EXCURSION

The Marlstone Formation of north-east Leicestershire

Leader: Albert Horton

1st July, 1998

Nearly 40 members met at the Old Dalby Ministry of Defence carpark on a cold and overcast 'summer' evening. The excursion had two objectives; the first was to study the stratigraphy and sedimentology of the Marlstone Formation and its enclosing sediments, the second to discuss the development of the Marlstone escarpment. The geological succession studied is summarised in Table 1.

Brownhill's and North Quarry form part of an important Nature Reserve. The sites must not be hammered or disturbed in any way. Access is by permit only from the Leicester and Rutland Wildlife Trust, 1 West Street, Leicester LE1 6UU.

Green Hill, Nether Broughton (SO 695 235)

This embayment at the south-western extremity of the Vale of Belvoir offers fine views northwards across the Vale to the distant escarpment of the Penarth Group (formerly Rhaetic). The Vale has a gently undulating topography formed by a series of small escarpments ranging from 1 to 10 metres in height, each representing a thin but resistant bed of limestone, sandstone, or nodular ironstone within the Charmouth Mudstone Formation. Green Hill lies on the main escarpment that bounds the Vale of Belvoir to the south-east. The escarpment is capped by the Marlstone Formation, which comprises up to

4.2m of oolitic ironstone overlying about 5 metres of sandstone ('Sandrock'). The underlying Dyrham Foundation consists of siltstones and silty mudstones and crops out the steep slopes below the Marlstone, where it gives rise to sharp hollows and a distinctive, gorse scrub vegetation. The downward passage from the Dyrham Formation into the mudstones of the Charmouth Formation lies about halfway down the scarp slope and, though ill-defined lithologically, is well marked by a line of springs. 'Cutting back' by these springs ('spring sapping') excavated the sharp hollows.

Mudflows and landslips occur in numerous places along the scarp and most probably formed during periglacial periods. To the west of Green Hill, the escarpment is capped by till ('chalky boulder clay'). To the east, near Stathern, till infills two valley-like depressions that cut the escarpment. Glacial deposits are absent from the Vale, perhaps reflecting the efficiency of stream erosion and transportation in sculpting the Vale's landscape. There is little doubt that the Marlstone escarpment lay some distance to the north of its present position at the time of the last (Anglian) glaciation to affect this area (500,000 years ago), but its former location is conjectural.

Formation	*Member*	*Former Name*
Whitby Mudstone Formation	Cephalopod Limestones Member Fish Beds Member	Upper Lias
Marlstone Rock Formation		Marlstone Rock Bed
Dyrham Formation	Sandrock Member	Middle Lias Silts and Clays
Charnmouth Mudstone Formation		Lower Lias

Table 1. Stratigraphy of the Liassic rocks.

Church Farm, Holwell (SO 7346 2371)

The Sandrock is exposed at road level near the farm, and consists of ferruginous and locally shelly, fine-grained calcareous sandstone. The grey micaceous siltstone and silty mudstone of the underlying Dyrham Formation is exposed at the road junction 50m to the north. The garden wall of the farm is built of Sandrock blocks, capped by micritic limestones originating from the Barnstone Member (formerly known as Blue Lias or Hydraulic Limestones) at the base of the Lias. Below the house, a retaining wall above the Sandrock includes several blocks of conglomeratic limestone with pebbles of fine-grained ferruginous siltstone. This bed commonly forms the base of the Marlstone Formation in the surrounding district.

Holwell is a classic "ironstone village" built of pale to rusty brown stone. To the consternation (and possibly fear!) of the villagers, the party examined the various different types of stone in a house wall. Most consists of ferruginous siltstone with shell-rich horizons, but examples of dark rusty brown finely oolitic ironstone and a paler, crinoid-debris rich ferruginous limestone were also seen. Nests of brachiopods occur in both the Sandrock and ironstone lithologies.

Brown's Hill Quarry (SO 742 235)

Here the party was able to study the Sandrock, the Marlstone Formation and the overlying Whitby Mudstone Formation. The Sandrock exposed in the floor of the quarry consists of pale brown, fine-grained ferruginous sandstone. It is a very uniform, relatively soft 'freestone', characteristics that favoured its extensive use as a building stone. Sadly it weathers readily, and the original Ashlar construction of many principal buildings has been destroyed, albeit over a period of almost seven centuries in the case of churches. The base of the Marlstone is marked by a shell-debris rich horizon; the conglomerate seen at some localities is absent here. The Marlstone is about 4.2m thick, and originally consisted of chamositic, sideritic, shell-debris rich limestone. Weathering has resulted in decalcification and alteration of the rock to an ore-grade ironstone, with a 'dried ore' iron content averaging 25% but ranging up to 40%. Locally, the ore was quarried between 1878-81 and from 1917 to 1993, with underground mining from 1931-42 in areas of thicker overburden.

The weathering, oxidisation and redistribution of the iron have destroyed many depositional structures, but cross-lamination still persists, picked out by crinoidal shell-debris and grain-size variations. Together with the presence of a robust and varied brachiopod, bivalve and belemnite fauna, the cross-lamination indicates accumulation under high-energy conditions. Ghosts after ooliths and shells can still be recognised in places.

The top bed of the Marlstone is exposed on a bared surface close to a mine adit. It is a ferruginous limestone with abundant, broken and randomly-arranged belemnites and a few ironstone pebbles — a true 'belemnite battlefield'. Currents were too weak to orientate the belemnites.

The onset of the Toarcian times was marked by an abrupt change in lithology and the deposition of the Fish Beds Member of the Whitby Mudstone Formation. The basal bed is a hard, pale buff-grey, very finely laminated micritic limestone with layers of very small, convex-upward orientated shells of ostracods and immature molluscs ('spat'). The remainder of the Fish Beds Member consists of very thinly laminated mudstones (paper shales). The laminae are composed of couplets of green calcareous mudstone alternating with brown bituminous mudstone containing abundant molluscan spat and thin-shelled bivalves, and uncommon ammonites, fish and insect debris. The calcareous mudstone may pass laterally into nodular limestones. One such bed, now decalcified but with fish spines, occurs some 0.15m above the base. A bed of nodular pyritic limestone occurs about 0.15m higher still.

The base of the Fish Beds Member records a major world-wide marine transgression with the creation of a quiet, deep water anoxic environment. Sediment supply was limited and deposition was slow below the depth of significant current activity. There was no bottom dwelling fauna due to the anoxic conditions and hence no bioturbation to disrupt the micro-lamination within the bottom sediment. Nevertheless, organic productivity was high at shallow depths, with algal blooms resulting in mass mortality of nektonic faunas and their accumulation as death assemblages on the seabed.

North Quarry (SO 742 237)

This quarry worked from 1943 to 1963 and the worked area was restored to grassland in 1974. This can be contrasted with the original hill and vale dumps at Brown's Quarry and the ancient Sandrock workings in the grass field to the west. The party divided into two groups at this stage. The wardens of the Reserve conducted tours of the site for one group while the waiting group continued to examine the geology in the quarry. Here, the gradual upward transition from the fissile Fish Beds Member to the blocky medium grey mudstones of the Cephalopod Limestone Member was studied. The mudstones contain scattered bivalves and ammonites, with fine shell debris and '*Chondrites*' type burrows. Some ammonites are preserved as uncrushed outer whorls; large *Hildoceras* are preserved in calcite micrite nodules and small *Dactylioceras* as sideritic phosphate nodules. A weathered bed of pale buff-grey micritic limestone nodules with large ooliths and pisoliths (up to 3mm) occurs at the top of the quarry. These grains also occur scattered throughout the enclosing slightly calcareous mudstone. The Cephalopod Limestones mark a change to less anoxic bottom conditions, the "Chondrites" burrows reflecting a slightly more oxygenated environment with gently agitated bottom waters.

The excursion concluded with a discussion of the origin of the Marlstone and its ooliths. The latter are an enigma, in that they are composed of minerals that suggest precipitation in reducing conditions, contrasting with the abundant evidence of current activity and oxygenated conditions in the host sediment. In the Marlstone, the ooliths originally consisted of chamosite, a ferrous iron phyllosilicate of the glauconitic group of minerals. In the Cephalopod Limestones Member, the ooliths are of calcium phosphate. Classic calcareous ooliths accrete in high-energy open water environments where aragonite is precipitated around a nucleus, yet both of the present examples are formed of minerals that occur only as traces in sea water. They therefore must have formed by processes other than direct precipitation. The Marlstone contains very little primary detrital clay. The chamosite occurs (in fresh specimens) both as oolite cores and rinds, and the ooliths are enclosed in calcite-siderite cement. Siderite replaces chamosite in some ooliths. The party discussed how ferric iron could have been transported into the basin as colloidal particles or as films adhering to clay particles or other detrital grains. It was suggested that reduction of ferrous to ferric iron was then accomplished by biogenic action in the mildly alkaline and reducing environments at shallow depths within the bottom sediment, and that the ferrous ions then reacted with detrital clay minerals to form berthierine glauconite, a mineral found in modern sediments. Siderite alteration and cementation took place in the more strongly reducing conditions at depth within the substrate in the absence of sulphate ions (pyrite forms in reducing conditions when sulphate ions are present). Chamosite then formed by the diagenetic alteration of berthierine. In the case of the phosphatic ooliths in the Cephalopod Limestone Member, the party concluded that these must have formed during early diagenesis by replacement of primary aragonitic ooliths by authigenic phosphate. Both the chamositic and phosphatic ooliths were thought to have been reworked from their sites of formation and transported into the environment of deposition; a high-energy, current-swept environment in the case of the Marlstone, and a quiet water setting in the case of the Cephalopod Limestones Member, where bioturbation dispersed the ooliths through the mudstone.

Albert Horton