FGS Field Trip to Charnwood Forest, East Midlands.

Led by Drs Steve Booth and John Carney

The localities visited lie to the N and N-W of Leicester. The sites visited on day one (Mount St Bernard Abbey, Charnwood Lodge, Warren Hills and Bardon Hill), led by Dr John Carney, and on day 2 (Bradgate Park), led by Graham and Liz in Keith's absence, were dominated by the Charnian Supergroup rocks of late Precambrian (possibly to early Cambrian) age. The rocks are igneous volcanic rocks (intermediate lavas – dacites and andesites - and intrusive diorite bodies, and ignimbrites - welded ash flows) and sedimentary rocks (mainly formed of clasts from the same lavas, called volcaniclastics), and included tuffs and tuffaceous sediments, agglomerates and slump breccias.

Cambrian-aged sandstones were examined at Bradgate Park and slates at the Swithland Wood Slate Quarry. This sequence of Precambrian-Cambrian strata form small outcrops on the tops of hills which jut through a younger blanket of thick Triassic mudstones (such outcrops are called inliers, i.e. where older rocks are surrounded by younger rocks). These red Triassic sediments were visible underfoot as we trudged down to and along the valley of Bradgate Park.

The last day was spent touring the offices and laboratories of the British Geological Survey (BGS) at Keyworth, led by Dr Steve Booth. This was a very interesting and informative visit viewing 3-D models and new methods of mapping, but space prevents description of this part of the trip in this newsletter. However FGS would like thank the BGS for their kind assistance that day and for their kind permission to reprint various photographs used in this article.

In late Precambrian times (ca. 600Ma), the British Isles were situated in the southern hemisphere but in two distinct areas. Scotland and the northern half of Ireland were located at about 60°S, on the southern edge of 'Laurentia', then still part of the supercontinent Gondwana. By contrast, England, Wales and the northern half of Ireland lay on the northern margin of 'Avalonia', a continental fragment that was splitting away from Gondwana and situated about 30°S of the Equator (Figure 1).

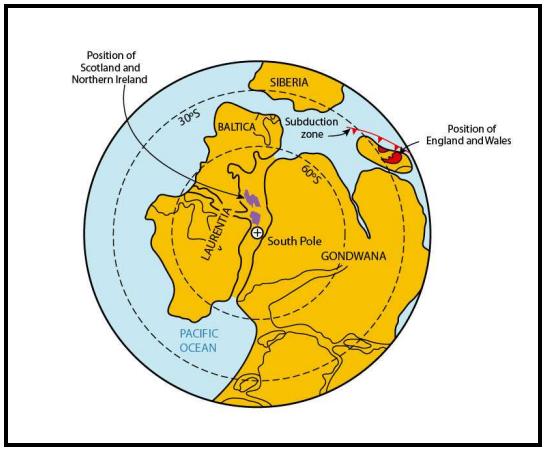


Fig. 1. The world in late Precambrian times ca 600Ma.

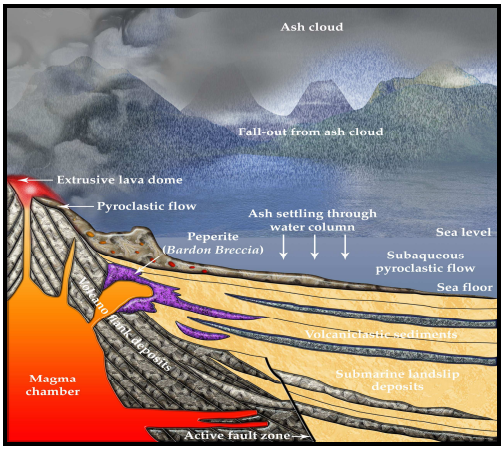


Fig. 2. Schematic of the Charnian Volcanic Province.

The northern margin of Avalonia (where Charnwood sat) was an active subduction zone. Magma rising from the melting of the subducted plate rose to form a series of explosively island arc volcanoes, similar to Soufrière Hills, Montserrat, in the Caribbean today (Figures 3, 4).

Fig. 3. Debris arising from a pyroclastic flow forms a fan running into the sea.

Fig. 4. Pyroclastic flow running out over the sea.

The volcanoes probably sat on the edge of a deep sea, into which, considerable layers of debris from the eruptions were deposited (as run off from the coast, aerial deposition and re-deposition as submarine landslides). Many vents ejecting material probably existed on the volcanic slopes and the numerous earthquakes associated with the underground movements of magma (especially when associated with collapsing caldera) made the slopes very unstable, consequently slumped sequences are relatively common. It is these volcanic rocks and marine deposits that form the Charnian Supergroup, a series of rocks in excess of 3,500m thick.

At Beacon Hill the outcrop comprised 560Ma rocks that showed the characteristic pattern of material deposited as turbidites. The beds varied between lighter, coarser grained material, 'sandstones' (Figures 5, 6), to darker, fine-grained mudstone deposits. Although of sandstone grain size, the 'sandstone' clasts were in fact of volcanic origin. Cleavage was clearly visible.

Fig. 5. A typical sand grade turbidite

Fig. 6. Sequence of coarse grained turbiditic rocks

At Bradgate Park, rocks of the Precambrian-aged Maxwell Group occurred. These were formed at a time of continuous volcanic activity and associated earthquakes. Blocks of volcanic rock as well as large amounts of ash and debris were blasted from volcanoes and settled in the surrounding seas. Earthquakes caused violent slumping of the sediments down steep submarine slopes, as demonstrated in the photograph below of the Sliding Slump Breccia (Figure 7). Visible are large pieces of broken rock, some contorted and bent in this violent episode.

Fig. 7. Slump Breccia (pieces over 35 cm long)

Fig. 8. A Sag Structure (see text for discussion)

The feature shown in Figure 8, also in the Sliding Stone Formation, caused some discussion. Further investigation suggested that there was tension along the bottom of it, as though the underlying beds had been stretched. John Carney's interpretation (private correspondence) is that 'the whole thing seems to propagate upwards from a thin sandstone bed. Perhaps this was fluidised and began to move slightly, causing the tensional structures and sagging in the beds above, which was then passively filled by later sediment towards the end of the event.' Since 575Ma, primitive soft-bodied animals had existed and their remains have been preserved in the volcaniclastic sediments of the area. One such was *Charnia Masoni*, see Figure 9 below.

Close to the ruins of Lady Jane Grey's house we examined thick rather homogeneous Cambrian-aged sandstones and an intrusion into the Charnian rocks. It is a diorite, a very colourful coarse grained igneous rock, with pink feldspar and green hornblende. We observed a highly polished surface which had been slickensided during fault movements. Subduction eventually ceased and with it volcanism in the area. Erosion gradually reduced the islands so that by Cambrian times (543Ma), the area was covered by a sea in which mud was deposited which would later form the Swithland Slates.

At Swithland Woods, the formation we saw was originally thought to be of Precambrian age, but the

discovery of the trace fossil *Teichichnus*, which is confined to Cambrian-aged rocks elsewhere, has put this formation into the late Cambrian. *(Teichichnus is a simple feeding burrow that shows vertically to obliquely oriented spreite and probably made by a bivalve.)* We walked around the perimeter of a disused quarry in the Swithland Greywacke Formation. These rocks are extensively cleaved and have, in the past, been quarried. The Romans used this slate for roofing and in later times it was used for both roofing and headstones. Some local graveyards have these headstones, some with sections of *Teichichnus* visible. Figures 10, 11 show this trace fossil.

Fig. 9. *Charnia Masoni*

Fig. 10. The trace fossil found at Swithland Woods

Fig. 11. Internet image of the trace fossil *Teichichnus*

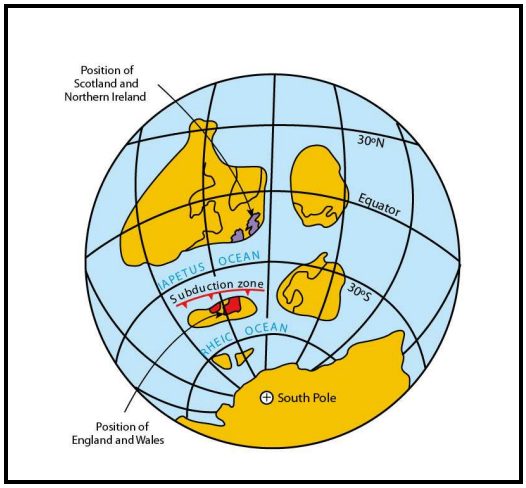


Fig. 12. The world, late Ordovician, ca 450Ma.

Towards the end of the Ordovician, ca. 450Ma, the microcontinent of Avalonia lay more or less equidistant between the remains of Gondwana in the south (separated by the Rheic Ocean) and Laurentia in the north (separated by the Iapetus Ocean), See Figure 12. Whilst Avalonia with what was to become England, Wales and southern Ireland had drifted south to lie about 50°S of the Equator, Laurentia had moved N to straddle the Equator, although the area where the north of the modern British Isles lay was about 20°S.

During this period, two important events were taking place. Subduction had started again to the N of Avalonia as had various types of igneous activity. Relevant to this area was the emplacement of slow cooling magmas at depth, which solidified to form the Mountsorrel granodiorite. The quarry at Mountsorrel, South of Loughborough, is the largest granite quarry in Europe.

Towards the end of the Silurian (ca. 420Ma) the area was caught up in a period of compression and mountain building, with fold structures (the SE-dipping Charnian Anticline) and low-grade metamorphism showing a strong WNW cleavage. This cleavage is found throughout the rocks of the area but most clearly visible in units such as the Swithland Slates. The Acadian Orogeny, part of the Caledonian Orogeny, saw the closure of the Iapetus Ocean and the collision of Avalonia with Laurentia along the Iapetus Suture. The suture runs approximately NE to SW and passes through the area of the Solway Firth. This event finally saw the joining together of the landmasses that form the modern British Isles. A major fault, the Thringstone Fault, was formed about this time. This fault forms the W boundary to the area and has had a major impact on the local geology and economy of the area.

During the Carboniferous Period the area straddled the Equator. Warm, shallow seas dominated with the deposition of limestone. However, most of the Charnwood area lay to the E of the Thringstone fault and formed an exposed mountain range. One of the few examples of Carboniferous Limestone occurs around Grace Dieu. The shallow seas gave way to swamps and forests, which form the basis of the N W Leicestershire Coalfields.

Early Permian times (ca. 290Ma) saw the closure of the Rheic Ocean in the south and the formation of the super continent, Pangaea, was almost complete. During the Permian Period (299-251Ma) the Charnwood area lay about 10°N in the midst of Pangaea. It was a stable area, on the London Platform, surrounded by areas of rift basin formation. Climatic conditions have been compared to those of Death Valley and erosion characterises this period with much of the Carboniferous sequence being removed.

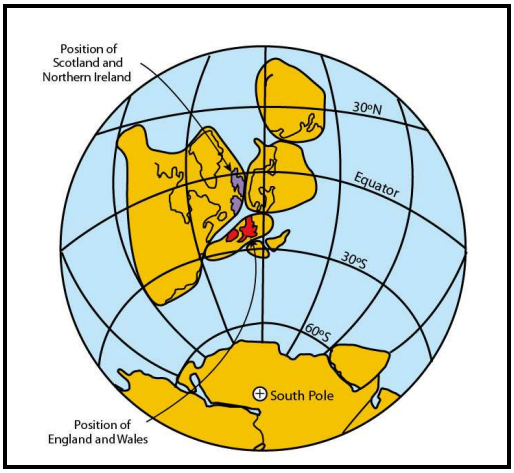


Fig. 13. The world, end of the Silurian Period, ca 416Ma.

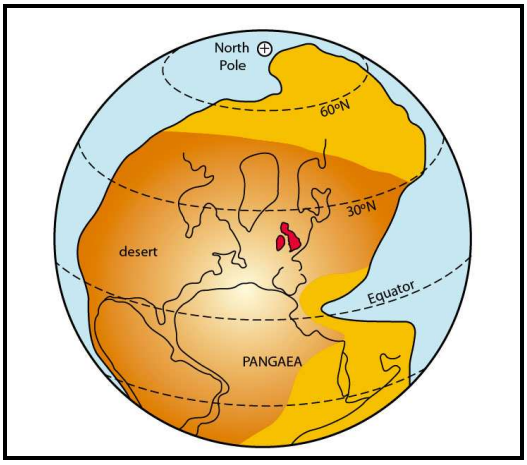
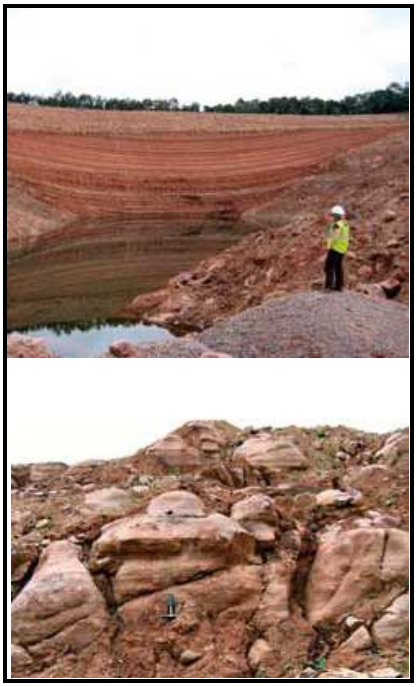


Fig. 14. The world, Lower Triassic, ca 250Ma.



Above: New Cliffe Hill Quarry, Stanton under Bardon, Leicestershire. Palaeovalley incised into Neoproterozoic rocks and filled by Mercia Mudstone. Top Right: Valley fill sediments; Btm Right: wind-eroded Charnian granodiorite tors underlying the Triassic.

The Triassic Period (251-200Ma) started with a period of fluvial deposition from large rivers that carried material from the Variscan Mountains to the S. The Charnwood area contributed material to these rivers. Examples of these deposits can be seen in the Shepshed Sandstone. The latter part of the Triassic Period was characterised by conditions akin to those in the present day Arabian Peninsula with a combination of flash floods forming deeply cut wadis, seasonal lakes, and for the most part, wind-blown, fine-grained silts and muds.

The result of this continental environment was the formation of a major unconformity which is illustrated dramatically below where the grey Precambrian-aged Charnian Volcanic Complex are overlain by the blanket of red Triassic fluvial and wind-blown sedimentary strata.

In the intervening period, up to the Quaternary (2Ma), the record of the Cretaceous, Jurassic and much of the Triassic strata has been eroded away. The Quaternary Ice Ages have left their mark as glacial tills and striations.

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Useful Websites:

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Maps

Ordnance Survey Explorer Series [1:25,000] – 245 and 246

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