Some observations on the geology of Slate Fell, Cockermouth

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Introduction

The summit of Slate Fell (elevation 171m) lies just inside the Lake District National Park 2km east of Cockermouth (Figure 1). The informal use of the term 'slate' is a misnomer in geological terms. Although bedded fine-grained rocks are present, these do not constitute geological slate. The summit is an excellent viewpoint, but perhaps its most striking feature is the presence of numerous pits and craters that extend over an area of several hectares (Figure 2). These are the result of historical quarrying operations. While many of these indentations are grassed over, informative exposures of sedimentary, igneous and thermally metamorphosed sedimentary strata remain.



Figure 1. Location map (© OpenStreetMap Contributors)

Bedrock geological setting

Slate Fell lies on the outcrop of the Kirk Stile Formation part of the Ordovician age Skiddaw Group. This formation comprises laminated mudstone and siltstone with greywacke sandstone units. Close examination of the published BGS map (British Geological Survey, 1997) reveals several features within the higher areas of Slate Fell:

- a northerly bedding dip in the Kirk Stile strata (50 degrees);
- two intrusions of diorite (probably sills, thought to be Devonian in age);
- cleavage apparently dipping steeply towards the north-east;
- a west-north-west trending fault;
- a north-west trending fault; and
- an area affected by thermal metamorphism.

The interpreted Watch Hill thrust runs west-east less than 1km to the north of Slate Fell. Watch Hill itself rises to the north on the opposite side of the valley, beyond Greenlands Farm, and diorite sills within the sedimentary sequence there can be discerned from the Slate Fell footpath (Davies, 2021).

Field observations

The northern and southern ridges (Figure 2) are separated by a small depression or valley corresponding to the west-north-west trending fault mapped by BGS. The northern face of the northern ridge aligns with the north-west trending fault mapped by BGS, this running along the hillside near the toe of the prominent rocky bluff ('North-eastern crag' in Figure 2). Features of the northern and southern ridges are described separately below.

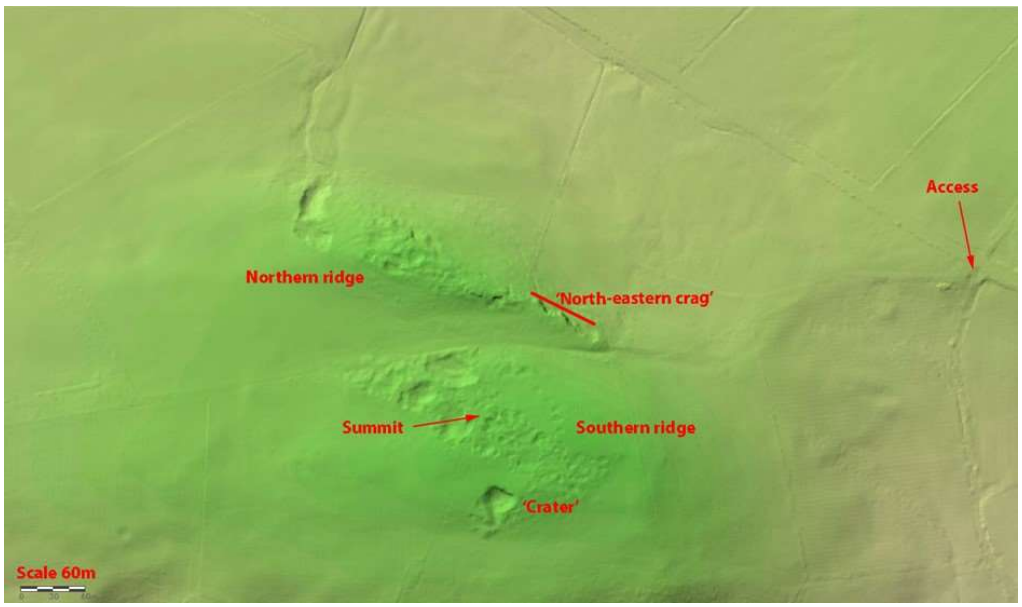


Figure 2. LiDAR remote sensing image showing 'pockmarked' evidence of historical quarrying activities across the northern and southern summit ridges. A convenient footpath access point on the Cockermouth to Embleton road is shown to enable correlation with Figure 1.

Northern ridge

Evidence of quarrying for both diorite and Kirk Stile strata extends over a distance of about 300 metres along the northern ridge.
The 'North-eastern crag' exposure is the largest on Slate Fell and although somewhat weathered and lichen covered, has several features of interest. A small and slightly separated exposure that the eastern end shows steeply dipping and possibly boudinaged Kirk Stile strata. The remainder (as far west as the fence line discernible in Figure 2) is an intrusion, assumed to be a diorite sill (Figure 3). The published BGS map shows no intrusion at this location (see Discussion).



Figure 3. Massive diorite at the 'North-eastern crag' on the northern ridge.

At least three narrow mineral veins have been hacked out within this exposure. These could relate to historical mineral exploration or even the very small scale extraction of gold and other minerals (see Figure 4 and Discussion).



Figure 4. A mineralised vein hacked out to a depth of over a metre into the rock face. For scale, the overall length of the yellow pencil is 14cm. NY 1462 3045.

Thermally metamorphosed ('hornfelsed') Kirk Stile strata are found to the west of this intrusion. Metamorphism has largely obscured traces of sedimentary bedding (Figure 5).



Figure 5. Hornfelsed strata. The pencil tip rests on a bedding surface. NY1456 3047

The degree of alteration varies, and some exposures appear to be essentially unaltered (Figure 6). The moderate northward dip of bedding at the exposure evident in Figure 6 is typical of the orientation seen in the scattered occurrences of Kirk Stile strata. Steeper and shallower dipping exposures also occur.



Figure 6. An example of regularly northward-dipping Kirk Stile strata, northern ridge. NY1454 3046

Southern ridge

As shown in Figure 2 and illustrated in Figure 7, the southern ridge has been quarried extensively (for Kirk Stile strata as well as for diorite).



Figure 7. Summit of Slate Fell. Part of the quarried-out southern ridge seen in winter.

A clean, south facing exposure of diorite is present in a crater-like excavation on the southern flank of the southern ridge (Figure 8). Approximately 4m thickness is visible. Low-angle joints present in the lower part dip northwards, this approximating to the local bedding trend.



Figure 8. Diorite exposed in an excavated crater, southern ridge (prominent in the lower part of Figure 2). NY1457 3027.

Discussion

While indicating the presence of a local thermal aureole, BGS mapping (British Geological Survey, 1997) is unclear about the overall area of Slate Fell deemed to be affected by thermal metamorphism. On the basis of examination in the field, some of the exposures of Kirk Stile strata appear to be unaffected or only slightly altered, although examination of fresh hand or microscope samples may allow thermal effects to be identified more generally. Colour banded bedding traces in hard indurated rock are visible in some exposures, and as shown in Figure 5, bedding is only weaky evident in hornfelsed areas.

The 'north-eastern crag' on the northern side of the northern ridge (Figure 3) has a weathered and partly lichen-covered surface and contains very extensive quartz veining. On close examination the rock can be seen to be a speckled igneous type, provisionally assumed here to be dioritic and intruded as a sill (similarly to other intrusions into Skiddaw Group strata in this district). This exposure has been described as diorite (Eastwood et al, 1968, page 135), possibly being part of a much larger diorite mass present underground. The existence of such relatively large intrusions is known from diorite outcrops between Cockermouth and Bassenthwaite that are several hundred metres across, a thickness of tens of metres being exposed at Embleton (Close) Quarry.

There are significant differences with regard to location and form of intrusions in this district between the reprinted 1960 BGS sheet (British Geological Survey, 1977) and the 1997 version (British Geological Survey, 1997). Focusing just on Slate Fell, the 1960 mapping includes the north-eastern crag occurrence, whereas it is not shown at all in the 1997 version. Moreover, the Slate Fell intrusions are identified as quartz dolerite in the 1960 map in contrast to the many others that are designated as diorite elsewhere (Watch Hill and Embleton areas for example).

One interpretation for the two prominent east-end occurrences of igneous rock at Slate Fell could be that the north-eastern crag (Figure 3) and 'crater' (Figure 8) exposures are two parts of the same sill, separated by the west-north-west trending fault. However the two exposures show markedly different characteristics in the field. The south-facing 'crater' exposure is relatively fresh and clean, showing speckled dioritic rock and jointing comparable to diorite sills elsewhere in the district, if not achieving columnar form in this case. In contrast the north-facing north-eastern crag has a darker and more massive appearance, a greater degree of weathering and a notable amount of quartz veining. The north-eastern crag may be petrologically different (perhaps quartz dolerite in line with the 1960 BGS map) and not an extension of the 'crater' diorite. Destructive sampling and thin section microscopic examination would be needed to clarify this point. This exposure lies between the two faults mapped by BGS (British Geological Survey, 1997), so it is possible that it represents a relatively narrow 'slice' of a sill.

It is assumed that the minor intrusions in the district are all related and Devonian in age. The Cockermouth memoir (Eastwood, 1968) classifies them broadly as dioritic lamprophyres having a range of compositions that encompass quartz dolerite and diorite types amongst others.

The hacked out mineral veins in the north-eastern crag might or might not be related to the discovery of gold at this location. Gold mineralisation has been reported at Slate Fell as well as Embleton (Close) Quarry which lies approximately 3km to the east (Cooper et al, 1991 , pages 45 and 50). Historically, lead was mined at Embleton, those earlier workings being destroyed by quarrying. Such mineralisation in and around the diorite intrusions into Skiddaw Group strata may be associated with the intrusion events themselves, although younger phases of mineralisation have also been identified in the district (Cooper et al, 1991). The quality and suitability of Skiddaw Group strata for use as building and walling stone vary considerably. The hardened nature of the sedimentary rocks at Slate Fell, yielding some tabular building stone, as well as the availability of strong diorite, may explain why quarrying was so intense here, albeit at an extended 'cottage industry' scale.

Historical shallow quarrying of rocks on the fells of the Lake District for local building stone or constructing stone walls or the foundations of Cumberland dikes (hedges) nearby is quite common, providing many informative exposures. However, the presence of dozens of mostly shallow excavations spread over several hectares on Slate Fell is striking. Some of the excavations may only have been for exploratory purposes because the voids of many are only a few cubic metres in volume. Regarding the naming of *Slate* Fell, this suggests that sufficiently sized slabs were obtained to provide worthwhile quantities of 'slate' roofing material. The historical date of quarrying operations has not been identified. It is speculatively suggested here that quarrying may be related to building construction activity in Cockermouth in Georgian times.

Conclusions

The top of Slate Fell provides an opportunity to examine Skiddaw Group strata and intrusions. The influence of faults on the local geomorphology can be considered as well as taking in the excellent views from this vantage point. The scale and extent of the shallow workings is impressive even to non-geological visitors. There is scope for more scientific investigation at this location, particularly around the interpretation of intrusions and the nature of mineralisation.

References

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