A preliminary geological assessment of Craiglea Quarry, Logiealmond, Perthshire

Decarbonisation & Resource Management Programme

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BRITISH GEOLOGICAL SURVEY

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A preliminary geological assessment of Craiglea Quarry, Logiealmond, Perthshire

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Editor

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Roofing slate, quarry, quarrying, Craiglea quarry, Logiealmond, Highland Border Slate.

Front cover

View from inside the main excavations at Craiglea quarry, looking west.

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Executive summary

This report describes the outcomes of a preliminary geological assessment of Craiglea Quarry, Logiealmond, Perthshire [NGR 294950 732290]. The quarry is a source of Highland Border Slate, a building stone that has seen widespread use throughout much of Scotland as a traditional roofing material. The extant worked faces of the quarry expose inter-layered metasandstone (psammite) and metamudstone (pelite) rocks; the latter is a true 'slate-rock' and would have been the target of the quarrying activities. The 'slate-rock' appears to be best-developed within a 20–30 m thick, inclined layer consisting predominantly of metamudstone.

Renewed extraction of slate at the quarry may be challenging due to the degraded state of the former quarry, where abundant screes cover the original workings and limit access. Furthermore, extracting significant quantities of high-quality slate would likely involve removal of a relatively high volume of psammite rock that may end up as waste unless a use for this material (as a 'by-product' of the slate quarrying) can be found. Nonetheless, recoverable slate is present and could be targeted by further extending the existing workings to the north-east or east.

1 Introduction

This report describes the outcomes of a preliminary geological assessment of Craiglea Quarry in Perthshire, which was undertaken in order to establish the geological context of the site, and to comment on the potential for renewed extraction of stone for masonry and roofing slate products.

Craiglea Quarry is situated on the Logiealmond Estate, *c.* 14 km north-east of Crieff. It is thought to have been operational as a roofing slate quarry for some one hundred years before becoming abandoned around the end of the 19th Century. Since then, the site of the former quarry has become somewhat degraded, with abundant screes now covering over the original workings. Large, conspicuous spoil heaps dominate the present site to the east and south-east of the quarry. These consist of both the waste rock created during block extraction, as well as 'trimmings' generated whilst finishing roofing slates and stones ahead of shipment.

Craiglea Quarry is a source of Highland Border Slate, a traditional building stone obtained at numerous quarries located within a narrow swathe of ground extending from the island of Bute in the Firth of Clyde to the town of Dunkeld in Perthshire (Figure 1). In the past, the slate produced in some of the quarrying areas was known by the name of the local area from which it was sourced (e.g. Aberfoyle Slate, Luss Slate, Dunkeld Slate). The various source quarries worked several constituent bedrock units ('formations') of the Dalradian Supergroup, which extends along the north-western side of the Highland Boundary Fault. The stone consisted originally of mud that was deposited on a sea floor during the second half of the Neoproterozoic Era and first half of the Cambrian Period (*c.* 800–500 million years ago), when the area that is now Scotland lay south of the Equator, at roughly the same latitude as Patagonia is today. Metamorphism during the Caledonian Orogeny (*c.* 470 million years ago) produced a planar metamorphic fabric in the stone, along which it splits readily. Highland Border Slate was used locally as well as being transported throughout the surrounding regions, mainly for roofing but also for masonry. Slate from the Aberfoyle quarries, in particular, has seen widespread use throughout much of Scotland as a traditional roofing material. However, Highland Border Slate is no longer actively produced at any quarry in Scotland.

Historic Environment Scotland (HES) has asked BGS to undertake this assessment as supplies of Highland Border Slate are needed for the repair and conservation of historically important buildings and structures. In principle, if stone block suitable for fashioning into roofing slate (as well as other building or paving stone products) can be routinely produced at Craiglea Quarry once more, this will be of benefit to the built and historic environment.

This report is based on observations made during a one-day visit to Craiglea quarry by Paul Everett and Graham Leslie (BGS), and a desktop review of BGS resources (including geological maps, memoirs, reports and rock collections), HES publications, aerial photographs and other historical documents.

Only a small number of previously published accounts contain information that is directly relevant to this assessment.

- The publication *Scottish Slates* by Richey and Anderson (1944) provides a highly informative account of the geological character and setting of the various 'slate belts' of Scotland, and a description of the associated workings and remaining reserves, as they were understood at the time. That publication is one of a series of 'wartime pamphlets' that collectively summarised the status of key natural resources in Britain at a time when national resource security was paramount. Several of the slate quarries on Luing and around Ballachulish were still active at the time *Scottish Slates* was published, though the industry was much reduced from its peak.
- More recently, Historic Scotland (now Historic Environment Scotland) commissioned two studies related to Scottish slate as part of early attempts to lay the groundwork for renewed production of traditional Scottish building stones generally. These studies resulted in detailed reviews of: (i) the quarries and quarrying history in each of the main

slate-producing areas of Scotland, with descriptions of the geological and performance characteristics (especially durability) of associated slates (Walsh, 2000); and (ii) the technical characteristics of the different Scottish slates, in particular their crystallinity, fabric and weathering properties (Walsh, 2002). The latter publication included an assessment of the feasibility of reviving the Scottish slate industry. Both publications are thorough and well-illustrated.

Section 2 of this report provides some background to the geological concepts and terminology associated with slate-rock, while our observations made at Craiglea Quarry are presented in Section 3. A review and synthesis of our findings are provided in Section 4, along with our conclusions on the potential for renewed slate extraction at the quarry.

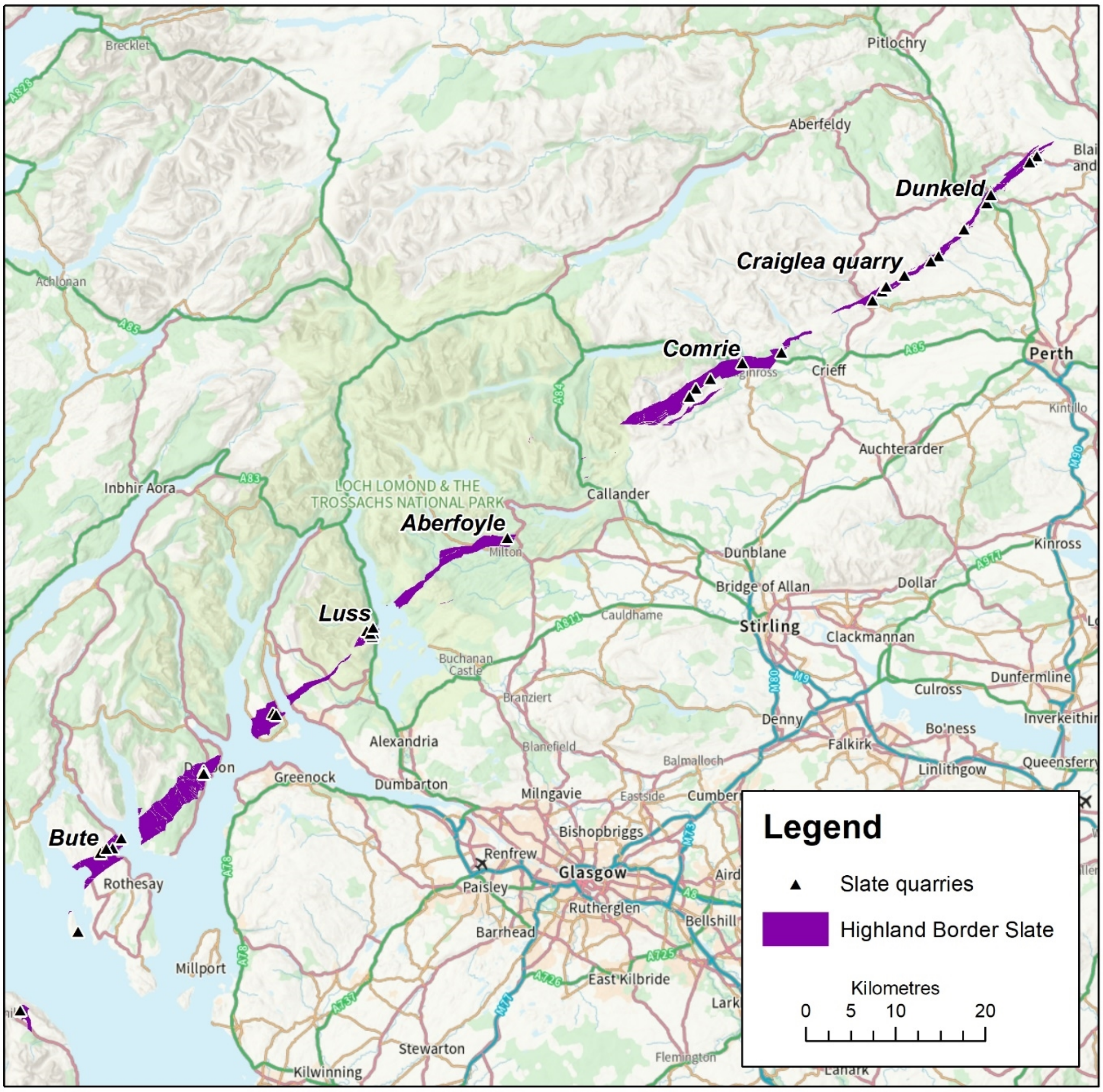

Figure 1. Map showing where the source bedrock units of Highland Border Slate crop out and the locations of former Highland Border Slate quarries.

Significant quarrying areas are named and the location of Craiglea quarry is shown. Data sourced from the Building Stone Database for Scotland. Contains Ordnance Survey data © Crown copyright and database rights 2022. Ordnance Survey Licence No. 100021290 EUL

2 Geological background

This section of the report provides some context for what follows, by describing the 'geological setting' of Highland Border Slate and the processes that led to its formation, and introducing some of the relevant technical terminology. We note firstly that the term *slate* is used widely to refer to both a type of rock and a roofing material, and as such can be confusing; for clarity, the more specific terms *slate-rock* and *roofing slate* are used, respectively, in this report to distinguish the natural geological material from the man-made product.

The Grampian Highlands of Scotland, which includes all of the ground between the Great Glen and the Highland Border, are underlain predominantly by a single geological entity: the *Dalradian Supergroup*. This very large geological unit comprises a thick pile of mainly sedimentary strata that accumulated between *c*. 800 and *c*. 500 million years ago on the floor of a shallow sea bordering an ancient continent called Laurentia. Different types of sediment within the Dalradian succession formed in different depositional settings: in very general terms, layers of mud were deposited in still water, layers of sand in agitated water, layers of gravel in flowing water, and layers of lime precipitated in still or agitated water. Layers of volcanic rock of mainly basalt composition also formed during periods when volcanoes were active; some volcanic layers formed on the surface of the sediment pile, while others formed as sheets or layers of magma that were injected into it and then solidified. As the pile accumulated, buried sediment was transformed into solid rock: mud sediment became mudstone, sand became sandstone, gravel became conglomerate, and lime became limestone. Each layer is a *bed*, and that layering is referred to generally as *bedding*.

Around 470 million years ago, all of the rocks in the *Dalradian Supergroup* were affected by the *Caledonian Orogeny*, a continent-scale mountain-building event caused by the collision of tectonic plates. *Metamorphism* – due to elevated temperature and pressure – transformed the sedimentary and volcanic rocks into metamorphic rocks: mudstone became *metamudstone* (or *pelite* if it was strongly metamorphosed), sandstone became *metasandstone* (or *psammite* if it was strongly metamorphosed), quartz-rich sandstone became *quartzite*, limestone became *metalimestone*, and volcanic rock became *metabasite*.

At the same time, *deformation* – resulting from compression as continental blocks first approached each other and then collided – caused the strata to become folded at a range of scales; the smallest individual folds can be less than one millimetre in size, while the largest recognised folds are more than 100 kilometres in extent. A fold that is convex upwards is an *anticline*, and one that is concave upwards is a *syncline*. These and other terms that are used to refer to the different parts of a fold are shown in Figure 2.

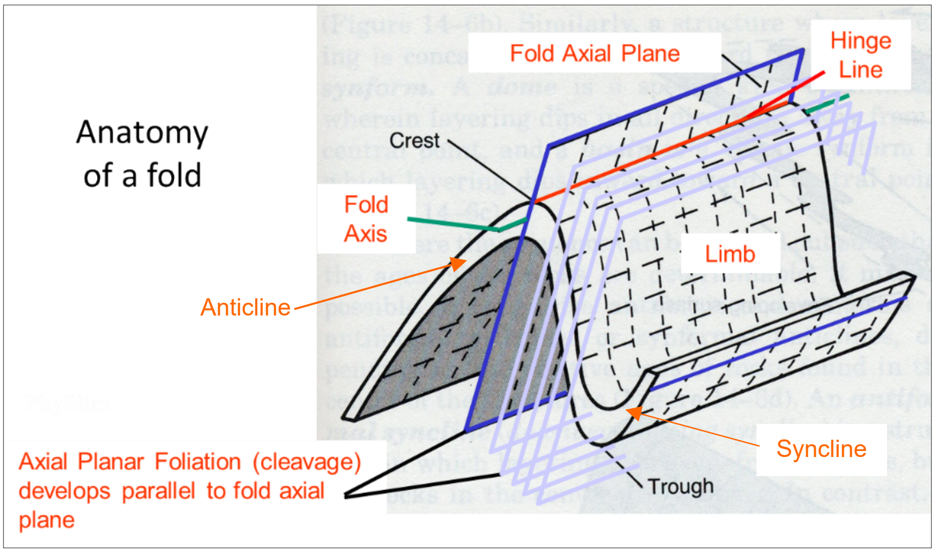

Figure 2. Three-dimensional relationship between a metamorphic cleavage and a fold structure.

The compressive force that caused the strata to fold also caused individual crystals to recrystallise and re-organise, such that closely spaced, often mineralogically distinct, layers developed in the rocks. New crystals grew within these layers, often aligned with each other and parallel to the direction of minimum force (i.e. at right angles to the direction of compression). The folded rocks therefore contain closely spaced thin layers and surfaces orientated parallel to the fold axis, along which the rock is often prone to part, or cleave; the parallel layers and surfaces that result from folding are therefore referred to collectively as *cleavage* (Figures 2–4).

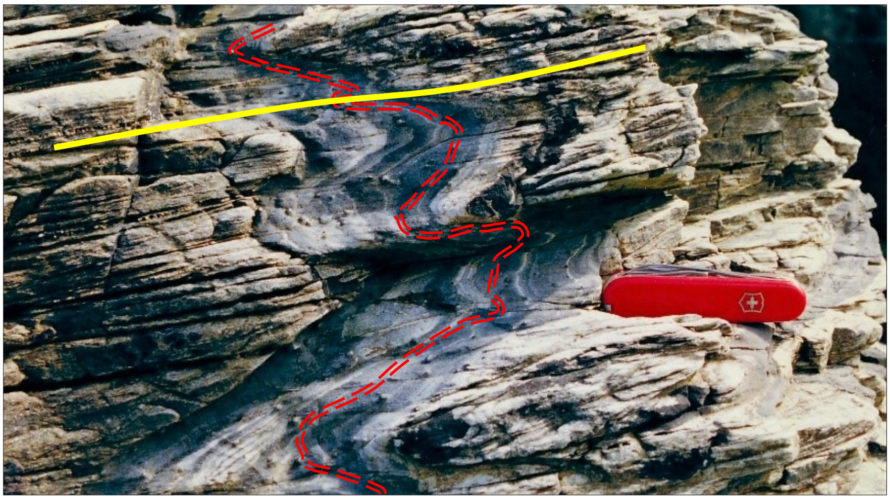

Figure 3. An example of bedding and cleavage at outcrop.

Several small folds (shown by the red trace) are developed in beds of buff metasandstone and grey-blue metamudstone. A strong metamorphic cleavage is superimposed throughout (general trend shown in yellow), parallel to the fold axial planes (*cf.* Fig. 2). The angular relationship between bedding and cleavage changes in different parts of each fold. Penknife for scale.

Cleavage develops best in rocks containing crystals that grow naturally as thin 'plates', as these can most effectively re-align to form parallel layers and surfaces. One of the best minerals in this regard is *mica*, which occurs in many rock types. Mica is actually a 'family' of minerals, the commonest types being *biotite* and *muscovite.* Mudstone usually contains a large proportion of very fine-grained mica, so folded and metamorphosed layers of mudstone usually have a well-formed and closely spaced cleavage defined mainly by aligned flakes of mica. Metamudstone that parts readily along cleavage into thin, tabular blocks is known as *slate* (herein referred to as *slate-rock*). The closely spaced and well-formed cleavage that is typical of slate-rock is commonly referred to as *slaty cleavage* (Figure 4). Cleavage is usually much less well developed in rocks that typically have little or no mica, such as sandstone.

All three of the main building stones of Scotland that have produced roofing slate – *West Highland Slate*, ***Highland Border Slate*** and *Macduff Slate* – correspond to metamudstone layers developed in different parts of the Dalradian Supergroup.

Sedimentary rocks that have not been metamorphosed and folded tend to part most easily along *bedding surfaces* (i.e. crudely parallel surfaces that separate, and form within, the rock layers). If a cleavage forms subsequently, there are then two sets of surfaces in the rock along which it can part – bedding and cleavage; the extent to which a rock prefers to part along one or both of these sets of surfaces depends on how cohesive they are.

In folded strata, the angular relationship between bedding and cleavage changes in different parts of each fold, because bedding follows the curve of the fold while cleavage related to that folding is everywhere parallel to the fold axial plane (Figure 4). Thus, bedding and cleavage can be essentially parallel, or nearly so, on the *limbs* of a fold, and more nearly at right angles (normal) to each other in the *fold hinge* (the *crest* or *trough* part of a fold, where the two opposing limbs meet). Those differences become more accentuated as the fold becomes more strongly developed and drawn out (*attenuated*).

The quality of slate-rock quarried for roofing purposes often depends on the *bedding-cleavage relationship*. Traditionally, the best and largest slates come from fold limbs, where bedding and cleavage can be near-parallel and the rock therefore will tend to split along just one set of parallel surfaces. By contrast, a fold hinge setting would generally be considered the less prospective, largely because bedding and cleavage are highly oblique to each other and the rock therefore can split along two non-parallel sets of surfaces. In many rocks, this will tend to produce squat, angular fragments of rock, or narrow elongate ‘pencils’ of rock, rather than thin, tabular (slate-shaped) blocks. However, thick beds of uniform composition and character may show less tendency to split along individual bedding planes and so may also be a good prospect for quality slate-rock.

Folds can be symmetrical or asymmetrical; in the latter case, they have one shorter and one longer limb (Figure 4). On long fold limbs, the angular difference between bedding and cleavage may be only a few degrees and thus hard to spot.

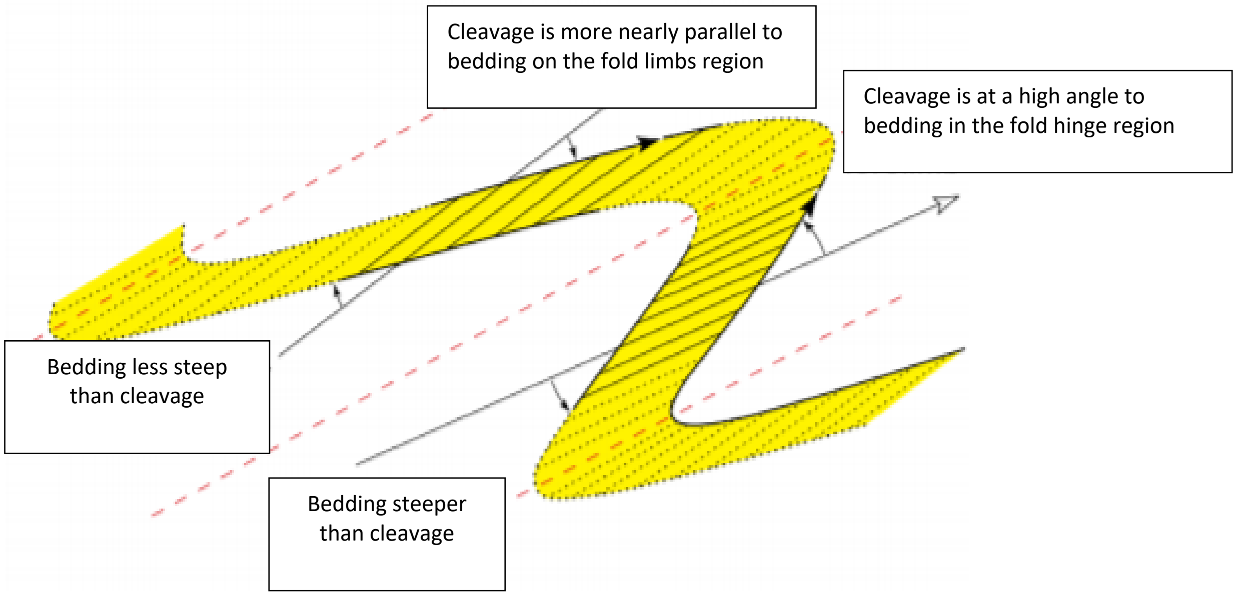

Figure 4. Changing bedding-cleavage relationship across an asymmetrical fold.

Bedding follows the curve of the fold. Note how the angle that cleavage makes with bedding changes systematically from one fold limb, across the fold hinge region, to the opposing fold limb.

Coloured banding that characterises some roofing slates, and is often referred to as *ribboning*, occurs when bedding and cleavage are oblique and the rock parts along cleavage rather than bedding; the coloured bands are the original sediment layers (i.e. bedding) now cut through by the cleavage and exposed on the cleaved surface.

Orogenies (such as the Caledonian Orogeny) are often complex, multi-stage events involving multiple phases of collision between tectonic plates. Rocks will likely be folded more than once, in different orientations, to differing degrees in different places, and under different geological conditions. New fold structures can form during each stage of deformation, and with each phase of folding a new cleavage usually forms; cleavage formed during younger events tends to overprint and modify (or even obliterate) older ones. Geologists will often refer to each phase of collision, and its deformation products, using the letter ‘D’; thus, D1 would signify the earliest discrete deformation event. Geologists then attribute other features related to that event in a similar manner, for example, F1 folds and S1 cleavage (S=surface) would both be related to D1.

The Caledonian Orogeny involved at least four more-or-less discrete phases of deformation. Of these, the first two – D1 and D2 – can be thought of as working together to produce very large-scale (km- to many 10s of km-scale) fold structures that created the essential architecture of the ‘Scottish Caledonides’ *c.* 470 million years ago. The main Dalradian rock units are, broadly speaking, aligned parallel to the trends of those major folds. As a general guide, major fold structures can be traced from north-east to south-west across the Grampian Highlands, including the Highland Border region. There, folds and cleavage already formed in a D1 deformation event are refolded into the generally steeply-dipping 'panel' of rocks referred to as the *Highland Border Steep Belt* (e.g. Stephenson and Gould, 1995). The structural geological details of this region are described in detail in Tanner *et al.* (2013). In that publication, exposures at nearby Little Glenshee are described in detail; these share many similar features with the structural geology of Craiglea Quarry.

Several geological factors can reduce the amount or quality of slate-rock in any given area. The following are among the most important:

- *Interbedded layers of other rock types* – this problem occurs most commonly near the top and bottom of thick beds of slate-rock, where layers of rock that are more characteristic of the preceding and succeeding layers (which could be, for example, metalimestone or quartzite) can be interbedded with the slate-rock, as a result of a transitional change from one depositional setting and/or sediment source to another.
- *Quartz veins* – these tend to occur in closely spaced sets and irregular masses, and where they do, the quality and amount of slate-rock that can be extracted can be greatly reduced. Quartz veins form in slate-rock because the metamorphism and deformation that converts mudstone into slate-rock simultaneously releases silica from minerals in the rock; the silica moves through the rock by migrating along cleavage surfaces, and tends to accumulate – and crystallise into quartz – in zones of relatively low pressure, such as fold hinges.
- *Fractures* – all types of fractures, including unmineralised joints, mineralised joints (veins) and faults, disrupt the continuity of the rock in which they form; in beds of slate-rock, they can greatly reduce the quality and amount of rock that can be extracted. Whereas folds tend to form when rocks are hot and deforming in a ductile manner, fractures tend to form later when they are cool and deforming in a brittle manner.
- *Overburden and ice damage* – superficial deposits, such as glacial till, sand, gravel, soil and peat, overlie much of the bedrock in Scotland, and can restrict access to it; in places, the thickness and instability (in engineering terms) of overburden impose a significant constraint on quarrying. Large ice sheets have moved across Scotland on several occasions during the 'Ice Age' (i.e. during the last *c.* 2.6 million years), and the abrasive effect of the ice as it moved has in some places damaged the bedrock immediately beneath. The *fissility* (propensity to split) of slate-rock makes it particularly susceptible to this process, and such rock can be physically damaged (and consequently more strongly weathered than usual) to a depth of several metres where this has happened.

3 Craiglea Quarry, Logiealmond, Perthshire

3.1 INTRODUCTION

Craiglea Quarry lies at an altitude of *c.* 470 m above sea level, on the south-east facing hillside some 1500 m north-west of Logiealmond Lodge, at NGR [294950 732290] (Figure 5).

Judging by the layout of the quarry and surrounding land, it appears that the quarry excavations were driven into the hillside from the south, and then expanded downwards to the south-west and north-east. A smaller excavation to the south is joined to the larger main workings to the north via a corridor cut through the bedrock. A shelf on the southern side of the main working is some 25 m above the deeper parts of the quarry; areas below the shelf level could not be accessed safely. Historical photographs show the extent and depth of the workings[1], and also considerable numbers of prepared slates of various hues, stacked and ready for transport.

The extent and make-up of the various spoil tips suggests that the quantity of high-quality slate that could be won from the quarry was somewhat limited without removing and generating a relatively high volume of 'waste'. Nevertheless, a significant excavation was achieved over time, apparently supplying slate for local roofing demand, perhaps until supplanted by more economic sources from further afield.

3.2 BEDROCK GEOLOGY

Craiglea Quarry worked metamorphic rocks of the Birnam Slate and Grit Formation (see, for example, Crane *et al.* 2002), part of the Dalradian Supergroup and one of the source bedrock units of Highland Border Slate. This unit has also been referred to as the Aberfoyle or Birnam Slates (e.g. Harris *et al.* 1994).

The extant worked faces of the quarry expose inter-layered metasandstone (psammite) and metamudstone (pelite) rocks; the latter is a true 'slate-rock' and would have been the target of the quarrying operations. The metasandstone layers will have largely gone to waste, though some of this material would have found other uses, such as for roadstone, rubblestone or walling stone.

The 'slate-rock' appears to be best-developed within a 20–30 m thick, inclined layer that is exposed in the north-eastern and south-western walls of the quarry, and which would have extended through the quarry void prior to extraction. Where seen, the slate is a greenish- to bluish-grey, fine-grained rock with subsidiary pale grey to brown sandstone layers locally developed within the dominant mudstone lithology. The 'slate-rich' layer appears to be bounded by more metasandstone-rich layers above and below (Figure 6). These metasandstone layers can preserve sedimentary structures such as cross-ripple and cross-bed laminations. Striping indicating the original depositional layering (bedding) can be seen on many of the cleanest exposures (Figure 7), especially in the eastern wall of the quarry. A few thin (centimetre-scale) irregular quartz veins are developed locally, but do not appear to be a significant element in any of the preserved exposures.

The rock mass tends to break apart into lozenge-shaped decimetre- to metre-scale blocks (Figure 8), either along bedding or along the slaty cleavage (S1). The cleavage is typically planar and unaffected by any later superimposed crenulation folding ('wrinkling'), such as that commonly exhibited by West Highland Slate. 'Craiglea slates' therefore possess cleavage surfaces that are either relatively flat, or slightly rough and flaky. Riving blocks into 8–14 mm thick tiles seems achievable, based upon material present amongst the quarry waste, and as observed on the roofs of buildings locally.

Bedding for the most part dips moderately to the west-northwest or west at 30–35° (example measurements: strike 026 / dip 32°WNW and strike 360 / dip 32°W). More northerly strike determinations are atypical. The S1 slaty cleavage is always more steeply inclined than the bedding (to the north-west); measurements of 042 / dip 45°NW, 043 / dip 42°NW and 056 / dip

[1] In one of a series of articles about the history of Glenalmond and Logiealmond, by Rosalind Pearson; a local history website – see http://www.glenalmond.biz/Almondglen/Craigleaquarry.pdf

63°NW are representative. Dips at the steeper end of this range may have been more common in the deeper (now inaccessible) parts of the working quarry (Richey & Anderson 1944).

Variation in the dip of the bedding observed in accessible exposures at the eastern end of the quarry suggest that open, upright folds are developed on a decametre-scale, with the S1 slaty cleavage axial planar to these folds. No particularly steep bedding dips were observed in this part of the quarry. The main worked layer of slate-rock appears to lie on the southern limb of a larger-scale synclinal fold.

No systematic examination of joint patterns was carried out, though a number of moderately dipping, NE–SW-trending, joints (un-mineralised for the most part) were noted. These contribute to the formation of the typical lozenge shaped blocks noted above.

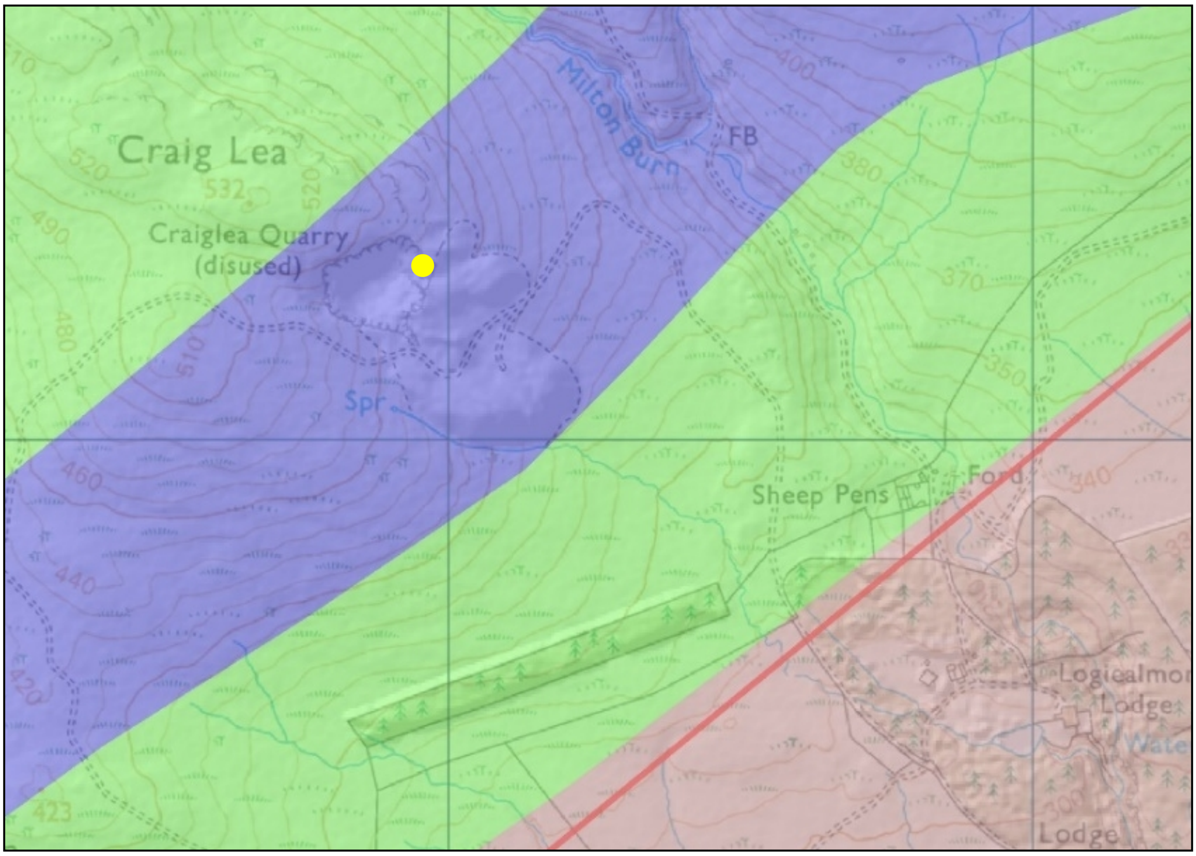

Figure 5. Bedrock geology of Craiglea Quarry and the surrounding area, draped on a topographical map with ‘hill-shade’ data.

Colour scheme: purple = Birnam Slate and Grit Formation; green = Ben Ledi and Leny Grit formations; brown = Arbuthnott-Garvock Group strata (Early Devonian). Red line is the trace of the Highland Boundary Fault. Principal new observations and photographs arising from this study taken from the location indicated by the yellow dot. Grid lines shown have 1 km separation. Geology from BGS DiGMapGB625 (the BGS 1:625,000 scale digital geological map of Great Britain). ‘Hill-shade’ overlay derived from NEXTMap Britain elevation data, from Intermap Technologies. Contains Ordnance Survey data © Crown copyright and database rights 2022. Ordnance Survey Licence No. 100021290 EUL.

Figure 6. Image of the eastern wall of Craiglea Quarry, looking east.

The principal band of slate-rock is delineated by the yellow lines seen near the centre of the image, a possible further layer may be present in the area highlighted by the yellow lines seen in the upper left. For location X above, see Figure 7 below. The thicker slate layer may be a favourable target for renewed extraction of slate, and this is discussed further in Section 4. Such extraction would progress further east from the outcrop that this image shows, essentially removing a volume of the thicker slate layer at the upper left.

Figure 7. Image showing bedding-cleavage traces in the eastern wall of Craiglea Quarry.

Pale banding (striping) dipping gently west-northwest (lying parallel to yellow dotted line) shows the bedding orientation in the slate-rock. The more-steeply inclined (S1) slaty cleavage (lying parallel to the white dotted line) is evident throughout the outcrop and appears moderately- to steeply-dipping in this deeper part of the workings.

Figure 8. Image showing a lozenge-shaped block of ‘Craiglea slate’, providing a typical example of how the rock tends to break apart.

Figure 9. Image showing waste piles located on the south-eastern flank of Craiglea Quarry, looking north-west.

The prominent pile on the left-hand side of this view is some 25–30 m high at its maximum development, and some 200 m wide at its base.

3.3 CHARACTERISTICS OF RECOVERABLE MATERIALS

Both the metasandstone and metamudstone lithologies obtainable at Craiglea Quarry are mainly bluish grey to grey in colour; occasionally they display greenish grey colour banding (Figure 10). They typically display a prominent foliation, along which they cleave readily. The broken surfaces of the metamudstone appear shiny, likely due to the presence of mica. The metasandstone can be massive, but it was found that much of it can be thinly split (comparable to the metamudstone), although the parting fractures are prone to waver and become comparatively less planar through larger blocks.

Highland Border Slates, based on example specimens originating from the full range of source quarrying areas, generally display blue-grey, greenish grey, purplish grey and grey colours (Figure 11). Highland Border Slates are therefore generally lighter in colour than the typically dark grey West Highland Slate (Figure 12a). We note, however, that some slate varieties from Aberfoyle (which found widespread use) are dark grey to dark purplish grey in colour, and can be difficult to distinguish from West Highland Slate at a distance (Figure 12b).

a. b.

Figure 10. Images of specimens of metamudstone (a.) and metasandstone (b.) collected at Craiglea Quarry.

(a.) a thinly (*c.* 8 mm thick) broken piece of metamudstone ‘slate-rock’ (BGS sample number ED12292); (b.) a thicker (*c.* 18 mm thick) piece of metasandstone displaying greenish grey colour banding (ED12293).

Figure 11. Image showing a selection of specimens of Highland Border Slate held in the BGS Building Stone Collection.

These samples display some of the typical colours and other visual characteristics of Highland Border Slate. The samples (from left to right) originate from: Aberfoyle, Luss (Auchengavin), Luss and Comrie.

a. b.

Figure 12. Images of two specimens (a. and b.) of roofing slate held in the BGS Building Stone Collection.

(a) West Highland Slate from Ballachulish quarry; (b) a dark grey Highland Border Slate variety from Aberfoyle quarry.

4 Review of assessment and conclusions

The recoverable materials at Craiglea Quarry (i.e. obtainable from the *in situ* rock mass and spoil heaps) consist of metasandstone and metamudstone ('slate-rock'). The majority of the exposed rock (and indeed the spoil) is metasandstone. Metasandstone and metamudstone layers are likely to be interbedded at a range of scales, though thicker developments of metamudstone appear within a 20–30 m thick inclined layer of true 'slate-rock' that appears to have been the principal target of previous quarrying activity. At present ground level, the bedding of these layers dips at a shallower angle than the (S1) slaty cleavage – a factor that is favourable for roofing slate production.

The main geological factors that would limit the quantities of roofing slate that could be produced at the quarry are:

1) the relatively high proportion of metasandstone in the rock mass; this is not as amenable to roofing slate production compared to the more limited volumes of metamudstone
2) the tendency for the rock to break apart into relatively small (<1 metre-scale) lozenge shaped blocks; the shape of the blocks in this case may mean trimming or sawing will be required to first produce faces perpendicular to cleavage that are then suitable for splitting and fashioning to produce riven tiles.
3) the possible presence of a NW–SE-trending fault, some 275 m to the north-east of the present eastern limit of the quarry, as suggested by previous geological mapping. This fault is believed to offset the 'belt' of slate-rock to the south-east on its north-eastern side, although the amount of any displacement is uncertain.

The thick metamudstone layer is encountered near the perimeter of the quarry void, at OS Grid Ref. [294950 732288]. Renewed extraction of slate could potentially target this layer by laterally extending the workings to the north-east (or east) of this point, for some tens of metres perhaps (see Fig. 6); this would, however, first require significant effort to remove or reduce the waste piles in that area in order to provide suitable access to the bedrock. The inter-banded nature of the metasandstone and metamudstone layers means that it is not possible to predict with any degree of certainty the quantities of slate-rock that could be obtained from this volume of bedrock without first undertaking a more detailed, and potentially complex, survey.

The spoil material is unlikely to provide a reliable source of roofing slate due to the generally small size of the spoil blocks and the fact that these will need to be further reduced during trimming. However, reprocessing of the waste piles (Figure 9) should yield useful material (both metasandstone and metamudstone) for a variety of end-uses, including crushed rock aggregate, walling and/or building stone, as well as facilitating the production of some roofing slate that could serve as a useful exemplar for establishing a market for the slate-rock. A potentially appealing strategy for the (re-)development of the quarry would be to first seek to remove and process the spoil for these end-uses, doing so in such a way that will allow better access to the in-situ slate-rock 'deposit' in the process. Once access to the bedrock is improved, quarrying activity could be focused on the slate-rock.

The particular variety of Highland Border Slate that could be produced at Craiglea Quarry should provide a close match for the grey and blue-grey varieties of Highland Border Slate that originated from the Comrie, Dunkeld, Luss and Bute quarrying areas. This would make it valuable for repairs to the slate roofs of traditional buildings in these areas, as well as providing a means to ensure that 'new-builds' are in-keeping with the local built heritage. However, the scale of demand for the material in this respect may be more limited than for a darker grey slate variety such as West Highland Slate or the dark grey variety Highland Border Slate from Aberfoyle Quarry (neither of which would 'Craiglea slate' provide a satisfactory match for); historic production figures for West Highland Slate quarries and Aberfoyle Quarry indicate that their output was far more widely used than that of the other Highland Border Slate quarries (Richey & Anderson 1944).

A business case for renewed extraction at Craiglea Quarry will be strengthened by taking into account the high volume of stone material that will be unsuitable for roofing slate production, and seeking to promote the useful ‘by-products’ obtainable from this material. The likely demand for the range of ‘by-products’ that could be supplied should be evaluated and comparisons drawn with existing competitor materials and suppliers.

Before any significant financial investment is made in the quarry, a number of large, representative samples should be extracted from the target resource and used for petrographic and geotechnical (physical) testing, in order to establish the technical performance characteristics of the material and provide assurance that the stone will perform as expected for the intended applications. This will also allow a comparison with the physical test results of competitor materials (potentially including other UK roofing slate types, as well as commonly imported slates from overseas) to be made.

If and when the business case is deemed sufficiently strong, further geological investigation would be worthwhile in order to more closely constrain the extent and location of the target lithology(ies) for the various intended end-uses. The information resulting from this more detailed investigation should be used to inform a quarry development plan.

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: https://envirolib.apps.nerc.ac.uk/olibcgi.

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