during the time Pangea existed this cycad was relatively widespread with a concentration in the southern continental mass of Gondwana. Today the modern African genus would appear to be a relict population rather than a result of floral migration.

A local interlude

The Cycadales were extant during the Triassic and it would be of great interest to discover the first Anisian form from our local strata. In the modern environment the more 'primitive' Cycad species tend to show a preference for moist habitats. Matching conditions may have occurred during deposition of the Tarporley Siltstones and it could be in this sequence that the first UK Anisian fragmentary forms may be recorded. However, palaeo soil acidity may have removed the macro organic evidence via taphonomic processes.

Conclusion

Finally, one of the oldest indoor pot plants in the world is to be seen at Kew Gardens. This is a specimen of the South African cycad *Encephalartos altensteinii* **(Figure 9).** It was brought to Kew by Francis Masson (one of Kew's first plant collectors) in 1775. Not only is this plant of historical horticultural interest but it and other members of the Cycadales are also of great geological interest with the modern distributions charting the break up of Pangea, although we currently know next to nothing about their original distributions around the Pangean supercontinent. Cycads also demonstrate unusual reproductive and adaptive survival mechanisms and resistance to the effects of extinction which removed the Benettitales from the scene by the end of the Cretaceous. They provide a tangible link back to a possible Carboniferous pteridosperm ancestry and have been witness to the great tectonic upheavals and 'catastrophic impacts' since the early Permian. The dinosaurian grazers may have long gone but mammals and birds have taken their place. Most mammalian and avian genera have intricately coevolved with the angiosperms (flowering plants). However, specialist insect pollinators such as thrips, the snout nosed weevil and other specialised beetles have evolved to ensure that the reproductive strategies of the cycads can continue. Today most cycads are endangered in their natural habitat and many species are microchipped so that they can be traced if illegally removed from the wild. Even in botanic gardens cages have been placed around many specimens to prevent collectors from removing suckering offshoots. It seems a shame that having come on a journey lasting over 260 million years that they might eventually succumb to human interference in their natural habitats. It is not for nothing that some commentators have announced that we are living through an extinction event as great as or greater than that at the K/T boundary.

Figure 9. One of the oldest indoor pot plants, *Encephalartos altensteinii*.

Acknowledgements

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HENRY CHARLES BEASLEY (1836-1919)

By Geoff Tresise

The study of footprints has the scientific name 'ichnology'. Henry Charles Beasley has rightly been called "by far the most important figure in the history of British ichnology". He was a book-keeper by profession, his geological interests at first "providing relaxation from an active commercial career." They were to become his main interest during the last twenty years of his life.

We know virtually nothing about his private life, apart from the fact that he was married with one child, his daughter Jessica. He was elected to the Liverpool Geological Society in January 1871 and was a member for almost 50 years. Like Mellard Reade, he served three times as president in three successive decades. During his first term in 1889 he chose 'The Life of the English Trias' as the theme of his presidential address but said surprisingly little about fossil footprints. There was certainly no indication that they would soon become his major field of work.

It seems most likely that Beasley's interest in local footprints was catalysed by the appearance in 1891 of the second edition of Morton's 'Geology of Liverpool' which dealt at length with the Storeton quarries. Beasley realised that nobody had yet tried to classify the Triassic footprints and his next and very important paper to the Liverpool Geological Society, delivered in 1895, was an attempt to do just that. Eight different types were recognised which he did not name but distinguished by the letters A to H.

For Beasley, the 1895 paper marked a watershed. From that time onwards, Triassic footprints became his overriding interest and he was to devote the rest of his life to extending and refining their classification. This work culminated in a series of reports for the British Association for the Advancement of Science which met at Southport in 1903, and set up a committee to study the flora and fauna of the British Trias.

Beasley was co-opted onto this committee and produced a series of six reports on their behalf – a substantially greater contribution than that of all the other members put together. The first two reports, produced in 1904 and 1905, extended his footprint classification by sub-dividing many of the eight groups he had set up ten years before.
In 1906, came a major advance. Beasley, once again the Liverpool Geological Society President, reported:

> "The South Quarry at Storeton having lately changed hands, a suggestion was made to Mr Charles Wells, the new proprietor, that he would much assist geologists if he would allow his men to preserve uninjured any good footprints that might be found. This he readily agreed to do with the result that, on reaching the footprint bed, the slabs were carefully raised and every facility given for their inspection."

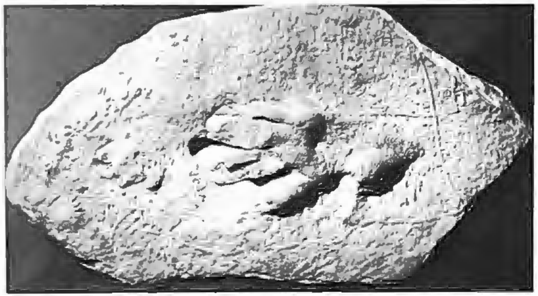
The area of the footprint bed quarried in 1906 was about 40 by 60 feet. From this small working floor between 20 and 30 slabs were raised, many of which were over six feet square. The slabs were left in an upright position and allowed to weather naturally so that the clay coating flaked away from the surface to reveal the detail of the footprints underneath.

Beasley then contacted a number of museums to tell them of the finds. Slabs were subsequently sent to the Natural History Museum, Hull Museum, Leeds City Museum, Leeds University, Bolton Museum, the Williamson Art Gallery in Birkenhead, Manchester Museum and University College, Liverpool. Beasley's report to the British Association for the Advancement of Science in 1907 was wholly devoted to a description of these finds.

The raising of the footprint-bearing slabs in 1906 was only the first, albeit most productive, of a series of such rescue operations. The method of quarrying ensured that, with the cooperation of Charles Wells and his workmen, the same operation could be repeated each year. In 1907, slabs were acquired by Liverpool Museum and the University of Liverpool and in 1910 by Manchester Museum and the Natural History Museum in London. However, in 1912 the finds were unexciting and this marked the last of the rescue operations, on each of which considerable time and effort must have been spent.

Beasley died at the end of 1919 but his geological activities came to an abrupt end in the summer of 1914. In January of that year, he read his last paper to the Society on a new type of footprint found at Weston near Runcorn – his alphabetical classification had now reached type Q. On 11 July he led a Society field trip to Flintshire. Thereafter he attended no Society meetings, he took no more photographs and made no further entries in his notebooks. In December 1916 he was made an Honorary Member of the Society, 45 years after he had joined. By then he was effectively house-bound and his letter of thanks regretted that "I can hardly expect to do any useful geological work."

He died at the age of 83 on 14th December 1919, leaving two important collections. One was his archive of over 370 photographs of fossil footprints, many of which he had taken himself. This was presented to the Liverpool Geological Society but is now housed in the archives of National Museums Liverpool. In addition, the year before his death, his fossil collection (which included some 70 footprint specimens) was purchased by Councillor Sydney Jones and presented to Liverpool Museum. Unfortunately it was almost totally destroyed during the Second World War – only one specimen surviving the blitz.



It is part of a *Chirotherium* track from one of the slabs raised from Storeton Quarry in 1906. By a happy chance, it appears to have been one of Beasley's particular favourites since he photographed it eight times – more often than any other of his specimens.

USE YOUR DIGITAL CAMERA TO VIEW MINERAL SLIDES UNDER POLARISED LIGHT

By Peter Rankilor

This is part two of a series of short articles on how to make your digital camera more versatile; how to get more out of it, and how to make your geology more interesting by using what are now commonplace devices - digital cameras and computers!

In the last article, I described how the digital camera lends itself to the microscopic examination of rocks, fossils, and mineral samples. In this article, I shall show you how easy it is to magnify images under a couple of crossed polarisers as commonly used with cameras or as taken from an inexpensive pair of sunglasses.

We don't need to go into the physics of polarisation of light too deeply. Suffice it to say that light from the sun or an artificial source is a mix of light waves. The light waves are of different intensities, wave lengths, and orientations. Generally, the orientation of all the different light waves varies through the full 360 degrees available.

However, when light is reflected from a non-metallic surface, it is partially polarised. That means that the direction of reflected vibrations tends to be predominantly aligned parallel to the reflecting surface as shown in **Figure 1**.

This fact is utilised by polarising sunglasses which have their lens molecules aligned in such a way as to absorb the polarised reflected light and thus reduce glare off the surface.

Because light is partially polarised from horizontal road or water surfaces, polarising glasses are particularly useful for drivers to reduce glare off a wet or snowy road, or fishermen, who can see through the glare off the water to observe fish beneath.

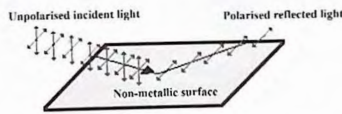


Figure 1. Reflection of light of non-metallic surfaces such as roads, snow, or water, results in partial polarisation parallel to the surface.

This is certainly one simple way that you can improve your study of geological objects - eliminate glare from the surface. This same technique helps with photographs of lakes, glaciers and snow scenes or rocks in rivers. You can reduce the polarised glare by absorbing it in a filter. It is useful that the reflected light from other objects is not absorbed by the polarising filter, and thus these do not become dimmer. With a polarising filter on your camera, the glaring objects become darker and clearer whilst the appearance of other objects remains unchanged. Ideal!

If you take a pair of polarising sunglasses and place one over the other as shown in **Figure 2**, you will see right through them with no problem. But if you rotate one pair of the lenses as in **Figure 3**, you will notice that when they are at right angles to each other, they cut out the light almost totally.

Figure 2. **Two polarising sunglasses parallel with each other. Light passes through both of them with minimum absorption.**

Figure 3. **Two polarising sunglasses placed at right angles to each other. Polarised light from the first lens is not allowed through the second lens at right angles.**

When polarisers are at right angles, they are known as 'crossed polarisers'.

The aspect of this that is relevant to geologists is that many natural minerals can also polarise light. Therefore, when light passes through minerals the light is affected and we can use this property to study them.

We simply insert a thin cut section of a mineral (a mineral slide) between the crossed polarisers.

In addition to polarising sunglasses, photographers are aware that it is possible to purchase a polarising filter to attach to the front of a camera lens. This filter absorbs the orientated reflected light from smooth surfaces and thus reduces the glare in the same way as the sun glasses.

If you fix one of these filters to your camera and you fasten the mineral slide in front of the other filter, both of which you affix to a window with tape, you can rotate your camera polarising lens until the crossed polarisers go dark and then you can photograph the mineral from a distance using your digital camera. I used the same mineral slide as I did in the first article of this series and **Figure 4** shows it stuck on my study window in front of a polarising filter.

Note that if you are using two camera filters, as shown, then the far one on the window must face the opposite direction than it would be if it were attached to the camera, i.e. the screw thread must be next to the pane of glass. It is also best to do this photography on a dull day with grey clouds to provide the background light, so that a blue colour cast is avoided.

In **Figure 4** I have placed the slide in front of the polariser. I have put a second polarising filter on the camera lens and rotated it until the polariser turns black. Then the minerals are being viewed through cross-polarisers and the artificial mineralogical colours can be seen.

Figure 5 shows a close-up of the mineral slide taken in ordinary light (with the polarising filter removed from the camera lens) with a six megapixel digital camera from a distance of about one metre. The slide was just taped up to my study window. It is possible to see various minerals including mica and the typical cracked patterns of olivine. However, without the polarising analyser filter on the lens it certainly lacks the characteristic tell-tale colours that allow us to identify other minerals with confidence.

Figure 6 shows the results of photographing the thin section through crossed polarisers. Any mineralogist will tell you that a polarising microscope is not just a method of looking at pretty colours; it is a scientific instrument that allows the viewer to measure particular properties, angles, and colours scientifically and accurately. The simple, but interesting, method I describe in this article is not for proper scientific analysis. Rather it is a free-of-charge method of obtaining more detail and information from a rock slide for either personal study or for demonstration. Used in the simple way described, the digital camera will not replace the microscope. However, it is a neat tool to have, since your digital camera is with you a lot more than your mineralogical microscope - if you have one!

I have found that the use of a polarising filter to remove reflected glare from polished mineral samples and crystals is much less successful. It seems that polished rock surfaces only impart a significant polarisation to the light when reflected at particular angles. The results are much better with transmitted light as shown, for example, in **Figure 6**.

The photography of crystals and fossils can be enhanced by using a tripod and a large f stop setting on the camera, to obtain an increased depth of focus.

Figures 7 and 8 show the improvement in a photograph of some amethystine quartz crystals in a druse, when the f stop is increased from f4.0 **(Figure 7)** to f22 **(Figure 8)**.

Amongst other things, this article is intended to show what can be achieved with the most straightforward of equipment and no special lighting conditions. **Figure 7** was therefore taken using normal indoor domestic lighting. I didn't set the camera to correct for the warm colour since I know I can restore it later using Photoshop. However, if you haven't got Photoshop, then you would be advised to try to get the colour correct by waiting for bright daylight conditions and/or setting your camera to compensate for indoor lighting.
Figure 8, which was taken with a stop of f22, had an improved depth of focus, making the photograph more detailed and more interesting. The change in exposure length has not affected the colour significantly, if at all.

The depth of focus helps the photograph, but the problem of varied exposure hides detail within the druse. Photoshop allows you to improve this considerably by permitting the differential lightening of the image. You can lighten one part without affecting other parts.

Photoshop also permits the labelling of diagrams. This is done by selecting the text button on the left hand side of the screen, clicking on the image and typing. The program automatically creates a new layer for each group of text typed. Thus, to manipulate these, you must press F7 at the top of your keyboard to list and show the different layers. When you type a new group of text, you will see a new layer shown in the listing. When you click on a layer in the listing, you can move and alter the text format. It's not too difficult, but easier for people who are used to the layers idea in Photoshop. It's rather like

Figure 4. Mineral slide mounted in front of a circular polarising filter for a 35 mm digital camera.

Figure 5. Mineral slide photographed using a standard 35 mm digital six megapixel camera, hand held. Even better results could be obtained using a tripod and a high f stop number.

Figure 6. The same mineral slide photographed between cross polarisers, on a tripod, using a standard 35 mm digital six megapixel camera. Characteristic mineral patterns and colours can be observed.

Figure 7. A druse cavity photographed using a tripod with the f stop set to 4.0. Small depth of focus.

Figure 8. The same cavity photographed with the camera set to f stop 22. Greater depth of focus is obtained, so more detail is recorded.

Figure 9. The same cavity photographed with the camera set to f stop 22 and processed in Photoshop to give enhanced colour correction and sharpening of the image.

Figure 10. A crop of the photograph in Figure 9, showing the amount of detail available for study and examination. The camera was about half a metre away from the specimen and held on a tripod.

working on multiple layers of transparent plastic - each word is written on a different layer over your image.

On **Figures 1** and **8** you can see some of the labelling inserted in Photoshop. Note the use of white writing where the image is dark and vice versa where it is light.

Figure 8 was enhanced using Photoshop image software and is shown as **Figure 9**. The two main things done were the restoration of a more-purple colour to the crystals, to make them look more like amethyst, and secondly, the crystals were differentially lightened to reveal more hidden detail. Finally, the image was sharpened.

It is reasonable to submit that the greatest improvement in the image comes from treatment with Photoshop.

Finally, and this harks back to my first article in this series, a small cropped area of **Figure 8** was extracted in Photoshop and enlarged, as shown in **Figure 10**. This reveals the remarkable amount of detail available for study and examination on an otherwise normal photograph, taken with a camera set about half a metre away from the crystals.
In summary, the use of a digital six megapixel camera and Photoshop can produce some remarkable images without the need for polarising or standard microscopes. It is interesting to note that even as this series is being written, camera resolution has increased well beyond

the six megapixel level. Ten megapixel cameras are common and models with more than 20 megapixel can be purchased (although still currently very expensive). The greater the megapixel size of the image, the more detail will be available for study.

However, there is a practical warning to be given. The camera used for this series is a Canon EOS 60D, which is a relatively expensive piece of equipment, using Canon's top quality lenses. It must be remembered that 'compact' cameras offering six to ten megapixel resolution have got limited lenses fitted to them. These lenses are not large and not as good a quality as on bigger cameras costing six times as much. The edges of images may not be perfect, but still, they will be good. There is another thing about the small compact cameras that are widely used today; they do not have much weight and thus are easily moved during the pressing of the shutter button. This leads to blurred images when magnified (as in **Figure 10** below). To avoid this, it is important to use a tripod (even a light weight small tripod will suffice). If there is no remote cable socket for a small camera, the best thing to do is to use the delay timer to activate the photograph. All small cameras are fitted with a delay timer. The automatic exposure is thus shake-free. Usually this is used for taking photographs where the photographer wants to be in the photo, but in technical photography it eliminates camera shake. In the third of this series of articles, I shall show you the technique and benefits of taking three-dimensional (3D) photographs of fossils and minerals, as well as your field photographs when outdoors - of course, using a digital camera. I shall also show you how to view three-dimensional images without having a mechanical viewer! I wonder how many of you will be able to do it - it's not easy!

Dr Peter Rankilor
December 2006.

JAN'S ROADSIDE ROCK SESSIONS – NO. 2: THE NANT FFRANCON / OGWEN VALLEY (PART 1 OF 3)

By Jan Heiland

Well, I have received some nice feedback on my first "Roadside Rocks" in the North Wales Geology Association Newsletter so here's another easy helping. Remember – my premise was that the sites should be no more than five minute's easy walk from the roadside, and concise enough for a quick visit during a casual afternoon's pottering.

This time in Roadside Rocks, we are going for a wander up the Nant Ffrancon Pass through Bethesda heading south-east on the A5. After about a mile turn right just before Ty'n-y-Maes at the small brown sign which says "Lon Las Ogwen". Follow the old road up the valley driving a couple of hundred yards and park carefully just the other side of Ceunant bridge (grid reference 632 643), with fine views up the valley.

Walk up the road for about another 200 paces until you come to a steep rock exposure on the right, just within the last stand of trees (grid reference 632 641). This little roadside exposure of Cambrian Marchlyn mudstone is best viewed in the oblique early-afternoon sun to appreciate that it is covered in superb beach-ripples – just like the strata high above you, but much easier to get at! It is held that much of the Cambrian sediments were laid down in a deepening basin, but these ripples indicate a shallower wave-base location for these beds, which are near the top of the series. More of these ripples can be examined later if you wish after passing through a gate (marked footpath) just north of your car – though not just yet as we still have more to see from this site.

Exposure of roadside ripples in Cambrian Marchlyn Mudstone

From our viewpoint, you should be able to look along the line of the road in front of you and see how this rippled outcrop lines up with matching steeply inclined strata on the skyline high in front of you (grid reference around 623 627) which sweep down through Cwm Graianog. These are the part of the Marchlyn – Camedd-y-Filiast formation.

The strata up above you show two apparently differing angles of dip. The steeper looking grits on the right (north) of Cwm Graianog represent the upper limit of the Cambrian, although a substantial unconformity means that the top of the Cambrian sediments have been eroded. Following this unconformity (at a notch on the skyline), the shallower dipping slates on the left (south) are the base of the Ordovician. A wall down the hillside to Tai Newyddion cottages (grid reference 631 635) approximates to the unconformable boundary. The peak at the back of Cwm Graianog, just left of the dipping strata, is a later microgranite intrusion that has melted its way up through the sedimentary rocks at the end of the Caledonian orogeny.

Cwm Graianog

The unconformity is an interesting one, as it is not represented by a neat flat boundary beneath the upper levels. In a very acutely forward-thinking observation, Ramsay (1866) realised that the Ordovician oversteps the Cambrian – i.e. an upward progression of Ordovician strata were laid against a slope of eroded Cambrian strata. This was one of Ramsay's key works in the area, as his overstep defines much of this boundary throughout Snowdonia.
Looking up the valley from here, all the strata dip generally to the southeast passing beneath the Cwm Idwal syncline. As we drive up the valley to the falls we will pass upwards through just over a vertical mile of sedimentary

strata. Later, at the end of this excursion we will look back and ponder this dimension.

Cwm Ceunant Mine

Before you leave this site, walk to the end of the trees and note the old Cwm Ceunant mines above you (grid reference 627 638). Dated at around 1760 these were once worked for arsenic and copper. Pyrrhotite (magnetic pyrite) has also been reported from these mines (Bick 2003).

Although the mines are not part of our excursion, it is worth noting that the old Ceunant arsenic smelting tunnels still exist on privately owned farmland hidden under the trees by the river Ogwen (grid reference 633 645). They are an extremely rare and early use of the calcining/sublimation process (Bick 2003). The Ceunant furnace is accompanied by more pits on the same arsenic lode, which ends with an open adit still draining directly into the river Ogwen! There were also other copper mines just down the valley at Dolawen. They are now buried beneath the slate tips along with part of the old 1792 coach road that you will be following.

Now walk back over Ceunant bridge and view a convenient little exposure of the Cambrian Carnedd-y-Filiast grits next to the road (on the right). A one metre unit of solid quartz-rich sandstone is bounded on both sides by mudstone beds showing clear ripples and cross-bedding. These hard Cambrian rocks form a "rock bar" across the valley which dammed back the glacier at this point, while the softer slates up the valley were scooped out to form lakes.

Cambrian Carnedd-y-Filiast grits

Collect your car and continue along the old road. Along the way, you will cross the Cambrian-Ordovician boundary at Tai Newyddion Cottages (grid reference 631 635), and about 300 yards further on will pass the old Gwaith copper mine in trees at the side of the road (grid reference 631 633). There is not a lot to see but there are old adits and spoil heaps in the trees, though sadly now well fenced off. This mine dates back to the late 1700s.

Soon, the road winds uphill, alongside the edge of the Cywion microgranite intrusion. We will pass it for now, but will be coming back to view it in detail in our next "Roadside Rocks" as it is an extremely interesting area with a lot of good and very convenient geology to look at.

The sequence of the Ordovician strata up this hill is widely debated, but generally coarse Glanravon (Caradoc) slates are giving way uphill into rhyolitic ash tuffs, with many varied strata and intrusions along the way.

Our next stop is just up the road at Idwal Cottage car park where we can enjoy a quick mug of well-deserved tea before continuing. We are not going to go up into Cwm Idwal, because that is a special trip itself. However, let's just climb up behind the snack bar and over a stile into the old quarry. This appears as a long slot which you can easily walk through but beware of falling rocks.

The strata here are almost vertical dipping east beneath the Idwal syncline. One thin, fine grained unit was quarried along a fault plane to produce excellent hones for sharpening scythes and chisels (Hubback 1987). There was even a forge here where Telford's road-builders had their steel tools sharpened using the stone. The hone strata grade from a darker mudstone up into a light coloured fine ash tuff. It is thought that the volcanic ash was carried by the wind before settling in muddy waters (Howells 1981). Return back through the quarry, or climb out of the other end and wander back to the car park area.

Hone Quarry

Now walk down the A5 on the left towards Bethesda until you reach a cutting just beyond the Ogwen bridge (grid reference 649 605). Although we are very close to the hinge of the Cwm Idwal syncline here, the cutting is actually in a small local anticline of Pitt's Head Tuffs. These form a well-known Snowdonia horizon, named after bedrock beneath a roadside erratic at grid reference SH 576 515 west of Beddgelert, that was said to look like the head of Mr Pitt, the one-time Prime Minister.

Pitt's Head Tuff and Ogwen Falls

The tuff here at Ogwen is a dark green-grey colour, with an almost glassy welded texture. You may be able to see small white feldspar crystals and separate the darker green-black fiamme fragments of crushed and welded pumice, within it. It is this hard rock that forms the "step" of the waterfall. Before moving on, it is worth scrambling up on top of this section, and seeing

how streaks of white quartz have filled expansion cracks within the tuff. This is also a good place to view our earlier sites in the valley and judge how they fit into the wider landscape.

If you look down into the valley you should be able to see a bridge, a boulder and a barn. The boulder is part of the huge rock fall that came down from high up on Pen-yr-Ole Wen in 1685.

Finally, cross the road, and climb carefully over the slate stile. Within a few yards, you can examine the rocks that lie immediately above the Pitt's Head Tuffs and you will find that they are sandstones. A few minutes careful searching here should reveal small crescent-shaped cavities. These are fossil brachiopods which are plentiful in the fossiliferous beds.

This is perhaps the moment to reflect on that vertical mile section of sedimentary rock that we have crossed. Remember how we started with Cambrian beach ripples down at Ceunant Bridge? Yet here we are, a mile higher up, at a similar sequence nearly 50 million years later, still looking at shallow-water fossils but this time in the Ordovician.

Look out for more "Roadside Rocks" in coming issues, when we'll come back to the Nant Ffrancon to look at intrusions, metamorphics and dykes, ranging from the Caledonian to the Tertiary.

Jan Heiland, North Wales Geology Association.

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JURASSIC ROCKS OF THE YORKSHIRE COAST
WHITBY 8th – 10th April 2005

By David Handley, Jim Spencer and Jane Michael

Leader: Dr Joe Macquaker

The main aim of this field course was to study the sedimentology of part of the classic Jurassic coastal section of North East Yorkshire and to investigate the fundamental processes that control the variability of lithofacies present in fine-grained sedimentary rocks.

The weekend was preceded by a talk from Joe on April 6th. We were introduced to the notion that mud rocks, which most researchers have described as being 'laminated' on the basis of textures visible in hand specimens, are actually, on closer inspection of thin sections, thin-bedded. In mudstone successions individual beds are commonly less than 10 mm thick and composed of a textured lower half that comprises 'marine snow', and an upper half that is textureless – presumably because it had been homogenised by bioturbation. The presence of this bioturbation is also indicative of a break in sedimentation sufficient to allow the sediment to be colonised prior to deposition of the next bed.

Once in Whitby, on Friday evening, Joe gave us a PowerPoint introduction to the weekend's activities. Late Saturday afternoon would include a microscope and slides session.

Saturday Morning
Staithes to Old Nab

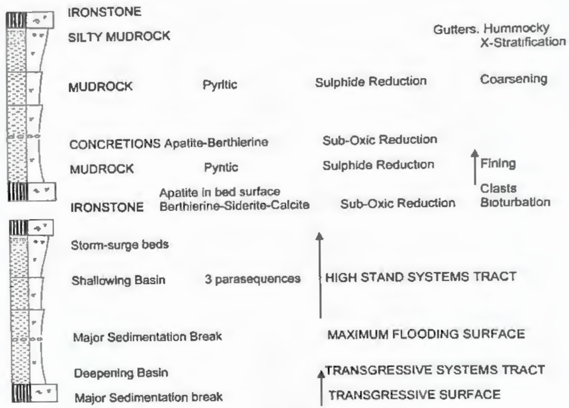
This section was visited primarily to study the scale of a sedimentary cycles present in mud rocks and ironstones of the Cleveland Ironstone Formation (Lower Jurassic), which form the cliff section between Staithes Harbour and Old Nab. The particular cycle that we studied in detail included a section from the *Avicula* Ironstone Seam up through mud rocks to the Raisdale Ironstone Seam. Here we observed individual thin beds, bedsets (paresequences) and systems tract scale variability in both plan (on the wave cut platform) and section (in the cliffs) view.

After walking on to Old Nab and marvelling at the profusion of trace fossils, we returned to Staithes, several of us clutching, believe it or not, lumps of Larvikite – from the harbour defences.

Saturday Afternoon
Port Mulgrave

The tiny, and now defunct, port at Port Mulgrave owes its existence to the surrounding geology. A jetty was built on this quiet part of the Yorkshire coast to transport the local ironstones by sea to Newcastle, where it was then converted into steel for shipbuilding. The ironstone mining industry began in the nineteenth century, continuing into the last century until about 1927. The shipping of ironstone paused during the First World War due to the threat from

U-Boats, and the disused jetty was finally demolished by the military to deny entry to German invaders during the Second World War.



This log (modified from Macquaker and Taylor, 1996) summarises observations and the many points of discussion.

Descent to the outcrops along the shore is by means of a long winding footpath down a staircase of steps. To the left of the path, near the bottom, a blocked-off tunnel can be seen, the remains of the railway transporting the ironstone to the coast. To the right of the path, in the cliffs of the headland to the south, a thick succession of horizontally bedded sandstones overlies black mudstones. Despite the low tide being unexpectedly high, owing to wild storms, the nearer outcrops of black mudstones, comprising the Whitby Mudstone Formation, were still accessible. The beach was strewn with rounded concretions; the larger ones (more than a metre) are known as "Whale Stones", and the smaller ones (approximately half metre), slightly higher in the succession, as "Curling Stones". The outcrop is obscured in part by slumping of the surface sediments.

Within the mudstones preserved on the foreshore there is a horizon of nodular concretions ("Curling Stones") and approximately two metres above these are a continuous bed of concretionary cement known as the "Top Jet Dogger". This package of Toarcian-aged black mudstones has traditionally been interpreted as being the consequence of slow sedimentation of mud in deep water under predominantly anoxic conditions. Recent work by Joe Macquaker of Manchester University suggests that conditions were not persistently anoxic and that their geological history was more varied. Thin section analyses reveal that these mudstones were composed of thin (millimetre-thick) units. Individual units commonly have erosive basal contacts, silt-rich bases and clay-rich tops. These upward-fining units are interpreted as distal storm beds that were deposited in deep water. Thin section analyses also revealed that in some cases the upper clay-rich parts of individual beds contain zooplankton faecal pellets and marine 'snow', but these textures have mainly been lost due to bioturbation. In some slides pervasive horizontal worm burrows can also be seen.

Beneath the nodular horizon," Top Jet Dogger", the package of thin mudstone beds fines upwards, whereas above the nodular layer the package coarsens upwards, but not continuously so; there are several breaks with reversion to a finer material. The interpretation here is that water level became very much deeper towards the nodular horizon – the deepest point – then shallowed again in the rocks that post-dated this unit. As its name suggests, the "Top Jet Dogger" is the unit where jet is found. The jet, small fragments of which were seen, formed when water-logged *Araucaria sp.* (better known as Monkey Puzzle Tree) sank in the deeper offshore deposits.

Sunday
Cloughton Wyke

Cloughton Wyke is in the Middle Jurassic where we investigated the non-marine Cloughton Formation and the Gristhorpe Member in particular. This part of the weekend continued to raise more questions than answers as there seemed to be more than one cause for everything. We saw brown, oxidized pyrite nodules, fallen slabs with ripple markings – some showing interference patterns (see picture below) and concretions with pyrite tubes (possibly formed enclosing worm burrows). On close inspection the mudstones in the whole sequence proved much more varied than at first sight.

Overall throughout this part of the studied succession there was a general upward-coarsening. Starting at the base, there was a cemented layer (grey) with rootlets that may have been a possible sequence boundary. This is considered a seat earth. Fossils such as *Diplocraterion sp.* have been found. As flooding occurred, marine pore water replaced the fresh water and the coal that had been present, was removed.

Joe outlined why the layer was cemented with ferroan-calcite cement and pointed out that cement precipitation post-dated burrowing but pre-dated compaction. Above this were dark marine muds with pyrite representing

transgression (deepening). A layer of concretions was immediately above this and probably represents a break in sedimentation (deepest water). Above this concretionary unit the muds became 'sandier' and paler reflecting an overall shallowing succession. Finally bioturbated, laminated sheet sands appear.

Joe's investigations, including thin sections of the mudstones in the whole area, show trace fossils at horizons once thought to have been deposited in anoxic conditions.

Group discussion looked at whether this represented a river system/switching delta lobes/crevasse splays or a marginal marine/lagoonal setting. Bioturbation seemed more typical of marine conditions. The question of the source of the sulphate for the pyrite nodules was raised. It certainly appeared that a coal layer was missing from this succession. With these points in our minds, we moved to the final locality, just round the bay to Hundale Point.

Ripple markings showing interference patterns

Hundale Point

We moved further up the stratigraphic column into the Scarborough Formation: top of the Hundale Sandstone, the Spindlethorn Limestone and the Ravenscar Shale Members.

The Hundale Sandstone Member is extensively bioturbated: variously by *Thalassanoides isp.*, *Rhizocorallium isp.* and *Planolites isp.* and these trace fossils were easy to see on the wave cut platform. Red Siderite nodules are also seen in this unit. These siderite nodules actually post-date quartz cementation and are probably late formed. The overlying Spindlethorn Limestone is generally a well-cemented bioclastic limestone. *Protocardia* and *Pseudolimea* are amongst the fossils found. Within this unit there are beds that are less well-cemented and muddier with some bedding parallel concretionary cements. The Spindlethorn Limestone Member comprises a stacked succession of 5, thin-parasequences each of which shallows-upward. The base of the Ravenscar Shale Member marks a rapid deepening event in this marine succession. There is a layer of nodules part way through the generally upward-fining sequence of the Ravenscar Shale Member. This level is likely to represent a maximum flooding surface: a time of very slow clastic sedimentation that allowed cementation to occur.

It is considered that even though there are parasequences that imply short term showing shallowing (e.g. in the Spindlethorn Limestone Member), overall the succession deepens. This may be due to local rather than regional effects in the marine environment.

Members of the group inspect the cliffs at Cloughton Wyke

Within the Hundale Sandstone, Siderite infilled burrows seem perplexing as these are pinkish red. Where has the iron come from and why has it differentially affected only the burrows? (See photo on next page) Joe had produced thin sections and considers the colouring is due to late infill of the burrows and to the porosity of the sandstone. During compaction, the pore waters gave up iron which remained round the quartz in the burrows resulting in the pinkish colour.

The weekend which had started fighting the wind and mountainous seas to see any exposures finished in sunshine. The only disappointment (apart from

not being able to stay longer to learn more) was not finding any dinosaur bones which Phil Manning had indicated were at Hundale Point.

Siderite infilled burrows (see text on previous page for further information)

None of the participants (seen eating lunch below) will ever look at mudstones the same way again. Persistent Toarcian Anoxia: we think not!! We've seen the evidence. Thank you, Joe.

David Handley
Jim Spencer
Jane Michael

May 2005

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LIVERPOOL GEOLOGICAL SOCIETY WEEKEND FIELD TRIP: THE CAUSEWAY COAST MAY 2006

By Tom Metcalfe

Leader: Alan Bowden

The Liverpool Geological Society's 2006 weekend field trip left Liverpool on the EasyJet flight to Belfast on Friday 19 May. On arrival at Belfast International Airport we travelled by minibus to the Causeway Hotel, Co. Antrim. We met on Saturday at 9:30 a.m. in the hotel car park, squeezed into the minibus and proceeded to find our first locality at **Lansdowne Crescent** on the seafront of the Victorian seaside town of Portrush. Here we were looking at the Portrush Sill, the largest outcrop of intrusive rock that we were to see at close hand, that weekend. The sill consists of a fairly coarse dolerite intruded into Lias mudstones which had been hornfelsed. From a distance the sedimentary nature of the mudstones was quite clear, but on closer examination the contact was not at all easy to make out. The dolerite was quite fine at this location and probably a chilled margin. The discovery of the fossils, mainly ammonites in the mudstones, meant we began to understand why this exposure had caused early geologists so much trouble.

Figure 1. Ammonites in the hornfelsed mudstones.

Then followed a discussion on how this outcrop had been used to support the Neptunist cause in the debate concerning the origin of the basalts during the late 18th century.

Next we returned to the minibus and our second locality, **White Rocks Beach.**

From a car park adjacent to the beach, the party walked to the beach and along the sand in an easterly direction. On our right the cliff line consisted of chalk, topped in places by basalts (we learned that these in fact were the Lower Basalts of the Antrim lava group and the chalk the Portrush Chalk). In places it could clearly be seen that dark coloured basaltic agglomerate had been thrust through the chalk. The chalk was clearly shattered close to the contact. We were left in no doubt that this contact was

volcanic in nature. As we walked along the beach we saw more examples of explosive vent features.

Figure 2. Basaltic Agglomerate, White Rocks Beach.

Back on the minibus and to our third locality, the one we were all waiting for, **Giant's Causeway.** As the group walked from the Visitors' Centre towards the Causeway, a noticeable outcrop of a red lateritic material was observed. This marks the top of the Lower Basalts and was formed during a period in which there was little if any volcanic activity in this part of Antrim. Above this was the first of the Causeway Basalts. Our attention was drawn to dykes, cutting the Lower Basalts one of which being more resistant, had formed a prominent feature known as the Camel's Back. As we turned the corner at the aptly named Windy Gap spheroidal weathering in exposures of the Lower Basalts were pointed out to us. We paused and took stock of the view ahead of us; here we learned that the Causeway Basalts had filled a river valley cut into the Lower Basalts. The eruption was of fissure-type, quite common in Iceland in the recent past. So to the Giant's Causeway itself, formed by the first flow of the Causeway Basalts into a steep sided river valley cut into the Lower Basalts. The landscape created was very different from the one immediately following the eruption of the first volcanic phase. The Palaeogene landscape onto which the Causeway Basalts were extruded was one of rivers and lakes with vegetation, some of which would have been recognisable today. The later basalts differ from the flows of the Lower Basalts in that they are considerably thicker, especially in the Giant's Causeway area. It seems, we were informed, that the Causeway Basalts are now mainly to be found only to the north of a once major fault, the "Tow Valley Fault". Our leader described how this zone of crustal weakness, trending NE-SW across Northern Ireland makes its appearance in Ireland near Ballycastle and is traceable to County Mayo. Movement on this zone is thought to have been associated with the outpourings of the Causeway Basalts. A greater volume of magma and the deeply eroded valleys on the Interbasaltic surface meant that the first flow here reached thicknesses of approximately 100 metres.

Figure 3. Tourists on Giant's Causeway.

We learnt that, although many basalts show forms of columnar jointing, this great thickness and the possible association of water during the cooling period may explain the spectacular columnar jointing of the Causeway Basalts. The group moved on to the three headlands the Little, Middle and Grand Causeway, examining the basalt columns at close hand, mingling with hundreds of our fellow tourists. Looking back inland the steeply sloping nature of the contact between the laterite of the Lower Basalts and a first flow of the Causeway Basalts was pointed out to us

Some of the group made the journey around Port Noffer to the exposure known as the Giant's Organ. This exposure is part of the first flow like the Causeway itself but above can be seen the columns of the second flow. We returned to the minibus and on to the last locality of the day – **Ballintoy Harbour and the Ballintoy Fault.** On the way we stopped briefly in a lay-by for an overview of the geology of White Park Bay.

Here the Portbraddan Fault and its probable extension, the Ballintoy Fault, has down thrown crust to the north about 100 metres. This meant that the Upper Basalts and the chalk are both at sea level at the western end of the bay.

Figure 4. The Giant's Organ.

Figure 5. Chalk on the left, basalt on the right at White Park Bay.

Arriving in the car park we were able to examine the effect of faulting on the chalk. We were clearly looking at a fault breccia which had been exploited in the past by waves to produce a cave in what is now a cliff above a raised beach. Following our leader we walked west along the coastal path towards White Park Bay, a pleasant walk on a pleasant afternoon. On our right, to the north, and therefore to the north of the fault zone were stacks and arches, probably consisting of tuffs of the early explosive stages of the Antrim Lavas. We proceeded further along the coastal path arriving at the eastern end of White Park Bay. Here we could see the probable line of the Ballintoy Fault where chalk stacks were close inshore and basalts further out to sea.

Figure 6. Chalk on the left, basalt on the right, eastern end of the bay.

The hunt for Lias clay followed, which we were informed, was sometimes exposed around the high water mark. We did find evidence of the grey clay, possibly just seepage, not enough to be sure that we found a true exposure but we could be sure that we were close to the base of the chalk. We also reasoned that of the slump-like structures visible when looking inland may indicate instability of the chalk on the Lias clay. Having enjoyed a pleasant afternoon we returned to Ballintoy Harbour. Just to the east of the harbour we were introduced to Bendoo Plug, a medium grained dolerite intrusion. From the 1:50,000 map series Northern Ireland sheet 7, it is possible to see that this intrusion is roughly circular and about 350 metres in diameter at the surface. A walk down to sea level shows that the contact zone, visible in the cliffs, has produced little change in the chalk which probably means that the Bendoo Plug was a transient feature and although almost certainly associated with the Tertiary basalts, did not play a large part in their extrusion. Information that the base of the Ballintoy Chalk (upper Campanian) contained the occasional ammonite led to the usual search with no luck!

However, trace fossils, possibly Thalassinoides were found, although apparently such are quite rare in the Antrim White Limestone.

Figure 7. Possible Thalassinoides in the Ballintoy Chalk.

Looking eastwards along the coast the party could see the massive cliffs of Fair Head, which were to play a part in the following day and so back to the Causeway Hotel and dinner.

Sunday 21 May 2006.

The day dawned fair again and the next locality reached from the National trust car park near the Larrybane, the party walked down to a limestone quarry on Larrybane Head, lithostratigraphically this chalk marks the base of the upper Campanian. Here the party examined "hardgrounds", caused it is thought by interrupted sedimentation possibly associated with shallowing of the seas above the chalk forming ooze. Quite why this shallowing occurred is not clear. Hardgrounds are also associated with faunal differences from that in the rest of the chalk. Another school of thought is that hardgrounds can be associated with climatic factors, possibly global cooling. Down to sea level and a short walk to the east brought the party to a cave in the chalk cliff. In the cave we observed stalactites which we were informed were very unusual not normally developing in chalks.

Figure 8. Examining the Larrybane Chalk.

The party returned to the car park and took the path to Carrick-a-Rede (apparently from the Scottish Gaelic "Carraig-a-Rade" meaning rock in the road - the road being the route of Atlantic salmon on their journey past Carrick Island). The production of our National Trust membership cards and the longest hike of the weekend so far, brought us to exposures of volcanic agglomerate, a tuff which consisted of volcanic ash, blocks of chalk, blocks of basalt and even some remnants of older rocks underlying the area. There are two tuffs in the area, one basaltic, one chalky and it seems likely that there were at least two phases of activity.

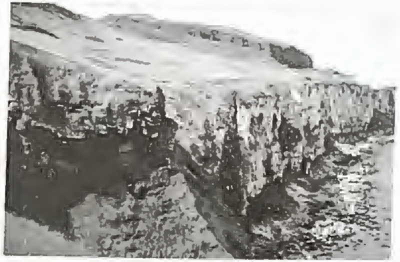

Figure 9. The contact is in there somewhere.

On our walk we saw evidence that the contact between the tuffs, dolerites and chalk can be very steep, confirming the vent-like nature of the deposit. The bridge, of course, had to be crossed. We all made it and found much of the island consisted of an intruded dolerite, possibly as a result of a later stage of volcanic activity in the area around the vent.

Figure 10. The party at the famous bridge.

The crossing to the island was well worth the trip just to get so close to the marine birdlife which abounded. Back to the car park and a bite of lunch at the National Trust café, then all aboard again and off to what was to be the last stop of the weekend **Murlough Bay.** The group walked north westwards towards Fair Head, on the left we eventually began to recognise exposures of a rather familiar sedimentary rock, if it wasn't of the Sherwood Sandstone Group or something very like it, we would have

been very surprised. As we walked the ground under our feet changed, becoming very wet under foot, indicative we felt of the possibility of a rock change, eventually we arrived at the now sealed entrance to two mine adits.

Figure 11. The party on the way to Lone Tree Mine.

This we were informed was the entrance to the Lone Tree Mine and indeed there was evidence of coal in the evacuated shale scattered around the entrance. These were Viséan rocks of the Murlough Bay Coal 'Group' which consist of up to ten thin coal seams and fireclays interbedded with dark shale, some with Marine bands. Above us the tertiary dolerite of the Fair Head Sill made an impressive headland, the sill intruded into Carboniferous shale and sandstones. We were informed that the sill oversteps eastwards through the Triassic sandstones to phase out in the chalk further round Murlough Bay. As we walked back towards the car park and then on to the eastern end of Murlough Bay, the appreciation that we were walking down through geological time became evident. It was explained that the Sherwood Sandstone we had noticed on the way out was unconformable on Carboniferous deposits dating from Viséan to Namunan and is itself overlain by a basal Cretaceous conglomerate. At the eastern end of the bay the Carboniferous rocks are faulted against rocks of the Precambrian Dalradian. The Murlough Bay Formation of quartz schists, thought to be from the Crinan subgroup are part of the Argyll group So there you have it, from the Tertiary to the Precambrian and most of it downhill, in about a mile!

Figure 12. Cyril examining Dalradian cobbles close to Carboniferous red beds.

Then we proceeded back up the hill, all aboard and back to Belfast International Airport. (By the way, there is no truth in the rumour that Cyril is a terrorist, he just had to hand his penknife in for safe keeping!) If you are tempted to take a look at the Causeway Coast yourself, I strongly recommend you purchase a copy of A Geological Excursion Guide to the Causeway Coast by Paul Lyle. It is an excellent little book and available from the National Trust at the Giant's Causeway if you are unable to obtain a copy before you leave these shores.

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Obituary: Norman Catlow
18 December 1932 -16 August 2005

This obituary was edited by Alistair Bowden from material supplied by Norman's children Roland, Brendan and Claire and a number of close friends.

Norman Catlow was incredibly bright and very widely read. He had many interests, all of which he pursued with deliberate thoroughness. But none of this led to self-interest - Norman was always keen to listen. He was a truly inspiring character; never arrogant and always humble, though quietly self-assured. His influence was far reaching and his absence leaves a huge void.

Norman was born in a house on Samuel Street, off New Hall Lane, in Preston, son of Alfred and Mary Catlow on 18 December 1932. Within a few weeks of his birth the family transferred to Harewood Road, Deepdale, in Preston (near to Preston North End football ground).

From an early age, Norman had a true thirst for knowledge, with interests in many diverse subjects. He was a very regular visitor to the Central Library in Preston and would read fiction and non-fiction, as well as keeping up with all the cutting edge scientific journals. It is no surprise that one of the most important events of Norman's early life relates to the Central Library, and is best told in his own words:

> "You had to be seven to join the Junior Library, and on my seventh birthday my Auntie Marion took me in town and enrolled me. It cost a penny, and was probably the best birthday present I have ever had because I have never since been without a library ticket - almost sixty years now. Say an average of three books a week for sixty years, - that would work out at something like 9360 books. Good value for a penny!"

Chemistry was Norman's primary area of expertise and again the story of how this started is best told in his own words:

> "My Uncle Harry, whom I had never met but heard much about, had attended Preston Grammar School and was a chemist in South Africa. He was always regarded as "the one who made a success of his life" and was held as an example of the benefits of education. I decided I could be a chemist too, without having an inkling of what chemistry was about.
>
> I started borrowing chemistry books from the library and found nothing at all in them about cough linctus and face cream. I asked someone who had attended the Grammar School for a few years, and he explained to me that there were two kinds of chemist, one sort like my Uncle Harry who worked in a shop and dispensed medicines, and another sort who worked in a laboratory and handled exotic

things like acids and alkalis. That sounded like the kind of work for me. Then I read in a comic about 'Little Tommy Lett and his Chemistry Set' - This character was portrayed as going around with a box of chemicals under his arm, whipping up the most marvellous mixtures as the occasion demanded - instant fireworks, nasty smells, invisible paint - This is what really decided me, and launched me into a life in the laboratory."

During his time at school he was continually making various "chemical concoctions" at home that he would demonstrate the following day at school. On one particular occasion Norman was caught with a home made explosive in school. He was severely punished for this, but the teacher concerned appeared to be amazed that a student of his age had the ability to produce such a substance! Another anecdote is from the war years. When there were black-outs, Norman used to tie a line, treated with chemicals that burnt with a bright light, across the street. He would then light the line at one end and in the dark, from the perspective of someone on the ground, it would appear that something was flying across the sky. This caused all sorts of local consternation. There was also a story about him blowing up a coal bunker!

Norman did not talk much about his time spent doing National Service. He spent some time training in the north east in or around Newcastle and probably served with the Royal Artillery. One story from this time relates to training at Barmouth, where he spent days on end shooting a World War II anti-aircraft 'akak' gun at drones being dragged behind a plane – they never hit a single one! Norman realised even in daylight how poor the air defences of our country were during World War II.

Upon completing his National Service Norman returned to Preston, taking up residence with his parents in Harewood Road again. He started work as an analytical chemist at British Nuclear Fuels Limited at Springfields. The first couple of years working in the labs were a "settling in period", and allowed Norman to explore various leisure pursuits: cycling, walking, natural history (in particular fungi), fishing and photography to name a few.

In the mid 1950 s Norman began night school classes at Harris Technical College in Preston. He was studying for a Higher National Diploma in chemistry. He would attend the night school after completing a full day at work. Several of Norman's colleagues from work were studying various subjects at the tech at the same time. Most weeks they would arrange to meet up for a coffee in Rowntrees café bar in Fishergate once lessons had finished.

It was in Rowntrees that Norman met Celine. They married in March 1959 at St. Wilfred's Catholic Church in the centre of Preston. (Celine is originally from County Mayo. The Republic of Ireland and its people became much loved by Norman and his family, as they spent their holidays there throughout the 1960 s and 70 s.) Once they had returned from their honeymoon Norman and Celine settled into life in their newly built house on Bankfield Avenue,

Fulwood, where Norman was to live for the rest of his life. During this time the couple also had a small allotment on Haslam Park

As an analytical chemist at Springfields, he used to receive drums of substances to analyse and sometimes these would have different coloured crystals on the top. Norman and some of his colleagues were intrigued enough to find out what these crystals were and why they were on the drums. This led him to going out looking for crystals on field trips and on to his love of geology. This interest clearly influenced the upbringing of his children who said:

> "We grew up in a house that was a treasure trove of crystals and fossils in every room and in the garden. We had wonderful daytrips to beaches, waterfalls and mountainsides that turned out to be geologically significant."

Norman joined Rodney Wright's University of Liverpool evening class in Preston at the end of the 1970's to pursue his developing interest in Geology. Classes were held on Thursday evenings, initially in Penwortham, but later in Fulwood. They ran for close on twenty years and whilst other students came for varying numbers of years and went, Norman was a continuing supporter. In this time he quietly absorbed a breadth of geological information from the courses, but also through his own studies, and he acquired an impressive knowledge and understanding. Norman's particular passion was for minerals and this seemed to fit well with his work knowledge as an analytical chemist. Norman rose from interested amateur to become someone whose geological knowledge and input was highly valued by all those around him; over the years his mineral identification skills progressively overtook his teacher's!

It was during this period that Norman originally became a member of the Lancashire Group of the Geologists' Association. He remained a stalwart until his death, attending almost every event both indoors in winter and at quarries, streams and random outcrops across Northern England in the summer He took on the role of Field Secretary and efficiently organised a diverse range of events over many years before he became Secretary of the society and one of its guiding lights. It was through his hard work and enthusiasm for the Lancashire Group of the Geologists' Association that Norman met so many people interested in geology throughout Lancashire and much further afield.

Upon retirement, Norman took on a 'volunteer job' at Clitheroe Museum. He visited one day a week for over ten years, seeing out over five curators and working with many other volunteers throughout this time. Norman organised and delivered a variety of public events in the museum and around Clitheroe whilst behind the scenes, he catalogued the LGGA library that was stored at the museum, looked after the RIGS records stored at the museum, and must have physically moved the collection of over 10,000 rocks, minerals and fossils many times over, due to various reorganisations. However, perhaps Norman's greatest contribution to the geology of Lancashire was to actually complete the documentation of the collection. Very few museum collections in the country or indeed in the world, can be said to be fully documented and fully accessible, yet Norman was the backbone of the team, providing invaluable continuity and knowledge flow, that actually fully documented all the geology collections at Clitheroe Castle Museum – an absolutely unique accomplishment.

Norman was also a founder member of the Lancashire RIGS Group, working tirelessly for over a decade on the conservation of significant geological sites and helping to make them more accessible. Throughout this time he played a pivotal role. The group had always swung between busy and quiet periods, but Norman was "like a piece of wire running through a fraying rope". In his trademark unassuming way, he would hold things together, always turning up to meetings and utterly dependable to actually get the job done – often spending days doing the work to enable projects to progress smoothly and professionally.

Norman was a well educated and very well rounded scientist, but his clear passion in his spare time was for geology. His work with geology enthusiasts, museum collections and important sites around the county has had a huge impact and will be the foundation of work that takes place for many years to come. As a mark of respect for Norman's huge contribution to the geology of Lancashire, the LGGA awarded him with the Learoyd Silver Medal. The shared respect that the geological community had for Norman can also be measured by the large number of geologists that attended his funeral. It was a terribly sad occasion, but one that brought home the very high regard in which Norman was held by so many people and the strong bond people felt for Norman as a friend. As was said at his funeral - Norman was a gentle man and a gentleman.

Norman is survived by his wife Celine, his children Roland, Brendan and Claire and his grandchildren Louise, Matthew, Aidan and Amelia.