EXCURSION

Clitheroe Reef Belt

Leader: Neil Turner (Wollaton Hall Museum)

Sunday 9th May 2010

The day was sunny and dry for meeting up at the Nick O' Pendle, on the road over from Clitheroe to Sabden. After a look at the geology map of Clitheroe, spread out on a bedding plane slab, the group climbed the hill at the side of the road cutting to see the view of Clitheroe and the Ribble Valley. The row of reef knolls stretches from Clitheroe Castle via Salthill and Bellman Park Quarry to the largest of them all, Worsaw Hill (Fig. 2). Nick O' Pendle was a glacial meltwater channel during the Pleistocene. The Bowland Fells were in clear view, and even Blackpool Tower could be identified.

Within the Craven Basin, the Bowland Sub-Basin is surrounded by a number of highs that were rigid blocks subsiding more slowly. To the south is the Central Lancashire High, to the northeast the Askrigg Block, and to the northwest the South Lakeland High. Lower Carboniferous marine sedimentation began on a shallow carbonate shelf or ramp that was subsequently fractured into the series of highs and lows within the basin. Although subsidence in the Bowland Sub-Basin started relatively uniformly, while the Chatburn Limestone was being laid down, it increased and became more uneven, which led to the development of deep water Waulsortian mud mounds of Tournaisian age. The Waulsortian mud mounds (previously referred to as reef knolls, knoll reefs or reef limestones) at Clitheroe are older than these in Derbyshire, but are thought to be roughly the same age as those in Ireland. After formation of the Waulsortian mud mounds, the Visean saw a switch to the hemi-pelagic Hodder Mudstone Formation. As the basin continued to subside it became deeper and more anoxic. When the surrounding apron reefs at Malham, Settle and Cracoe became established,

Figure 1. *Limestone seat with tiles of crinoids at locality 6 on the Salthill Quarry trail where fossil crinoids have been commonly found (photos: Richard Hamblin).*

Figure 2. Worsaw Hill, largest of the Waulsortian mud mounds in the Clitheroe area.

skeletal carbonate input into the basin largely ceased, as marked by the pelagic Hodderense Limestone. The Pendleside Limestone marked a return to limestone turbidite, with its many debris flows derived from the surrounding carbonate shelf. The succeeding Bowland Shales were laid down before a delta spread southwards and the Pendle Grit was deposited.

Pleistocene ice moved southwest down the Ribble Valley, leaving behind over-steepened hillsides, as at the northern side of Longridge Fell, valley floors filled with glacial drift, glacial meltwater channels as at the Nick O' Pendle, and glacially smoothed and scratched limestone pavements as were to be seen later in the day.

The top of the Bowland Shales are overlain by the Pendle Grit, a sand-rich, submarine slope complex of channels and fans. At the Nick O' Pendle, the Pendle Grit is thought to have formed at the distal end of a delta as a product of deposition from turbidites. Paul Kabrna explained how the Pendle Grit is a good reservoir rock and has been used by the hydrocarbon companies for training students in oil exploration. The Bowland shales are potentially ideal source rocks for oil, so the overlying Pendle Grit is well placed for migration and storage of hydrocarbons in the sandstone.

The Pendle Grit at the Nick O' Pendle is a medium grained arkosic sandstone, exposed in three small quarries. The massive sandstone bodies are commonly scoured or fluted, particularly at the base of beds. Undulose bedding planes have many shale clasts that may define amalagamation surfaces. Discrete shale clast breccias at the base of beds may indicate the presence of debrites, one of which was seen in the central quarry. Analysis of these debrites can indicate the density of the turbidite. The group then crossed the road and looked at Pendle Grit beds in a small disused quarry with wavy channel bedding and some good load casts exposed on the underneath of one bed.

After driving to the car park of the Calf's Head, Worston, the group walked to two exposures in the A59 road cuttings just east of Clitheroe. The Crow Hill Waulsortian mud mound was built by bacteria forming and then holding together the lime mud that became the micritic limestone seen in the first exposure. Waulsortian mud mounds are not found elsewhere in the geological column, and this led to speculation

Figure 3. Bellman Park Quarry, showing core beds of a Waulsortian mud mound on the left, flank beds to the right and Pendle Hill in the background.

Figure 4. *Calyx of crinoid,* Amphoracrinus gilbertsoni*, found in Bellman Park Quarry.*

whether the type of bacteria had become extinct after the Lower Carboniferous, leaving no organism able to form the mud mounds. It was also considered why the Waulsortian mud mounds should all be arranged in a line in the Clitheroe area; one possibility is that they formed over a line of methane seeps that helped the bacteria to form on the sea bed.

The group then went to the Peach Quarry Limestone, also in the A59 road cutting. Unlike the Crow Hill limestone that is massive, unbedded, micrite with few fossils, the Peach Quarry Limestone consists of thick, well-bedded limestones and thin shale beds with abundant crinoid ossicles. This is a lenticular bed, only found on the eastern side of the Clitheroe anticline, and is thought to have been storm-generated. It represents a period of basin shallowing that took place prior to deposition of the Salthill mudmounds.

After lunch, the group followed the Salthill Quarry geology trail using the Geologists' Association field guide (Bowden, 1997). After the 'bank beds' at the core of the hill at Salthill were formed, in Tournaisian times, a period of fragmentation and erosion of the mound left an unconformity, over which inter-bank, flank and biosparite limestones were draped. At trail points 2 and 9, two small mud mounds are seen, and these are thought to be the start of a third phase of limestone mud mounds in the area (the first phase is at Coplow Quarry, and the second is the line from the Castle through Salthill to Twiston. Geopetals (fossil spirit-levels) in the hollows of crinoid stems, seen at point 3, have been used to determine that the flank beds had been laid down horizontally prior to Variscan tectonis that left their present dip of about 25º south. Farther round the trail, point 6 has a great diversity of crinoids that have been collected in the past. A stone seat has been made of large slabs of crinoid-rich limestone, set with some tiles depicting crinoids (Fig. 1). Glacially smoothed limestone slabs lie at point 8.

The group then crossed the road into Bellman Park Quarry (Fig. 3), another in a Waulsortian mud mound, and were met by Simon Moorhouse, the Operations Manager for Castle Cement. At the first outcrop of what appeared to be crinoid-rich flank beds members found two crinoid calyces identified as *Amphoracrinus gilbertsoni* (Phillips) and *Gilbertsocrinus* sp. (Fig. 4). Behind the northern face of the quarry, another excellent area of glacially smoothed and striated limestone had only recently been discovered by Castle Cement. A locally rare goniatite was found in a large loose block. Practically unstratified bank beds in the northern faces of the quarry consist of grey-blue micritic limestone. Folding could be seen in the western face, and a Productoid brachiopod was found in another large loose block.

After returning to the cars, most called it a day, but two members went on to Angram Green where the largest Waulsortian mud mound forms Worsaw Hill and the ridge on the side of Pendle Hill formed by the harder Pendleside Limestone could be viewed. Salthill Quarry, Bellman Park Quarry and the A59 cutting at Crow Hill are all Sites of Special Scientific Interest (SSSIs) and we thank staff at Natural England and Simon Moorhouse, Peter del Strother and others at Heidelberg Cement (Castle Cement) for helping the visit to take place.

Further reading

Aitkenhead, N., McBridge, D., Riley, N. & Kimbell, S.F., 1992. Geology of the country around Garstang. *Mem. Brit. Geol. Surv*., Sheet 67 (England and Wales).

Bowden, A., Webster, M. & Mitcham, T., 1997. Salthill Quarry Geology Trail. *Geol. Assoc. Guide*, 58.

Del Strother, P., 2008. *History of Ribblesdale Cement*. Castle Cement: Clitheroe.

Donovan, S.K., Lewis, D.N. & Kabrna, P., 2005. An unusual crinoid-coral association from the Lower Carboniferous of Clitheroe, Lancashire. *Proc. Yorks. Geol. Soc*., **55**, 301-304.

Donovan, S.K., Lewis, D.N. & Kabrna, P., 2006. A dense epizoobiontic infestation of a Lower Carboniferous crinoid (*Amphoracrinus gilbertsoni* (Phillips)) by *Oichnus paraboloides* Bromley. *Ichnos*, **13**, 1-3.

Donovan, S.K. & Westhead, S., 1987. *Platycrinites contractus* (Gilbertson) and a new *Platycrinites* from the Lower Carboniferous of northern England. *Proc. Geol. Assoc*., **98**, 211-215.

Earp, J.R., Magraw, D., Poole, E.G., Land, D.H. & Whiteman, A.J., 1961. Geology of the country around Clitheroe and Nelson. *Mem. Geol. Surv*., Sheet 68 (England and Wales).

Turner, N.S., 1985. Coplow Quarry, Clitheroe, Lancashire. *Geological Curator*, **4**, 337-340.