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Onshore Geology Series

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TECHNICAL REPORT WA/87/41
Geology of the Abbeystead area (SD 55 SE).
Part of 1:50,000 Sheets 59 (Lancaster) and 67 (Garstang).

R A HUGHES

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1. INTRODUCTION

This report describes the geology of BGS 1·10,000 Sheet SD 55 SE, part of the 1:50,000 Sheets 59 (Lancaster) and 67 (Garstang). The area was first mapped by R.C. Tiddemann on the scale of 1:10,560, and was published on the Primary Series Sheets 91 NE and 91 SE in 1884. The present survey was carried out between 1984 and 1986 by R.A. Hughes, E.W. Johnson, and A. Brandon, under the supervision of Dr A.J. Wadge, Regional Geologist. The southern two thirds of the area was mapped by R.A. Hughes, and the northern third (including the important sections of the River Wyre and its tributaries) by Drs Brandon and Johnson.

Approximately the southern third of the area is peat and heather covered moorland, used only for sheep grazing and grouse shooting. Hawthornthwaite Fell Top [5790 5148] is the highest point at 478 m, and lies on the watershed of the Bowland Fells. To the south-west of here the land drains into the headwaters of Langden Brook. To the north-west of the watershed the land drains into the River Wyre. The remainder of the area is relatively lower-lying and flat, and is used for pasture and for growing fodder crops. The northern part of the area is incised by the westerly flowing River Wyre and its tributaries. (The Marshaw Wyre and the Tarnbrook Wyre join at Abbeystead to form the River Wyre).

The area contains the southern end of the Wyresdale tunnel, the geology of which was described by Johnson (1981). The southern portal of the tunnel was the site of a fatal explosion in May, 1984. The mapping of the northern third of the sheet was a response to the demand for detailed geological information for use in the ensuing public enquiry. The results of this work are presented in Wilson, Brandon, and Johnson (1985). The only other work in the area is in the extreme north-west of the sheet, which was mapped by Moseley (1954).

2. GEOLOGICAL SUCCESSION

DRIFT

QUATERNARY

- Landslip
- Alluvial fan deposits
- Alluvium and river terrace deposits
- Peat
- Head
- Glacial sands and gravels
- Till

SOLID

NAMURIAN

Roeburndale Formation

- Rowton Brook Sandstone
- Hall Gill Sandstone
- Long Bridge Sandstone
- Caw Mill Sandstone

Brennand Grit Formation

Pendle Grit Formation

3. PENDLE GRIT FORMATION

All the high ground in the southern half of the area is formed of rocks belonging to the Pendle Grit Formation. Exposures are extremely numerous but rarely continuous in the many streams which drain this area, such as Long Reedy Clough [58 50], Stake Clough [58 50], the headwaters of Langden Brook [59 50], Black Clough [59 51], Hawthornthwaite Greave [56 51], Catshaw Greave [56 51], Meer Brook [58 52], and Grizedale Brook [50 55]. Because of the soft weathering characteristics of the finer grained rocks, most exposures are of the harder weathering sandstones. The base of the formation is not exposed in the area, but an estimated thickness of approximately 300 m is present.

The sandstones of the Pendle Grit Formation exposed in Hawthornthwaite Greave [56 51] are typical of numerous exposures elsewhere on the sheet. They are predominantly medium- to coarse-grained, rarely pebbly, feldspathic and commonly micaceous, massive, and thickly bedded. Well-formed bedding planes are uncommon, but the rocks are penetrated by surfaces which appear to be sub-parallel to the apparent bedding planes. More thinly bedded, medium- to fine-grained sandstones are less common, and are often interbedded with laminated siltstones. These interbedded sandstones and siltstones commonly have sedimentary structures characteristic of turbidites: the more massive bedded, coarser-grained sandstones are generally devoid of sedimentary structures.

Graded sandstone beds, up to 0.25 m thick, with ripple scale cross-laminations, sole structures and siltstone intraclasts are present in Hawthornthwaite Greave [5647 5194] some 50 m upstream from the sheepfold south of Fellside Farm. Similar suites of sedimentary structures, including current rippled bedding planes, are present at several localities throughout Langden Brook, Long Reedy Clough, and Stake Clough [58 50]. A particularly fine example of a linguoid rippled bedding plane is present in the stream bed [5882 5045] some 90 m west of the confluence of Stake Clough and Long Reedy Clough. Evidence of sandstone bodies with channel forms is rare, but possible channel sandstones are present in the banks of Black Clough [5983 5179]. Flute marks on the soles of sandstone beds here indicate palaeocurrents flowing from the north.

Lithological variation within the formation is responsible for discontinuous topographical features present on the north-west facing slopes of Fellside Fell [56 51] and the north facing slopes of Hawthornthwaite Fell [59 52]. The rocks which produce these negative topographical features are not exposed within the present area, but on adjacent sheets the features are seen to be produced by soft weathering, interbedded fine-grained sandstones and siltstones.

4. BRENNAND GRIT FORMATION

4.1 Local details

The Brennand Grit Formation overlies the Pendle Grit Formation in the east of the area, but dies out westwards so that on the western boundary of the sheet the Pendle Grit Formation is overlain directly by the Roeburndale Formation. In the east the top of the Brennand Grit Formation is faulted so that its true maximum thickness is unknown: it is at least 65 m.

The formation is very poorly exposed throughout its area of crop. With one exception all exposures are in the extreme east, where the major sandstone bodies within the formation were once worked for stone. Many small disused pits are still visible, but overgrown, and in one pit [5880 5385] 50 m north-west of High Barn 0.5 m of deeply weathered, coarse-grained, feldspathic sandstone is exposed. In the immediate vicinity and in two disused pits in the area of New Barn [5950 5369 and 5964 5375] are abundant loose blocks of coarse-grained, commonly pebbly sandstone typical of the formation. The rocks between the major sandstones are exposed only in Hawthornthwaite Greave [5635 5212] to the south-east of Fellside Farm. Here they consist of thinly bedded, fine-grained sandstones. These rocks are better exposed on Sheet SD 65 SW, where they consist of interbedded, parallel-laminated, fine- to medium-grained sandstones and siltstones.

4.2 The lateral impersistence of the Brennand Grit Formation

To the north-east of the present area, in the headwaters of the Tarnbrook Wyre, the *Cravenoceras cowlingense* Marine Band lies approximately 112 m above the top of the Brennand Grit Formation (Wilson et al., 1985). The 112 m thickness consists of interbedded fine-grained sandstones and siltstones. To the south-west of the present area on Sheet SD 54 NW (Pedder's Wood section - see Biostratigraphy research Group report PDL 84/266) the *C. cowlingense* Marine Band overlies typical Pendle Grit facies sandstones, with no evidence of Brennand Grit facies present lower in the succession. In the present area, tenuous evidence (see Wilson et al., 1985) suggests that this marine band lies approximately 15 m above the top of the Hall Gill Sandstone.

This evidence clearly suggests that the coarse-grained sandstone facies of the Brennand Grit Formation die out south-westwards from the Brennand area. The westernmost exposures of the Brennand Grit Formation are in the north-east of

Sheet SD 55 SE. South-west of here the crop of the formation is heavily drift covered, but there is no evidence of Brennand Grit facies in the west of the sheet, and the formation is interpreted as dying out in the intervening area.

5. ROEBURNDALE FORMATION

The remainder of the succession present on the sheet belongs to the Roeburndale Formation. Generally, the formation consists of interbedded fine- to medium-grained sandstones and siltstones, but four named sandstone units have been identified in the western part of the sheet. Exposures of the formation are almost entirely limited to the River Wyre and its tributaries, notably Cam Clough [56 53] and Inchaclough [58 54]. The total thickness of the formation is at least 505 m and may be more, part of the sequence being faulted out.

5.1 Cam Clough and the lower part of the River Wyre [55 53]

These stream sections contain the only structurally uninterrupted sections through the Caw Mill Sandstone, the Long Bridge Sandstone, and the lower leaf of the Hall Gill Sandstone on the sheet. Exposures are common but very discontinuous.

The Caw Mill Sandstone is exposed at one locality only [5607 5209], approximately 200 m north-west of the road bridge over the stream. Some 4 m of thickly bedded, medium- to coarse-grained sandstone at the top of the unit are exposed. The boundary with the overlying siltstones is not not exposed. The 37 m of thinly interbedded fine-grained sandstones and siltstones between the Caw Mill and Long Bridge Sandstones are exposed at several localities downstream from here. The siltstones are dark grey, weakly laminated, and soft weathering, and commonly contain ironstone nodule bands. At one locality [5599 5296] slumping in siltstones and fine-grained sandstones indicates soft sediment deformation.

The overlying Long Bridge Sandstone is also exposed at several localities downstream. In the banks of Cam Clough [5565 5342] some 400 m west of Marl House, thickly bedded medium-grained sandstones with thin siltsotne interbeds are exposed. The Long Bridge Sandstone is also exposed along strike in the River Wyre [5560 5384] immediately downstream from Abbeystead dam. Here some 6 m of interbedded fine- to medium-grained sandstones up to 1.4 m thick are interbedded with thin siltstones.

The Long Bridge Sandstone is separated from the succeeding Hall Gill Sandstone by approximately 22 m of siltstones and thin, fine-grained sandstones which are exposed at numerous localities in the banks of the River Wyre. The Hall

Gill Sandstone is present in two leaves, the lower of which has a maximim thickness of 5 m, the upper 10 m. The upper leaf is not exposed on the present sheet, but the lower leaf is seen at a number of localities on the south bank of the River Wyre in the extreme west of the area. In a small gully [5530 5373] some 380 m west-south-west of the Abbeystead dam, the lowest 0.9 m of the lower sandstone leaf is seen overlying siltstones. The sandstones are medium-grained and thickly bedded. At the western end of Crow Wood [5504 5369] the same sandstone is exposed in an un-named minor tributary.

5.2 Bond Clough [56 53]

Further exposures of siltstones in the lower part of the Roeburndale Formation are present in the upper part of Bond Clough. Downstream a fault brings these siltstones into juxtaposition with sandstones younger than the *Eumorphoceras bisulcatum ferrimontanum* Marine Band. The siltstones are weakly parallel-laminated, with thin fine-grained sandstone laminae and thin sandstone beds.

5.3 The River Wyre and surrounding areas west of the Marshaw Faults

A west-south-west trending fault which passes just south of Abbeystead village, and the Marshaw Faults conveniently delimit an area of considerable stratigraphical importance to the present sheet. Within this area the general younging direction is to the south, and exposure is restricted to the south bank of the Marshaw Wyre immediately south of Abbeystead House. The *E. bisulcatum ferrimontanum* Marine Band is exposed here [5675 5445], overlain by approximately 18.9 m of interbedded fine- to medium-grained sandstones and siltstones in a cliff section. The marine band itself consists of at least 3.0 m of parallel-laminated siltstones, in part calcareous, with numerous bitumenous wackestone bullions. Another exposure of the marine band is present in the south bank of the Marshaw Wyre some 90 m east of here [5683 5444] along strike. The fauna collected from these two localities is described in detail in Biostratigraphy Research Group Report PDL84/239, and includes *Anthracoceras glabrum*, *Cravenoceras* sp.; and *Eumorphoceras bisulcatum* cf. *ferrimontanum*. These fossils are indicative of the E2a2 *E. bisulcatum ferrimontanum* Marine Band.

To the south of the Marshaw Wyre in this area the marine band is overlain by a thickness of approximately 85 m of interbedded sandstones and siltstones in the Doeholme Syncline, including two discrete sandstone beds. The lower of

these two sandstones is exposed in the south bank of the Wyre overlying the marine band at the first locality described above. It is aproximately 12 m thick and consists of medium-grained sandstones, thickly bedded with some graded units, with siltstone interbeds. The upper of the two sandstones is exposed in Bond Clough [5651 5409] downstream from the fault mentioned in section 5.2 above. The sandstone is coarse-grained, feldspathic, and thickly bedded. The succeeding beds are not exposed on the sheet.

To the north of the Marshaw Wyre in this area are rocks older than the *E. bisulcatum ferrimontanum* Marine Band, including the Rowton Brook Sandstone (of Wilson et al., 1985). There are no exposures through this part of the sequence, the ground being covered by drift with a maximum proven thickness of 34.5 m [borehole SD 55 SE/2, at 5564 5428]. The outcrop of the Rowton Brook Sandstone has been constructed from borehole evidence (the sandstone is present in borehole SD 55 SE/1 [5561 5456]), and from evidence on adjacent sheets.

5.4 The area between the Far House Barn and Bank Wood Faults

There are no exposures in this area, but the inferred position of the *E. bisulcatum ferrimontanum* Marine Band on the map is based on borehole evidence. Borehole SD 55 SE/2, sited immediately west of Far House Barn [5564 5428], revealed 4.62 m of dark grey mudstone with calcareous bands, containing *Posidonia corrugata*, underlying 34.5 m of till. These mudstones are correlated with the marine band, and the succession is known to young to the north from dips measured in the tunnel, which passes beneath this ground.

5.5 The area between the Marshaw Faults

The level within the Roeburndale Formation of the interbedded sandstones and siltstones exposed in this area is unknown due to the absence of marker bands. Exposures are numerous but discontinuous in the bed and banks of the Marshaw Wyre. The sandstones are dominantly fine- to medium-grained and laminated; the siltstones are dark grey and weakly laminated. The thickest sandstone unit is between 8 and 10 m thick, with a disconformable base, and is exposed in an inaccessible cliff section [5748 5422] north of Whinnyshaw Plantation.

5.6 The area between the Higher Emmetts Fault and the Marshaw Faults

Exposure in this area is limited to the banks of the Marshaw Wyre and the lower parts of Inchaclough. All exposures are of rocks younger than the *E. bisulcatum ferrimontanum* Marine Band, the inferred position of which is shown on the map. Exposures in the Marshaw Wyre are once more numerous but discontinuous. The succession consists of interbedded fine- to medium-grained sandstones and siltstones, with ironstone bands and signs of soft sediment deformation. A 3.4 m thick siltstone unit with a highly erosive base is exposed in a cliff section on the south bank of the Wyre [5865 5413]. Further upstream on the north bank of the river in Border Side Wood [5785 5410] is an exposure of interbedded siltstones and sandstones showing soft-sediment slumping.

The lower part of Inchaclough contains a well-exposed strike section through approximately 20 m of interbedded fine- to medium-grained sandstones and siltstones. Some of the sandstones have current-rippled tops, while the siltstones are internally parallel-laminated.

5.7 The area north of Higher Emmetts Fault and the Millers House Fault

The rocks present in this area are, on lithological evidence, younger than the Brennand Grit Formation, and on stratigraphical evidence (the *Cravenoceras cowlingense* Marine Band crops out on the sheet to the north) older than this marine band. The most continuous exposures are once more in a strike section in Inchaclough, where approximately 25 m of the succession are exposed. The rocks are weakly laminated à siltstones with ironstone bands, interbedded with thin, fine- to medium-grained sandstones. Further exposures of similar lithologies are present in the extreme north-east of the area in the stream section alongside Harry Wood [598 548] and an un-named stream to the east [599 549].

6. STRUCTURE

The structure of the area is dominated by north-west trending faults and east-north-east trending folds. These structures are probably the expression in the Carboniferous cover rocks of dextral transpressive movements in the pre-Carboniferous basement rocks. The structural development of the area is discussed by Arthurton (1985) and Hughes (1987).

6.1 Faults

The major fault set within the area is the Marshaw Fault set, which consists of two parallel, north-west trending faults with minor splays. The precise throw of each of these component faults is unknown, but the net throw of the set is down to the north-east. The amount of throw is indeterminate due to the absence of accurately defined marker bands. The Higher Emmetts Fault, which throws down an indeterminate amount to the south-west, has a similar trend to the Marshaw Faults.

In the higher ground of the southern part of the map several faults have the same trend as the Marshaw Faults, but some have indeterminate throw directions. The fault which crosses Fellside Fell [56 51] is exposed in two un-named tributaries of Long Reedy Clough on the north-east facing side of White Moss [5786 5080 and 5808 5062]. Another small fault with the same trend is exposed in Weasel Clough [594 504].

Because of thick drift cover in the area, it is doubtful whether the Bank Wood and Far House Barn Faults would have been identified in the field, had they not been encountered in the Wyresdale Tunnel. The throw on these two faults is thought to be to the north and south respectively. Wilson et al. (1985) pointed out that the throw on the Far House Barn Fault, while thought to be down to the south, is uncertain, and depends wholly on the possible presence of the *E. ferrimontanum* Marine Band in borehole SD 55 SE/2 (see above).

The throw of the Miller's House Fault in the north-east is undoubtedly down to the north, but the amount of throw is indeterminate because the horizon within the Roeburndale Formation of the rocks on the northern side of the fault is unknown.

6.2 Folds

All the major folds within the area have axial traces trending east-north-east. The Doeholme Syncline [56 54] appears to have a westerly plunge, but the structure is very poorly exposed. In the north-west of the area, two folds - one synclinal and the other anticlinal - were encountered in the Wyresdale Tunnel. In the high moorland of the south of the area the watershed of the Bowland Fells is itself the culmination of an anticlinal fold. Steep northerly dips readily identify the northern limb of this structure, but south of the fold axis dips are more variable, and the southern limb is therefore less well-defined.

7. QUATERNARY

7.1 Till

Till covers much of the lower-lying ground in the northern part of the sheet. Large, unweathered cliff sections through the till are uncommon because it is so prone to landslipping, but small sections are common on riverbanks. The till is a dense, dark grey, stony clay with abundant erratics. Palaeozoic igneous rocks, probably from the Lake District, and Carboniferous Limestone are the two most abundant erratic types. Good sections through typical till, consisting of dense, dark grey clay with abundant erratics, are present in the banks of Catshaw Greave alongside the road east of Fell Barn [558 521]. The maximum proven thickness of till is 43.5 m in borehole SD 55 SE/2 to the west of Abbeystead village.

7.2 Glacial sands and gravels

Three areas of glacial sands and gravels are present in the north-west of the sheet. The areal distribution of the deposits suggests that they were deposited on a till surface. The deposits themselves form well-drained, rounded hills which stand proud of the flat-lying till landscape. The good drainage of the sands and gravels relative to the surrounding poorly drained till areas is responsible for a marked difference in vegetation type between the two deposits. South of Chapel House Farm [552 546] the deposits have been worked on a local scale.

7.3 Head

Head deposits are ubiquitous on the lower parts of the steeper slopes throughout the area, such as Catshaw, Fellside, and Hawthornthwaite Fells. They consist of an unsorted accumulation of material of varying grain sizes which has moved downslope under the influence of gravity, initially in conditions of periglacial freeze-thaw. The composition of the head reflects the composition of the parent material, and in this area the head is sandstone rich. Most of the north facing slopes of Catshaw, Fellside, and Hawthornthwaite Fells are covered with head of variable thickness. Sections through the head are rarely seen, but on the banks of Catshaw Greave and Hawthornthwaite Greave the head consists of up to 3 m of unsorted sands and clays with large sandstone blocks.

7.4 Alluvium and river terrace deposits

The most extensive areas of river alluvium are along the valleys of the Mi shaw Wyre and Tarnbrook Wyre, and the upper reaches of Langden Brook in the extreme south-east. Outside these areas alluvium is limited to small strips in the Ç narrow valleys of the minor streams. The deposits consist of poorly sorted clays, sands and gravels. The maximum thickness of the river deposits is unknown, but is likely to be several metres.

7.5 Alluvial fan deposits

Alluvial fan deposits have been deposited where changes in gradient reduce the kinetic energy of the moving water and the load-bearing capacity of the stream. A typical example is present where Langden Brook is joined by Weasel Clough in the south-east [593 500], and is composed of locally derived, unsorted material up to boulder size.

Harvey and Renwick (1987) have recently described a number of Holocene alluvial fans in the Bowland Fells. They recognise two periods of contemporaneous erosion and fan deposition; the first after c.5400 BP but before c.1900 BP, the second at c.900 BP. It is not known to which phase of fan formation the alluvial fan deposits of this area belong.

7.6 Hill peat

Much of the upland in the south of the sheet is covered by peat, which has been mapped where its thickness consistently exceeds 1 m: thinner deposits are widespread. The peat blankets are being actively eroded, most notably on the top of Hawthornthwaite Fell [58 51], where a once continuous peat blanket now consists of a series of peat hags highly dissected by drainage gullies and larger, peat free areas. The causes of peat erosion are complex and manifold, and are discussed in detail by Tallis (1985).

7.7 Lowland peat

Two areas of lowland peat have been mapped in the low-lying, poorly drained area of the north of the sheet. A small area of peat is present in the extreme north-west [550 549], and a more extensive area occurs at Ouzel Moss [580 548]. The thickness of these deposits is unknown, but certainly exceeds 1.2 m.

Because these peat deposits thin laterally, the mapping of their boundaries is difficult. In these two cases the boundaries have been mapped where breaks of slope suggest rapid thinning of the peat.

7.8 Landslip

Landslips are common throughout the area, and occur most commonly on the steeper valley sides. In the south the slips are mostly of solid rock and are rotational, in the north they are mostly in the drift deposits and are non-rotational. Typical examples of rotational slips occur along the valley of Langden Brook opposite Higher Raven Scar [585 504] and opposite Raven Scar [590 503]. The banks of the River Wyre are landslipped almost throughout their entire extent downstream of Well Brook [584 536]: most of these slips are probably non-rotational slips affecting only the drift deposits.

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