# SWILLEYS IN THE COAL MEASURES OF NOTTINGHAMSHIRE INTERPRETED AS PALAEO-RIVER COURSES

by

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## Summary

Within the Top Hard seam a coal-filled channel, 725 feet wide, is bounded by clastic levee-like deposits and meanders between two cannel-coal lenses, each covering tens of square miles. Similar structures are known within the Deep Hard, Deep Soft and Abdy seams, and they are compared to the ancient roddens and meres of the Fenlands in eastern England. These channels are interpreted as river courses which became established and were abandoned within the period of deposition of the seam concerned. The significance of stratigraphic relationships between the clastic rocks and the three coal types recognised in the field is discussed in relation to conditions of deposition.

## Introduction

Miners refer to any pronounced hollow, usually an elongated hollow in the topography of the base of a coal seam, as a "swilley". Variants such as "swalley" (Clarke, 1963) are prevalent in other coalfields. Raistrick and Marshall (1939, pp. 96 - 97) briefly described "swilleys", without mentioning any locality, and suggested that they were contemporaneous structures. The prime purpose of this paper is to put on record a description of a particular type of "swilley" known in the Coal Measures of Nottinghamshire. This is a ribbon-like type, of depositional origin, sometimes laterally associated with extensive lenses of cannel-coal. This ribbon, in cross-section (fig. 1), consists of a "hollow" bordered by two "brows" with relatively steep dips into the hollow and gentle dips away from it, down the "swilley-flanks" (fig. 1). A change of gradient of one degree of arc can usually be detected from surveyors' levellings where the "flank" ends and the regional gradient begins. The term "swilley" in the body of this paper refers to the complete topographic feature between "flanges", that is thin claystone beds as shown on Text-fig. 1.

A swilley within the Top Hard seam, at the boundary between the Modiolaris and Similis-pulchra Zones, is described in detail, and notes are added concerning similar "swilleys" within other seams in the same district. The reader is referred to Edwards (1951) for the stratigraphical position of these seams within the Coal Measures of the Carboniferous system.

Swilleys are important in coal mining because, in their vicinity, strata control is more difficult than usual for the district concerned, and the thickness of the worked coal is exceptionally variable. For these reasons swilleys have on occasions even formed the boundary between adjacent colliery workings.

## The Top Hard swilley

The course of the best known swilley is proved along most of 22 miles by workings in the Top Hard seam of Nottinghamshire and is shown in fig. 1 lettered A to L. A cross-section X Y (Text-fig. 1) is drawn through E and shows the present topography of the seam floor, a clay-flange with an underlying "floor coal" regarded as part of the Top Hard (Anon, 1942), and the relationship of the main part of the seam to the floor topography. The coal thickness is plotted at twelve times the vertical scale of the floor topography in order to reconstruct approximately the uncompacted peat at the time of accumulation of the highest layers. The top of the seam as shown does not follow the swilley-hollow, suggesting that the remaining undulations are principally due to post-peat differential compaction. The topography of the seam floor and its relationship to seam thickness is closely comparable in the vicinity of D. Moreover, at other localities, especially between B and H, records show that the seam is exceptionally thick in the swilley-hollow and unusually thin on the brows. The coal thickness also gradually increases laterally down the "swilley-flanks" beyond which it is augmented by the floor coal which is a few inches thick (Text-fig. 1). This floor coal is known to incorporate clay laminae in those colliery records nearest to the swilley, and is accordingly often described as "bat". Such sections are frequently recorded between A and F and the maximum recorded thickness of clayey seat-earth (known to colliery officials as "dirt") between the floor and main coals is 18 inches.

Above the floor-coal a flange of clay with stigmarian roots extends out laterally from the swilley-flanks between the "pecked" and "dotted" lines shown on fig. 1; this is only adequately recorded between localities A and F. This clay is usually 0 - 2 inches thick and is laterally continuous with sediments below the brows. Outside the dotted lines detailed records sometimes refer to a dullish coal layer between the main and floor coals. This layer is less than an inch thick and contains up to 20% ash.

In the vicinity of C, above the clay-flange, the main seam consists of "bottom brights" (3 - 8 inches), "hards" (18 - 22 inches), and "top-brights" (13 - 17 inches), (Anon, 1942). The bottom-brights thins towards the brows, and at three localities (table 1) at least, the hards subdivision rests upon the seat-earth at the brows. The top-brights across the swilley-brows and hollow at C shows no significant variation in thickness, and the hards are of normal thickness for the immediate locality on the brows ($18\frac{1}{2}$ inches) and extra thick in the hollow (24 inches). The bottom-brights subdivision in the swilley-hollow is especially thick (14 inches) and is underlain by a few inches of dirty bright coal (46% ash) confined to the hollow. This is probably the floor-coal.

Seam thicknesses and the associated swilley topography are recorded in some detail south and east of H; a summary is given in Table 1. At C, special observations made at Gedling colliery, on a coal face and within roadways as the working advanced across the swilley, revealed a very close relationship between the main coal thickness and the topography of its floor. Contours of the hollow at C, above an inclined datum representing the regional dip, and isopachs of the main coal are parallel and co-axial. The seam is thickest exactly down the centre of the hollow. The contours also reveal that prior to the tectonic tilt the two brows rose to the same height above the bottom of the hollow.

| Locality | | Swilley dimensions (feet) | | | Coal thicknesses (inches) | | | |
|---|---|---|---|---|---|---|---|---|
| Ref. (fig. 1) | Colliery | Total width, flanks + hollow<br>w | Width of hollow brow to brow<br>v | Depth of hollow below brows<br>d | In hollow<br>h | On brows<br>b | At outer edge of flanks<br>f | Symmetry of cross-section |
| C | Gedling | 3,250 | 670 | 25 | 66 | 30* | 42 | Symmetrical |
| D | Calverton | 4,000 | 700 | 20 | 51 | 26* | 39 | Asymmetrical with broad topped west brow |
| E | Calverton | 3,700 | 750 | 20 | 55 | 26* | 39 | Asymmetrical with broad topped east brow |
| F | Newstead | 4,600 | 700 approx. | 22 approx. | 66 | 30 | Unknown | Asymmetrical |
| G | Newstead | 5,200 approx. | 750 | 20 approx. | 76 | Less than 39 | 45 | Symmetrical |
| H | Kirkby | Unknown | 800 approx. | 22 approx. | 71 | 32 | Unknown | Unknown |

Table 1 Dimensions of Top Hard swilley, at right angles to its axis, and associated maximum, minimum and normal recorded coal thicknesses. Letters w to f refer to fig. 2.

* "bottom brights" subdivision recorded absent

Fig. 1 shows two faults throwing a little over two feet. Such faults are a common feature of the swilley course; they occur along much of its known length on both or one brow and are arcuate in plan following the swilley course closely. Their displacements at the seam boundaries are equal to or less than 4 feet except midway between F and G, where a throw of 8 feet is recorded. Straight faults in the vicinity of, and parallel to this fault, but not in the swilley ribbon, suggest that the 8 feet may be the result of tectonic rejuvenation. Of the 117 throws recorded on the swilley-brows, 109 are directed down towards the swilley-hollow. At C, one of these faults has a throw of 18 inches down towards the swilley-hollow in the coal seam, but dies out upwards to four inches in an ironstone layer 4 feet above the seam. Thus the brow-top faults are closely related in plan and section to the swilley, and the evidence points to a compactional origin contemporaneous with the deposition of measures not far above the Top Hard seam. Mudstones or fine siltstones overlie the seam throughout most of the area concerned. None of the brow-top faults has been located in the one to three seams worked above and below the course of the swilley. Striations on the top surface of the seat-earth at C are located on the sides of the hollow and directed at right angles to the swilley axis; they appear to be further evidence of compactional movements.

The course of the swilley from A to I (fig. 1) is plotted from levels on the floor of underground roadways within the seam, measurements of thin coal on the brows coupled with thick coal in the swilley-hollow, and also the position of brow-top faults where they serve to link locations of the first two lines of evidence. From I to J only records of thick coal and a presumed brow-top fault are available and J to K is hypothetical. The course from K to L is approximate and is derived from thicknesses recorded in opencast workings.

Compactional movements during the deposition of sediments immediately overlying the seam, the pronounced hollow-brow topography of the seam base, and the splitting of the floor-coal away from the main coal at the outer edges of the topographic ribbon and towards the swilley- hollow, suggest that ribbons of relatively uncompactable sediments underlie the brows.

A second Top Hard swilley within the bounds of Text-fig. 1 is recorded at Thoresby colliery and lettered M N; this may branch off the swilley A L within the Kirkby colliery take, between H and J, but unfortunately no positive information regarding its course has come to hand.

## Top Hard cannel-coal

Cannel-coal is sometimes present within sections of the Top Hard seam, its top being at precisely the same horizon as the clay-flanges; both occur 3 - 5 inches below the base of the hards subsection. Two extensive lenses of such cannel coal are located within the area covered by fig. 1; one immediately N.N.W. of Nottingham city and another within the triangle: Mansfield - Chesterfield - Worksop. The swilley A L meanders past the eastern limit of the former and passes north-westwards between the two.

The southern cannel lens has an area of 16 square miles and innumerable sections, as many as 1,000 per square mile are recorded in parts, enable detailed isopachs to be drawn; the zero, 6 inch and 24 inch lines are reproduced on fig. 1. The maximum thickness recorded is 2 ft. 2 ins.

The northern cannel lens has an area of 74 square miles and a reasonable scatter of sections is to hand, sufficient to enable its approximate limits to be drawn. The maximum thickness known is 2 ft: 7 ins., at a point where it is of inferior quality.

Both cannel lenses have variable ash contents; values from 6 to 21% are recorded. The purer variety has occasionally been turned on a lathe and used for ornaments. A "dirt band", that is a clay bed, is sometimes present above, and occasionally below the southern cannel lens. The upper clay is the thickest and reaches a maximum of 4 inches.

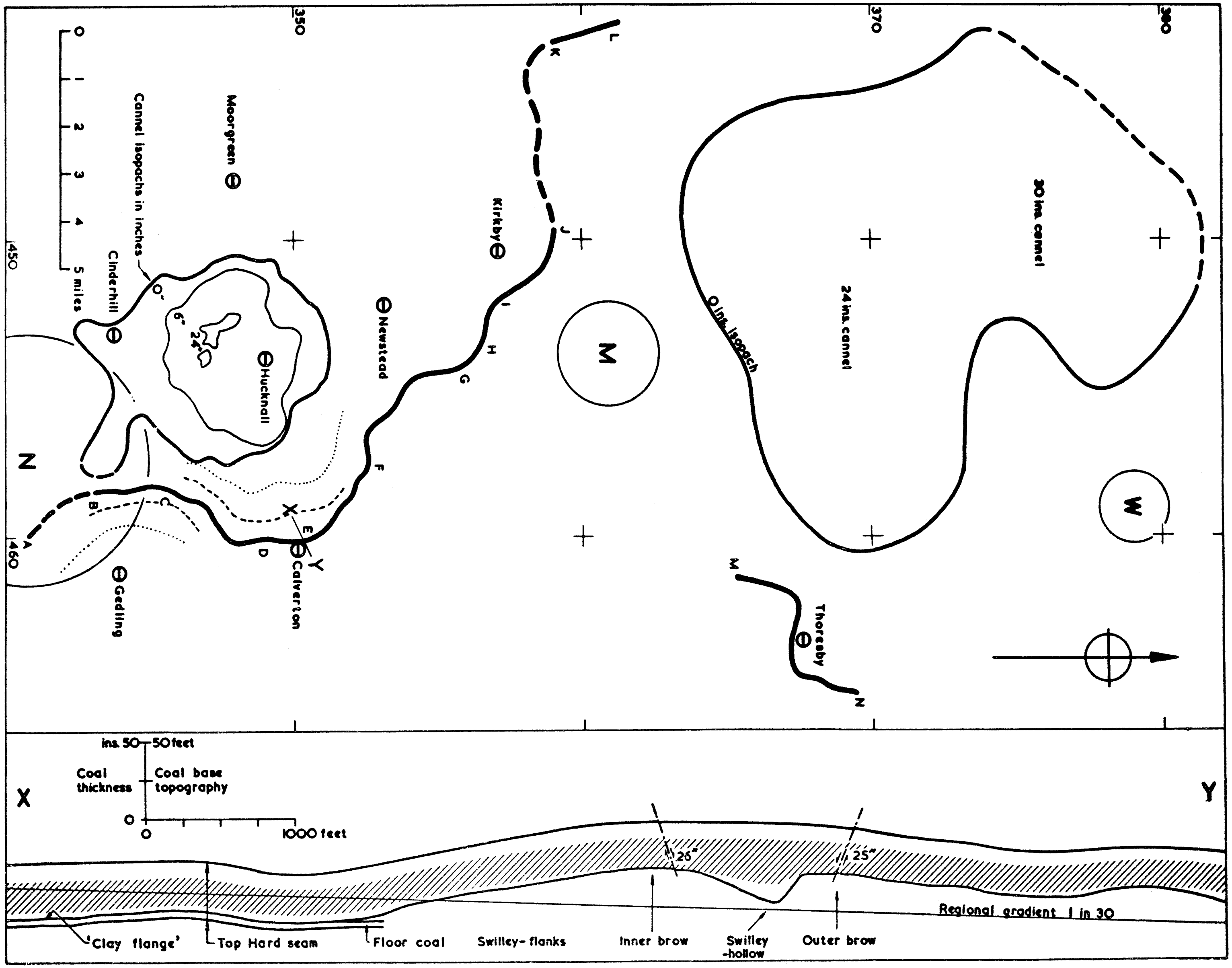



FIG. 1. Swilleys and cannel-coal lenses within the Top Hard Seam. The map shows isopachs of two cannel lenses and the course of two swilleys AL and MN as thick lines. The thin "pecked" and "dotted" lines represent the outer limits of swilley-flanks and clay-flanges respectively. N = Nottingham, M = Mansfield, W = Worksop. Collieries referred to in the text are named and the site of the shafts indicated by a circle with horizontal bar. The section XY is drawn as indicated through E, with hard-coal hatched and bright-coal left blank; see text for further explanation.

As the southern cannel lens thickens towards its centre, the floor coal thins until cannel entirely replaces floor coal. It was mentioned above that the floor coal has a high clay content near the swilley-flanks, and that its probable representative in the bottom of the swilley hollow has a high ash content; this suggests that the sediments beneath the brows are the lateral equivalents of the floor coal. Thus the cannel with its associated clay beds, floor coal and sediments beneath the brows are probably contemporaneous.

## The Deep Hard and Deep Soft Swilleys

A swilley located in the Deep Hard seam, at about the middle of the Modiolaris Zone (Edwards, 1951), runs N. N. E. through Hucknall colliery shafts (fig. 1). This is proved by roadways in the seam around the shafts, and its western half is well known from boreholes, mostly drilled down from the Deep Soft horizon at Cinderhill colliery. These holes continue down to seams below the Deep Hard, proving that poorly laminated or unlaminated siltstones with occasional sandstone, many plants including Neuropteris, Pinnularia and stems in varied attitudes, underlie the western brow. In all, a length of about three miles of swilley are known, and three miles further west at Moorgreen a second swilley is present (Nat. Co-ords. E.4496, N. 3492), but few details are available. These two swilleys are roughly parallel.

The topography of the seam floor and the relationship of seam to floor is closely comparable with that of the Top Hard swilley described above. Bright coal is overstepped by a hard coal bed which thereby comes to rest upon the seat-earth on the swilley-brow just as in the Top Hard example. The Deep Hard swilley-hollow, however, is occupied by inferior coal and cannel at Hucknall, unlike that at the Top Hard horizon further east.

Recent workings at Hucknall colliery are revealing another swilley at the Deep Soft horizon, one cyclothem above the Deep Hard, trending more or less parallel to the Deep Hard swilleys. Both the Deep Hard and Deep Soft swilleys have dimensions comparable with those of the Top Hard swilley given in Table 1 (w, v and d). A cannel lens is present south-east of Nottingham city at the Deep Hard horizon and at a similar horizon to the sub-brow silts within the Deep Hard. The plan relationship of swilley to cannel lens is not yet proved, however.

## The Abdy Swilleys

A swilley at the Abdy seam horizon, about the middle of the Lower Similis-pulchra Zone, is located (Nat. Co-ords. E.4549, N.3463) in workings from Cinderhill colliery (fig. 1), 2 miles north-east of the shafts, where the seam is known locally as the "Low Bright". Workings and boreholes at Cinderhill, Bestwood, Hucknall, Linby and Calverton collieries (fig. 1) provide between 0.5 and 1.0 samples per square mile, sufficient to construct isopachytes of the Abdy seam. These strongly suggest an extensive swilley system comprising at least two, and probably three swilleys, trending E. N. E. with relatively small inter-swilley areas.

The Abdy seam comprises a main coal and a floor coal, both of which consist mainly of bright coal. Between these beds of coal the boreholes prove wedge-shaped ribbons of sandstone and siltstone and flanges of siltstone and mudstone. These clastics are over 2 ft. thick at most localities in the area covered by Text-fig. 1. The wedges reach a maximum known thickness of 27 feet and are often poorly laminated siltstone with Pinnularia, plant stems, and Neuropteris or Alethopteris, but the thicker sections contain more sandstone with laminations or discordant layering and comminuted plant debris.

At the locality in Cinderhill colliery workings, mentioned above, the relationships of strata in the vicinity of the swilley-hollow are recorded. In this hollow, the floor coal is separated from the main seam by 0.5 inches of mudstone with plant remains, but on the lower slopes of the hollow, only 12 feet away, a pale greenish sandstone wedges in between these seams. A similar sandstone occurs as small lenses in the top three inches of the floor coal in the hollow. The main seam thins progressively outwards from hollow to brow, from 37 inches to 28 inches. The lowermost 10 inches of the 37 inches in the hollow is exceptionally bright vitrainous coal, and laps against the swilley slope accounting for the thinning. On the higher slope and at points further removed from the hollow, a seat-earth is developed below the reduced main coal.

Mudstone grading upwards to fine siltstone forms the six feet of roof measures observable underground, and at most localities at and around Cinderhill colliery the basal few inches to two feet, overlying the main coal, is darker and more shaley than above with lamellibranch fragments, fish remains and a little pyritic and phosphatic material. This dark bed is absent over the swilley-brows and is exceptionally thick, 27 inches, in the swilley-hollow at the Cinderhill locality. Traceable light and dark laminae in the succeeding lighter bed show only a slight thickness variation from the hollow to brow.

Two slickensided layers within the 27 inch dark bed die out towards the swilley-slope and a smooth parting 66 inches above coal in the hollow lies only 28 inches above coal on the brows. This parting approximates to the bedding. Tectonic faulting and folding is very mild in the vicinity of this locality and the layers and parting are probably compactional features related to the marked lateral changes in the strata close below.

The Abdy swilleys differ from the Top Hard and Deep Hard swilleys in at least four ways: the main coal contains no dense hard coal, the sediment between main and floor coals is more sandy, the flanges are thicker and more extensive, and there are no associated cannel-coal lenses. These differences might all be due to higher precipitation and/or lower evaporation at the time of deposition of the Abdy seam. Compare the remarks on possible climatic variations made by Smith (1962, pp. 459 - 461).

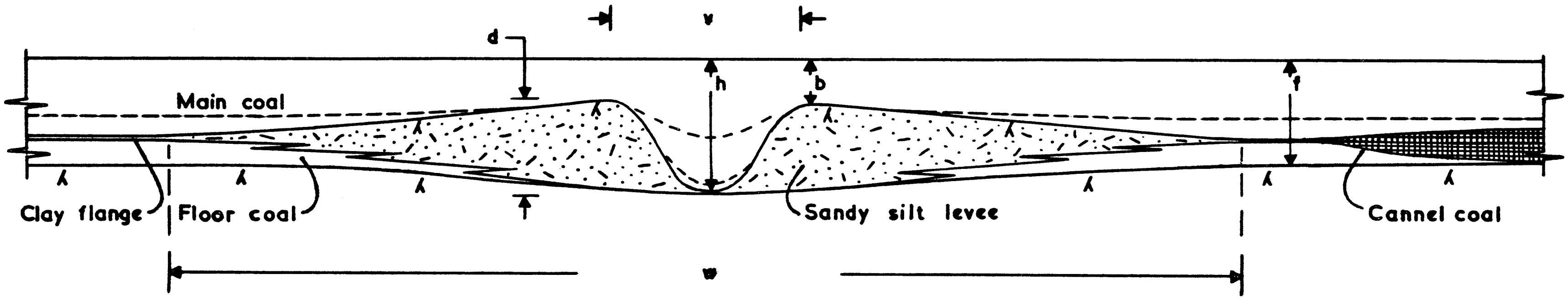
## Origin of the Swilleys

A generalised cross-section of a coal-filled swilley is shown in fig. 2. This sketch section is compiled principally from knowledge of the Top Hard swilley, but is supplemented by borehole information in the vicinity of the similar Deep Hard swilley at the Hucknall and Cinderhill collieries. This borehole information concerns the floor coal and the silt-sand wedges underlying the swilley-brows. Borehole information concerning swilleys at the Abdy horizon support this reconstruction,excepting that at the Abdy horizon the floor coal re-unites with the main seam in the swilley hollow.

The stratigraphic relationships shown in fig. 2 between coal beds, clastic wedges and a cannel lens are comparable with those between the Fenland peats, the Little Ouse rodden-silts with their clay flanges and the Red Mere marl respectively, as described and illustrated by Jennings (1950). The coal-filled swilley-hollows are matched by the peaty filling of the hollow between the rodden-silts. Jennings shows that the roddens are levees of an extinct river which ponded back a lake forming the site of marl deposition. He quotes other examples of the same phenomena.

The sinuosity of the Little Ouse rodden, that is the paired ridges which are the present surface expression of the silt levees, is comparable with that of the Top Hard swilley-brows, and the plan juxtaposition of rodden and lake-marl is not unlike that of the Top Hard swilley-brows and the cannel-coal lenses, although these coal measure features are on a larger scale.

This close comparision and the geometry of the coal measure deposits per se, leaves little doubt that the coal measure swilleys record the course of Carboniferous rivers across coal-swamps. These rivers, in typical cases, deposited silts and a little sand in the form of levees raised above coal-swamps on either side, and during periods of flood carried a little mud beyond the outer limits of the levees to form the clay-flanges. In some cases water was ponded back in places by the levees between floods, forming lakes in which mud accumulated when the river was most active, and humic mud during less active periods. Humic mud which formed on lake bottoms is generally considered to be the origin of cannel coal (Smith, 1962, p.451).




Text-Fig. 2    A generalised cross-section across a typical swilley, based principally upon the Top Hard swilley at Gedling and Calverton Collieries, supplemented by borehole information relating to the Deep Hard swilley at Hucknall and Cinderhill Collieries. Approximately to scale with coal thicknesses exaggerated X 12 with respect to the clastic rocks and the vertical scale of the clastic rocks exaggerated X 10 with respect to the horizontal scale. The inverted 'Y' symbol indicates seat-earth. The "pecked" lines within the main coal represent bedding planes.

At a later stage the river course was abandoned, and deposits, often peat, gradually filled the channel as peats accumulating on either side encroached upon the levee flanks.

In the case of the Top Hard and Deep Hard swilleys, when the peats finally covered the swilley-brows, a new peat-type began to accumulate; this is indicated by superposition of the base of the hards sub-division on the top of the swilley-brows. Following Smith (1962, pp. 458 - 460), this suggests that during Top Hard and Deep Hard times the climate was suitable for the development of raised bogs and that this convex water-retaining and hence self-perpetuating condition was attained about the time when the peat surface had built up to the level of the old river levee crests. Thus the swamp drainage level at this late stage was apparently more or less the same as the original river flood level; both of these are water levels at times of absolute minimum gradient. This suggests that subsidence in the vicinity of the swilley-brows topped by the hards subdivision was negligible relative to some point many miles downstream from which base-level was controlled. Clearly these matters must be investigated further by studying the miospores and petrography of hards and brights in samples collected from swilley-brows and hollows.

After deposition of the main coal bed and during the accumulation of muds and silts overlying the seam, the silt/sand levees were the centres of differential compaction involving minor faulting and probably other distortions. Later very slight tectonic bending brought the rocks described in this paper to their present geometrical form.

It is outside the scope of this paper to describe the evidence from other river channels in coal measures, some of which have already been discussed by many authors under the heading of "washouts" or sandstone filled channels. In conclusion, however, it appears from other underground and closely spaced borehole evidence in Nottinghamshire that there are all transitional forms between coal-filled swilleys and large compound sandstone ribbons comprising sandstone-filled channels and sandstone deposited either side of the channels. The rivers depositing the larger compound sandstone ribbons appear to have continued to flow along courses in more or less the same geographical position, during the accumulation of several cyclothems.

## Acknowledgements

Much of the information contained in this paper was collected fifteen years ago, and the author is indebted to many mine surveyors for a large proportion of the facts, especially those concerning the reaches of the Top Hard swilley north of E (Text-fig. 1).

Thanks are also due to Mr. A. Dawe, late of the Coal Survey, Nottingham, for organising the sampling of seam sections across the Top Hard swilley at point C (Text-fig. 1), and for making other analysed sections available to the author.

Permission to publish this paper was granted by Mr. A.A. Bowker (Production Director, East Midlands Division, National Coal Board).

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## References


ANON 1942. The Top Hard Seam. Dept. Scientific Industrial Res., Physical and Chemical surv. of the Nat. coal resources, No. 53, Lond., 194 pp.

CLARKE, A.M. 1963. A contribution to the understanding of washouts, swalleys, splits and other seam variations and the amelioration of their effects on mining in South Durham. Trans. Inst. Mining Eng., vol. 122, pp. 667 - 706.

EDWARDS, W. 1951. The concealed coalfield of Yorkshire and Nottinghamshire. 3rd. Ed. Mem. Geol. Surv., Lond., 285 pp.

JENNINGS, J.N. 1950. The origin of the Fenland meres. Geol. Mag., vol. 87, pp. 217 - 225.

RAISTRICK, A. and MARSHALL, C.E. 1939. The nature and origin of coal and coal seams. Eng. Univ. Press, Lond., 282. pp.

SMITH, A.H.V. 1962. The palaeoecology of Carboniferous peats based on the miospores and petrography of bituminous coals. Proc. Yorks. Geol. Soc., vol. 33, pp. 423 - 474.


(Manuscript received 30th April, 1965)