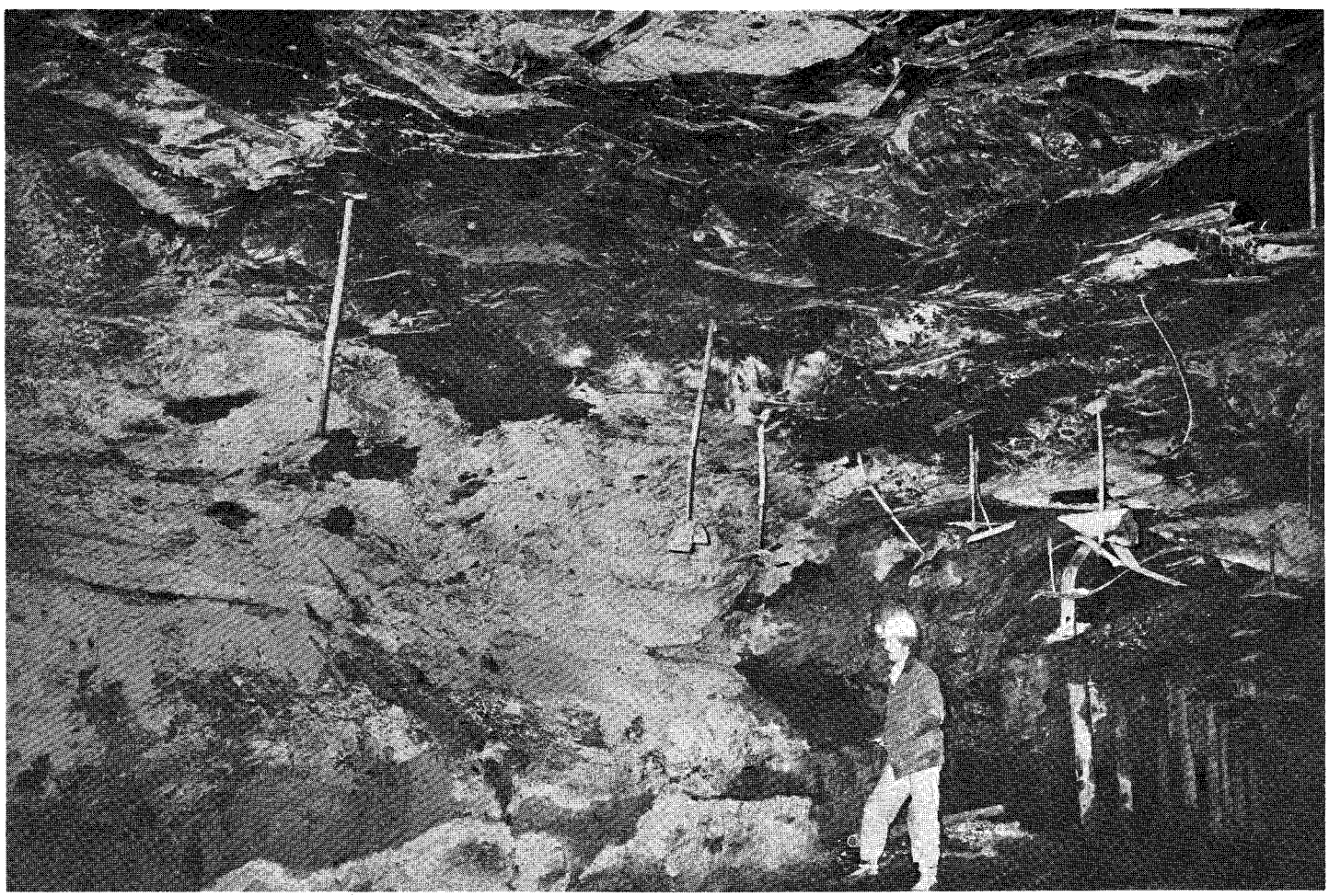
VIRGINIA DIVISION OF MINERAL RESOURCES PUBLICATION 55

GEOLOGIC FEATURES RELATED TO COAL MINE ROOF FALLS - A GUIDE FOR MINER TRAINING

Robert C. Milici and Thomas M. Gathright, II



COMMONWEALTH OF VIRGINIA

DEPARTMENT OF MINES, MINERALS AND ENERGY
DIVISION OF MINERAL RESOURCES
Robert C. Milici, Commissioner of Mineral Resources and State Geologist

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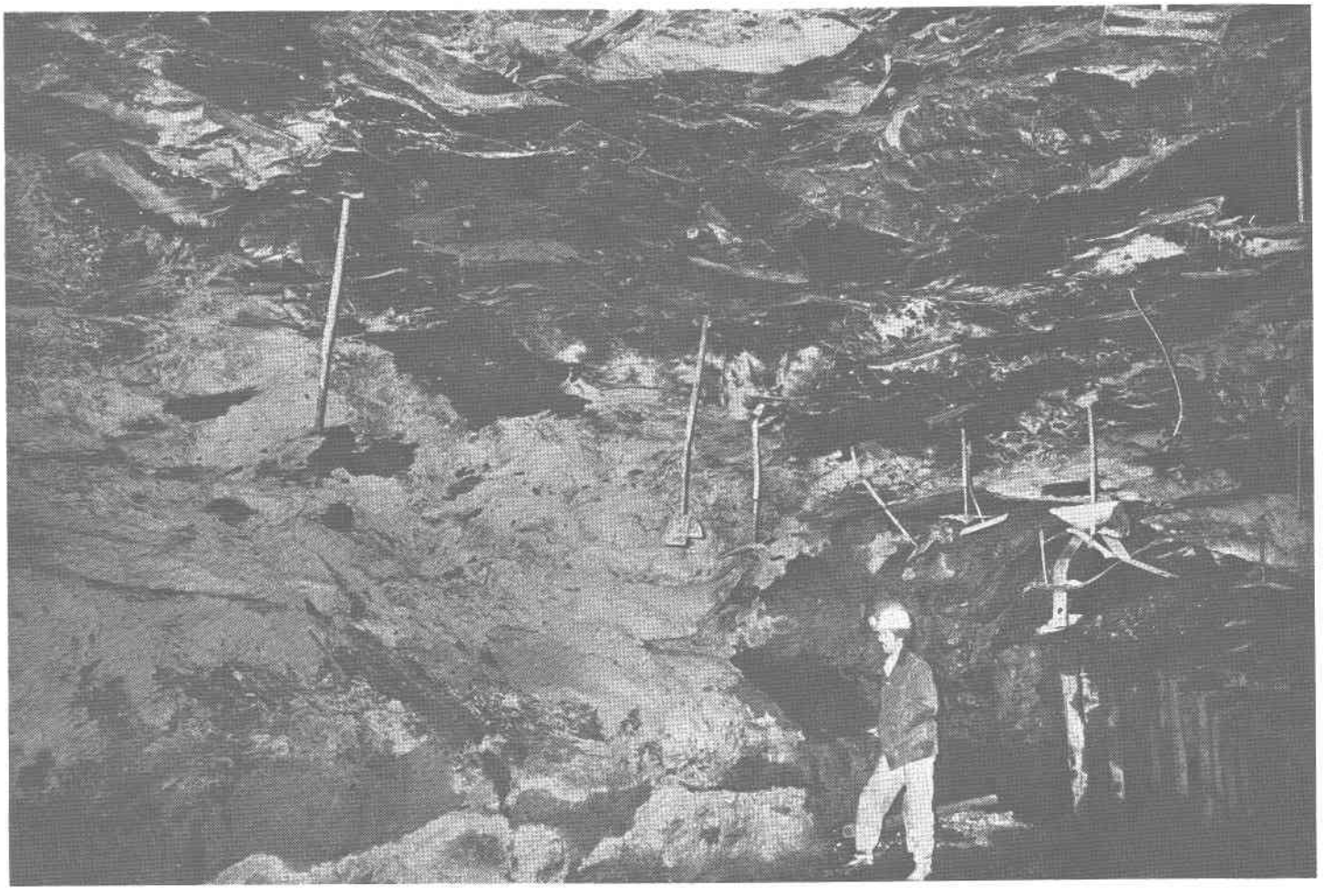

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FRONT COVER: Result of roof fall in typical type A mine roof (see text for mine roof classification). The fall developed in tectonically deformed shales above decollement at top of the Raven coal seam and within 100 feet of a major sandstone channel.

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DEPARTMENT OF MINES,
MINERALS AND ENERGY

Richmond, Virginia

O. GENE DISHNER, Director

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF PURCHASE AND SUPPLY
RICHMOND

1985

Portions of this publication may be quoted if credit is given to the Virginia Division of Mineral Resources.
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PREFACE

This publication is designed to introduce coal mine safety and supervisory personnel to some of the geologic factors which have caused ground control problems in the southwest Virginia fields. The text is a companion to a 35 mm slide set which covers much of the same material. In addition, the slide set may be modified for companies to include relevant geologic features in the mines currently being worked by them.

The publication is the result of work by the Virginia Division of Mineral Resources which in part was supported by the Appalachian Regional Commission and published in Report ARC-CO-7232-80-1-302-0206.

The writers would like to acknowledge the interest and cooperation of industry during the conduct of the study, especially Penn Virginia Resources Corporation, Westmoreland Coal Company, and Paramont Mining Corporation.

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INTRODUCTION

Miner training in roof control should provide the information necessary to recognize areas of immediate, substantial danger, so that they may be avoided by the miner and so that appropriate supplemental supports may be constructed prior to major roof failure. Although the best appearing roof has some potential to fall, an irregular roof which separates along a geologic discontinuity constitutes the greater threat to safety. Geologic features are more easily understood when studied on the surface rather than underground. The miner, however, must be able to make quick judgements in the confined, confused, and poorly lighted conditions of the mine.

Table 1. Significant geologic features related to miner training.

1. **Principal rock types of the coal measures:**
   a. Conglomerate
   b. Sandstone
   c. Siltstone
   d. Shale
   e. Coal
   f. Seat earth (underclay)
2. **Secondary lithologic features:**
   a. Ironstones
   b. Fossil tree trunks
   c. Fossil stems and leaves
3. **The coal bed:**
   a. Thickness variations
   b. Cleat
   c. Faults and folds
4. **Roof fractures — Type A roof:**
   a. A-type roof; polished and slickensided bedding; fractured C-type roof
   b. Dip angle of fractures — high vs. low
   c. Trend of fractures with respect to entries and crosscuts
   d. Fracture intensity — high vs. low
5. **Stratigraphic variations in immediate and main roof — Type B roof:**
   a. Rider coal beds
   b. Shale and clay partings in sandstone
   c. Cross-beds
6. **Sandstone channels — Types C, Cb roof:**
   a. Channel bottom irregularities
   b. Channel boundary conditions

Significant geologic features related to miner training are listed in Table 1. Each miner should be able to recognize the principal rock types and some of the secondary features commonly encountered in the coal measures (Table 1, Items 1 and 2). Variations in coal bed thicknesses (Table 1, Item 3) are at best caused by stratigraphic changes and at worst by faulting, either within or across the coal bed. Deformed coal beds generally have broken and folded cleats, slickensides are common, and coal beds are structurally thickened or thinned in some places. Deformed coal beds are usually not in themselves problems in mining, except where the coal bed is substantially thickened and thinned and where faults and folds extend from within the coal into the overlying roof.

Miners should know as much as possible about roof fractures and folds (Table 1, Item 4). Large and dangerous falls are commonly associated with closely spaced, steeply dipping, slickensided fractures in shale which trend either parallel to the entries or parallel to cross cuts. Similarly, steeply dipping fractures in sandstones are also a major cause of roof falls. Roof strata are more easily supported and there are fewer horsebacks and falls where roof fractures extend upward from the coal bed at moderate to low angles, and especially where fractures trend at an oblique angle to entries and cross cuts.

Miners should be aware of the deleterious effects of sandstone channel bottom irregularities and of the stratigraphic variations in the immediate and main roof that also contribute significantly to roof falls (Table 1, Items 5 and 6). These features are commonly recognized only after the weak zones are exposed by one or more falls but may also be recognized during excavation of the roof (e.g., construction of overcasts), or by the roof bolting crew while drilling test or bolt holes. Sudden changes in elevation of a sandstone-over-shale contact in the main roof suggest sandstone channel boundaries. These changes can be readily recognized when drilling a series of closely spaced roof bolt holes. Other examples would be rider coal beds and seat earth above the main coal bed and shale partings and interbeds within an otherwise homogeneous sandstone. Associated minor features which contribute to localized roof control problems include such things as an abundance of carbonized plant debris and "kettle bottoms" of ironstones or fossilized standing tree trunks.

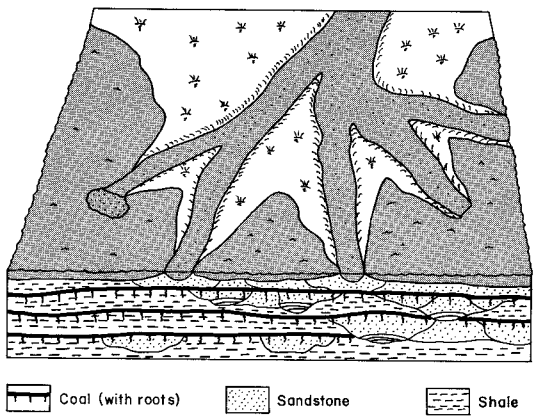


Figure 1. Diagram showing the deposition of mud, silt, sand, and gravel. Mud and silt generally accumulate in quiet, standing water. Sand is deposited in river channels and at the mouths of the channels. Peat accumulates in marshes and swamps adjacent to the channels. With burial the sediments are lithified (turned to stone), thereby forming shale (slate), siltstone, sandstone, conglomerate and coal.

ROCKS

Rock layers commonly found with coal are formed from deposits of mud, silt, sand, and gravel. These deposits accumulated along ancient rivers, on river deltas, and along coastal areas (Figure 1). The mud, silt, sand, and gravel beds were turned to stone (lithified) as they were deeply buried in the earth beneath younger sediments. Layers of plant material which accumulated with them (peat) were changed progressively to soft coal (lignite) and then the various stages of harder coal (bituminous, anthracite) by heat and pressure within the earth.

Lithified mud, called shale (or "slate") is a very fine-grained rock which is generally in colors of green, gray, or black. Some shales are red, but these are not usually found associated with coal. Some shale deposits contain abundant amounts of carbonized plant fossils (Figure 2), and others may contain irregular or disc-shaped nodules of brownish gray ironstone (Figure 3). Because the muds which formed the shale may have been deposited in ancient swamps, some shale beds contain the remnants of ancient trees (Figure 4), either short standing trunks or longer logs now lying on their side.

Lithified silt, called siltstone, is similar in appearance to shale, with the exception of its slightly coarser grain size. In contrast with shale, siltstone is generally tougher and in outcrop forms prominent beds or ribs (Figure 5). It too may contain ironstone nodules or disks, plant fossils and fossil tree trunks.

Lithified sand, called sandstone, is coarser grained than siltstone. In general, individual sand

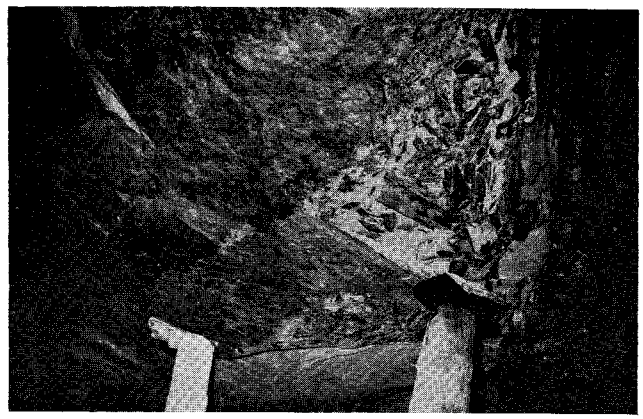


Figure 2. Carbonized plant fossils in shale roof rock, Imboden coal bed. Where abundant, plant fossils decrease strength of roof shales and may result in the formation of horsebacks or small roof falls.

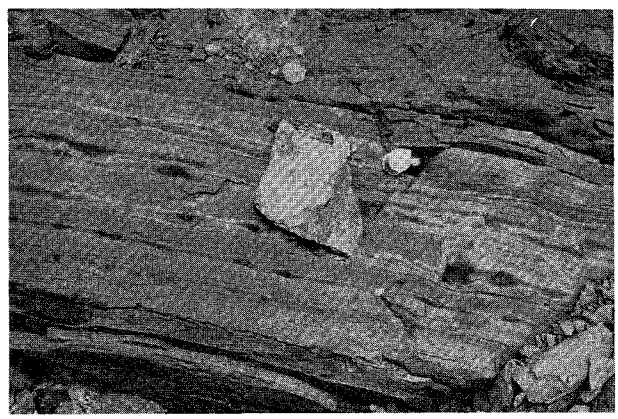


Figure 3. Siltstone bed with small ironstone nodules along bedding. In places ironstones may be a foot or more across. Large ironstones in the immediate roof may constitute a hazard to miners.

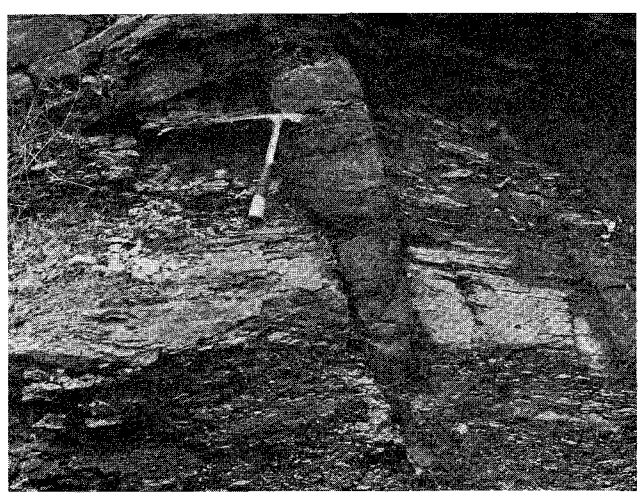
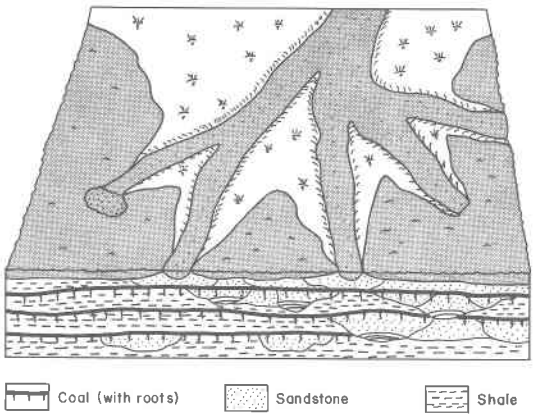


Figure 4. Fossil tree standing in life position. When mine workings uncover these from below, pieces of the fossilized tree, or "kettles" may fall.



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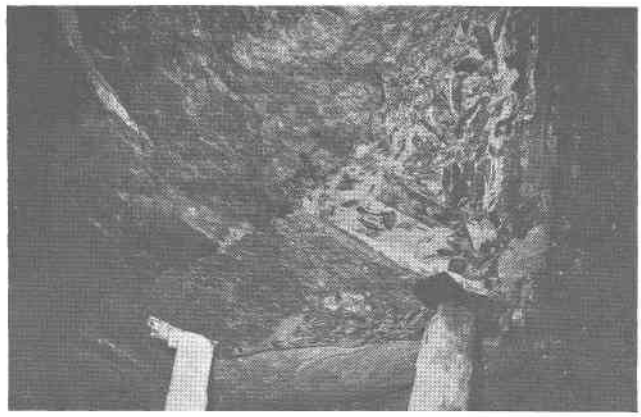

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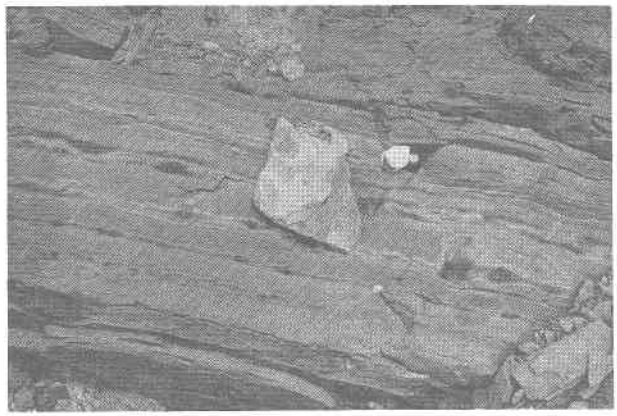

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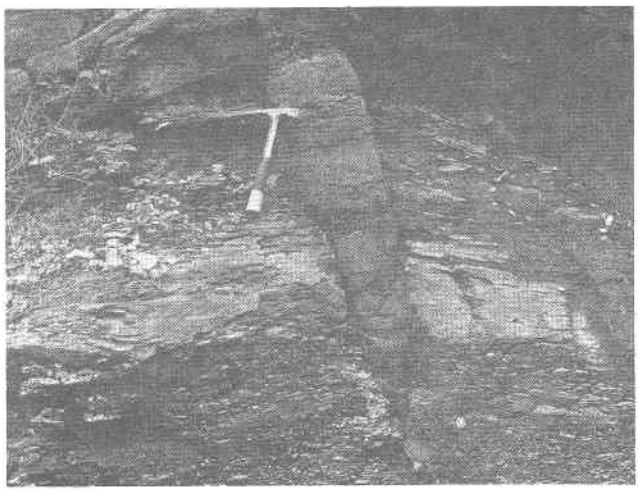

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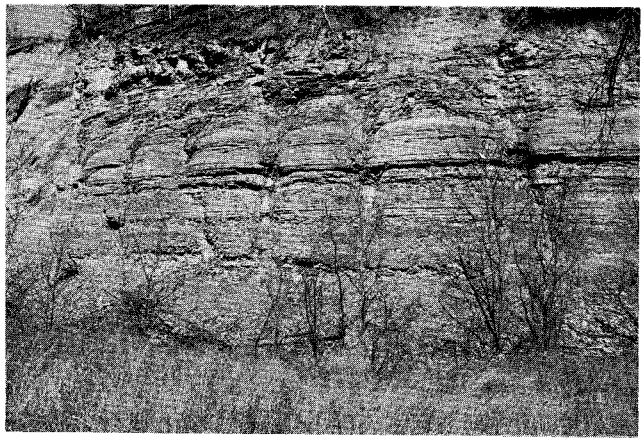

Figure 5. Prominent beds or ribs of siltstone in strip mine highwall. Vertical features are zones of weathering along joints, where groundwater has had the opportunity to penetrate the strata.

grains can be seen with the unaided eye and the rock is rough to the touch. Sandstone is generally gray in color, but on the outcrop weathers to shades of yellow, orange, or brown. Sandstones grade into rocks called conglomerates with an increase in grain size. Conglomerates contain larger fragments (gravels, boulders) of rock imbedded within the sand matrix (Figures 6 and 7). These larger pieces commonly range from pieces the size of a small pea to those the size of a large nut several inches across. In places, conglomerate may contain very large boulders, but this type of rock is rare in coal fields.

The principal rock types of the coal measures, from fine to coarse, are: shale ("slate"), siltstone, sandstone, and conglomerate. Coal, of course, is the most important to the miner and industry. Coal beds commonly overlie rooted claystones or

Figure 6. Conglomeratic sandstone. Sand grains were deposited together with quartz-pebble gravels, and when lithified they formed this very conglomeratic sandstone and conglomerate.

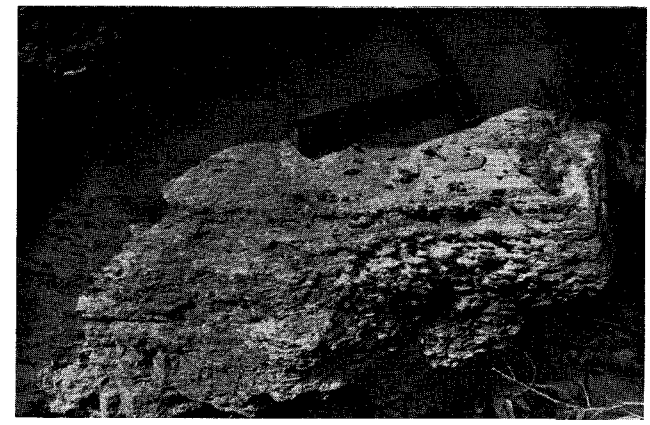

Figure 7. Ironstone pebble conglomerate in sandstone.

Figure 8. Seat earths between coal beds. These seat earths formed from clay and silt which had collected below peat-forming marshes or swamps. When the peat was buried and coalified, the seat earth was lithified and turned into a soft, crumbly shale. Seat earths commonly contain numerous impressions (fossils) of the rootlets of the peat-forming plants.

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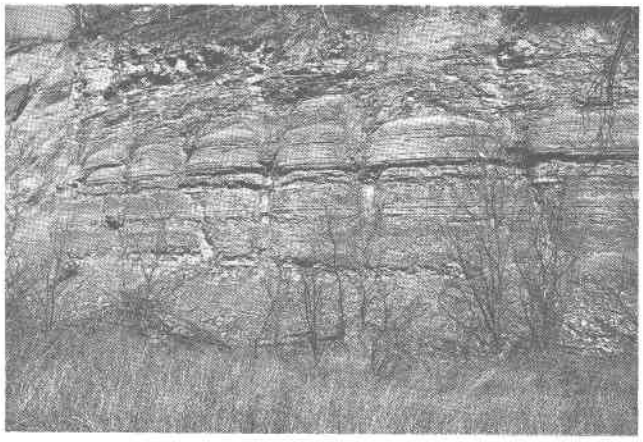
Each miner, thus, should be able to recognize shale "slate", siltstone, sandstone, and conglomerate. In addition he should know clay, fossil plant leaves and stems, fossil tree trunks, and ironstone nodules.



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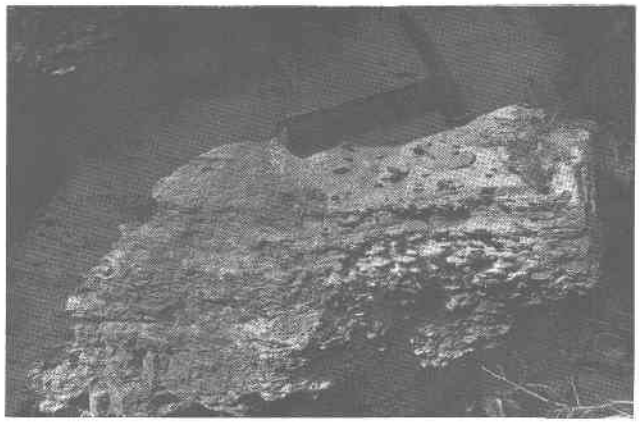

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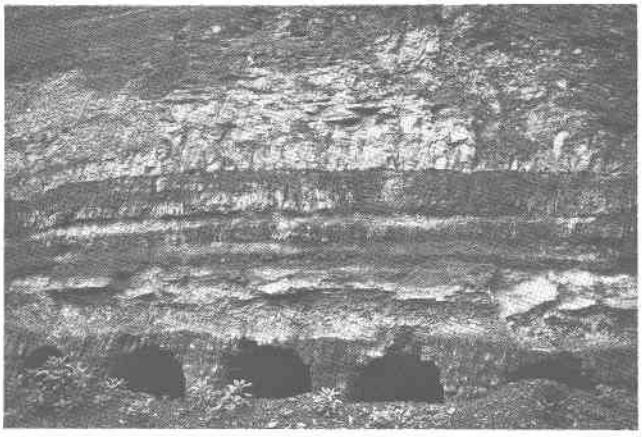

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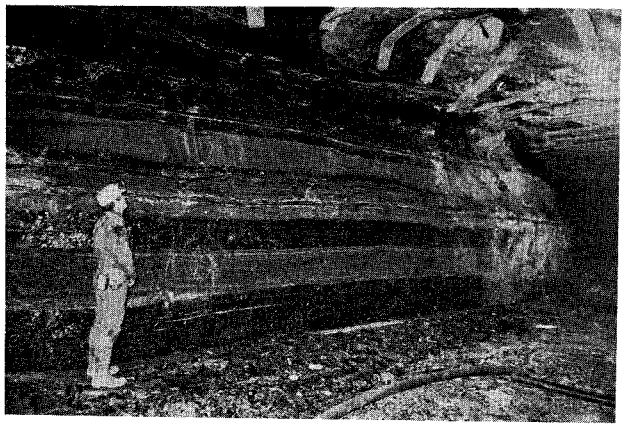


Figure 9. Shale middlemen separating coal beds.

STRATA (LAYERS)

Mud, silt, sand, and gravel (called sediments) are commonly deposited in layers or blankets called strata (Figure 10). Some strata are widespread, whereas others may be restricted to narrow bands or channels (Figures 11 and 12). Because these channels commonly represent channels of ancient rivers, the distributaries of ancient deltas, or channels through ancient beaches, they are most often filled with sand. Adjacent areas, where the water did not move as swiftly, contain finer grained sediments (mud, silt). Some peat beds overlie or are overlain by muds and silts which are cut by these channels (Figure 13). Other peat beds either overlie or are overlain by extensive sand blankets. Still others may be almost entirely overlain by mud or silt, with few (if any) channels through them (Figure 14).

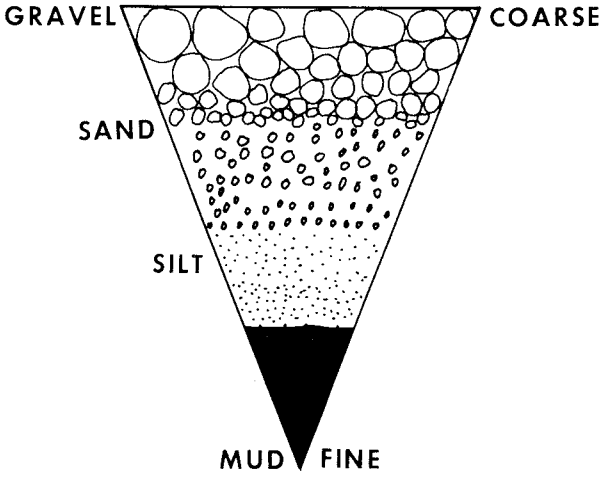


Figure 10. Relationship of sediment type to particle size.

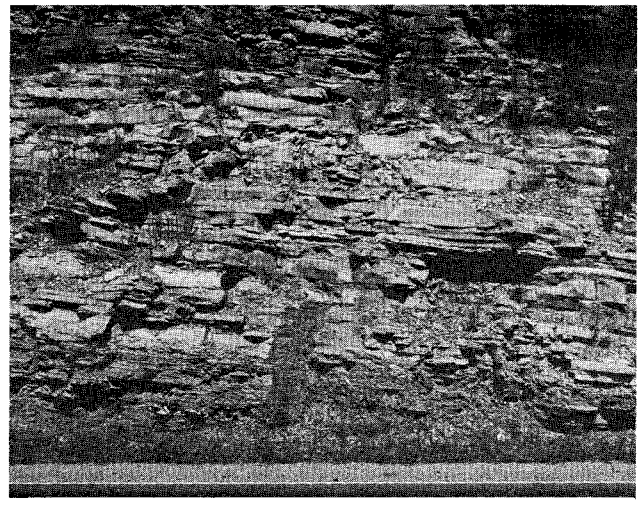


Figure 11. Thick, well stratified sandstone. Blanket sandstones may persist laterally over a considerable distance.

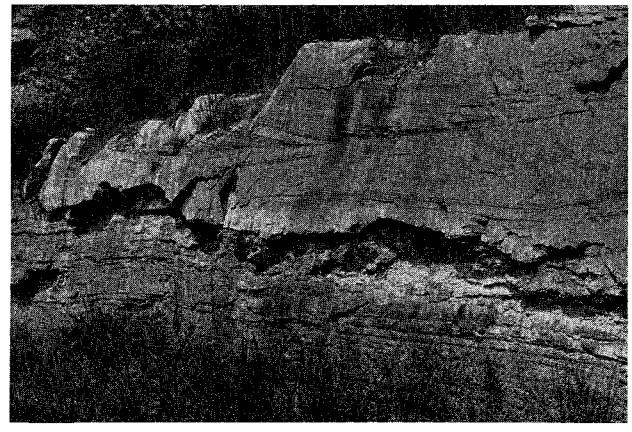


Figure 12. Channel sandstone. Channel sandstones may cut down to and through coal beds.

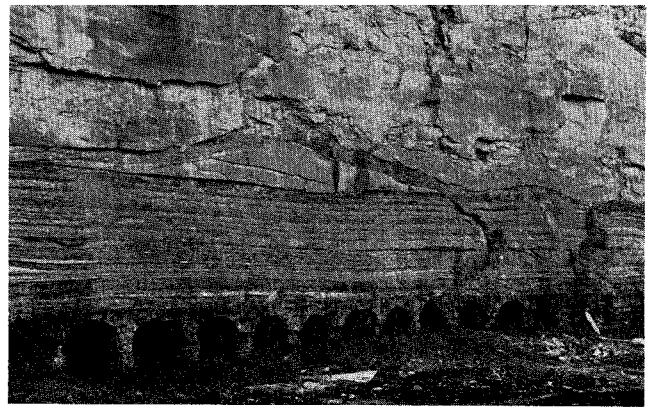
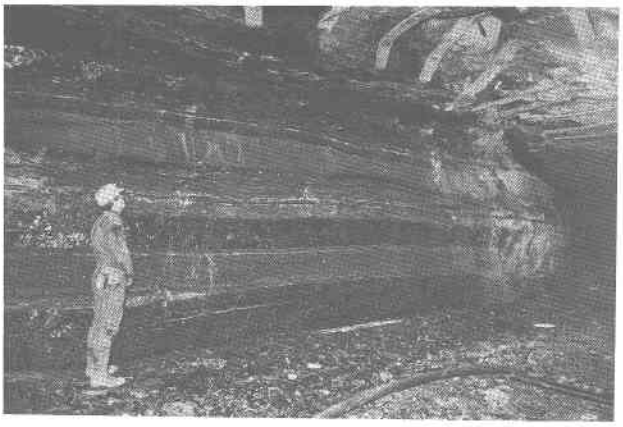


Figure 13. Mud, silt and peat, now lithified to shale and siltstone and (auger-mined) coal. Note thick channel sandstone in upper half of photograph.



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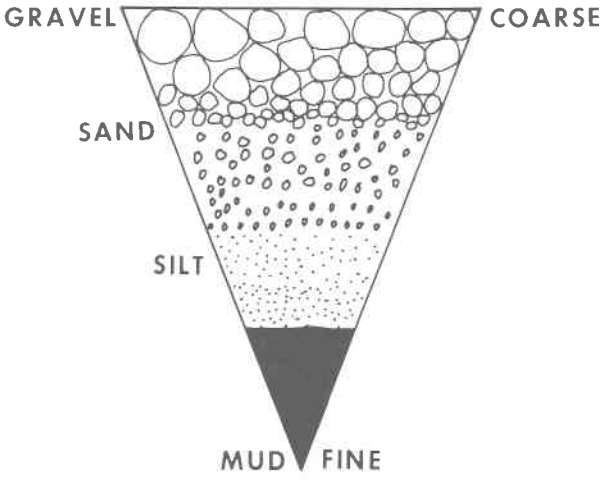


Figure 10. Relationship of sediment type to particle size.

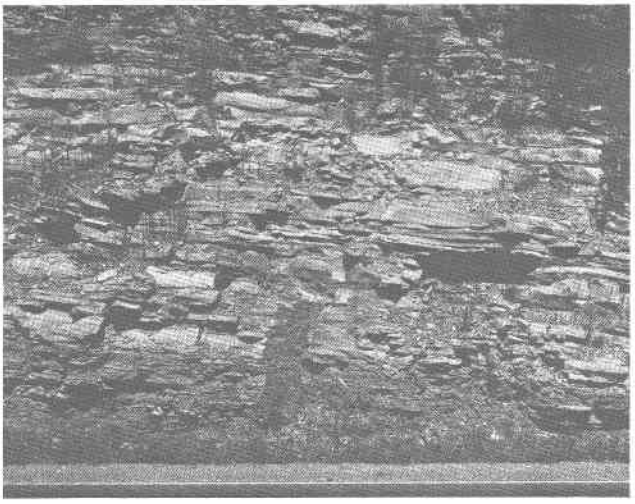


Figure 11. Thick, well stratified sandstone. Blanket sandstones may persist laterally over a considerable distance.

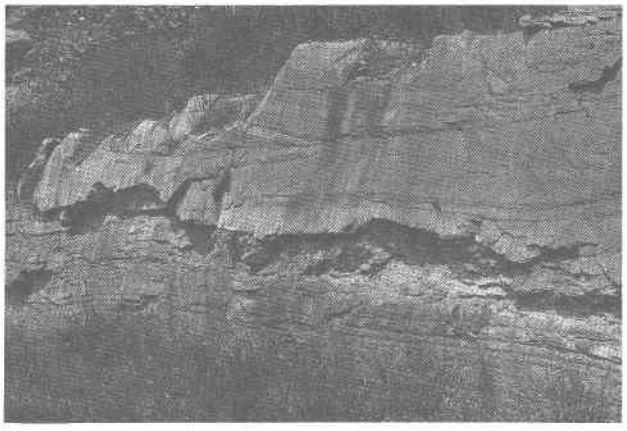


Figure 12. Channel sandstone. Channel sandstones may cut down to and through coal beds.

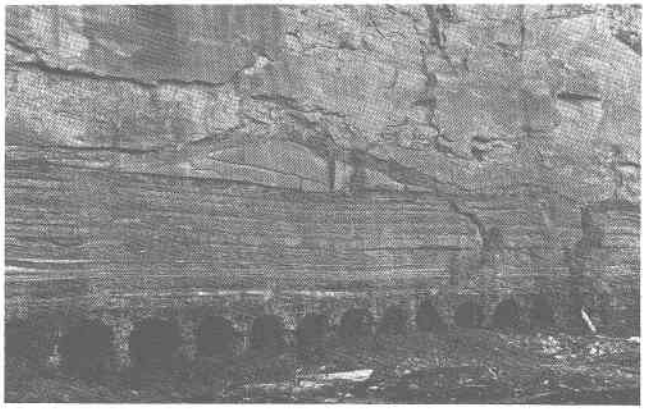


Figure 13. Mud, silt and peat, now lithified to shale and siltstone and (auger-mined) coal. Note thick channel sandstone in upper half of photograph.

Figure 14. Coal bed (lithified peat) overlain by shale (lithified mud, silt). Note well developed blocky cleat and thin shale partings in coal bed.

The sediments are subsequently buried deep within the earth where, under elevated temperatures and pressures, they are turned to stone (lithified) (Figure 15). Subsequently, the strata may be exhumed after extended periods of uplift and erosion, and during mountain-building processes they may be thrown into folds or broken by faults.

Boundaries between sandstone and siltstone or shale in the immediate roof are important to recognize because they are commonly sites of major roof falls. The nature of these boundaries, whether abrupt or gradational, also bears upon their capability to persist unbroken in the coal mine roof, as coal is removed by mining and the roof is supported by roof bolts or other means.

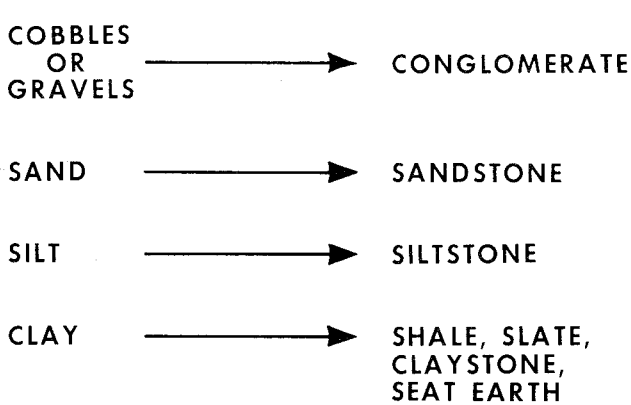


Figure 15. Relationship of sediments to sedimentary rock types.

THE COAL BED

Coal is a combustible rock which consists primarily of the carbonized remains of plant fossils. Uncombustible mineral matter (sulfur, ash) is disseminated throughout coal beds. Coal beds commonly have thin partings of shale or clay and, in some coals, middlemen a foot or more thick are mined and separated from the coal during washing.

Most coal contains one or more directions of cleating. Cleats are joints in the coal which tend to be perpendicular to bedding. They are usually closely spaced and are restricted to individual beds or benches of coal. Most often there are two prominent cleat directions which are commonly at right angles, or nearly so. The dominant cleat, the one which is through-going, is called the face cleat. Cleats which terminate against the face cleats are butt cleats.

Variations in coal bed thickness are primarily caused by stratigraphic or structural changes in the bed. Common stratigraphic changes are the addition or deletion of layers of coal on the bottom or top of the seam. Structural changes may be caused either by folding (bending) of the coal bed and enclosing strata or by faulting. In places where faults cut coal beds at an angle, a structural roll may be formed and the bed may either descend or rise in the direction of mining. Faults within coal beds tend to follow thin shale beds or partings. Cleats are commonly destroyed and the coal may be extensively slickensided where it is faulted. In some places, bedding-parallel faults are confined within the coal bed or are in carbonaceous shale at the top of the coal (Figure 16). Where faults parallel to bedding cut diagonally from one shaly parting to another, the coal bed may be duplicated and structurally over- thickened. Where faults rise

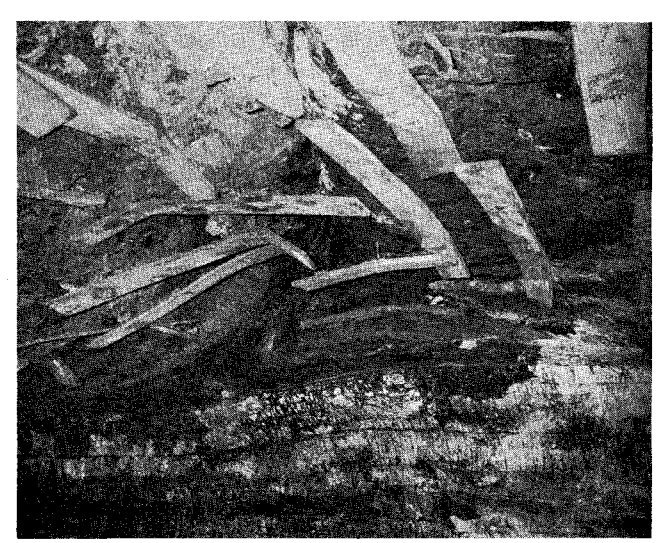
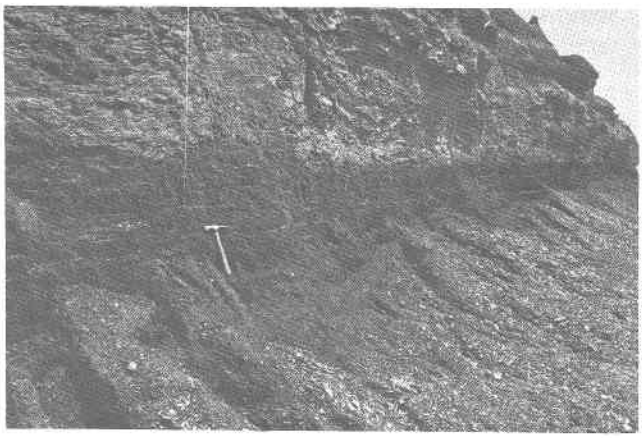


Figure 16. Folded shale roof above fault parallel to top of coal bed.



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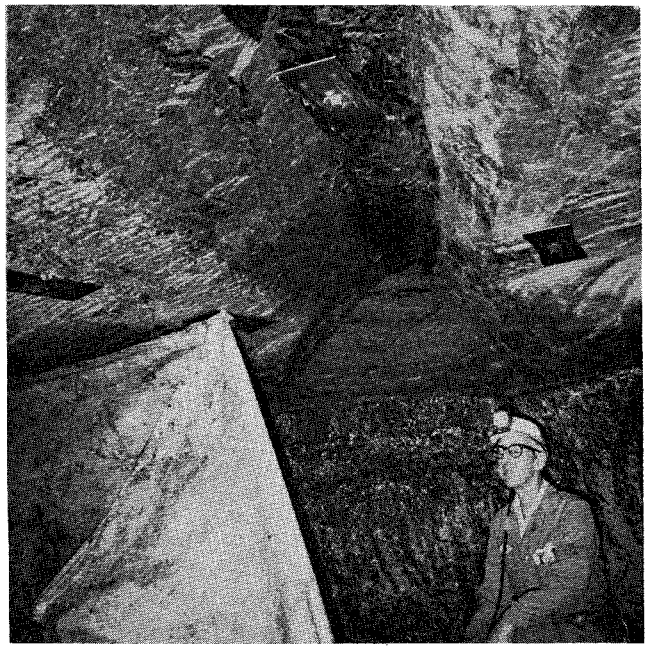


Figure 17. Powdery fault gouge (white) on fracture in mine roof. Faults and bedding intersect to form horseback.

from the coal bed into the overlying roof, bad roof conditions may exist (Figure 17).

GEOLOGIC DISCONTINUITIES IN MINE ROOF STRATA

Discontinuities in coal mine roof strata are either of structural or stratigraphic origin. Where these discontinuities are few and conventional roof bolting techniques are effective, the roof is considered to be stable (Table 2). Where the roof fails significantly, either between the bolts, by pulling bolts loose or by shearing bolts, the roof is considered as unstable. Unstable roof contains geologic discontinuities of sufficient degree to cause small rock falls, horsebacks of varying size, and major roof falls that block entries and crosscuts. These conditions commonly require support, such as posts, cross bars, and cribs, in addition to roof bolts. Fractured roof rock is a main cause of roof falls (types A, AB, AC, BCf, and BSf) (Figure 18). Stratigraphically induced weaknesses (Type B) and channel boundaries (Type Cb) are also major contributors to poor roof conditions and roof falls (Table 2, Figure 18).

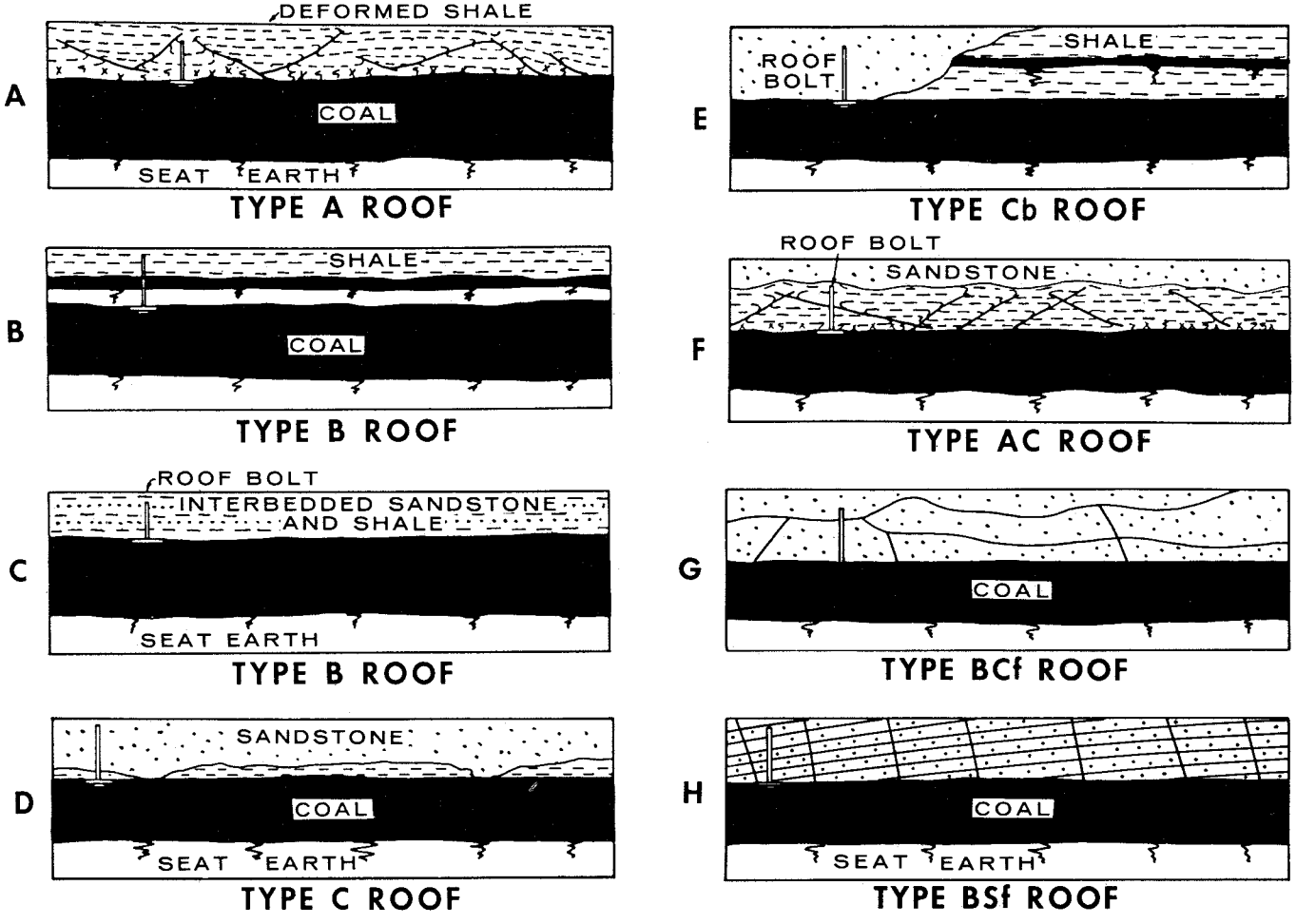
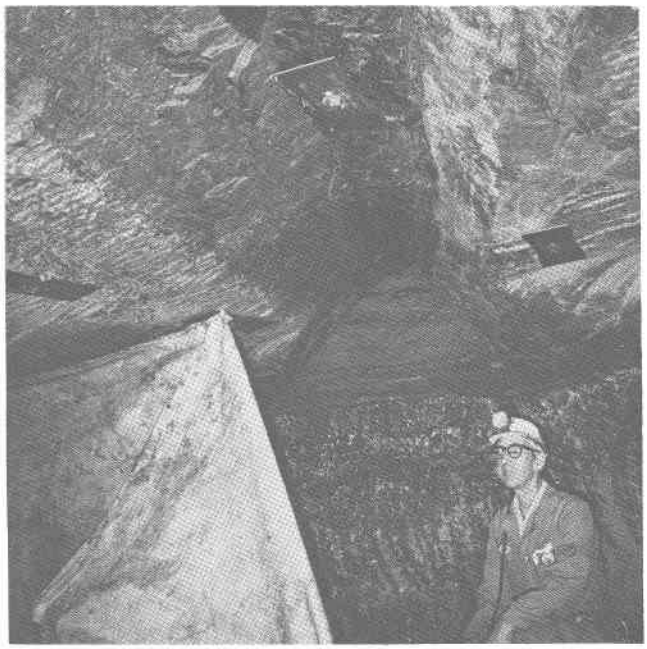


Figure 18. Generalized diagrams of roof types.



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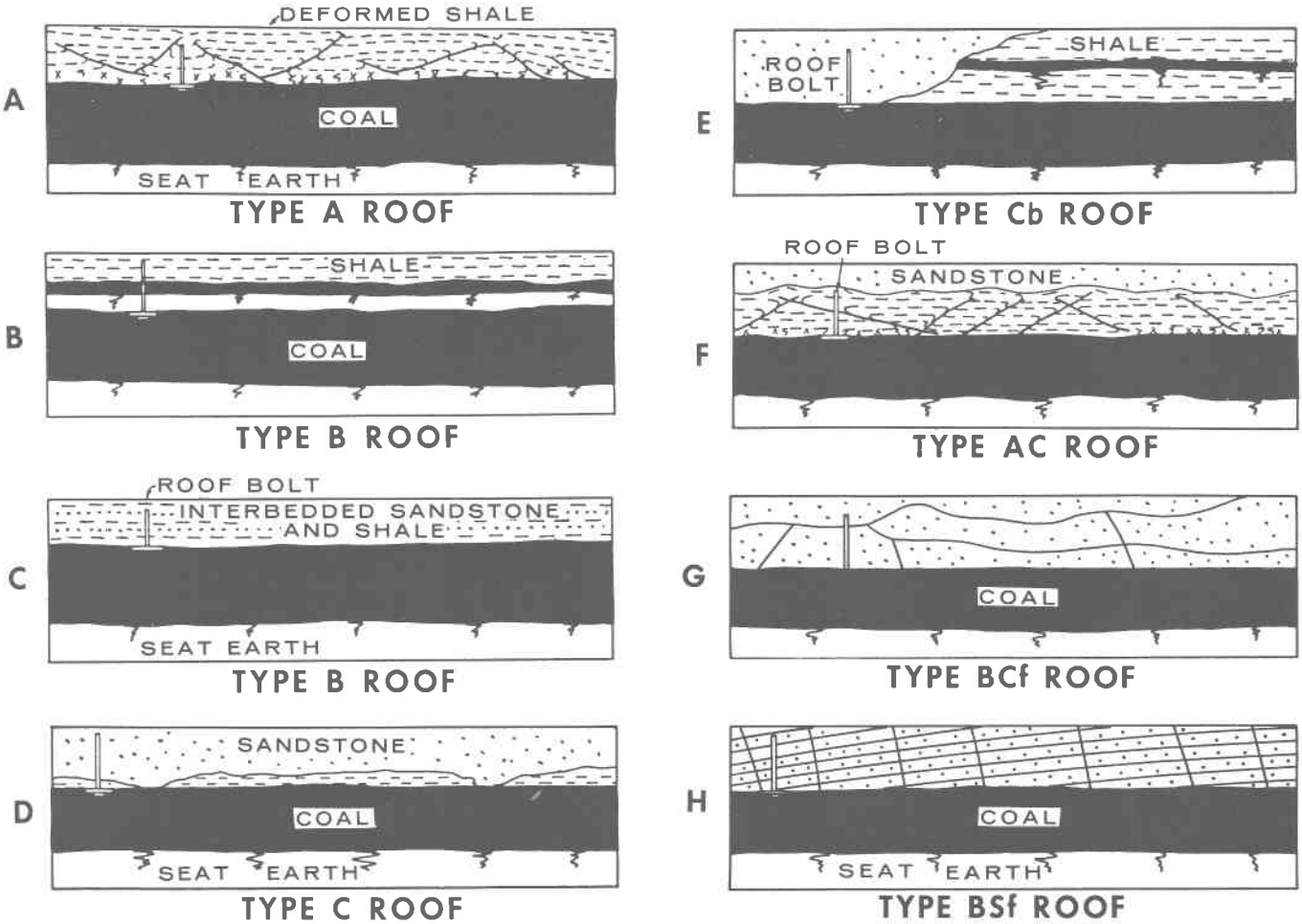


Figure 18. Generalized diagrams of roof types.

Table 2. Classification of immediate roof types in coal mines in southwestern Virginia.

Roof Type	Description
	UNSTABLE ROOF CONDITIONS
A	Roof surface uneven, slickensided and polished by faulting. Failure occurs along slickensided and polished surfaces; most common in shale and siltstone roof slate.
B	Roof is composed of rock which tends to break along subhorizontal bedding planes, cross beds, rider seams, shale and clay partings and other stratigraphic zones of weakness, excluding those related to channel sandstones. Includes soft sediment slump features.
AB	Slickensided surfaces related to faulting in shale intersect zones of stratigraphic weakness.
AC	Slickensided surfaces related to faulting in shale intersect channel bottoms or sides.
Cb	Channel boundary condition in immediate roof occurs where sandstone cuts down sharply through shale and siltstone to or near the top of a coal bed.
BCf	Channel sandstones contain numerous fractures. In places fractures intersect bedding surfaces and outline major roof falls.
BSf	Planar, rippled or cross bedded sandstones contain numerous fractures, which in places intersect bedding surfaces and outline major roof falls.
	STABLE ROOF CONDITIONS
SS	Stable sandstone roof occurs where undeformed planar bedded sandstone with few zones of stratigraphic weakness lies directly on coal.
Sh	Stable shale roof occurs where undeformed planar bedded shale or siltstone constitutes immediate roof. These may be bases of sequences which increase in grain size upward or relatively homogeneous strata which contain few zones of internal weakness.
ASh	Roof is intermediate between major roof types; it contains some polished and slickensided beds, but not to a large degree.
C	Roof consists of channel sandstone with irregular base. Channel bottoms, load casts and other protuberances extend downward into shale above coal. Differential compaction may result in numerous slickensided and polished fractures in shales and siltstones between tops of coal beds and channel bottoms.

The dominant stable roof types are composed of sandstone (Type SS) and shale (Type Sh). Mine roof types ASh and C are classified as stable, even though they contain more geologic discontinuities than types SS and Sh. These discontinuities, however, are generally capable of being supported by roof bolts without the need for additional support.

UNSTABLE MINE ROOF

Fractured Mine Roof (A, AB, AC, BCf, BSf).— The unstable Type A roof is caused by small- to moderate-scale faults in shale and siltstone at the top of coal beds (Figure 18A). Bedding surfaces and low- to high-angle fault surfaces in the roof are polished, slickensided, and may contain films of powdery fault gouge (Figure 17). Faults and bedding surfaces intersect to form obtuse angles, and may form the boundaries of roof falls. Drag folds are commonly associated with thrust faults (Figure 19). Thrust faults in the immediate roof, with displacements of a few inches to several feet, flatten downward into deformed shale or into deformed, interbedded shale and coal at the top of the coal bed (Figure 20). The deformed zone at the top of the coal bed ranges generally from a fault gouge less than one inch thick to a faulted and folded zone a foot or more thick which may exhibit complex folding and duplication of beds (Figure 21).

Roof falls associated with A roof types are bounded by the low- to moderately-dipping slickensided fractures. The falls range from small horsebacks to features which may be many tens of feet long and commonly extend upwards into the roof for a few tens of feet.

Fractured sandstones may be grouped into two broad categories, fractured channel sandstone (Type BCf roof) and fractured bedded sandstone (Type BSf). The principal difference between these two types is the bedding. Channel sandstones tend

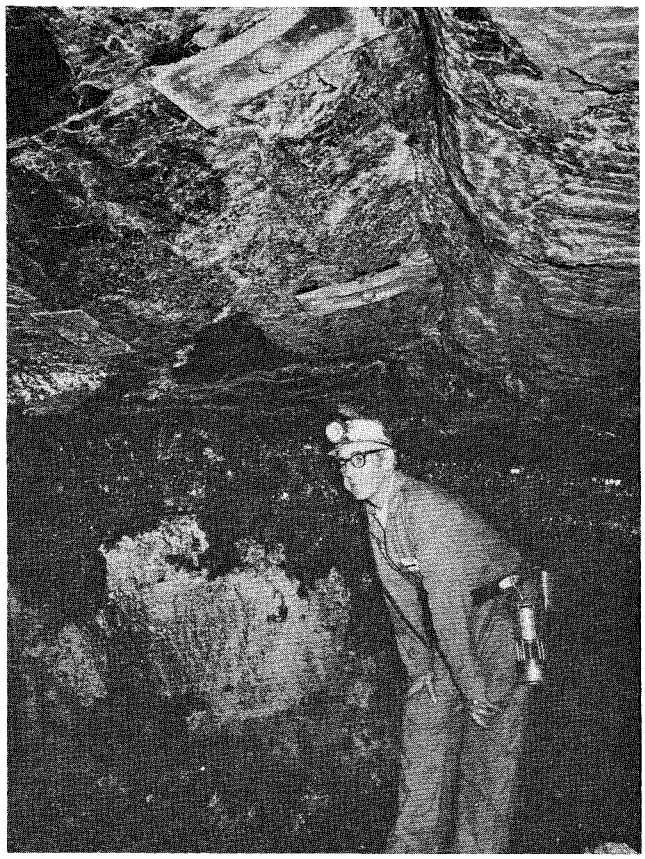


Figure 19. Small drag fold (over miner's head) in shale above coal. A fault follows the top of the coal bed.

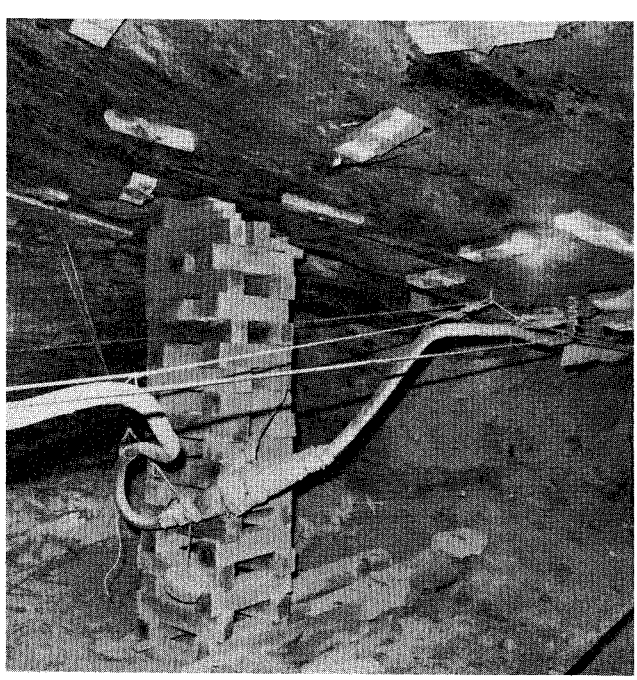


Figure 20. Fault extending from top of coal bed up into roof (right to left).

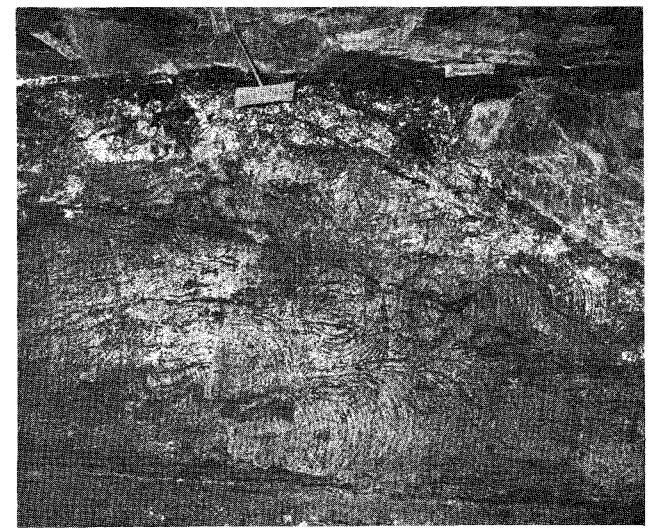
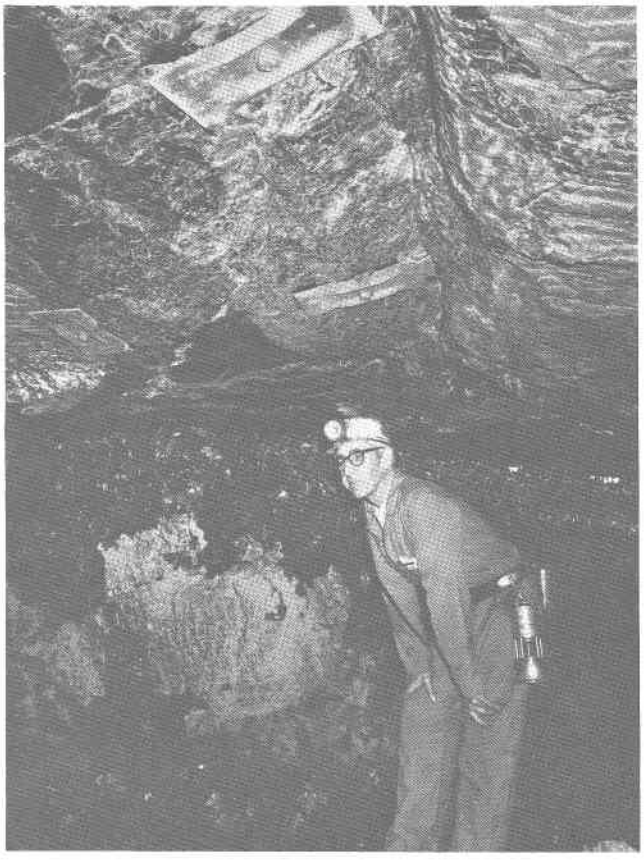


Figure 21. Coal bed overthickened by faulting.

Figure 22. Thick-bedded channel sandstone. Note irregular base. Underground, at or near the top of a coal bed, the base of the sandstone would form a Type C roof.

to be massively bedded and exhibit widely separated bedding surfaces (Figure 22). Channel sandstones may contain partings or thin interbeds of shale along bedding. In contrast, low angle planar bedded sandstones, ripple bedded sandstones and cross-bedded sandstones may exhibit numerous closely spaced bedding surfaces (Figure 23). These bedding surfaces, especially where they contain shale partings, are weak zones within the rock which may combine with fractures to produce roof falls (Figure 24).



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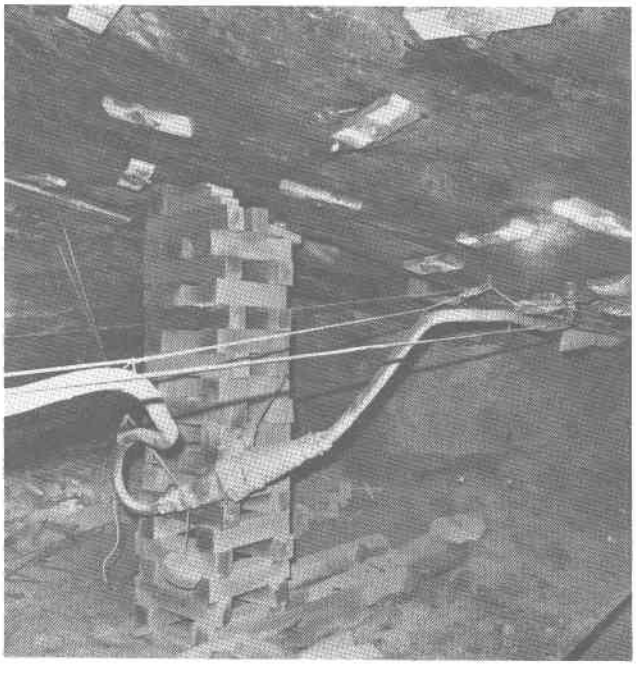

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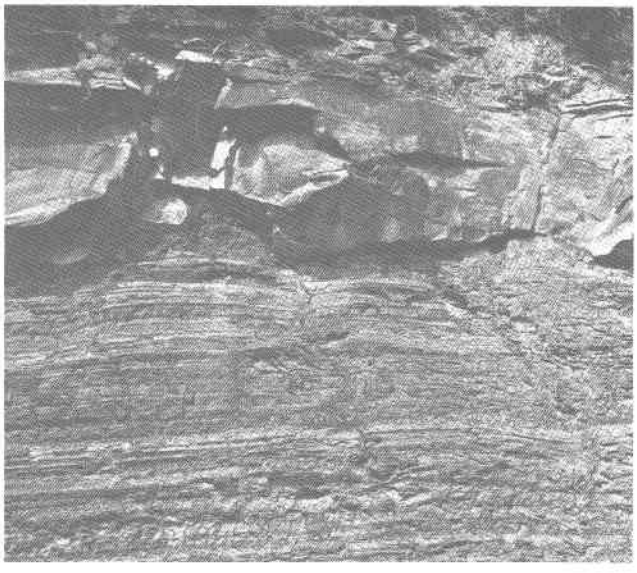

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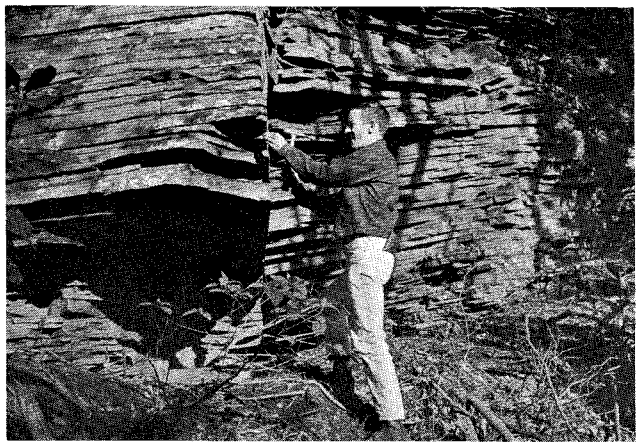


Figure 23. Thin-bedded planar or ripple bedded sandstone.

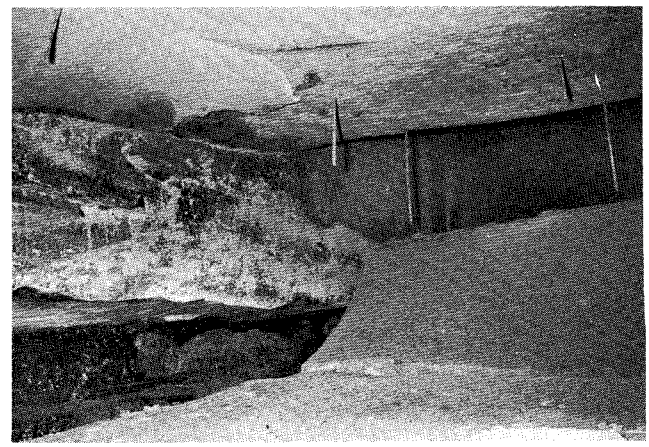


Figure 25. Roof fall in fractured channel sandstone; Type Cf roof.

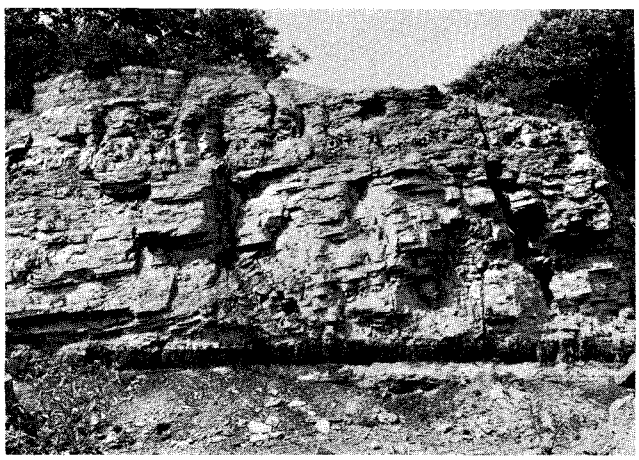


Figure 24. Underground, the steeply dipping fractures would intersect the inclined beds to produce wedge-shaped roof falls. The sandstone would produce a Type BSf roof.

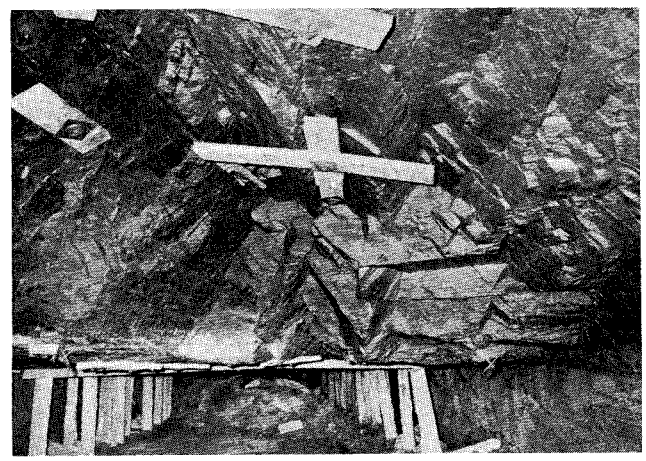


Figure 26. Steeply dipping, closely spaced fractures that are trending parallel to entry; the site of two fatalities; Type A roof.

In both channel sandstones and bedded sandstones, moderately to steeply inclined fractures may combine with bedding surfaces to produce roof falls (Figure 24). Because large blocks of sandstone are involved, roof falls in fractured channel sandstones tend to be large (Figure 25). In contrast, horsebacks and roof falls in bedded sandstones tend to be smaller, and to produce smaller fracture- and bedding-bounded pieces.

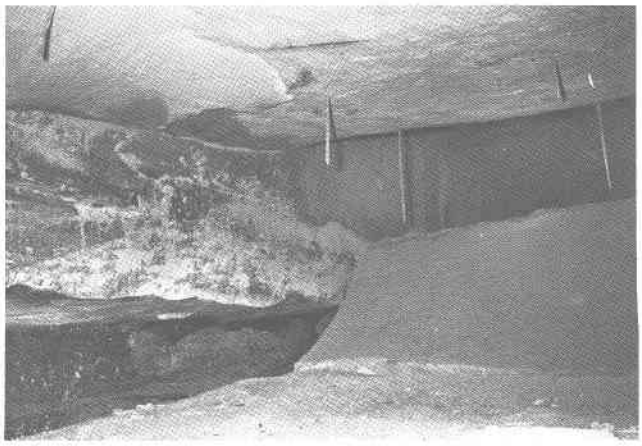
Fractures.—Fractures may be defined by their orientation and inclination, called strike and dip by geologists. The orientation of fractures with respect to the directions of mine workings is important in determining their tendency to fail. In the places where fractures trend parallel to entries and cross cuts, the roof may be more difficult to hold than in those places where fractures trend at an angle to the workings (Figure 26).

Fracture inclination, or dip, is also an important factor in determing the strength of the immediate or main roof. Roof which has fractures with high inclinations (or dips) is generally more difficult to support than a roof which contains an equal number of low-dipping fractures.

An additional factor which pertains to fractures is their intensity, or number of fractures in a given volume of rock. Obviously, a greatly fractured roof would be more difficult to support than a roof with few fractures.

In summary, fractures parallel to an entry, with steep inclinations and high intensity, would produce a most difficult roof control problem in all types of rocks.

Figure 23. Thin-bedded planar or ripple bedded sandstone.



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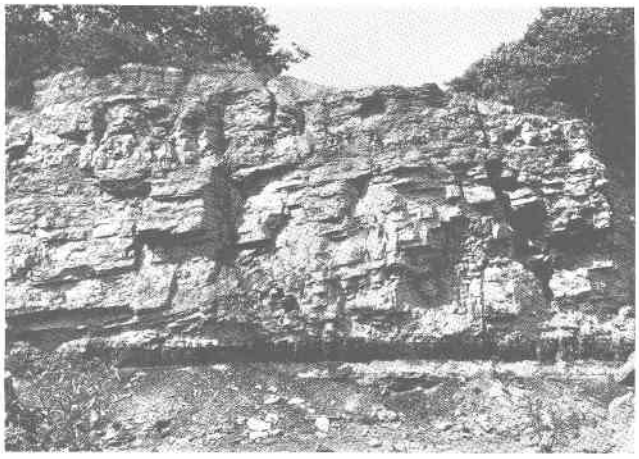

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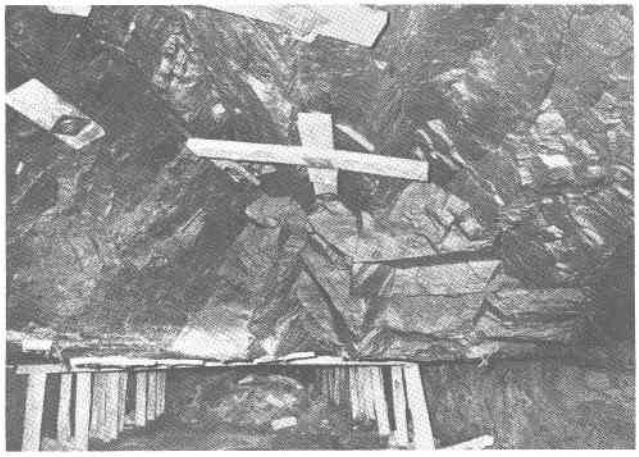

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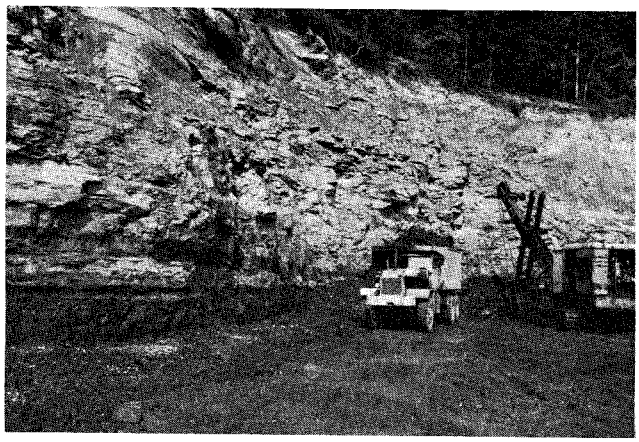

Figure 27. Strip mine, showing rider coal bed. Underground this situation would form a Type B roof.

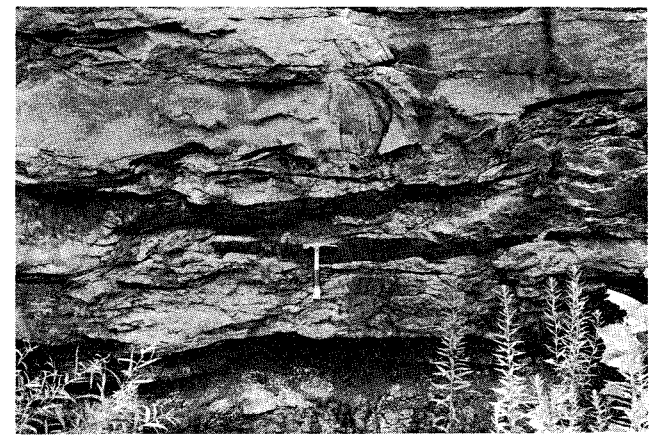

Figure 28. Channel sandstone with coal partings less than three feet above thick coal seam. An area of potential roof fall exists because of discontinuities formed by coal partings and irregular bedding in the sandstone; Type BC roof.

Stratigraphic Variations (B).—Roof classified as Type B contains zones of stratigraphic weakness, excluding the special cases associated with channel deposits, and failure is related to separation along those zones of weakness in the immediate or main roof. Examples of this type of roof would be the occurrence of slickensided seat earth and rider coal beds in the immediate roof or a few feet above the coal bed (Figure 27); planar bedded or cross bedded sandstones which contain weak partings of shale and siltstone (Figures 18C and 24); abrupt contacts between beds of sandstone and shale; and soft sediment slump deposits, which may or may not contain numerous slickensides. A roof with an abundance of plant fossils or kettle bottoms would also be classified as a Type B roof. Kettle bottoms result from such things as standing fossilized tree stumps or ironstone cobbles or boulders in the immediate roof.

Sandstone Channels (C, Cb).—Sandstone channels contribute to roof falls in two principal ways: (1) sandstone channel bottoms are commonly irregular because of scour and fill effects and the formation of load casts (Figure 22), and (2) in places they contain an abundance of fossil plant debris (Type C roof; Figure 18D) or thin irregular pieces of coal a few feet across (Figure 28). In the first case, where channel sandstones cut downward through previously deposited shale roof rock near (within a foot or two) but not into the coal bed, irregular pockets of shale are preserved between the top of the coal and the base of the channel. This shale, which generally cannot be adequately suspended from the base of a sandstone channel-fill by roof bolts, tends to separate and fall in small- to moderate-sized pieces.

Channel boundary areas, where there is a moderately inclined contact between sandstone and shale, are also sites for significant roof control problems (Type Cb roof, Figure 18E). Commonly the sandstone remains unbroken in the roof, whereas the adjacent shale separates and breaks apart in sizeable roof falls (Figure 29).

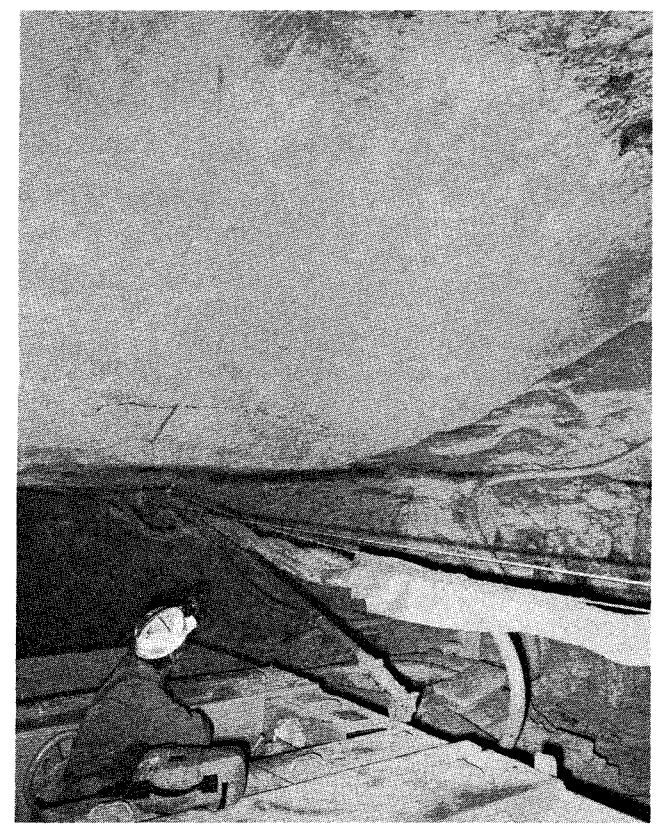

Figure 29. Channel boundary. This type of geologic condition is the cause of major roof falls; Type Cb roof.

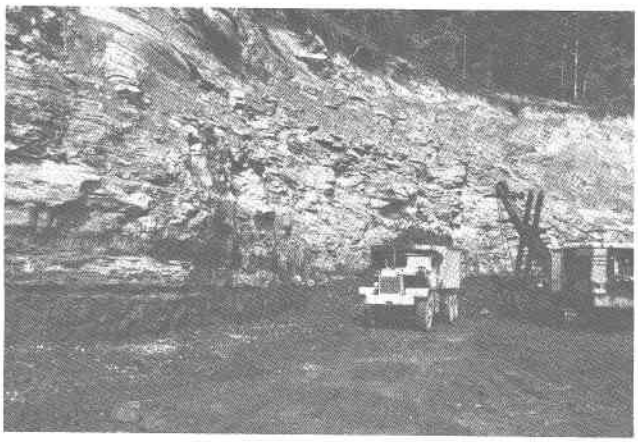

Figure 27. Strip mine, showing rider coal bed. Underground this situation would form a Type B roof.

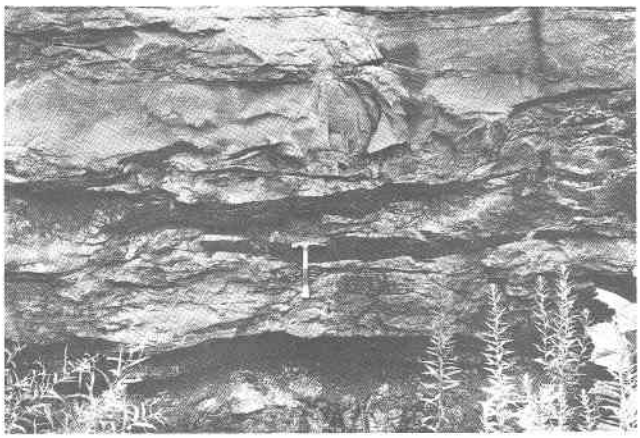

Figure 28. Channel sandstone with coal partings less than three feet above thick coal seam. An area of potential roof fall exists because of discontinuities formed by coal partings and irregular bedding in the sandstone; Type BC roof.

Stratigraphic Variations (B).—Roof classified as Type B contains zones of stratigraphic weakness, excluding the special cases associated with channel deposits, and failure is related to separation along those zones of weakness in the immediate or main roof. Examples of this type of roof would be the occurrence of slickensided seat earth and rider coal beds in the immediate roof or a few feet above the coal bed (Figure 27); planar bedded or cross bedded sandstones which contain weak partings of shale and siltstone (Figures 18C and 24); abrupt contacts between beds of sandstone and shale; and soft sediment slump deposits, which may or may not contain numerous slickensides. A roof with an abundance of plant fossils or kettle bottoms would also be classified as a Type B roof. Kettle bottoms result from such things as standing fossilized tree stumps or ironstone cobbles or boulders in the immediate roof.

Sandstone Channels (C, Cb).—Sandstone channels contribute to roof falls in two principal ways: (1) sandstone channel bottoms are commonly irregular because of scour and fill effects and the formation of load casts (Figure 22), and (2) in places they contain an abundance of fossil plant debris (Type C roof; Figure 18D) or thin irregular pieces of coal a few feet across (Figure 28). In the first case, where channel sandstones cut downward through previously deposited shale roof rock near (within a foot or two) but not into the coal bed, irregular pockets of shale are preserved between the top of the coal and the base of the channel. This shale, which generally cannot be adequately suspended from the base of a sandstone channel-fill by roof bolts, tends to separate and fall in small- to moderate-sized pieces.

Channel boundary areas, where there is a moderately inclined contact between sandstone and shale, are also sites for significant roof control problems (Type Cb roof, Figure 18E). Commonly the sandstone remains unbroken in the roof, whereas the adjacent shale separates and breaks apart in sizeable roof falls (Figure 29).

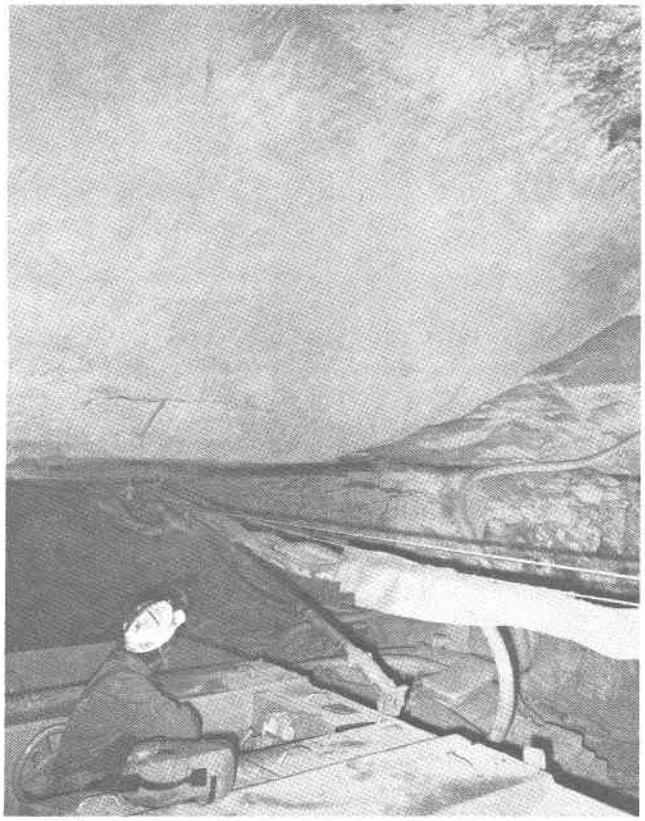

Figure 29. Channel boundary. This type of geologic condition is the cause of major roof falls; Type Cb roof.

In places Type A shale or siltstone roof may intersect sandstone channels where they cut downward near the immediate roof, thereby forming an intermediate Type AC roof (Figure 18F). In this situation, channels increase the structural weakness of the roof because they combine the deleterious effects of irregular channel bases or lateral channel boundaries with those of extensively broken and slickensided shales.

STABLE MINE ROOF

Stable sandstone, siltstone, and shale roof rocks (Types SS, Sh) contain few structural and stratigraphic zones of weakness, so that they may be readily supported by roof bolts (Figure 30). All gradations exist between stable and unstable roof types. For example, in some places a stable shale or siltstone roof may change gradually along an entry into a Type A roof. The change occurs first with observable polishing on flat bedding surfaces in the immediate roof, and then with regular increasing deformation the immediate roof rock is folded and cut by numerous polished and slickensided fractures. The roof thus grades from a Type Sh into ASh and then into a Type A roof along the entry.

Figure 30. Stable shale roof.

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Figure 30. Stable shale roof.

GLOSSARY

BEDDING — Surfaces dividing sedimentary rocks of the same or different lithology.
CHANNEL — The area contained by a stream or river. Ancient channel fill deposits in the coal measures are commonly lenticular sandstone bodies.
CLEAT — A joint or break in the coal which tends to be perpendicular to bedding. (See also: FACE CLEAT AND BUTT CLEAT)
CROSS BED — Secondary bedding which is inclined at some angle to the main bedding surfaces within a single strata of rock.
DIP — The acute angle that a surface (bedding fracture, etc.) makes with the horizontal.
BUTT CLEAT — A fracture which terminates against the face cleat.
FACE CLEAT — The dominant fracture in a coal seam.
FAULT — A fracture or zone of fractures along which movement has occurred.
FAULT GOUGE — Soft claylike material found along some faults.
FIRECLAY — (See SEAT EARTH), but generally restricted to seat earths with good firing properties.
FRACTURE — A general term for any break in a rock.
GOUGE — (SEE FAULT GOUGE)
HORSEBACK — A linear or circular indentation a few feet across in the roof of an underground coal mine.
IRONSTONE — An iron-rich sedimentary rock; commonly found in the coal field as irregular or disk-shaped nodules within shale or sandstone.
JOINT — A fracture in a rock.
KETTLE BOTTOM — A cast of a vertical fossil root or tree trunk or large ironstone concretion exposed in the roof of an underground mine.
LOAD CASTS — An irregular bulge on the underside of sandstones; commonly formed by rapid deposition of sand on soft mud.
PARTING — A separation or accumulation along bedding within a coal of mud, silt, or sand; usually thin, but when thick often called a middleman.
RIDER COAL BED — A thin coal bed located just above or near the top of a mined coal.
SEAT EARTH — Claystone or siltstone underlying a coal seam, usually containing fossilized roots.
SLICKENSIDE — A polished and smoothly striated surface that results from frictional sliding along a fault surface.
STRATA — Layers of a particular rock type.
STRIKE — The direction or trend of a surface (bedding, fracture, or fault plant). Measured as a horizontal line along the surface.
UNDERCLAY — (See SEAT EARTH)