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TECHNICAL REPORT WA/97/82

GEOLOGY OF THE BECKBURY AND WORFIELD AREA

1:10 000 sheets SJ 70 SE and SO 79 NE
Part of 1:50 000 sheet 153 (Wolverhampton) and 167 (Dudley)

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1. INTRODUCTION

This report describes the geology of 1:10 000 sheets SJ 70 SE (Beckbury) and SO 79 NE (Worfield) (Figure 1). This area was first surveyed geologically at the 1:10 560 scale by R W Pocock and T Robertson in 1922 and 1923, and published on County Sheets Staffordshire 44SW, 44SE and 61SW, and Shropshire 52NW, 52NE, 52SW, 52SE, 59NW and 59NE. The one-inch Geological Sheet 153 (Wolverhampton) was published in 1929, and the accompanying sheet memoir (Whitehead et al.) dates from 1928. A 6 km strip at the western margin of the area ($^{2}99$ - $^{3}05$) was surveyed by R J O Hamblin in 1970-72 as overlap from Telford Special Sheet, published in 1978. The remainder was surveyed between 1997–98 by E Hough (north of northing $^{2}97$) and by A J Barnett (south of northing $^{2}97$).

Most of the area is included in East Shropshire and covers the small villages of Ryton, Beckbury, Badger, Ackleton, Hilton, Worfield and part of the Cosford Airfield. The hamlet of Burnhill Green, in the south-east of the district, lies within South Staffordshire. Although most of the district is rural, and given over to farming, the Royal Air Force, based at Cosford is an important employer.

The area is one of gently undulating topography through which the River Worfe and its tributaries have cut deeply incised valleys. The main access routes are the A464 in the north (Shifnal to Wolverhampton) and the B4176 in the south (Telford to Dudley).

The district is underlain by Permian and Triassic rocks, which dip gently eastwards. The succession forms part of the western margin of the South Staffordshire Basin, a half-graben lying between the coalfields of South Staffordshire and Coalbrookdale.

Approximately 60 per cent of the area is covered by patchy drift, mainly comprising till and glaciofluvial sand and gravel. The River Worfe is flanked by terraces along much of its course. These grade downstream into the Severn terrace system (Wills, 1924; Hamblin and Coppack, 1996). The Lightmoor Channel, a Late Devensian over-deepened sub-glacial meltwater channel (Hollis and Reed, 1981), is incised across the south of the district.

All National Grid references in this report lie within 100 km grid squares SO and SJ, and are given as eight figure numbers, prefixed accordingly, within square brackets. All borehole depths are given in metres below ground level.

Reports covering contiguous 1:10 000 sheets have been prepared as follows:

to the north (Shifnal area) (Bridge, 19)
to the east (Albrighton and Pattingham) (Barnett and Bridge, 19)
to the west (Hamblin and Coppack, 1995), and
to the south (Whitehead and Pocock, 1947).

2. GEOLOGICAL SEQUENCE

All strata are present at surface within the district.

Quaternary (not necessarily in order of superposition)

Head

Peat

Alluvium and Alluvial Fan Deposits

River Terrace Deposits of the Worfe: 1st, 2nd and Higher Terraces (undifferentiated)

Glaciofluvial Deposits

Glaciolacustrine Deposits

Till

Triassic

Mercia Mudstone Group

Sherwood Sandstone Group
- Bromsgrove Sandstone Formation
- Wildmoor Sandstone Formation
- Kidderminster Formation

Permian

Bridgnorth Sandstone Formation

3. PERMIAN

3.1. Bridgnorth Sandstone Formation (formerly 'Lower Mottled Sandstone')

The Bridgnorth Sandstone is the oldest unit proved in the district. The formation is of early Permian age (Holloway, 1985) based on its stratigraphic position above the Upper Carboniferous Salop Formation and below the Triassic Sherwood Sandstone Group; age-diagnostic fossils are so far unknown from the formation.

The Bridgnorth Sandstone has a narrow outcrop between The Sands and Grindle House. A water borehole at Grindleforge, sited close to the top of the formation, penetrated 103.7m of red and mottled, fine-grained sandstone, interpreted as Bridgnorth Sandstone, overlying 15.2m of beds assigned to the Enville Member of the Salop Formation. On the evidence of this borehole, the Bridgnorth Sandstone has an estimated total thickness of about 128 m hereabouts.

Borehole No.2 at Cosford Pumping Station proved 23.4 m of 'red sandstone with marl' from 256.4m to the base of the borehole at 279.8 m (Figure 2). These beds were assigned to the Bridgnorth Sandstone by Whitehead et al. (1928).

The Hatton Grange Water Borehole provides a cored section of the upper 26.3m of the formation (Appendix 2). The strata comprise compositionally mature, pebble-free sandstone, with well-developed cross-bedding and subordinate planar-bedded. Alternating fine- and medium-grained units are common and give rise to so-called 'pinstriped' lamination. This typically develops as a result of grainflow (coarser-grained laminae) or grainfall (finer-grained laminae) on the slip face of aeolian dunes, and is a strong indication of an aeolian origin for the sediment (Clemmensen and Abrahamsen, 1983). Low- and high-angle cross-bedded units ('Axg' and 'Axh' facies, modified after Miall, 1977), interpreted as forming in an aeolian dune environment, compose 88 per cent of the cored section. The remaining 12 per cent of the sequence is planar-bedded ('Al' facies, modified after Miall, 1977), forming from a dry sandsheet (interdune) environment, where major dune development is rare. Calcite concretions, present at 52.5, 53.5, 55.7 and between 56.3 and 56.4 m have a pseudo-cylindrical form. These may have formed around plant roots and indicate periods of poor soil development, and, as paleosurfaces, indicate possible stillstands of sediment supply. The formation formed from many generations of barchan dunes in a 'sand sea' (large desert) (Shotton, 1937), which was sand-saturated (Karpeta, 1990).

4. TRIASSIC

Figure 2 shows comparative sections, drawn from borehole logs, of the lower part of the Sherwood Sandstone Group.

4.1. Sherwood Sandstone Group

4.1.1. Kidderminster Formation (formerly 'Bunter Pebble Beds') Induan - ?Olenekian Stage

The crop of the Kidderminster Formation reaches a width of 1200 m between Hinnington Road and Hatton Grange, but is displaced westwards, out of the district, by the Harrington Fault, which trends north-eastwards from the Severn Valley, through Grindle to 150 m north of Blubber Hole. The formation rests unconformably on the Bridgnorth Sandstone Formation. The base is not exposed in the district, but is encountered at 256 m below ground level in Cosford Pumping Station No. 2 Borehole.

Four boreholes at Stableford [37640 29810] prove up to 137.2 m of the formation. A complete section through the formation measuring 115.4 m was proved at Cosford Pumping Station No. 2 Borehole (Whitehead et al. 1928). Other incomplete sequences were proved by Beckbury Pumping Station No. 1 Borehole (113.4 m), Cosford No. 4 Borehole (96 m), and Cosford Grange Borehole (116 m).

The basal beds, which normally form strong topographic features at outcrop, give rise to only subdued topography around The Sands [7540 0470]. Evidence from Cosford Pumping Station No. 2 Borehole, drilled 3 km to the east, suggests that this may be due to the relatively poor development of a basal conglomeratic unit, hereabouts.

Cores through the lowermost 52.3 m of the formation were recovered from the Hatton Grange Borehole. These showed a sequence comprising sandstone, silty sandstone and sporadic pebbly sandstone (Appendix 2). In general, the sandstone is moderately- to moderately-well sorted, and ranges in grainsize from very fine sand to pebble grade. Aeolian grains reworked from the Bridgnorth Sandstone are common in the basal 8 m; they comprise the majority of a 2 cm-thick massive bed of sandstone at 43.6 m, but become rare to absent above this level. Set bases are mainly sharp or erosional. Current ripple lamination is developed in the finer and more silty beds. Pebbles are both intraformational (mudclasts and sandstone) and extraformational (volcanics, chert and quartz). The sequence has been interpreted as a series of stacked fluvial or sheetflood events (Warrington, 1980). Strata of this type fall within lithofacies C of Steel and Thompson (1983), which they interpret as broad channel infillings. Finer grained units, similar to lithofacies E of Steel and Thompson (1983) represent abandoned channel infillings and are only well developed between 7.2 and 6.3 m. Once formed, these finer-grained beds would be susceptible to removal by the next sheetflood event and incorporated within overlying beds as intraformational clasts (for example, at 48.4 m). Aeolian exposure and deposition within the formation is suggested by desiccation cracks at 49.75 m and the thin bed of aeolian sandstone at 43.6 m.

North of Oldforge Bridge, a 20 m cliff section [SJ 7533 0323] exposes approximately 5 m of the lower part of the formation. The section is dominated by reddish orange, trough- and planar- cross-bedded sandstone sets which commonly exceed 1 m in height; these are ordered into cosets up to approximately 3 m thick. The sandstone is generally coarse- to medium-grained, and moderately-sorted. The grains are typically sub-angular, but also present are some well-rounded aeolian grains reworked from the Bridgnorth Sandstone. Spherical and sub-spherical quartzitic pebbles, up to 6 mm in diameter, are scattered throughout the sandstone sets. Intraformational mudclast fragments, less common than quartzitic pebbles, are mostly oriented along major and minor set bounding surfaces. A planar-laminated mudstone bed, up to 5 cm thick, occurs near the base of the section. It is cut out to the west by a small sandstone channel. Palaeoflow directions to the east-north-east and west-south-west are indicated by the azimuth of foreset bedding.

The upper, pebble-free part of the formation is described in written logs from the Stableford boreholes. The logs, which are of poor quality, indicate that this pebble-free facies is up to 69.2 m thick in Stableford No. 3 Borehole. The sequence is described therein as soft, red and grey sandstone with sporadic marl beds. The strata are probably transitional lithologically between the Kidderminster Formation and Wildmoor Sandstone. The inclusion of these beds within the former is based upon overlying beds being marl-free. Beds from the upper part of the Kidderminster Formation are exposed in a small quarry [SJ 7626 0378] to the south of Hell's Pool. The quarry exposes approximately 7 m of orange-red pebbly sandstone, which is trough cross-bedded. Pebble lags, mostly composed of angular and rounded intraformational mudclasts up to 2.4 cm in diameter, are fairly common along the base of sets, which range in thickness between 0.2 and 1.3 m. Cross-bedding indicates a predominant depositional flow to the north-east (N006° to N079°).

4.1.2 Wildmoor Sandstone Formation (formerly 'Upper Mottled Sandstone') ?Induan - Olenekian Stage

This formation crops out along the Worfe Valley from Cosford Airfield to Folley, and in fault blocks at Pasford. It is mostly drift covered, with exposure limited to cliff sections along the deeply incised valleys of the Worfe and its tributaries, Mad Brook, Wesley Brook, Cosford Pool and Nun Brook.

There is an upward passage from the Kidderminster Formation into the Wildmoor Formation, with pebbles becoming less common, and eventually absent, up-sequence. The base of the formation is usually taken at a point where the sandstone becomes pebble-free. In parts of this area, however, some sparsely pebbly beds, reported in boreholes, have been included within the Wildmoor Sandstone. This is the case in Cosford Pumping Station No. 2 Borehole, where the lower 30.4 m, described as 'red sandstone with white seams and occasional pebbles' is included with the Wildmoor Sandstone. The Stableford, Beckbury No. 1 and Cosford No. 4 borehole all terminate in a non-pebbly facies of the Wildmoor Sandstone, typically, a soft red and grey sandstone, in part loamy and micaceous.

A section through the whole formation measuring 128.5 m was proved by the Cosford Grange Borehole. Thicker sequences were recorded in Stableford No. 4 Borehole (239.2m), and Hilton No.1 Borehole (254.4m), though in the former case, the written log gives few lithological details, making identification of the base of the formation difficult. Given the position of these boreholes in the sequence, the Wildmoor Sandstone is estimated to attain a maximum thickness of 267m.

A disused quarry at Ryton [SJ 7612 0256] exposes 4 m of strata from the middle part of the formation. Beds are fine-grained and silty, and are ordered in cross-bedded and planar-parallel sandstone sets. The cross-bedded sets have erosional bases and are up to 0.89 m thick; planar-parallel sets are generally thinner (0.09 - 0.12 m). A very thin, continuous mudstone bed is present in the lower part of the exposure. North of the Worfe [SO 7662 9813], cliffs expose a series of poorly developed, upwards-fining units, each up to 0.95 m thick. These are composed of fine-grained, planar- and cross-bedded pebble free sandstone, each becoming siltier towards the top. The outcrop as a whole is also siltier towards the top. At [SJ 7775 0438], sets are laterally persistent over tens of metres. The top of the formation is exposed south of Cosford Pool [SJ 7872 0444], where it is bright orange and thin- to medium-bedded. Asymptotic cross-bedding dips gently to the east. Laterally extensive outcrops (up to 100m) occur along the banks of the Worfe at [SO 7640 9685] and [SO 7577 9600]. The exposed strata consist of orange-red, fine- to medium-grained sandstone. Primary sedimentary structures are dominated by large-scale trough cross-bedding (set heights of 1-1.8m) although smaller scale (set heights of 0.1-0.35m) trough and planar cross-bedding also occur. Palaeocurrent measurements indicate a unimodal north-west to north-north-westerly palaeoflow.

Regionally, the formation is remarkable for its lithologically uniformity, comprising orange-red, fine-grained silty sandstone, with thin clay and marl beds and pale green reduction zones. The environment of deposition has been variously described as subaerial (Whitehead et al. 1928), shallow lacustrine (Hains and Horton, 1969) and distal braid-plain (Powell, 1991). A shallow lacustrine environment is unlikely; centimetre-scale cyclicity and lithological heterogeneity, both of which are good indicators of lacustrine deposition (Selley, 1985), are not seen at crop or in borehole sections. A braid-plain deposit would be lithologically varied because braided systems are often supplied with sediment seasonally (Selley, 1985), resulting in 'very variable, even random vertical sequences' (Miall, 1977). These variations are not observed in the Wildmoor Sandstone. The absence of pebbles and well-formed channels, and the high incidence of planar-parallel bedded sandstone are also atypical of deposition in an environment of variable discharge. It is suggested, therefore, that the formation accumulated in a lower energy environment, where as a result of basin filling and lowering gradients, conditions were transitional between braided and low sinuosity fluvial systems.

4.1.3. Bromsgrove Sandstone Formation (formerly 'Lower Keuper Sandstone') Anisian Stage

The Bromsgrove Sandstone occupies a broad tract of land from Cosford Airbase in the north to Chesterton in the south. It is partially drift-covered at outcrop, and gives rise to a fairly well featured topography of ridges and valleys broadly oriented north-south. The formation is estimated to be 105 m thick, and is composed of reddish brown sandstone and subordinate mudstone. The formation is disconformable on the Wildmoor Sandstone. Mudstone beds, which are rare in the lower part of the formation, are thicker and more numerous higher up, as the transition ('the Waterstones' of Whitehead et al. 1928) with the Mercia Mudstone Group is reached.

The base of the formation is erosional, and exposed at Cosford Pool [SJ 7872 0444] (Figure 3), and in a quarry at Spring Coppice [SJ 7608 0023]. At Cosford Pool, the lowermost beds are erosively-based troughs. The thicker sandstone units contain pebbles up to 3 cm in diameter.

Strata just above the base of the formation are exposed in Monks Quarry [SJ 7827 0456] (Figure 4). The section shows three main laterally continuous, trough cross-bedded, pebbly sandstone cosets up to 0.98 m thick which are overlain by a 2 m shaley mudstone unit. Cross-bedding measurements from the sandstones indicate a westerly palaeoflow. A road cutting at Beckbury [SJ 7662 0146] exposes 2.83 m of pebbly, trough cross-bedded sandstone which is overlain by 2 m of red silty sandstone. Clasts are typically intraformational (mudstone clasts, and pebbles reworked from the Kidderminster Formation) but some are extraformational (chert, angular vein quartz). Sandstone units are up to 1.5 m thick, with erosional bases. Cross-bedding is preserved in the upper 0.72 m of the pebbly sandstone. An exposure in similar lithologies, 120 m north of the Kennels at Whiston Cross [SJ 7960 0365], also shows a westerly palaeoflow.

A cliff section along Badger Dingle [SO 7631 9911] exposes 10.8 m in the mid-part of the formation (Figure 5). Erosional-based, upward-fining sandstone units in the basal 5 m of the section pass upwards into trough cross-bedded units and finally planar-bedded sandstone. Pebbles of quartz and mudstone are common throughout some sets, and form lags concentrated at the base of others. Palaeoflow directions, interpreted from foreset azimuths, are variable. Farther east along Badger Dingle [SO 7706 9933], concretions are present at the top of some fining upward units. These may result from root development, and indicate the formation of a poor soil.

Quarries along Stratford Brook expose sections through the upper part of the formation. Cross-bedded, brown sandstone sets up to 0.6 m thick are exposed in a 10 m section in a disused quarry south of Pearl Covert [SO 7895 9727]. At Chesterton Mill Farm [SO 7914 9786], sandstone cosets are about a metre thick, with clasts up to 8 cm in diameter lying along major set bounding surfaces. In both sections, siltstone beds are not present, and the sandstone is fine- to coarse- grained and poorly sorted. The Bromsgrove Sandstone is also well exposed around 'The Walls' national monument [SO 786 967] immediately south of Chesterton (see Appendix 11.3).

The formation was deposited within a semi-arid fluvial, possibly braided environment (Warrington, 1970; Wills, 1970), with erosionally-based channel sandstones at the base of fining-upwards sequences. Finer-grained units, sometimes with a mudstone or siltstone channel-plug preserved at the top, may represent the infilling of abandoned channels (Warrington, 1970), or overbank deposits.

4.2. Mercia Mudstone Group (Ladinan - ?Carnian Stage)

The basal beds of the Mercia Mudstone comprise a sequence of interbedded mudstones and sandstones. The junction with the underlying Bromsgrove Sandstone is transitional and diachronous, but is placed at the base of the lowest substantial mudstone within this transitional sequence. The basal beds crop out from [SJ 8000 0248], 400 m east of Little Whiston Farm, to Brewers Lodge Plantation [SO 7926 9935], from where they are faulted north out of the district. The lower part of the group occupies an eastern facing, mostly drift-covered slope. No exposures were seen during the period of resurvey, but the basal beds augur as a reddish-orange to brown, slightly silty claystone.

5. QUATERNARY

The distribution of glacial drift (Till and Glaciofluvial Sand and Gravel) is generally restricted to topographic hollows east of the Worfe. Alluvium and River Terrace Deposits are associated with the River Worfe and its tributaries.

The Lightmoor Channel

The Lightmoor Channel is an infilled, over-deepened subglacial meltwater channel (Hollis and Reed, 1981). It trends south-eastwards from Woodside in Telford, between Stableford and Cranmere on SO79NE, and continues onto Sheet SO79SE (Hollis and Reed, 1981; Hamblin, 1986) (Figure 6). The channel is deepest at Sandford [SO 788 928], 4 km south of the district, where it is infilled by up to 55 m of drift (Whitehead and Pocock, 1947). The sequence of deposits within the Lightmoor Channel was described by Hollis and Reed (1981) from sand pits at Hilton. They recorded proglacial lacustrine deposits (generally laminated clay, sand and silt), overlain in places by glaciofluvial sand and gravel, in turn, capped by Irish Sea Till. This association they interpreted as forming during oscillation of the Late Devensian ice front prior to final retreat. No sections proving the stratigraphy of the Lightmoor Channel sequence were seen during the period of resurvey.

5.1. Till

Much of the district is covered by a thin mantle of Late Devensian till (Morgan, 1973). The maximum thickness proved in boreholes is 3.5 m at Cosford Airbase. Till is a stiff reddish-brown sandy and pebbly clay, containing lenses of sand and gravel or laminated clay. A study of the erratic content of the till was carried out by Hollis and Reed (1981), and their findings are shown in Table 1.

	Sample 1	Sample 2
Total number of pebbles in sample	258	319
PEBBLE TYPE (% of total sample)		
'Bunter'-type quartzes and quartzites	48	54
Reddish sandstones (Triassic and Barren Measures)	7	9
Non-reddish sedimentary rocks (Carboniferous, Devonian, Silurian and Cambrian)	19	8
White, grey, purplish and greenish quartzites (Cambrian and Pre-Cambrian)	6	4
Uriconian and Carboniferous igneous rocks (Wrekin area)	8	3
Igneous and metamorphic rocks (North Wales, Lake District and South Scotland)	9	16
Flint	<1	1
Unidentified	3	5

Table 1:Lithology and probable origin of pebbles larger than 2 cm in samples of gravels from the 'Irish Sea drifts' (till) of Hollis and Reed (1981). Redrawn from Hollis and Reed, 1981.

A high proportion of pebbles are of local derivation, coming mostly from the Kidderminster Formation. Other clasts can be matched with lithologies found in the Wrekin, North Wales, the Lake District and South Scotland, indicating ice-advance from a predominantly northerly direction (Wills, 1924). Fossil marine shells, which included Turritella, were collected from the till sheet in the Badger and Ackleton area, and are described in Lister (1862).

5.2. Glaciolacustrine Deposits

A flat area measuring 100 by 250 m north-east of Badger Farm [SJ 7690 0050] is underlain by pale orange pebble-free clay, which is slightly sandier to the north. This would probably have been deposited within a shallow glacial lake.

5.3. Glaciofluvial Sand and Gravel

These deposits occur in association with till or glaciolacustrine clay. They are composed of bedded and unbedded sand and gravel with subordinate beds of silt and clay. The gravels include abundant pebbles reworked from the Kidderminster Formation, as well as material from further afield (for example, slate from Wales, and Lower Carboniferous limestone from Lilleshall or Wenlock Edge). Field relationships indicate that in some areas the sand and gravel is overlain by till, as for example, in a pit at [SJ 7593 0157], at Davenport House [SO 7535 9544] and to the north-west of Bradney at [SO 7708 9600]. Elsewhere the sand and gravel deposits clearly cut down through till and therefore post-date it, for example, immediately to the east of Rowley Coppice [SO 7660 9698]. This latter relationship becomes more pronounced in the west of the district and is proved repeatedly in auger holes (for example, around [SO 7596 9733], [SO 7553 9750] and [SO 7661 9694]). The close association of till and sand and gravel led Wills (1924) to hypothesise that the 'two deposits are intimately connected, and probably deposited in part contemporaneously'. The deposits in the north of the district are generally poorly featured, their margins being sometimes marked by a slight convex break in slope. South of Beckbury and Whiston Cross, the sands and gravels are better featured, forming mounds up to 2 m high. On the valley sides south of northing $^{2}98$, deposits of Glaciofluvial Sand and Gravel form terrace-like deposits which can only be distinguished from the Higher Terraces of the River Worfe (see 5.4) on the basis of their intimate association with till. According to Whitehead and Pocock (1947) these terrace-like features 'pass insensibly into the Third or Main Terrace of the Severn and Stour'.

An exposure through part of the drift sequence at Hilton Sand Pit [SO 777 951], 2.5 km to the south of Chesterton, was described by Hollis and Reed (1981). They observed an upper, sandy deposit (the 'Hilton Sands'), which is up to 15 m thick resting on a lower, silty unit (the 'Hilton Silts') which is up to 4.3 m thick. The upward-coarsening from a silt to a sand-dominated deposit was assigned to a decrease in the water depth of a proglacial lake, in which the deposits accumulated. On SO79NE, however, the compositional and morphological similarity of these deposits when augured precluded applying Hollis and Reeds classification over the district.

5.4. River Terrace Deposits of the Worfe

A flight of terraces has been identified along the valleys of the Worfe and Stratford Brook. Fragmentary deposits of sand and gravel with a terrace-like form are preserved at heights of over 23 m above the alluvial plain (over 69 m OD) south and west of Ackleton. These have not been divided, and are included as Higher Terraces (undifferentiated). The Second Terrace is between 4 and 20 m above the alluvium, and the First Terrace is up to 4 m above the level of the alluvial plain. Terraces also occur along Mad Brook and Hilton Brook. The terraces of the Worfe are graded to those of the River Severn (Wills, 1924; Hamblin and Coppack, 1996), though the exact correlation is, however, speculative, and a formal relationship between the two systems has yet been established.

5.4.1. Higher Terraces of the Worfe (undifferentiated)

Flat-topped deposits of sand and gravel occur along the southern Worfe catchment. The bases of these fragmentary terrace remnants range from 65 m to 78 m above OD. The Higher Terraces may correlate with either the Main or Kidderminster Terraces of the Severn (Hamblin and Coppack, 1996). Upstream of Ironbridge Gorge, the Main Terrace is overlain by till (Hamblin and Coppack, 1995). The Higher Terraces may therefore predate the maximum advance of Devensian ice-sheet. The Higher Terraces west of the Worfe are discussed by Hamblin and Coppack (1996), and no further reference is made to them in this report. East of the Worfe, the base of these deposits is commonly about 69 m above OD, except at Dalepiece Rough [SO 7650 9870], where it rises to 75 m above OD, and south of Cranmere Cottage [SO 7592 9785], where it falls to 65 m above OD.

5.4.2. Second Terrace of the Worfe

Second Terrace deposits are mainly found in the south of the district (SO79NE) and consist of orange-brown sand and pebbly sand. The deposits are best developed between Hilton and Wyken [SO 769 954] where they form an extensive flat attaining a maximum height of 55 m OD. Immediately north-west of Hilton the Second Terrace can be sub-divided into lower and upper facets. The lower facet occurs up to 50 m OD, the upper to 59 m OD. Similar upper and lower divisions were identified in the Worcester Terrace of the River Severn by Whitehead and Pocock (1947). These have also been recognised during the present (1998) re-survey of the Apley Park district (SO79NW).

5.4.3. First Terrace of the Worfe

The First Terrace is best developed and probably thickest towards the south of the district, between Stableford [SO 759 987] and Worfield [SO 759 957], where it is up to 650 m wide and about 4 m thick. The deposits consist of orange-brown sand and pebbly sand. North of Stableford, the terrace is typically 1-3 m above the alluvium and up to 200 m wide (but commonly significantly less). The upper surface of the terrace is slightly undulose.

5.5. Alluvial Fan Deposit

A small alluvial fan deposit is present 100 m east of Pasford Cottages [SO 8000 9844]. The deposit has a cone-like form, and is likely to have a similar composition to alluvium.

5.6. Alluvium

The well-developed alluvium along the Worfe valley is up to 240 m wide between Sheepwalk Coppice and Rowley Coppice [SO 762 971]. It is usually composed of dark brown organic silt and sandy silt with sporadic gravel lenses. The alluvium is probably no more than 3 m thick in the district. Narrow alluvial tracts flank Nun, Stratford and Hilton Brooks, Cosford Pool, Mad Brook, Wesley Brook, along parts of Badger Dingle and unnamed streams at [SJ 7812 0046], [SJ 7995 0153], [SO 7526 9830], [SO 7510 9550] and [SO 7910 9620].

5.7. Peat

A thin spread of peat floors a shallow, north-trending valley between Caynton Cottages and Lower Snowdon. South of Rous's Covert and Fox Covert, the peat rests on Glaciofluvial Sand and Gravel; north of this the deposit overlies till. A reservoir recently dug e at [SJ 7830 0233] proved the deposit to be at least 2 m thick.

The Bog, centred around [SO 7530 9760], is a peat-based depression up to about 3 m deep. It measures 380 m by 190 m, and rests on a plateau capped by Glaciofluvial Sand and Gravel. It has been interpreted as a kettle hole (Whitehead et al. 1928). The Bog would have formed when a buried block of ice trapped within the Glaciofluvial Sand and Gravel melted (Bates and Jackson, 1987). This would have created a hollow in the overlying sediment in which water ponded and peat formed.

5.8. Head

Head is a unit of drift which includes unconsolidated deposits derived from processes of hillwash, solifluction or soil creep. Thin deposits of head and colluvium are likely to be present wherever the downhill mass movement of drift or weathered bedrock has occurred. At Hilton [SO 778 957], head deposits form prominent solifluction lobes of medium- to coarse-grained orange-brown sand and brown clayey sand. Immediately to the west, a heterogeneous deposit of sand, pebbly sand, clayey pebbly sand and pebbly sandy clay mantles the steep slopes surrounding Rowley Farm [SO 7674 9605]. Extensive head deposits also occur on the western side of the Worfe Valley, north of Worfield [SO 759 957]. The deposits consist of grey, yellow, orange-brown, red and green mottled clayey sand and sandy clay. Smaller deposits of head occur throughout the district and are typically composed of dark and light brown pebbly silt, sand and clay. Within the Ryton area, head is found at the base of dry valleys, at [SO 7999 0173], [SJ 7640 0233] and [SO 7502 9847]. Head in the district is probably less than 2 m thick.

6. STRUCTURE

The strata within the district comprise part of the post-Carboniferous fill to the Stafford Basin. The dipslope of the Bromsgrove Sandstone east of Badger Farm and Beckbury is inclined approximately 2^{o} eastwards. This may be taken as representative of the regional dip, as measurement of true dip at outcrop is complicated by the cross-bedded nature of the rocks.

The **Harrington Fault**, which juxtaposes the Bridgnorth Sandstone and the Wildmoor Sandstone, has an estimated throw of about 120 m at Hatton Grange.

A west-trending fault is inferred between The Sands [SJ 752 049] and The Slips [SJ 766 049] to explain the apparent juxtaposition of the Wildmoor Sandstone and the Kidderminster Formation. Throw on this fault is estimated at about 90 m to the north.

A series of small faults with displacements of only a few metres cut the base of the Bromsgrove Sandstone between Caynton Hall and Badger Farm.

The **Patshull Fault** is a major bounding fault and probably represents a basinward continuation of the Breward Fault. It can be traced from the south of the district, 500 m west of Galatea Farm [SO 7946 9516], to Bishton Manor [SJ 8040 0175]. The fault throws strata of the Bromsgrove Sandstone and Mercia Mudstone to the west down against Wildmoor Sandstone and Bromsgrove Sandstone to the east.

The **Pasford Fault** is exposed in a waterfall section 100 m north of Pasford Brook [SO 7994 9911]. The fault dips 82^{o} to N004, and is within a shear zone which is up to 70 cm wide. Bromsgrove Sandstone (dark brown and buff medium grained sandstone with mudclasts) is downthrown to the north against Wildmoor Sandstone (1.6 m of soft red sandstone). The Pasford Fault is truncated to the west by the Patshull Fault.

At Hilton [SO 777 956] a north-westerly-trending fault throws down the base of the Bromsgrove Sandstone approximately 35m.

7. ECONOMIC GEOLOGY

7.1. BRICKCLAY

Till and/or mudstones within the Bromsgrove Sandstone were formerly dug for brickmaking at [SO 7865 9540] and [SO 7885 9545].

7.2. Sand and Gravel

Sand and gravel has been worked from the Second Terrace of the Worfe and from within the Lightmoor Channel at Hilton Sand Pit [SO 7770 9504]. The First Terrace has also been worked between Badger Farm and Highford [SJ 7580 0025]. Smaller pits in Glaciofluvial Sand and Gravel have been dug at Beckbury [SJ 7595 0150], Badger Mill Farm [SO 7827 9965] and 100 m to the north of Mere Pool Cottage [SO 7515 9650].

7.3. Building Stone

The Wildmoor Sandstone was formerly worked in a quarries at Ryton [37612 30256] and Worfield [SO 7565 9646] , and may have been used as a building stone or a moulding sand.

Small quarries within the lower beds of the Bromsgrove Sandstone Formation are fairly common throughout the district; all are currently disused. Quarries along Cosford Brook, for example, Monks Quarry [SJ 7827 0457], were reputedly worked from medieval times. Other disused quarries are located at Spring Coppice [SJ 7610 0022], Stratford Brook [SO 7895 9728], [SO 7907 9771], along Badger Dingle [SO 7631 9911] to [SO 7750 9923], and Hilton [SO 7800 9520] and [SO 7793 9546].

8. MAN-MADE DEPOSITS AND WORKED GROUND

8.1. Made Ground

The largest area of made ground in the district is associated with former gravel workings, 500 m west of Badger Farm, and is 5-6 m in height. Other deposits include road embankments at [SJ 7800 0454] and [SO 7978 9938], and spoil dug from reservoirs at [SJ 7697 0014] and [SJ 7831 0228].

8.2. Worked Ground

Worked ground is associated with:

Road cuttings, at [SJ 7784 0467] and [SO 7576 9848].
Reservoirs, at [SJ 7990 0377], [SJ 7910 0235], [SJ 7830 0232], [SJ 7750 0085], [SJ 7690 0015] and [SO 7890 9750].
Disused clay pits, at [SO 7865 9540] and [SO 7885 9545].
Sand and Gravel pits, at [SJ 7595 0155], [SJ 7580 0025], [SJ 7597 0014] and [SO 7827 9965].
Disused sandstone quarries at [SJ 7827 0457], [SJ 7610 0022], [SO 7565 9646], [SO 7895 9728], [SO 7907 9771], [SO 7631 9911], [SO 7750 9923], [SO 7800 9520] and [SO 7793 9546].

8.3. Infilled Ground (Worked Ground and Made Ground)

Former workings in second terrace deposits at Hilton Sand Pit [SO 7770 9504] have been backfilled.

8.4. Landscaped Ground

An area of landscaped ground at Hatton Grange [SJ 7646 0430] covers approximately 1 hectare. It is an area which has been levelled for ornamental gardens and the buildings of the main house. A golf course at [SO 779 969] has undergone some minor landscaping.

9. GEOLOGICAL HAZARDS

This section is intended as a summary of the principal geological hazards identified in the area at the last date of survey. It is not exhaustive and should not be used under any circumstances to replace any part of a geological investigation.

Unconsolidated deposits in the area have been divided into Head, Peat, Alluvium, River Terraces, Glaciolacustrine Clay, Till, Glaciofluvial Sand and Gravel, and Made Ground. These deposits are internally heterogeneous, can be highly compressible, and give rise to excessive and differential settlement of superposed structures. For this reason particular care should be taken in the siting of any construction on such deposits. Head may contain relic shear surfaces, of importance to slope stability and foundation design (Hutchinson et al., 1973). The presence of relatively impermeable till beneath Glaciofluvial Sand and Gravel may cause the presence of a perched water table. Running conditions may be encountered in unconsolidated sand and gravel if encountered below the water table.

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11. APPENDICES

11.1. Boreholes referred to in this report

Sheet	Name	NGR	BGS ref. No.	GL (m above OD)	Depth below GL (m)
SJ70SE					
	Grindleforge	7524 0348	SJ70SE 1	51	137.2
	Cosford Pumping Station No. 2 (B)	7807 0461	SJ70SE 2	61	279.8
	Beckbury Pumping Station No. 1	7572 0152	SJ70SE 4	56	214
	Hatton Grange	7608 0425	SJ70SE 6	70	78.8
	Cosford Grange	7850 0450	SJ70SE 8	77	77.4
	Cosford No. 4	7814 0466	SJ70SE 9	60	75.6
	RAF Cosford (78 boreholes)	793 046	SJ70SE 10-88	76-84	10 max
SO79NE					
	Stableford 1	7640 9811	SO79NE 10	48	304.9
	Stableford 2	7638 9812	SO79NE 11	48	274.4
	Stableford 3	7635 9589	SO79NE 12	48	304.9
	Stableford 4	7632 9813	SO79NE 8	48	274.4
	Hilton 1	7765 9591	SO79NE 2	47	258.0

11.2. Hatton Grange Applecore log

Hatton Grange

SJ 7608 0425 SJ 70 SE 6

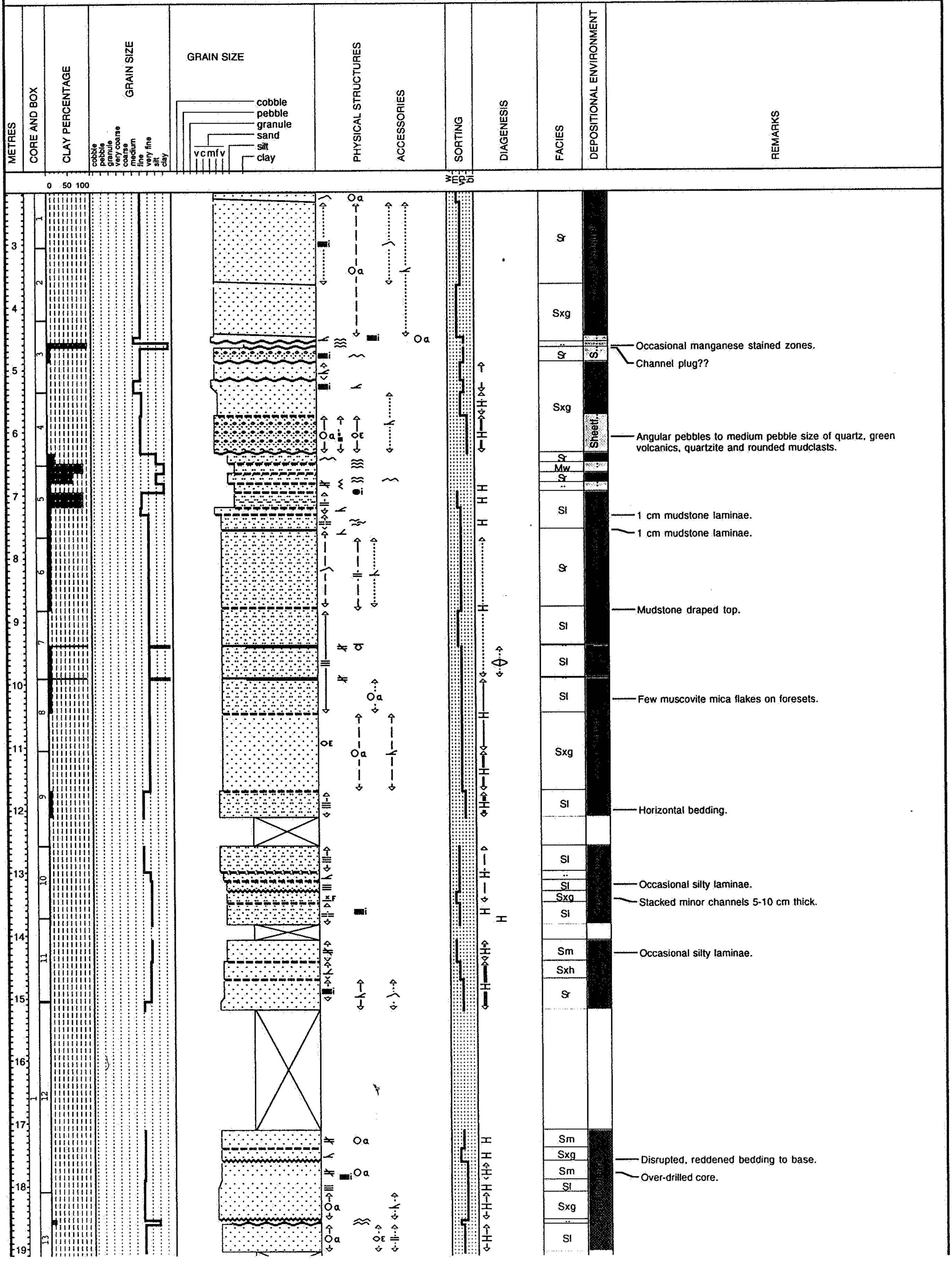
KdM

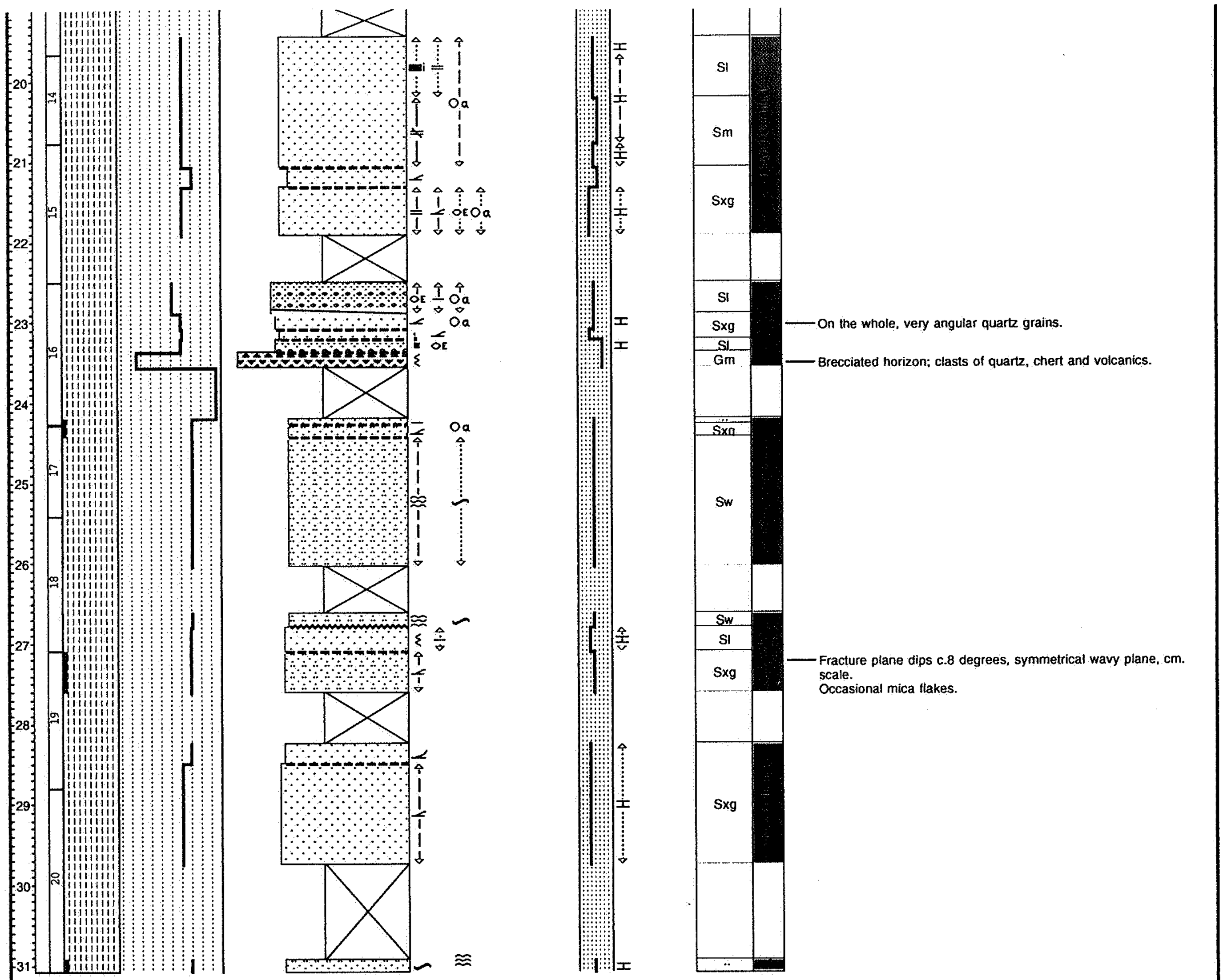
Date logged: 23 05 97

Logged by: Ed Hough

Ground: 70.00 m KB: 0.00 m

Remarks: Core 1, ST boxes 1 - 7
(EH box 1 = basal stick, ST box 1)
2.16 m - 31.07 m.





LEGEND

LITHOLOGY

SANDSTONE	SILTSTONE	argil siltst	BRECCIA
silty sandst	sandy siltst	CLAY/MUDSTONE/SHALE	pebbly sandst

CONTACTS

Sharp	Scoured	Uncertain	Undulating
Inclined			

PHYSICAL STRUCTURES

rc current ripple	xf trough/festoon cross-strat.	rcl climbing current ripple
lp parallel lamination	wp parallel wavy lamination	gf normal grading/ fining upward
dl load cast	l lamination, general	lpc cont. parallel lamination
lpd discont. parallel lamination	wnc cont. non-parallel wavy lamination	wnd discont. non-parallel wavy lamination
wpc cont. parallel wavy lamination	r ripples, general (set height<3cm)	xl low angle cross-stratification (5-15°)
xh high-angle cross-stratification (15-30°)	m structureless/massive, general	vd clay drape
vr rubble	xt tangential cross-bedding	

LITHOLOGIC ACCESSORIES

Ge extraclast, general	ag aeolian grains	Gim mudstone intraclast
Gima angular mud-intraclast		

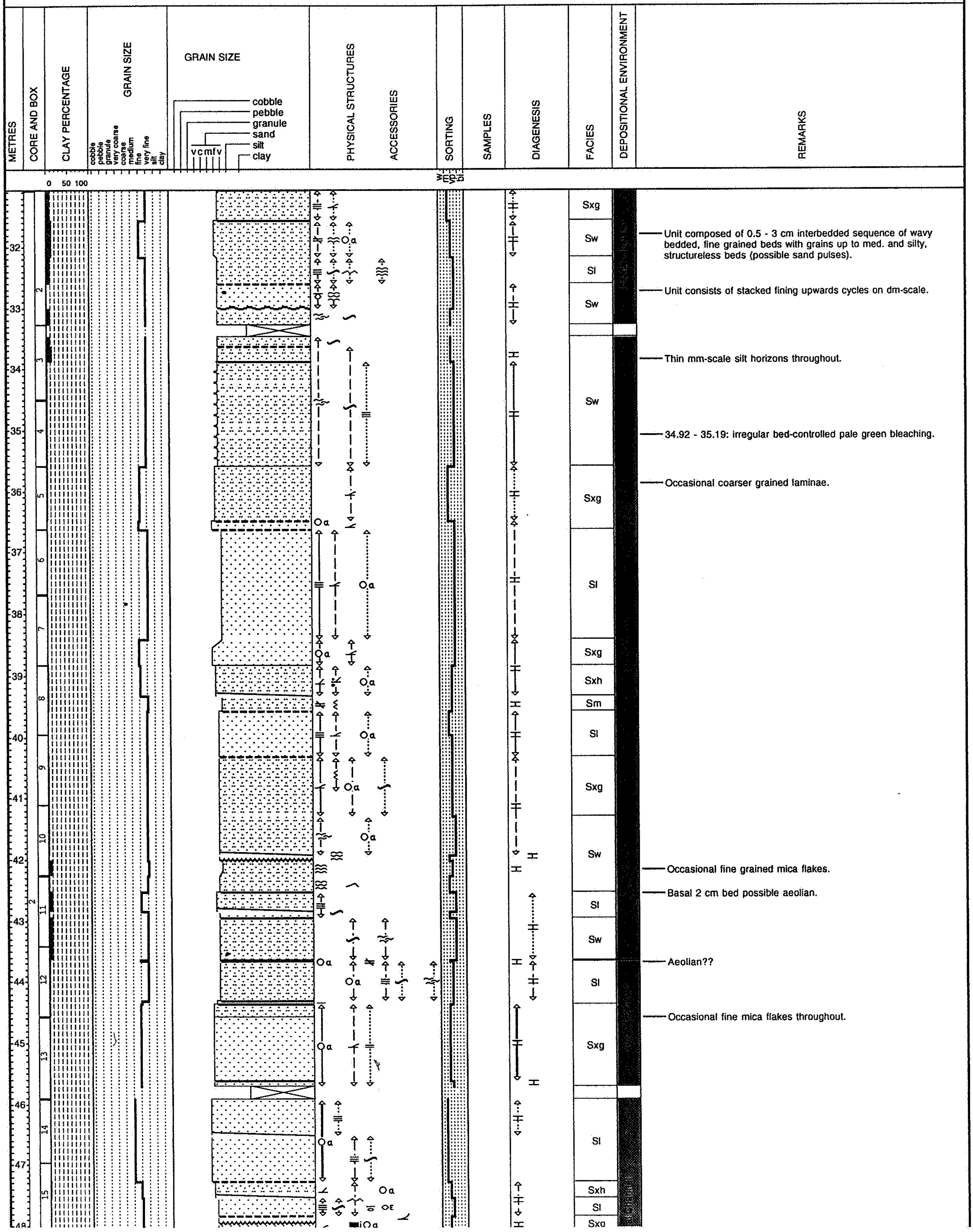
DIAGENESIS

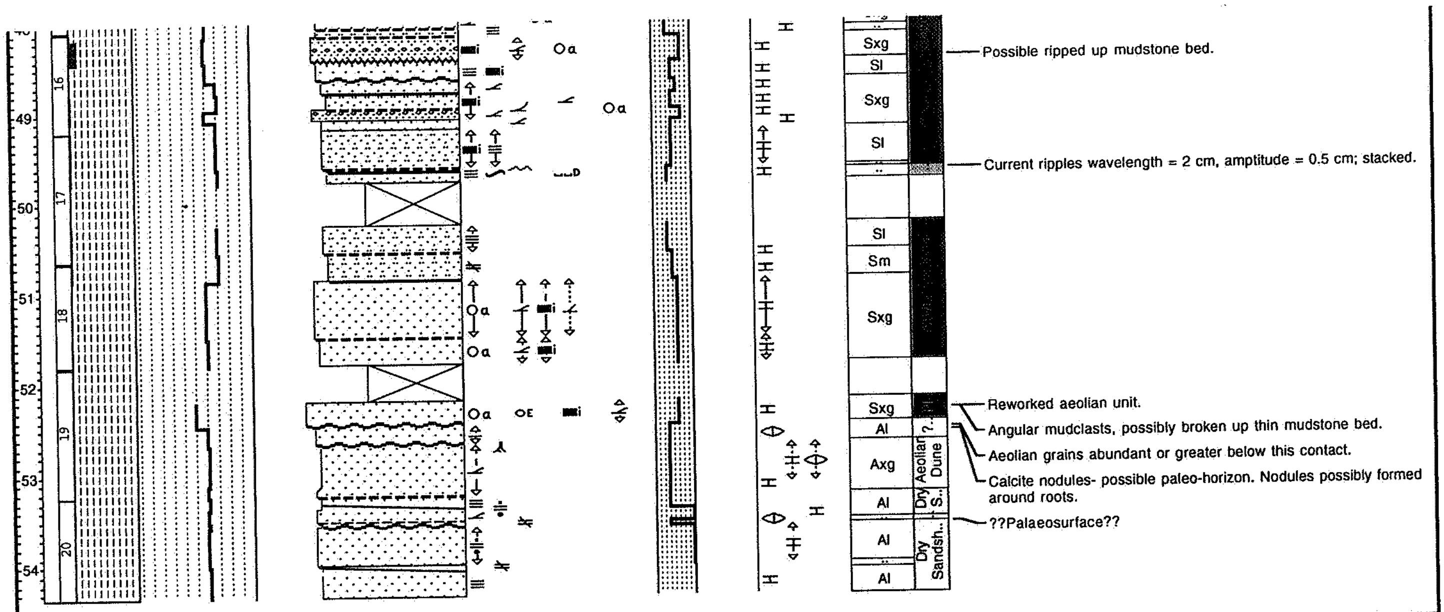
Anca calcite concretion	Amca calcite cement

Hatton Grange

Date logged: 28 05 97
Logged by: Ed Hough
Ground: 0.00 m KB: 0.00 m
Remarks: Core 2, (ST boxes 7 - 14)
EH box 1 = basal stick, ST box 7

KdM
52.50 BnS





LEGEND

LITHOLOGY

SANDSTONE — silty sandst — pebbly sandst

CONTACTS

Sharp — Scoured — Uncertain — Undulating — Inclined

PHYSICAL STRUCTURES

- rc current ripple
- dl load cast
- lpb parallel bimodal grainsize lamination
- wnd discont. non-parallel wavy lamination
- xl low angle cross-stratification (5-15°)
- m structureless/massive, general
- vr rubble
- lp parallel lamination
- l lamination, general
- lpc cont. parallel lamination
- wpc cont. parallel wavy lamination
- xh high-angle cross-stratification (15-30°)
- vcd desiccation crack
- or rootlets
- wp parallel wavy lamination
- lg granule lamination
- wnc cont. non-parallel wavy lamination
- r ripples, general (set height<3cm)
- xhb high-angle bimodal grsz lamin x-strat (15-30°)
- vd clay drape
- xt tangential cross-bedding

LITHOLOGIC ACCESSORIES

- Ge extraclast, general
- ag aeolian grains
- Gima angular mud-intraclast

DIAGENESIS

- Anca calcite concretion
- Amca calcite cement

Hatton Grange

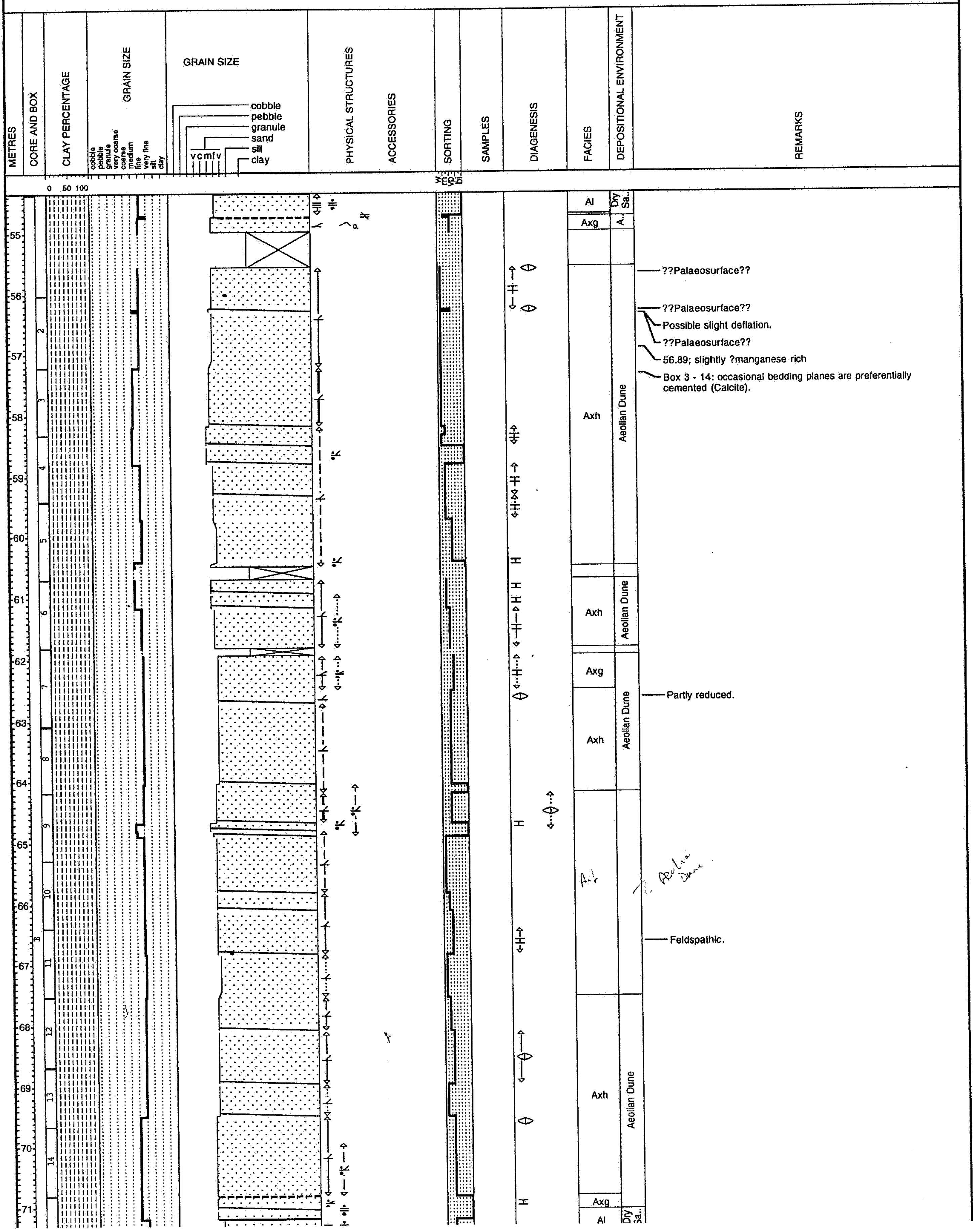
Date logged: 29 05 1997

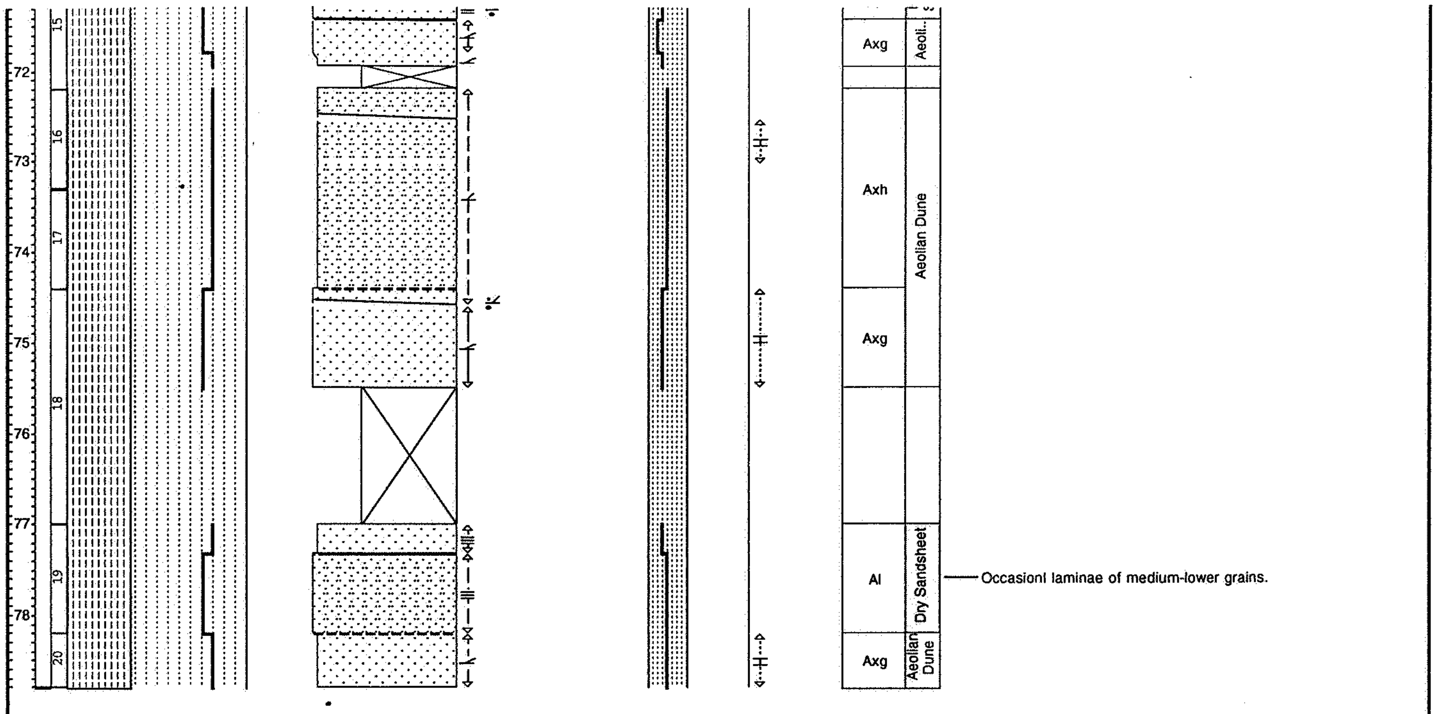
Logged by: Ed Hough

Ground: 0.00 m KB: 0.00 m

Remarks: Core 3, (ST boxes 14 - 20)
EH box 1 = middle stick, ST box 14

BnS





LEGEND

LITHOLOGY

SANDSTONE

silty sandst

CONTACTS

Sharp

Uncertain

Inclined

PHYSICAL STRUCTURES

rg aeolian ripple

xl low angle cross-stratification (5-15°)

xhb high-angle bimodal grsz lamin x-strat (15-30°)

lpb parallel bimodal grainsize lamination

xlb low angle bimodal grsz laminated x-strat (5-15°)

m structureless/massive, general

lpc cont. parallel lamination

xh high-angle cross-stratification (15-30°)

DIAGENESIS

Anca calcite concretion

Amca calcite cement

11.3. Logged section in Bromsgrove Sandstone

The following section was recorded at [SO 7876 9685].

	Thickness (m)
Sandstone, red-brown, medium- to coarse-grained, planar-lamination with local soft sediment deformation	0.40
Sandstone, red-brown, medium- to coarse-grained, trough cross-bedding	0.20
Sandstone, red-brown, medium- to coarse-grained, trough cross-bedding	0.25
Sandstone with scattered pebbles, red-brown, medium- to coarse-grained, trough cross-bedding	0.65
Sandstone with scattered pebbles, red-brown, medium- to coarse-grained, planar and trough cross-bedding	0.15
Sandstone with scattered pebbles, red-brown, medium- to coarse-grained, trough cross-bedding	0.20
Sandstone with scattered pebbles, red-brown, medium- to coarse-grained, trough cross-bedding, large dewatering structure*	0.55
Pebbly sandstone, red-brown, medium- to coarse-grained, trough cross-bedding	0.25
Pebbly sandstone, red-brown, medium- to coarse-grained, trough cross-bedding	1.00
Pebbly sandstone, red-brown, medium- to coarse-grained, cross-bedding	0.70

* The large dewatering structure referred to above is a type of convolute bedding taking the form of a sharp anticline. It attains a height of 1.7m and consequently disturbs several of the overlying beds.

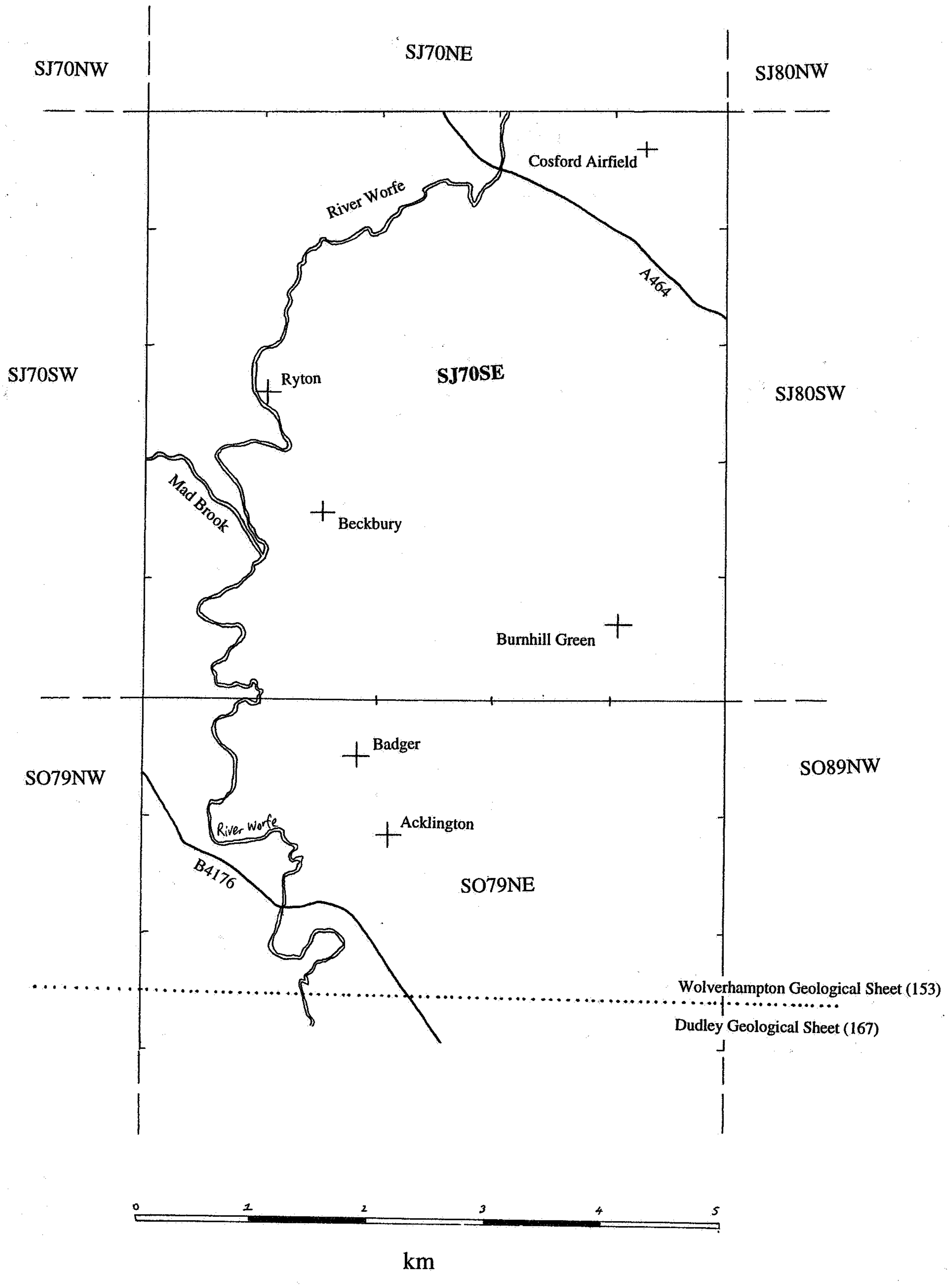


Figure 1: Location map of the district surveyed and adjoining 1:10 000 National Grid Sheets.

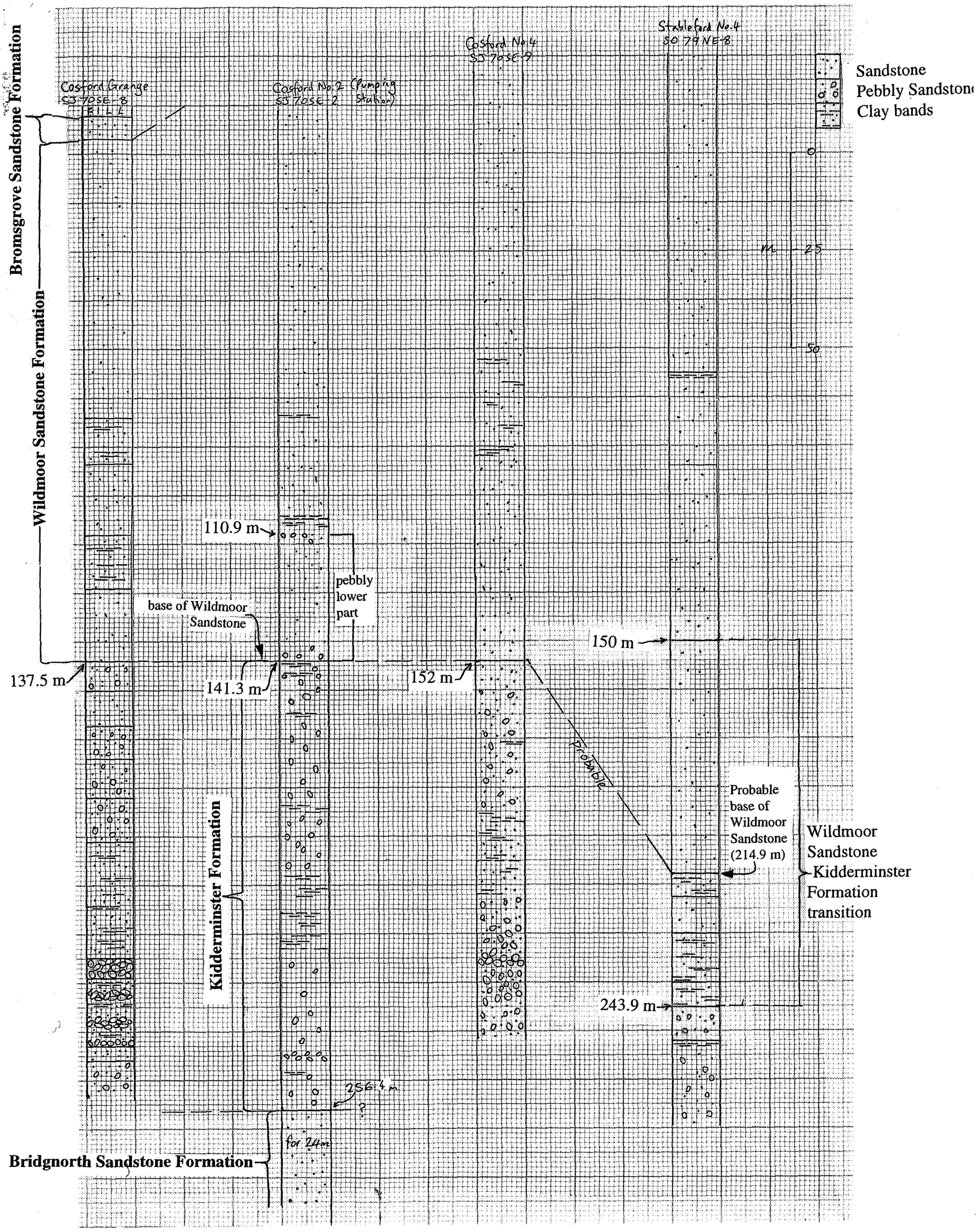


Figure 2: Comparative sections of the lower part of the Sherwood Sandstone Group (Kidderminster Formation and Wildmoor Sandstone Formation). Depths in m. below ground level.

GN

Field Slip Identifier 1:10 000 sheet	part	version	Geologist Code	Location number	Page	of	Date Day	Month	Year
SJ 70 SE	NE		EH		1	1	29	04	1997

NGR 37872 30444

BmS/WrS contact, south of Cosford Pool.

Bedding Strike | Dip | Dip az

VARIES.

Specimen numbers

500-600m — sandstone, brown. current bedded. trough cross bedded, sets have erosional bases. palaeocurrents to both East and west. Some thin (<20cm) well bedded cross sets. Thicker sets have pebbles to 3cm. 6/196

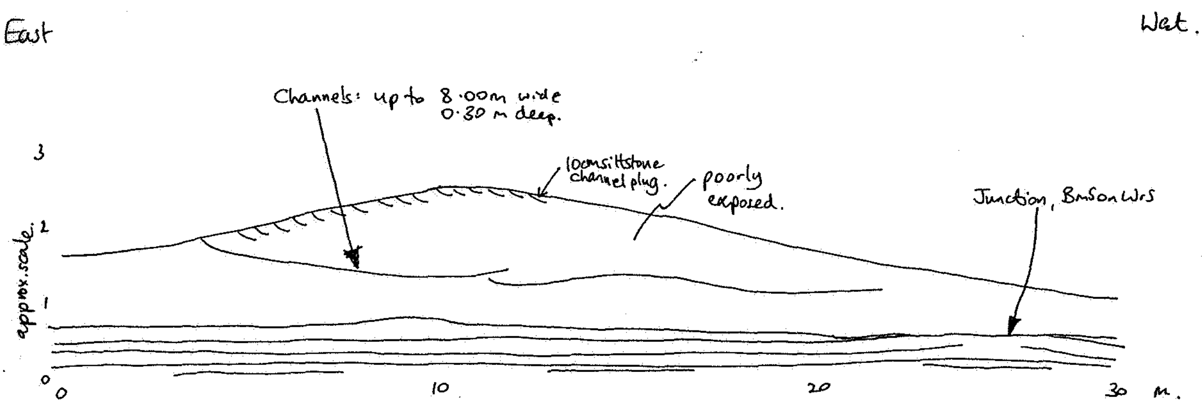
E. — W.

Junction - BmS has downcut 25cm into WrS. 6/149.

0.82m — thin,- med bedded bright orange & cream silty sandstone. Asymtotic cross sets indicate palaeoflow to E. 8/126.

BmS/WrS

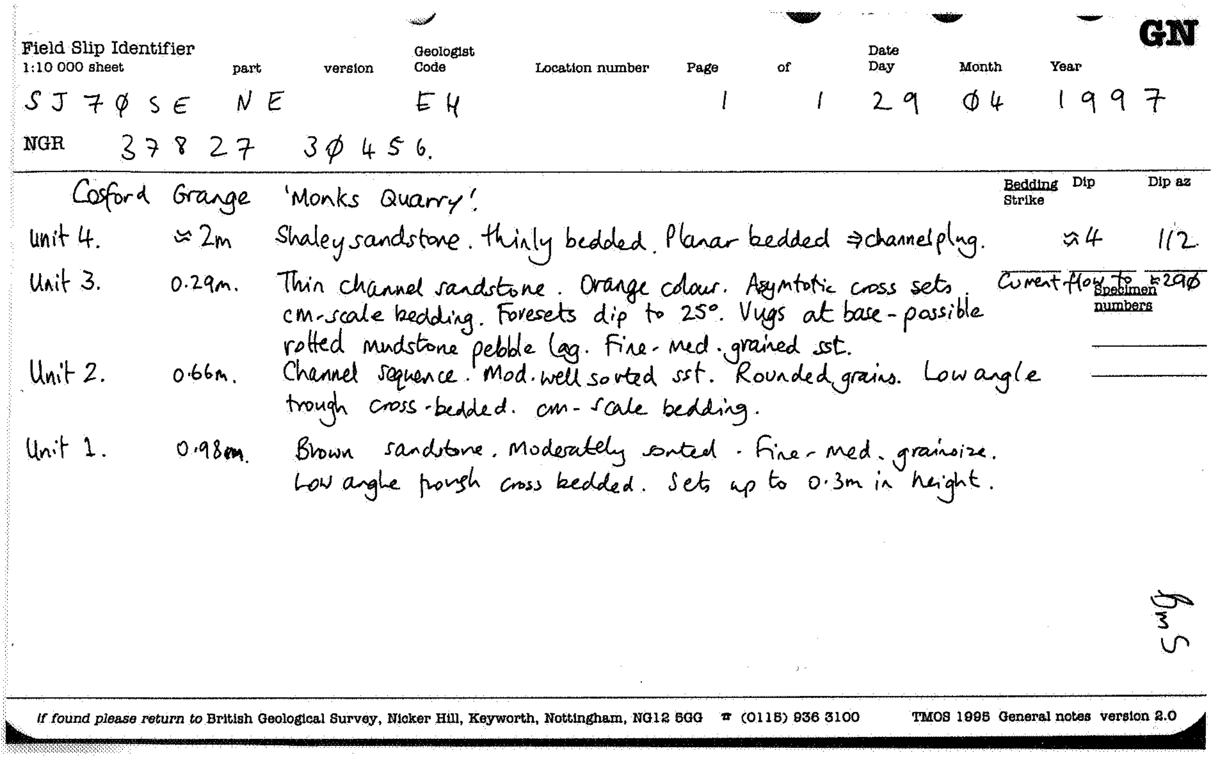
If found please return to British Geological Survey, Nicker Hill, Keyworth, Nottingham, NG12 5GG ☎ (0115) 936 3100 TMOS 1995 General notes version 2.0



BmS: poorly sorted. medium grained red sandstone. Some spherical (reworked aeolian?) grains.
WrS: angular, sub spherical grains

Over to N side valley (7874 0446) mudstone ~~pebble lags~~ drapes on foresets and some mudstone clasts up to 60mm x 15mm.

Figure 3: Section south of Cosford Pool [SJ 7827 0444], showing the junction between the Wildmoor Sandstone Formation and the overlying Bromsgrove Sandstone Formation.



GN

Field Slip Identifier
1:10 000 sheet SJ 70 SE | part NE | version | Geologist Code EH | Location number | Page 1 of 1 | Date Day 29 Month 04 Year 1997

NGR 37827 30456.

Cosford Grange 'Monks Quarry'.

			Bedding Strike	Dip	Dip az
Unit 4.	≈2m	Shaley sandstone. thinly bedded. Planar bedded ⇒ channel plug.		≈4	112
Unit 3.	0.29m.	Thin channel sandstone. Orange colour. Asymtotic cross sets. cm-scale bedding. Foresets dip to 25°. Vugs at base - possible rotted mudstone pebble lag. Fine - med. grained sst.	Current flow to ≈290		
Unit 2.	0.66m.	Channel sequence. Mod. well sorted sst. Rounded grains. Low angle trough cross-bedded. cm-scale bedding.			
Unit 1.	0.98m.	Brown sandstone. Moderately sorted. Fine - med. grainsize. Low angle trough cross bedded. Sets up to 0.3m in height.			

Specimen numbers

If found please return to British Geological Survey, Nicker Hill, Keyworth, Nottingham, NG12 5GG ☎ (0115) 936 3100 TMOS 1995 General notes version 2.0

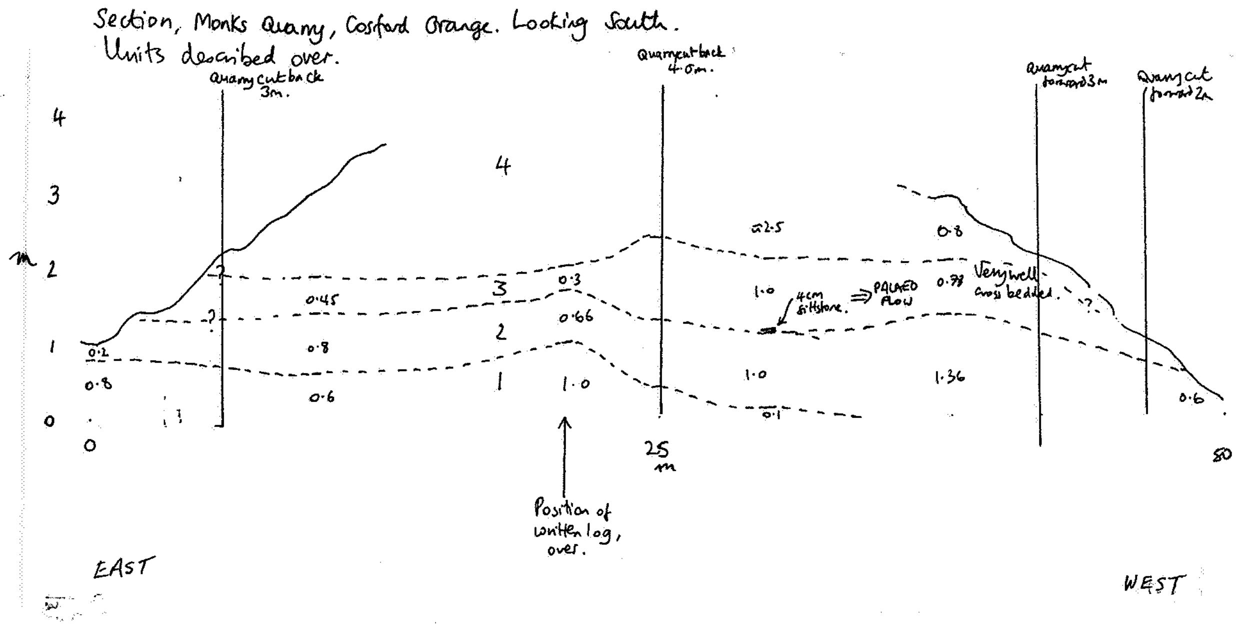
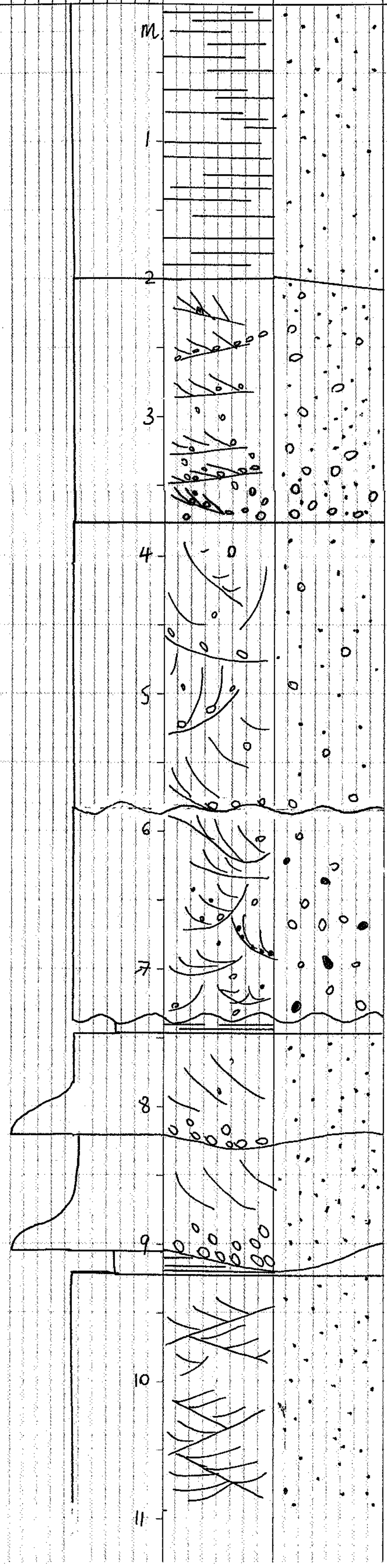


Figure 4: Section from 'Monks Quarry', Cosford Grange [SJ 7827 0456], in the lower part of the Bromsgrove Sandstone Formation.

BRITISH GEOLOGICAL SURVEY Sheet 1 of 1

Borehole/Well No.	Location Badger Dingle	NGR/Lat. & Long. 7631 9911 (SO)
	~~KB~~/Ground level approx +65-73m OD	Logged by Ed Hough

Stratigraphy	Carbonates: Calc. R, Calc. A, Calc. L / Average grain size: C P G VC C M F VF Si C	Sedimentary structures	Graphic lithology	Lithological description



2m Weathered brown, fine-med. grained poorly sorted micaceous sst; flaggy, mm-cm-scale bedding.

1.75m pebbly sandstone sets 0.3-0.96 m thick. planar low angle cross-bedded. Red mudstone pebble lags to the base of sets. Overall orange colour. Poorly sorted. Pebbly (mostly quartz pebbles). Passes eastwards (down section) to channel-based sandstone sets, more pebbly, topped by thin (<10cm) mudstones/siltstones. Cross bedding 21/azimuth 309.

2.1m. As above, but fewer pebbles and pebble lags. Set height 0.5-0.9m (generally) Cross sets 27/314 Erosional base

1.52m. very pebbly sandstone. Very high angle cross bedding. Pale pink pebbly sandstone. mud clasts (intraformational) common (●) Clast size up to 8cm. Trough cross bedded, 1 small channel at top, 0.39m thick, 7+m wide. Erosional based unit

0.07m. Planar bedded silty claystone. bedded on cm-mm scale. dips 6/007.

0.74m. Pebble cross bedded set. Pebbly based.

0.82m. As above.

0.09m Red, silty claystone.

1.72m Planar cross bedded sandstone, low angle sets. Sets 0.3-0.7m thick. Erosional based. Dip 21/040. Brown colour.

Figure 5: Log of 10.8 m from the mid part of the Bromsgrove Sandstone Formation, exposed along Badger Dingle.

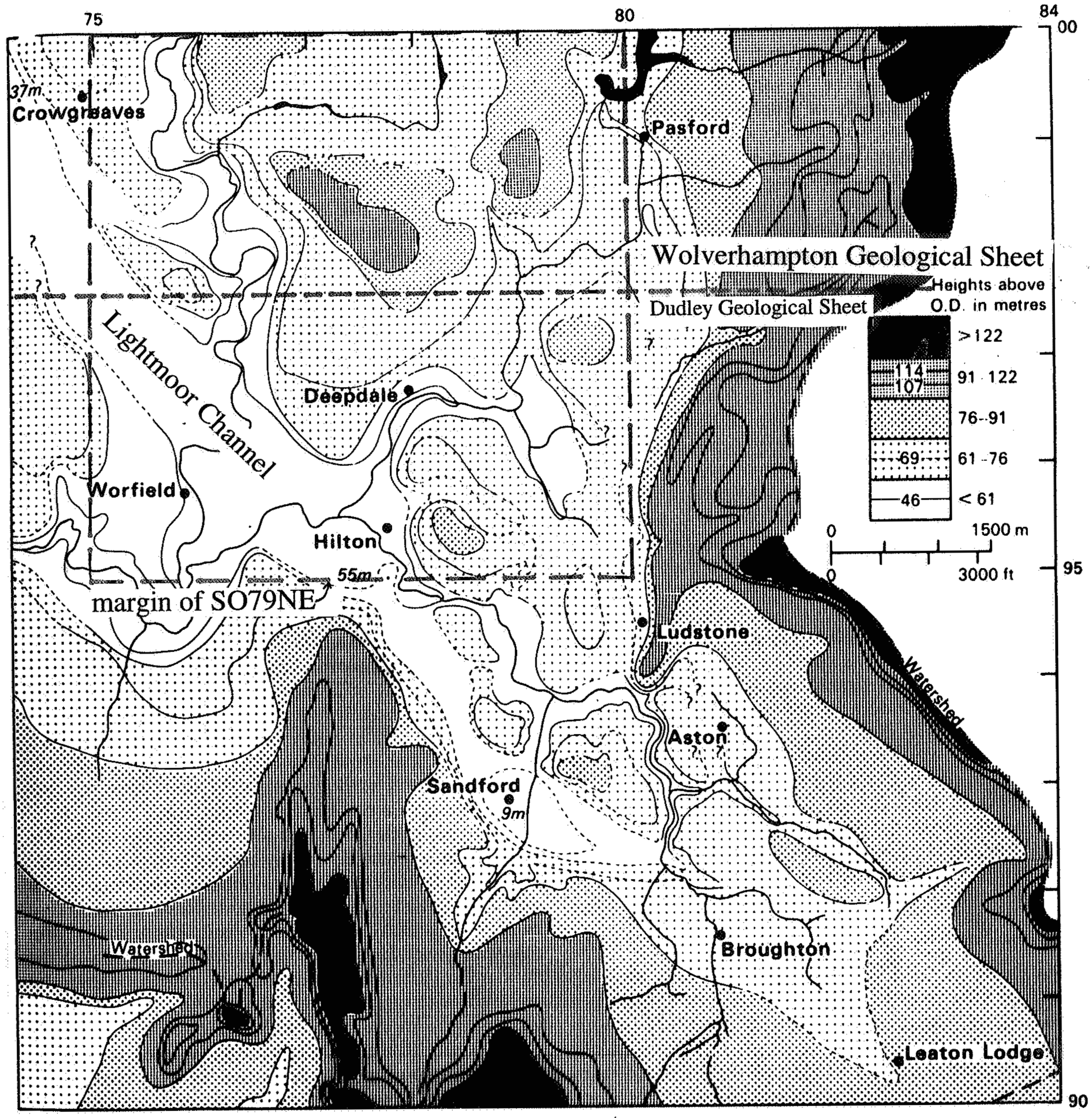


Figure 6. Location of the southern part of the Lightmoor Channel, and the topography of the sub-drift surface in the Southern Worfe Catchment (from Hollis and Reed, 1981).