

I 28.23:5360/c.3

Bureau of Mines
Report of Investigations 5360



EFFECTIVENESS OF BLEEDER ENTRIES
IN VENTILATING PILLARED AREAS
OF BITUMINOUS-COAL MINES

BY D. S. KINGERY AND D. D. DORNENBURG

U. S. GOVT
DOCUMENTS

OCT 29 1957

LIBRARY
COLLEGE SCHOOL OF MINES
GOLDEN, COLORADO

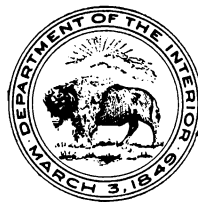
United States Department of the Interior — September 1957

metadc38664

EFFECTIVENESS OF BLEEDER ENTRIES IN VENTILATING PILLARED AREAS OF BITUMINOUS-COAL MINES

BY D. S. KINGERY AND D. D. DORNENBURG

* * * * * **Report of Investigations 5360**



UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Marling J. Ankeny, Director

Work on manuscript completed August 1956. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Report of Investigations 5360."

September 1957

FOREWORD

The Bureau of Mines recently completed a series of 8 ventilation studies in 7 test areas in the bituminous coalfields of Pennsylvania, West Virginia, and Indiana, to determine the effectiveness of bleeder entries in ventilating pillared areas of bituminous-coal mines.

A summary report of data on five areas was presented before the Coal-Mining Section, 44th National Safety Congress, Chicago, Ill., on October 25, 1956, and was published in the transactions of the meeting.

Because of the important subject and the significant findings and recommendations, the Bureau feels that this comprehensive report will be of much interest to all who are a vital part of the coal-mining industry.

JAMES WESTFIELD

Assistant Director - Health and Safety
Bureau of Mines

EFFECTIVENESS OF BLEEDER ENTRIES IN VENTILATING PILLARED AREAS OF BITUMINOUS-COAL MINES

by

D. S. Kingery^{1/} and D. D. Dornenburg^{2/}

CONTENTS

	<u>Page</u>
Summary and conclusions	1
Introduction	2
Acknowledgments	2
Comments on bleeder entries	2
Method of conducting survey	3
Discussion of test areas	3
Area 1, mine A, Pittsburgh coal bed	3
Area 2, mine A, Pittsburgh coal bed	7
Area 3, mine A, Pittsburgh coal bed	9
Area 4, mine B, Pocahontas No. 4 coal bed	12
Area 5, mine B, Pocahontas No. 4 coal bed	14
Area 6, mine C, Pocahontas No. 4 coal bed	16
Area 7, mine D, Indiana No. 5 coal bed	19
Area 8, mine A, Pittsburgh coal bed	21
Recommendations	23

1/ Mining health and safety engineer, Bureau of Mines, Region V,
Pittsburgh, Pa.

2/ Former mining health and safety engineer, Bureau of Mines,
Region V, Pittsburgh, Pa.

ILLUSTRATIONS

<u>Fig.</u>		<u>Page</u>
1.	Bleeder system with very little airflow through gob	4
2.	System of regulated air that could be induced to flow through gob area shown in figure 1	4
3.	Area 1, mine A, Pittsburgh coal bed	5
4.	Area 2, mine A, Pittsburgh coal bed	8
5.	Area 3, mine A, Pittsburgh coal bed	10
6.	Area 4, mine B, Pocahontas No. 4 coal bed	13
7.	Area 5, mine B, Pocahontas No. 4 coal bed	15
8.	Area 6, mine C, Pocahontas No. 4 coal bed	17
9.	Area 7, mine D, Indiana No. 5 coal bed	20
10.	Area 8, mine A, Pittsburgh coal bed	22

SUMMARY AND CONCLUSIONS

The data obtained from this study cover test areas that are gassy to ultragassy and pillared areas of different sizes and degrees of tightness. The methods of controlling ventilation, applying bleeders, and supporting bleeder entries varied in the different test areas.

It was not possible to study all conditions likely to be encountered in coal mines. Undoubtedly, there are areas where bleeder entries, even though properly planned and maintained, might prove unsatisfactory. However, on the basis of this study, the following observations were made:

1. Tests showed that each bleeder system studied provided some movement of air through the pillared area; the quantities of air delivered to the pillar line, ranged from 23 to 82 percent, depending mainly on the extent to which bleeder returns were used as main returns from the section.

2. Pressure measurements taken across pillared areas showed maximum pressure drops ranging from 0.05 inch of water for a shallow gob to 2.69 inches for a very deep gob. The pressure differentials varied with the size and tightness of the gob but proved adequate to induce airflow across worked-out areas or through fringes of the gob to the bleeder return system.

3. The analysis of air samples (collected in vacuum-bottles) from the bleeder entries showed that methane was removed from gob areas by the ventilating current at rates varying from 0.4 c. f. m. per 100,000 square feet for an extremely large, old area to 74 c. f. m. per 100,000 square feet for a small ultragassy area.

4. The distance through pillared areas that air traveled to reach the bleeders varied. It was apparent that shallow, open gobs offered little resistance to airflow. However, enough air flowed through even fairly tight gobs to drain off substantial quantities of methane. It is assumed that accumulations of methane remained in high, caved areas, but a continuous flow of air past such places greatly diminishes the hazard of any sizable outburst of methane.

5. The characteristics of the overlying roof strata proved to be an important factor in the tightness of falls within the pillared area. Massive sandstone or sandstone and shale formations usually broke into large pieces or slabs and created open gob areas. Brittle limestones or limestone-shale and similar formations, which broke into small fragments and tended to fill voids solid, contributed the maximum resistance to airflow.

6. The layout of the bleeder system and the manner in which bleeder entries were supported determined the efficiency of the bleeder entries. Obstructed bleeder entries did not permit enough air to flow and limited the movement of air across gob areas.

7. Planned control measures were necessary to maintain effective bleeders; as the pillar line retreated and the caved area became larger and tighter, more openings to the bleeder were needed.

INTRODUCTION

Coal mining always has been a hazardous occupation. The highly mechanized methods now being employed to extract coal have created new problems and dangers. One apparent hazard that plagues the coal-mining industry is the emission of methane and its accumulation in worked-out areas, where the danger of explosion is now magnified because of the proximity to active places where electric-powered machines and workmen are concentrated. In many instances ventilation is confined to air currents sweeping across the working faces and very little penetrates the worked-out areas. Where methane is released, limited ventilation often presents difficulties when an attempt is being made to remove gas from roof falls in the vicinity of active working faces. Any interruption in ventilating the pillar line - failure of doors or check curtains, etc. - could cause methane to flow from the gob area into working places. Another hazard is the possibility that a major fall in a pillared area containing methane could push an explosive mixture into active working places.

To effectively avert explosion disasters and provide safeguards to life and property, the Bureau of Mines has been studying specialized ventilation designs to bleed off air-gas mixtures from worked-out areas.

"Bleeder" entries (the accepted terminology) may be defined as "special returns", developed and maintained as part of the ventilating system to drain off air-methane mixtures from pillared areas into the mine return circuit. Bleeder entries have been advocated by State mining departments and the Federal Bureau of Mines for many years, but they are not used generally. The effectiveness of special returns under different roof conditions has been a controversial subject among coal-mining officials. However, it is felt that, where bleeder entries are used properly and maintained as part of the ventilating system, they permit the continuous movement of air through or around pillared areas, so that methane can be drained from the gob into the mine return system. In addition to removing methane bleeder systems also aid in removing blackdamp.

This report presents detailed data on 8 field studies of bleeder entries in 7 test areas in gassy bituminous-coal mines in Pennsylvania, West Virginia, and Indiana.

ACKNOWLEDGMENTS

The fieldwork for this study was conducted by the authors under the technical supervision of G. E. McElroy, former chief, Mine Ventilation Section, Branch of Health Research, Bureau of Mines, Pittsburgh, Pa. Special acknowledgment is due officials of the cooperating mining companies for making the study possible. The authors also wish to acknowledge the assistance of A. C. Jones, G. L. Lynch, and J. Zeleskey, Federal coal-mine inspectors, of the Bureau of Mines.

COMMENTS ON BLEEDER ENTRIES

Based upon the tests, it is concluded that in most applications a bleeder system of ventilation will reduce the possibility of dangerous accumulations of mine gases in pillared areas, provided the bleeder ventilation system has been well planned and is reasonably free of obstructions.

Many so-called bleeder systems do not work effectively because adequate pressure drops have not been established across the pillared area. Even if a bleeder entry has been provided, unless airflow is induced through the pillared area by some means of regulation it will simply move along the relatively open fringes of the gob to the nearest junction of the bleeder entry with the mine return system. This allows quantities of methane, which could be released suddenly, to accumulate in the back end of the bleeder entry and in the gob. (See fig. 1.) Such bleeder systems are ineffective and, even if no more dangerous than areas without bleeder entries, are an additional hazard in that the illusion of safety is created because they exist and dependence is placed on them. Figure 2 shows how regulated airflow could be induced across the gob area shown in figure 1.

METHOD OF CONDUCTING SURVEY

In each test area the quantities of air entering and returning were determined by anemometer traverses, supplemented by smoke-travel measurements for very low velocities. Measurements were made at both ends of the pillar lines, at junction points with the mine return circuits, at intervals in the bleeder entries adjacent to the gob areas, and elsewhere as necessary to determine the quantity and distribution of airflow through the gob.

Absolute-pressure determinations were made in each test area by precision altimeters. A base was established in the intake to working sections, where observations were made at 5-minute intervals on 1 instrument, and pressure readings were taken with a traveling instrument at intervals along the pillar line and in the bleeder entries around the worked-out areas. From these observations, the existing differences in pressure - inches of water between the base and the various points around the gob area - were determined.

Samples of mine air were taken in vacuum bottles at several places along the intake side of the gob, in returns from the sections, and at selected points around the pillared area to determine the quantities of methane picked up by air passing through gob areas and along the pillar line.

Supplementary information - the manner in which bleeder entries were supported, their general physical condition, the composition of roof strata, and the height and relative tightness of falls in the pillared areas - was obtained wherever it was possible to observe conditions.

DISCUSSION OF TEST AREAS

Area 1, Mine A, Pittsburgh Coal Bed

This test was conducted in a large mine operating in the Pittsburgh coal bed in western Pennsylvania. The mine was emitting 4,535,000 cubic feet of methane in 24 hours. The area, as shown in figure 3, had two sets of working butt-entries. The extent of the pillared area was approximately 1,000 feet on the south and 800 feet on the west, with a stepped pillar line approximately 1,300 feet long. The total caved area was computed to be approximately 500,000 square feet.

A single entry along the southside served both as a bleeder entry and a return-air course from the area and was connected through a regulator to the mine return system near the far corner of the gob. The bleeder was separated from the gob by solid-concrete-block stoppings, (erected at 100-foot intervals in the cross-cuts that connected it to the gob) in which holes had been made as the pillar line

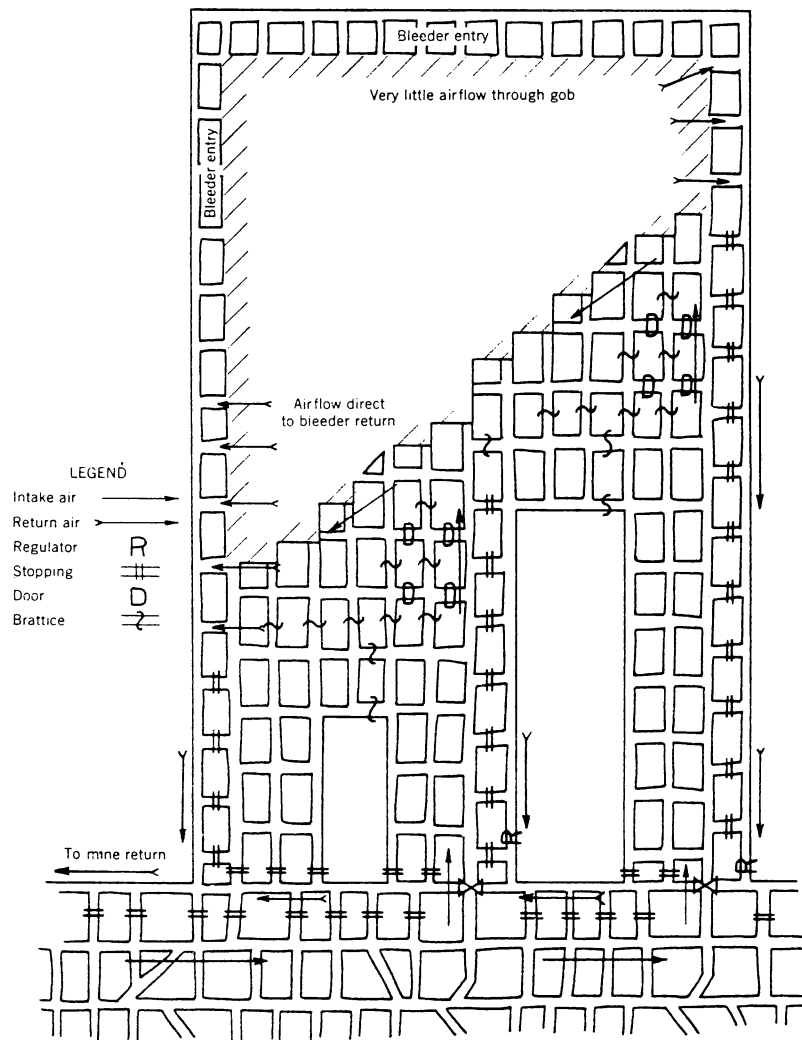


Figure 1. - Bleeder system with very little airflow through gob.

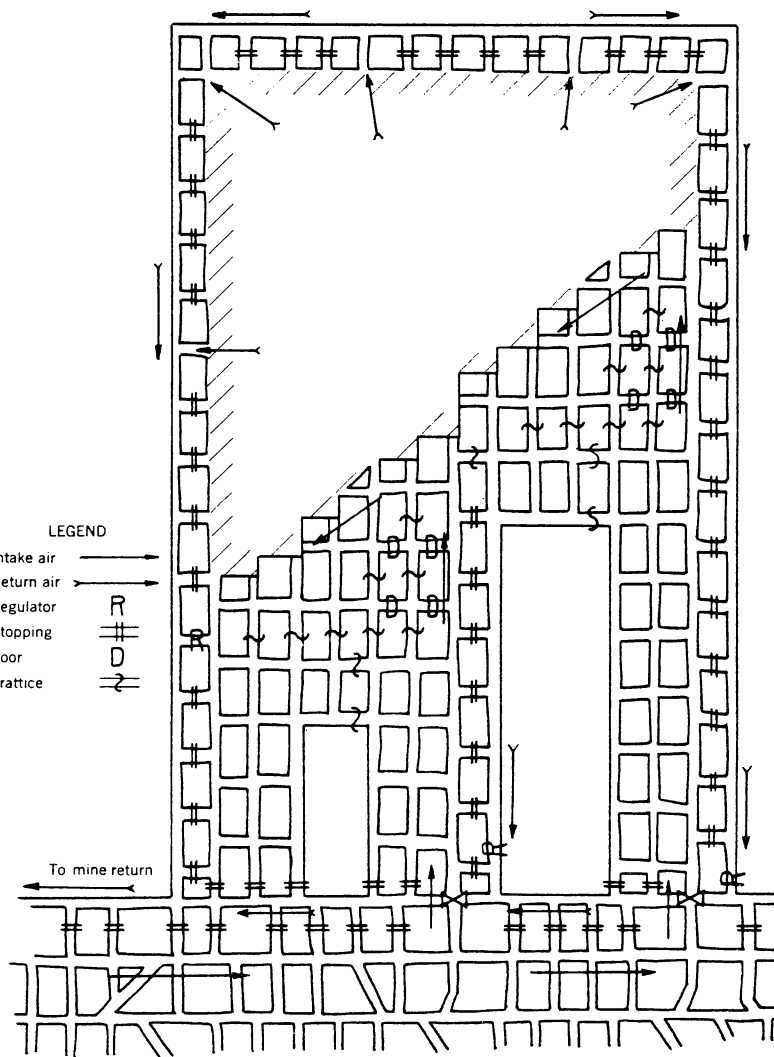


Figure 2. - System of regulated air that could be induced to flow through gob area shown in figure 1.

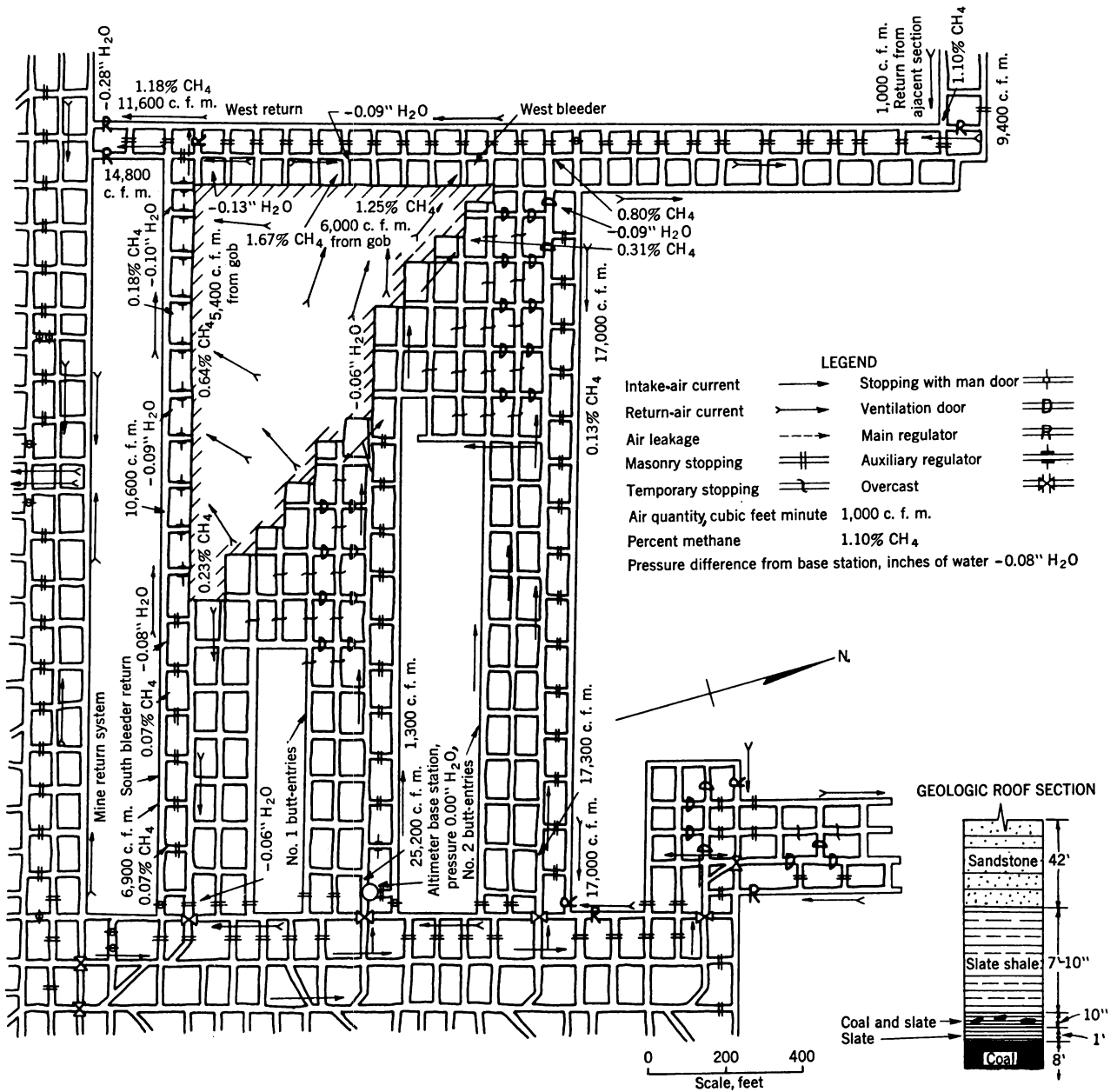


Figure 3. - Area 1, mine A, Pittsburgh coal bed.

retreated to permit airflow from the gob. The west bleeder entry was open to the gob through crosscuts on 75-foot centers and was separated from a parallel return entry by solid-concrete-block stoppings in connecting crosscuts. This bleeder-entry return joined the pillar-line return at the west end of the operating area, and the combined return was coursed through regulated paths to the mine return system. Air flowed both north and south along the west bleeder.

Both the south and west bleeder returns had been roof-bolted, and also center-posted where heavy roof was indicated. All bleeder entries and returns were open, and it was possible to travel around the entire area. Only minor falls were encountered.

The geologic structures of the mine roof progressed from drawslate to a thin coal bed to shale and sandstone formations, varying from laminated to semimassive. In the pillared area falls caved 8 to more than 15 feet above the coal bed. The fallen material varied in size from large blocks to small pieces; the predominance of smaller sizes indicated that the gob area probably would become tight when the pillared area was enlarged.

Intake air entered the area from both Nos. 1 and 2 butts. The air was controlled at the pillar faces by a system of doors and temporary stoppings and was split near the center of the pillar line to provide a two-way sweep and to assure that corners of the pillar line were ventilated adequately. Much of the intake air from No. 2 butts, after ventilating the westernmost faces, was returned down the No. 2 butt back entry, with some going out through the west return. Most of the air from No. 1 butts, after ventilating the easternmost pillar faces, either passed through the gob to the south bleeder return entry or entered it directly from the southeast corner of the pillar line.

The air quantities entering or leaving the test area were:

Quantities of air, c. f. m.

<u>Entering</u>		<u>Leaving</u>	
No. 1 butts	25,200	No. 2 butts to mine return	17,000
No. 2 butts	17,300	South bleeder to mine return ..	14,800
From adjacent section ...	<u>1,000</u>	West return to mine return	<u>11,600</u>
Total	43,500	Total	43,400

The air that passed through the gob to the bleeder return system was assumed to be the difference in quantities of air measured at bleeder intakes and the quantities that passed from the bleeder system.

Quantities of air, c. f. m.

<u>Intake to bleeders</u>		<u>Return from bleeders</u>	
South bleeder	6,900	At gob corner south bleeder ...	14,800
West bleeder	3,400	At gob corner west bleeder	<u>11,600</u>
From adjacent section ...	<u>1,000</u>	Total	26,400
Total	11,300		

The difference (15,100 c. f. m.) that passed through the pillared area was equivalent to 35 percent of the total quantity of intake air, indicating that this small gob area created little resistance to airflow.

Analysis of the pressure data showed a pressure drop of about 0.06 inch between the base station and midpoint of the pillar line. From the midpoint of the pillar line, pressure drops ranged from about 0.02 inch at the southeast edge of the pillar to a maximum of about 0.07 inch across the far corner of the gob. Small pressure drops such as these were enough to induce airflow through the gob, which in this area had not yet caved tight.

The analysis of air samples from the pillar corners and bleeder returns indicated that this particular area was relatively very gassy. Air samples from the far corner of the gob showed 1.67 percent methane, and methane concentrations along the south bleeder progressively increased from 0.07 percent to 0.18. The percentages of methane in the west bleeder were substantially higher than in the south bleeder, because all the air that entered the west bleeder passed through the gob, while approximately 46 percent of the air passing the south bleeder started as relatively pure intake air. Concentrations of methane in the west bleeder ranged from 1.67 percent at the corner of the gob to 0.76 percent near the edge of the pillar line. The ventilating currents removed about 175 c. f. m. of methane from the area, of which about 140 c. f. m. (201,600 cu. ft. per day) was from the interior of the gob - equivalent to 28 c. f. m. (40,300 cu. ft. per day) per 100,000 square feet of gob area.

Area 2, Mine A, Pittsburgh Coal Bed

This test area was in the same mine as area 1. The area, as shown in figure 4, had 4 sets of butt-entries, 1 completed, 1 worked out except for material recovery, and 2 working. The extent of the pillared area was approximately 2,200 feet on the north, 1,700 feet on the east, and 850 feet on the west, with a stepped pillar line approximately 2,600 feet long. The total pillared area was computed to be approximately 2.6 million square feet.

A single entry served as a bleeder along the north side of the gob area and also carried a return current from active workings. The entry was connected to the gob through open room necks and through a regulator to parallel entries of the mine return system near the northeast corner of the gob. The east bleeder return system had three parallel entries connected to the gob through small openings in stoppings, previously used as regulators; man doors in stoppings, partly open; and leakage through masonry stoppings, crushed from caving. These bleeder returns carried a regulated split of direct return air but were not regulated where connected to the mine return circuit near the northeast corner of the gob.

The north bleeder return was supported by wooden crossbars and posts, and for several hundred feet west of the northeast corner of the gob had caved to the extent that it was difficult to travel. However, it was open enough for movement of air. The east bleeder return entries were roof-bolted and center-posted along the southern half of their length and were standing exceptionally well. However, beyond the roof-bolted area numerous falls had occurred.

The geologic structure of the mine roof progressed from drawslate to a main roof of sandrock, ranging from semimassive to laminated and friable in texture. The falls were 15 to 20 feet above the coal bed and the fragments varied in size; although movement of air was traced over and by the edges of falls, the pillared area was considered tight.

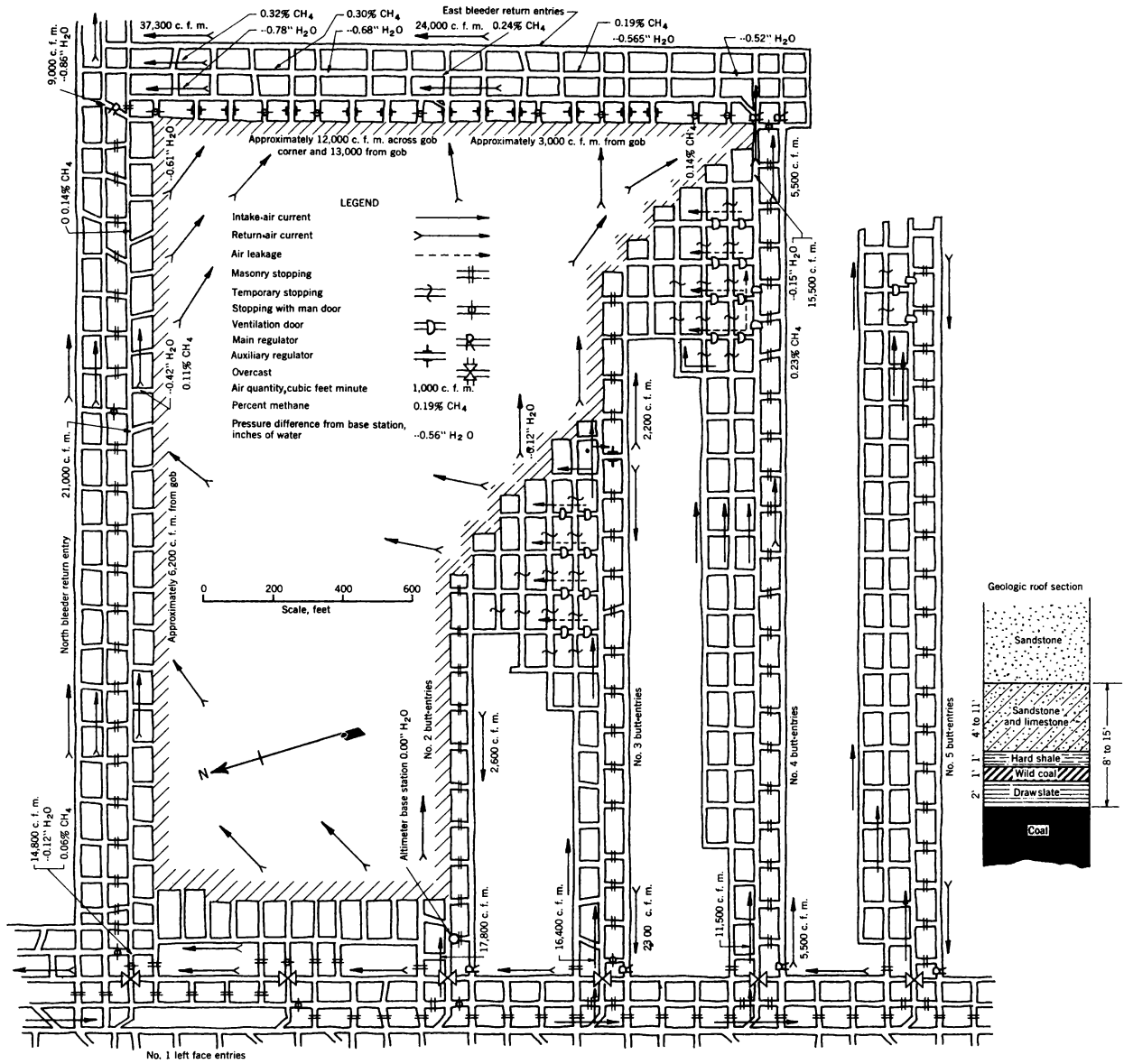


Figure 4. - Area 2, mine A, Pittsburgh coal bed.

Intake air entered each of the working butts and was controlled at the pillar line by a series of double doors and temporary brattice stoppings. In addition to intake air, 5,500 c. f. m. of return air from No. 5 butts entered the bleeder-return system through the No. 4 butt back entry. The intake air in No. 3 butts was split at the pillar line to ventilate the pillar step between No. 4 butts operations and the pillar work north of No. 3 butts. A regulator was placed at the southeast edge of the pillar line to induce airflow through the gob. Small quantities of air were coursed through the back entries of Nos. 2 and 3 butts, which could be used as emergency returns if the bleeder system failed to function properly.

The total quantity of air entering the area was about 51,200 c. f. m., of which about 46,300 c. f. m. reached the northeast corner of the gob through the bleeder return system, and 10,500 c. f. m., or 23 percent of the intake air delivered to the pillar lines, crossed the gob area. Of the 10,500 c. f. m. crossing the pillared area, 6,200 c. f. m. entered the north bleeder and 4,300 c. f. m. entered the east bleeder. In addition to the 10,500 c. f. m. that passed entirely through the gob area, much of the air at the intake sides of the bleeder returns was air that had passed across corners of the gob or through some part of the pillared area.

Analysis of the pressure data showed a pressure drop of about 0.12 inch between the base station and the pillar line and progressive increases in the pressure drops between the pillar line and the bleeder entries to a maximum of 0.49 inch at the northeast corner of the gob area. A slight difference in pressure existed between the 2 bleeder entries at the northeast corner of the gob, causing approximately 12,000 c. f. m. to flow across the corner from the north to the east bleeders; the latter had an unregulated connection to the mine return.

The analysis of air samples from pillar corners and bleeder returns indicated that the pillared area was not very gassy. Air passing through the gob picked up only small quantities of methane. The increases in methane content between intake and return ranged from 0.06 to 0.14 percent along the north bleeder and from 0.14 to 0.32 percent along the east bleeder. The ventilating currents were removing about 122 c. f. m. of methane from the area, of which about 78 c. f. m. (112,300 cu. ft. per day) was drained from the interior of the gob - equivalent to about 3 c. f. m. (4,300 cu. ft. per day) per 100,000 square feet of gob area.

Area 3, Mine A, Pittsburgh Coal Bed

This test area was in the same mine as areas 1 and 2. The area, as shown in figure 5, had 2 sets of working and 3 sets of completed butt-entries. The extent of the pillared area was approximately 5,000 feet on the north, 2,300 feet on the east, 3,100 feet on the south, and 1,500 feet along the west, with a stepped pillar line approximately 2,100 feet long. The total caved area was computed to be approximately 10 million square feet.

A single entry on the north, connected through regulators on both east and west ends to the main mine return system, served as a bleeder entry. This bleeder heading was separated from the gob by solid-concrete-block stoppings in which holes had been made as the pillar line retreated to permit airflow from the gob. The east side of the pillared area was served by a single bleeder entry, open to the gob through room necks, and a parallel return entry, separated from the bleeder by solid-concrete-block stoppings. The east bleeder-return entry was connected to the mine return system opposite No. 2 butts. The south and west sides of the pillared area were provided with single bleeder entries, open to the gob through room necks. A parallel return entry on the south was being used as part of the mine return. The west bleeder joined the north bleeder at a common northwest junction, and the south bleeder entry joined the east bleeder at the southeast corner of the gob.

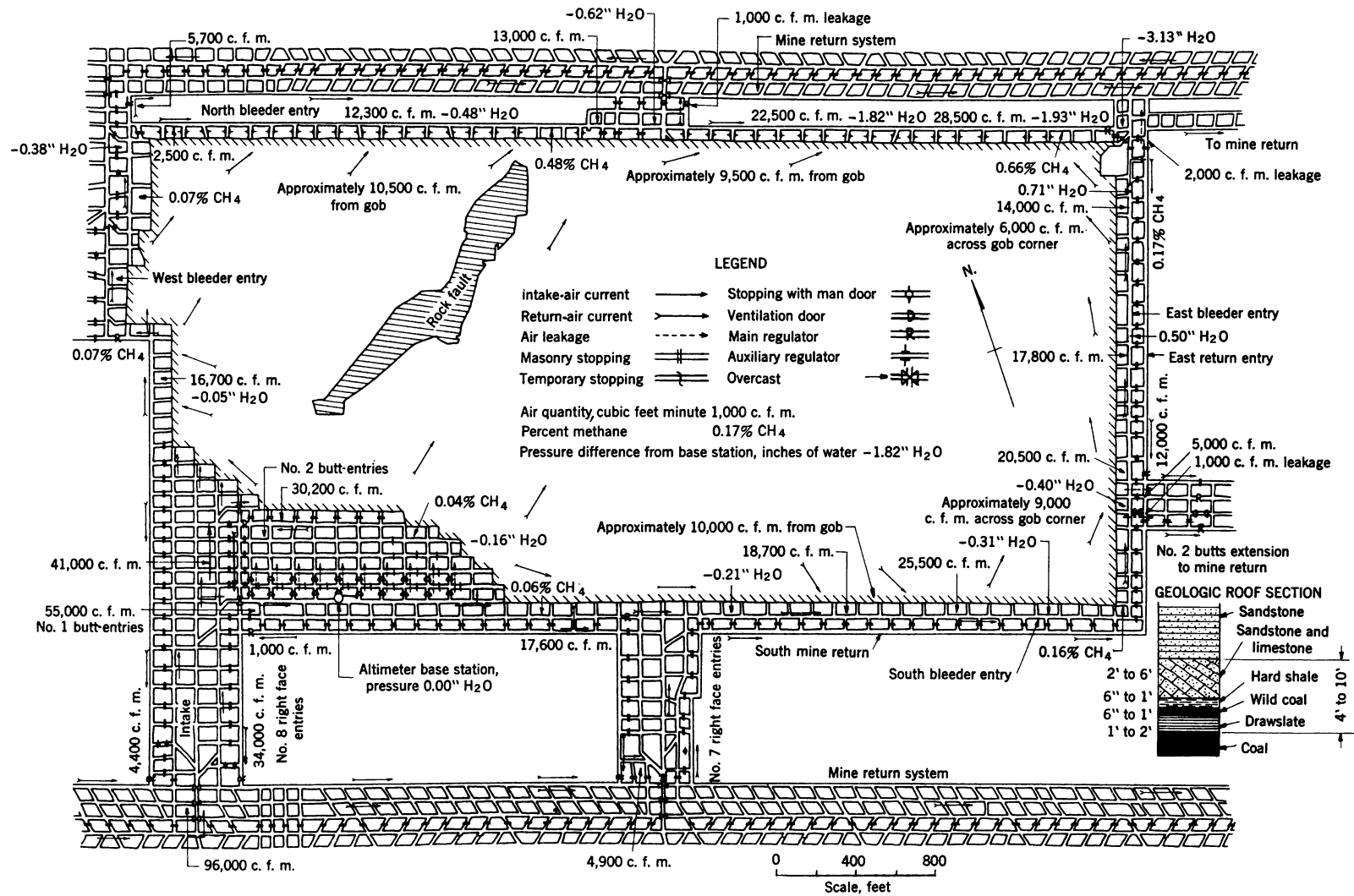


Figure 5. - Area 3, mine A, Pittsburgh coal bed.

The north and west bleeder entries had been supported by wooden crossbars and posts and were caved in many places. The east and south bleeder entries were roof-bolted and center-posted along most of their lengths and had been affected by only a few major falls.

The geologic structure of the mine roof progressed from drawslate, shale, and "wild" coal to semimassive sandstone and limestone. A large fault extended across the northwest part of the gob area. New falls caved 8 to 12 feet above the coal bed, and the broken fragments ranged from very large to small pieces. Most of the old falls checked from the bleeder entries appeared to have caved tightly; consequently, this particular gob area provided a severe test of bleeder efficiency, as it was large and tight and had an extensive rock fault, which further obstructed airflow.

Intake air entered the area from the No. 8 right face entries, then was split, part entering No. 1 butts and the remainder continuing down the No. 8 right face entries to pillar workings. The intake air to No. 1 butts was split; part was used to ventilate the pillar workings and approximately 17,600 c. f. m. entered the bleeder-return system at the southeast corner of the pillar line. Most of the air that swept past the pillar faces was returned down the back entry of No. 2 butts and the east return entry of No. 8 right directly to the mine return system. Other returns were through the west bleeder and the west return entry of No. 8 face entries. The air was controlled along the pillar line by doors and temporary stoppings. Regulators were used to establish airflow along the pillar line and to induce airflow through the gob.

The total quantity of air entering the area was about 96,000 c. f. m. of which 38,400 c. f. m., after sweeping the faces, was returned without entering any part of the bleeder-return system. The remainder, 57,600 c. f. m. (it was assumed), passed through or by the pillared area; 20,100 c. f. m. of this air was measured entering the bleeder returns; consequently, 37,500 c. f. m. (39 percent) of the intake air passed through some part of the worked-out area. Probably only a small percentage of the 37,500 c. f. m. actually passed through the center of this large and tight gob. However, the fact that air could be traced across parts of the gob proved that the potential hazard of methane accumulations had been reduced.

Analysis of the pressure data showed pressure drops between the intake side of the gob area and ends of the pillar line, with a maximum drop of about 1.8 inches across the gob to the northeast corner of the gob. The pressure drop in the north bleeder return between the intake and the far corner of the gob was 1.55 inches. The pressure drop in the east bleeder system along the pillared area was 0.40 inch. Corresponding drops occurred along the south bleeder returns and from the inby side of the pillar line to both ends. Without the substantial differences in pressure that existed, it is doubtful that the 37,500 c. f. m. measured could have entered this extensive, pillared area.

The analysis of air samples from the bleeder returns showed that, along the north bleeder return, the methane content ranged from 0.07 percent at the intake to 0.66 percent near the return regulator. The methane content along the south and east bleeder entries ranged from 0.06 percent at the south edge of the pillar line to 0.16 percent at the southeast corner of the gob and remained fairly constant along the east bleeder, reaching 0.17 percent at the junction with the return circuit. Air samples taken along the pillar line showed less than 0.10 percent methane. The ventilating currents were removing about 235 c. f. m. of methane from the area, of which 215 c. f. m. (310,000 cu. ft. per day) was crossing the gob area to bleeder returns - equivalent to 2.2 c. f. m. (3,100 cu. ft. per day) per 100,000 square feet of gob area.

Area 4, Mine B, Pocahontas No. 4 Coal Bed

This test was conducted in a mine operating in the Pocahontas No. 4 coal bed in southern West Virginia. The mine was emitting approximately 5 million cubic feet of methane in 24 hours. The area, as shown in figure 6, had 4 sets of butt-entries, 3 completed and 1 active. The extent of the pillared area was approximately 1,800 feet on the north, 1,600 feet on the west, and 2,600 feet on the south; mining was active along the east side. The total caved area was computed to be approximately 3.3 million square feet.

Single bleeder entries were established along the north, west, and south boundaries of the pillared area. The bleeder headings were interconnected and connected to the mine return system near the southwest corner of the gob and midway along the west bleeder. The north and west bleeders were open to the gob. Along the south bleeder, except near the southwest corner of the gob, masonry stoppings had been built to separate the bleeder from the gob. At the time of the survey most of the stoppings were crushed, and air was leaking through into the bleeder entry.

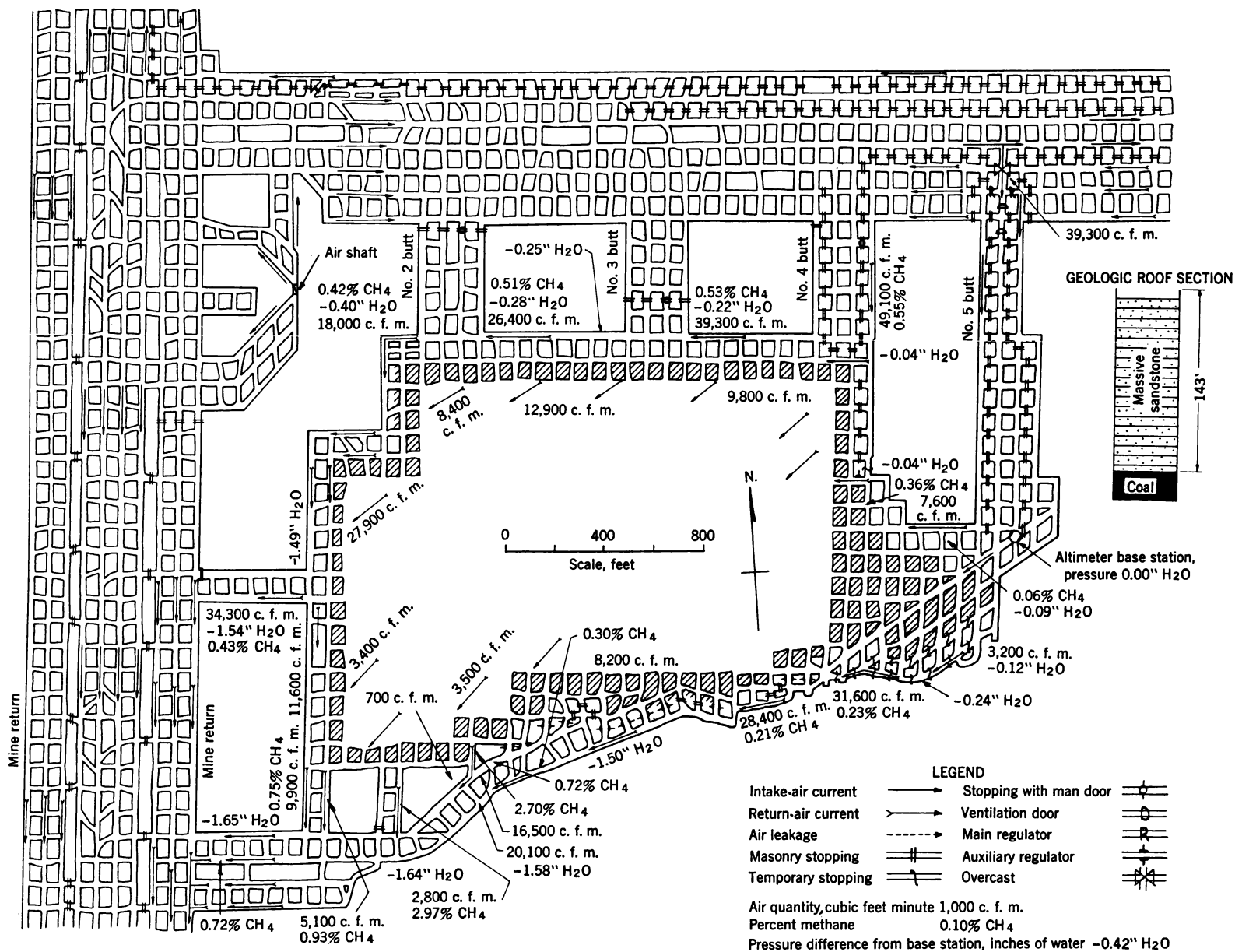
The bleeder headings had been supported by wooden crossbars, with extra posts where poor roof was indicated. The north bleeder had only occasional falls; the south bleeder was under very heavy roof, and although cribs had been placed to supplement first timbering, numerous falls were encountered and the bleeder was not open for travel throughout its entire length. The west bleeder entry also was caved badly. Because the falls were open, however, air movement through the bleeders was good.

The roof overlying the coal bed was massive sandstone, ranging from 30 to over 100 feet in thickness. The falls indicated that the first break was 5 to 8 feet above the coal bed; fallen material was mostly slab fragments. Subsequent breaks varied in height, and the fallen material usually was thick blocks. Open falls indicated that the interior of the worked-out area would permit movement of air.

Intake air entered No. 5 butt-entries and was controlled at the working faces by means of line brattice and check curtains. Most of the intake air, after ventilating the working faces, passed through the southeast corner of the gob to the south bleeder. In addition to the intake air entering the section, approximately 49,100 c. f. m., which had been used to ventilate development work, was returned through No. 4 butt-entries to the northeast corner of the pillared area. The return air passed through the north bleeder and gob to the west and south bleeder entries, and from there it entered the mine return system.

A total quantity of 88,400 c. f. m. of air was entering the section, of which 31,600 c. f. m. of the 39,300 c. f. m. intake air from No. 5 butts swept across the pillar line and entered the south bleeder through the southeast pillar step. The quantity increased to 55,100 c. f. m. before reaching the mine return. Approximately 31,100 c. f. m. of the return air entering the north bleeder entry at No. 4 butts passed into the worked-out area. The quantity of air that actually passed through some part of the pillared area was determined by subtracting from the total intake of 88,400 c. f. m., the quantity of air (21,200 c. f. m.) that did not enter the gob - 18,000 c. f. m. in the north bleeder and 3,200 c. f. m. of the intake to the south bleeder. This quantity (67,200 c. f. m.) is 76 percent of the intake air in the area, which indicates that this particular gob was quite open.

Analysis of the pressure data showed pressure drops ranging from 0.04 to 0.09 inch between the base station and edge of the pillar line. Progressive drops were measured across the worked-out area, reaching maximums of 1.54 inches at the west



bleeder connection with the mine return and 1.65 inches at the south bleeder connection with the mine return.

The analysis of air samples from the bleeder returns showed the area to be liberating substantial quantities of methane. The ventilating currents were moving about 280 c. f. m. (403,000 cu. ft. per day) of methane from the pillared area - equivalent to about 8.4 c. f. m. (12,000 cu. ft. per day) per 100,000 square feet of gob area.

Area 5, Mine B, Pocahontas No. 4 Coal Bed

This test area was in the same mine as area 4. The area, as shown in figure 7, had 5 sets of main entry panels, 3 completed and 2 active. The extent of the pillared area was approximately 7,000 feet along the south, 6,000 feet along the north, 4,800 feet along the angle and west headings, and 3,500 feet along the east. The total caved area was computed to be approximately 60 million square feet.

Single entries, to serve as bleeder returns, were established around the pillared area; however, subsequent mining in the vicinity of the No. 3 mains panel destroyed the effectiveness of the west bleeder entries. Mining was active in Nos. 6 and 7 mains; the Nos. 3, 4, and 5 mains were connected to the south bleeder entry and served as returns from the gob area. Along the north bleeder masonry stoppings had been constructed between the bleeder and the gob; however, openings had been placed in most of them to permit airflow into the bleeder. In No. 6 mains, stoppings had been erected along the east gob to prevent intake air from short-circuiting directly into the return entry.

The older bleeder headings had been supported by wooden crossbars and posts. The bleeders, particularly in the northwest area, were caved badly. The more recently constructed bleeders were supported by roof bolts and had only occasional falls.

The roof overlying the coal bed ranged from massive sandstone to a brittle limestone-sandstone combination. The falls caved 10 to possibly over 30 feet above the coal bed. Most of the fallen material was irregular pieces, ranging from large blocks to small fragments.

The quantity of intake air that entered No. 6 mains working section (54,600 c. f. m.) was split 4 ways: Approximately 8,000 c. f. m. returned immediately through the west entries of No. 6 mains; approximately 16,000 c. f. m. entered the worked-out area but was short-circuited to the east bleeder of No. 6 mains; measurements taken in the south bleeder showed that 8,400 c. f. m. entered this bleeder return; and remainder of the intake air (22,200 c. f. m.) swept the pillar line and was believed to travel through the southern portion of the gob, with only a small part moving across the gob to the north bleeder entry. The quantity of intake air entering No. 7 mains (101,100 c. f. m.) was split several ways - 25,900 c. f. m., after ventilating the face workings, was returned down the west entries of No. 7 mains; and approximately 24,900 c. f. m., after ventilating face workings, moved to the east bleeder of No. 6 mains and was returned through No. 6 mains. The quantity of air passing through the shallow gob to the north bleeder was approximately 33,700 c. f. m. Leakage between intake and return entries supplied the remaining 16,600 c. f. m. of the intake air.

Air measurements taken in the bleeder returns showed that 26,900 c. f. m. of the 33,700 c. f. m. passing through the shallow northeast portion of the gob

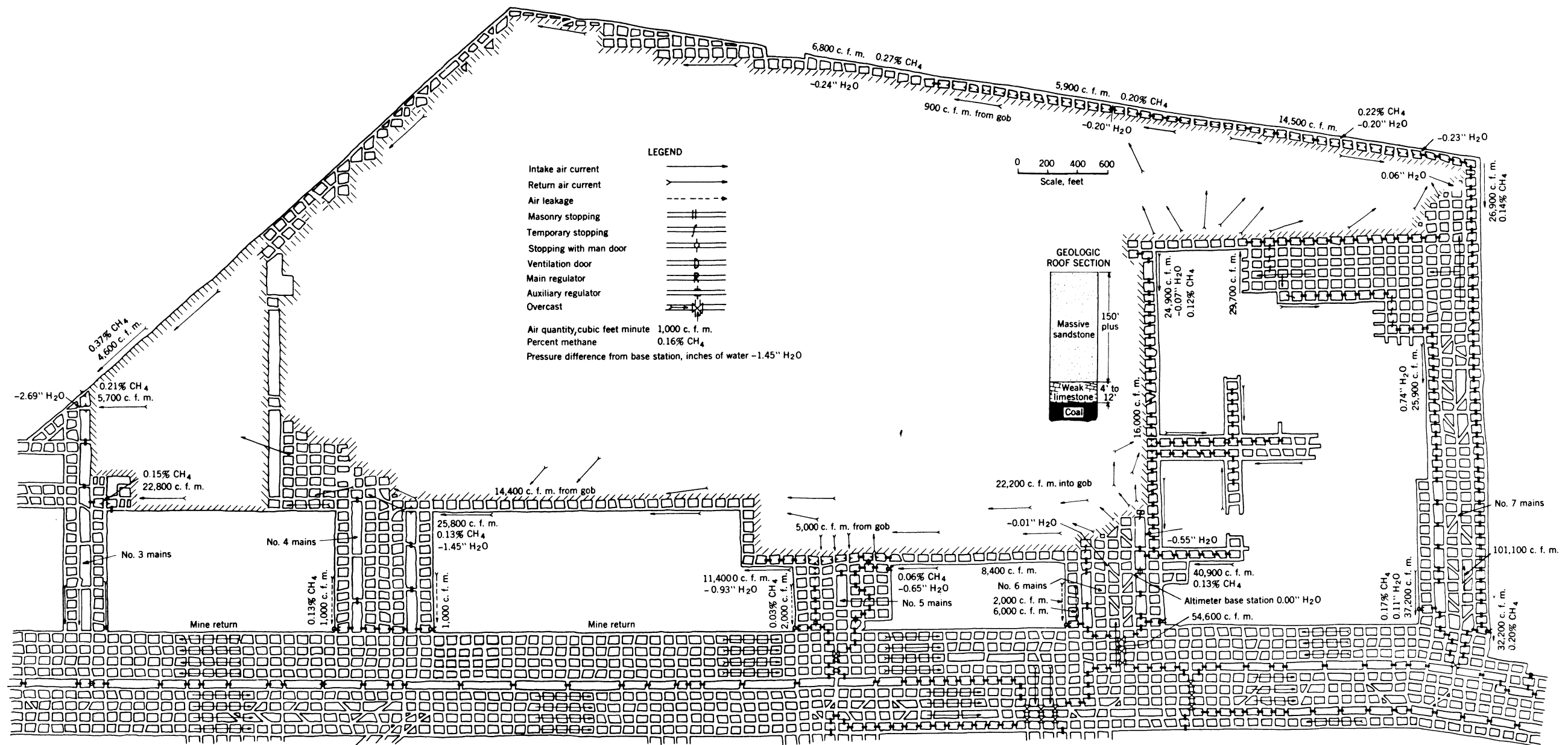


Figure 7. - Area 5, mine B, Pocahontas No. 4 coal bed.

was returned immediately down the east entries of No. 7 mains. Air in the south bleeder increased from 8,400 c. f. m. at No. 6 mains to 25,800 c. f. m. near No. 4 mains and decreased to 22,800 c. f. m. near No. 3 mains. Air measurements taken in the north bleeder entry opposite Nos. 3, 5, and 6 mains showed that only 6, 800 c. f. m. of air was passing through the bleeder.

Approximately 155,700 c. f. m. of air entered the area, and 55,900 c. f. m. (36 percent) of the intake air passed through some part of the pillared area. A much greater percentage of air could be induced to flow across this open gob by changing the regulators at the mouth of No. 7 mains and on the east bleeder of No. 6 mains.

Analysis of the pressure data shows pressure drops across the worked-out area ranging from 0.13 inch across the shallow gob opposite No. 6 mains to 0.41 inch toward the south across the wide gob opposite No. 5 mains. The pressure drop between the base station at No. 6 mains and the junction with No. 3 mains and the west-angle bleeder was 2.69 inches. The most direct route of travel to the southwest corner of the gob was along the southern fringe of the gob area. Only a small part of the air from Nos. 6 and 7 mains traveled along the northern edge of the gob.

The analysis of air samples from the bleeder returns showed the area to be liberating methane ranging from 0.06 to 0.37 percent. The ventilating currents were removing about 217 c. f. m. of the methane (312,500 cu. ft. per day) from the pillared area - equivalent to 0.36 c. f. m. (520 cu. ft. per day) per 100,000 square feet of gob area.

Area 6, Mine C, Pocahontas No. 4 Coal Bed

This test was conducted in a mine operating in the Pocahontas No. 4 coal bed in southern West Virginia. The mine was emitting approximately 8 million cubic feet of methane in 24 hours.

The area (see fig. 8) had one set of operating butt-entries. The pillared area was 1,200 feet on the northside, 1,700 feet on the south, and 500 feet on both the east and west sides. The total caved area was computed to be approximately 1.1 million square feet, with a pillar line 600 feet long.

Double bleeder entries were established along the south, east, and west boundaries, and a single bleeder along the north. Pillar mining was active across the northeast corner of the area. All bleeder entries were connected at common junction points, and the only outlet for the bleeder airflow was through the main regulators on the connection of the west bleeder with the mine return system. Wooden stoppings of 1-inch lumber, reinforced by several layers of brattice cloth, were used to separate the gob area from the air courses along both the south and west bleeders. Under heavy ground these stoppings appeared to hold up quite well and although deformed did not leak excessively.

The control plan was to maintain pressure against the pillar line and the north edge of the gob with intake air to restrict airflow into the north, west, and south bleeders, so that, except for leakage through crushed stoppings, the air that passed through the pillared area entered the bleeder-return system at the southeast corner of the gob. Air from the pillar line entered the south bleeder through crushed stoppings or was forced into the south bleeder at the southeast corner of the gob. This method of control prevented air from short-circuiting around the pillared area and assured that a certain amount of air would reach the southwest corner of the gob, which was difficult to ventilate.

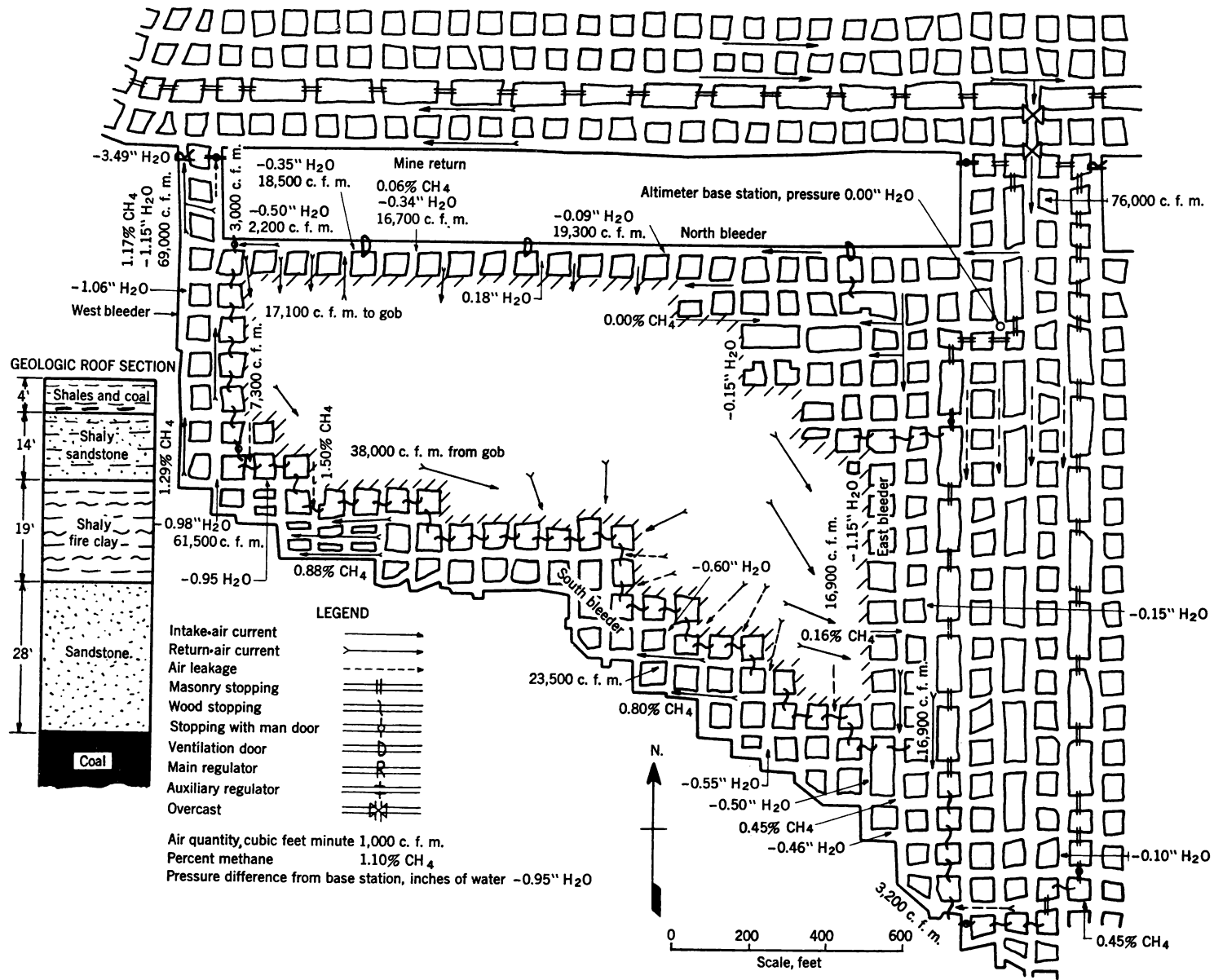


Figure 8. - Area 6, mine C, Pocahontas No. 4 coal bed.

The north and west bleeder entries had only minor falls. Wooden posts and crossbars were used for support. These were supplemented by timber cribs where the roof indicated unusual weight. The south bleeder entries were caved from the southwest corner of the gob east for approximately 1,000 feet. However, because the falls were open, air movement through the bleeders was adequate.

The roof overlying the coal bed was comprised of sandstone, approximately 29 feet thick, overlain by a series of shale and shaly sandstone beds of different thicknesses. The falls appeared to cave 6 to 8 feet above the coal bed; material fell in slabs, ranging from 3 inches to several feet thick. Above the fallen material the roof appeared to be broken but supported by its natural arch. It was impossible to determine the height of falls in the pillared area; however, the quantity of airflow traced through the gob indicated that the worked-out area was open.

A total of 76,000 c. f. m. of intake air entered the 2 north butt-entries and was conducted to the pillar line by a series of stoppings and brattice checks. Approximately 72 percent of the intake air reaching the active section was used to ventilate the pillar line. The remaining 28 percent entered the north bleeder, and ultimately most of the air entered the pillared area.

Quantities of air measured along the north bleeder to determine the distribution of airflow showed that, between the intake edge and connection to the west bleeder, air passed both into and out of the gob. The actual quantity of air that entered the gob (17,100 c. f. m.) passed through the gob to the south bleeder.

Air measurements taken along the south bleeder showed that approximately 16,900 c. f. m. of air passed around the southeast corner of the gob; it was augmented by 3,200 c. f. m., which leaked from an adjacent section. The total quantity of air (20,100 c. f. m.) that entered the south bleeder entries increased to 23,500 c. f. m. after traveling 800 feet. The quantity of air that reached the junction with the west bleeder at the southwest corner of the gob was 61,500 c. f. m., which indicated that 38,000 c. f. m. passed from the north, central, and western parts of the worked-out area.

Air measurements taken in the west bleeder showed that 71,000 c. f. m. of air passed from the west bleeder entry into the main mine return circuit, indicating that approximately 7,300 c. f. m. entered the west bleeder from the west edge of the pillared area.

The quantities of air thought to pass through some part of the gob were 16,900 c. f. m. to the east bleeder, 38,000 c. f. m. to the south bleeder, and 7,300 c. f. m. to the west bleeder - a total of 62,200 c. f. m. or approximately 82 percent of the intake air to the pillar line.

Analysis of the pressure data shows pressure drops of 0.80 inch across the pillared area from the pillar edge to the southwest corner of the gob, and 0.45 inch across the narrow portion of the gob. The drop from the pillar line to the junction with the mine return circuit was computed as 1.00 inch.

The maximum content of methane detected was 1.50 percent at the southwest corner of the gob. Return air in the bleeder system, just before entering the mine return circuit, contained 1.17 percent of methane. The ventilating currents were removing approximately 831 c. f. m. of methane from the area, of which 815 c. f. m. (1,174,000 cu. ft. per day) was from the interior of the gob - equivalent to 74 c. f. m. (107,000 cu. ft. per day) per 100,000 square feet of gob area.

Area 7, Mine D, Indiana No. 5 Coal Bed

This test was conducted in a mine operating in the Indiana No. 5 coal bed in western Indiana. The mine was emitting approximately 783,000 cubic feet of methane in 24 hours. The test area was a single, rectangular panel that had been worked out with continuous mining machines. The extent of the pillared area was approximately 1,600 feet on the east and 700 feet on both the north and southsides, with a caved area computed to be 1,120,000 square feet. (See fig. 9.)

Single, interconnected, bleeder-return entries, open to the gob through room necks, were established on all sides of the panel. The east and west bleeder entries were connected to the mine return system 200 feet north of the pillared area.

The bleeder headings were supported by roof bolts, supplemented by wooden posts set approximately 5 feet apart. The east bleeder contained a few large falls but was open for travel along its entire length. The west and north bleeder entries, however, were blocked by many large falls and impounded water; consequently, it was not possible to make observations at the northwest corner of the gob.

The roof strata overlying the coal bed consisted of many unconsolidated shale beds, varying from 1 to 20 feet in thickness. The falls indicated a weak roof; the fragments varied from large to small sizes. The first break caved 10 feet or more above the coal bed, and subsequent breaks reached an undetermined height. Broken fragments filled most of the void spaces, making the gob tight and limiting airflow through it.

A total of 13,600 c. f. m. of intake air entered the panel and was split 3 ways; 1,000 c. f. m. entered the west bleeder, 800 c. f. m. entered the pillared area, and 11,800 c. f. m. entered the east bleeder.

Three regulators, installed approximately 400 feet apart, were used in the east bleeder to force air from the entry into the gob. Of the 11,800 c. f. m. entering the east bleeder, 8,600 c. f. m. passed through the first regulator, and the remainder (3,200 c. f. m.) entered the east fringe of the gob. The air passing through the second regulator measured 9,300 c. f. m., indicating that 700 c. f. m. had entered the bleeder from the gob. At the third regulator 9,600 c. f. m. was passing through, which showed that an additional 300 c. f. m. was passing out of the gob. The quantity of air measured at the east bleeder junction with the mine return was 9,900 c. f. m., indicating that only 3,700 c. f. m. was passing out of the west bleeder.

Because of the tightness of the gob area, probably very little air passed through the interior of the gob. Most of the air entering the gob was believed to pass along the fringes of the gob parallel to the bleeder entries. The bleeder ventilating system, even in this tight gob area, was removing methane and, consequently, was effective.

The quantity of air flowing into or along the fringes of the gob was approximately 4,000 c. f. m., or 42 percent of the intake air to the panel. This was determined by subtracting the quantity of air that entered the west bleeder (1,000 c. f. m.) and the quantity flowing through the first regulator (8,600 c. f. m.) from the quantity of intake air (13,600 c. f. m.).

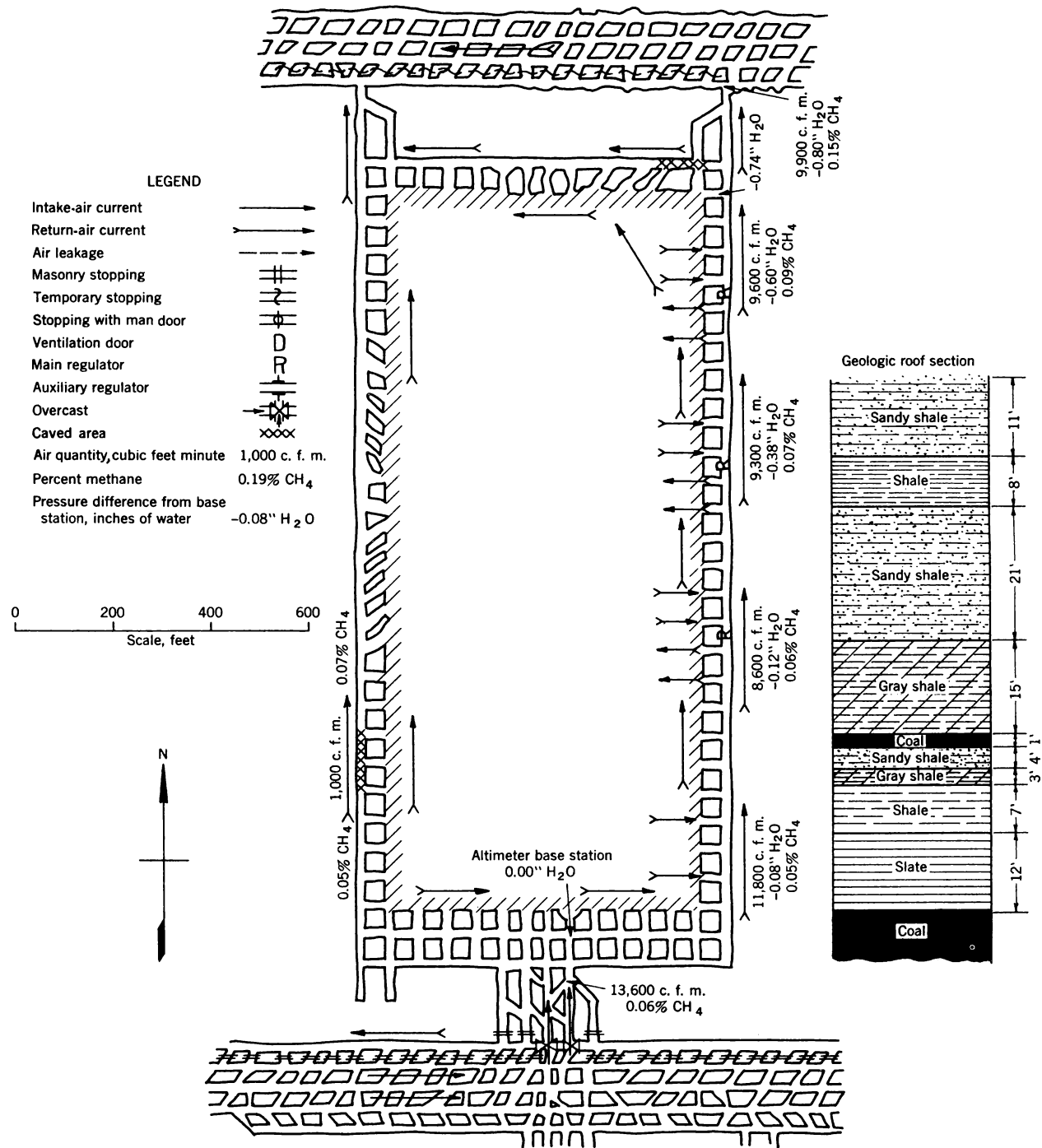


Figure 9. - Area 7, mine D, Indiana No. 5 coal bed.

Analysis of pressure data showed a drop of 0.80 inch from the south side of the gob to the east bleeder junction with the mine return. The pressure drops along the east bleeder ranged from 0.08 to 0.74 inch, and much of the resistance was caused by the regulators. It was not possible to measure the pressure at the junction of the west bleeder and the mine return; however, because this is on the same mine return circuit, the pressure probably was slightly lower than that measured at the east junction.

The ventilating currents were removing 12 c. f. m., or (17,300 cu. ft. per day), of methane from the area - equivalent to 1.07 c. f. m. (1,540 cu. ft. per day) per 100,000 square feet of gob area. This quantity, although not large, could grow into a large body of methane if permitted to accumulate and under certain barometric changes or if ventilation was interrupted, could constitute a serious explosion hazard.

Area 8, Mine A, Pittsburgh Coal Bed

This test was made approximately 1 year later in the same area shown in figure 3. During the interval, as shown in figure 10, three additional butt-entries were driven, and the pillared area had increased from approximately 500,000 to 2,500,000 square feet. The arrangement of bleeder entries was as shown in figure 3, except that now air flowed in the west bleeder return toward the southwest connection with the mine return, and airflow in the south bleeder was now toward the southeast connections with the mine return circuit. The small split of return air that had entered the bleeder system from an adjacent section had been discontinued since completing No. 4 butts.

The west bleeder and parallel return entry were caved badly, and numerous falls had occurred in the south bleeder entry.

Roof bolts had been used to support the roof; however, because of the heavy, unconsolidated structures immediately overlying the coal, the 4- and 5-foot roof bolts had not proved adequate. The gob area fell tight, and apparently very little air passed through the main body of the gob. The airflow was along the fringes, in the partly open bleeders, and across the corners of the gob.

The ventilating system had been changed since the previous study, and the intake air now entered the working area through No. 4 butts. The intake air that entered No. 5 butts passed into the west parallel return-entry without ventilating producing areas.

Part of the intake air from No. 4 butts that was ventilating the pillar line, returned down the back entry of No. 4 butts, part entered the west bleeder return, and the remainder entered the gob.

The quantities of air entering and leaving the test area were:

Quantities of air, c. f. m.

<u>Entering test area</u>		<u>Not passing through gob</u>	
No. 4 butts	24,700	No. 4 butts	4,800
No. 5 butts	12,400	No. 5 butts	6,700
Total	37,100	Intake to west bleeder returns	14,750
		Total	26,250

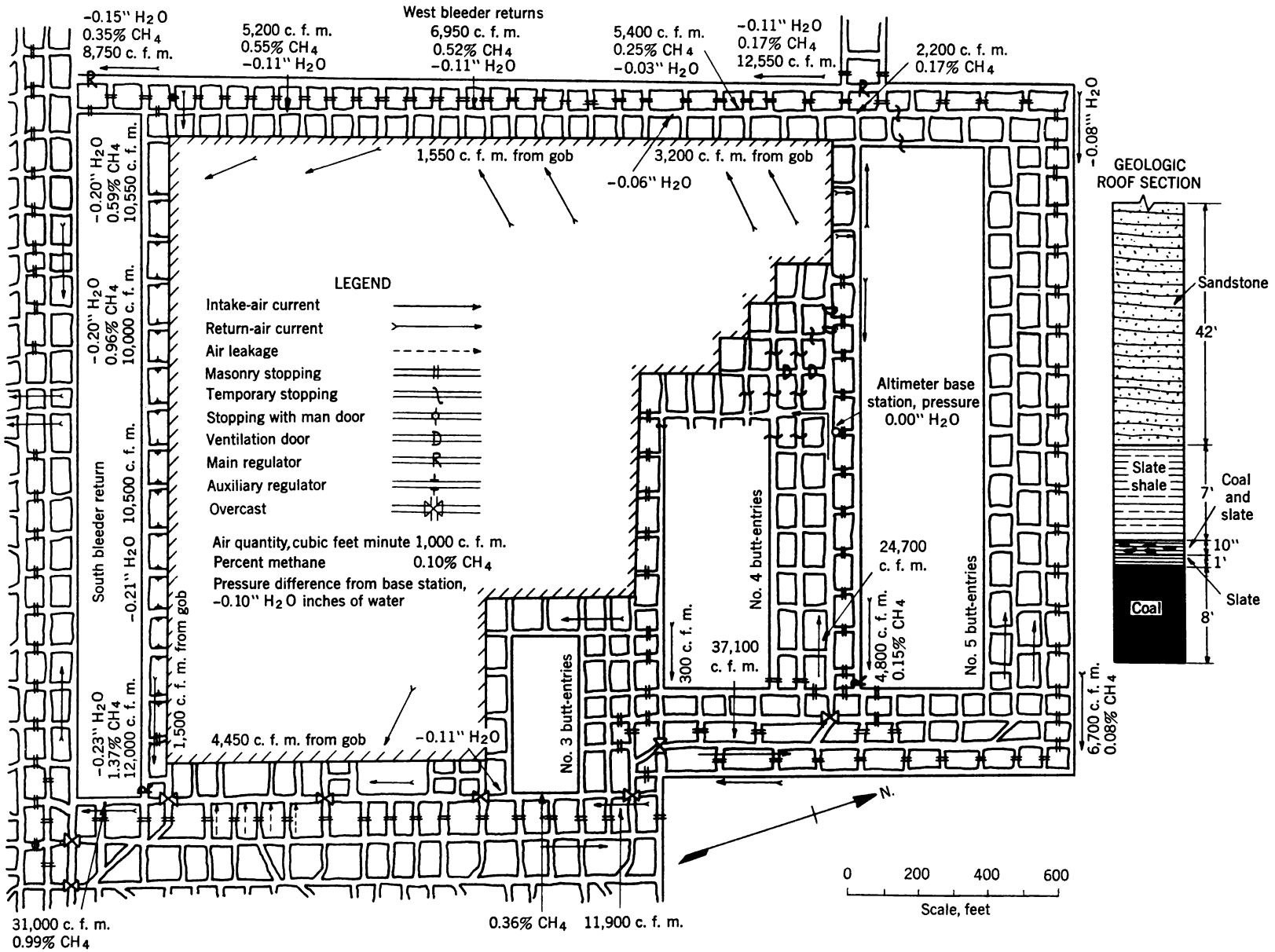


Figure 10. - Area 8, mine A, Pittsburgh coal bed.

The difference (10,850 c. f. m.) between the quantity of intake air and the air that bypassed the pillared area was assumed to have entered the gob and flowed across the corners or fringes of the gob to the bleeder entries - equivalent to 29 percent of the air delivered to the area. Approximately 26,250 c. f. m., of air however, was returned past the pillared area through the bleeders and returns connected to the gob and assisted in draining methane.

Analysis of the pressure data again showed that this area was operating under relatively low pressures. The drops were only 0.20 and 0.23 inch of water respectively, between the base station near the pillar line and the southwest and southeast corners of the gob. These small pressure drops were not enough to force air across the main gob; however, they did induce airflow through the fringes and across the corners of the gob and through bleeder entries to connections with the mine return circuit. Consequently, methane was drained from three sides of the gob area.

The analysis of air samples showed that the area still was releasing substantial quantities of methane. The methane content in the air moving along the west bleeder increased from 0.17 percent to 0.55 and along the south bleeder from 0.55 percent to 1.37. The ventilating currents were removing about 340 c. f. m. from the area, of which about 296 c. f. m. (426,000 cu. ft. per day) was removed from the gob - equivalent to 11.8 c. f. m. (17,00 cu. ft. per day) per 100,000 square feet of gob area. During the previous test of this area (see Area 1), 28 c. f. m. (40,300 cu. ft. per day) per 100,000 square feet of gob area was being removed.

RECOMMENDATIONS

The following recommendations, based upon data and observations from this investigation, are believed pertinent to safe application of bleeder ventilating systems:

1. Special attention should be given to supporting bleeder entries (headings) when they are driven and during subsequent maintenance to assure that they will remain open. This study indicated that roof-bolted entries held up better than timbered entries; it showed also that with roof bolts additional supports, such as regularly spaced cribs or center posts, are desirable.

2. Bleeder entries should not be permitted to become blocked by roof falls or impounded water, enough maintenance should be provided to keep them open at all times to airflow.

3. Weekly inspections of bleeder entries should be made by a mine official to determine the physical condition of each bleeder and its effectiveness in removing methane from the gob. Such inspections should be recorded.

4. When bleeder entries are expected to serve adjacent working panels and also to remain as bleeder returns for an area after the area has been mined out, extra support (such as barrier pillars) should be provided to keep them open.

5. Ventilating pressure should always be applied to gob areas to direct the airflow away from trolley wire, electrical installations, or active workings.

6. If a bleeder ventilating system is to be used, plans for future mining should include development of bleeder entries and control procedures to be followed when mining reaches the retreat stage and the bleeders begin to function.

7. Complete dependence should not be placed on bleeder entries as section returns. Supplementary return-air courses should be provided to function should the bleeder entries fail. The return entries used during development are used commonly for this purpose, as indicated in figures 3 and 4.

8. Regulation of the bleeder system should assure pressure all along the pillar line without creating short circuits where excessive airflow through the pillared area robs the remainder of the pillar line of needed ventilation.

9. Flexible control measures and regulated airflow should be provided in the bleeder ventilating plan to prevent short-circuiting the air across the corners of the gob to the bleeder and thereby prevent a sweep of the interior of the gob. This usually can be accomplished by stoppings that cause the air currents to pass into or through the gob before reaching connections to the bleeder entry. The number of bleeder connections required varies with the extent and tightness of the gob.

10. Ventilating pressure should be applied so that the intake air will flow from the working areas across the gob to openings from the gob to the bleeders on the far sides of the gob area. Where the gobs are connected to the bleeders is important; for, if the connections are misplaced, airflow will not be induced to the far corners of the gob; and the air could be short-circuited across the gob, leaving large areas unventilated.

