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Kettlebottoms: Their Relation to Mine Roof and Support

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UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

ILLUSTRATIONS

KETTLEBOTTOMS: THEIR RELATION TO MINE ROOF AND SUPPORT

By Frank E. Chase[1] and Gary P. Sames[1]

ABSTRACT

Kettlebottoms are columnar masses of rock--the preserved casts of ancient tree stumps--embedded in coal mine roof strata (of which they are a part). Because unsupported kettlebottoms can detach from a mine roof without warning, they are a hazard to miners.

The primary objectives of this investigation were (1) to better define and describe kettlebottoms and (2) to evaluate kettlebottom support techniques in terms of safety and effectiveness. A telephone survey of mine operators, interviews with Mine Safety and Health Administration (MSHA) personnel, and underground mine visits were conducted in Pennsylvania, West Virginia, and Kentucky.

Information gathered during this investigation indicates that the size and frequency of kettlebottoms in mine roof are dependent upon past geologic events and biological processes active during the deposition of roof sediments. To ensure the safety of mine personnel, all undermined kettlebottoms should be supported. The roof should be bolted next to kettlebottoms less than 3 ft in diameter, close enough to allow a portion of a wood or steel header to be extended beneath each kettlebottom for support. Two bolts and a wood plank or steel strap should be employed to support kettlebottoms over 3 ft in diameter.

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INTRODUCTION

The Bureau of Mines investigates geologic structures involved in accidental roof falls to provide the mining industry with descriptive information necessary to recognize and safely support these hazardous structures. Support recommendations are based on the physical characteristics of a structure and the structure's effect on mine roof stability. Where possible, unstable conditions associated with geologic structures are projected into adjacent unmined portions of the coalbed.

"Kettlebottom(s)"[2] is the term most commonly used by miners to describe the fossil casts of ancient trees that are found above today's coalbeds. Kettlebottoms occur throughout the Appalachian coal regions, but are most abundant in the Pottsville Age deposits of southern West Virginia and eastern Kentucky. Kettlebottoms tend to be small local features of erratic occurrence, but have been observed in clusters or pockets above coalbeds in the Pottsville formations.

The erratic nature of kettlebottom occurrences makes them difficult to predict in advance of mining. Furthermore, because kettlebottoms are relatively small and are an integral part of the roof sediments, they are not detectable by core drilling. Therefore, in order to safely and effectively deal with kettlebottoms, the miner at the working face must be able to recognize them in the mine roof and understand the potential hazards they present. This is probably most true in coal seams where conditions during coal formation were not optimum for the preservation of tree stumps, but where rare, sporadic kettlebottoms do occur. Any presence of kettlebottoms in mine roof should alert miners to the liklihood that others will occur in the same area.

GEOLOGIC HISTORY OF KETTLEBOTTOMS

ORIGINS

The trees from which kettlebottoms originated grew in ancient peat swamps which have since undergone geologic transformation to become present-day coalbeds. A typical kettlebottom located above a coalbed is depicted in figure 1.

The casts of Calamites, Lepidodendron, and Sigillaria trees (fig. 2) are the ones most commonly recognized and found preserved in mine roof. These trees constituted a major element of the Carboniferous swamp-forests and contributed significantly to the formation of coals. Forming the largest plants of the period, most were like present-day trees in size and habit, attaining heights of 75 to 110 ft (1-2, 10).[3]

Calamites grew in the shallow, sometimes brackish water of ancient lower delta plains. This tree grew with its roots and part of its trunk in the water, like mangrove trees in present-day swamps. Calamites ranged from 10 to 30 ft high and from 2 to 3 ft in diameter at the base. The root systems of

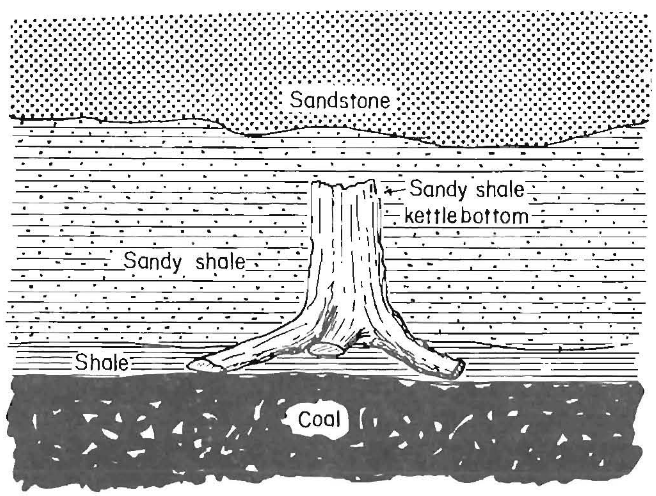

FIGURE 1. - Typical kettlebottom above a coalbed.

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[2]Also known as bells, coal pipes, pots, caldron bottoms, tortoises, and camelbacks.

[3]Underlined numbers in parentheses refer to items in the bibliography at the end of this report.

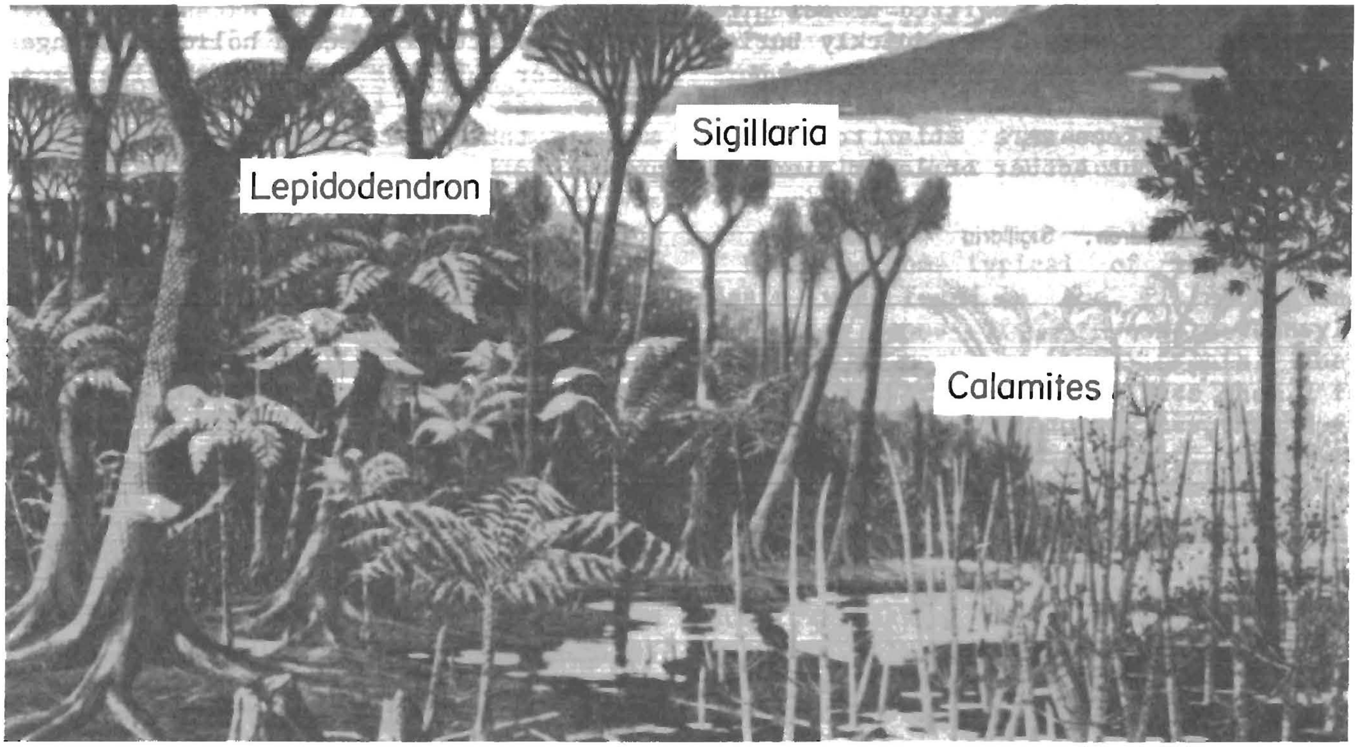

FIGURE 2. - Lepidodendron, Sigillaria, and Calamites in a coal-age swamp-forest. (From Kukuk (5); used by permission.)

Calamites and other smaller plants trapped sediments and eventually built up a soil on which the larger, less saline-tolerant Lycopods (Lepidodendron and Sigillaria) could grow. Once established, Calamites, Lepidodendron, and Sigillaria spread rapidly and formed vast forests on the upper delta plain (6, 8). Lepidodendron were often more than 100 ft tall and had slender trunks that tapered gradually from a diameter of more than 2 ft at the base. The form of Sigillaria often varied considerably. Some had short, squat trunks (20 ft high and 8 ft in diameter at the base), while others were tall and slender, similar to Lepidodendron (8).

The roots of Lepidodendron and Sigillaria, called Stigmaria, usually spread over a large area. Because Stigmaria grew relatively near the swamp surface, they avoided the oxygen-poor deeper layers of the peat. They were able to provide adequate support and anchorage for the large trees and hold their trunks above the swamp water (9).

PRESERVATION

Calamites, Lepidodendron, Sigillaria, and other plants in the ancient coal swamps were continually growing, reaching maturity, and dying. Dead trees and other plants extending above stagnant swamp waters were subject to decay by microscopic organisms (bacteria and fungi). Most of the Carboniferous trees had pulpy interiors that were readily hollowed out by decay, leaving a shell of the more resistant outer wood and bark layers. Often, these erect, hollowed-out trees and stumps were later infilled and preserved by an influx of sediment-laden waters. This was accomplished either by steady, widespread submersion of the peat swamp (8) or by localized flooding of sediment-laden stream channels in the back swamp (4-5).

In areas where the peat bed was gradually being submerged, silt and mud slowly smothered smaller plants and trees, infilled stumps, and surrounded larger trees. In areas of localized flooding, a rapid influx of sediments quickly buried small plants, stumps, and the lower portions of trees. In both cases, the larger, sturdier trees were able to survive for a while, but sooner or later died and began to rot. Trunks extending above water eventually became hollow. Changes in water currents or progressive decay broke off the trunks, leaving buried stumps that were quickly infilled and preserved (fig. 3).

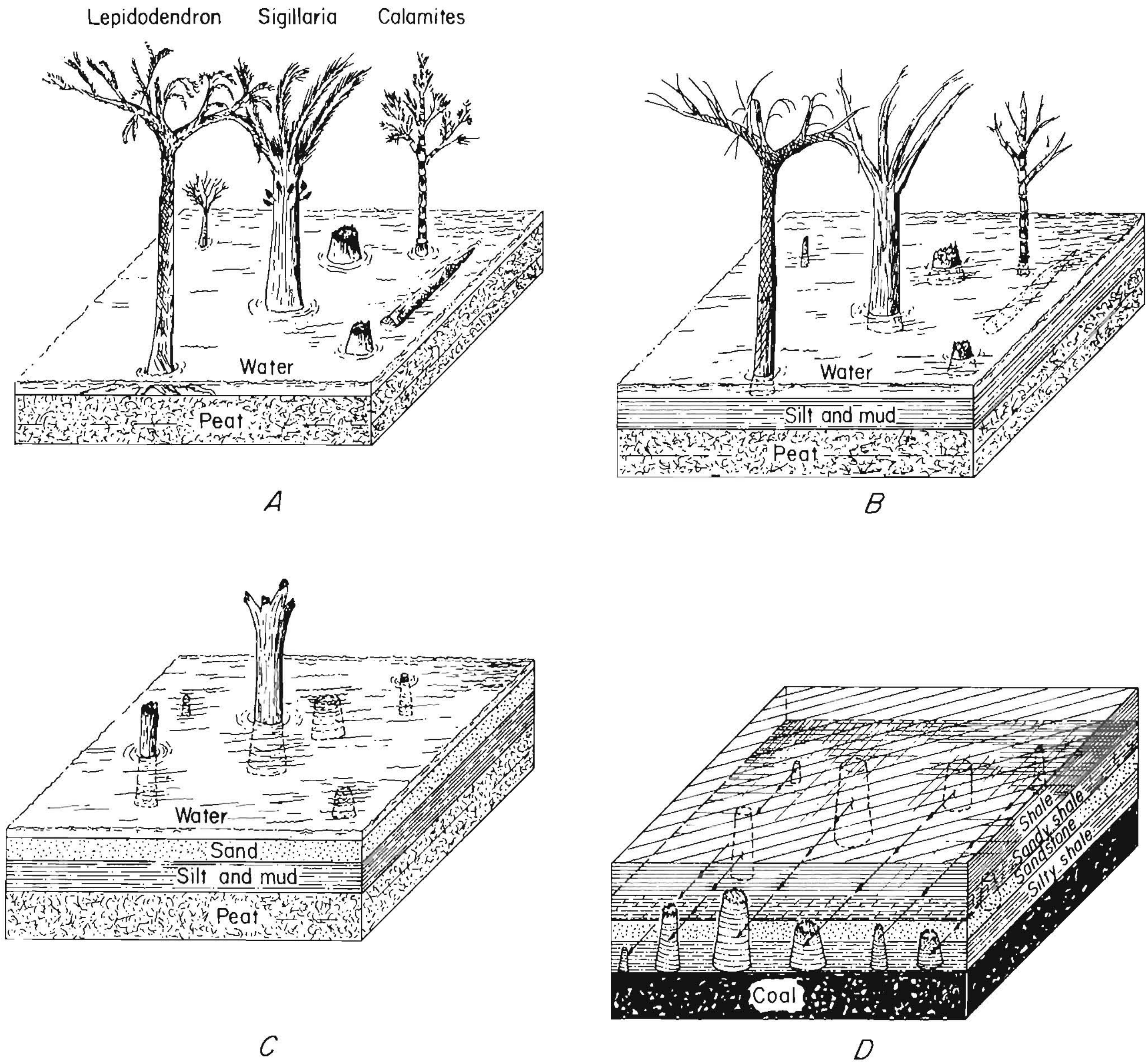

FIGURE 3. - A generalized model for kettlebottom formation. *A*, Lepidodendron, Sigillaria, and Calamites growing in normal swamp-forest. *B*, Sedimentation overcomes peat formation, choking and killing trees and swamp. *C*, Dead trees become hollow through decay and eventually break off to water level. *D*, Continued sedimentation infills stumps, and lithification forms coal, roof rock, and kettlebottoms.

KETTLEBOTTOMS IN MINE ROOF

OCCURRENCES

Kettlebottoms occur in coal mines in the United States, Great Britain, Poland, and elsewhere (1, 8, 10). This study was limited to the eastern United States and was primarily conducted in the Dunkard and Pocahontas coal basins (fig. 4). The investigation included a literature search, a telephone survey of mine operators with mines in various seams, interviews with MSHA personnel, and underground visits to observe and photograph kettlebottoms in mine roof. Operators were surveyed in regard to their experiences with kettlebottoms, and MSHA personnel were interviewed to discuss kettlebottom support techniques. Within the Dunkard and Pocahontas Basins, many mines operating in seams of different ages reported kettlebottoms of varying size and frequency. The largest and most frequent occurrences were reported and observed in the Pottsville Age deposits of southern West Virginia and eastern Kentucky.

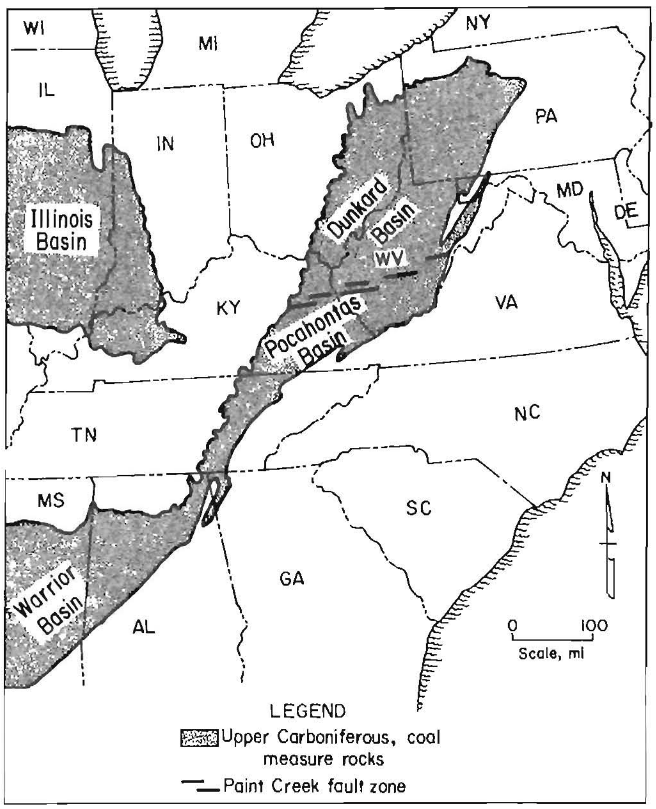

FIGURE 4. - Map of general study area in the Dunkard and Pocahontas coal basins.

Kettlebottoms typical of the Dunkard Basin were found in the Pittsburgh and Sewickley Seams of southwestern Pennsylvania and northern West Virginia. They were usually rare, small (less than 2 ft in diameter), and extended less than 2 ft into the roof. In contrast, seams in the Pocahontas Basin, like the Harlan of southeastern Kentucky and the Campbell Creek (No. 2 Gas) of southern West Virginia, have gained notoriety because of numerous, large kettlebottoms (3 to 8 ft in diameter) that extend 4 to 8 ft into the roof. Similar variability in kettlebottom size and frequency was also observed within the same seam at different geographic locations.

PHYSICAL CHARACTERISTICS

Kettlebottoms are easily recognized in the roof of underground workings by their characteristic circular outline (fig. 5). The diameter, height, and composition of casts vary widely. These characteristics are the result of past geologic events (flooding, subsidence, and changes in sea level) and biological factors and processes active during the deposition of the roof sediments (type of vegetation, position on delta, and rate of decomposition).

Kettlebottoms observed underground ranged from 6 in to 6 ft in diameter, but averaged 2-1/2 ft. Rare occurrences of kettlebottoms 8 ft in diameter and larger were reported by both (MSHA) and mining personnel but were not observed directly by the authors.

The height kettlebottoms extend into the roof is also variable, but appears to be consistent in any one area of a mine.

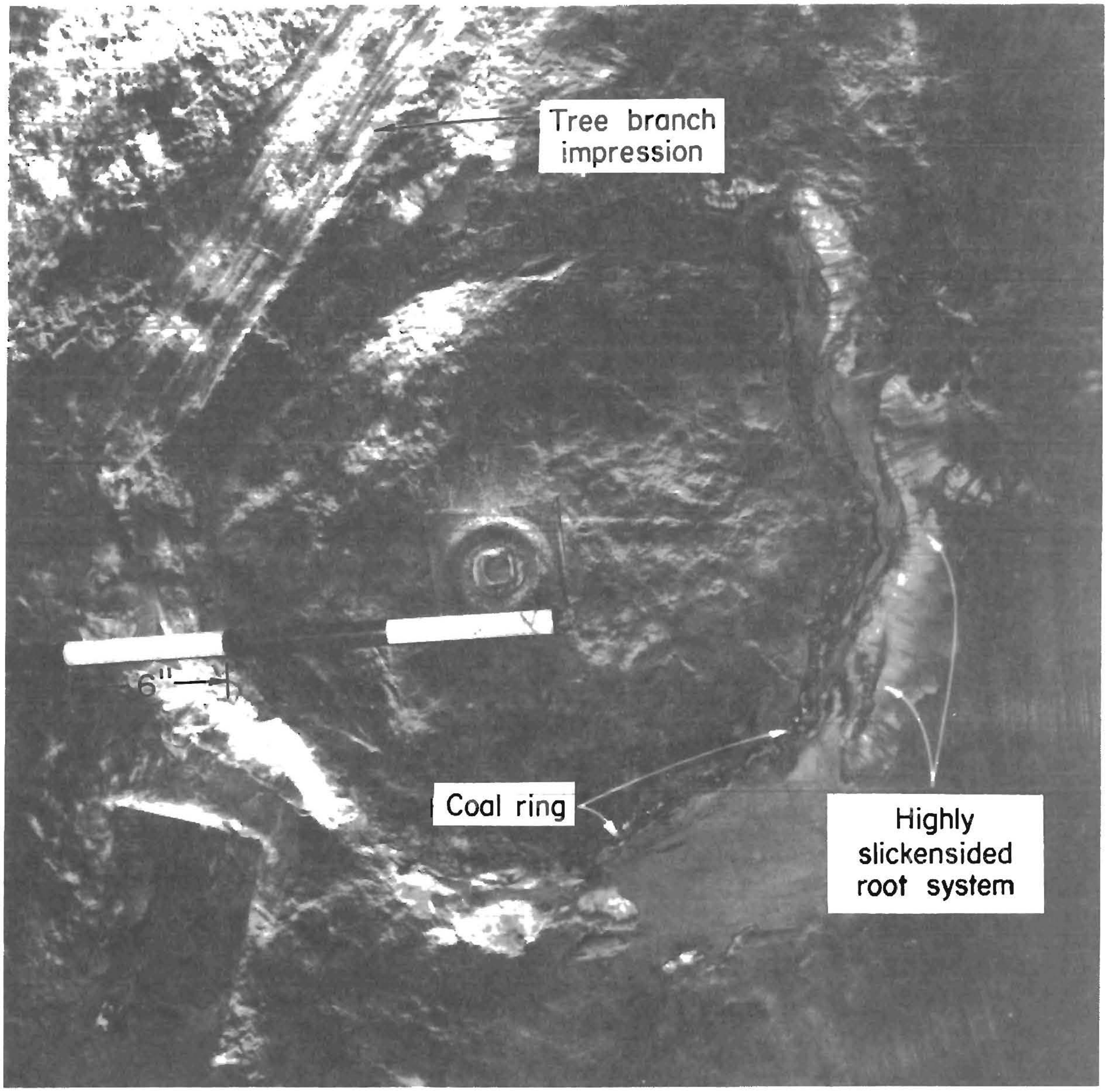

FIGURE 5. - Typical kettlebottom in mine roof showing characteristic circular outline and other common features.

Casts extending 8 ft into the roof were noted in southern West Virginia; however, casts extending as high as 15 ft have been documented in outcrop (6).

In many instances the composition of the cast was identical to adjacent roof strata. In other cases, the composition of the cast differed in both lithology and character from that of the surrounding roof rock. Sediments that make up the cast can be more or less coarse, dense, and/or fossiliferous than those immediately adjacent (figs. 6 and 7). Compositional similarities or differences were probably controlled by the height above water that the tree stumps extended at the time of infilling. This is evidenced by the fact that sediments found on top of the coal within a kettlebottom will often correspond to those deposited several feet above that same horizon elsewhere (fig. 3).

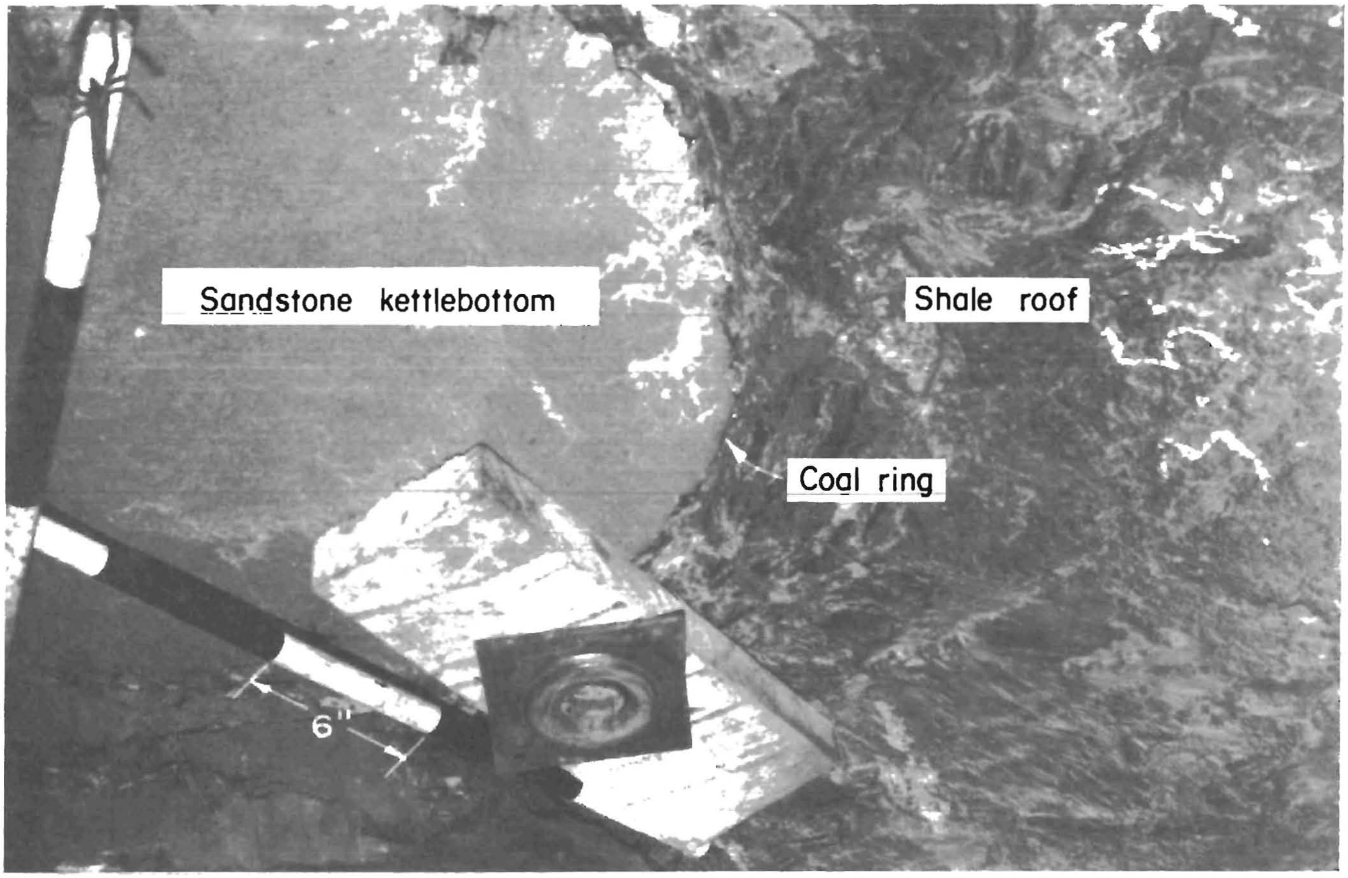

FIGURE 6. - Sandstone kettlebottom in shale roof.

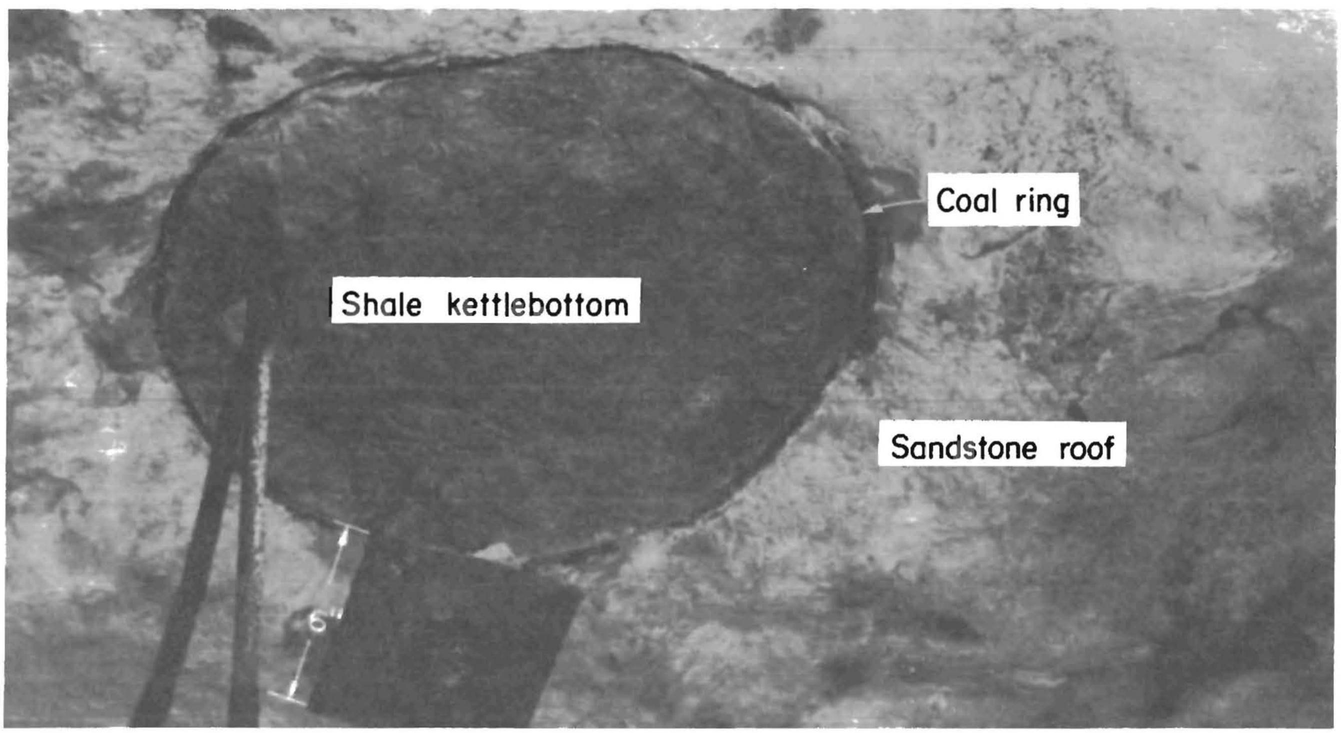

FIGURE 7. - Shale kettlebottom in sandstone roof.

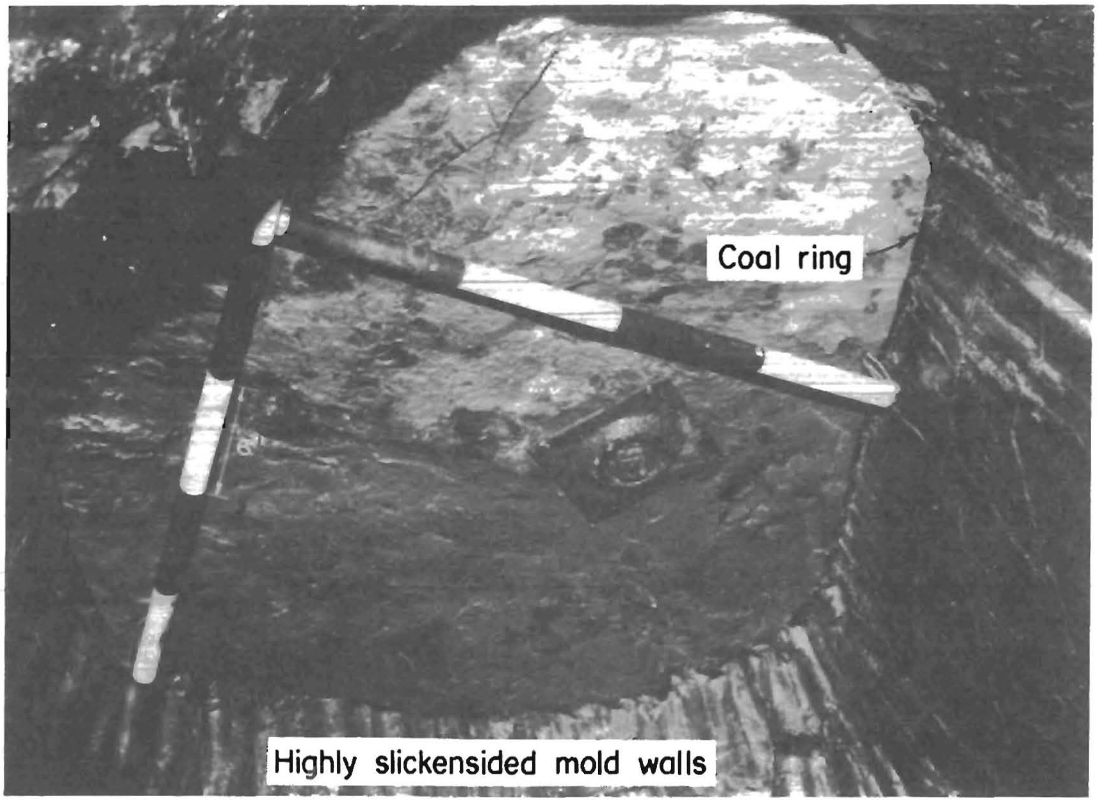

FIGURE 8. - Kettlebottom mold illustrating slickensided surface.

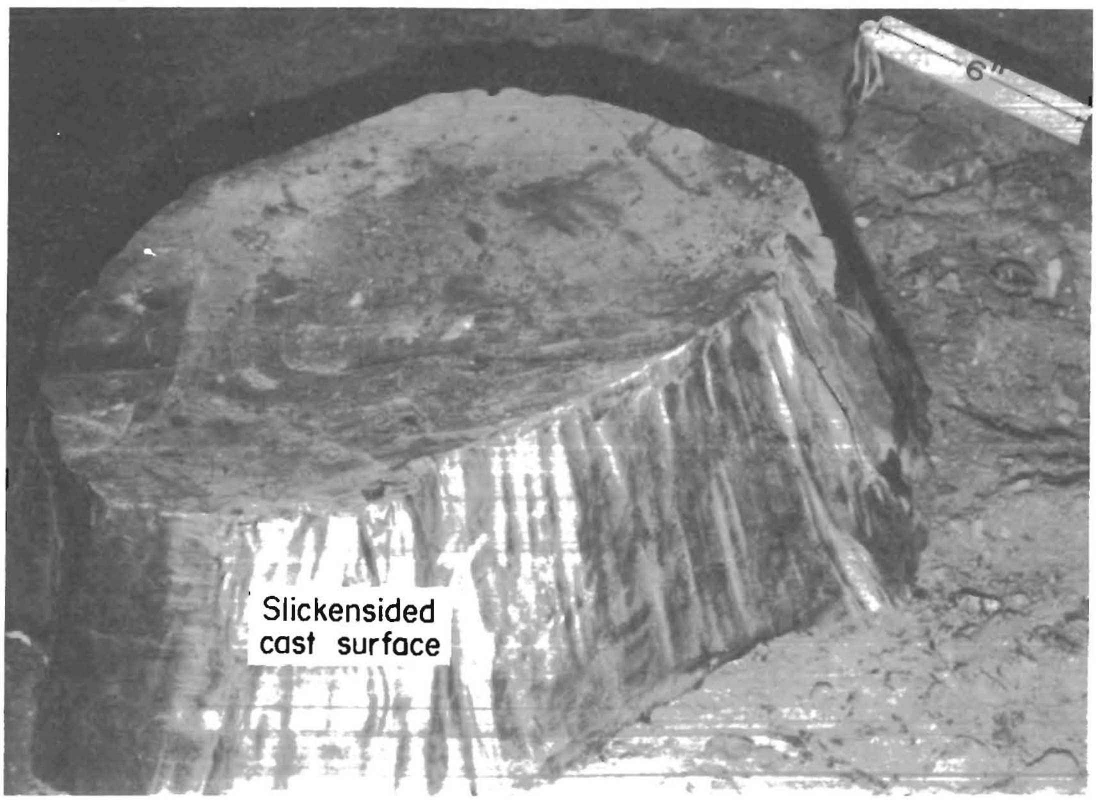

FIGURE 9. Kettlebottom cast illustrating slickensided surface.

Kettlebottom mold and cast surfaces are highly slickensided (figs. 8 and 9). A characteristic layer of coalified bark remnants, a coal ring, which varies from a film to 3/4 in thick, usually separates the kettlebottom mold from its cast. Cohesion between the mold and cast is weak; after mining, only the tensile strength along bedding planes prevents kettlebottoms from detaching.

Detachment of a kettlebottom from a mine roof is illustrated in figure 10. The structural characteristics depicted in this illustration determine if, when, and how a kettlebottom will fail in tension. When the bedding bonds are strong and the coal ring is sketchy or absent, the kettlebottom is unlikely to detach. This situation is evidenced in Stone, KY, where in 40-year-old mine workings, not one of the numerous sandstone kettlebottoms present has detached (from a massive sandstone roof). The other extreme can be witnessed in several mines located in southern West Virginia and southeastern Kentucky, where kettlebottoms detach suddenly, without warning, during or after mining (fig. 11).

When the cast material is homogeneous and well cemented, the cast will detach as a single plug (fig. 9); this is how kettlebottoms most commonly detach. Poorly cemented casts tend to detach in platy slabs (fig. 12). Some kettlebottoms were found to be more resistant to weathering by humid mine air than adjacent roof strata (fig. 13).

SUPPORT

For safety reasons, all kettlebottoms not dislodged after initial mining should be supported. Common support techniques observed underground are illustrated in figure 14. Methods *A* and *B* are frequently employed; however, unless temporary support is provided, these methods subject the bolter to risk because the vibration during drilling is sometimes sufficient to dislodge the kettlebottom. In addition, bolting method *A* relies on the premise that the cast is shorter than the bolt, which is not necessarily true.

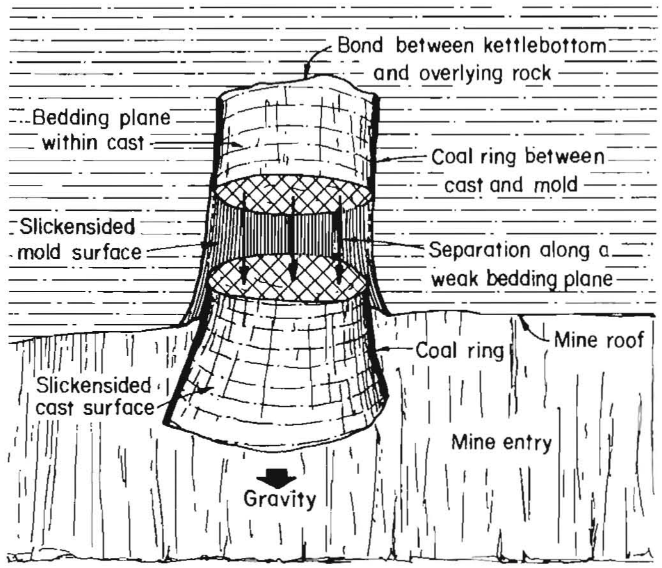

FIGURE 10. - Kettlebottom detaching along a weak bedding plane.

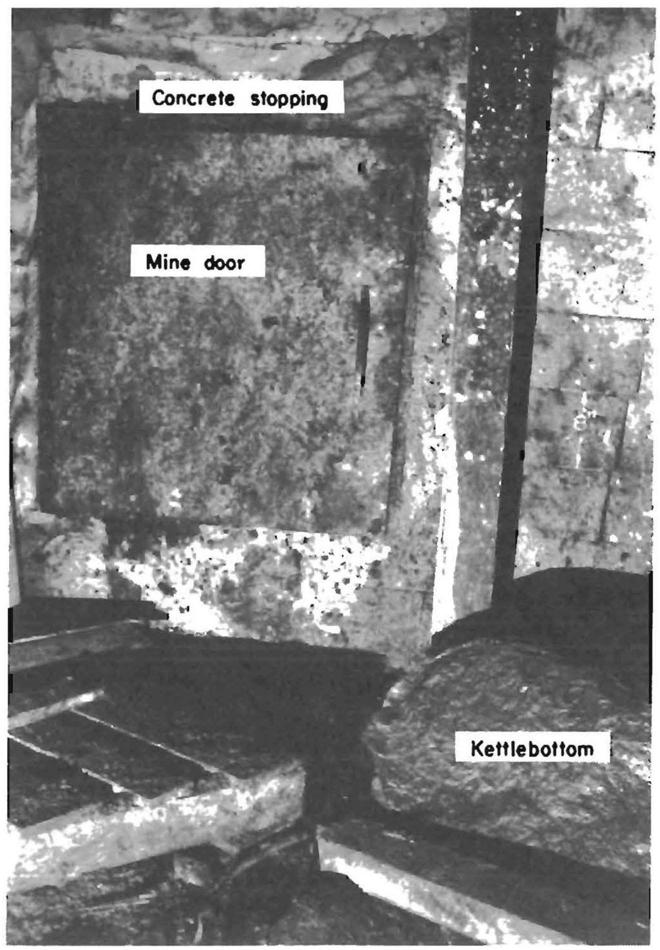

FIGURE 11. - Unsupported kettlebottom after detachment in a heavily traveled area.

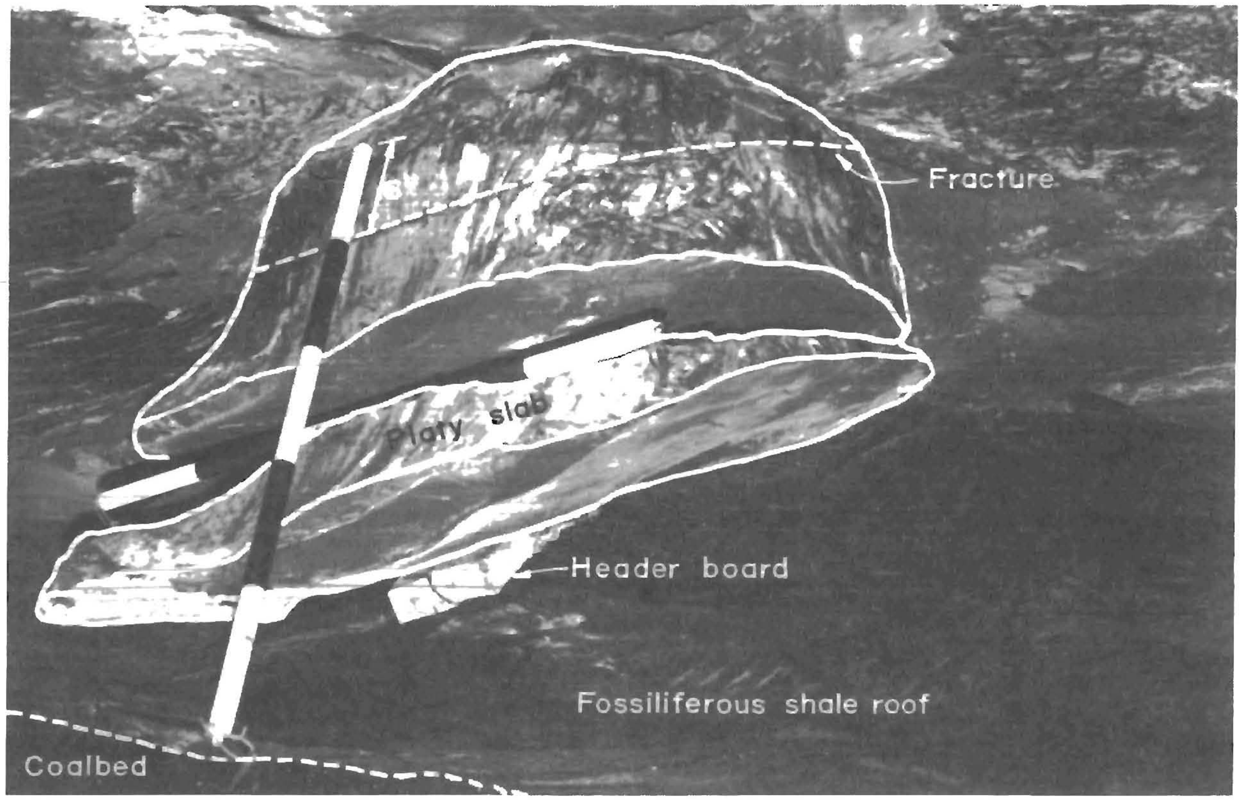

FIGURE 12. - Kettlebottom detaching in platy slabs.

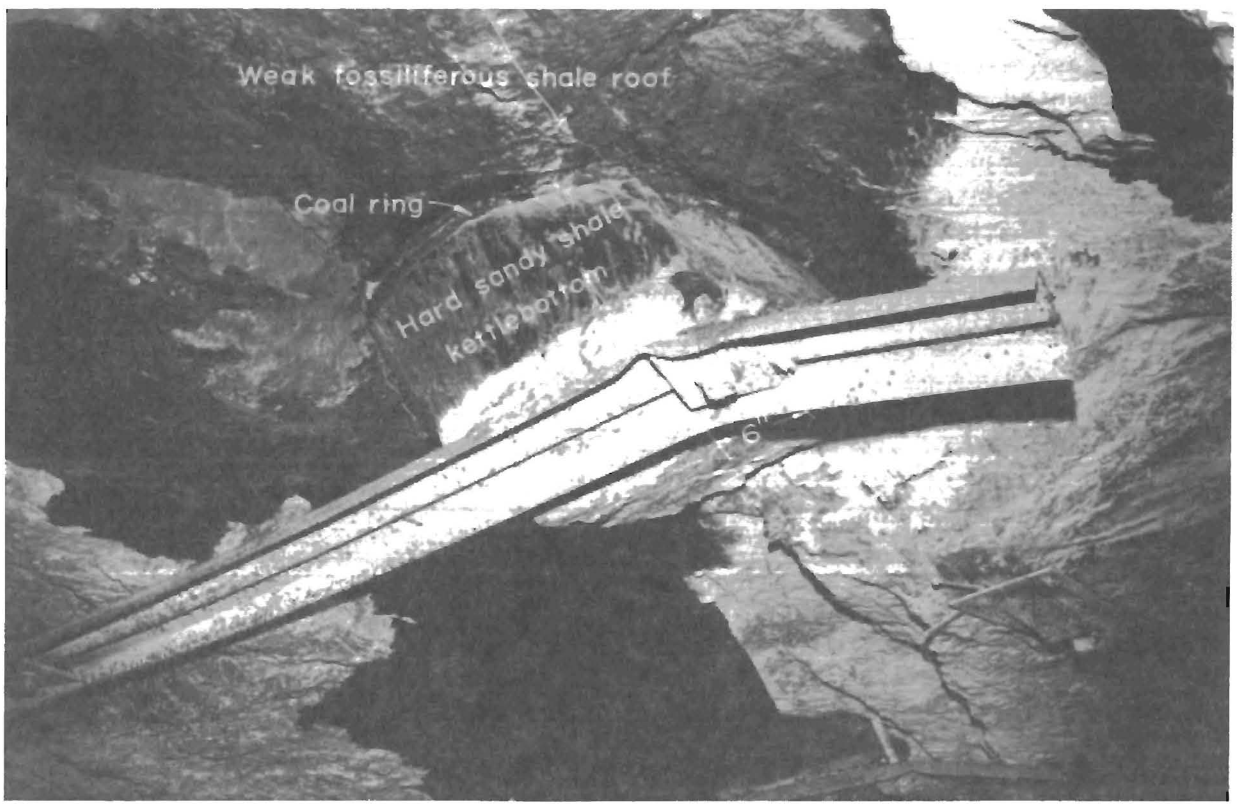

FIGURE 13. - A kettlebottom more resistant to weathering than the surrounding mine roof.

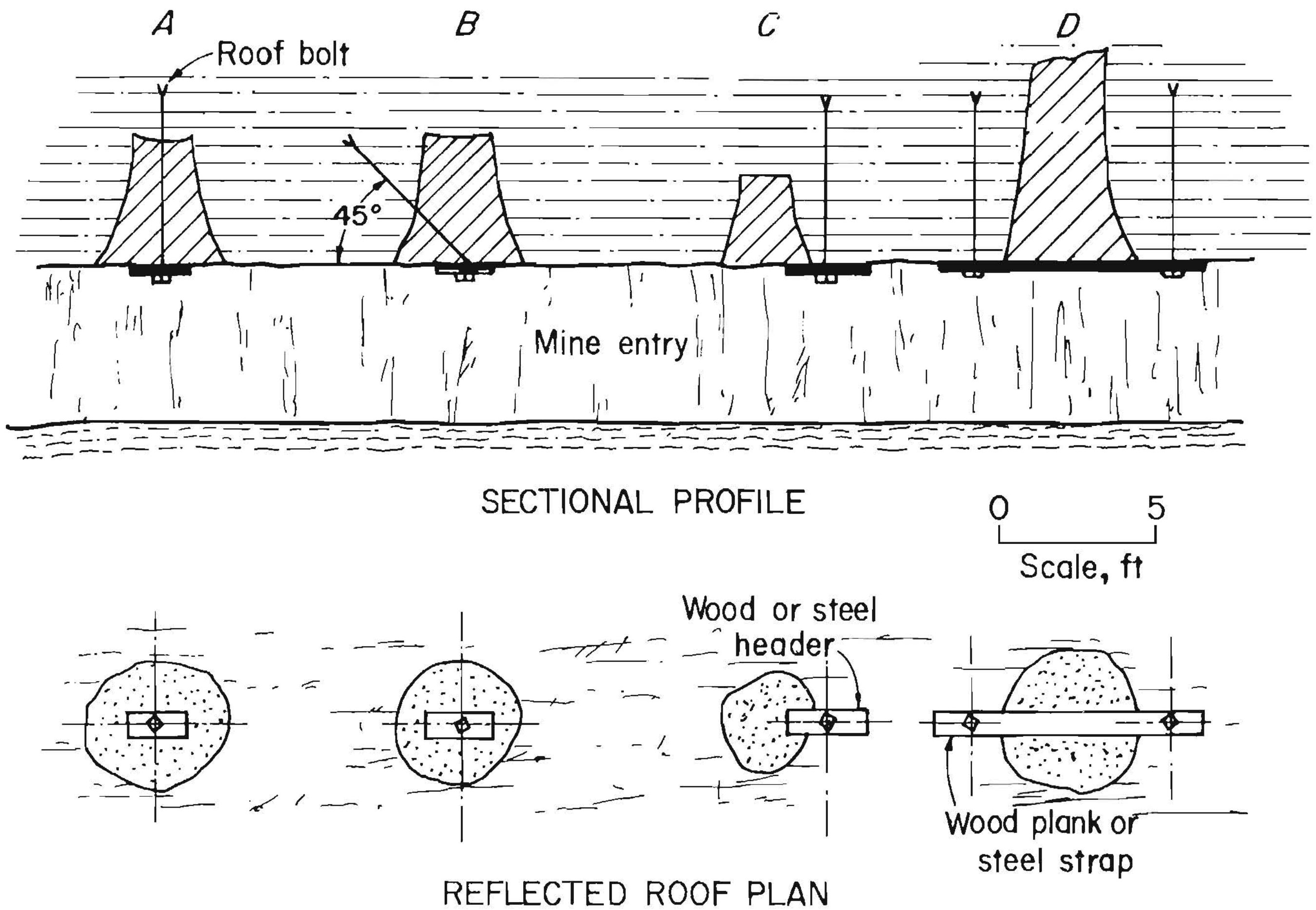

FIGURE 14. - Common support techniques.

Bolting method *C*, which employs a wood or steel header for support, is recommended for kettlebottoms less than 3 ft in diameter. Kettlebottoms over 3 ft in diameter should be secured with two bolts and a wood plank or steel strap ("bacon skin") (method *D*).

Sometimes a kettlebottom can be properly supported by one of the above methods using a bolt already in place, depending on the kettlebottom's location with respect to the regular bolting pattern. However, if there are no bolts in the regular pattern close enough to the kettlebottom to sufficiently support it, an additional bolt is recommended.

A common problem in mines during the summer and fall months is the swelling, spalling, and overall deterioration of moisture-sensitive shales because of humid mine air. The practice of leaving the top 4 to 6 in of coal (head coal) to protect weaker roof shales from humid mine air masks the presence of kettlebottoms in the roof. This practice is not advised where kettlebottoms are present or suspected because the head coal may not provide sufficient support for the casts. In addition, roof sag induced by retreat mining tends to pop out unsupported kettlebottoms, increasing the risk of injury by casts hidden by the head coal. Supporting kettlebottoms prevents the creation of roof voids and minimizes the area of roof adversely affected by moist air.

CONCLUSIONS AND RECOMMENDATIONS

1. Kettlebottoms are small, local features of erratic occurence that cannot be detected by core drilling or predicted in advance mining. Miner awareness at the working face of what kettlebottoms are and the potential hazards they present is necessary for work safety and for the proper installation of roof support in areas where kettlebottoms may occur.

2. All kettlebottoms not dislodged during initial mining should be supported. The roof should be bolted next to kettlebottoms less than 3 ft in diameter, close enough to the kettlebottom that a portion of a wood or steel header will extend beneath it for support. Two bolts and a wood plank or steel strap should be employed to support kettlebottoms over 3 ft in diameter. Kettlebottoms should never be drilled without first providing temporary support, because vibration during drilling is sometimes sufficient to detach the kettlebottom.

3. Supporting kettlebottoms helps to maintain the integrity of the mine roof and lessens the effects of humid mine air in open voids.

4. Supporting kettlebottoms during initial mining can avoid later problems and hazards during retreat mining, when roof sag tends to pop out unsupported kettlebottoms.

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