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**The Geologic Character of Some
Coal Waxes at the Westland Mine
in Southwestern Pennsylvania**

By Noel N. Moebis

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UNITED STATES DEPARTMENT OF THE INTERIOR

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UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary
BUREAU OF MINES

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CONTENTS

	<u>Page</u>
Abstract.....	1
Introduction.....	1
Acknowledgments.....	2
Geologic setting.....	3
Mining methods.....	4
Description of roof rock.....	5
Washout problem.....	6
6-West section.....	7
8-West section.....	9
2-South section.....	11
3-South section.....	12
Discussion.....	13
Roof conditions near washouts.....	16
Delineation of washouts.....	22
Conclusions.....	23
References.....	25

ILLUSTRATIONS

1. Map showing location of Westland Mine and trend of sandstone roof rock.....	3
2. Location of washouts in Pittsburgh coalbed.....	4
3. Generalized columnar section of mine roof rock.....	5
4. Distribution of washouts at the Westland Mine.....	6
5. Location of drill holes and thickness of coal penetrated.....	7
6. Illustration of a hypothetical slump structure.....	7
7. Cross section of washout in 6-West section of mine.....	8
8. Drill hole section located ahead of 6-West face.....	8
9. Cross section of washout in 6-West section of mine.....	9
10. Cross section of limestone split at face of 8-West section.....	9
11. Schematic cross section of 8-West and drill hole 613.....	10
12. Cross section of 2-South section showing clay embayments in coalbed near washout contact.....	11
13. Cross section of entry in 2-South.....	11
14. Cross section of washout in 3-South.....	12
15. Drill holes showing geologic conditions ahead of 3-South face.....	13
16. Sequence of events leading to washout and marginal split.....	14
17. Cross section of structure in 18-West section of Gateway Mine.....	15
18. Isopach of rash member of roof strata.....	16
19. Isopach of Pittsburgh sandstone.....	17
20. Washout and roof falls in 6-West section.....	18
21. Hazardous roof conditions in 6-West section at heavily slickensided washout contact.....	19
22. Overbreak of incompetent roof strata abutting slickensided washout contact.....	20
23. Roof falls and limestone split in 8-West section.....	21
24. Roof falls and washouts in 2-South and 3-South.....	22
25. Example of simple depositional model.....	23

THE GEOLOGIC CHARACTER OF SOME COAL WANTS AT THE WESTLAND MINE IN SOUTHWESTERN PENNSYLVANIA

by

Noel N. Moebs¹

ABSTRACT

The coal wants at the Westland Mine in southwestern Pennsylvania consist chiefly of elongated, sandstone-filled channels with slickensided basal contacts. Tentatively identified as washouts, these channels are about 1,000 feet long and 300 feet wide, are erratic in occurrence and trend, and are difficult to delineate from the customary core drilling pattern. Roof conditions are hazardous adjacent to the washout contact, but roof stability is generally unaffected greater than 30 feet away.

INTRODUCTION

The terms coal want and washout are used interchangeably in many coal mines to designate virtually any unanticipated absence of the coalbed. Washout is used here for uniformity and as a more appropriate term for the conditions studied. A washout is defined (4)² as a channel or channellike feature in a sedimentary deposit produced by scouring action of flowing water and later filling with sediments. This description generally fits the washouts, cutouts, or want zones encountered in the bituminous coalbeds of the Appalachian Region, where the channel fill material is commonly, but not always, sandstone.

Washouts range from the scouring or removal of only the top several inches of the coalbed to erosion of the entire thickness of coal and underlying seat rocks. Washouts also vary greatly in width. Partial washouts that are long and narrow constitute a roof roll in miner's terminology, while broad partial washouts constitute areas of low coal.

Washouts in English coal measures compare closely with those in the United States and have received much attention in the literature because of related mining problems. Raistrick and Marshall (9) summarized the origin and character of washouts in England, while Clarke (1) reviewed recently developed operating procedures for anticipating washouts and roof rolls on mechanized

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²Underlined numbers in parentheses refer to items in the list of references at the end of this report.

longwall faces where interruption of face advance is very costly. Clarke concludes that while actual position of roof rolls and channel washouts cannot be predicted, some short-term warning of these features might be achieved by analysis of routine underground geologic mapping.

A renewed effort by the Bureau of Mines to rapidly and inexpensively locate washouts in advance of mining through the application of geophysical techniques (7) currently is undergoing field trials with the object of developing a prototype high-resolution seismic measurement system for mapping channel sands under shallow cover (less than 1,000 feet). A different approach is being attempted by geologists specializing in the reconstruction of sedimentary environments of the coal measures using drill hole data. This technique also is in a developmental stage but is seriously limited by the wide spacing of exploratory drill holes and the lack of precise core logs. Therefore, mine operators still depend chiefly on underground development to accurately delineate the margins of washouts, a costly procedure in both time and money.

An increase in the incidence of roof falls along the margins of washouts has been reported at several mines in southern Pennsylvania region; thus, the primary objective of this study was to investigate this relationship at the Westland Mine and to describe some roof rock structures in this marginal zone. A secondary objective was to determine the geologic character, trend, and width of selected washouts. Although this study was conducted at only four selected sites in one mine in a small portion of the Pittsburgh coalbed, some features described here may occur in other coalbeds or localities.

This investigation was conducted by analysis of existing drill core logs, by drilling five additional holes to help delineate washouts, and by mapping the geology of the entries near the washouts.

ACKNOWLEDGMENTS

The author is grateful for the full cooperation of the Pittsburgh Coal Co. Division, Consolidation Coal Co. In particular, Westland Mine supervisors generously contributed much time in accompanying the author and his coworker, John L. Ellenberger, underground and provided data on sections of the mine that are no longer accessible.

GEOLOGIC SETTING

The Westland Mine is situated about 22 miles southwest of Pittsburgh in a part of the Dunkard basin where the sandstone roof rock ranges from 0 to 60 feet in thickness and trends northwestward across the southwest corner of Pennsylvania (fig. 1). Basal scour is undulating in places, locally incising down to and through the coalbed to form sandstone-filled washouts. While most washouts occur directly beneath the main sandstone body (fig. 2), some have been exposed during mining in fringe areas where thin "finger" or shoestring sands extend outward from the main sandstone body. These small channels are not represented on the map because they could not be shown in detail at this scale.

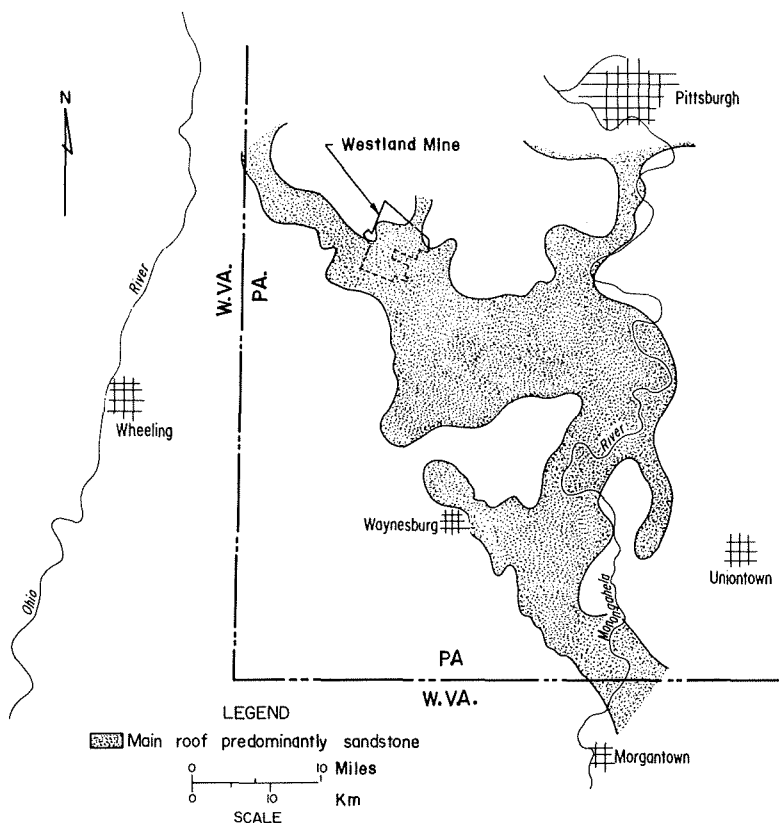


FIGURE 1. - Map showing location of Westland Mine and trend of sandstone roof rock.

The sandstone is chiefly medium-grained, micaceous, and argillaceous. Crossbedding is common. Some beds are poorly cemented and friable and disintegrate into loose sand, while other beds separate readily along mica-rich or shaly bedding plans into flaggy slabs, thus contributing to roof support problems in the mine. These sandstones that overlie and locally truncate the Pittsburgh coalbed are believed to represent braided channel deposits formed on a deltaic platform that superposed a large peat swamp now represented by the Pittsburgh coalbed.

MINING METHODS

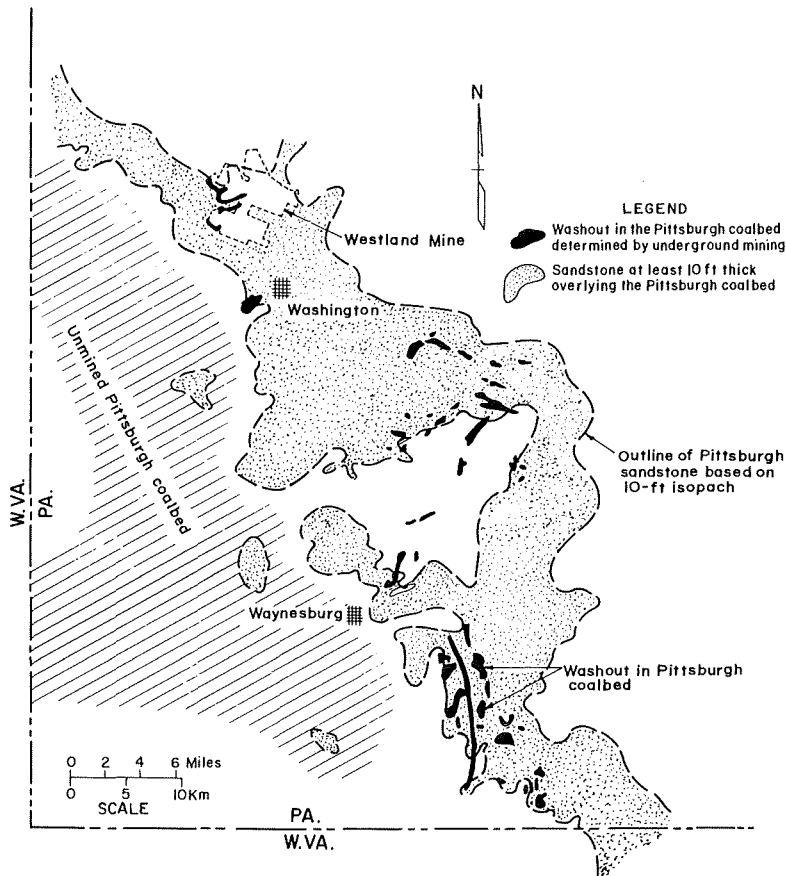


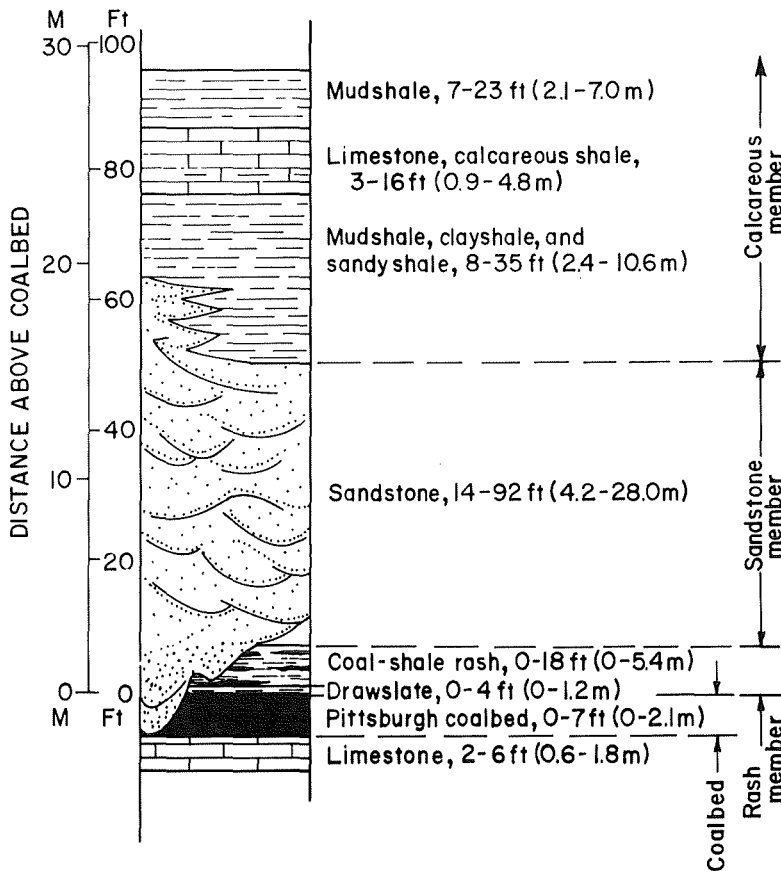
FIGURE 2. - Location of washouts in Pittsburgh coalbed.

erratic zones of low coal, splits, washouts, and roof rolls, severely limiting a uniform mine layout.

On the east side of the mine, several of the entries being advanced towards the longwall area encountered highly unstable "snap top" roof conditions, resulting in several high roof falls over 20 feet high while crossing beneath a stream valley at depths of about 200 feet. This condition was attributed to a concentration of high lateral in situ stresses commonly occurring under stream valleys, which develop during overburden removal by erosion.

This report concerns only the selected sections on the west side of the main haulage where washouts were accompanied by occasionally bad roof conditions. These sections, designated either as 6-West, 8-West, 3-South, or 2-South, were abandoned because washouts of unknown width were encountered in the face. The termination of these entries necessitated revisions in the mine layout and development of new sections until it could be determined whether the direction of development should be continued or the washout circumvented.

The Westland Mine was developed as a drift mine some 38 years ago. Beginning from outcrop, a set of mains was driven S 22° W for a distance of 4.6 miles, and sections were developed by butt entries on both sides of the mains. Coal was extracted by the conventional retreat mining system using a cutting machine, drill, and explosives to break the coal, which was then loaded and transported on track to the drift mouth. After the 1950's, the milling type of continuous miner was introduced but track haulage continued. In 1976, a section of the mine on the east side of the main haulage was developed for longwall mining because the east side of the mine generally had been free from problems of washouts and roof rolls, while the west side had been plagued for years with



DESCRIPTION OF ROOF ROCK

For convenience, the column of strata above the Pittsburgh coalbed at the Westland Mine can be divided into three members: rash, sandstone, and calcareous shale (fig. 3). The lowest member which lies directly above the Pittsburgh coalbed, consists of from 1 to 18 feet of generally incompetent interbedded coal and shale, here referred to as rash. This member is variable in thickness and composition, with much intertonguing, pinching out, and lenticular structure. The base of the rash sequence is a drawslate, several inches to 3 feet in thickness, consisting of a claystone that is removed during first mining because it disintegrates in moist air and cannot be adequately supported by conventional

FIGURE 3. - Generalized columnar section of mine roof rock.

methods. When the drawslate has been removed, a more competent bed is bolted to form the roof, commonly the rider coal. The rider coal also protects the overlying rash member from the weakening effects of the moisture in the humid mine air.

The sandstone member lies next in sequence above the rash member and sometimes truncates the rash with a scoured contact. The sandstone occurs as thin, sheetlike beds, lenticular bodies, thick massive beds, or narrow stream-channel fillings. While the thin beds (less than 2 feet thick) are sheetlike in form, the lower surfaces of the thicker more massive beds commonly are marked by convex, wavelike scour marks. The undersurfaces of both the scours and more linear channels are always heavily slickensided, probably owing to the effects of differential compaction between less compactable sandstone and more compactable fine-grained rash. The sandstone is micaceous, argillaceous, and medium grained. Some beds are poorly cemented, where others separate readily along mica-rich bedding planes. Flat or curving fragments of coaly material also occur in some sandstone beds, seriously reducing the strength of the rock.

The following values are representative of the physical properties of sandstone from the roof rock:

Compressive strength.....	9,300 psi
Tensile strength.....	760 psi
Modulus of elasticity.....	0.71×10^6 psi

These values are comparable with test results obtained from Pittsburgh sandstone roof rock in an adjoining county of southwestern Pennsylvania (8). However, these values probably do not reflect the strength of the rock in actual situations because rock samples with pronounced inclusions of weak coal, shale, or mica are rarely tested in the laboratory. Core samples of the rash member from the Westland Mine were too weak to withstand preparation and testing procedures.

WASHOUT PROBLEM

During development of the portion of the west section of the mine, several washouts and an occasional split were unexpectedly encountered necessitating a modification of the mining plans for that particular area. These are illustrated in figure 4. Despite some 20 drill holes distributed over an area of about 3 square miles in the west section, it was impossible to delineate the boundaries of the washouts with precision greater than a few hundred feet.

During the course of this study, an additional five holes were cored just beyond the face at two of the washouts, 6-West and 3-South (fig. 5) to help delineate the structures. Nonetheless, the character of these washouts and their relation to roof stability remained unresolved, and it was concluded

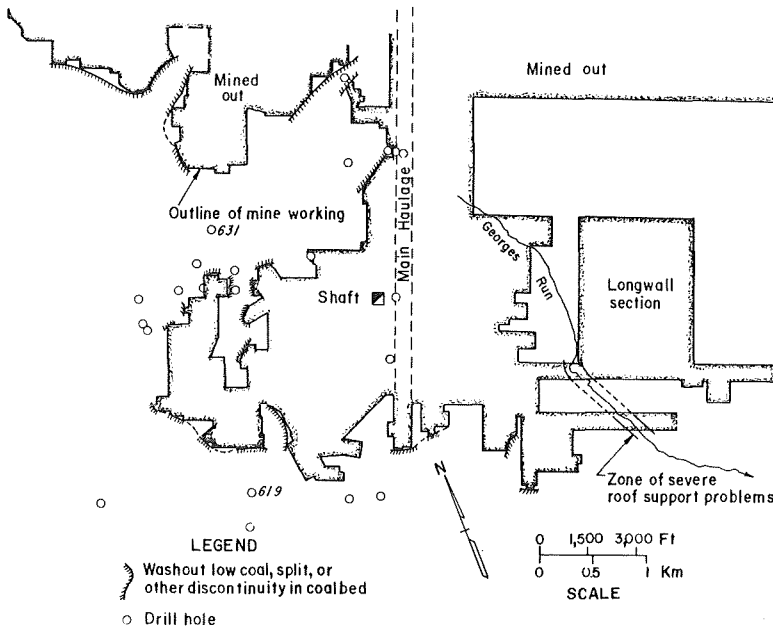


FIGURE 4. - Distribution of washouts at the Westland Mine.

that closer examination of entries near these washouts would be necessary. It was first suspected that the washouts exposed in the mine might consist of slump structures bordering the main channels (fig. 6), but the absence of contorted bedding, breccia, "slump-balls" (6), or other evidence of disturbed sediments in any of the drill holes indicates that the washouts might consist chiefly of sand-filled channels. Four sites in the west section of the mine were selected for detailed study. These sites all were terminated by washouts, or, in one instance, a split or low-angle slump in the coalbed.

Beginning northernmost, the sites described are as follows:

Site	Feature
6-West..	Washout.
8-West..	Split or low-angle slump.
2-South.	Washout.
3-South.	Washout.

6-West Section

The 6-West entries, driven northwestward, were terminated along the edge of a linear, northeast-trending washout characterized by a contact between the coalbed and roof strata that is slickensided and dips about 15° southeast towards the face (fig. 7). Three drill holes located between 100 and 260 feet from the face (fig. 8) indicate that the washout structure is approximately 160 feet wide. Rock strata exposed at the face are nearly horizontal and similar in lithology to that in drill hole No. 1. The

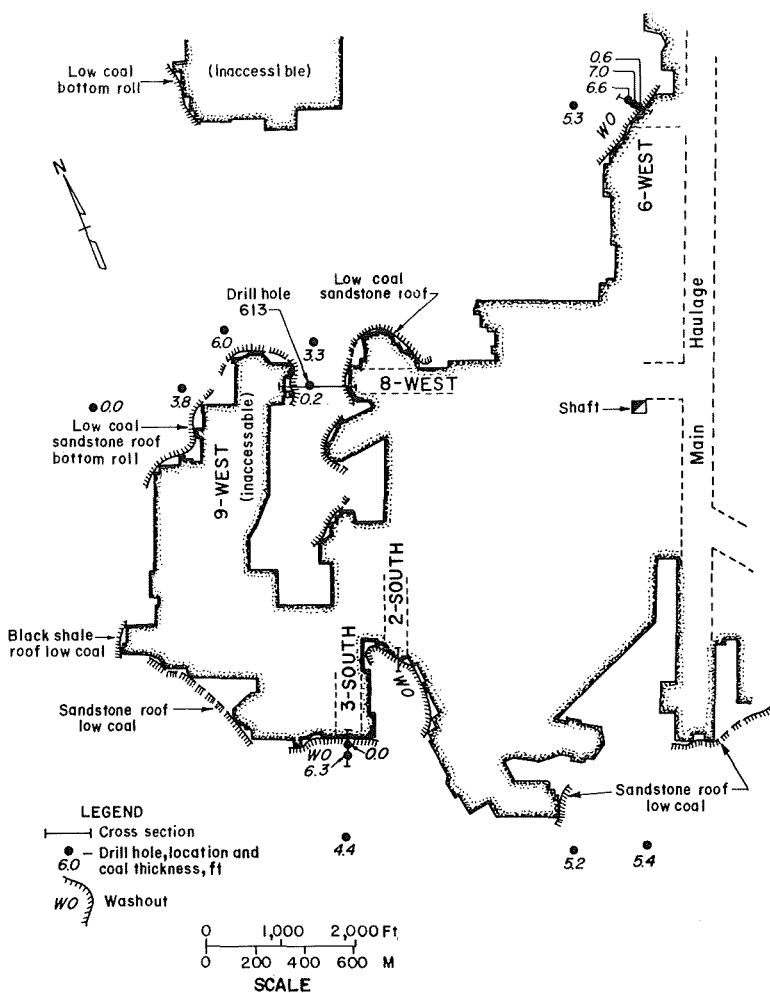


FIGURE 5. - Location of drill holes and thickness of coal penetrated.

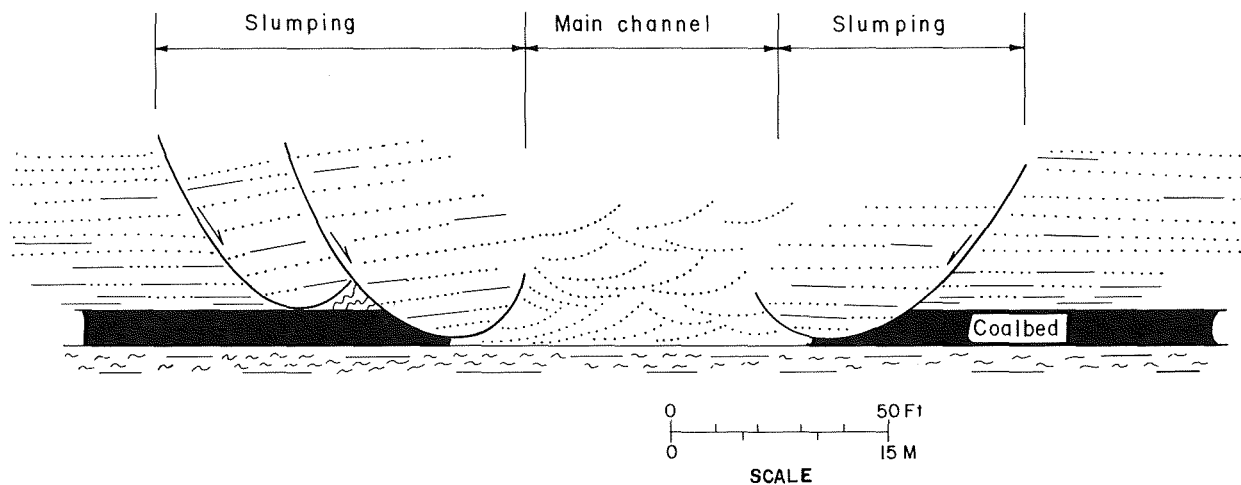


FIGURE 6. - Illustration of a hypothetical slump structure.

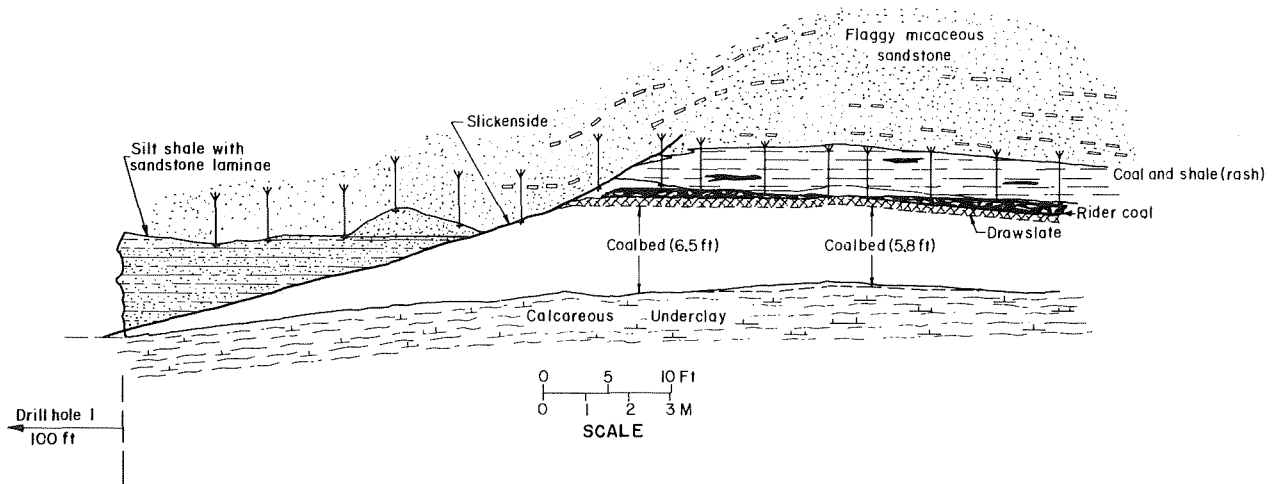


FIGURE 7. - Cross section of washout in 6-West section of mine. Location of the section shown in figure 5.

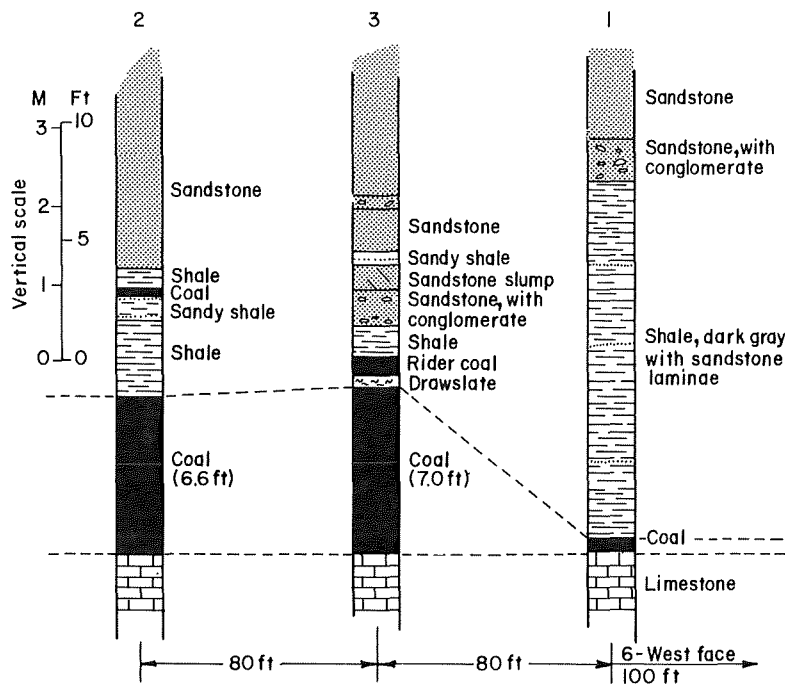


FIGURE 8. - Drill hole section located ahead of 6-West face.

overall structure suggests a channel in the coalbed at least 1,000 feet long and 160 feet wide that was filled with sand and mud, in which the basal contact of the channel was highly slickensided during compaction. Normal coal thickness exposed in the 6-West entry was about 5.8 feet, but within 15 feet of the washout this increased to 6.5 feet. This increase in thickness is commonly recognized by miners as in indication of a washout or other unusual condition shortly beyond the face. It is attributed to a squeezing of peat away from the less compactable sand filling the channel. The coal thickness in drill hole 3, located on the northwest or opposite flank of the washout, is 7 feet thick, again indicating an anomalous condition in the vicinity.

The relations illustrated by the cross section in figure 9, located 350 feet northeast of the section just discussed, are similar except that the slickensided basal contact of the washout dips 22° towards the face and the coal cleat just beneath the washout is tilted some 18° from vertical, a rarity in the nearly horizontal coalbed.

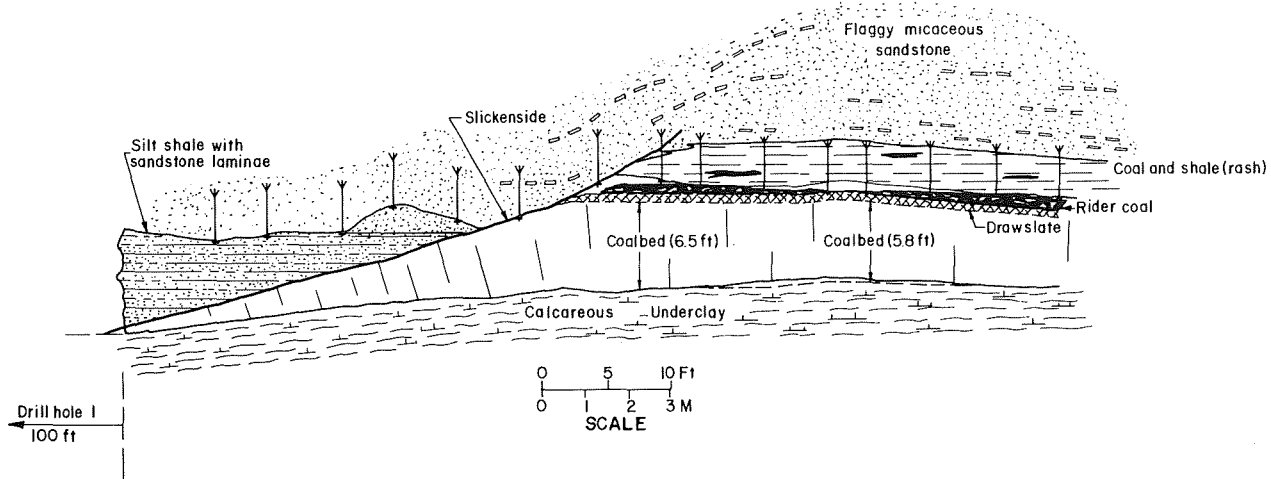


FIGURE 9. - Cross section of washout in 6-West section of mine.

8-West Section

The 8-West entries were terminated along the edge of a rock split estimated to be 500 feet wide and some 1,200 feet long in a northeast-southwest dimension (fig. 5). The split consisted of a claystone-capped fossiliferous limestone wedge 3 feet thick near the face and pinching out completely about 29 feet outby the face (fig. 10). This limestone resembles rock underlying the coalbed. Since there is no evidence whatever of a limestone in drill hole 613, located 500 feet beyond the face (fig. 11), it is assumed either that the rocks making up the split have been removed by later erosion or that the split sediments were contemporary with the channel at drill hole 613. Since the sandstone overlies the coal in the entries, it appears more likely that the channel at drill hole 613 has cut down through preexisting split material. Another possibility is that the split can be attributed to the remnant of a calcareous, mud-filled levee flank depression or levee lake formed as a result of a natural levee that developed along the flanks of the

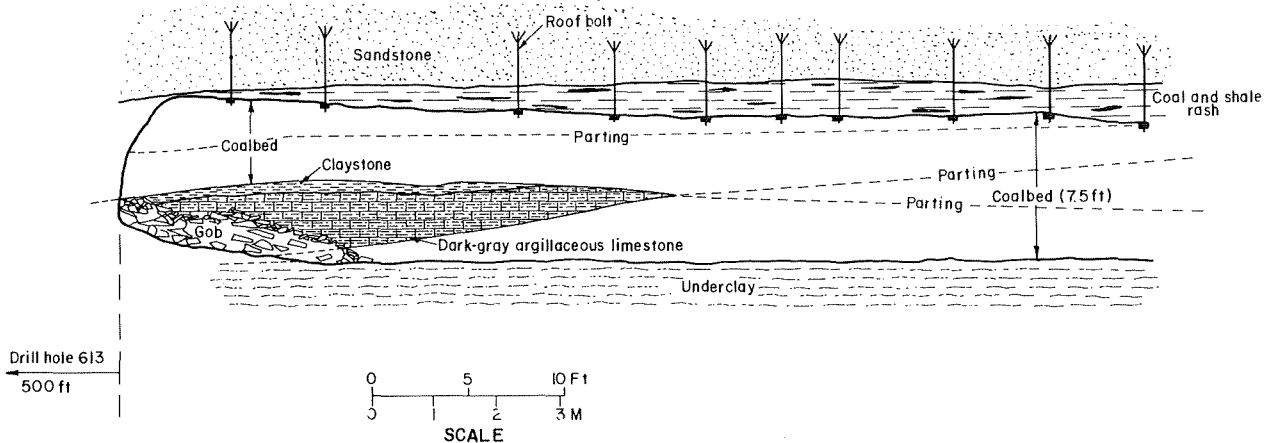


FIGURE 10. - Cross section of limestone split at face of 8-West section.

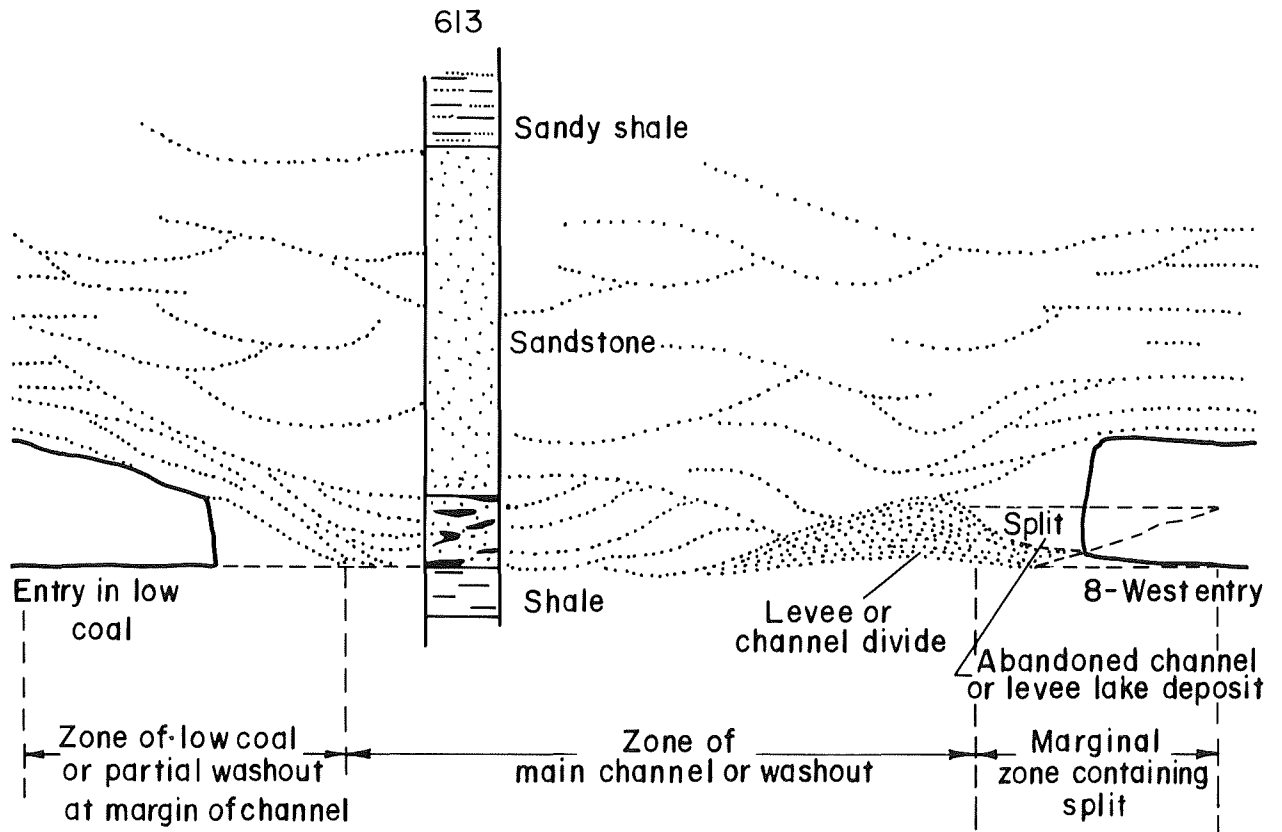


FIGURE 11. - Schematic cross section of 8-West and drill hole 613.

now sand-filled main channel beyond the face. Swamp vegetation would have encroached upon the mudfill, eventually enclosing the mud lens within the peat bed. Later erosion would have removed the levee and adjacent portion of the mud lens, leaving only the edge of the lens exposed in the coalbed, an indication of channel or washout ahead of the face. Friedman (2) described a similar but larger scale feature occurring on the flanks of the Terre Haute Channel (washout) in southwestern Indiana. Still another possibility is that the split consists of a wedge of limestone from beneath the Pittsburgh coalbed that was moved upward into position by means of a low-angle rotational slump.

Figure 11 is a diagrammatic illustration of the relations of 8-West face to drill hole 613 (see fig. 23 for location) and an entry 200 feet west of drill hole 613. The geology between entries is largely hypothetical but serves to emphasize the cross-bedded, intertonguing character of the sandstone filling the channel complex and the remnant of the limestone split on the east flank of the channel.

The coalbed in the entry west of drill hole 613 had diminished in thickness rapidly as mining progressed, indicating that a complete washout lay shortly beyond the face. This was confirmed by drill hole 613, which penetrated only a few thin coal shards in sandstone at the Pittsburgh coalbed interval.

2-South Section

The 2-South entries were terminated along the edge of a north-south trending washout characterized by a slickensided contact between the coalbed and roof strata that dipped 25° to 30° towards the face. Figures 12 and 13 illustrate the structure in two adjacent entries on 2-South. The washout is continuous along trend for at least 1,300 feet and is estimated to be a maximum of 400 feet wide. No drill holes are located close enough to this washout to delineate it with further precision.

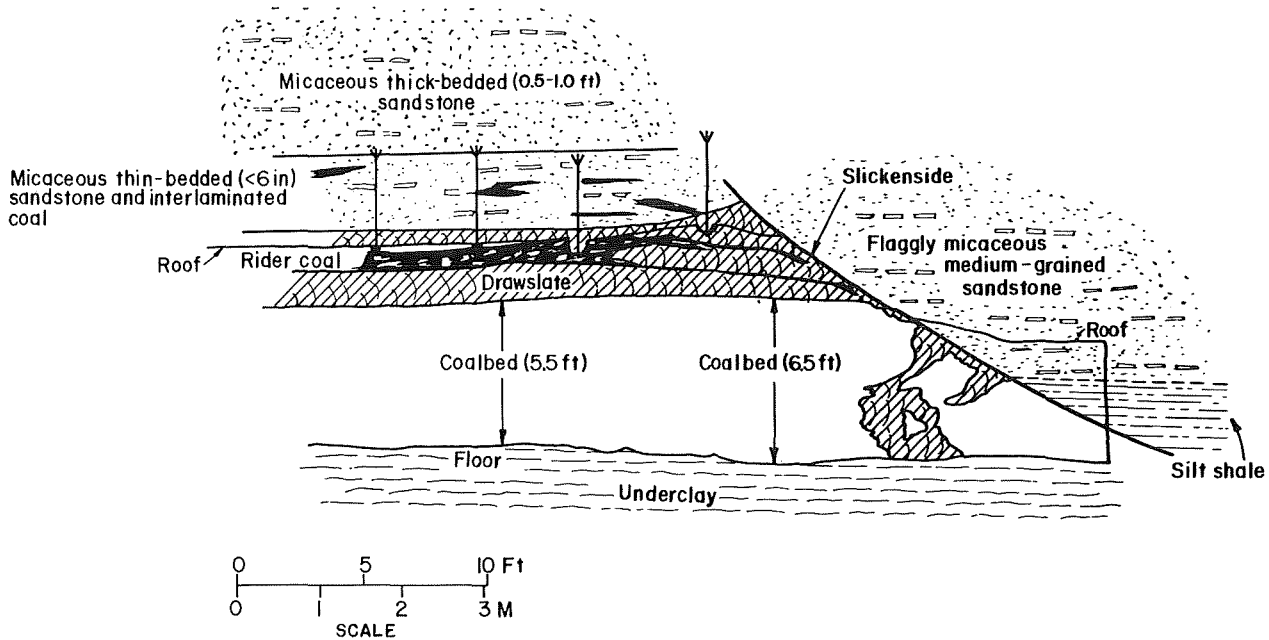


FIGURE 12. - Cross section of 2-South section showing clay embayments in coalbed near washout contact.

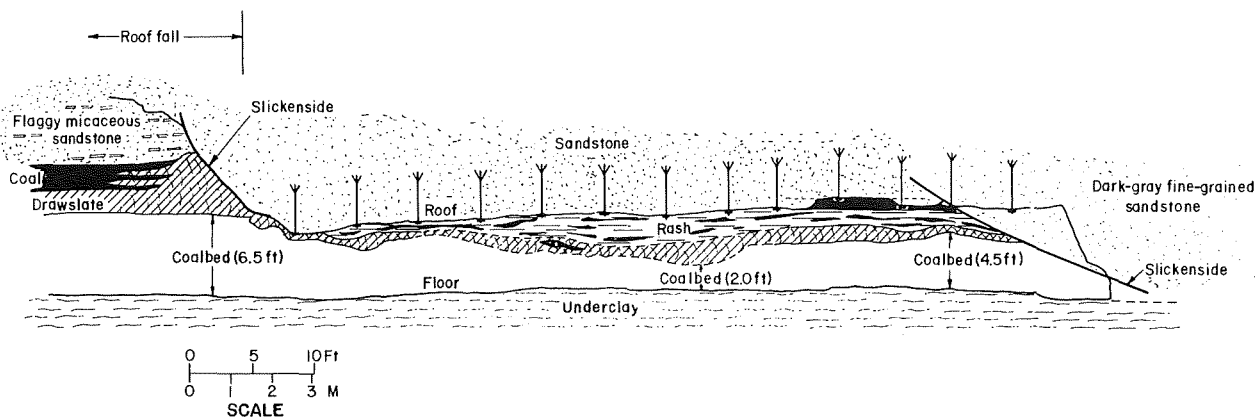


FIGURE 13. - Cross section of entry in 2-South.

Figure 12 shows embayments of claystone within the coal beneath the highly slickensided underside of the washout, indicating that the coalbed was somehow disturbed and mud that once existed in part of the now sand-filled washout was deposited in the irregular voids.

Figure 13 shows the edge of a sandstone-filled channel structure near the left end of the section. Between this structure and the face, the coal was thinner than normal, ranging from 2.0 to 4.5 feet in thickness, which necessitated mining of up to 4 feet of drawslate and rash to provide room for equipment to operate and to establish a firm roof.

The presence of laterally continuous drawslate and rash, and the somewhat thicker than normal coal on the left flank of the channel, indicate that the zone of low coal between the channel and the face probably results from compaction by the thick superjacent sandstone that constitutes the main roof. Near the face, the sandstone cuts down through the coalbed in another channel or scour structure similar to that in section A (fig. 13) in a nearby entry. The pinching out of the rider coal as the washout is approached indicates that there was a preceding event during which no coal was deposited prior to the channel formation.

3-South Section

The 3-South entries were terminated along the edge of a linear northwest-trending washout. Several of the entries encountered a slickensided contact between the coalbed and roof strata that dipped 15° to 25° towards the face,

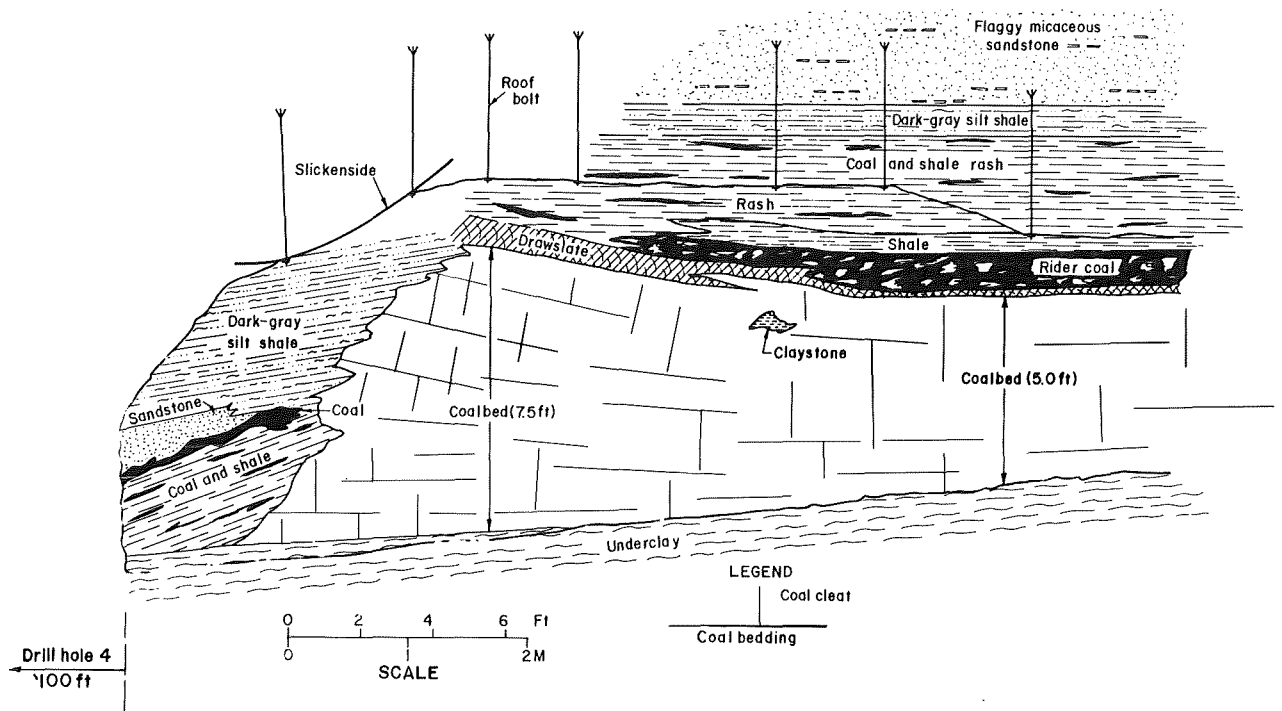


FIGURE 14. - Cross section of washout in 3-South.

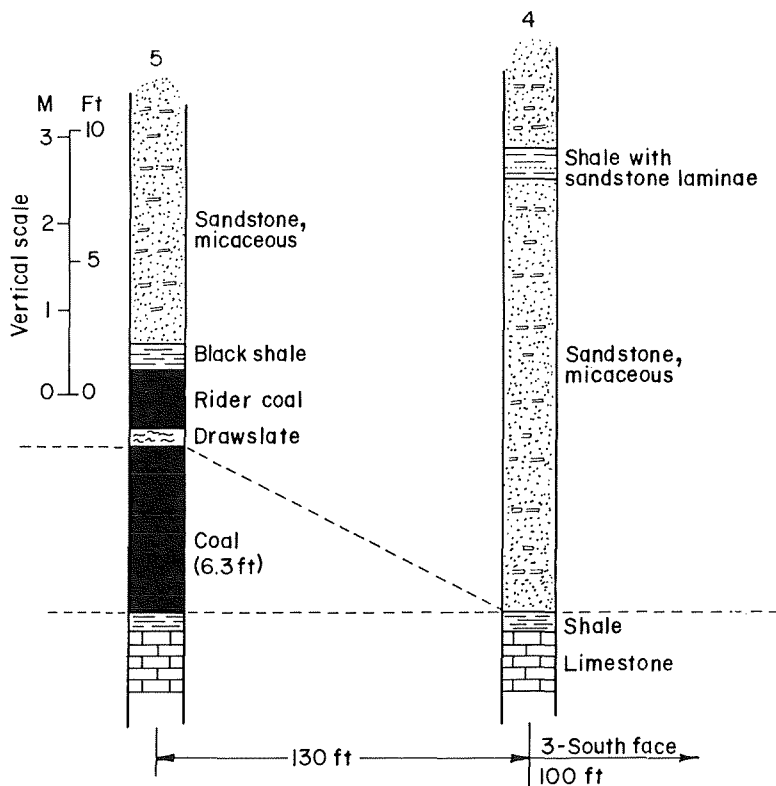


FIGURE 15. - Drill holes showing geologic conditions ahead of 3-South face.

coal is entirely occupied by sandstone. Had the face advanced a short distance farther, sandstone would have completely replaced the shale presently exposed in the face. Within 10 to 15 feet in by the ragged edge of the washout the coalbed thickened rather abruptly to 7.5 feet, providing some advanced warning that abnormal conditions existed shortly ahead.

DISCUSSION

Four selected sites in the Westland Mine have been described at which entries were terminated because of washouts or splits. Several other sections in the mine also were terminated because of low coal with sandstone roof or because of splits in the coal; but the precise nature of these terminations is not known.

At the four sites described, the prominent features are summarized in the following tabulation:

Section	Washout or split			Contact dip, degrees	Coal thickness, feet	
	Width	Trend	Structure		Normal for section	Near contact
6-West.....	150	NE	Washout....	15	5.8	6.5
8-West.....	500	N-NE	Split.....		6.0	7.5
2-South....	^e 400	N-S	Washout....	25-30	5.5-6.5	4.5-6.5
3-South....	150	NW	...do.....	15-25	5.0	7.5

^eEstimated.

similar to those in sections 6-West and 2-South, but at least one entry penetrated a steeply dipping, ragged contact in which the coalbed ended abruptly against shale and rash (fig. 14). The dipping structure in the roof indicates that shortly beyond the face, the entry probably would have been terminated by a slickensided channel as in other entries.

Two drill holes located 100 and 230 feet from the face (fig. 15) indicate that the washout is approximately 150 feet wide. Entries encountered the washout for at least 1,000 feet along strike, thus the overall structure resembles a channel similar to the washout described in 6-West. Drill hole 4, located 100 feet beyond the face, indicates that the position of the

The widths of the washouts range from about 150 feet in 6-West and 3-South to 700 feet in 8-West including the split. These dimensions appear less than most of the washouts in southwestern Pennsylvania (as shown in fig. 2) because for clarity these washouts are somewhat enlarged and generalized. The washouts display no overall uniformity of trend but locally show some preferred direction, resembling segments of stream channels, usually confined to the area overlain by the Pittsburgh sandstone, and probably were formed by the scouring action of the streams that transported the sand into the coal swamp.

The termination of the 8-West by a limestone split rather than a sandstone channel or split is uncommon if not unique in the mine area. However, as Friedman (3) demonstrated, splits can be genetically related to washouts and can develop near the flanks of major channels, providing some indication of the proximity of a washout. As Friedman explained,

"Sand and some silt were deposited in the main channel, and tributary streams deposited smaller amounts of mud and very little sand. The swamp vegetation encroached upon the mud-covered flood plains and peat later formed over the mud. In this manner, alternative deposition of peat and mud resulted..."

In line with this explanation the possible sequence of events leading

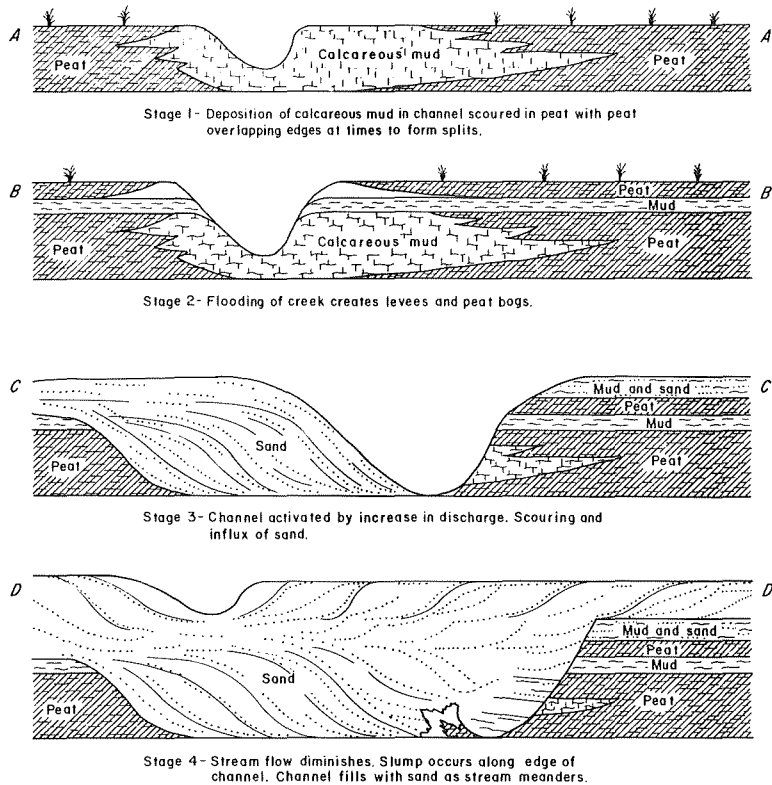


FIGURE 16. - Sequence of events leading to washout and marginal split.

to the formation of a washout and marginal calcareous split similar to the situation in 8-West is illustrated in figure 16.

Another alternative is that the split resulted from a low-angle rotational slump, but in either case a coal want ahead of the entry is indicated.

Washout Contact

The contact between the edge of the washouts and the coal in sections 6-West, 2-South, and 3-West is characterized by a highly slickensided, slightly convex surface dipping from 15° to 30° towards the face. The striations on the contact invariably parallel the dip of the contact, indicating simple downdip movement of the sandstone fill relative to the coalbed and shale

roof strata. Slickensides parallel to the contact commonly develop in the adjacent argillaceous rocks for a distance of several feet from the contact.

Two minor, but perhaps significant, geologic features were observed near washout contacts. First, the rider coal either becomes splayed, split, or pinches out within 1 to 10 feet of the washout. Second, in most instances, cleat diverges as much as 25° from the vertical beneath the basal contact of the washouts.

Coal thickness adjacent to the contact differed from the normal thickness found in each of the four mine sections. In sections 6-West, 8-West, and 3-South, coal thickened 0.7 to 2.5 feet greater than normal for the section, while in 2-South the coal thickened 1.0 foot in one entry measured but thinned erratically about 2.0 feet as the washout was approached. These changes in thickness occurred within 10 to 60 feet of the washouts.

A somewhat unusual washout occurring in a nearby mine might be worthy of mention at this point to illustrate that the character of washouts is far from being uniform even in the same coalbed and locality. Here the Pittsburgh coalbed was terminated by the usual slickensided contact (fig. 17), but continued at an elevation some 20 feet below normal floor level, gradually rising again to its original level and reaching full thickness. Some features suggest slumping has occurred near the margin of the washout. As with the Westland Mine, this washout was long and narrow, undetected by the customary exploratory drilling, and disrupted normal mining operations in the section.

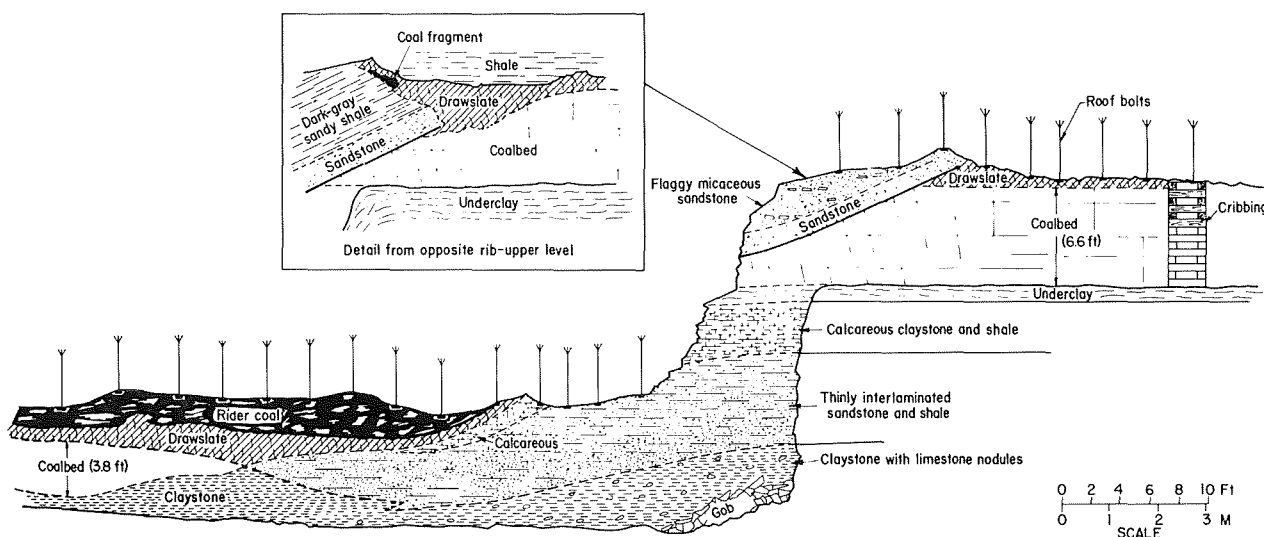


FIGURE 17. - Cross section of structure in 18-West section of Gateway Mine.

ROOF CONDITIONS NEAR WASHOUTS

The roof conditions marginal to washouts were investigated by an inspection of roof stability within a few hundred feet of the washouts and by mapping all significant roof falls.

An analysis of drill hole data revealed that washouts occurred almost exclusively west of the main haulage where the interval between the coal and the base of the Pittsburgh sandstone was about 2 feet or less (fig. 18). The sandstone thickness, however, provides little, if any, evidence as to areas of high potential for washouts (fig. 19).

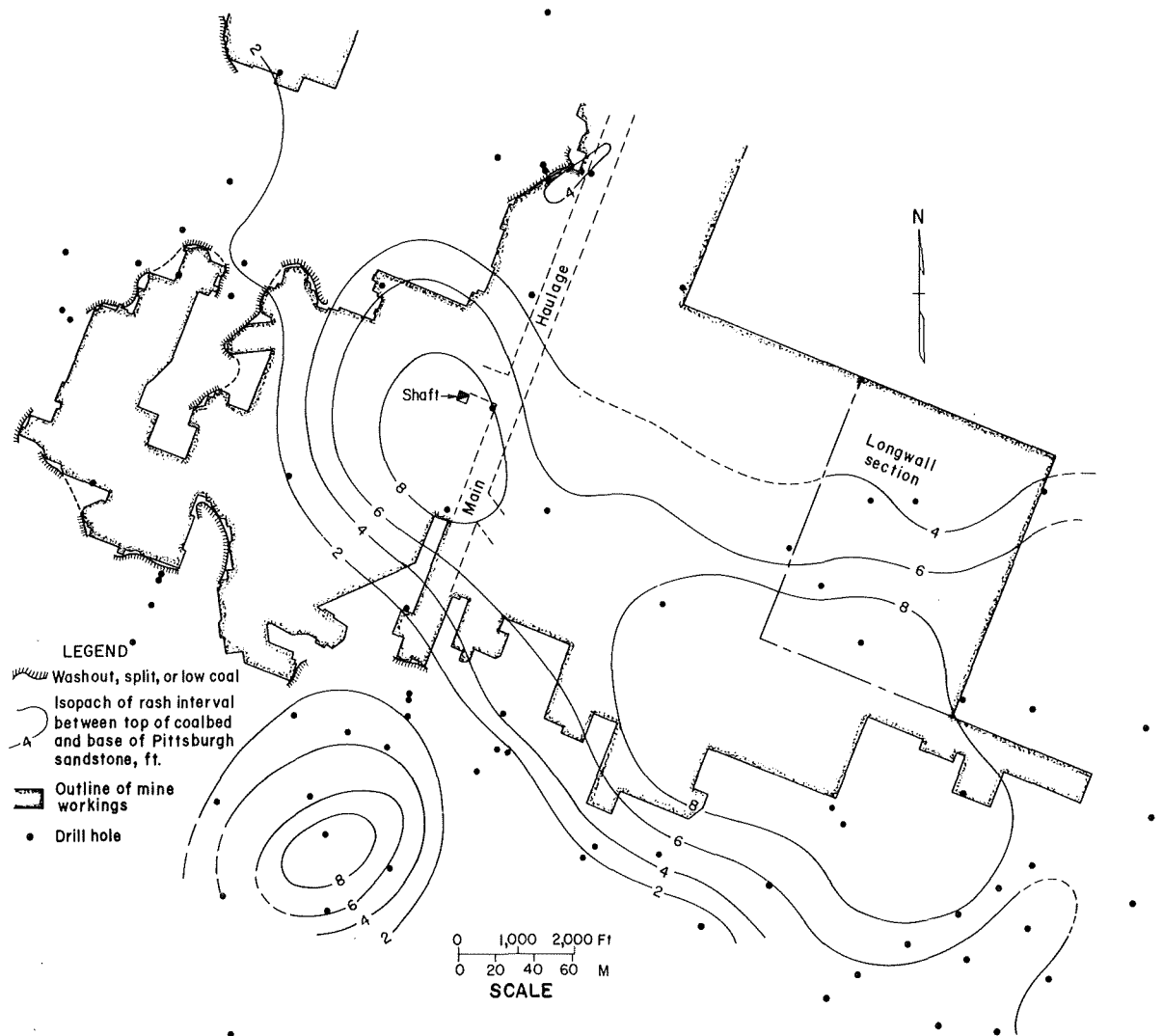


FIGURE 18. - Isopach of rash member of roof strata.

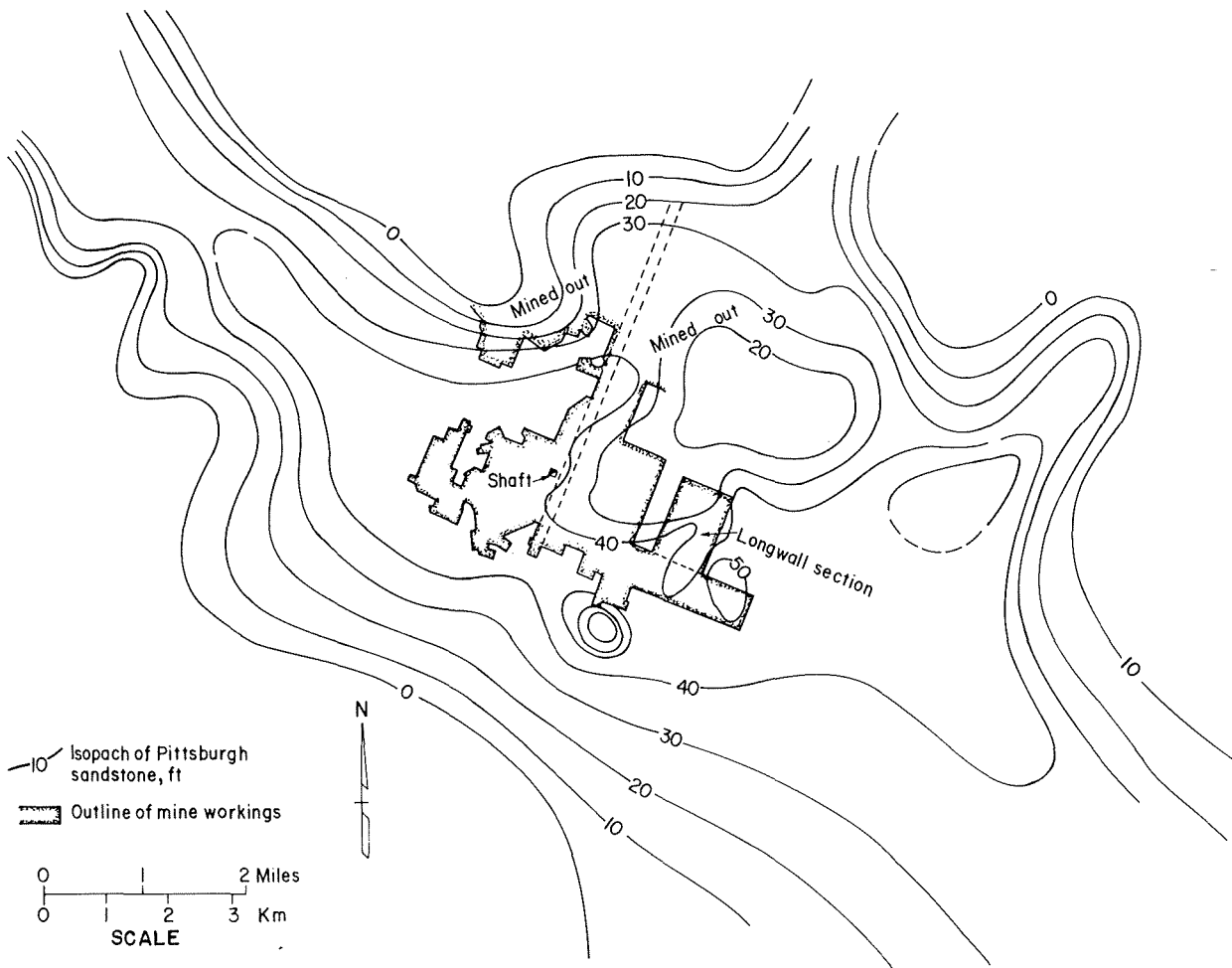


FIGURE 19. - Isopach of Pittsburgh sandstone.

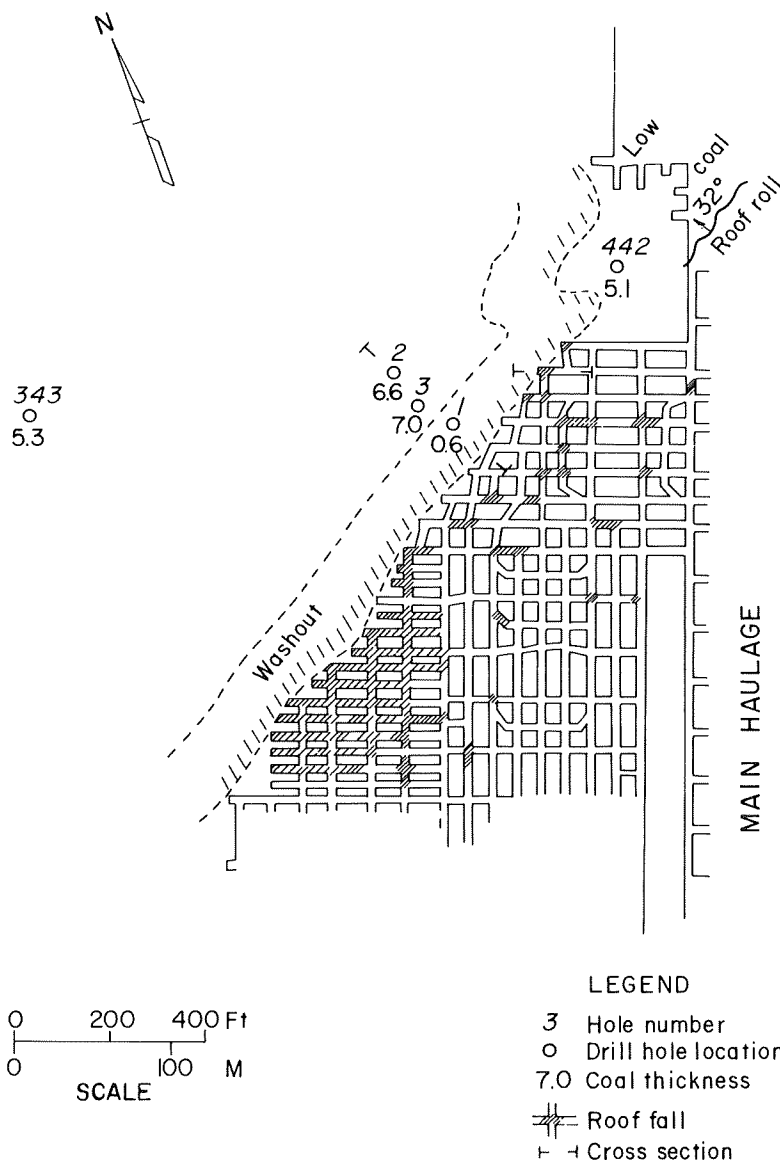


FIGURE 20. - Washout and roof falls in 6-West section.

incompetent coal and shale strata terminate against the slickensided contact (figs. 21 and 22).

Beginning with 6-West (fig. 20), scattered roof falls were located in the northern part of the section and within 500 feet of the main haulage, while numerous falls were located in the rooms in the southwestern part of the section. Management reported that all of these falls occurred long after 1968, when mining was completed in the 6-West section, and the concentration of falls in the southwestern part can be attributed to the greater extraction and widening of rooms, and therefore, greater expanse of exposed roof, than elsewhere. The scattered falls in the northern part occur largely at intersections where micaceous flaggy sandstone is interbedded with shale or constitute a poorly bonded sequence of strata in the immediate roof. A sequence of this type is prone to failure over the large span of the intersection and where remedial support is not normally practiced in abandoned sections. Although not evident in figure 20, very hazardous roof conditions occur within a few feet of the washout contact where relatively



FIGURE 21. - Hazardous roof conditions in 6-West section at heavily slickensided washout contact. Fallen rock consists chiefly of argillaceous sandstone.

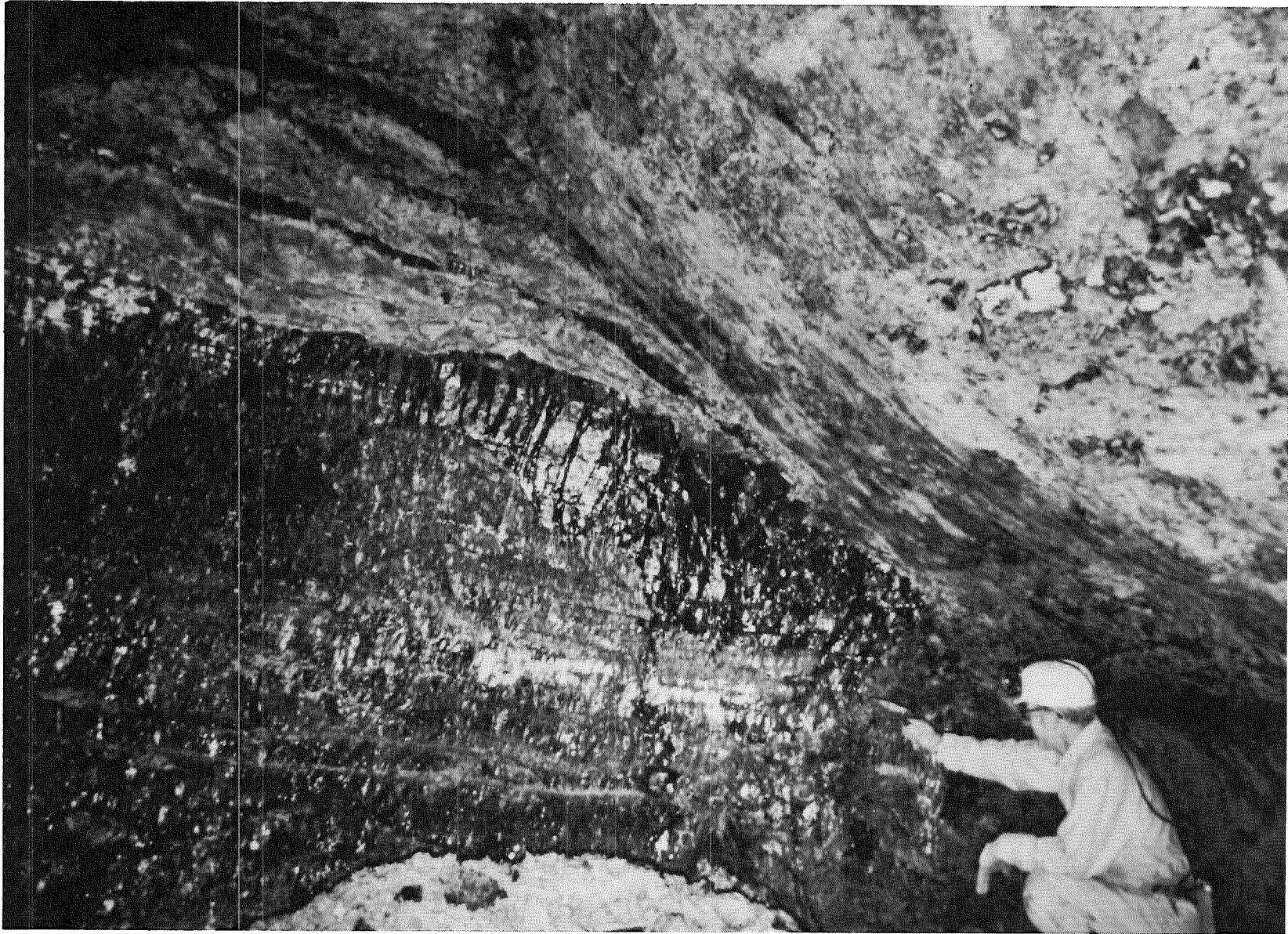


FIGURE 22. - Overbreak of incompetent roof strata abutting slickensided washout contact. Claystone and coal roof strata usually collapse on removal of coal near washout contact.

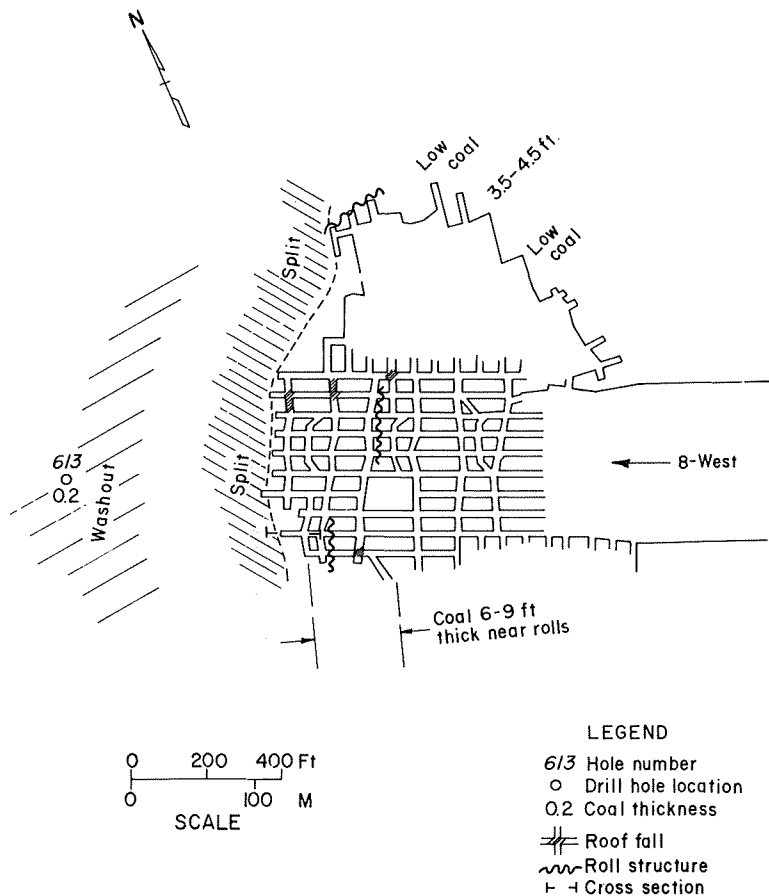


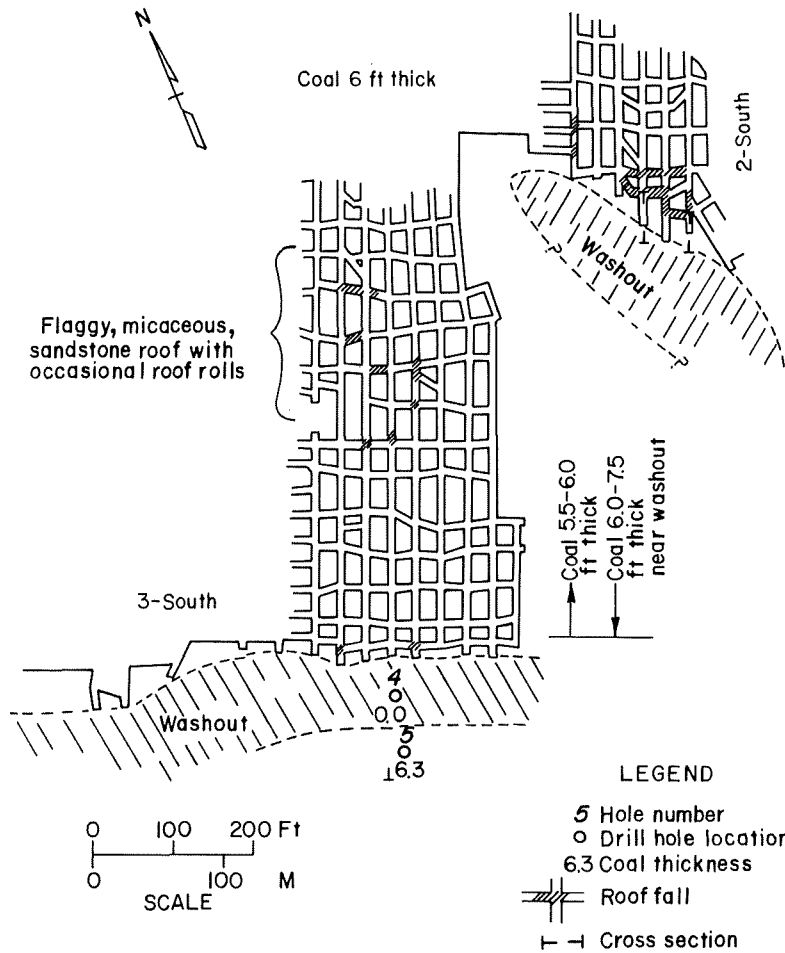
FIGURE 23. - Roof falls and limestone split in 8-West section.

coal and shale terminated abruptly against the slickensided edge of the roll; this was supported for a time, but eventually collapsed within 2 years.

In the 3-West section, roof falls are rare near the washout at the face (fig. 24), although some overbreak occurred along the slickensided contact. Several isolated falls occurred several years after mining at 600 to 1,000 feet outby the face, exposing roof structures and flaggy micaceous sandstone in the roof. Otherwise roof conditions in 3-South remain very good.

In 8-West section, roof falls were rare (fig. 22). While flaggy sandstone occurs in the immediate roof, the washout contact is located somewhere beyond the face and split and therefore does not affect roof stability in the entries that remain open and in good condition (fig. 23).

In 2-South (fig. 22), large, virtually continuous roof falls occurred within 100 feet on the face but did not occur at the face along the washout contact, although conditions there were hazardous because of the slickensides and about 3 feet of incompetent strata were taken down before attempting to bolt the roof. The large continuous falls are attributed to the effects of a large sandstone roof roll some 70 to 80 feet from the face (fig. 13) that parallels the edge of the washout. About 5 feet of



DELINEATION OF WASHOUTS

The Westland Mine was developed largely on the basis of information obtained by the customary exploratory core drilling in which drill holes were located on roughly a 2,500- to 5,000-foot spacing, but with many exceptions because of topography, water supply, surface rights, and culture. Concurrent with mine development, several additional holes were drilled for special purposes with spacing sometimes as close as 200 feet but more commonly ranging from 700 to 1,000 feet. In the portion of the mine west of the main haulage, washouts were encountered and entries terminated and redirected, largely because even the additional core drilling had failed to establish the size or shape of the washouts with any precision.

FIGURE 24. - Roof falls and washouts in 2-South and 3-South.

The latest effort to delineate the washouts so that additional coal reserves could be mined systematically consisted of the three drill holes located beyond the face of 6-West and the two holes located beyond 3-South. This drilling indicated the strongly linear character of the washouts at these sites.

Evidence from 2-South face and adjacent entries indicated that 2-South also was terminated by a linear washout of relatively limited width. In view of this latest drilling information, and until proven otherwise by a continual review and analysis of the geology, mine planning should proceed on the premise that any additional washouts that are encountered are likely to be strongly linear and 300 to 400 feet wide. The split and related washout in 8-West were not fully explored by core drilling, and the situation is somewhat more complex here; however, a narrow linear washout located beyond the face, split in the face, and near drill hole 613 still remains a good possibility. Thus, when a split is encountered, the probability is high that the combined width of the split and the channel beyond the split lies between the face and the coalbed on the other side of the washout. In 8-West, this combined width would be on the order of 700 feet for both structures.

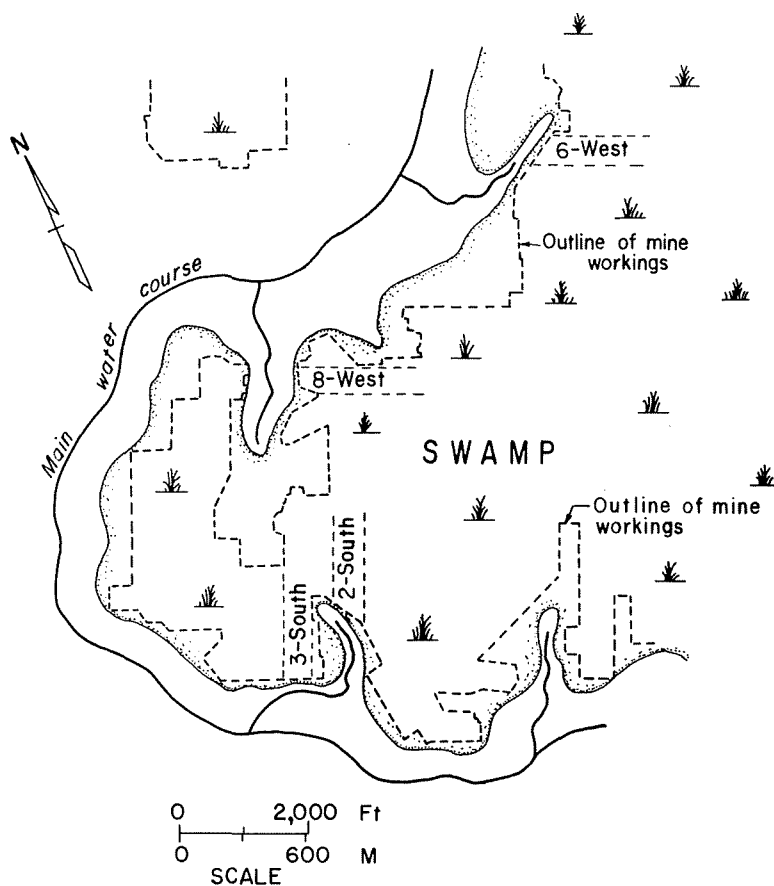


FIGURE 25. - Example of simple depositional model.

The trends of the washouts and of roof roll structures in the same sections of the mine showed little preferred direction that could have facilitated planning entry projections. However, the sampling was too small in number to be significant. A study of roof roll trends in a section of the Gateway Mine (8), located 20 miles southwest of the Westland Mine, showed some preferred direction but also showed curving, discontinuous rolls and cross structures. Hylbert (5), using structure contour and isopach maps to determine axial trends of sandstone roof rolls in two mines located in eastern Kentucky, found some subparallel rolls but also some divergence and branching, indicating the difficulty of predicting the trends of washouts by mapping minor but related scours in the roof. How-

ever, these small-scale scours and paleochannels in the mine roof are genetically related to the washouts that cut deeper into the coalbed and are larger in size, and should provide some clue as to their character.

Once initial core drilling of a property has been completed and segments of major washouts located, some perspective of washout trends might be achieved through construction of even the simplest form of depositional model, such as the sample illustrated in figure 25. This could provide targets for additional core drilling or indicate the optimum projections for underground exploration.

CONCLUSIONS

A description and analysis of three washout structures and a genetically related split in the coalbed at the Westland Mine leads to the following conclusions:

1. The washouts consist of linear, discontinuous, sometimes gently curving paleochannels 300 to 700 feet wide that scoured down through the peat and became filled with sand.
2. The coalbed is terminated by the heavily slickensided undersides of the paleochannels that dip 15° to 30° toward the center of the channel.

3. A very hazardous roof condition exists within 10 to 20 feet of the washouts described because of the large, well-developed slickensides paralleling the paleochannels.

4. Roof farther than 10 to 20 feet away from the edge of a paleochannel generally remained stable despite lack of maintenance except in rooms, widened entries, and intersections.

5. Washouts occur chiefly west of the main haulage, a portion of the mine where an isopach map indicates that the coal-sandstone (rash) interval is about 2 feet or less.

6. The directional trends of linear washouts, while clearly discernible in underground exposures, are not uniform, but widely divergent.

7. Customary spacing of exploratory drill holes is not adequate to delineate narrow washouts on the order of 300 to 700 feet wide, especially as the directional trends are not uniform.

8. Since an impractical amount of core drilling would be required to delineate washouts prior to mining, shallow seismic techniques might help in detecting their existence. This was attempted along a 2,500-foot profile across the western edge of the Westland Mine, but results were inconclusive.

9. Once existing drill core and geologic data on a proposed mine site have been fully analyzed, a suggested approach is to determine the geometry of the first washout encountered by detailed supplementary core drilling and proceed on the premise that additional washouts will be similar in shape and size. As additional washouts are encountered underground, their character also should be studied closely to establish similarities with others in hopes of determining a common pattern, trend, or shape that would enable mine operators to better cope with the problem of unexpectedly encountering coal discontinuities.

10. Construction of a simplified depositional model might lend some perspective to the location and trend of washouts.

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