EXCURSION

The Lincolnshire Limestone

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Three quarries between Duddington and Wansford, south of Stamford, were visited on a dry bright day.

First was the Bullimore's quarry at Duddington (at SK995013). The leader outlined the probable palaeogeography of these Jurassic limestones some 160 million years ago. The region was than at Mediterranean latitudes. Global climate was warmer than today, with no ice caps at the poles. Sea level was higher than it is at present. Deposition of the limestones was in a situation equivalent to that on the Bahama Banks today. Low lying land masses shelved gradually into shallow shelf seas, which gave way to deep water some distance from land. Terrestrial sediment input was small, and the carbonate was precipitated both by evaporation of warm sea water, and after its use by the molluscan fauna to build their shells.

Near to shore, silica sands were deposited, while further seawards, in water no more than 4-5 m deep, carbonate deposits accumulated along with some finer calcareous muds. At the seaward limit of the shallow shelf, wave action build an offshore barrier where moving water caused the formation of oolitic carbonates. Each oolith is a series of concentric spheres of carbonate around a small nucleus. Rolled by wave action, these ooliths eventually grew too heavy to be moved further, and were buried by the next generation of sediment.

Tidal fluctuations caused currents in the lagoonal area behind the off-shore barrier, so that cross-bedding and ripple marking is common. Localised channelling within the carbonates is ascribed to tidal scouring by currents related to breaches in the off-shore oolitic barrier. Long-term subsidence caused encroachment of the sea on to land, with the consquent landward migration of the oolitic barrier.

In the Duddington quarry, the lowest beds exposed are the Collyweston Slates, although the exposure was obscured by flooding at the time of the excursion. Collyweston "Slate" is a carbonate-cemented sandstone containing some mica, which aids splitting of the stone along the bedding planes. The quarrymen achieved this by leaving blocks of stone exposed to winter frosts, which left thin slabs that were trimmed by hand to form the slates.

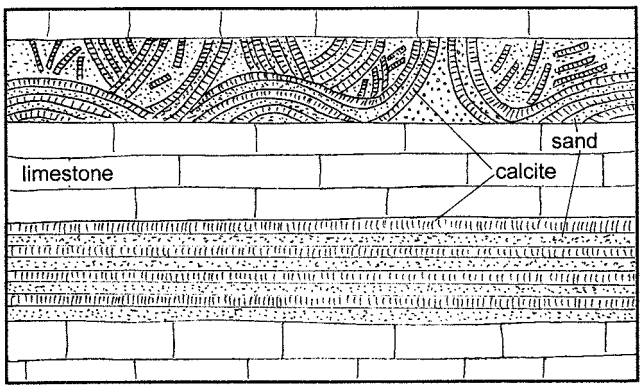

Figure 1. Alternating bands of sand and calcite, in units about 10 mm thick, some with contortions and some not, between beds of uniform limestone, in Crossley's Quarry.

The succession above the Collyweston beds becomes decreasingly siliceous and increasingly calcareous. It yields lignified wood and fossils of the fern *Phlebopteris woodwardii*.

Cross-bedding of the carbonates is prominent in some parts of the quarry, and has been measured by Prof David James. He has found that small to medium scale cross-bedding, of both trough and tabular type, shows wide variation in orientation, but 26 fairly reliable group-averaged readings from all three quarries show a 2:1 domination of flow in the NW-SE quadrants relative to the NE-SW quadrants. In both quadrants flow reversals, locally of herring-bone type, are abundant. No channel margins were seen. Together with the layer-cake stratigraphy, this suggests low-gradient, sinuous tidal channels migrating across and within the ooid bars. Flow variance is much less on the small scale, and at least three sets of local flow reversing can be seen in different areas of the Duddington quarry. There were sandy tidal flats, and back-barrier floodplains transgressed by ooid bars, which created their own lagoons with channels to the sea.

The second visit was to the Crossley's Quarry (at TF030006), operated by Bardon Roadstone. Here the exposure is not so deep as at the Duddington quarry. This is partly due to erosion and partly to the lensing out of the whole sequence of the Lincolnshire Limestone a few kilometres south.

The dominant feature at Crossley's is the de-calcification of the limestone, along with spheroidal weathering. The lower beds are strongly blue-hearted. The blue/grey colour is due to finely disseminated pyrite, FeS_2, which weathers to hydrated iron oxides that give the weathered rock its golden brown colour. More plant remains, and the fossil gastropod *Nerinea* were found. The weathering leaves spheroidal corestones - the quarrymen's *doggers*, from 200 mm to a metre or more in diameter, with horizontal bedding planes that can be traced through most.

Some strange thinly bedded structures remain an enigma. Beds of sand and calcite, each little more than 10 mm thick, are either horizontally bedded, or are contorted into curious structures (Fig. 1).

The final visit was to the Thornhaugh quarry (at TL058999). This extends deeper than the base of the limestone and exposes the sands of the Grantham Formation, previously known as the Lower Estuarine Series or the Variable Beds. Locally these are a pure silica sand with root beds and a few thin coaly horizons, some of which may represent wild-fire events. They have been used to make refractory products. The limestone beds are entirely of the lagoonal back-reef facies. The lower levels are particularly rich in fossils of plant fragments, corals, bivalves and echinoderms. Some quarry faces reveal Pleistocene cryoturbation (see the report elsewhere in this issue).