Appendix 2

Edited field trip guides from the 18th Extractive Industry Geology Conference 2014

held at

University Of St Andrews

11th to 14th June 2014

1) MAP OF FIELD TRIP LOCATIONS

2) GLENSANDA QUARRY (GRANITE)

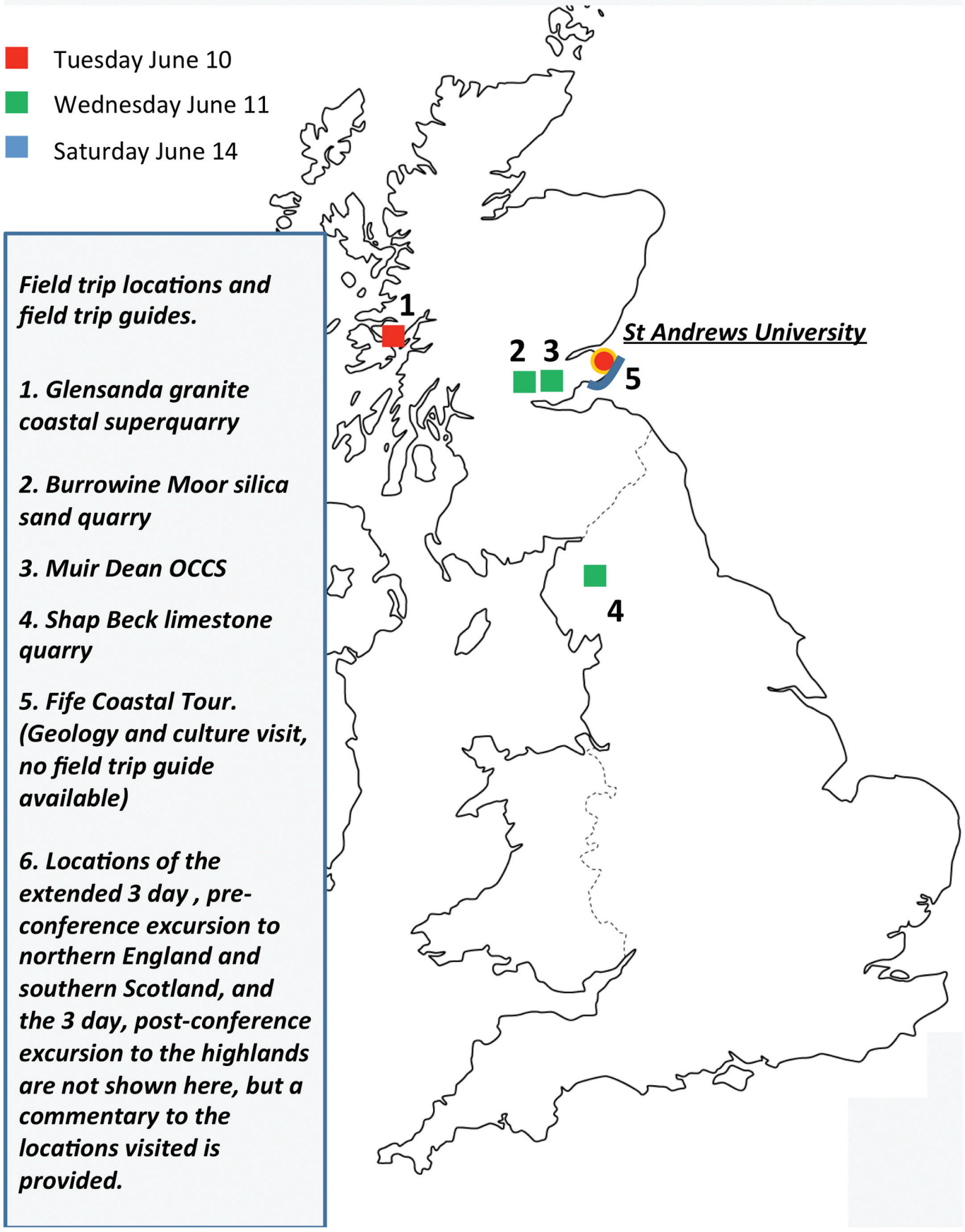
3) MUIR DEAN OPEN CAST COAL SITE (COAL)

4) BURROWINE MOOR QUARRY (SILICA SAND)

5) SHAP BECK QUARRY (LIMESTONE)

6) PRE-CONFERENCE EXTENDED 3 DAY EXCURSION TO NORTHERN ENGLAND AND SOUTHERN SCOTLAND AND POST-CONFERENCE EXTENDED 3 DAY EXCURSION TO THE HIGHLANDS OF SCOTLAND

18th EIG Conference 2014: St Andrews University
Map of field trip locations



Field trip locations and field trip guides.

1. Glensanda granite coastal superquarry

2. Burrowine Moor silica sand quarry

3. Muir Dean OCCS

4. Shap Beck limestone quarry

5. Fife Coastal Tour. (Geology and culture visit, no field trip guide available)

6. Locations of the extended 3 day , pre-conference excursion to northern England and southern Scotland, and the 3 day, post-conference excursion to the highlands are not shown here, but a commentary to the locations visited is provided.

GLENSANDA COASTAL SUPERQUARRY

OPERATED BY AGGREGATE INDUSTRIES

Field trip location

Aggregate Industries, Rhugh Garbh Depot, Barcaldine, Oban, Argyll, PA37 1SE.

Date and Time

Tuesday June 10th 2014, 09.30-16.00

INTRODUCTION

Glensanda Quarry is Europe's largest granite 'super quarry' and is the flagship of the Aggregate Industries portfolio. It is located on the West Coast of Scotland approximately 12 miles north west of Oban and lies immediately adjacent to the western coastline of Loch Linnhe. The quarry is currently excavating approximately 6 million tonnes per annum of granite aggregates but has a current capability to excavate up to 9.5 million tonnes per year. The current planning permits and statutory licenses for the quarry would permit up to 15 million tonnes of aggregate a year to be excavated. Due to the remote location of the quarry there is no access to it by road. All vehicles, personnel and materials are transported to/from the quarry by barge, boat and other vessels. Due to the scale of operation the port facilities are substantial, in fact it is one of the top ten ports by volume in the UK. The main berth at the quarry can accommodate very large self loading / unloading vessels. A typical example being the vessel Yeoman Bridge owned by Aggregate Industries, capable of carrying a capacity of 96,000 tonnes.

The quarry is located at the top of the mountain (approximately 600m elevation) and some distance from the offices and processing facilities. The quarry is unique in the UK in that it utilises a 300m vertical 'glory hole' shaft and a 1.8km horizontal tunnel into the mountain to recover the stone worked in the quarry. A second, raised bore glory hole and new primary crusher station are currently under construction and should be close to commissioning at the time of the visit.

Figure 1. *Location map.*

GEOLOGICAL BACKGROUND:

The site extracts Strontian granite. The Strontian pluton occurs on the northwest side of the Great Glen Fault and is assigned to the Argyll and Northern Highlands Suite of late Caledonian granitic intrusions on the basis of its geochemical and isotopic characteristics. The pluton falls into the category of 'forceful' intrusions, thought to have emplaced by diapirism. As a means of pluton emplacement this mechanism is questionable, and alternative solutions have been presented. The Loch Sunart Geological Conservation Review (GCR) presents a cross section through the northern part of the Strontian pluton. Significant features include evidence for intrusion of basic magma contemporaneous with pluton emplacement, and fabrics resulting from syn-emplacement deformation. The pluton extends over an area of some 200km² in a north to south trending outcrop from the northwest shores of Loch Linnhe to the southern slopes of Meall a' Ghruith. It comprises; (i) an outer hornblende-biotite granodiorite facies, with porphyritic and non-porphyritic variants ('tonalite' and 'granodiorite' of early workers), and (ii) an inner biotite granodiorite ('biotite granite' or 'adamellite' of early workers) that extends eastwards as a vein complex cross-cutting the metasedimentary envelope.

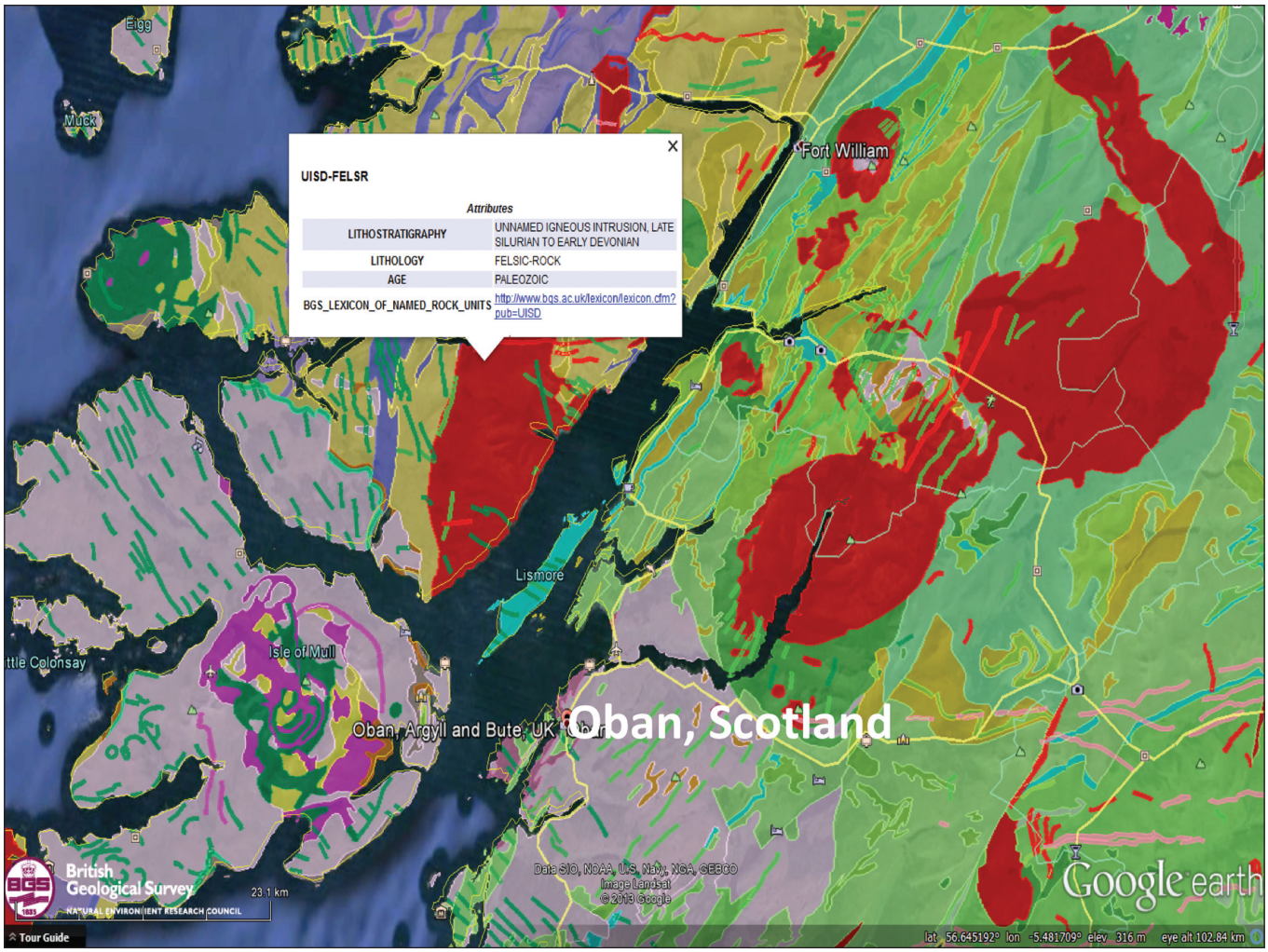


Figure 2. *Geological map.*

MUIR DEAN OPEN CAST COAL SITE

OPERATED BY HARGREAVES SERVICES PLC

PRODUCT: COAL

Field trip locations

Muir Dean Open Cast Site, Crossgates, Off the B981 – south of Crossgates, Fife, Scotland, KY11 7ES.

Date and Time

Wednesday June 11th 2014, 12.00 to 14.00.

INTRODUCTION

Originally operated by ATH Resources the site has been recently acquired by Hargreaves Services plc following the ATH liquidation in December 2012. ATH applied for, and was refused planning permission in October 2005. Following an appeal (sustained subject to Section 75), the decision by the local council to refuse the application was overturned by the Scottish Government. This decision caused considerable local opposition.

The site covers an area of 180ha of mixed farming and woodlands. The original intention was to produce 2 million tonnes of coal over 4.5 years (450,000 tonnes pa) with work commencing in April 2008. The site is currently being worked for coal and is also in a backfilling and restoration phase as a result of ATH Resources going into liquidation and Fife Council consequently calling in the £7 million restoration bond to enable the site to be restored.

After the liquidation of ATH Resources, Hargreaves acquired the mothballed site and commenced restoration works. When completely reinstated, the site will be grassed over, with a new loch created. The company is currently infilling two large voids at the southern edge of the 225-hectare site, with work expected to be completed around April/May 2014. It will then start 18 months of extracting the remaining coal reserves, with cash from the coal going into restoration work as well. A water treatment facility will be finished by the end 2014 and is expected to solve water pollution issues at the Fordel Day Level. It is expected that 80 jobs will be created by the operation.

Coal production hit a record low in the third quarter of 2013, down 32 per cent – or 1.3million tonnes from the same period in 2012. This was mainly due to the closure of collieries and mining companies, but despite the decline, coal accounted for a third of UK electricity needs in the same quarter of 2013. Hargreaves intend to see Muir Dean contribute to the tonnage mined in the UK in 2014 before the site is fully restored.

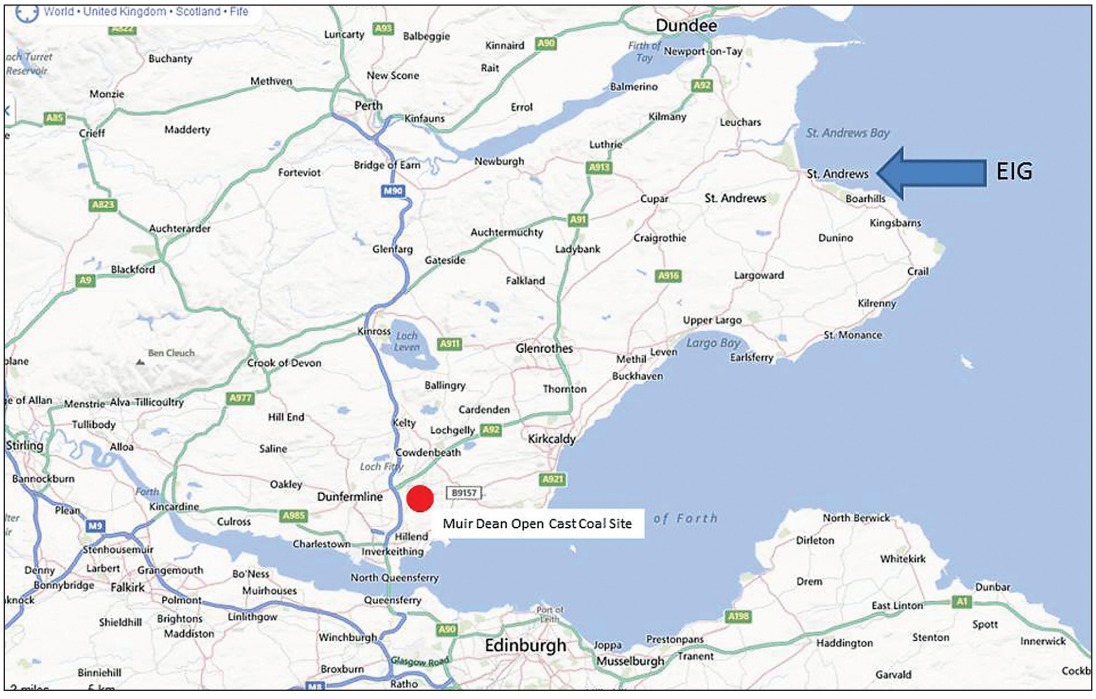


Figure 1. *Location map.*

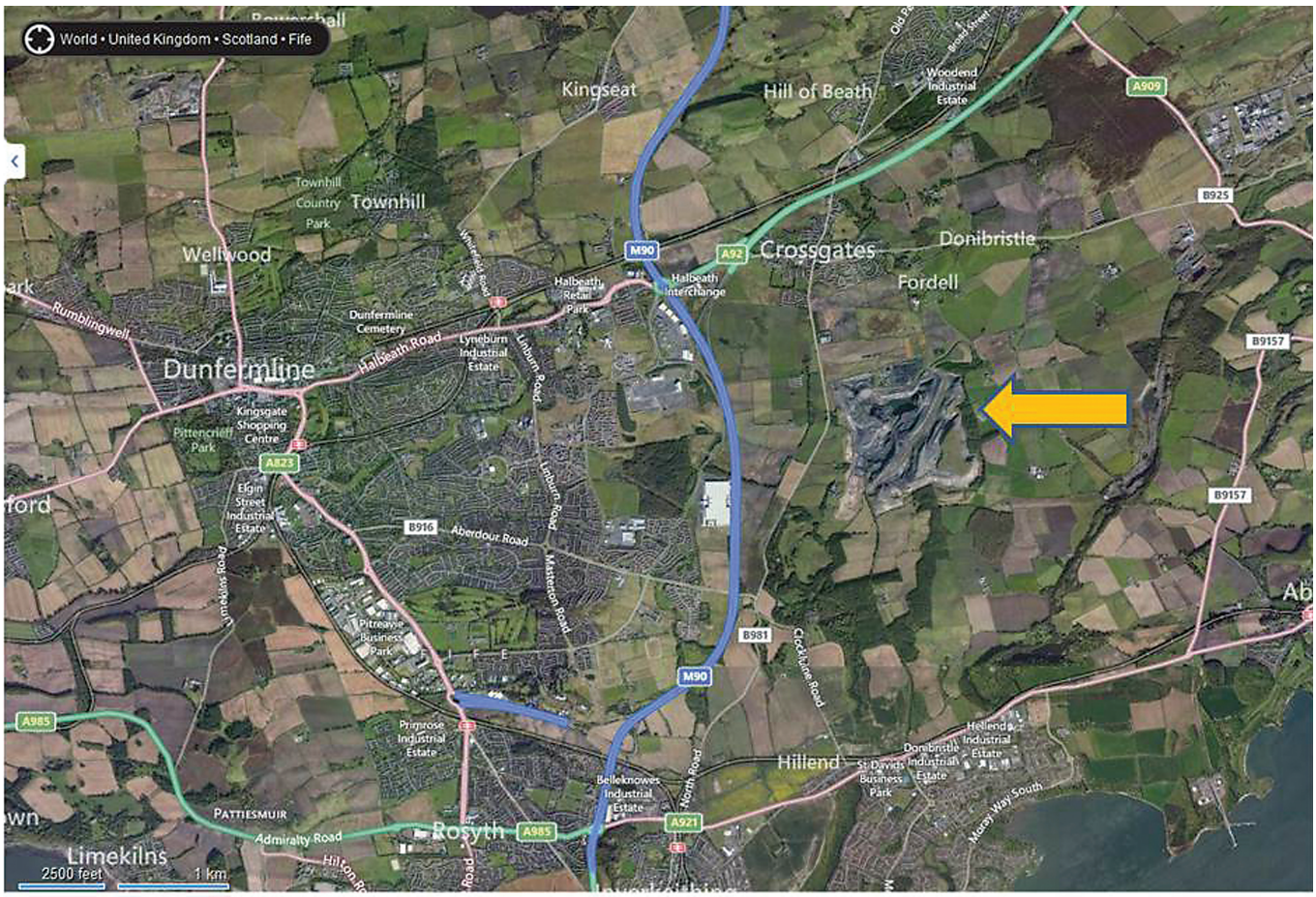


Figure 2. *Location map.* Source: Bing Maps and Microsoft Corporation

Geological Background

The site is located within the Carboniferous Clackmannan Group of late Dinantian and Namurian times. The Clackmannan Group consists of a lower unit of coarse sandstones, siltstones, mudstone, and limestones with thin coals and ironstones known as the Lower Limestone Formation, and an overlying sequence of similar rocks known as the Limestone Coal Formation. It is capped by Upper Limestone Formation and the sandstones of the Passage Formation. The latter includes fireclays, siltstones, mudstones, ironstones, coal and seatearths. Coal reserves came come from 6 seams; Glassee, Mynheer, Jewel, Fivefoot, Twofoot and Dunfermline Splint Seams.

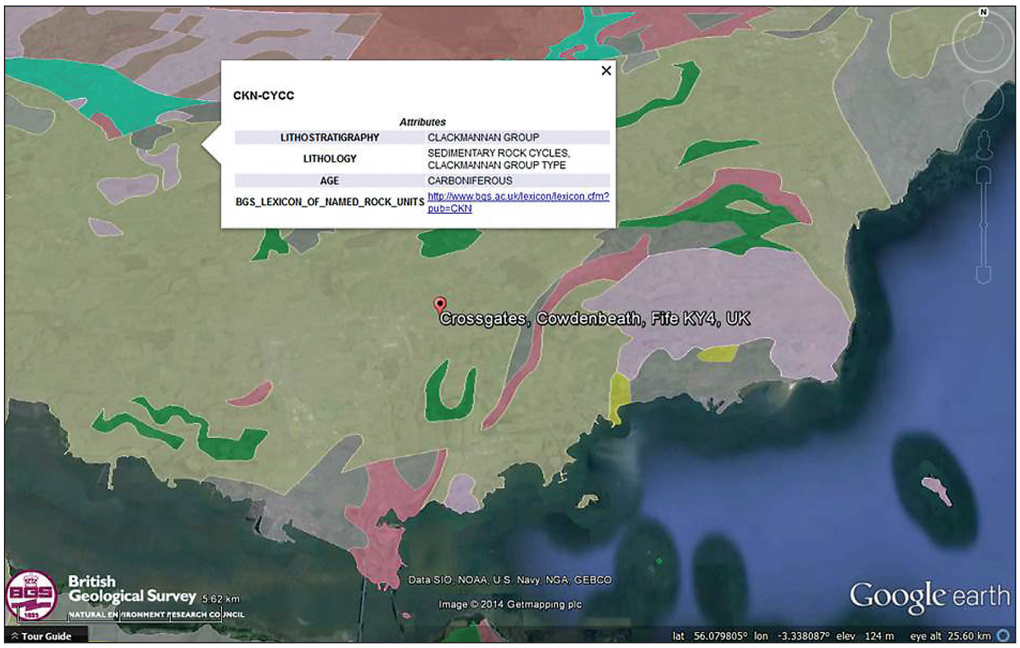


Figure 3. *Geological map.*

BURROWINE MOOR QUARRY

OPERATED BY PATERSONS QUARRIES

PRODUCT: SILICA SAND

Field trip location

Burrowine Moor Quarry, Fife Silica Sands (a division of Patersons of Greenoakhill), Bogside, Alloa, Scotland, FK10 3QD.

Date and Time

Wednesday June 11th 2014 at 13.00.

INRODUCTION

Quarrying of sandstone has taken place on the Burrowine Moor site under a planning permission since 1985. The silica sand reserve at Burrowine is notable for its uncharacteristically low iron content that allows it to be used in a relatively raw state in the production of specialist colourless glass products such as bottles and jars. The chemical characteristic of the Burrowine sand ensures that products created using it are noteworthy for their lack of imperfections. This exceptional quality allied with the relative lack of processing affords Burrowine sand fit for an industrial purpose. The Silica Sand Planning Fact Sheet for Scotland, produced by the Scottish Government in partnership with the British Geological Survey (BGS) recognises Burrowine as one of the primary sources of industrial sand in the country, and one of only four in Scotland that is suitable for the manufacture of colourless glass containers. The fact sheet also states that it is the `only known silica sand deposit in Scotland capable of producing sand for flint glass manufacture without (acid) leaching.'

The main types of sand produced are construction sand and industrial or silica sand. Silica sand includes sand used for glassmaking but it also embraces grades of sand used for a variety of other uses such as in recreation and horticulture.

GEOLOGICAL BACKGROUND

Scotland contributes about 0.4 x10^6 tonnes of silica sand to the UK total of c.4.0x10^6 tonnes. (UK Minerals Yearbook, 2012). Most comes from the Midland Valley where siliceous ganisters provide high quality material. Burrowine Moor quarry extracts from bedrock in

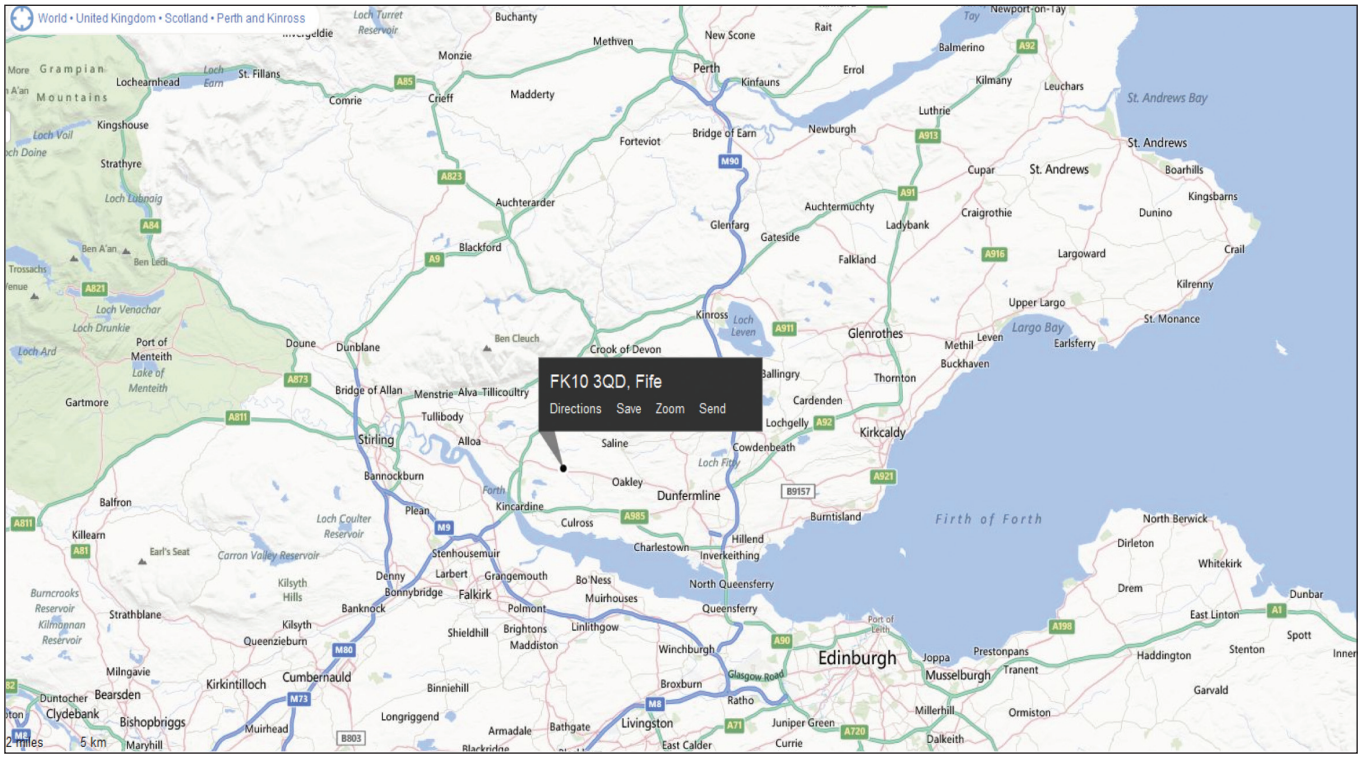


Figure 1. *Location map.*

Carboniferous Clackmannan Group. The Clackmannan Group is a suite of rocks of mostly Namurian age laid down during the Carboniferous period in the Midland Valley of Scotland. The Group consists of a lower unit of coarse sandstones, siltstones, mudstone and limestones with thin coals and ironstones known as the Lower Limestone Formation, an overlying sequence of similar rocks known as the Limestone Coal Formation, then an Upper Limestone Formation and at its top the sandstones of the Passage Formation. This last formation also includes fireclays, siltstones, mudstones, ironstones, coal and ganisters. The silica sand comes mainly from a 10-15m white sandstone near the No3 Marine Band in the Passage Formation and the site's planning permission allows for extraction from a sequence of four beds of silica sandstone (quartz arenite) that form part of the Passage Group. Although some of the iron sandstone is iron stained selective working produces glass sand with 99% SiO_2 and 0.02% iron oxide. Depositional environments are related to the repeated advance and retreat of fluviodeltaic systems into an embayment of varying salinity. The group is overlain by the Coal Measures.

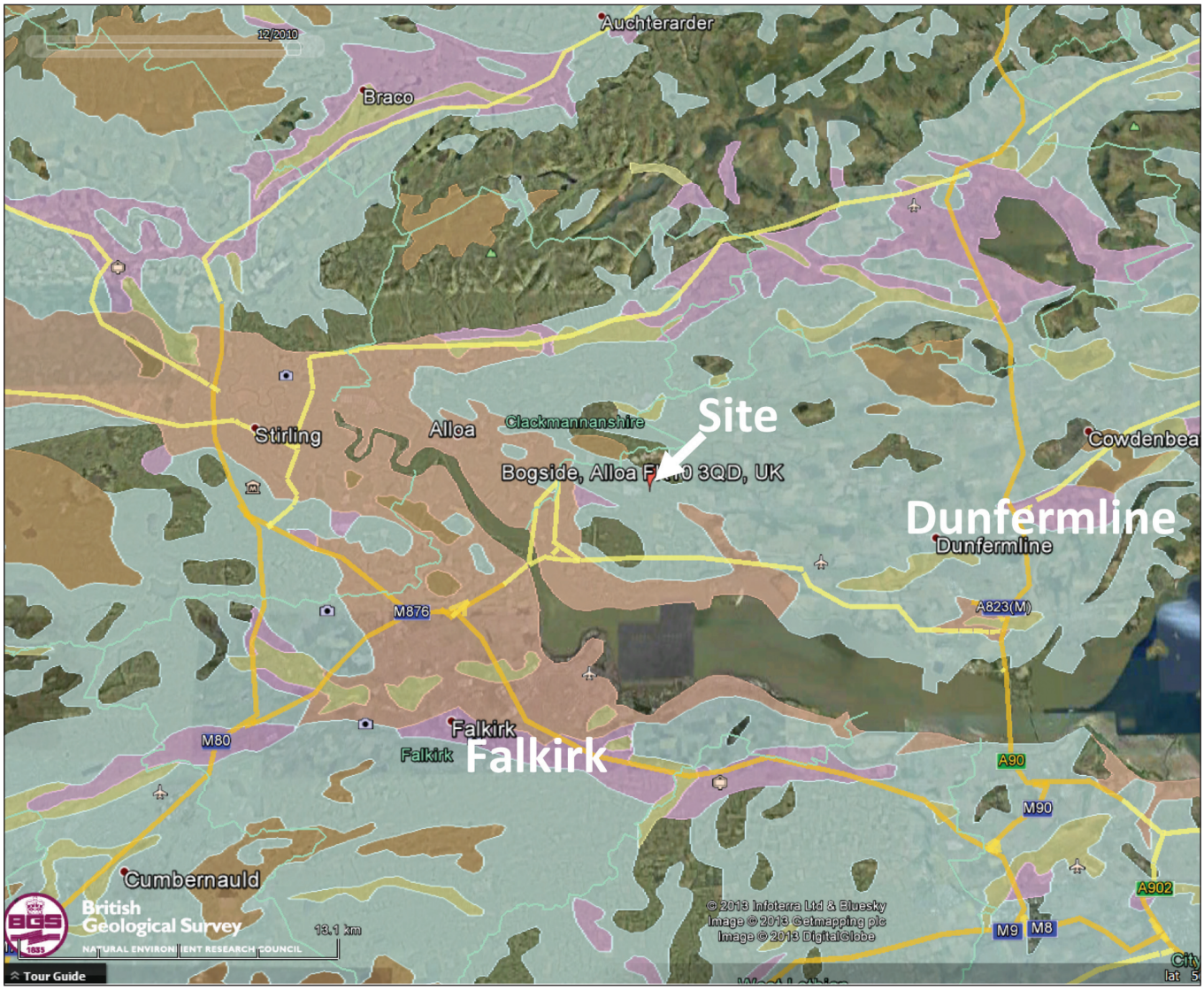


Figure 2. *Geological map.*

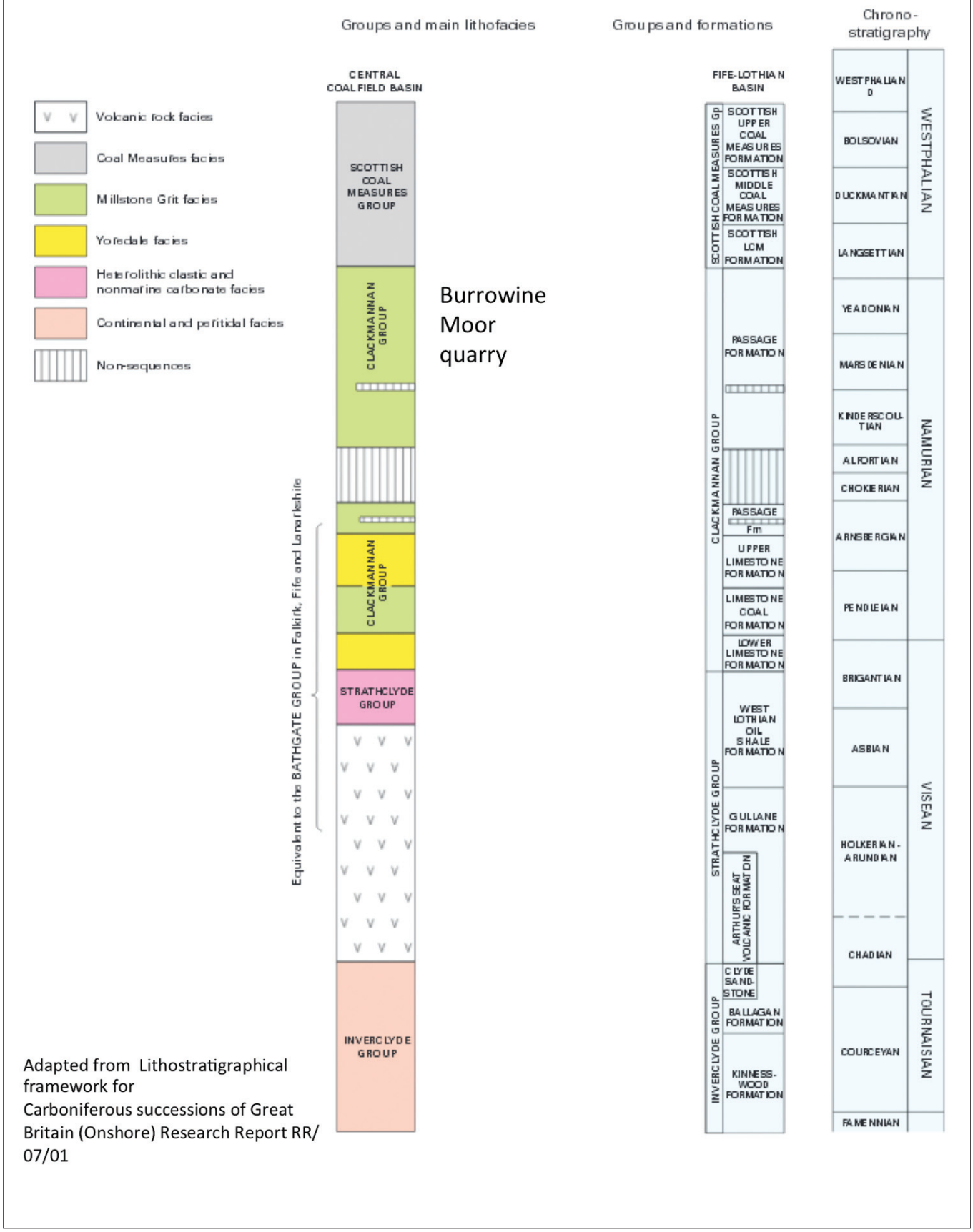


Figure 3. *Stratigraphic section.*

SHAP BECK LIMESTONE QUARRY

OPERATED BY HANSON UK

PRODUCT: LIMESTONE

Field trip location

Hanson UK Shap Beck Limestone quarry, Shap Beck Quarry, Shap, Penrith, Cumbria, CA10 2NX.

Date and Time

Wednesday June 11th 2014, 10.00 to 12.00.

Introduction

Shap Beck is a limestone quarry situated off the A6 in a rural area about two miles north of Shap village, seven miles south of Penrith and some 25 miles south of Carlisle. The quarry is the second largest in the Hanson group and produces around 500,000 tonnes of stone a year. The limestone found at Shap is very pure and around100,000 tonnes a year is used at the nearby Shap Fell works, owned by Tata Steel, to produce burnt lime, a fluxing agent in steel manufacture. The quarry also supplies local and regional markets and has on-site plants for making ready-mixed concrete and asphalt for road surfacing. There are 21 people employed directly and the quarry supports a further 30 jobs for drivers and contractors. The site extends to 118 hectares.

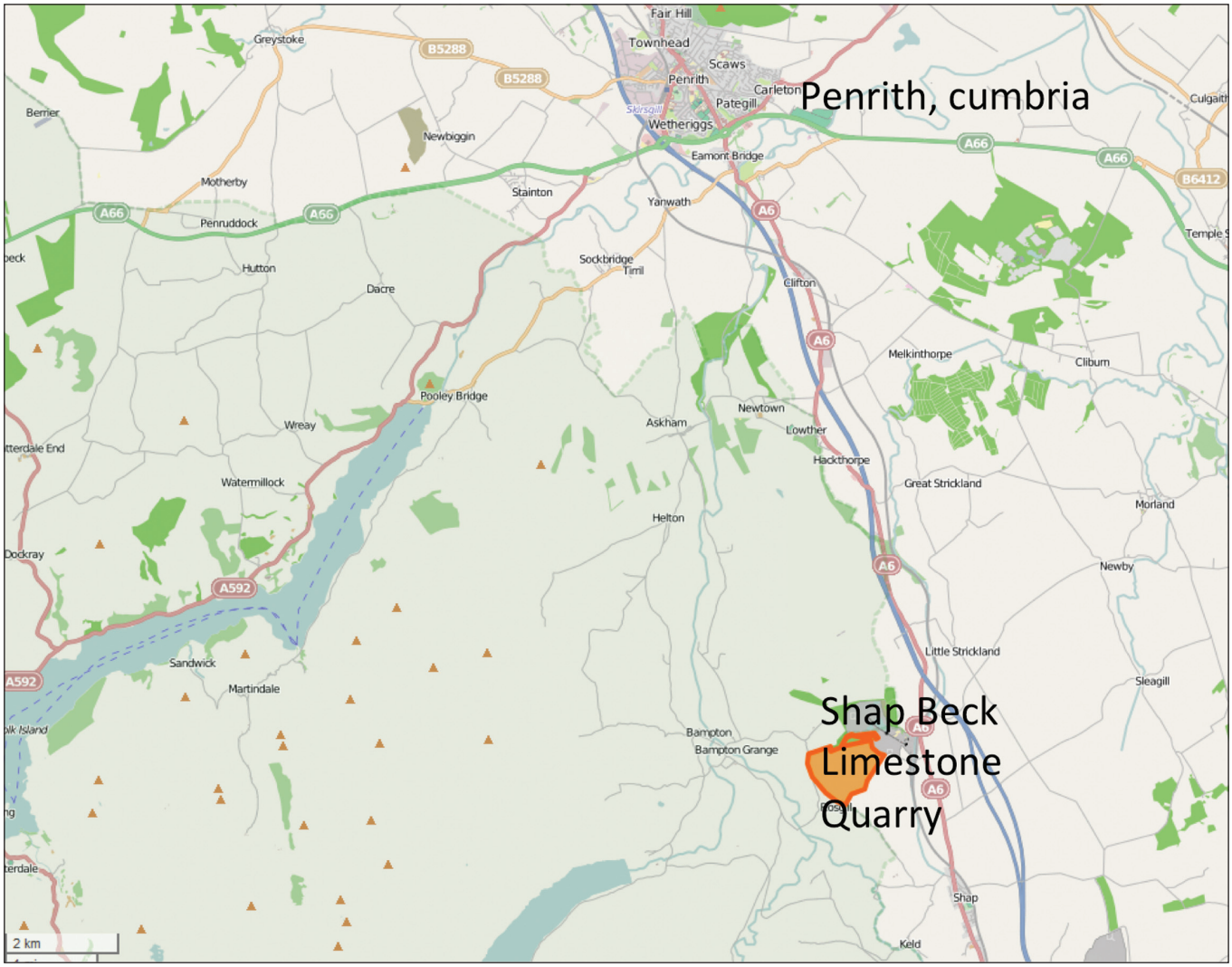


Figure 1. *Location map.*

Geological Background

Lower Carboniferous limestones – limestones with subordinate sandstone and shales. The limestone deposit contains both high quality white limestone and standard quality pink limestone. The high-grade mineral is utilised in the manufacture of steel. Pink limestone is more often utilised as a general aggregate and roadstone and utilised locally and regionally.

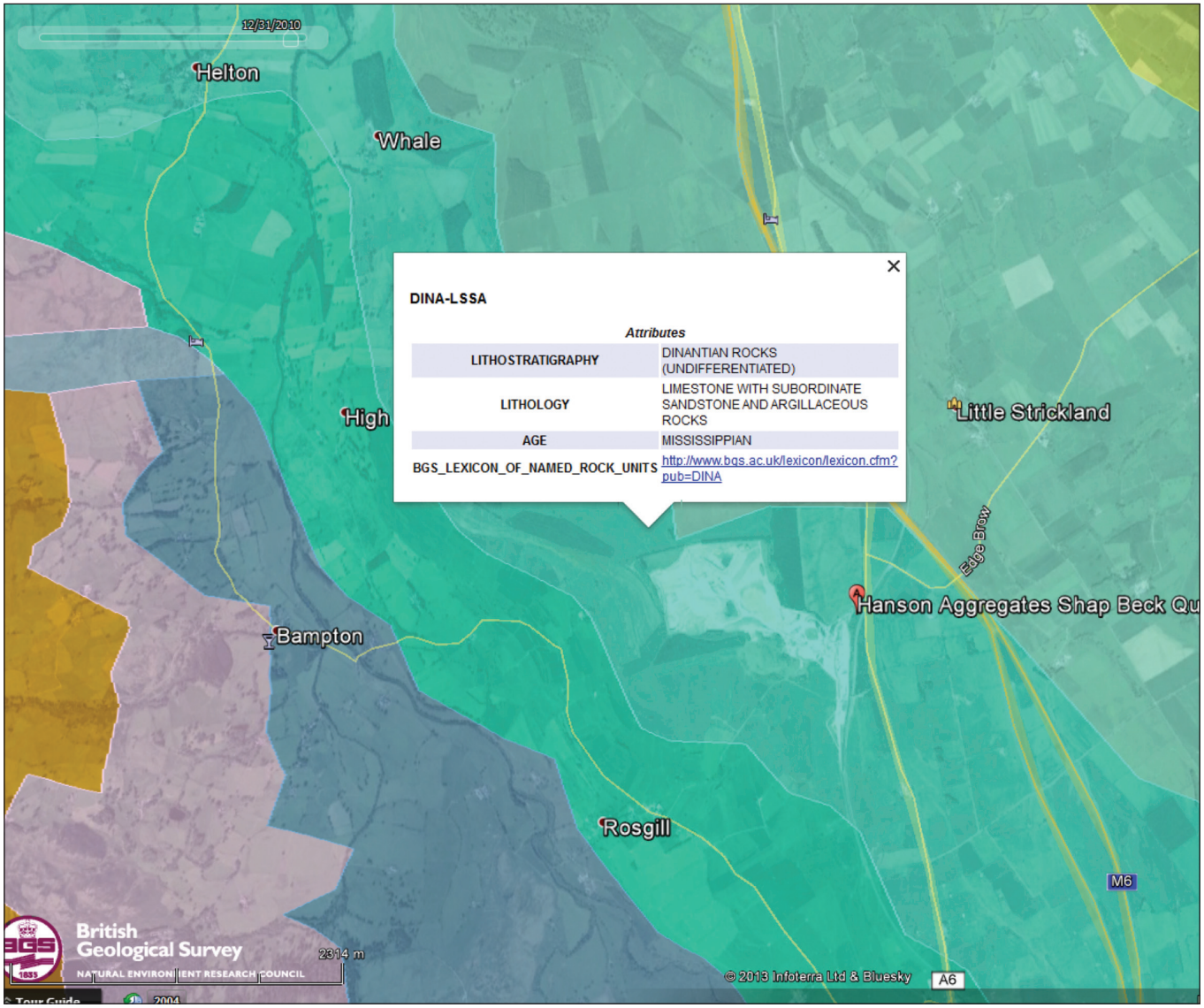


Figure 2. *Geological map.*

PRE-CONFERENCE FIELD EXCURSION TO SOUTHERN SCOTLAND AND NORTHERN ENGLAND 8TH TO 11TH JUNE, 2014

by P.W. Scott, Camborne School of Mines, University of Exeter and Peter W. Scott Ltd.

The aim of the excursion was to show some of the geology and industrial mineral resources of Southern Scotland and Northern England to the North American delegates who were attending the conference. The excursion started in Edinburgh and stops were made at Hutton's Unconformity in Jedburgh and at Carter Bar where the geology of the distant Cheviot Hills and surrounding area was described. A visit was made to Barrasford Quarry, near Corbridge, Northumberland, where the Great Whin Sill and overlying limestone are extracted. This was followed by a visit to the Roman Wall at Housesteads. On the following day a visit was made to Thrislington Quarry, near Ferryhill, Co. Durham, where the Permian Raisby Formation (Magnesian Limestone) is extracted for use as aggregate and high purity dolomite is calcined to produce dolomitic lime for the steel industry. Several stops were made along Weardale to explain the geological setting of the mineralisation of the Northern Pennine Orefield and observe some of the former mining activity. The final stop was an underground visit to Killhope Mining Museum.

A visit to Birkshead Mine, and the restored areas of Newbiggin Mine, near Appleby was made on the next day. At Birkshead Mine, gypsum is extracted from the Upper Permian A Bed which is some 35m thick. Some 9m are extracted from the upper part of the seam using room and pillar methods. The restored Newbiggin Mine has been returned to agriculture and merges in with the rural landscape of the Eden Valley. A late afternoon drive through the Lake District completed the day.

Shap Beck Quarry was visited on the last day. This quarry is in the Carboniferous limestone Knipe Scar Limestone Formation. Crushed rock aggregate coated roadstone, ready mixed concrete and agricultural lime are produced, along with the feedstock for the Shapfell Lime Works. The latter has three modern Mearz lime kilns and provides lime flux for the steel industry and lime products for other applications. The excursion concluded with the journey to the conference venue at St Andrews, via a stop to view the Forth Bridge.

The leaders for the excursion were Adrian Charters, Duncan Wardrop, Clive Mitchell and Peter Scott. The managers and geologists of the quarry and mining companies are thanked for hosting the visits.

POST-CONFERENCE FIELD EXCURSION TO THE SCOTTISH HIGHLANDS

13th to 16th June, 2014

by P.W. Scott, Camborne School of Mines, University of Exeter and Peter W. Scott Ltd.

The excursion was designed for the North American delegates to illustrate the geology and scenery of the Highlands, to take in some of the culture and to visit some extractive operations. The excursion departed from St Andrews immediately following the conference and travelled to Dunkeld. The barytes mine at Foss near Aberfeldy was visited on the following day, passing Schiehallion en route. Foss Mine is a stratabound deposit located in the Ben Eagach Schist Formation made up of Proterozoic metasedimentary rocks. It is the major source of barytes in the UK. The remainder of the day was spent travelling via Fortingal, Killin, Crianlarich, Glen Coe, the slate quarries at Ballachulish, which once were a major source of roofing materials, Fort William and the Spean Bridge Commando Memorial to Inverness.

The following day's excursion was to the northwest Highlands, initially visiting Morefield Quarry in Ullapool. This quarry is situated within Durness Limestone of Cambro-Ordovician age, and is overthrust by the Archaean Lewisian Gneiss, which forms the overburden to the most recent extractive operations. The thrust contact can be seen in the quarry face. The quarry produces aggregates as well as agricultural lime. The internationally important and Site of Special Scientific Interest (SSSI) Knockan Crag was visited next. This exposes the foreland stratigraphy of Lewisian Gneiss, Torridonian Sandstone, the complete Cambrian sequence of quartzites, dolomitic mudstones, sandstones and the Durness Limestone and the Moine Thrust, with Moine schists overlying. Further stops were made beside Loch Assynt, including the ruins of Ardvrek Castle, and the brucite marble at Ledbeg, before returning to Inverness.

The first visit on the final day was to Daviot Quarry, a few miles to the south of Inverness, with a brief stop at Culloden Moor en route. Daviot Quarry is in granitic schist and produces a wide range of aggregate products. This was followed by a visit to Tomatin Distllery, a stop at the roche moutonnée at Nethy Bridge and at Tomintoul. The excursion concluded with a visit to Balmoral Castle, returning to St Andrews via Braemar, Glenshee and Blairgowrie, and finally Edinburgh.

The leaders for the excursion were Graham Smith, Duncan Wardrop, Adrian Charters and Peter Scott. The quarry and mining companies are thanked for hosting the visits.