REPORT

Middle Jurassic Sequence at Ketton

At Ketton, in County Rutland, Castle Cement has one of the most extensive quarrying operations in the country. Lincolnshire Limestone (Inferior Oolite) and Upper Estuarine Clay (Rutland Formation) are worked to produce cement. A by-product is the Freestone oolitic limestone used as high quality building stone by the several local stone masonry operations.

Quarrying in recent years has revealed a nearly complete sequence of the limestones and clays of the Middle Jurassic across a small graben (Fig. 1). Exploratory work has reached the Upper Lias Clays, and Kellaways Sand (and possibly the Oxford Clay) are exposed at the top. All the intervening limestone and clay bands are present, except for the Lower Cornbrash. However, a rather battered specimen of the ammonite *Clydoniceras* was found at the base of the Upper Cornbrash (Abbotsbury Formation) and seems to have been reworked from the Lower Cornbrash before redeposition in the Upper Cornbrash.

An exploratory excavation in the middle of the quarry floor exposes the uppermost beds of the Lias Clay. Above this, Northamptonshire Sands Ironstone, once widely extracted to supply the steel industry at Corby, exhibits a boxwork structure resulting from spheroidal weathering. Poorly preserved bivalve shells are commonly found in the ironstone.

Immediately above the ironstone are the Lower Estuarine Beds (the Grantham Formation). These are fine sandy deposits, which vary considerably over a wide area. At Ketton, they are golden brown and almost as fine as dust. In other quarries, the same horizons are of a fine, white, silica sandstone that has been used for refractory products.

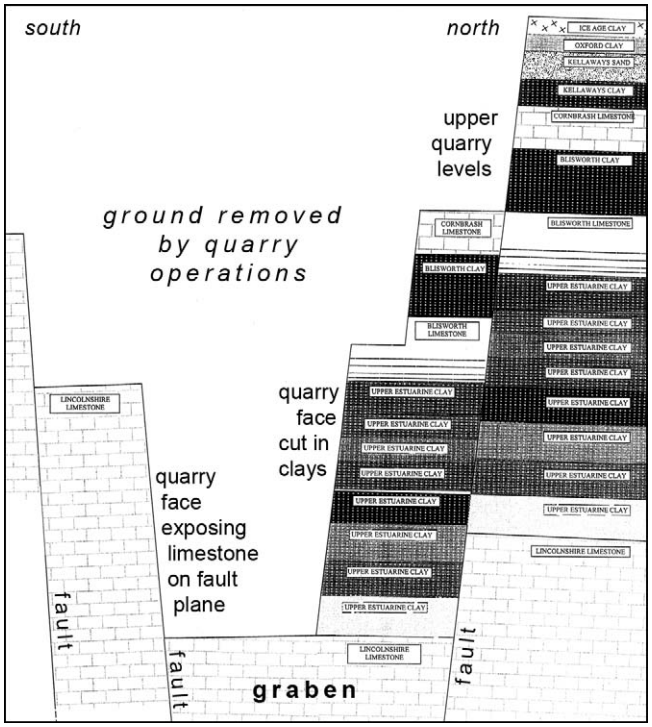

Figure 1. *Diagrammatic profile of the Jurassic succession exposed across the graben zone in Ketton Quarry.*

Figure 2. *Looking east along the line of the fault plane which forms the exposed face of Lincolnshire Limestone on the right. To the left, the downthrown Rutland Formation is capped by Blisworth Limestone, Blisworth Clay and Cornbrash. Where the main fault meets the skyline, the Cornbrash abuts the Blisworth Limestone to form an apparently continuous limestone band, though the fault can be traced from there across the floor of the upper quarry.*

Overlying the Grantham Formation, the lowest beds of the Lincolnshire Limestone are sandy, micaceous deposits cemented by calcium carbonate. In the nearby mines at Collyweston, one bed produces the Collyweston stone slates. These are riven along the bedding planes by exposure to winter frost, and the resulting thin "slates" form the picturesque roofs of the older buildings in the surrounding villages. These sandy limestones are not used in the manufacture of cement, and they form the floor of the main quarry.

The working face in the Lincolnshire Limestone is some distance from the excavation into the lower beds. The limestone grades upwards from a rather muddy rock to a nearly pure carbonate in the Oolitic Beds at the top (Fig. 2). The Oolitic Beds are believed to have formed as an off-shore, wave-agitated barrier with an extensive quiet lagoonal area on the landward side; they display no bedding planes and few fossils. The lagoonal beds show prominent horizontal bedding and vertical jointing, and are more fossiliferous. Bivalve shells and Nerinid gastropods are found. Rarely an ammonite is found - *Fissilobiceras* or *Sonninia*.

Above the limestones a disconformity represents the Bajocian uplift, when erosion removed an unknown quantity of bedrock from low-lying plains exposed for perhaps 5 Ma. Questionable features here include a karstic surface and some buried podsols.

The area then subsided at the start of the Bathonian. The lowest beds of the succeeding Rutland Formation (Upper Estuarine Series) are clays of freshwater origin that formed in an inland lake behind a coastal barrier. The bottom beds are highly siliceous and have been used in refractory products elsewhere. At the very base of the freshwater beds, an intermittent ironstone band is the horizon that yielded the remains of the dinosaur *Cetiosaurus* in a nearby quarry in 1968. This fossil may be seen in the Leicester New Walk Museum.

Above the freshwater beds lies a rhythmic sequence of some seven bands of differing colours. Each cycle begins with a densely shelly deposit at the bottom, which gradually gives way to vertical root beds at the top. These are then sharply truncated by the next shelly horizon. These probably formed in tidal mud flats (as around the Wash today), interrupted by periods of sea-floor subsidence.

The Blisworth Limestone (Great Oolite) lies above the Rutland Formation. This is highly fossiliferous, with many bivalves such as Pholodomya, Pleuromya and Modiolus. Ammonites are very rare but Nautilus is found. The echinoid *Clypeus* is common, as are gastropods and brachiopods. Occasional fish teeth occur and the humerus of a plesiosaur was found in the spoil from the Blisworth Limestone, though it is possible that this was an erratic. Above is the Blisworth Clay, green and purple and 4-5 m thick.

Next comes the Cornbrash (upper) known as the Abbotsbury Formation. Marked by a bed of abundant *Pleuromya* at the base, it is highly fossiliferous. The ammonite Macrocephalites is present, with many bivalves and brachiopods. The upper surface of the Cornbrash is paved with the giant clam *Lopha marshii.* Above the Cornbrash lie 6 m of the Kellaways beds, clay at the base and sandy above. Above these, there is a very small corner of clay, probably the base of the Peterborough Member of the Lower Oxford Clay. Ammonites are known from here, though the precise horizon of their origin is uncertain; seepage from the faulted limestone causes the clays to slump and become mixed (Fig. 3).

A cover of glacial till obscures all at field level. Probably Anglian, this yields Lias belemnites and *Gryphaea*, as well as chalk and flints, all exotics from North Lincolnshire or Yorkshire.

The main fractures are hinge faults striking roughly E-W to form a graben that dies out to the west (Fig. 4). Maximum observed throw is about 10 m, down to the north in two steps. The age and cause of the faults are uncertain. They may well be Pleistocene. The limestones lie above the Lias clays that are exposed in valley-sides, where loading pressure has caused widespread cambering, with valley bulging, noticed especially in the Welland valley when the pipeline was built to supply the Rutland Water reservoir. However, older tectonic faulting is also known in the area, specifically the Tinwell-Marholm fault.

The fault system and the whole exposure lie towards the limit of Castle Cement's quarry. When working ceases in this area, the operators are willing to create a RIGS, as it is the only place in the British Isles where the whole Middle Jurassic limestone and clay sequence can be seen in one quarry.

Acknowledgement

Grateful thanks to David Bagshaw and Barry Bedford, Castle Cement's managers at the site for being so helpful in granting continuing access to their exposed geology.

Alan Dawn, Stamford Geological Society

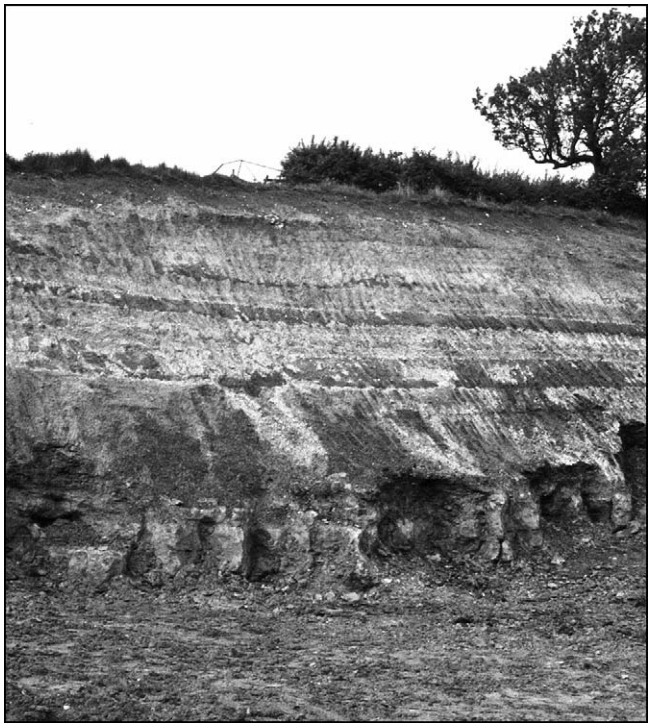

Figure 3. *A high level of the quarry with a floor of Blisworth Clay. Cornbrash limestone is exposed at the foot of the face, with Kellaways clays and sands above, and a cap of Oxford Clay probably survives just beneath the tree.*

Figure 4. *Looking west along the fault zone to where it dies out in the distance.*