Appendix 2

Edited field trip guides from the 17th Extractive Industry Geology Conference

held at Edge Hill University 5th to 8th September 2012

1) DINGLE BANK QUARRY (SILICA SAND)

2) SHAP PINK QUARRY (GRANITE) AND ROAN EDGE QUARRY (HIGH PSV GREYWACKE/GRITSTONE)

3) RIBBLESDALE CEMENT WORKS AND BELLMAN AND LANEHEAD QUARRIES (LIMESTONE)

4) ARCOW QUARRY (GRITSTONE)

DINGLE BANK QUARRY

OPERATED BY CHELFORD SILICA SAND (SIBELCO UK)

Field trip location

Dingle Bank Quarry, Lower Withington, Chelford, Nr Macclesfield, Cheshire, SK11 9DR.

Date and Time

Wednesday 5th September 2012. 10.00-13.00

Field Trip Objectives

- Visit silica sand pit.
- View sand processing operations.
- Observe restoration practices.

Geological Background

Chelford Sand Formation: 'White to buff, well-sorted sand, with minor gravel, silt and peat lenses with sporadic in situ tree stumps and wood clasts.' (BGS Lexicon)

The sand formation is a unique deposit of material that has only been located at this specific area in the UK.

The strata are Quaternary in age, being deposited in the Pleistocene epoch, during the most recent cycle of glacial and interglacial periods. The exact time the material was deposited is debated, but it is widely believed to be between 100,000 and 40,000 years ago. The white Chelford sands directly overly the Triassic Mercia Mudstone formation, which represents a large unconformity in geological history. The feature is confined to a series of palaeovalleys that trend southeast to northwest, being up to *c.*25m deep and a few hundred metres wide.

The sedimentology of the material indicates that the sand was deposited in an interstadial environment, with some major features such as cross bedding, being prevalent in some of the quarry faces, displaying Aeolian traits. Features such as channels created by running water are also present and an organic bed found within the sand formation also hints at the depositional environment being akin to a present day Tundra type environment, with woodland and a large source of water, such as a river delta being present. Flora and fauna such as plants, trees and even preserved beetles have been found inside the organic bed which forms a central unit within the sand. This bed was investigated by Simpson and West (1957).

The sand's uniqueness owes to the fact that the sand has been re-worked by natural processes (e.g. river and wind transportation) many times, resulting in natural sorting, which gives the deposit a highly homogenous grain size, with a low content of heavy minerals (such as chromite) and low consistent levels of iron and other oxides, making the 'white' sand particularly suitable for the production of float (sheet) glass.

Overlying the white sand, is a another sand formation, The Gawsworth Sand formation, which is less well sorted and contains a higher clay and pebble content, suggesting that it is of fluvio-glacial origin.

Additional information on the geology of the deposit and area can be found in the following publications:

- Worsley, P. 1991. Glacial deposits of the lowlands between the Mersey and Severn Rivers. In Ehlers, J., Gibbard, P.L. and Rose, J. (Eds.), 1991. Glacial deposits in Great Britain and Ireland. Balkema, Rotterdam.
- Simpson, I.M. And West, R.G. 1958. On the stratigraphy and palaeobotany of a Late Pleistocene organic deposit at Chelford, Cheshire. New Phytologist. Volume 57, Issue 2. pp239-250.

Production

Overburden removal and sand extraction is undertaken by mobile plant, with a small team comprising of excavators, bulldozers and dumper trucks removing the overburden and placing those materials (soil and clay) either into temporary stockpiling areas or directly into restoration areas to agreed profiles. The sand is extracted by wheeled loading shovels and is fed into a conveyor which transports the material to the main processing site. The quarry areas are all de-watered to allow 'dry' working which is advantageous for quality control and blending purposes. The water removed is discharged in accordance with appropriate consents to adjacent water courses.

The processing plant at Chelford is divided into two; one plant deals almost exclusively with the raw white sand and another deals with the Gawsworth sand. The white sand plant receives a blend of white material from the quarry conveyor which is delivered into a live stockpile area and is then screened at 1mm. The rejects from the screening (>1mm) are transported to a separate area. All material passing the 1mm screen is transported into a cyclone which removes clay and silt fines. After this processing stage, the sand is pumped through a series of classifying units which removes the coarser

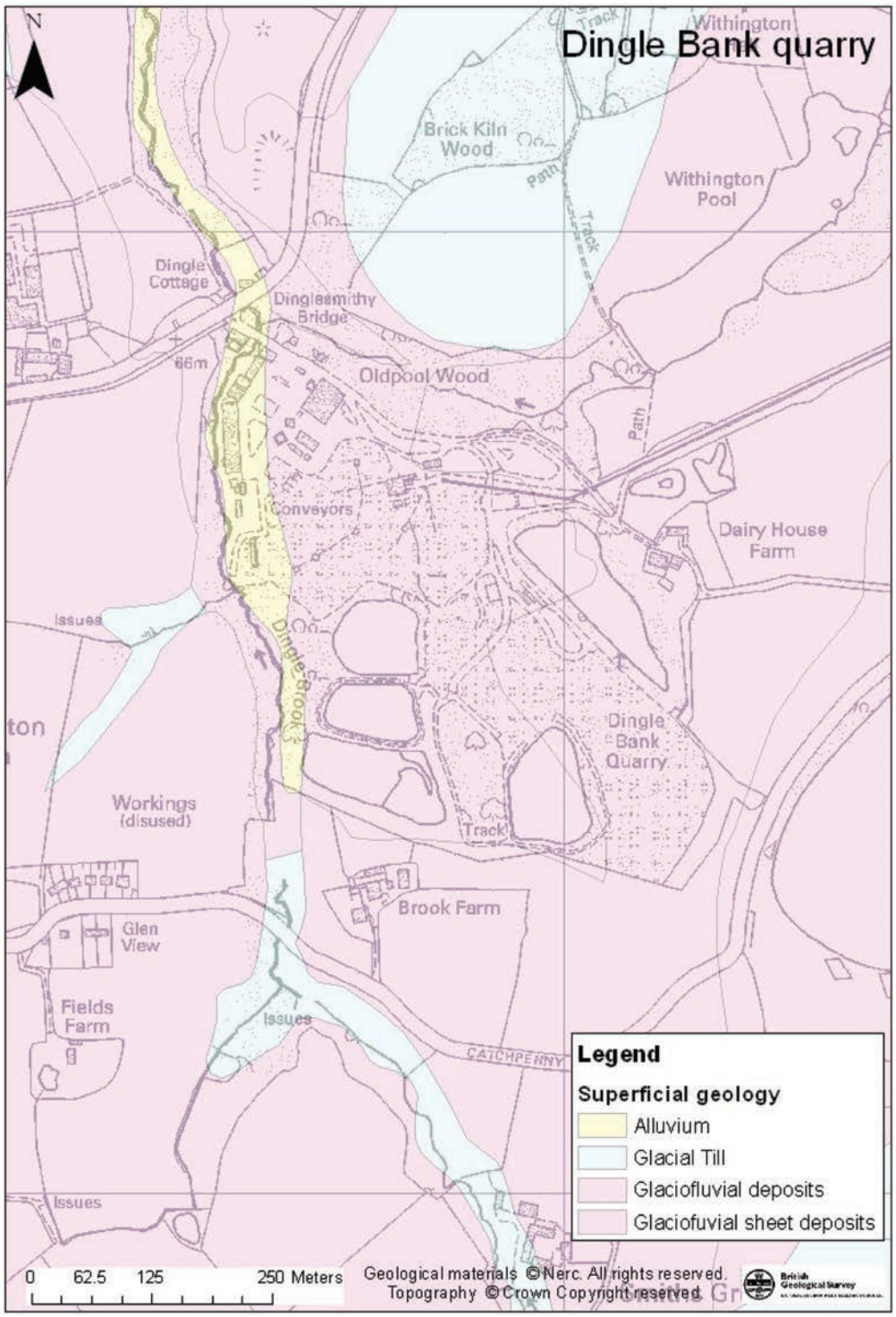
fractions of sand and any denser minerals such as chromite, splitting the fractions of sand into the various graded products that the site requires. Heavy refractory minerals such as chromite would be severely problematic for glass manufacture and these are efficiently removed by the processes employed.

The red sand (or Gawsworth sand) plant receives material which is also screened through either a 1mm or 0.8mm screen. Material passing the screen transfers into a 4-way classifier to split the sand by size grades, and is then transferred into three hydrosizers. The smaller particles pushed out from the hydrosizers are transferred to a stockpile tower for sale. The undersize material (larger particles) from the hydrosizers are then split into further grades for sale.

A drying plant on site dries sand as required, to be sold as a dry product either in bulk or bagged product.

A dry screening plant is also present on site. It is fed with coarse dried material from the white sand plant. The material is physically screened through two sets of mesh's to clean cut the material and allows the precise sizing of product grades, which are again sold as a bulk, or bagged product.

In addition to the sale of sand for glass manufacture, the quarry sells sand products into a wide range of end uses and applications, including water filtration, horticultural and leisure products (root zones, sand/soils, top dressings.) In overall terms, some 95% of the sand extracted from the quarry face can be processed for sale.



SHAP PINK AND ROAN EDGE QUARRIES

OPERATED BY CEMEX

Field trip locations

Shap Pink Quarry, Shap, Penrith, Cumbria, CA10 3QQ.

Roan Edge Quarry, New Hutton, Kendal, Cumbria, LA8 0AP.

Date and Time

Wednesday 5th September 2012. 11.00-12.30 at Shap Pink Quarry, 14.00-15.30 at Roan Edge Quarry.

Field Trip Objectives

- Visit internationally famous Shap Pink Granite quarry.
- Visit the Roan Edge high PSV quarry and view the processing operations.

Geological Background

Shap Pink Quarry

The Shap Pink granite quarry is named after the rich pink tones of the rock. This is due to the mineralogy content within the strata, in particular the high percentage of feldspar phenocrysts present.

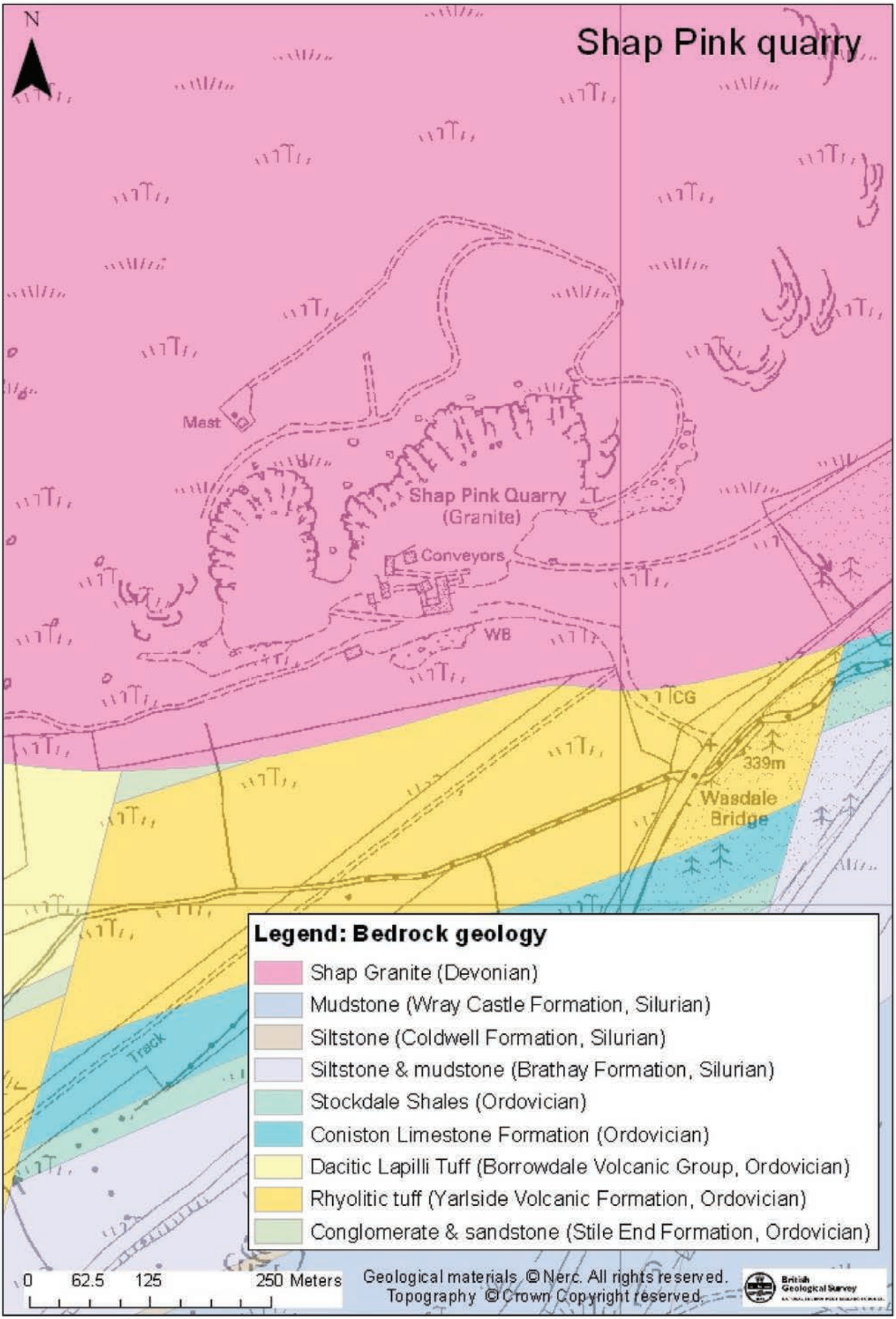
The granitic intrusion is in the form of a laccolith with sub-parallel sheets meeting in the centre. The dykes radiating from the parent mass cut through and alter not only rocks of the Borrowdale Series, but through rocks of all ages up to and including Ludlow strata. This indicates that the granite was intruded in Devonian times.

Despite the fact that this stone is an excellent building material, few buildings today are actually being constructed of granite masonry. This is due to the high cost of present day production and the modern trend of steel and concrete fabrication.

Roan Edge Quarry

The supply of high PSV (polished stone value) aggregates is critical to the road construction industry. The Roan Edge quarry is perfectly located off the M6 to supply the infrastructure market across the midlands and north of the country. Roan Edge Quarry extracts a Greywacke/Gritstone; a sequence of massive, thick, deformed, convoluted beds, folded and faulted, belonging to the Kirkby Moor Formation of Silurian age.

The Polished Stone Value (PSV) was designed as a predictive measure of the susceptibility of a stone to polishing, when used in the wearing surface of a road (BS812:Part114:1989). A higher value signifies greater resistance to polishing. Roan Edge Quarry typically achieves a value of 65 PSV. Contributing factors for achieving a high PSV are mineralogy and grain size. Rocks which comprise minerals with sufficiently different hardness or which were friable are found to give high results.


N
Shap Pink quarry
Mast
Shap Pink Quarry
(Granite)
Conveyors
WB
TCG
339m
Wasdale
Bridge
Track
Legend: Bedrock geology
Shap Granite (Devonian)
Mudstone (Wray Castle Formation, Silurian)
Siltstone (Coldwell Formation, Silurian)
Siltstone & mudstone (Brathay Formation, Silurian)
Stockdale Shales (Ordovician)
Coniston Limestone Formation (Ordovician)
Dacitic Lapilli Tuff (Borrowdale Volcanic Group, Ordovician)
Rhyolitic tuff (Yarlside Volcanic Formation, Ordovician)
Conglomerate & sandstone (Stile End Formation, Ordovician)
0 62.5 125 250 Meters
Geological materials © Nerc. All rights reserved.
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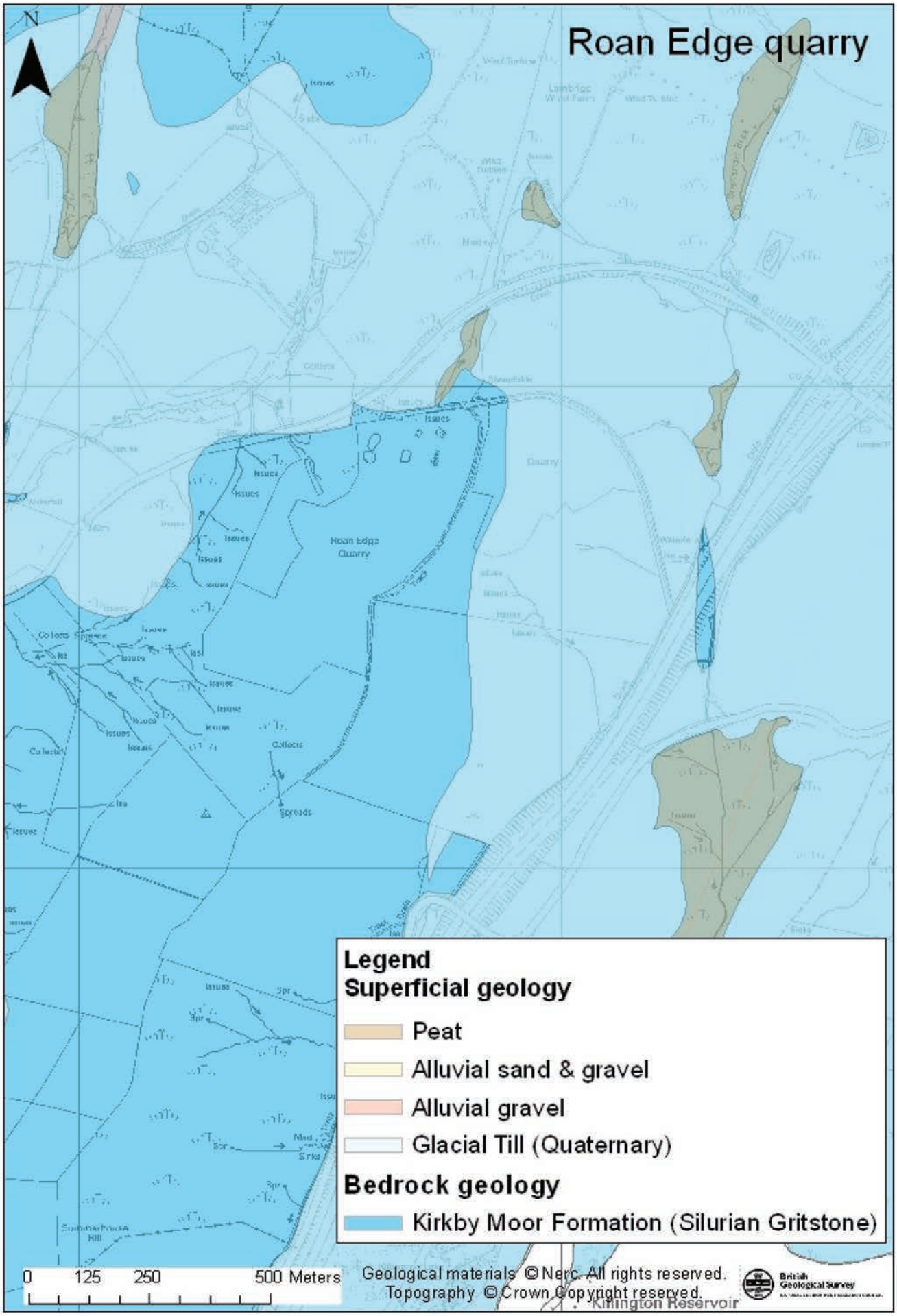
British Geological Survey


Roan Edge quarry
N
Legend
Superficial geology
Peat
Alluvial sand & gravel
Alluvial gravel
Glacial Till (Quaternary)
Bedrock geology
Kirkby Moor Formation (Silurian Gritstone)
0 125 250 500 Meters
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British Geological Survey
Roan Edge Quarry
Issues
Colluvium
Spreads
Quarry
Killington Reservoir

RIBBLESDALE CEMENT WORKS AND BELLMAN AND LANEHEAD QUARRIES

OPERATED BY HANSON CEMENT

Field trip location

Ribblesdale Works, Clitheroe, Lancashire, BB7 4QF.

Date and Time

Saturday 8th September 2012. 10.00-13.00

Field Trip Objectives

- Visit the cement works.
- View limestone feedstock quarries (Bellman and Lanehead).
- Observe mud mound limestone at Bellman Quarry.

Geological Background

Lanehead Quarry

Carboniferous, Chatburn Limestone Formation (CHL) of the Tournaisian-Visean Epoch. Well-bedded, mostly grey to dark grey packstone limestones with chert lenses and subordinate partings or thin beds of shaly calcareous mudstone and siltstone.

Bellman Quarry

Carboniferous, Clitheroe Limestone Formation (Knoll Reef) (CLLK) of the Visean.

Predominantly pale grey and commonly coarsely crinoidal, packstones, wackestones and subordinate grainstones and mudstones with Waulsortian mudmound reef limestones present at two levels

Some of the beds at Bellman quarry are associated with the geological phenomenon known as 'Waulsortian mud mounds'. They are the opposite of more normal limestone sea mounds (reefs formed in shallow water and containing abundant fossils) in that they form in deeper water, have no bedding planes and contain very few fossils and are usually light grey in colour. They were mounds of micrite formed in aphotic deep water (130-300m). The mud accumulated *in situ* as steep sided micrite mounds (up to 50º) aided by bacteria for growth which also acted as a binding mechanism. Some mounds grew up to 200m in height and as they approached the photic zone algal growth was possible. As a consequence of eustatic sea level changes and basin subsidence they often preserve evidence of deep to shallow water changes and vice versa.

Additional information on the geology of the area can be found in the following publications:

- Wood, R. 2001. Are reefs and mud mounds really so different? Sedimentary Geology. 145 pp161-171.
- Del Strother, P. 2012. A guide to the quarries of Hanson Cement, Clitheroe.

Production

Quarrying first took place in Ribblesdale 400 years ago. Hansons Ribbledale Cement Works is sited in the Ribble valley on the edge of Clitheroe, Ribblesdale, Lancashire and was set up in 1936 as a joint venture between Tunnel Cement and Ketton Portland Cement. Following the decommissioning of England's last wet process kiln a single modern 'dry' process kiln has been operating since 2004. This was the first in the UK to use a gas cleaning system to convert sulphur dioxide into gypsum. This reduces the amount of sulphur dioxide produced during the production process by 90%, and halves the very small amount of dust and ammonia, making it one of the most environmentally friendly kilns in existence.

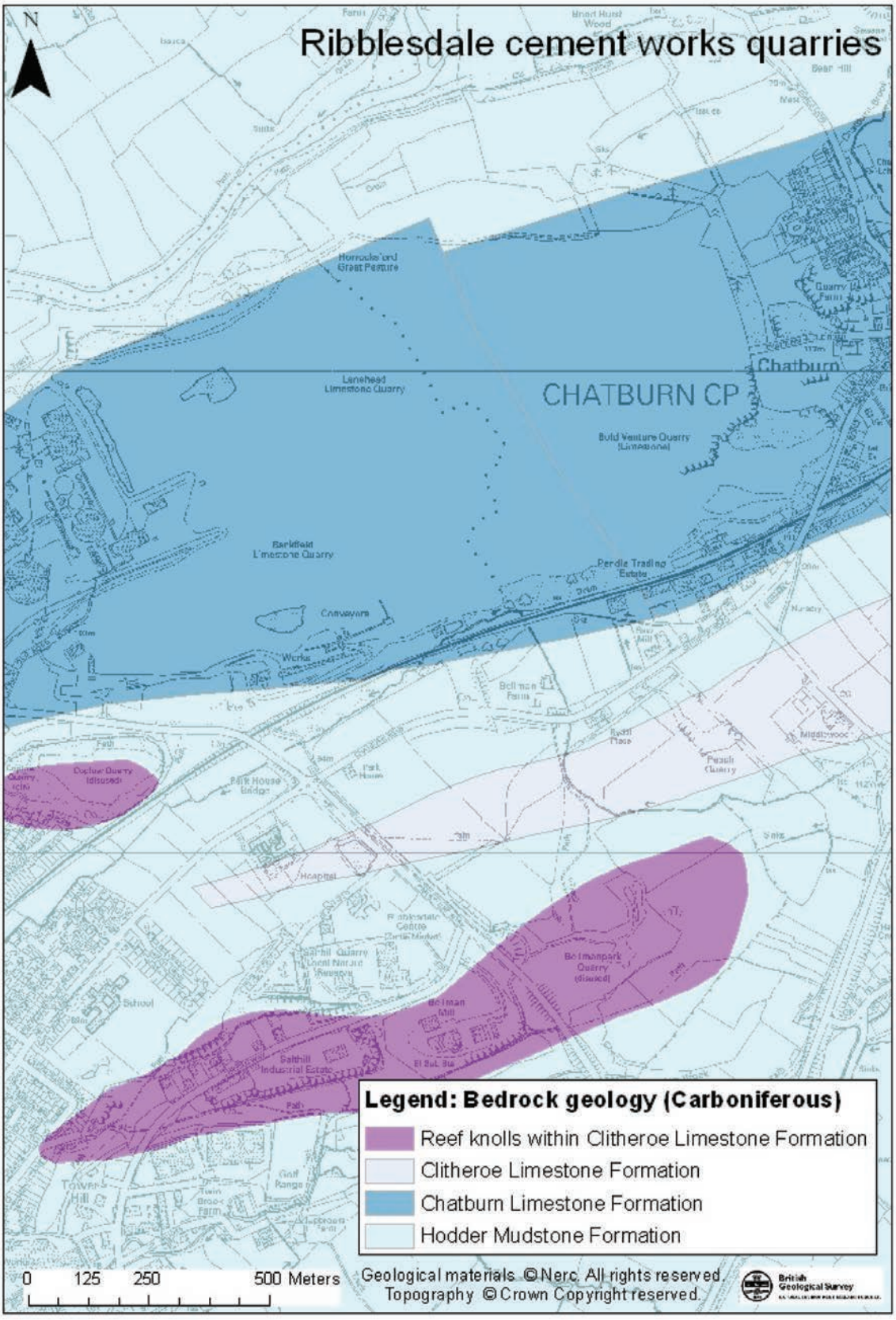
Ribblesdale's output is used in large parts of the north of England and Scotland. About 80% is supplied in bulk tankers while the other is distributed as bagged product. The most popular product produced in Ribblesdale is CEM I Portland Cement.

Cement from Ribblesdale has been used in such high profile projects as Manchester United's home at Old Trafford, Manchester International Airport and The Deep, Hull's £45 million submarium that's so deep that the fish tank has to be cleaned by 'deep sea' divers. In Scotland, two major contracts have been the Skye Bridge and the upgrading of the A77 road to the M77, between Glasgow and Kilmarnock.

Limestone feedstock comes from the adjacent Carboniferous Limestone Lanehead quarry and is blended with higher quality stone from the nearby Bellman quarry to achieve the required chemical balance. A planning application was granted in 2001 to extract 30 million tonnes of limestone over a period of around 30 years from this site. These quarries are the type location for the Carboniferous Limestone Salthill Bank Beds and the Salthill Cap Beds of the Clitheroe Limestone Complex.

Both quarries have become a haven for wildlife and a research programme has been commissioned into the fauna and flora to be found in Lanehead quarry. The wildlife found there is even more diverse than that found at some nature reserves. A study looked closely at the plant and insect life and identified nesting peregrine falcons and ravens as well as 80 other species of birds.

Reports of these activities and other company developments are included in 'Open Door', a newsletter circulated to every household within a five-mile radius of the works, produced as a means of keeping the local community informed.



ARCOW QUARRY

OPERATED BY LAFARGE TARMAC (PREVIOUSLY TARMAC)

Field trip location

Arcow Quarry, Helworth Bridge , Horton-in-Ribblesdale Settle, North Yorkshire, BD24 0EW.

Date and Time

Saturday 8th September 2012. 10.00-13.00

Field Trip Objectives

The western faces of Arcow Quarry present some of the largest geotechnical challenges in the UK extractive industry. The range and complexity of the failure mechanisms at work, coupled with the constraints of working within a pre-determined and partially formed quarry geometry within the National Park and adjacent to a SSSI, presents a major challenge to formulating a workable and economically viable solution.

- Visit the quarry.
- View and appreciate the range of failure mechanisms operating on the western faces and the main controls on the global stability of the face.
- Observe the ongoing works to address the geotechnical problems.
- Observe the on-going restoration works which will ultimately culminate in a restoration scheme delivering significant ecological enhancement and a potential geological heritage site.

Geological Background

The succession present in and around Arcow Quarry comprises highly folded, cleaved and faulted Silurian rocks capped in the west by sub-horizontally bedded Carboniferous Limestone.

Three main rock groups are recognised within the Silurian strata, the general succession being as follows:

CARBONIFEROUS LIMESTONE

.....unconformity

	Lower Ludlow Series	Horton Flags
SILURIAN	Wenlock Series	Austwick Grits
		Austwick Flags

The quarry extracts the Austwick grits, made up of predominantly gritstone with occasional flagstone and siltstone.

The Horton Flags consist of interbedded mudstones, siltstones and flagstones, and are located in the southern extent of the quarry.

The Austwick Flags comprise fine-grained, thinly laminated mudstones with minor horizons of fine grained laminated greywacke and outcrop towards the northern site boundary.

The Silurian strata exposed within the quarry lie on a fold limb between the hinges of a large synform and antiform. The synform hinge lies to the south of the quarry and the antiform hinge to the north. There are small parasitic folds on this fold limb that are represented as minor antiform and synform structures that plunge to the east-south-east.

Geotechnical background

The western faces of Arcow Quarry have experienced a range of geotechnical problems from early in the development of the site. The full range of classical rock slope failure mechanisms, i.e. Planar, Wedge, Toppling and Ravelling are all present on a range of scales. However, the main control on the global stability of the Western Faces is low angle planar sliding involving hundreds of thousands of tonnes of rock.

The challenge of dealing with the geotechnical problems on the western faces of Arcow Quarry has a long history with a variety of options being explored and rejected on either technical or economic grounds. Approximately 12 years ago the possibility of completely redesigning the geometry of the western face was explored and the initial feasibility evaluation indicated that this had the potential to deal with the primary cause of instability. The final solution then evolved over the following two to three years and is in the process of being implemented.

Production

Arcow quarry has operated for many years producing durable stone with naturally high skid-resistence

properties (60+ PSV). Stone with these properties is only available from a limited number of sources nationally.

Material produced at Arcow Quarry is predominantly used in the manufacture of asphalt in Greater Manchester, West Yorkshire and Lancashire.

The viability of working such a problematic reserve is heavily influenced by the key strategic role that the quarry plays in the supply of roadstone across the north of England.

The specialist blasting techniques employed to minimise the impact on overall stability are far beyond the requirements of most aggregate quarries.