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Field Meeting Report: Bromfield Sand and Gravel Pit, nr Ludlow, Shropshire, led by Ed Webb, 22nd April 2005

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ROSENBAUM, M.S. (2006). Field Meeting Report: Bromfield Sand and Gravel Pit, nr Ludlow, Shropshire, led by Ed Webb, 22nd April 2005. *Proceedings of the Shropshire Geological Society*, **11**, 12-17. Exposures were examined of a thick sequence of fluvioglacial sediments which are being actively extracted for building materials and construction aggregates. The bedrock geology is the Raglan Mudstone Formation (the Downtonian of the Pridoli Stage at the top of the Silurian), and is hundreds of metres in thickness. The Pleistocene superficial geology comprises well-bedded sandy gravels with occasional thin beds of sand. There appears to be very little silt or clay except at the base, where some 0.1 m of red-brown laminated silty clay occurs. The sandy gravels have the appearance of having been deposited by moving water, probably a braided river. The laminated silty clay appears to have been deposited within still water, possibly on a lake bed. The likelihood is that these deposits have been transported by glacial ice and then washed out by meltwater to be laid down by braided rivers; the earliest (lowest) part of the sequence might have been sedimented as a deltaic deposit within a temporary glacial lake (the thin clay at the base may represent a lake-bed mud). Some very large boulders have been encountered at the bottom of the fluvioglacial sequence at Bromfield, for which the name "tobogganite" has been suggested, with the implication of rafting across compacted snow.

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1. INTRODUCTION

The field excursion, led by Ed Webb, met at the site offices of the Bromfield Sand & Gravel Co. Ltd. on April 22nd, 2005, just off the A49 at Bromfield [SO 482 773].

This occasion enabled members to examine exposures of a thick sequence of fluvioglacial sediments which are being actively extracted for building materials and construction aggregates. The pit commenced operation in 1966, once an exhaustive archaeological study of the Bronze Age and Roman settlements on the site had been completed (Stanford, 1983), and has been extracting aggregates at a fairly constant rate throughout. Reserves are expected to maintain operations for at least a further 20 years.

Extraction currently takes place in panels 200-300 m across using a single bucket drag line. The sediment is transferred to a conveyor belt which transports it to the crushing and screening plant. Extraction is achieved in the dry. However, even though water is seen in the base of the excavation during the winter months, it does not have to be actively dewatered. Nevertheless the River Onny flows at a higher level, suggesting that the river may be either perched above the main water table or that its alluvium acts as a hydraulic barrier.

2. GEOLOGICAL SETTING

The bedrock geology is the Raglan Mudstone Formation (the Downtonian of the Pridoli Stage at the top of the Silurian), and is hundreds of metres thick (BGS, 2000). The nomenclature has a complex history, largely because litho-stratigraphical terms had been applied and had once (wrongly) been equated with time; international convention now requires chrono-stratigraphy to be employed except at the local level. A completely new set of names has therefore been assigned in an attempt to get modern rules of nomenclature adopted and to avoid (?) confusion with the earlier literature and mapping. The beds outcropping in the pit were formerly assigned to the Ledbury Group (Allen, 1977). Before the reclassification of the stratigraphy in the early 1980's by Bassett *et al.* (e.g. 1982) they were regarded as being of Lower Devonian age, part of the Lower Old Red Sandstone.

The Raglan Mudstone Formation is characterised by repeated sedimentary cycles that fine upwards, a typical cyclothem being 10-20 m thick with a distal fluvial channel environment comprising fine-grained micaceous ripple cross-bedded sandstones and siltstones passing up into an overbank or floodplain environment

characterised by predominantly massive red-brown siltstones with sporadic intraformational conglomerate horizons and, towards the top, pedogenic calcretes representing soil formation and possible slight erosion or periodic exposure. The massive character suggests destruction of the bedding by bioturbation (e.g. by worms, animal burrows and plant rootlets). *[The term "marl" has often been used for this lithology, but this is incorrect since there is no significant calcareous component]*. Occasional pockets of pale green-grey colour are seen, usually within coarser beds of sediment or along joints, suggesting local reduction of the (red-brown) iron oxide minerals during diagenesis. The source of the sediment is thought to be far to the northwest (Allen, 1974), the rivers draining south-eastwards in a relatively hot equatorial climate with low seasonal rainfall. These are the same lithologies as found in northern Ludlow where the mud was once extracted by remoulding the siltstones to feed a major local brick and tile manufacturing industry. Indeed, a degraded exposure of this Formation is still visible at the back of the Whittle bus garage in Fishmore Road, Ludlow.

In an attempt to encourage the use of local materials, in the 1990's the clay from the Raglan Mudstone Formation here at Bromfield was extracted to make bricks (fired in a commercial kiln near Gloucester). The extension to the Church Inn by Ludlow's parish church of St Laurence utilised these bricks. However, the extraction was difficult and incompatible with the dragline method used for the aggregate, so production of bricks using clay from Bromfield has now ceased.

The superficial geology (formerly known as 'drift') comprises well-bedded sandy gravels with occasional thin beds of sand. There appears to be very little silt or clay except at the base, where some 0.1 m of red-brown laminated silty clay occurs. The sandy gravels have the appearance of having been deposited by moving water, probably a braided river. The laminated silty clay appears to have been deposited within still water, possibly on a lake bed.

The likelihood is that these deposits have been transported by glacial ice and then washed out by meltwater to be laid down by braided rivers; the earliest (lowest) part of the sequence might have been sedimented as a deltaic deposit within a temporary glacial lake (the thin clay at the base may represent a lake-bed mud); Peter Toghill (*pers. comm.*) has also suggested that that the gravels may all be of post-glacial alluvial origin, washed down by the River Onny since the gorge was cut and the river sourced right up to its modern headwaters.

The gravel beds seen within the 200-300 m width of the face being actively worked in April 2005 at Bromfield are essentially horizontal and lack any sense of false bedding (e.g. foreset bedding) which might be expected in a glacial lake delta environment. However, topset bedding would have this appearance and could be consistent with the upper portion of a glacial lake delta sequence. If a braided river was responsible then the floodplain would appear to have been very wide since there is no apparent channelling of the beds. However, some of the coarser beds show clear imbrication, indicating deposition by water flowing generally southwards. The exact mode of origin is unknown. However, the mode of bedding development, presence of pebble imbrication, loose density of the deposit, absence of silt and clay (except at the base), and the crude sorting by grain size all suggest deposition by rapidly flowing water rather than directly by glacial ice, although such water transport is unlikely to have been for very far. This deposit is therefore unlikely to be a glacial till ("boulder clay") even though this might be implied by some smaller scale geological maps covering the area. There is no evidence of steeply inclined bedding, as found in similar deposits further south in Herefordshire and ascribed to the thrusting of glacial ice. Detailed further examination of the exposures may hopefully reveal evidence that will help resolve the debate.

The composition of the gravel is very varied. The following lithologies were noted, in decreasing order of abundance: siltstone, sandstone, conglomerate, shale, limestone, quartzite, dolerite, rhyolite, andesite, slate, vein quartz, tuff with quartz veins, granite. There were also some unusual lithologies for the area, including a conglomerate that appeared to be from the transgressive base of the Silurian, and fossil soils (pedogenic deposits) of silcrete. Some of the lithologies are characteristic of the Stiperstones and Longmynd areas, i.e. to the north-west, such as dolerite with feldspar phenocrysts (similar to the Ordovician Criggion intrusion), Arenig (Lower Ordovician) quartzite (Stiperstones Quartzite), Llandovery (Lower Silurian) *Pentamerus* limestone (Shelve), and Caradoc (Ordovician)

green-grey and red-brown banded siltstone (Chatwall Sandstone: "Soudley Stone"). These could have been transported by the River Onny, flowing through the Plowden gap after this had been opened by glacial action. However, other lithologies are characteristic of the Stretton area to the north, such as the coral-bearing limestone (Mid Silurian Wenlock Limestone) with *Heliolites*, *Halysites* and *Favosites*; other lithologies are from much farther afield (chert and granite, possibly from the Irish Sea). There was no apparent occurrence of lithologies from the east, for instance Dhu Stone (dolerite from the Clee Hills) or Devonian sandstone and conglomerate (Old Red Sandstone). The implication is that the majority of the sediment has been derived from the north-west, i.e. along the Onny valley from west Shropshire, but there is also a component of material that has come from the north, quite probably fluvioglacial outwash flowing through Marshbrook from glacial ice melting in the Stretton valley.

Some very large boulders have been encountered at the bottom of the fluvioglacial sequence at Bromfield pit. These were not observed *in situ*, but several have been placed as a revetment on the banks of the River Onny. One is a coral-bearing slab of Wenlock Limestone some 3 m across and almost one metre thick; such reefal material is known to outcrop on Wenlock Edge to the north-east, but how it was transported to Bromfield is unknown; there is no evidence of glacial ice movement from the north-east, although the early literature reports occurrences of till on high ground southwest of Much Wenlock (Maw, 1864) and evidence of a major glacier reaching Morville (Wills, 1924). Although the 3 m block is far too large to have been transported by river water *[David C Smith suggested the name "tobogganite", with the implication of rafting across compacted snow]* it is nevertheless plausible that a major river once flowed down Corve Dale, swollen by the meltwater from that northern glacier.

Stratigraphically the sand and gravel at Bromfield has been mapped by the BGS (2000) as the "Bromfield Sand and Gravel (Second Terrace)" and ascribed to the Late Devensian as a "Glaciofluvial Sheet Deposit: sand and gravel; including possible deltaic deposits of Glacial Lakes Orleton and Wigmore". The Devensian glaciation has been the most recent to affect this area, 120,000 to 11,000 yrs BP; its coldest phase ended around 18,000 yrs BP. During the Devensian the low ground hereabouts, west of the Clee Hills, was the meeting point of glaciers from the north (Irish Sea, with one lobe through Church Stretton, a second down Ape Dale which occasionally spilt across Wenlock Edge into Corve Dale, and a third to Morville, just beyond the present-day head of Corve Dale), west (through the Clun Valley) and south (from the Wye Valley, the northern lobe flowing across the low ground between Leominster and Mortimer's Cross). The river valleys responded to the onset of a colder climate and consequent drop in base level (since sea level dropped by many tens of metres as the water worldwide became locked within the glacial ice) and to the influx of meltwater loaded with sediment from the glaciers. A complex network of river channels and terrace deposits resulted, and some river capture and relocation took place. Evidence comes from the direction in slope of the higher river terrace deposits of the Rivers Teme and Lugg a little to the south, across the border into Herefordshire and Worcestershire, and some detailed clast orientation studies of the gravels at Bromfield surveyed by Peter Cross (1971), a detailed account being published by Cross & Hodgson (1975).

The glacial ice on occasion dammed the river valleys to create temporary lakes, for example the Glacial Lakes Wigmore and Orleton (Hodgson, 1972). The impounded water sometimes led to overflow and erosion of new channels, notably that from Glacial Lake Wigmore, which caused the River Teme to flow east from its original southward path through Aymestrey, and instead lead east to Ludlow.

Bromfield is located on a relatively wide, flat expanse of low ground, dipping gently southwards. Topographically this has the appearance of a "sandar", a sheet of fluvioglacial sediment deposited by torrents of meltwater issuing from a melting ice margin (Brandon, 1989). The wide, flat expanse of low ground also has the appearance of a lobe of fluvioglacial sand and gravel deposited in a delta within a glacial-dammed lake (Rosenbaum & Wilkinson, 2006). Could this have been Glacial Lake Orleton? At its peak, this lake is believed to have extended north from Orleton (just beyond the prominent aerial farm at Woofferton), through Ludlow, to reach as far north as Bromfield and possibly to Onibury beyond. The ice then still

damming Glacial Lake Orleton prevented the Teme's southerly progress. The resulting lake eventually spilt over to the east and enhanced erosion of the pre-existing valley floor enabled the river to continue flowing east through Tenbury Wells and drain into the River Severn, *reversing* the direction of flow of its former tributary in the present-day Lower Teme valley. The consequence is a misfit river within the Lower Teme valley which still occasionally floods since the drainage of excess water is somewhat inefficient.

How do we know that melting glaciers were responsible? The rivers Corve, Onny and Teme are too small today to transport large quantities of gravel, whereas meltwater from glaciers dumping their load could; the composition of some of the pebbles reveals an origin many miles to the north, which can be explained by the passage of the Irish Sea glacier that came down across the North Shropshire plain and reached as far south as the Stretton Valley, a little to the north of the area in view. However, the details of the glacial advance are still unclear and many theories have been proposed (see, for example, Hains, 1969).

LOCALITY 1: Northern boundary [486 775]

Late Devensian fluvioglacial sandy gravel is here exposed, above the access track at the north end of the pit, close to the boundary with the railway. Below is a settling lagoon for water that has been used in processing the aggregate, impounded by a bund made of red-brown mudstone from the Raglan Mudstone Formation.

The Group noted the bedding, imbrication, degree of sorting, and the lithologies of the gravel component (Figure 1). They went on to consider the identifying features that would be diagnostic of the mode of deposition of this sediment; these confirmed its origin as a fluvioglacial deposit. The shallow angle of the bedding and the absence of channelling were consistent with deposition by a braided river fed by meltwater from a nearby glacier.

LOCALITY 2: Working face [483 774]

A lower section of the fluvioglacial sandy gravels has been exposed here by the dragline excavation. Similar features to those noted at Locality 1 were again observed. Beneath may occasionally be seen fragments of red-brown mudstone from the Raglan Mudstone Formation which outcrops beneath the floor of the working pit. At the base of the fluvioglacial sandy gravels occurred a bed comprising some 0.1 m of red-brown laminated silty clay. This could not be seen *in situ*, but blocks had been excavated by the drag line (Figure 2).

Figure 1. Vertical face at the northern boundary of the Bromfield Sand & Gravel pit, close to the railway, looking north north east, exposing Late Devensian fluvioglacial sandy gravel. Bedding exhibits imbrication, indicating flow towards the right (east south east); note the degree of sorting, and the varied lithologies of the gravel component. The length of the scale rule is 150 mm.

Figure 2. Fragment from the floor of the working pit with, at the bottom, green-grey mottled red-brown mudstone from the Raglan Mudstone Formation and, at the top, red-brown laminated silty clay, possibly glacio-lacustrine (*see text*).

The clay appeared to contain pebbles, but it was not clear if these were originally emplaced within the clay or had been accidentally incorporated during excavation. The presence of pebbles as drop stones from melting ice rafts would not be unexpected. Apparently similar material has been recovered from boreholes at Stanton Lacy, one kilometre to the north-east (Peter Toghill, *pers. comm.*). Alternatively this silty clay material may be weathered Raglan Mudstone, remoulded by ice action (periglacial or glacial).

The composition of the gravel clasts is very varied, as previously noted. Discussion considered their likely mode of origin: some appeared to have affinities to Longmyndian rocks, others to Shelve and the Stiperstones; the granite is supposedly akin to that found in Eskdale in the Lake District! The fossils within the limestone blocks are diagnostic (both Ordovician and Silurian examples were observed).

The occurrence of a huge (12 m) slab of sandstone from the north-east corner of the base of the pit (now flooded) is more likely to have been a sandstone bed within the Raglan Mudstone Formation than from the fluvioglacial deposit.

LOCALITY 3: River Onny [478 775]

In the banks of the River Onny, by the bridge carrying the new conveyor belt over the river to the next panel to be worked for gravel extraction, may be seen *in situ* exposures of the fluvioglacial sandy gravel, overlain by about one metre's thickness of silty alluvium. The large blocks of stone have been placed here to stabilise the river banks and had been extracted by the drag line from the base of the fluvioglacial sequence within the pit.

The possible origins of the larger blocks generated some discussion, including the proposal of an occurrence of "tobogganite" as previously noted.

LOCALITY 4: Aggregate processing plant [482 773]

The sediment transferred from the pit by conveyor belt is fed initially through a crusher to break down any cobbles to gravel size. It is then washed, screened and sorted into sand and gravel (fine, medium and coarse). Water from within the pit is used, together with natural spring water from within the site, to wash and screen the aggregate. Much is recycled, and any waste is trapped within a lagoon where the silt and clay settles out. Water pumped back to the Onny is thereby cleaned to a higher standard than the local river water!

During the Society's visit, the three sand bins had just one filled with local sand (dark brown in colour), the other two were filled with red sand imported from Donnington near Shrewsbury (or possibly from Bodenham near Hereford). A fourth bin contained pale brown "Cotswold" aggregate which had been imported from fluvioglacial gravels near Swindon, comprising mostly flint rather than the oolitic limestone that most geologists would associate with Cotswold stone. The largest stock piles were of gravel locally derive and predominantly grey-brown in colour.

The meeting concluded with a vote of thanks to the Site Manager, Paul Walters, for having facilitated such an interesting visit.

ACKNOWLEDGEMENTS

The Society would particularly like to thank the Site Manager for Bromfield Sand & Gravel, Mr Paul Walters, for arranging permission for the Society's visit and not only escorting the party around the workings but also increasing our appreciation of the site.

Disclaimer - The information contained in this account has been prepared following a summary of the geological literature of the area and visits to all the locations described. Its sole aim is to provide a record of what was seen and provide an insight into its geology. It should not be used for any other purpose or construed as permission or an invitation to visit the sites or localities mentioned. Visits to Bromfield Sand & Gravel always require the prior agreement of the Site Manager, tel. 01584 856 258.

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