ROCK MECHANICS INSTRUMENTATION PROGRAM FOR KAISER STEEL CORPORATION'S DEMONSTRATION OF SHIELD-TYPE LONGWALL SUPPORTS AT YORK CANYON MINE, RATON, NEW MEXICO

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16. Abstract This report presents the results of a rock mechanics instrumentation program designed to determine the rock mass response due to longwall mining a thick coal seam utilizing shield-type supports at the York Canyon Mine near Raton, New Mexico. The data collected during this study is unique in that it represents the results from mining a super-critical longwall panel in a known geologic environment with cross-and along-panel topographic variations. Data from the program indicates the following: (1) Topography significantly influences the magnitude and distribution of surface movements. (2) The angle of draw decreases in topographic lows and also where cross panel slopes face outward from the panel centerline. (3) Subsidence started when the face was an average distance of 0.2h (h=depth) from a given surface point and was essentially complete when the face was 0.84h beyond the surface point. (4) Underground mining activity produced almost instantaneous surface movement and major surface subsidence ceased almost as soon as mining ceased. (5) Predicted subsidence over ridge tops was 17% to 21% greater than that actually measured. (6) No correlation could be established between coal hardness and panel power consupmtion. (7) The width of the pressure arch is apparently related to the depth of overburden. Pressure arch widths were 60% less than the widths predicted from other studies. (8) Total recorded entry convergence rarely exceeded 0.4-in. (5) With longwall face advance, the roof tends to move towards the face and towards the panel. The magnitude of movement is much less than anticipated.

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This report is a summary of the work recently completed as part of this contract during the period April 1, 1975 to September 1, 1976. This report was sumitted by the authors on January 21, 1977.

Assistance in this Rock Mechanics Instrumentation Program was provided by Dr. John F. Abel, Jr., Faculty Associate. Messrs. Grant Brooks and Collin Stewart were responsible for field work and data collection at the project site.

Mr. William Sikes, Kaiser Steel Corporation, is gratefully acknowledged for his assistance and cooperation.

REA

EXECUTIVE SUMMARY

The objective of this particular rock mechanics instrumentation program was to determine the response of the rock mass to longwall mining of a thick coal seam utilizing shield-type supports. Measurements were made in the rock along the ground surface, above the coal seam, in the coal seam, and immediately below the coal seam.

The instrumentation program was specifically designed to provide the following information:

(1) Determine the occurrence, timing and magnitude of mining-induced subsidence.

(2) Provide a detailed description of the geologic setting of the longwall panel including the pertinent physical and engineering properties of the coal and surrounding strata and descriptions of all faulting and other major geologic discontinuities.

(3) Determine the extent of strata separation and caving which occurred above the panel as a result of mining. To obtain this data, multiple-position borehole extensometers were installed in boreholes drilled from the surface through the coal seam.

(4) Determine the changes in stress in coal pillars adjacent to the panel and in the face abutment ahead of the advancing longwall panel face.

(5) Provide a thorough description of roof falls, floor heaving and other similar immediate (local) ground control problems.

(6) Thoroughly describe conditions encountered, methods and techniques used in negotiating **shield**-type supports through fault zones and/or coal seam displacements.

The longwall test panel instrumented for this study was Kaiser Steel Corporation's York Canyon Mine located approximately 40 miles west of Raton, New Mexico, and 10 miles south of the Colorado - New Mexico border in Township 31 North, Range 19 East. The demonstration panel was denoted as Fourth North (4N) longwall. It had a total developed length of 2500 ft and a face width of 550 ft. The final mined-out panel length was 1587 ft at the headgate and 1602 ft at the tailgate. The seam mining height in the panel area was approximately 10 ft. The average depth of overburden above test panel 4N is 350 ft although it ranges from 240 - 440 ft. The panel centerline was oriented northwest - southeast and the direction of mining advance was towards the southeast. Roof support at the face was provided by Hemscheidt shields. The shield-type supports weigh 12.5 tons each. They can be used in seam heights ranging from 5 ft 8-in. to 11 ft 9-in.

Surface Instrumentation

The surface instrumentation portion of this project attempted to determine the magnitude and extent of surface subsidence resulting from mining a super-critical longwall panel with rapid cross-and along-panel topographic variations in a known geologic environment.

This instrumentation program showed that topography does indeed significantly influence the magnitudes and distributions of surface movements resulting from underground extraction. A maximum subsidence of 7.1 ft was measured along the panel centerline and indicated that the maximum subsidence in topographic lows was between 25% and 30% less than the subsidence noted under ridge tops. This was attributed to three factors: (1) greater overburden depth caused greater subsidence under ridge tops, (2) excess "piling up" of overburden in draws due to horizontal movement of overburden from each opposite facing slope decreased measurable subsidence in topographic lows, and (3) an arching effect caused by increased compressional forces present in the bottom of draws decreased subsidence.

The angle of draw was decreased in the areas of topographic lows and also where side panel slopes face outward from the panel centerline. The angle of draw was increased in those cases where: ridges were present, slopes on the sides of the panel faced the centerline, and where steep slopes faced the direction of face advance. For longwall panel 4N subsidence started when the face was an average distance of 0.2h (h = overburden thickness) from a given surface point and was essentially complete when the face was 0.84h beyond the surface point. Initial subsidence was delayed on all subsidence development curves. This is attributed to the influence of thick sandstone beds overlying the coal seam in panel 4N. These results contrast to NCB (National Coal Board) data which predicts the onset of subsidence when the face is at a distance of about 0.7h from a given surface point.

The average angle of draw for longwall panel 4N was 15.5^{o} as compared to the NCB average of 35^{o}. Thick sandstone beds and steeply dipping joints in the rock overburden were no doubt responsible for the decrease in the average angle of draw.

The results of surveys made during periods of mining activity and over periods of mine holidays indicated that underground activity produced almost instantaneous surface movement and that major surface subsidence ceased almost as soon as mining ceased.

Maximum predicted super-critical subsidence, using NCB values, for the two extremes of overburden depth for prediction parameters was 17% and 21% greater than actual measured subsidence along the perpendicular. When comparing predicted vs. measured subsidence in the draws the percentage is even greater. For example, the average h for monuments 6N and 7N is 251 ft and the measured subsidence at both monuments was 5.1 ft. The predicted subsidence for these conditions is 7.9 ft making the predicted subsidence in the draw about 55% greater that that measured.

Horizontal movement data indicated that tensile strains reverse to compressive strains between 10^o and 20^o inside the mined area. NCB studies show this average to be somewhere between 5^o - 10^o. The point where measured subsidence was half the maximum measured subsidence was also 10^o to 20^o inside the mined area. This indicates that for the 4N longwall panel the transition point can be either the point of half maximum subsidence or the point where the strain profile goes from tension to compression.

Higher tensional strains develop first over areas of least overburden under dynamic conditions and after conditions stabilize over areas with the most overburden. The maximum tensional strains occurred just inside the mined-unmined coal interface. The maximum compressional strains occurred under topographic lows along the centerline and had the characteristic "camel's back" in the profile along the perpendicular.

Predicted tensional strains were 15% to 20% less than the measured tensional strains along the perpendicular when an overburden h of 242 ft was used, whereas, predicted compression strains were greater on the tailgate side and less on the headgate side than the corresponding measured compressional strains.

The maximum tensional strain measured over the 4N longwall panel was +35,633 u-in./in. and the maximum compressional strain measured was -33,917 u-in./in. The NCB states that the maximum tensional strain that can develop over a super-critical width of extraction is 0.65 S_{max}/h and the maximum compressional strain is 0.51 S_{max}/h. The minimum overburden "h" along the centerline where these maximum strains were measured was about 250 ft and the maximum subsidence measured along the centerline was 7.1 ft. This gives a maximum +E from NCB formulas of 18,460 u-in./in. and a -E of 14,484 u-in./in. This shows that the maximum strains developed over the 4N longwall panel are almost twice the predicted strains given by NCB formulae for a super-critical width of extraction. This indicates there is a great variation between the numerous NCB studies made in flat to gently rolling terrain and this particular North American study made at the mountainous York Canyon Mine terrain.

Underground Instrumentation

The subsurface instrumentation program was designed to determine loads imposed upon the shield supports by longwall mining and the reaction of the rock mass to mining advance and to correlate the observed reactions and loads with the geologic structure in the panel area. The subsurface program included a longwall panel instrumentation sequence and a program of laboratory and in situ physical rock property determinations.

The laboratory determinations of the physical properties of the roof sandstone, the coal and the floor sandstone were made by testing 91 specimens from 5 diamond coreholes and from bulk samples of coal from the face.

These tests indicate that the roof sandstone was extremely variable in physical rock properties. This wide scatter of test results is attributed to the localized presence of thin beds of coal and carbonaceous shale. The coal was the most uniform of the three rock types tested and was characterized as relatively low strength and stiffness coal. The floor sandstone was the most competent rock tested and was characterized by high compression strength with low elastic stiffness.

In situ testing consisted of a series of plate bearing tests and coal hardness determinations. The plate bearing tests generally paralleled the results of laboratory testing, but recorded rock strengths were smaller as a consequence of in situ anisotropies. In addition to the three rock types tested in the laboratory, plate bearing tests were performed on the boney coal at the top of the seam and the carbonaceous shale at the bottom of the seam. The testing indicated that both were low strength, low elastic stiffness material with variable physical rock properties.

Rock hardness data indicates that coal hardness is extremely variable. No discernable trends were noted.

Subsurface instrumentation was subdivided into three categories: support load instrumentation, face instrumentation and entry instrumentation.

Support Load Instrumentation:

Records of support loads were obtained with hydraulic pressure recorders. The data indicates that the shields are subjected to differential loading at the time the shields are set. It was observed that the east, or headgate leg of each shield was subjected to a positive pressure differential of 200 psi. The only exceptions were the tailgate shields where barrier pillar effects overrode the trend.

The pressure differential appears to result from stresses imposed by the higher topography to the east of the panel area.

The data also indicates that the face faulting encountered during mining operations caused a redistribution of roof loads into areas of high stresses separated by low fault zones.

Face Instrumentation:

Face instrumentation was installed in an attempt to correlate support load history, panel power consumption and coal hardness. Because variations in coal hardness exceeded the sensitivity of the power consumption recorder no correlations could be established.

Entry Instrumentation:

Four types of entry instrumentation were utilized; panel pressure cells, convergence instrumentation, differential roof-floor horizontal movement instrumentation and roof-sag instrumentation.

Panel Pressure Cells: Eight of twenty installed pressure cells were influenced by mining activity. These indicated that the width of the pressure arch is apparently related to the depth of overburden and that the irregular topography above panel 4N yielded pressure arch widths 60% less than the widths predicted from the literature.

Convergence Instrumentation: The convergence recorded during the last 10 ft of face advance was considerably less than that reported in previous studies. Previous workers (National Coal Board, 1965, p. 5 and Alder, 1968, p. 63-65) indicate that convergence of 1/2-inch per ft of face advance can be expected. Total recorded convergence for panel 4N instruments rarely exceeded 0.4 inches.

Differential Roof-Floor Horizontal Movement Instrumentation: In general, the data indicated that with face advance, the roof tends to move towards the face and towards the panel. The rate of horizontal movement during the last 10 ft of face advance averaged 0.05-inches. This is less than the 1/2-inch rate reported by the National Coal Board.

Roof-Sag Instrumentation: Roof-sag instrumentation indicated that the massive roof sandstone behaved like a uniformly-loaded cantilever beam prior to caving.

Only a single ground control problem was encountered during mining of panel 4N. A slip in the roof rock provided lateral loading of the two headgate shields and a soft floor failed to provide any resistance to the induced moment. The two shields were uprighted without difficulty after leaning against the rib at an angle of about 30°. Caving of the roof proceeded well after an initial span of 85 ft opened up behind the shields. The caving pattern behind the headgate and tailgate shields tended to open up with spans of 20 to 50 ft before caving. Along the interior portions of the shield face the roof remained caved uptight behind the shield line.

Caving was controlled by the major east-west joint set. The cave consisted of large angular blocks of roof sandstone that varied in size 2 ft to 8 ft on a side.

During the latter part of mining operations, the shield face was negotiating two fault zones without any significant problems.

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LIST OF SYMBOLS, TERMS AND DEFINITIONS

Following is a list of definitions associated with various symbols and terms used throughout this report. These definitions are consistent with those normally used for subsidence engineering work.

SYMBOLS	TERMS	DEFINITIONS
	Abutment	The region adjoining an excavation which is normally subjected to increased stress as a consequence of the redistribution of load. This may be at the front of, at the sides of or at the rear of a working face.
	Abutment pressure	The load per unit area on an abutment.
ζ	Angle of draw (limit angle)	The angle of inclination from the vertical of line connecting the edge of the workings and the edge of the subsidence area.
	Convergence	Movement of roof and floor towards each other after removal of mineral. The rate of convergence is measured as either: (1) the convergence for a given advance of the face; or (2) the convergence in a given time.
	Convergence (initial)	The amount of convergence of the roof and floor in the face directly after working and prior to stowing.
	Critical Width	That width the working of which causes the complete subsidence of one point on the surface.
	Sub-critical width	A width of working smaller than the critical width. (When a sub-critical width is being worked, the point on the surface under examination does not under complete subsidence.)

SYMBOLS	TERMS	DEFINITIONS
	Super-critical width	A width of working greater than a critical width. (A width on the surface undergoes complete subsidence).
h	Depth	The vertical distance between the floor of the seam being extracted and and any arbitrary datum - usually the surface.
v	Displacement	The horizontal displacement of a point caused by any working.
V	Displacement (maximum)	The maximum horizontal movement of a point caused by working a sub-critical area.
V_{max}	Displacement (maximum possible)	The maximum horizontal movement of a point caused by working a critical area.
$v_x v_y$	Displacement in the direction of co-ordinate axes.	The partial displacement in the direction of the axes of a co-ordinate system, on which the calculations are based.
d	Distance	Any horizontal distance.
	Face	1. Strictly, any surface exposed by excavation for development or for the getting of mineral; 2. More generally, the supported area in the vicinity of the place at which mineral is worked.
	Face length	The distance between rib-sides or goaf-sides of a coal face.
	Face width	The distance between the line of coal face and the waste edge.
	Panel	The area of coal extracted by a long-wall face.
L	Panel length	The dimension of a panel measured in the direction of the line of face advance.
w	Panel width	The transverse distance across a panel, usually equal to the face length.

SYMBOLS	TERMS	DEFINITIONS
	Pillar	A block of coal or mass of ore left unworked.
p	Pillar width	The shortest dimension of a rectangular pillar.
	Pressure arch	A zone of increased stress surrounding the relaxed strata which is created when any excavation is made, resulting in the redistribution of the normal strata pressures on to the abutments.
	Profile (longitudinal)	A curve depicting subsidence on a section drawn parallel to the direction of advance of an underground excavation.
	Profile (transverse)	A curve depicting subsidence on a section drawn at right-angles to the direction of advance of an underground extraction.
	Ribside	Interface between actual coal mined within the panel and adjacent chain or barrier pillars.
l	Station interval	The horizontal distance between two observation stations.
$\pm e$	Strain	Change in length per unit of length $e = \frac{\Delta \int l}{l}$ (direction to be specified)
$\pm E$	Strain (maximum)	The maximum strain (lengthening or shortening) in a trough.
$\pm E_{max}$	Strain (maximum possible)	The maximum possible strain (lengthening or shortening) in a trough.
s	Subsidence	The vertical movement anywhere within a subsidence trough.
S	Subsidence (maximum)	The maximum vertical movement caused by working a sub-critical area.
S_{max}	Subsidence (maximum possible)	The maximum possible vertical movement of a point on the surface caused by working a critical area. (This corresponds, in general, to the seam thickness multiplied by the subsidence factor.)

SYMBOLS	TERMS	DEFINITIONS
$\frac{S}{2}$	Subsidence (half)	The point where subsidence has half the amplitude of that of the maximum in the profile. (This coincides with the transition point "t").
a	Subsidence factor	The ratio of complete subsidence to seam thickness, i.e. S_{max}/m.
	Subsidence development	The manner in which surface subsidence starts increases and finishes in relation to the position of the advancing face of an underground excavation.
	Subsidence development curve	A line on a graph depicting the changing subsidence of a surface point in relation to the position of the face of an excavation passing through the critical area of that point.
m	Thickness (of seam) extracted	
	Time-Subsidence curve	The values of subsidence of a given point on the surface plotted against time as a base.
t	Transition point	The point of transition between concave and convex curvature of a subsidence profile.
	Trough (subsidence)	The surface depression caused by subsidence.
μ		Denotes micro-measurements. Used for strain measurement (micro-inches per inch).
E	Modulus of Elasticity (Young's Modulus)	Ratio of normal stress to normal strain for a particular material where the increase in strain is caused by the increase in stress.
u	Poisson's ratio	Ratio of the transverse normal strain to the longitudinal normal strain under uniaxial stress in the longitudinal direction.

SYMBOLS	TERMS	DEFINITIONS
Φ	Angle of Internal	The maximum angle of obliquity between the normal stress and the resultant strain acting on a surface within a soil or rock.
c	Cohesion	A portion of the shear strength of a material. It has the nature of an intergranular binding force.

SECTION I

INTRODUCTION

This report presents the results of a rock mechanics instrumentation program titled: "Rock Mechanics Instrumentation Program for Kaiser Steel Corporation's Demonstration of Shield-Type Longwall Supports at York Canyon Mine, Raton, New Mexico" (Contract No. RD-R-0174). This instrumentation program was designed and implemented for Kaiser Steel Corporation's contract with the U.S. Bureau of Mines titled: "Demonstration of Shield-Type Longwall Supports at the York Canyon Mine, Raton, New Mexico" (Agreement No. S0144066, KSC Contract No. RD-R-0150).

The objective of this particular instrumentation program was to determine the response of the rock mass to longwall mining of a thick coal seam utilizing shield-type supports. Measurements were made in the rock along the ground surface, above the coal seam, in the coal seam and immediately below the coal seam.

The instrumentation program was specifically designed to provide the following information:

(1) Determine the occurrence, timing and magnitude of mining-induced subsidence.

(2) Provide a detailed description of the geologic setting of the longwall panel including the pertinent physical and engineering properties of the coal and surrounding strata and descriptions of all faulting and other major

geologic discontinuities.

(3) Determine the extent of strata separation and caving which occurred above the panel as a result of mining. To obtain this data, multiple-position borehole extensometers were installed in boreholes drilled from the surface through the coal seam.

(4) Determine the changes in stress in coal pillars adjacent to the panel and in the face abutment ahead of the advancing longwall panel face.

(5) Provide a thorough description of roof falls, floor heaving and other similar immediate (local) ground control problems.

(6) Thoroughly describe conditions encountered, methods and techniques used in negotiating shield-type supports through fault zones and/or coal seam displacements.

The longwall test panel instrumented for this study was denoted as the Fourth North panel (panel 4N). It had a pre-mining length of 2500 ft and a face width of 550 ft. The seam mining height in the panel area was approximately 10 ft. The average depth of overburden above test panel 4N is 350 ft although it ranges from 240 to 440 ft. Roof support at the face was provided by Hemscheidt shields. The shield-type supports weigh 12.5 tons each. They can be used in seam heights ranging from 5 ft 8 in. to 11 ft 9 in.

LOCATION

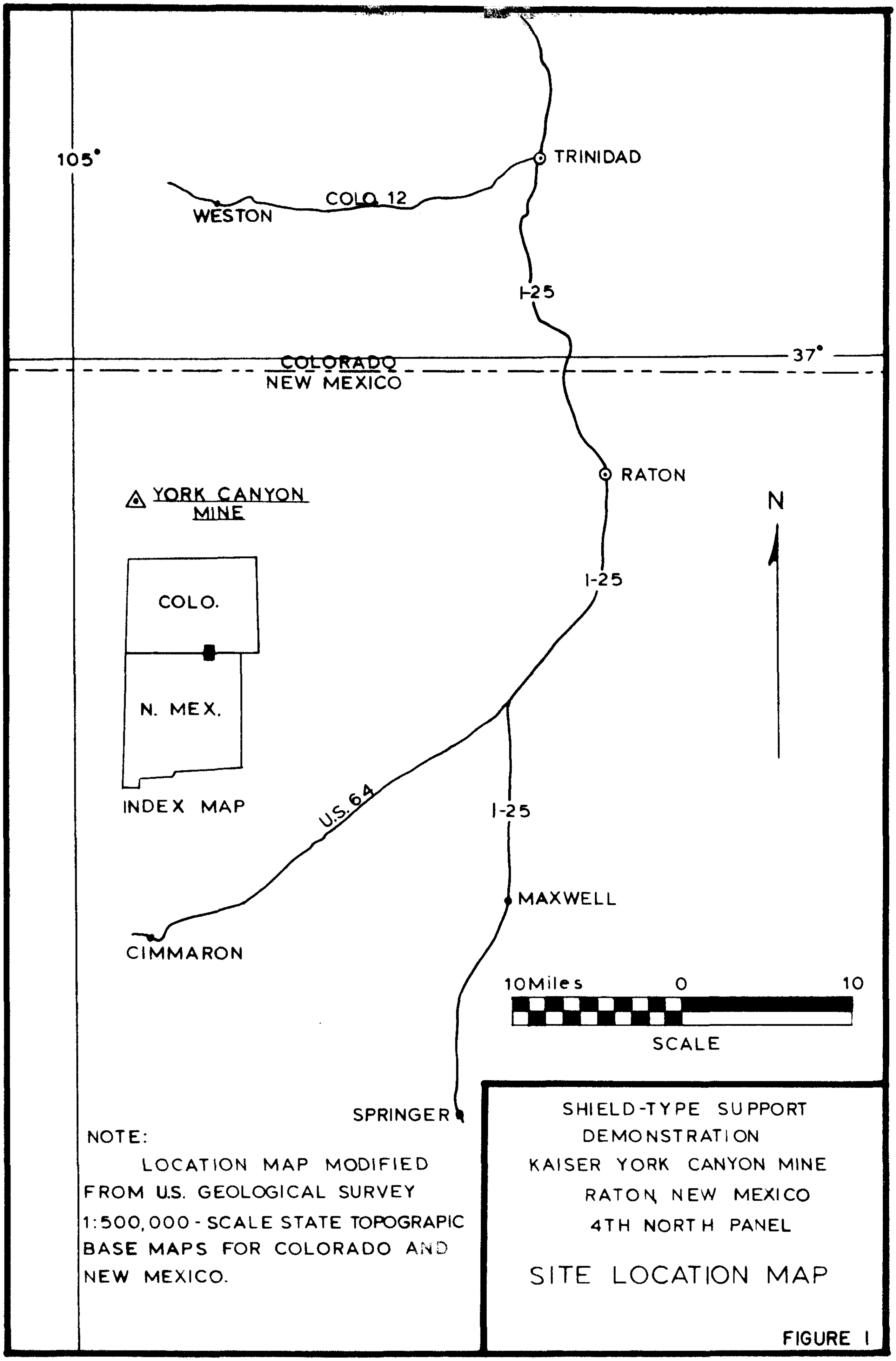
Kaiser Steel Corporation's York Canyon Mine is located approximately 40 miles west of Raton, New Mexico, and 10 miles south of the Colorado - New Mexico border in Township 31 North, Range 19 East (Figure 1). The demonstration panel was denoted as the Fourth North (4N) longwall. The panel was located approximately 3300 ft in from the Prospect Portal (Figure 2). The panel was 550 ft in width with a final mined-out panel length of 1537 ft at the headgate and 1602 ft at the tailgate. The panel centerline was oriented northwest-southeast and the direction of mining advance was towards the southeast.

TOPOGRAPHY

Regional Topography

The topography of the region is irregular, developed on variably resistant, slope-forming beds of sandstone, siltstone, shale and coal. York Canyon and Road Canyon are the principal drainages in the area and have provided the controlling factors in the development of topographic landforms.

The topography in the site area is composed of three principal landform types: flood plains, valley slopes and broad ridge crests. The flood plains are generally flat and featureless and range from 400 to 800 ft in width. The stream channels are entrenched 5 to 10 ft below the flood



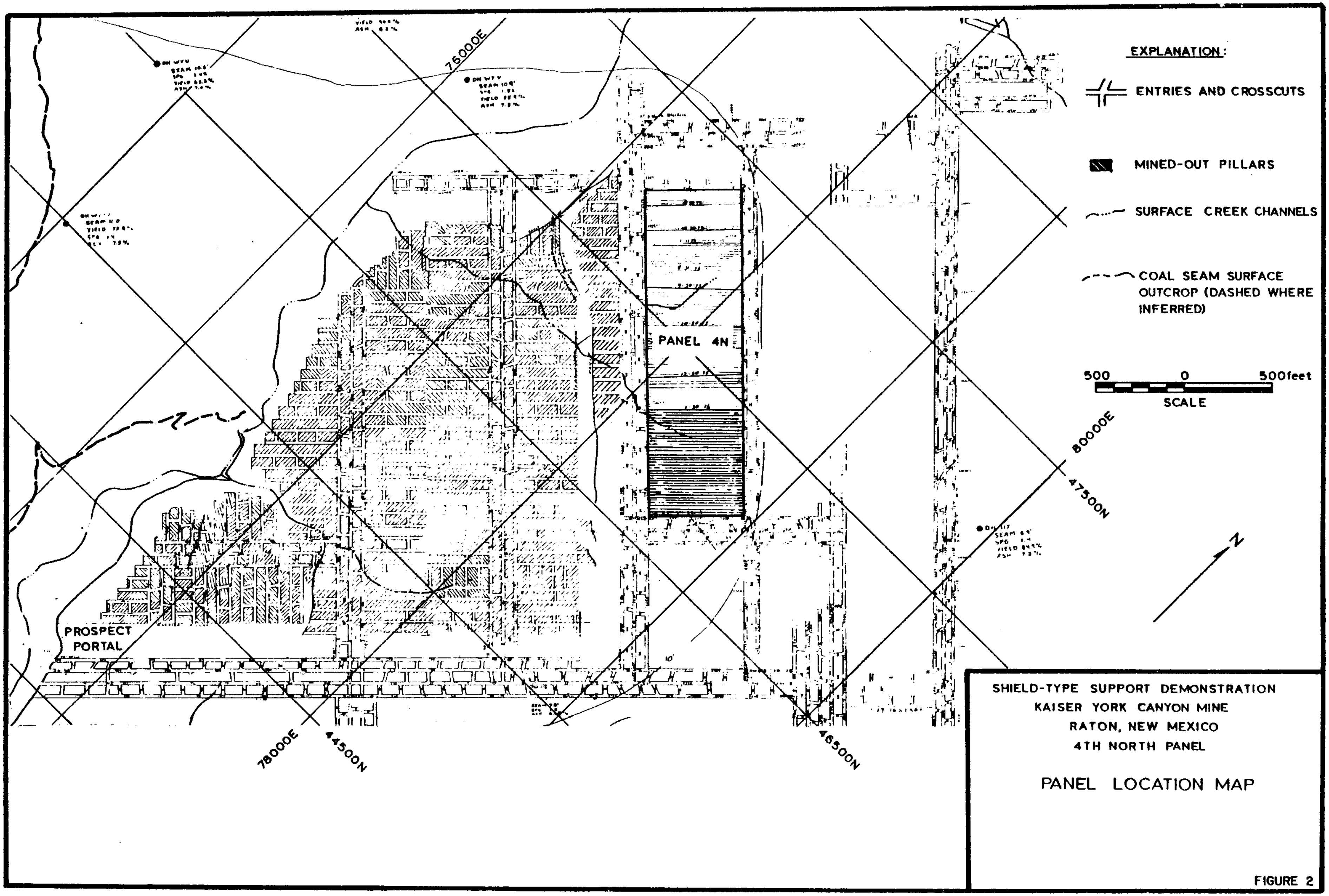
NOTE:

LOCATION MAP MODIFIED FROM U.S. GEOLOGICAL SURVEY 1:500,000-SCALE STATE TOPOGRAPIC BASE MAPS FOR COLORADO AND NEW MEXICO.

SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

SITE LOCATION MAP

FIGURE 1



SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

PANEL LOCATION MAP

FIGURE 2

plain surface. The ridges consist of broad, relatively level uplands that separate drainage areas. They are subparallel to the canyon trends and average from 500 to 1500 ft in width. The valley slopes are moderate, averaging between 8 and 9 degrees, and the horizontal distance from the edge of the flood plain to the edge of the ridge crest averages 4000 ft. The valley slopes generally exhibit several distinct terrace benches. As a result, the average 8 to 9 degree slope is actually composed of 15 to 20 degree slope segments connecting relative level, terrace benches, 400 to 500 ft wide.

Panel Topography

The topography above the test panel consists of a dissected, terraced valley slope which connects the flood plains of Road and York Canyon with the adjacent ridge crest (Figure 3). The slope dips moderately to the southwest and strikes north-south. The average slope angle is between 8 and 9 degrees but this represents slope segments of 10 to 20 degrees that connect the terrace benches.

The slope has been modified with a system of subparallel gullies which serve as primary tributaries to York Canyon. These gullies trend east-west to northeast-southwest. The gully sides are north and south facing with slope angles from 12 to 16 degrees above the test panel. The gullies are separated by narrow ridges, 100 to 200 ft wide. The difference

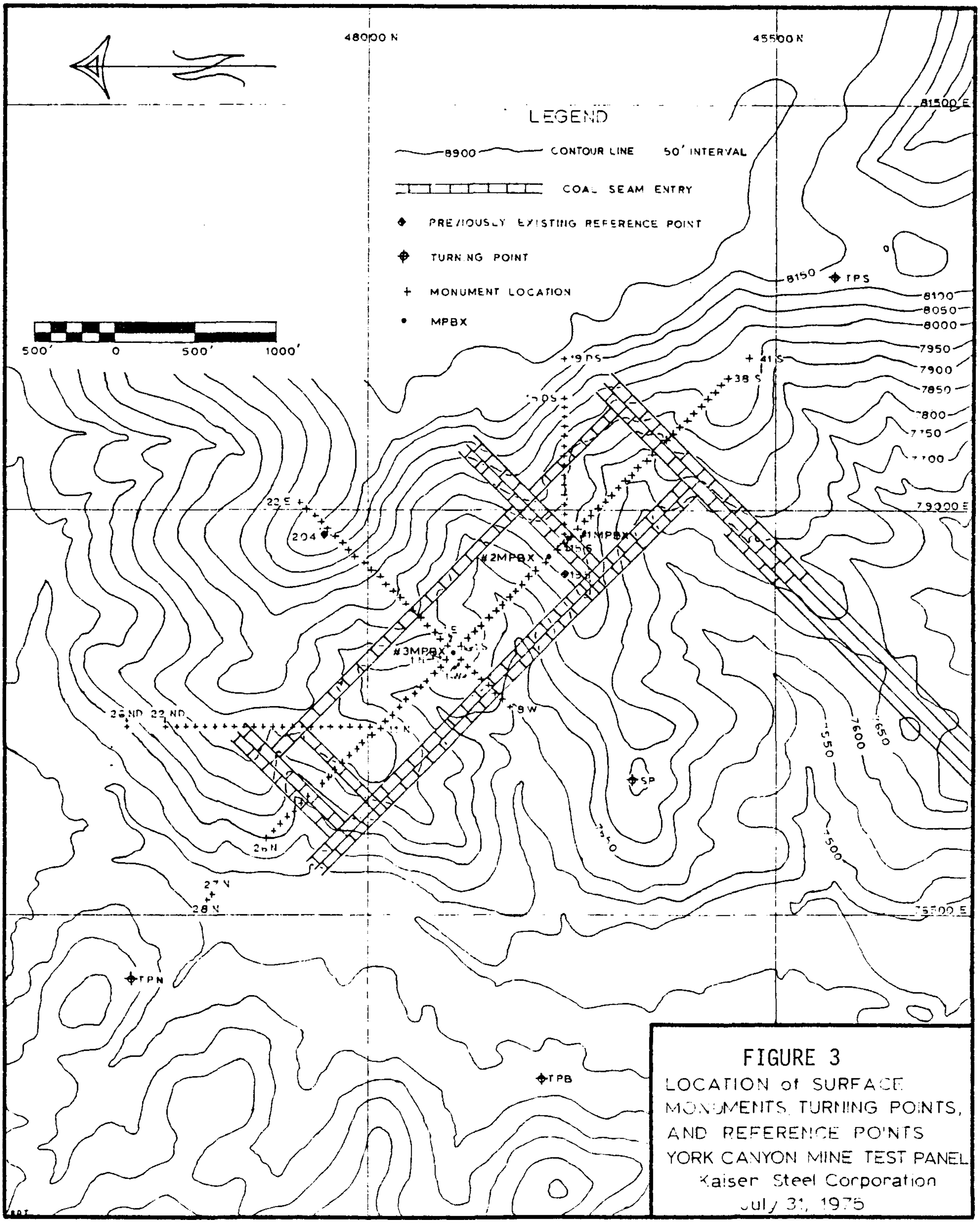


FIGURE 3
LOCATION of SURFACE MONUMENTS, TURNING POINTS, AND REFERENCE POINTS
YORK CANYON MINE TEST PANEL
Kaiser Steel Corporation
July 31, 1975

PHOTO 1 TOPOGRAPHY ALONG PANEL CENTERLINE

in the elevation from ridge to gully bottom varies between 100 and 200 ft and averages 175 ft. Two of these gullies, spaced 800 ft apart, intersect the panel centerline (Figure 3).

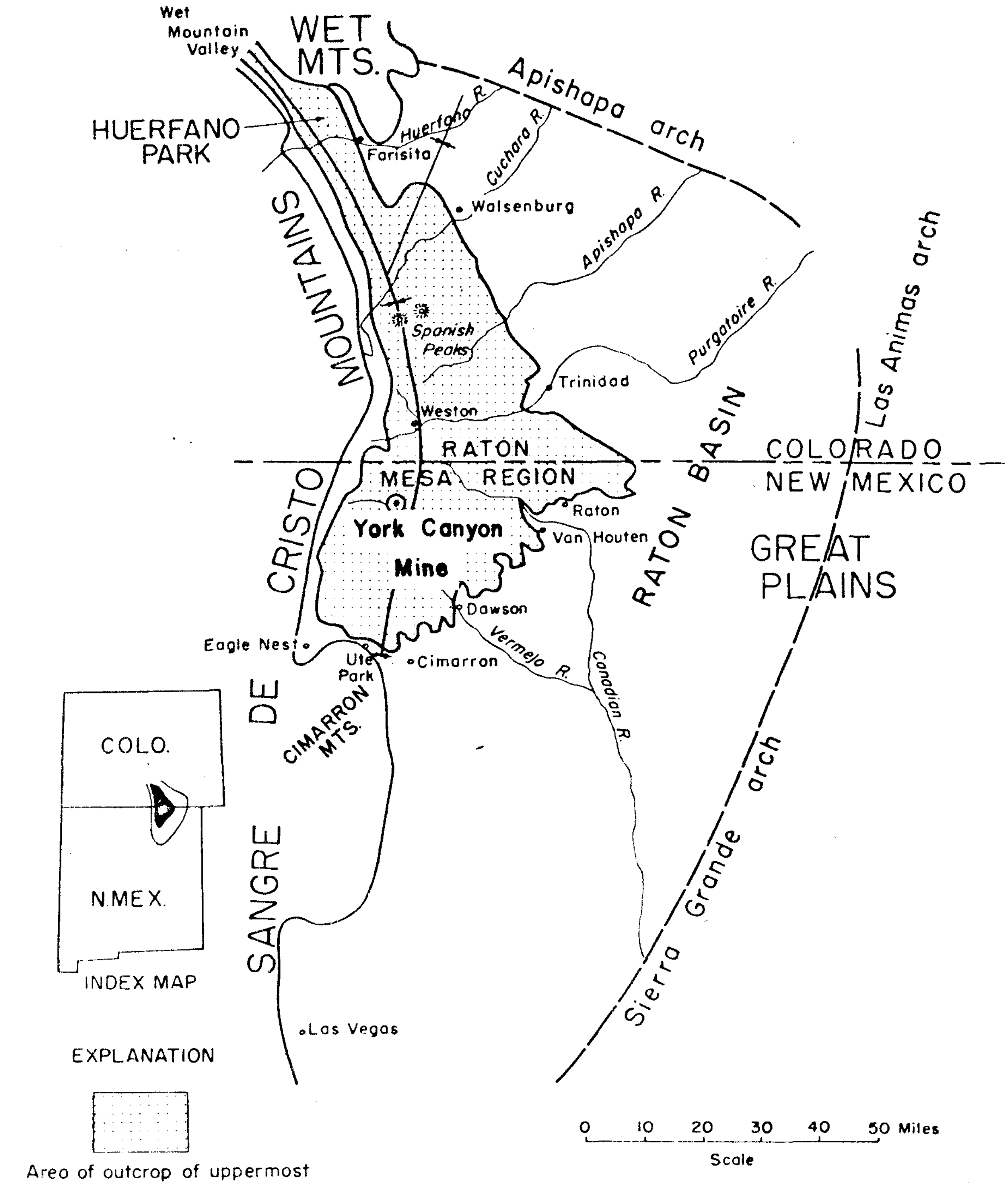
The panel centerline approximately parallels the slope trend (Figure 3). Elevations are higher along the headgate (northeast) side of the panel. Elevations vary from a high of approximately 7900 ft at the southeast corner of the panel to a low of 7650 ft in the gully bottoms along the central portion of the panel. The elevation at the northwest corner of the panel is approximately 7750 ft.

Development of the topography is controlled by the geologic framework. Ridges are generally capped by sandstone while valley bottoms are underlain by shale. Most topography elements are developed along the north-south, east-west or northwest-southeast trends which parallel the regional joint patterns and geologic structure.

GEOLOGY

Regional Geologic Setting

The York Canyon Mine is located in the southern part of the Raton Basin (Figure 4). The Raton Basin is a large arcuate structural and depositional trough that extends roughly from Huerfano Park, Colorado, to Cimmarron, New Mexico (Pillmore, 1969, p. 125). The basin is asymmetrical, with a steep western limb and a gently dipping eastern limb (Woodward and Snyder, 1976, p. 126). The basin is bounded on



EXPLANATION

Area of outcrop of uppermost Cretaceous and lower and middle Tertiary formations.

Axial trace of Raton basin

NOTES:

1. Map modified from Johnson and others, 1966, p. 89, Fig. 1.

2. Regional stratigraphic section is presented on Fig. 6.

SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

REGIONAL GEOLOGIC MAP

FIGURE 4

the west by the foothills of the Sangre de Cristo Mountains and on the east by the Sierra Grande-Las Animas Arch (Johnson and others, 1966, p. 88). To the south, the basin merges with faulting and folding into the Cimmarron Mountains (Johnson and others, 1966, p. 88).

The development of the Raton Basin began during Late Cretaceous time when the North American plate drifted over an eastward dipping subduction zone (Woodward and Snyder, 1976, p. 126). The principal direction of crustal movement during deformation was oriented vertically. Compressional stresses, related to crustal shortening, were subsidiary (Woodward and Snyder, 1976, p. 126). As the Sangre de Cristo uplift began to rise, the adjacent Raton Basin began to sink as thick continental sediments were deposited (Woodward and Snyder, 1976, p. 126).

Sedimentary rocks comprise a majority of the stratigraphic sequence within the Raton Basin. The section consists of alternating shales, sandstones and siltstones with lenses of coal. The rocks are subdivided into five formations (Figure 5) and vary in age from Late Cretaceous to Paleocene (Pillmore, 1969, p. 125). The stratigraphic section represents the final regression of the Cretaceous sea and the subsequent deposition of sand, silt, mud and carbonaceous debris on low-lying flood plains, in coastal swamps and on deltas (Johnson and others, 1966, p. 94).

Tertiary dikes and sills of considerable lateral extent

AGE		FORMATION	LITHOLOGY
TERTIARY	PALEOCENE	POISON CANYON FORMATION	Medium - to very course-grained sandstone with interbedded shale.
TERTIARY / CRETACEOUS	PALEOCENE / UPPER CRETACEOUS	RATON FORMATION	Fine- to course-grained arkosic sandstone with interbedded gray shale and coal beds.
CRETACEOUS	UPPER CRETACEOUS	VERMEJO FORMATION	Interbedded gray shale, carbonaceous shale, coal beds and gray arkosic sandstone (NON-MARINE).
CRETACEOUS	UPPER CRETACEOUS	TRINIDAD SANDSTONE	Buff to gray, fine- to medium-grained arkosic sandstone (TRANSITIONAL).
CRETACEOUS	UPPER CRETACEOUS	PIERRE SHALE	Dark gray, non-calcareous shale (MARINE).

NOTES:

1. Modified from Pillmore, 1969, p. 129, Table 1 and Clark, 1966, p. 60 - 61.
2. A Regional Geologic Map is presented on Figure 5.

SHIELD-TYPE SUPPORT
DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

REGIONAL STRATIGRAPHIC SECTION

FIGURE 5

have been intruded throughout the area, locally destroying large amounts of coal (Pillmore, 1969, p. 125). However, the instrusives are not present in the area of the mine.

Panel Geology

The York Canyon Mine produces coal from the York Canyon seam in the coal-bearing zone of the Raton Formation (Pillmore, 1969, p. 134-135).

The coal bearing zone consists of variably resistant, mostly slope-forming beds of sandstone, siltstone, mudstone and shale, with locally occurring coal beds of minable thickness (Pillmore, 1969, p. 129).

Stratigraphy:

A program of field observations, cored test borings and borehole geophysical logging was utilized to determine the stratigraphic relationships of the geologic materials above panel 4N. Field observations consisted of the inspection of surface outcrops above the panel and measurements of coal seam stratigraphic relationships in the entries adjacent to the panel.

Cored test borings were drilled into the roof and floor strata in entries adjacent to panel 4N. The borings were generally oriented vertically, but some were drilled at an angle of 45^{o} to better define the contact relationship between the coal and the near-roof and floor rock strata. The borings were drilled to depths of 15 to 20 ft.

Geophysical borehole logging was performed by Kaiser personnel on three boreholes drilled into the panel for the installation of multiple position borehole extensometers (MPBX). These logs, in conjunction with logs of cuttings for each hole, were utilized to provide additional stratigraphic data for the central portion of the panel.

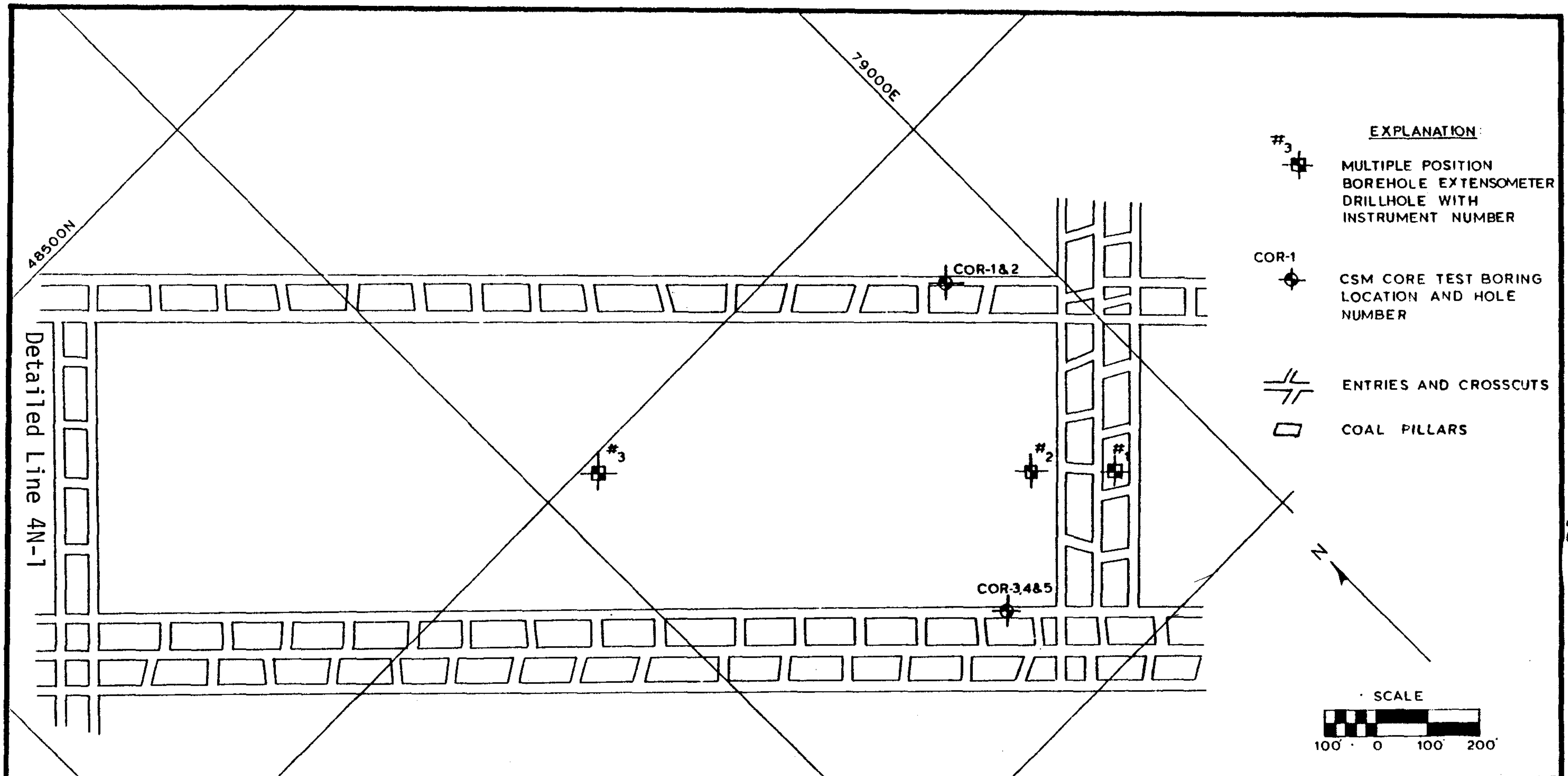
Figure 6 shows the locations of the cored test borings, and Figures 3 and 6 show the location of the MPBX boreholes. Appendix A presents descriptions of the field methods utilized to determine the panel stratigraphy.

The stratigraphic section above panel 4N is composed of two components: the rock overburden and an overlying veneer of unconsolidated soils and weathered bedrock.

Unconsolidated Overburden: The unconsolidated overburden is divided into soils developed in place and soils deposited in the area after a transportation phase.

The transported soils above the test panel are generally colluvial, alluvial or a combination of both. A colluvial material is that which has been deposited by the action of gravity. The soils covering the slopes above the test panel are principally colluvial in nature. These soils are derived from outcrops of sandstone and shale and are composed of 30 to 50 percent, blocky, flaggy and slabby fragments of sandstone and siltstone in a sandy, silty, clayey matrix.

Detailed Line 4N-1



SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

LOCATION OF TEST BORINGS

FIGURE 6

An alluvial material is that which has been deposited by the action of water. Alluvial deposits above the test panel are restricted to the gullies or draws dissecting the slopes. These soils are similar in composition to the colluvial soils but the percentage of the coarse faction is greater.

The in-place soils are principally restricted to the tops of terrace benches and along the ridge lines. The compostion is variable, depending upon the underlying parent material. Where the parent material is sandstone, the soil tends to be a sandy clay with numerous sandstone fragments. Soils derived from shale bedrock tend to be silty clays with only occasional sandstone fragments.

The thickness of the unconsolidated overburden is variable and depends upon the location. Thinnest deposits occur along the slopes where the average thickness is generally less than 5 ft. The thickest deposits occur along the bottoms of the draws or gullies where thickness of up to 20 ft have been observed in road cuts. The in-place soils occurring along the ridge lines and on the terrace benches appear to average 7 ft or less in thickness.

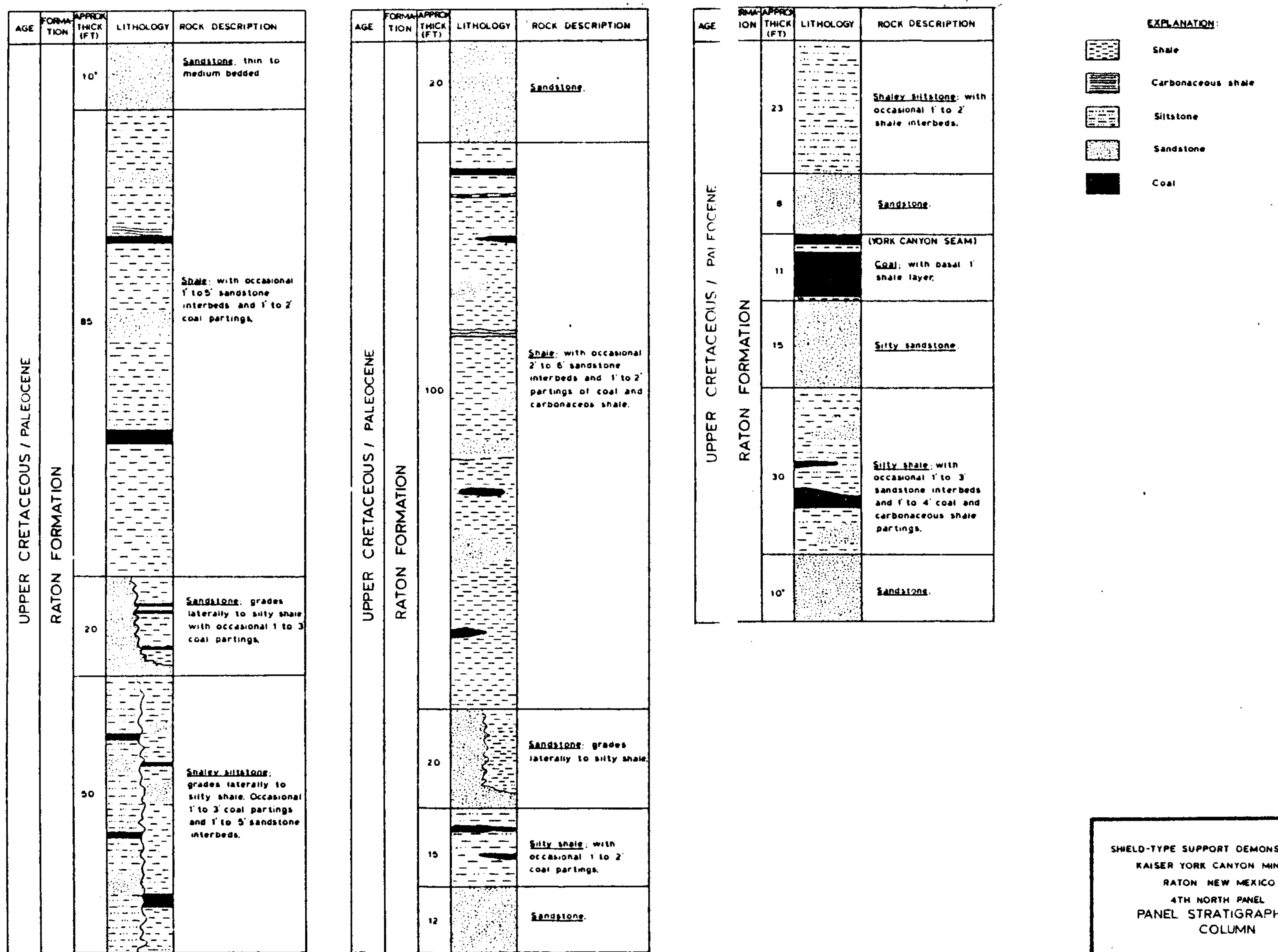
All soils are underlain by a zone of weathered bedrock. The thickness of this zone tends to be fairly constant throughout the area above panel 4N and is apparently independent of rock lithology. A geophsical velocity profile performed over panel 4N indicated a low velocity layer (approximately 1500 ft/sec) down to about 35 ft. This correlates well with the logs of cuttings from the MPBX holes in the area of panels 5N and 6N. The cuttings logs indicate weathering of the bedrock down to depths of 30 to 50 ft.

Rock Overburden: The stratigraphy of the rock overburden above panel 4N is complex, representing deposition of fine-grained sand, silt, mud and carbonaceous material on flood plains, in swamps and on prograding deltas (Johnson and others, 1966, p. 96). Rock layers tend to be thin with rapid lateral variations in lithology.

The stratigraphic section is composed principally of shale with numerous thin beds of sandstone, siltstone, carbonaceous shale and locally occurring lenses of coal. Occasional sandstone channel deposits are present within the stratigraphic sequence. A generalized stratigraphic section, representing the typical lithologic seccession above panel 4N, is presented on Figure 7. The following table summarizes the relative percentages of the various lithologies encountered in the boreholes drilled for the installation of MPBX instrumentation.

RELATIVE PERCENTAGES OF VARIOUS ROCK
LITHOLOGIES IN OVERBURDEN

MPBX Hole	Shale (%)	Sandstone (%)	Siltstone (%)	Carbonaceous Shale (%)	Coal (%)
4N-3	45	38	7	4	6
4N-2	53	13	25	1	8
4N-1	71	12	4	7	6



SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON NEW MEXICO
4TH NORTH PANEL
PANEL STRATIGRAPHIC COLUMN

FIGURE 7

The predominate lithology above panel 4N is shale which comprises 40 to 50 percent of the stratigraphic section. The shale units tend to be thinly laminated, locally calcareous and contain numerous thin interbeds of siltstone, sandstone and carbonaceous material.

The units generally lack strength and locally exhibit slickensided fracture planes. When exposed in outcrop, the shales are slope-forming and weather to silty clays. Unit thicknesses vary from a few feet to over 100 feet. The average bed thickness observed in outcrops and in the MPBX boreholes in the area of panel 4N is about 15 to 20 ft.

Sandstone units comprise approximately 20 percent of the stratigraphic section above the test panel. These units occur as widespread beds with variable thickness and locally occur as channel-type deposits with variable thickness and lateral extent. The beds are generally laminated to thin bedded, fine- to medium-grained quartz in a matrix of silt, shale and calcareous cement. The beds locally contain numerous thin partings of shale and carbonaceous material. The channel deposits tend to be similar in composition but are more massive and exhibit cross-bedding. While they were not observed in the panel area, these channel deposits locally exhibit slump faulting (Zuess, 1967, p. 60). The sandstones are competent, strong units. When exposed in outcrop, the units form vertical to near-vertical slopes and weather into blocky, flaggy and slabby fragments. Unit thicknesses for the bedded deposits vary from a few feet to a maximum observed thickness of about 20 ft. The channel deposits vary in thickness from 5 ft to about 40 ft.

Siltstone comprises approximately 10 percent of the stratigraphic section in the panel area. The siltstones contain variable amounts of sand and shale in the matrix, and the units are generally laminated to medium bedded. Unit thicknesses vary from less than one foot to a maximum of about 20 ft. The siltstone units generally lack strength although locally, where the percentage of shale in the matrix is low, the units are very competent. When exposed in outcrop the units are generally slope-forming and weather to clayey silts and silty clays.

Coal, bony coal and carbonaceous shale comprise the remainder of the stratigraphic section in the panel area. These units are generally thinly laminated to thin bedded and vary in thickness from less than one foot to a maximum of about 5 ft. They are generally incompetent units and lack strength. When exposed in outcrop the units are slope-forming and weather to silty clays.

The rapid lateral and vertical variations of lithology within the stratigraphic section make a detailed presentation of the geologic framework difficult. It is possible only to present a generalized picture of the vertical and lateral distribution for the strata above panel 4N.

The geophysical data indicates that there is a general increase in the amount of shale in the overburden section in the direction of face advance (southeast). The following table indicates that this increasing shale content is concentrated in fewer beds.

PERCENT OF BEDS IN OVERBURDEN EXHIBITING
A PARTICULAR LITHOLOGY

MPBX Hole	Shale (%)	Sandstone (%)	Siltstone (%)	Carbonaceous Shale (%)	Coal (%)
4N-3	44	21	16	11	8
4N-2	51	9	26	4	10
4N-1	43	13	11	16	18

The overburden above panel 4N grades laterally towards the southeast with thickening shale beds and a corresponding decrease in the sandstone content. The siltstone content is locally variable with no significant trends apparent. The coal and carbonaceous shale content is relatively constant, but the number of beds tends to increase towards the southeast as a result of the increasing shale section.

The stratigraphy of the coal seam and adjacent roof and floor rocks is illustrated on Figure 8.

The York Canyon seam averages about 12.0 ft in thickness throughout the longwall panel. The main part of the seam is a 9-ft bed of high volatile, A-bituminous, banded coal. Above

THICKNESS (FT)	LITHOLOGY	ROCK DESCRIPTION
8.0+		SILTSTONE; medium dark gray; shaley with a trace of fine sand; carbonaceous; thinly laminated; firm to strong.
6.0 - 15.0		SANDSTONE; medium dark gray; carbonaceous; medium-to-fine-grained; laminated to medium bedded with occasional 0.01' carbonaceous partings; strong.
1.0 - 1.5		COAL; black; shaley; banded; firm.
0.7 - 1.5		SHALE; carbonaceous; weak to firm.
8.0 - 10.0		COAL; black; banded; A-bituminous; occasional 0.1' to 0.3' siltstone partings; firm to strong.
0.8		SHALE; carbonaceous; weak to firm.
13.0		SANDSTONE; medium gray; carbonaceous; medium to very fine-grained; laminated to thin bedded with 25% carbonaceous laminations; strong.
1.0+		SHALE; carbonaceous; firm.

SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

COAL SEAM STRATIGRAPHY

FIGURE 8

this bed is a layer of thinly laminated, carbonaceous shale. This shale layer varies in thickness from 0.7 ft at the northwest end of the panel to about 1.5 ft at the southeast end. This shale layer separates the lower, main coal unit from the top or roof coal. This roof coal bed averages 1 ft to 1.5 ft in thickness throughout the panel. Development work generally extracts the complete 12-ft section while the average thickness mined by the longwall operation is 1.03 ft, leaving a portion of the top coal.

The roof immediately above the coal seam consists of a sandstone unit and an overlying siltstone unit. The sandstone unit is medium- to fine-grained, fresh and strong. While the unit has a laminated to thin bedded structure, the bonding between beds is very strong and the sandstone acts as a single, massive unit. The thickness varies from 6 ft to 15 ft and averages 8 ft. The siltstone unit is thinly laminated to medium bedded, shaley and contains a trace of fine sand. The test borings into the roof never penetrated the entire unit. The maximum thickness cored was 8 ft.

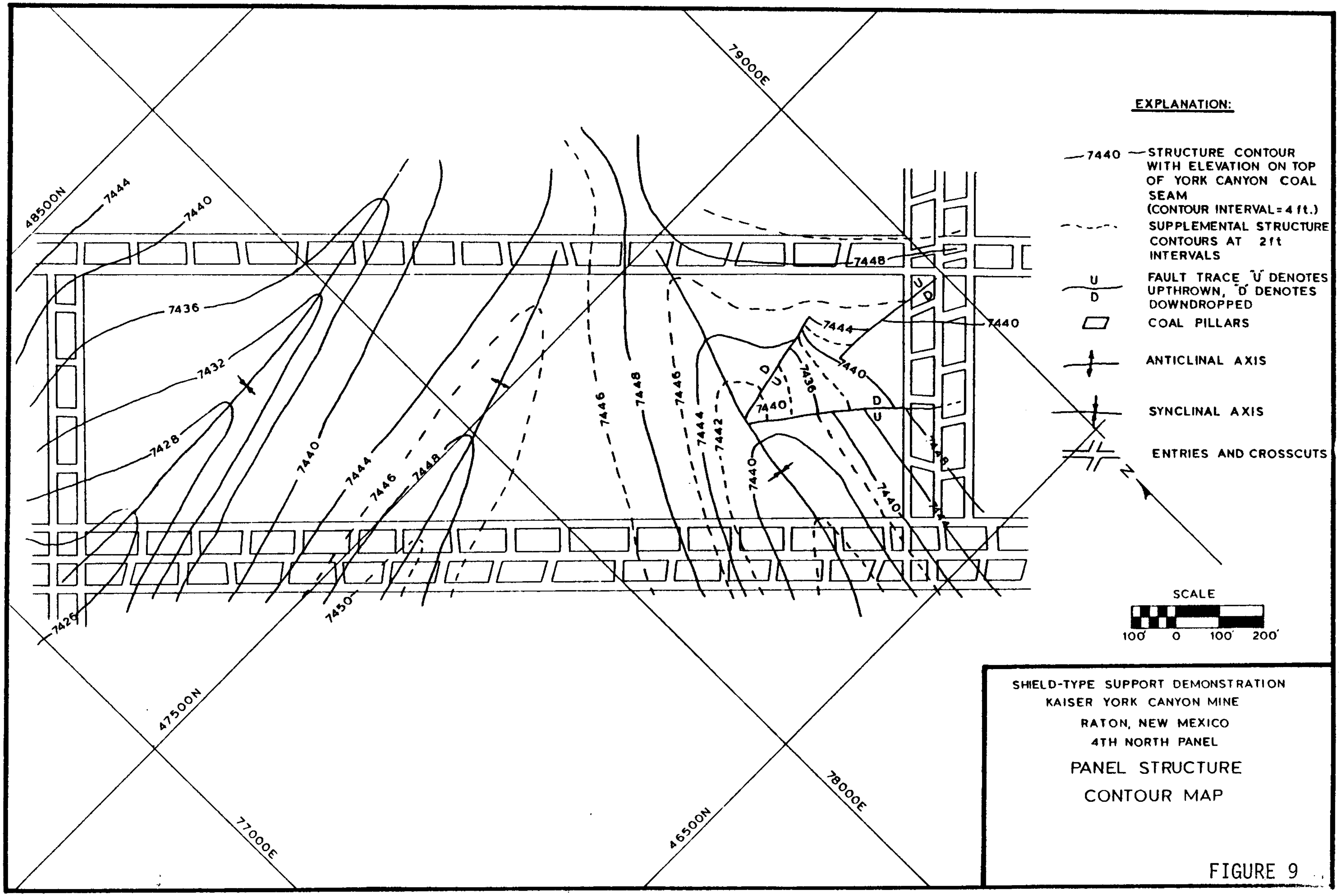
The floor immediately below the coal seam consists of a thin shale layer with an average thickness of less than 1 ft. The shale layer overlies a medium- to fine-grained, laminated to thin bedded sandstone unit. The sandstone is fresh and strong but contains weaker beds composed of numerous thin partings of coal and carbonaceous siltstone. The thickness averaged 13 ft in the core test borings. In the area of panel 4N the sandstone unit overlies a thinly laminated, firm, carbonaceous shale of undetermined thickness.

Geologic Structure:

The geologic structure of the coal seam and surrounding rock strata was determined through a program of field investigations performed underground in the area of panel 4N, on the surface above the panel and in the open strip mining pit. A description of the field methods utilized is presented in Appendix A.

In the area of the panel, the coal seam and surrounding units are essentially flat-lying with an average strike of approximately N20°W. This trend is modified by shallow folding and localized faulting throughout the panel area. The folding consists of small-scale anticlinal and synclinal forms that are probably related to differential compaction and consolidation of underlying sediments. Figure 9 presents a structure contour map drawn on the top of the coal seam. This figure indicates the orientations and locations of the faults and folds located within the panel area.

Jointing Patterns: Jointing and fracture patterns within the coal seam and surrounding rock were determined with the detailed line method described by Savely (1972). This method is described briefly in Appendix A. A total of six detailed



SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

PANEL STRUCTURE CONTOUR MAP

FIGURE 9

line surveys were performed; five underground, adjacent to panels 4N, 5N and 6N, and one along the headwall of the open strip mining pit. The location of the underground line (4N-1) adjacent to panel 4N is shown on Figure 6. Figure 10 presents Schmidt Equal Area Net plots of the structural data. The following table summarizes the joint data recorded at station 4N-1 and at the headwall of the open pit.

SUMMARY OF MEASURED JOINT ORIENTATIONS

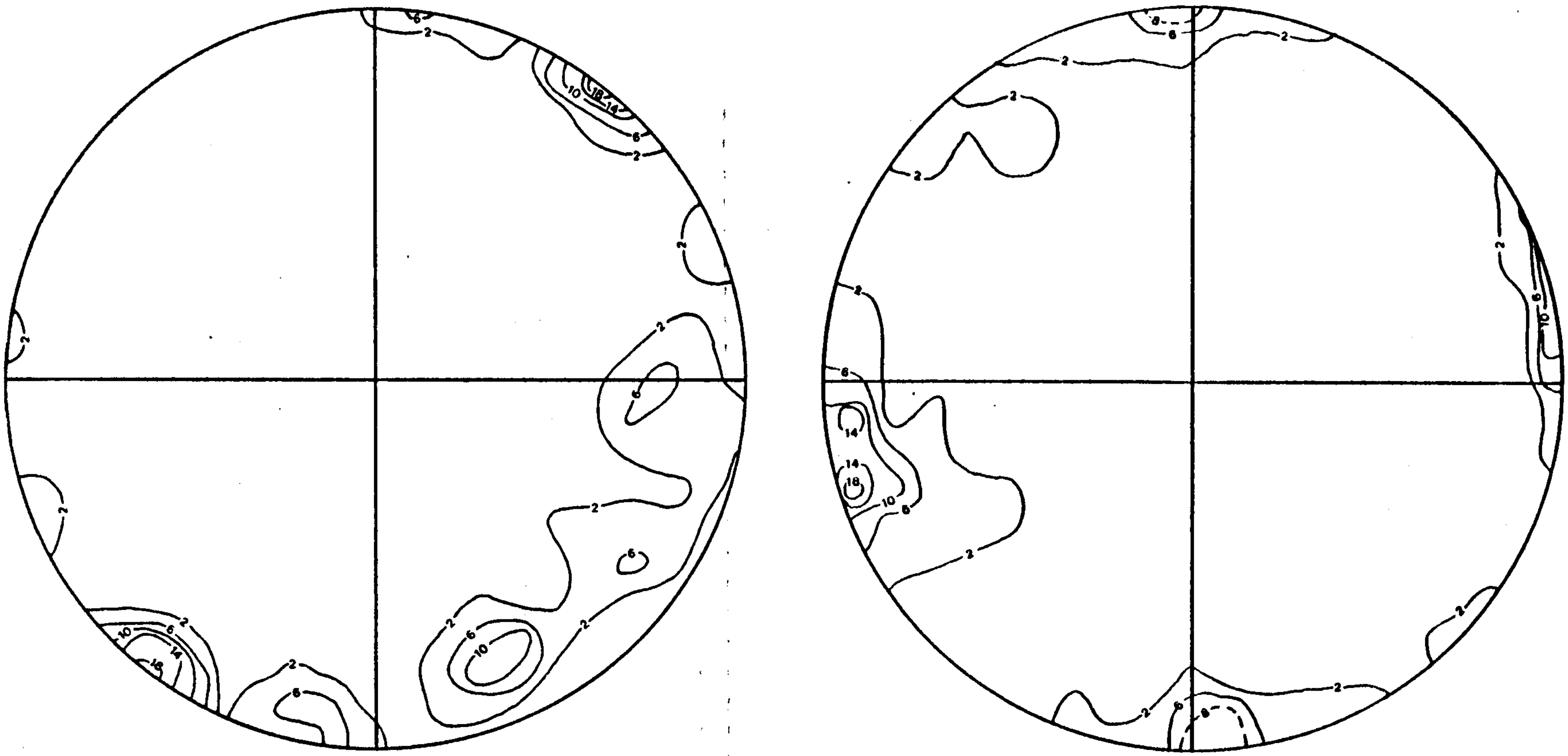
Location	Percent Total Points	Strike	Dip (°)	Notes
4N-1	19.2	N53°W	Vert	Butt cleat
	11.5	N80°E	75NW	Face cleat
	9.0	N77°W	83NE	
Roof	18.1	N18°W	88NE	Minor set
Sand-Stone	14.5	N06°W	82NE	Minor set
	9.6	E-W	Vert	Major set

The determination of the major and minor joint orientations was based on the following factors:

1. Frequency of occurrence
2. Trace length

78 TOTAL POINTS PLOTTED — NORTH

83 TOTAL POINTS PLOTTED — NORTH



4N - 1

ROOF SANDSTONE

EXPLANATION

—— CONTOUR LINE

---- SUPPLEMENTAL CONTOUR

CONTOUR INTERVALS: 2-6-10-14-18-22%

FIG. 10. LOWER HEMISPHERE SCHMIDT EQUAL AREA PLOTS OF POLES TO JOINTS FROM DETAILED LINES

3. Continuity

4. Spacing

5. Termination relationships

The joint orientation selected as the face cleat, or the major set, tended to be longer, more continuous and more widely spaced than the other orientations. This principal orientation generally cut across the other joint trends.

The face cleat in the 4N seam trended east-west (N80^{o}E to N77^{o}W) with a high-angle northerly dip. Cleat spacing averaged between 2 and 3 ft with a maximum spacing of 5 ft and a minimum spacing of about 6 inches. The face cleat exhibited smooth, planar surfaces. It tended to be closed to locally open up to 0.01 ft. Lateral continuity and length averaged from 5 to 12 ft.

The butt cleat trended N43^{o}W with a near-vertical dip. The cleat spacing averaged between 1 and 2 ft with a maximum spacing of about 4 ft and a minimum spacing of about 1 inch. The butt cleat exhibited irregular, curvilinear surfaces which tended to be calcite coated. The cleat was generally open (up to 0.01 ft) to locally closed. Lateral continuity and length both averaged less than 5 ft.

Jointing patterns in the overlying sandstones were determined from observations in entries adjacent to the longwall panel, on the outcrop and a detailed structural data line along the headwall in the open pit.

Two significant joint trends were apparent in the roof sandstone: the major set striking east-west and the minor set with an average strike of N12^{o}W. Dips tended to be vertical to steeply inclined to the north. Joint spacing averaged 3 to 5 ft with a maximum spacing of 5 to 8 ft. The minimum spacing was approximately 1 ft. Joint surfaces tended to be planar and smooth. Joints observed underground were generally tight while surface joints were open up to 0.1 ft.

The face cleat is related to the major joint trend. In some locations, individual joints could be traced from the floor through the coal seam and into the capping sandstone. The butt cleat did not appear to be related to the minor joint set. The butt cleat generally terminated at the capping sandstone.

Examination of joint relationships in outcrop and along the headwall in the open pit indicated that individual joints were well developed in the stronger sandstone units and thin shale and siltstone units, but they tended to die out vertically in the thicker, less competent, shale units. In many cases an individual joint could not be traced within a shale unit thicker than 5 ft while it is well developed within overlying and underlying sandstone beds.

Faulting: The faulting encountered during mining operations in the York Canyon Mine could be grouped into three general patterns. Two of the patterns exhibited specific trends while the third type of faulting was characterized by random distribution and orientations.

The two specific trends were oriented approximately north-south and N45°W. They were defined by zones of subparallel, normal faulting with variable offsets and by zones of highly fractured, unstable of "bad" roof.

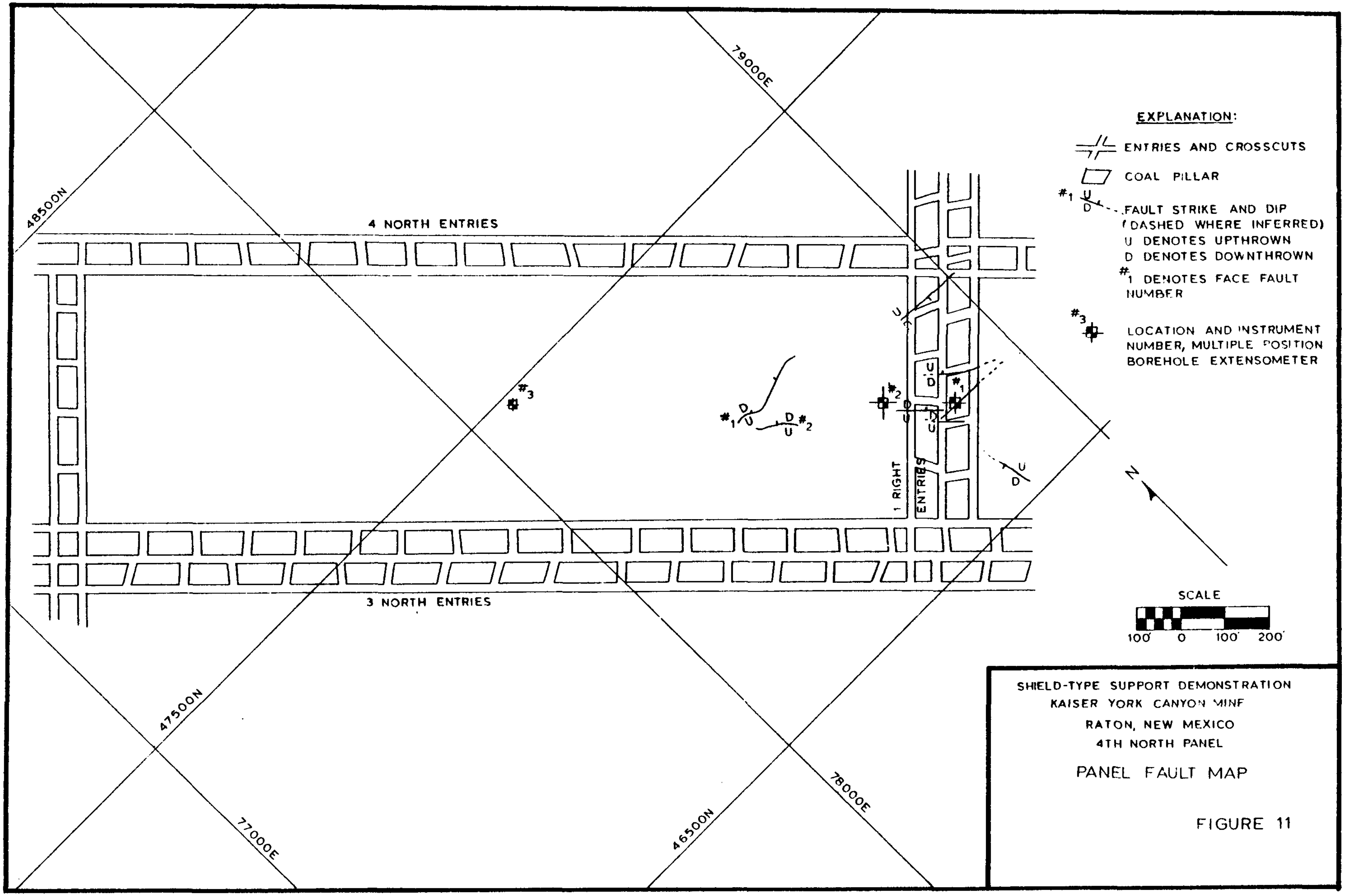
The north-south orientation was subparallel with the minor joint set observed in the rock strata overlying the coal seam. This orientation follows the trend of major structural elements in the region. The Sangre de Cristo Mountains and the Raton Basin, as well as related small-scale folding and faulting, all trend approximately north-south (Baltz and Bachman, 1956, p. 107-108, Clark, 1966, Figure 1 and p. 62-64 and Woodward and Snyder, 1976, map and p. 125-127). The N45°W orientation was subparallel to the butt cleat observed in the coal seam.

Faulting along both orientations exhibited normal-type displacements and appeared to have resulted from tensional stresses developed during the Cenozoic epeirogenic rise of the Raton Basin (Woodward and Snyder, 1976, p. 126).

The randomly oriented faulting encountered in the mine was most probably related to differential consolidation of sedimentary units within the stratigraphic sequence. According to Pillmore (1976, p. 250), thicknesses of sediment composed of vegetal trash, clay and mud are more compactible than comparable thicknesses of sand or silt. As a result, faulting occurs around the margins of the sand and silt areas. Zuess (1967, p. 60) observed numerous examples of deformation resulting from slumping in trough crossbedding in channel sandstones. The random faulting was probably formed either during deposition or just after deposition was completed.

The linears defined by zones of faulting and poor quality roof extend for distances of up to 6000 ft. However, the lateral extent of individual faults within these zones is generally less than 500 ft. Displacements on these faults vary from less than 1 ft to over 20 ft. While definitive data is lacking, it appears that most faulting dies out in the vertical direction. This is a result of the penecontemporaneous nature of some of the faulting and the tendency for the shale units to absorb deformation. The faulting tends to die out in the less competent strata where failure is plastic in nature as opposed to semi-brittle failure in the more competent strata.

Three separate fault zones were encountered within panel 4N or adjacent to it. The locations of these fault zones are shown on Figure 11. One of the fault zones was located within the panel and one was located at the southeast end of the panel along the First Right entry. The third zone was encountered during pillar robbing operations in the Third North entry adjacent to the panel on the southwest (tailgate) side. The Third North and First Right faulting

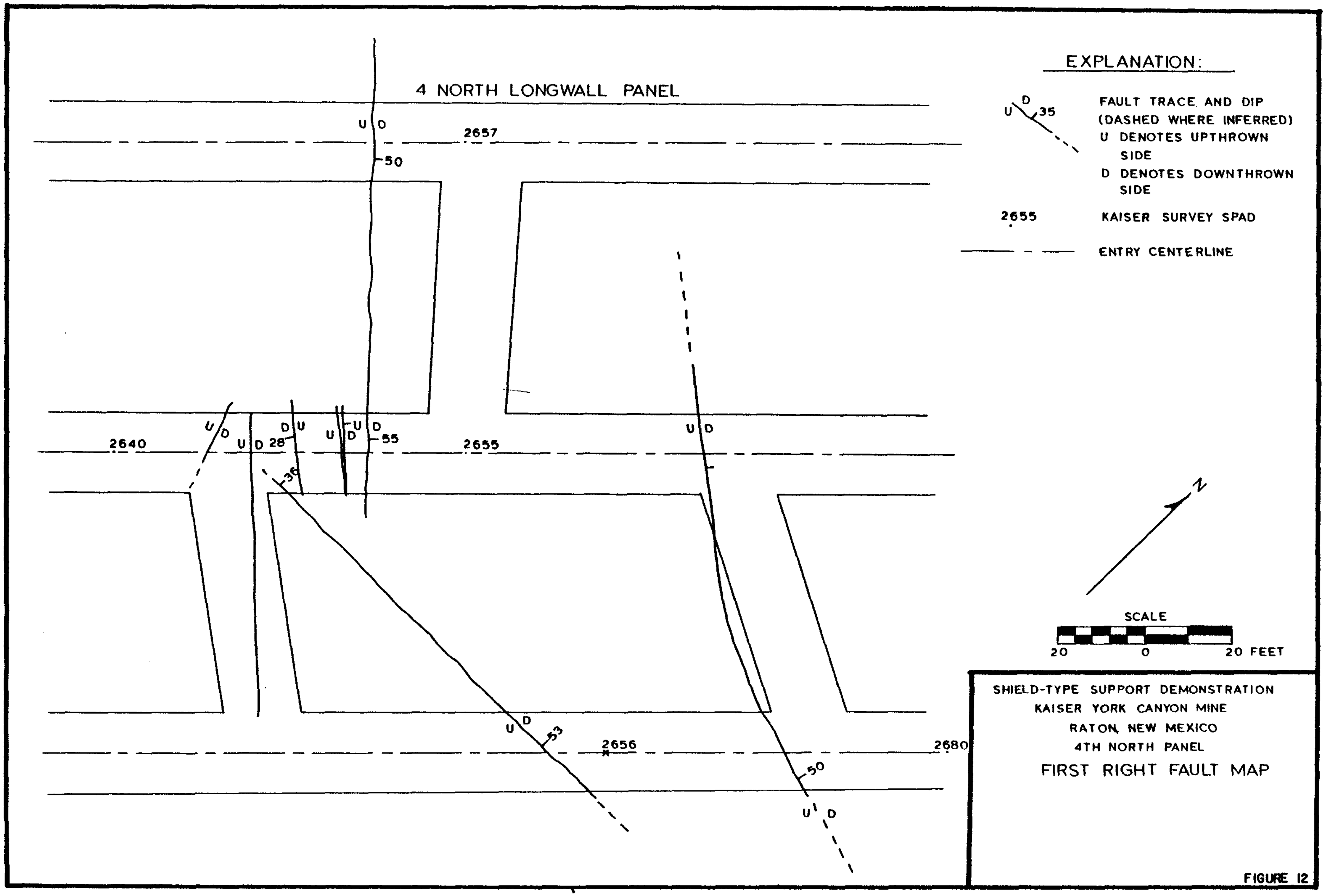

79000E
48500N
47500N
46500N
77000E
78000E
4 NORTH ENTRIES
3 NORTH ENTRIES
1 RIGHT ENTRIES
#3
#1
#2
U
D
N
EXPLANATION:
ENTRIES AND CROSSCUTS
COAL PILLAR
FAULT STRIKE AND DIP (DASHED WHERE INFERRED)
U DENOTES UPTHROWN
D DENOTES DOWNTHROWN
#1 DENOTES FACE FAULT NUMBER
LOCATION AND INSTRUMENT NUMBER, MULTIPLE POSITION BOREHOLE EXTENSOMETER
SCALE
100' 0 100' 200'
SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL
PANEL FAULT MAP
FIGURE 11

followed the N45°W trend. The Third North fault was a normal fault of indeterminate offset with a lateral extent of about 2300 ft. The First Right zone was a series of subparallel normal faults which generally dipped to the northeast with offsets of 1 to 15 ft. The individual faults within this zone died out laterally and averaged about 150 ft in length. A detailed map of the main fault zone along First Right is presented on Figure 12. In addition to the major fault zone, a single fault, which trended N85°W and dipped south, occurred along First Right near the headgate entry (Figure 8).

The faulting encountered along the longwall face consisted of two faults as shown on Figure 11 and 13. These faults exhibited two trends: N50°W and east-west.

Fault #1 (Figure 13) was the first fault encountered along the working face. It was a normal fault, which trended east-west and dipped to the north. Offsets observed along the working face varied from less than 1.0 ft when the fault was first encountered, to 6.0 ft when mining ceased. Fault #2 was a normal fault and trended N50°W with a northeasterly dip. Offsets observed along the working face varied from approximately 1.0 ft of intial offset to 5.0 ft when mining ceased.

The two faults do not appear to be related. Fault #2 is apparently a continuation of the fault zone encountered along First Right (Figure 11). Fault #1 dies out along strike


4 NORTH LONGWALL PANEL
EXPLANATION:
FAULT TRACE AND DIP (DASHED WHERE INFERRED)
U DENOTES UPTHROWN SIDE
D DENOTES DOWNTHROWN SIDE
2655 KAISER SURVEY SPAD
ENTRY CENTERLINE
2657
2640
2655
2656
2680
N
SCALE
20 0 20 FEET
SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL
FIRST RIGHT FAULT MAP
FIGURE 12

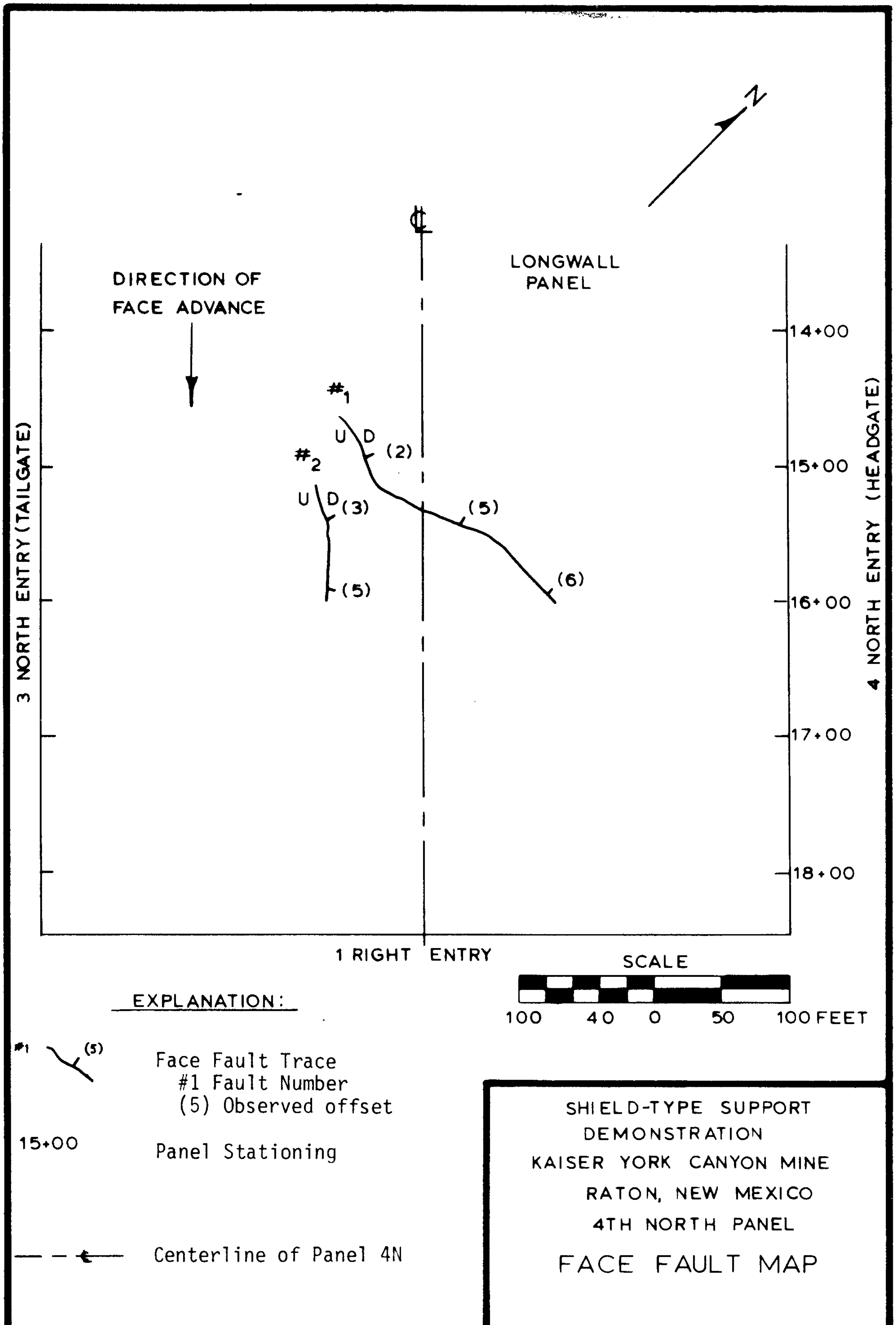

N
DIRECTION OF FACE ADVANCE
LONGWALL PANEL
3 NORTH ENTRY (TAILGATE)
4 NORTH ENTRY (HEADGATE)
#1
U D (2)
#2
U D (3)
(5)
(5)
(6)
14+00
15+00
16+00
17+00
18+00
1 RIGHT ENTRY
SCALE
100 40 0 50 100 FEET
EXPLANATION:
#1 (5)
Face Fault Trace
#1 Fault Number
(5) Observed offset
15+00
Panel Stationing
Centerline of Panel 4N
SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL
FACE FAULT MAP

FIGURE 13

to the west where no evidence of faulting was noted along the headgate entry (Figure 13). It parallels the trend of the major joint set and the face cleat in the coal.

All faulting encountered within and adjacent to panel 4N did not appear to adversely affect the roof rock to any significant degree. The roof rock tended to be broken and badly jointed only in zones within 4 ft of the fault. No large shear zones were noted adjacent to the fault zones. All fault planes tended to be clean, curvilinear breaks with little or no associated drag folding.

Groundwater:

Groundwater was not a significant factor in the longwall mining operation. No severe seepage problems were observed along the working face or along entries adjacent to the longwall panel.

Infiltration of surface waters provided the principal source of groundwater. Permeabilities within the stratigraphic section were dependent upon the joint systems. Observations during mining, the tight nature of the joints and the lack of defined joints within the shale units indicate that the seepage rates probably averaged between 10^{-4} and 10^{-5} cm/sec. However, in some faulted areas within the mine, seepage rates appeared to average between 10^{-3} and 10^{-4} cm/sec.

As the mined-out areas caved, the vertical permeability of the rock strata was increased. Observations indicated that even in the caved areas, seepage rates generally did not exceed 10^{-3} cm/sec.

LAND USE

The York Canyon Mine is located in an area with a semi-arid to sub-humid climate (Yi-Fu and others, 1969, p. 159). The area is characterized by approximately 20 inches of annual precipitation (Yi-Fu and others, 1969, p. 18). Temperature variations range from an average daily maximum of 65°F. to an average daily minimum of 31°F (Von Eschen, 1961, p. 47). Summer high temperatures generally reach the low 90°F range while winter low temperatures generally average in the low 20°F range.

Vegetation in the area consists principally of trees, low shrubs and grasses. It is moderately forested. The trees are primarily evergreens, 0.5 ft to 1.5 ft in diameter and spaced 5 to 10 ft apart. The underbush is moderate to locally dense, averaging less than 5 ft in height. Pinon and Rocky Mountain Juniper are the most numerous species of evergreens with occasional small stands of Ponderosa pine and Douglas fir. The underbush is principally Rocky Mountain White Oak with small cactus and sturdy grasses. Vegetation density and composition vary with slope orientation. Pinon, juniper and oak occur on north and south facing slopes but trees are generally larger and more numerous on the south facing slopes. Ponderosa pines are generally restricted to the north facing slopes while Douglas fir occurs on both north and south slopes.

The regional area is utilized primarily for cattle ranching with some timber cutting operations and localized coal mining activity. The timber harvest is principally of Ponderosa pine and Douglas fir for lumber and mine props. While the regional area is dotted with numerous abandoned coal mining camps, the York Canyon Mine is the only active operation in the region. The area also provides private hunting and fishing.

The surface area immediately above the longwall panel is used for cattle grazing at the present time.

SECTION II

SURFACE INSTRUMENTATION

INTRODUCTION

There has been extensive literature published in the past 30 to 40 years regarding the description and analysis of mine subsidence observations. The observations come from coal fields in Holland, Poland, Germany, the USSR, France, Belgium, Hungary, and the U. K., as well as regions where potash, rock salt and iron ore have been mined. The early observations were concerned primarily with the magnitude of subsidence, the period of settlement and the angle of draw. During recent years, investigations of ground movement associated with mining bedded deposits have been extended to determine the nature, magnitude and distribution of ground movements which occur at intermediate underground mining locations as well as at the surface.

With the increase in mineral consumption in the U. S., it is inevitable that mining operations will progressively extend beneath industrial and residential areas. A knowledge of the effects of underground workings on surface ground movement will allow us to determine which seams, what type of extraction method, and the mining pattern and sequence required to minimize adverse surface effects. Thus one of the purposes of this program was to provide needed subsidence data for the rapidly expanding documentation of subsidence effects in and for the development of a complete subsidence prediction model for North America.

In subsidence engineering there are three basic terms associated with different minimum widths of extraction. These are:

(1) Critical width: That minimum width of working which causes the complete or maximum vertical subsidence of one point or line of points on the surface.

(2) Sub-critical width: Any minimum working width smaller than the critical width. (When a sub-critical panel width is being worked, no point on the surface above the working area undergoes complete or maximum vertical subsidence).

(3) Super-critical width: Any width of working greater than a critical width. (An area on the surface undergoes complete or maximum vertical subsidence).

One of the objectives of this project was to determine the magnitude and extent of surface subsidence resulting from mining a super-critical longwall panel, panel 4N, in a known geologic environment and with rapid topographic variation along the panel centerline. Indeed, the mountainous topography at the York Canyon Mine provides a unique opportunity to compare subsidence results with the vast amount of subsidence data collected by the National Coal Board (NCB), in England, primarily associated with flat or gently rolling terrain. A detailed description of the topography and stratigraphy in the longwall test panel area is contained in the geology section of this report (Section I).

The procedure for determining subsidence and the analysis of subsidence results at the York Canyon Mine are discussed in the following sections.

SURFACE SUBSIDENCE NET

A surface subsidence net was installed that provided adequate surface subsidence information for accurate data collection, analysis and subsequent interpretation. The approach adopted for longwall test panel 4N has been used in the United Kingdom and elsewhere. One row of subsidence monuments was installed along the centerline of the panel and one row perpendicular to the panel centerline. This method was supplemented at longwall test panel 4N by the addition of two diagonal lines of monuments radiating from the centerline at 45^{o} angles. One diagonal line passed through the north corner of the panel and the other diagonal line passed through the south corner (the panel centerline is oriented NW-SE). These additional diagonals were installed to measure subsidence effects at the corners of the longwall panel.

A total of 136 surveying monuments were installed over longwall test panel 4N. The monument lines were extended a distance of 1.4h (h = depth) beyond the perimeter of the panel to insure that no surface subsidence would go undetected and also allow determination of the final angle of draw outside the panel.

In addition to the subsidence net, four turning points were constructed at strategic locations outside the area of influence from current mining activity and at positions where they would provide maximum visibility of the various rows of subsidence monuments. The exact location of these turning points was determined by triangulation from established mine control points in the area. These control points were part of the York Canyon Mine survey control net.

Positions of the monuments along the panel centerline, the perpendicular and the two diagonals were initially located using a Wild T-1AE Theodolite and chaining. All monument locations were surveyed by using doubled angles for horizontal control and level chaining for vertical control and separation distance.

Figure 3 shows the location of surface monuments, turning points and reference points used for subsidence monitoring in the area of longwall test panel 4N.

Monument Positioning

The appropriate distance between monuments is always a matter of concern for subsidence monitoring. The National Coal Board (England) suggests a monument spacing of 0.05h to 0.1h. The monument spacing is important because horizontal strains over the panel area are calculated on the basis of monument spacing. The distance over which the average horizontal strain is determined is termed "bay length". Because of the curvature of the subsidence profile, the maximum horizontal strains calculated from measurements made over longer bay lengths are smaller than those calculated on measurements made over correspondingly shorter bay lengths (Kapp, 1973).

Obviously there is a practical limit to the reduction of the distance between monuments in the field. The time associated with the construction, monitoring and the calculations can become excessive and therefore very expensive. Also monument spacing which is too close may result in measurements of apparent ground movements which record the motion of the individual joint blocks in which they are anchored. Individual joint block movements may be locally anomalous. These joint block movements can locally overwhelm the average horizontal strains. Because this study was conducted in mountainous terrain, it was often impossible to establish a line of sight directly between monuments. Multiple turning point locations were necessary to monitor the monuments over actively subsiding segments of the subsidence net. For these reasons it was decided to place monuments on 60 ft centers; this results in an average depth ratio of 0.16h, as compared to 0.1h or 0.05h recommended by the NCB, for a panel having an average depth of 350 ft. This spacing proved to be very satisfactory for subsidence monitoring and subsequent horizontal strain calculations.

Monument Access

The topography above longwall panel 4N consists of a series of ridges and draws which are approximately perpendicular to the centerline of the panel (Fig. 3). The abruptness of the ridges and draws along the centerline of the longwall panel made it impossible to construct a road alongside the centerline monuments. However, a road was constructed roughly parallel to the panel centerline and approximately 300-400 ft to the side of panel 4N. Where topography permitted, the road was located as close to the centerline monuments as possible. A short side road was constructed to provide access for a rotary drilling rig to the location of the northernmost multiple-position borehole extensometer (MPBX). The location of the other two MPBX's was on a flat ridge top that intersected the panel centerline and the access road. In addition a side road was built down a ridge to provide access to one of the turning points used in monitoring the subsidence net. There was an existing road which intersected the southern tip of the centerline and the eastern end of the proposed perpendicular of the subsidence net. The steepness of the roads and their clay base made it necessary to use 4-wheel drive vehicles in adverse weather conditions and towing equipment. Severe rainstorms caused deterioration of the roads and made it necessary to blade the roads twice during the course of mining panel 4N.

Monument Construction

In order to utilize the full sensitivity of the surveying instrumentation and provide the stability necessary for its use, permanent monuments had to be constructed. A decision was made to use concrete monuments for the entire surveying net.

To insure stability, particularly during the winter months, it was felt that the monuments should be embedded at least 3 ft below surface and preferably in bedrock. Two factors prevented this type of construction. First, the terrain was too steep to afford accessibility to any type of mechanized digging or drilling equipment. Second, the time for monument construction would not permit hand digging for all the monuments. Therefore, it was decided that 6 and 8 ft lengths of 5/8-in. rebar would be used to anchor the monuments into the bedrock. A 175 cfm compressor, 500 ft of air hose and a light weight sinker were used to drill a 1-7/8 inch diameter hole 2 - 3 ft into bedrock at each monument location. The rebar was grouted into the hole using mortar mix. One 80 pound bag of actual mortar mix made enough mix to grout 8 to 12 holes -- the actual number being dependent upon hole depth. A crew of four could drill and grout rebar in 30 to 40 holes per day.

Concrete form tubes (sonatubes), 12 inches in diameter and 4 to 4-1/2 ft in length, were placed over the rebar and leveled.

At each monument location, the tubes were dug down approximately 1 ft around the rebar. Subsequently each sonatube was filled with concrete. Each monument required between 4 and 5 sacks of "sacrete" concrete mix. Each bag of "sacrete" would make around 0.95 cu ft of concrete weighing about 100 pounds. Because of the steep terrain, the concrete had to be manually carried in 5-gal. buckets to each monument location. The form tubes were filled to the top with concrete and then a 7-in. x 7-in. steel trivit adapter plate was set on top of the soft concrete and thus became an integral part of the permanent monument once the concrete cured. Photo 2 shows a typical monument with a target positioned on the trivit adapter plate.

The turning points were constructed without rebar because of their inaccessibility. A hole was dug down approximately 3 ft and an 8 ft sonatube was placed in the hole and filled with concrete. In order to provide a stable platform from which to survey, a patio was poured around the outside, but independent of, the monument. Each turning point required about 9 sacks of concrete mix for construction.

Approximately 600 man-hours were consumed in the direct construction of all surface subsidence monuments at a cost of about $95 per monument.

Surface Monitoring

Surface monument monitoring was conducted with an AGA Geodimeter

PHOTO 2 SURVEY MONUMENT WITH TARGET POSITIONED ON TRIVIT ADAPTER PLATE

(Model 76)(Photo 3) and a one-second theodolite (Wild T-2)(Photo 4). Subsidence measurements were determined to one-one hundredth of a foot. The use of the pre-drilled trivit adapter plate on the top of each monument enabled the target and instrument to be positioned in the same location on the monument each time monitoring occurred.

The frequency of readings were related to face advance rate, seam thickness extracted and monument spacing. Monitoring frequency was maintained at one to two times a week in active subsidence areas until subsidence appeared to cease. At this point monitoring was conducted bi-monthly, monthly, and finally every two months in order to insure that subsidence had totally ceased in that area.

MULTIPLE-POSITION BOREHOLE EXTENSOMETERS

Three 4-1/2 inch diameter rotary drill holes were drilled from the surface above longwall panel 4N for subsequent installation of multiple-position borehole extensometers (MPBX's). The boreholes were drilled by Kaiser Steel Corporation's exploration group located in Raton. The cuttings were logged from each hole and each hole was also geophysically logged. The results are presented and discussed in the geology section of this report (Section I).

Two of the boreholes (No. 1 and No. 2) were located on the panel centerline and on opposite sides of a fault (Fig. 11).

PHOTO 3 AGA GEODIMETER POSITIONED ON SURVEY MONUMENT

PHOTO 4 WILD T-2 THEODOLITE POSITIONED ON SURVEY MONUMENT

Both holes were drilled to a depth 20 ft below the bottom of the coal seam. The respective depths were 433 ft for hole No. 1 and 437 ft for hole No. 2. The purpose of these two MPBX's was to show the fault's effect on subsidence and strata separation as mining approached and subsequently progressed through the fault area. However, about six months after MPBX installation it was decided that mining in longwall panel 4N would not progress through the fault zone area. These instruments will however monitor the effects of room and pillar mining in this area after completion of longwall mining of panel 4N and removal of the shields, etc.

The third MPBX was installed in a surface borehole located on a ridge top at the intersection of the perpendicular and centerline of the subsidence monitoring net (Fig. 3). The bottom of the hole was 20 ft below the base of the coal seam and had a total depth of 365 ft. The MPBX was installed to monitor the development of strain in the coal ahead of the advancing face and the development of vertical tensile rock strain in the overburden behind the longwall face. The relationship between face position and the magnitude of overhead strata separation induced in the overburden was also determined with this instrument.

MPBX Installation

The multiple position borehole extensometers used at panel

4N were purchased from, and installed by, Terrametrics of Golden, Colorado. Type HG anchors were used because they are especially designed for use in soft ground. These anchors were 6-in. long overall and equipped with a flat copper pipe which was wound around the anchor body in a concentric circle and fastened to it. The anchors were inflated by means of a hydraulic hand pump via 1/4-in. O.D. nylon tubing which had a bursting pressure of 1500-2000 psi.

Five anchors were installed in each MPBX hole. Anchor spacing is shown in Figure 14 and consisted of the #5 anchor 20 ft below the coal seam, the #4 anchor in the middle of the coal seam the #3 anchor 10 ft above the coal seam, the #2 anchor 50 ft above the #3 anchor and the #1 anchor 140 ft above the #2 anchor. Anchors were laid out on the surface and manually connected with the required lengths of 3/8-in. flexible "sealite" conduit. Stainless steel piano wire (0.041-in. diameter) was used to connect each anchor to the instrument head. Wires from anchors #4 and #5 were in a conduit separate from anchors #1, #2 and #3. This was done so that when the coal shearer severed the wires for anchors #4 and #5 the remaining three anchors would not be disturbed.

When the anchor string was completely assembled it was manually lowered into the borehole. Once in place, all anchors were inflated with a hand pump starting with the deepest anchor first. The instrument head was then grouted into place with a quick setting

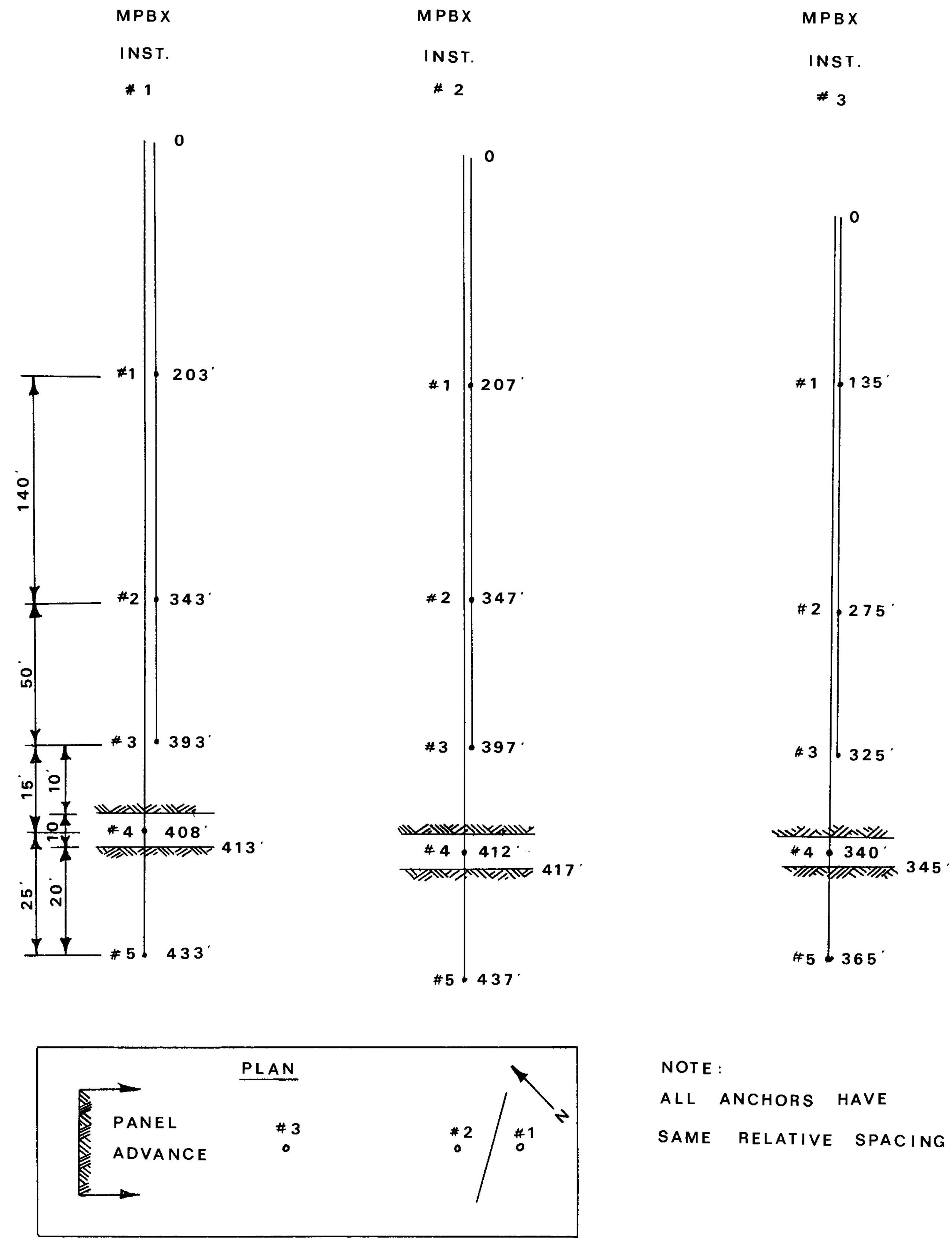


FIG 14 MPBX ANCHOR POSITIONS

York Canyon Mine Test Panel

cement. Each anchor wire was inserted through individual plungers and pulled to a tension of 10 pounds. The coil spring extensometer was then field tested by making in situ wire elongation tests to verify wire lengths and spring constants. These wire elongation factors were later used to reduce the recorded displacements to true displacements.

Chart recorders (Photo 5) were then installed on each MPBX and locked steel protective housing were bolted to the concrete pads (Photo 6). The chart recorders were driven by a 2-speed clockwork motor. Drum revolutions could be set at one revolution per week or one revolution per day. The charts had a convergence range of 5 inches and a sensitivity of 0.025 inches. The variable length of the individual wires and the resulting variable stretch provided an actual anchor movement range of up to 19 in. for the full 5-in. chart range for the anchor at 433 ft depth.

ANALYSIS OF SURFACE SUBSIDENCE DATA

Vertical Movement

The determination of the extent and magnitude of mining induced vertical subsidence is extremely important -- particularly under constraints of multiple land use. The following sections present and discuss the vertical subsidence data obtained in the area of longwall panel 4N.

PHOTO 5 CHART RECORDER FOR MPBX MONITORING

PHOTO 6 STEEL PROTECTIVE HOUSING ON MPBX

Subsidence Profiles:

As mentioned in the introduction, the 4N longwall panel is of super-critical width. Because of this super-critical width, the vertical subsidence measured above this panel was the maximum that could occur from mining 10 ft of coal at the York Canyon Mine. Subsidence profiles were plotted for the survey monuments over the north diagonal, the centerline and the perpendicular. The original surface profile was drawn for each row of monuments and used for the datum. Vertical subsidence was then plotted directly under each monument to the nearest 0.10 ft. Figures 15 thru 17 show the final subsidence profiles for centerline, perpendicular and north diagonal. In addition to the final subsidence profiles, Figures 18 and 19 show the traveling subsidence profiles along the perpendicular and centerline relative to various face positions. The traveling subsidence profiles can be correlated with face advance as shown in Figure 20.

The maximum subsidence detected over panel 4N reached 7.1 ft in the vicinity of Station 12N. It appears that maximum subsidence occurs under ridge tops and minimum subsidence under draws or topographic lows. Subsidence decreased from 25 to 30 percent in the draw between Stations 3N and 10N. The subsidence at Monuments 6N and 7N, which are in the bottom of the draw, was only 5.1 ft. Subsidence then increased along the monuments south

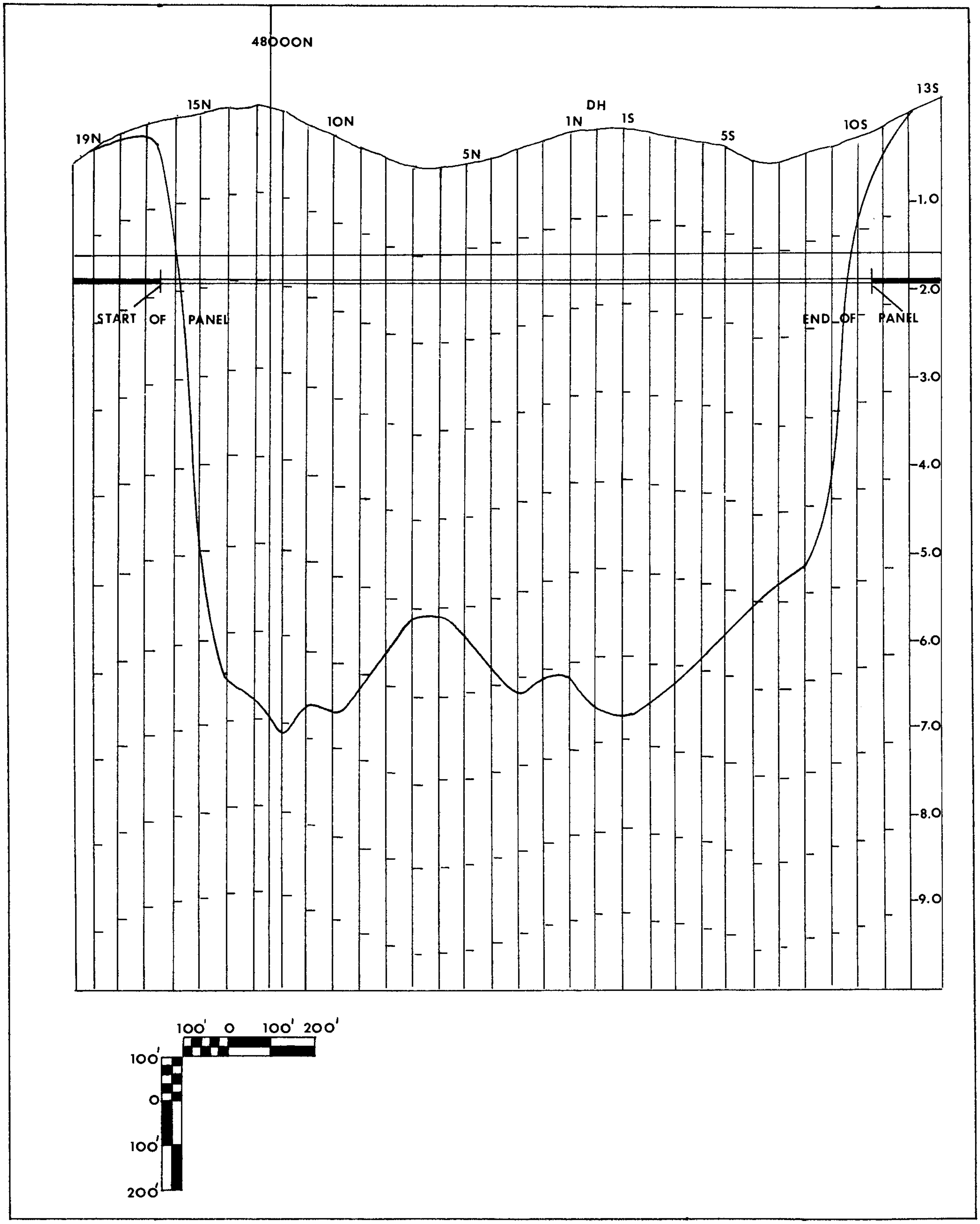


FIG 15 FINAL SUBSIDENCE PROFILE—PANEL CENTERLINE (19N—13S)

York Canyon Mine Test Panel

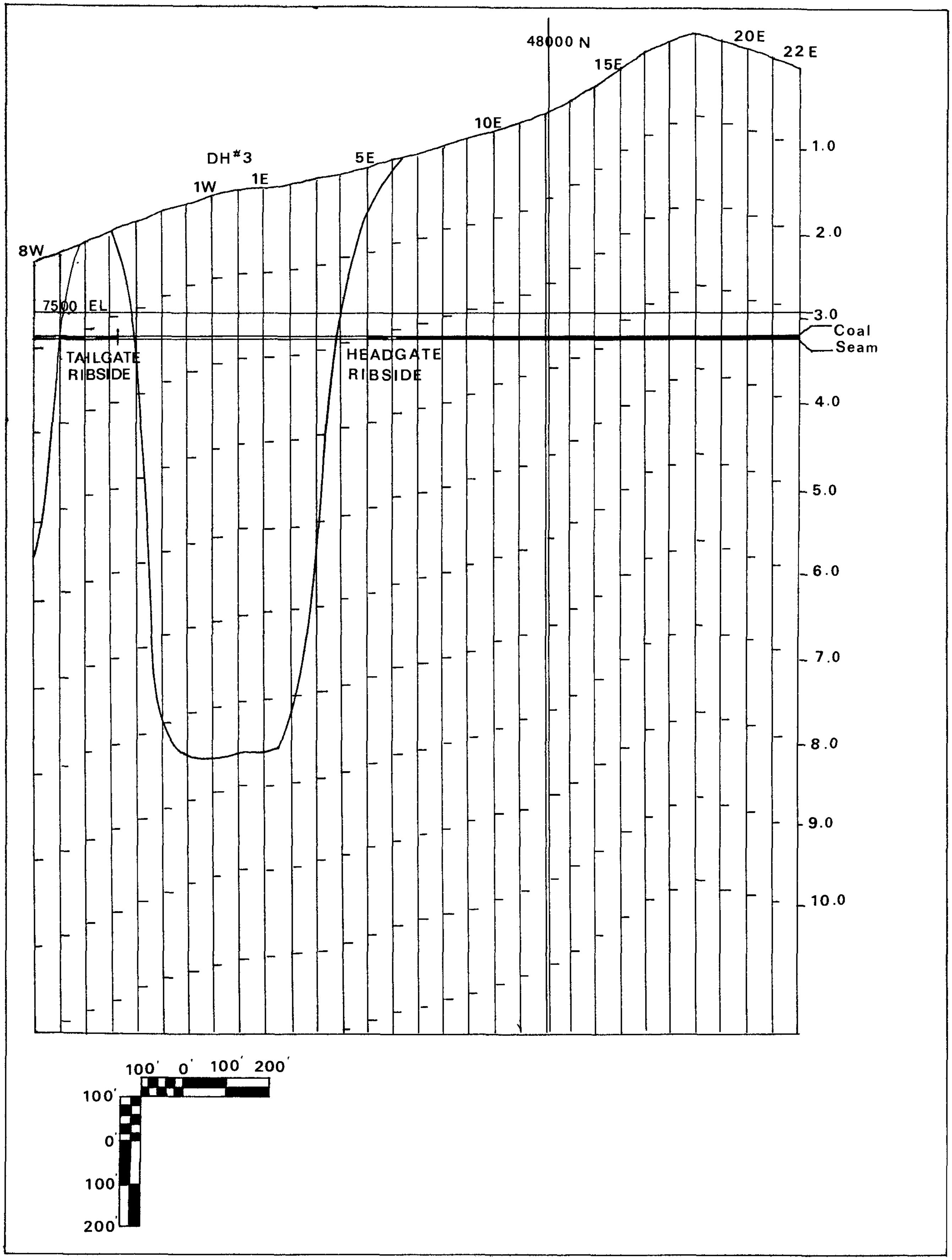


FIG 16 FINAL SUBSIDENCE PROFILE — PANEL PERPENDICULAR (8W–22E)

York Canyon Mine Test Panel

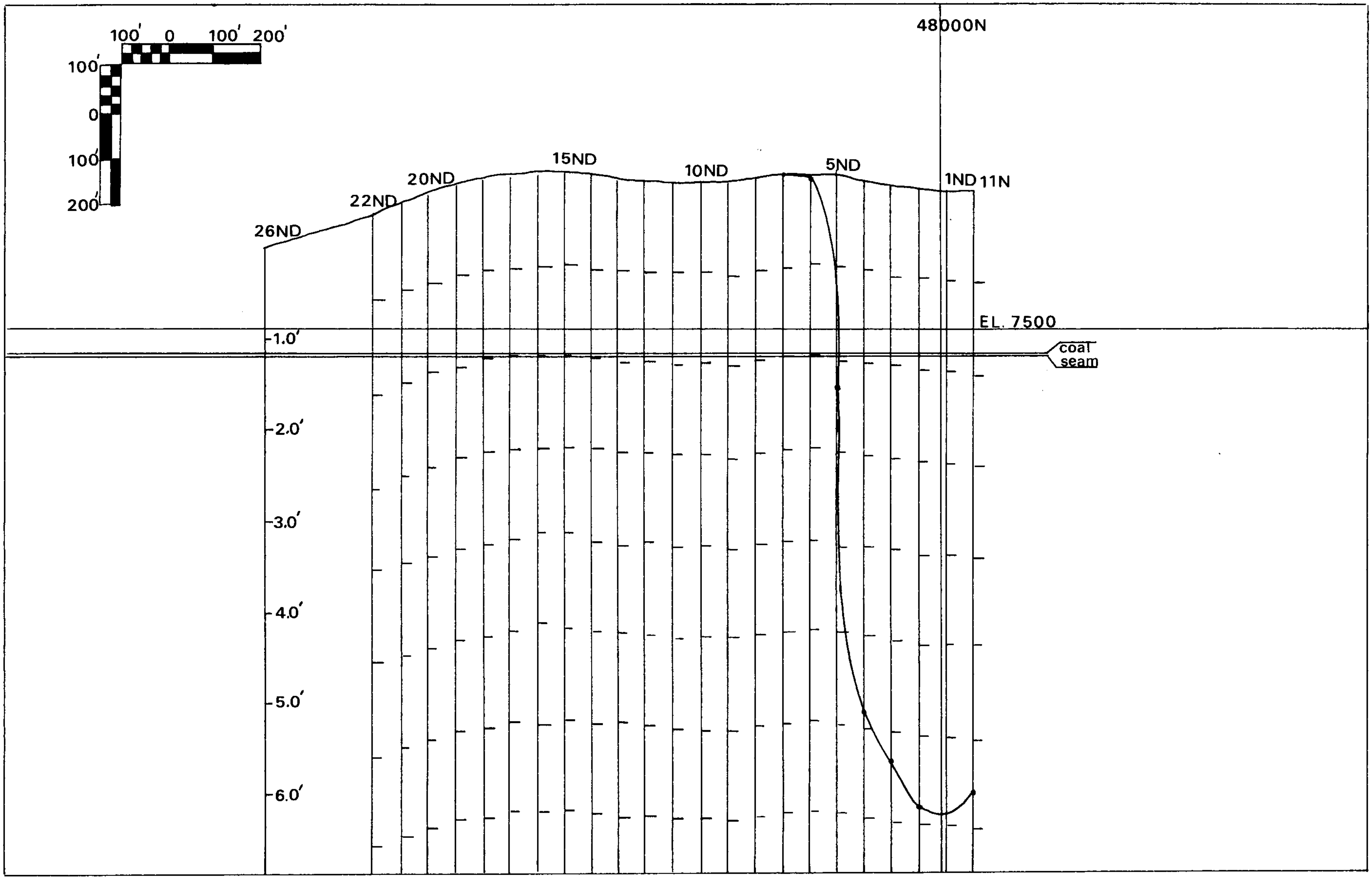


FIG17 FINAL PROFILE – NORTH DIAGONAL (26 ND - 11 N)

York Canyon Mine Test Panel.

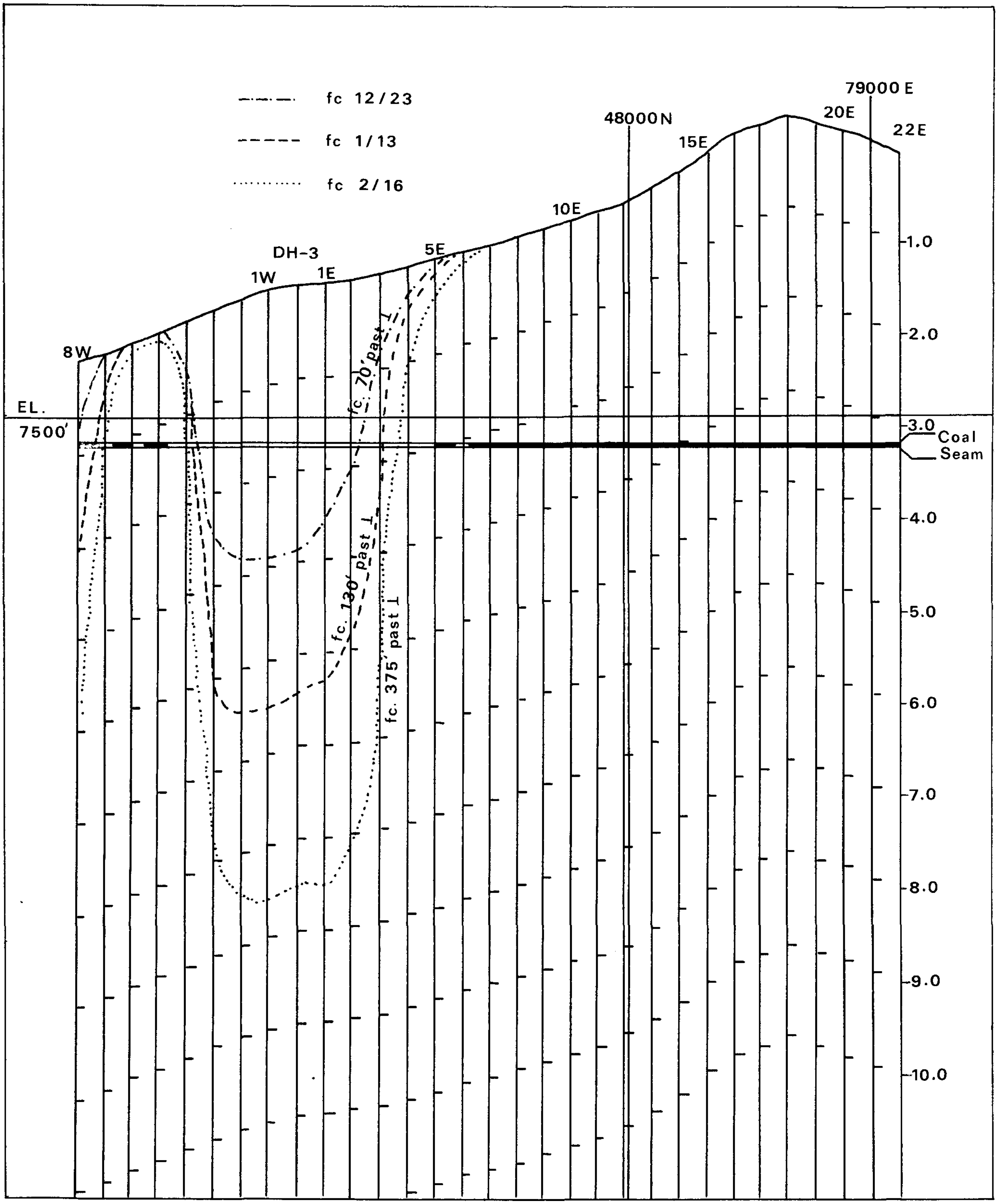


FIG 18 TRAVELING SUBSIDENCE PROFILES (8W-22E)

York Canyon Mine Test Panel.

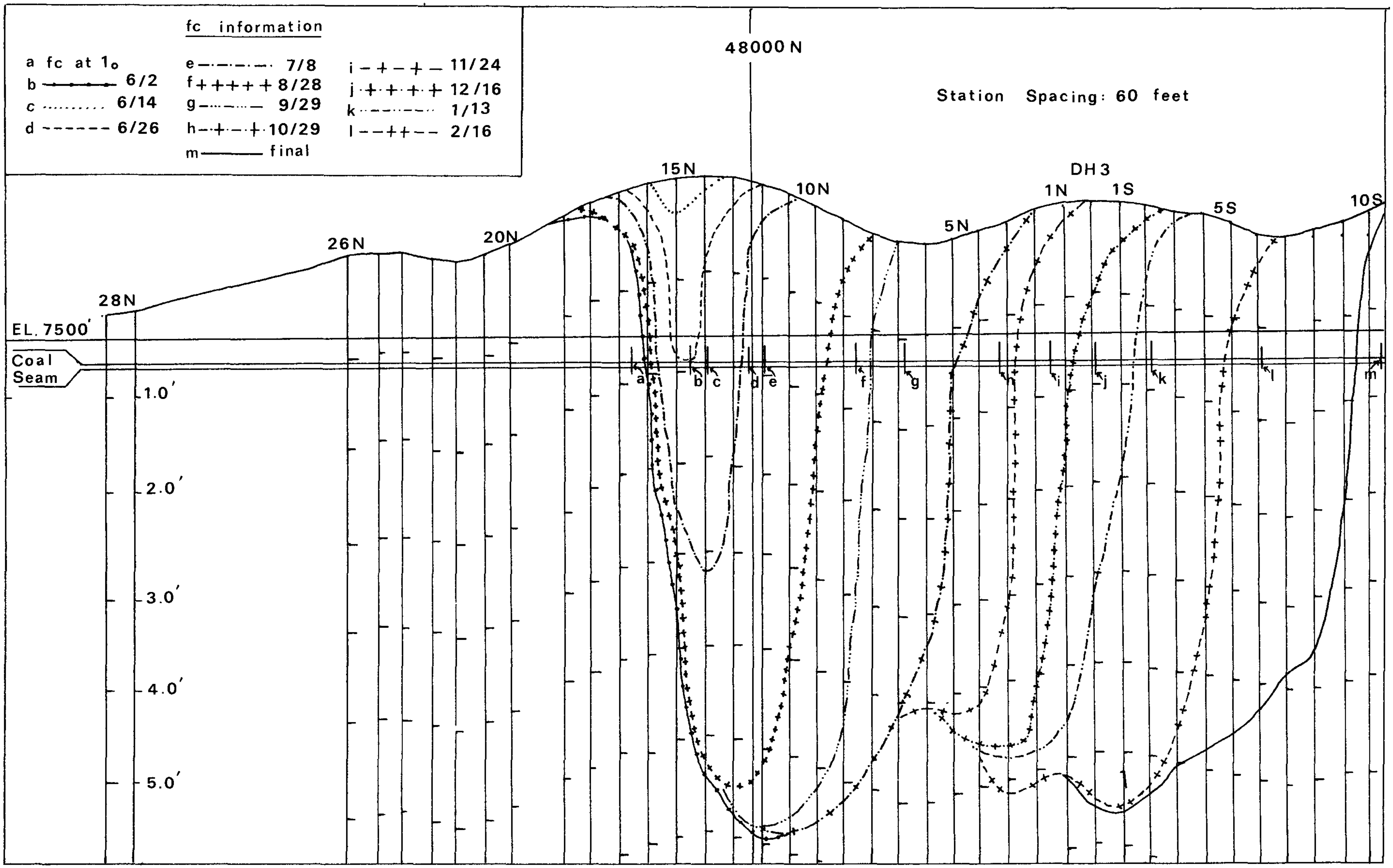


FIG 19 TRAVELING SUBSIDENCE PROFILES (28N - 10S)

York Canyon Mine Test Panel

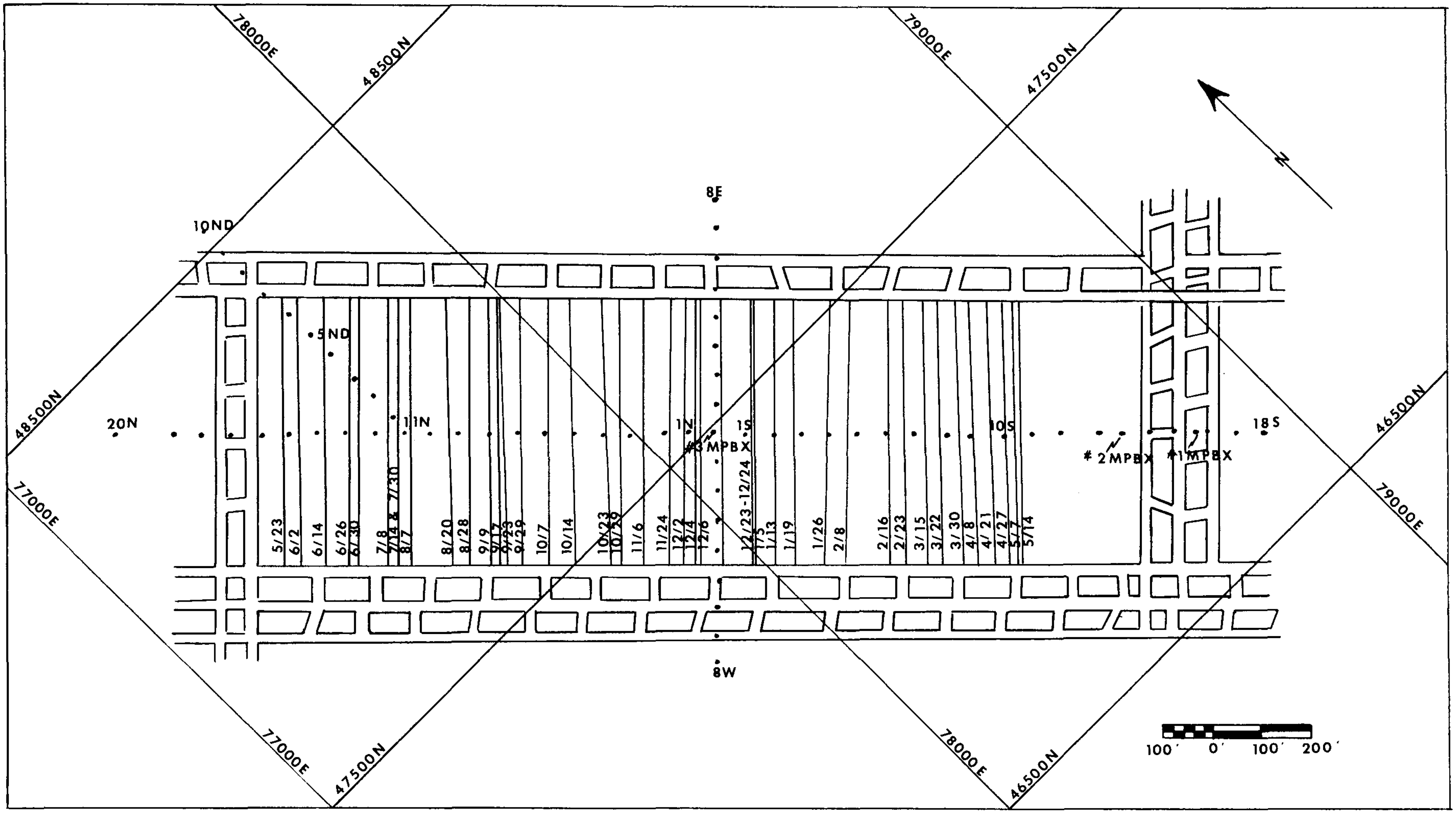


FIG 20 LONGWALL FACE POSITIONS.

York Canyon Mine Test Panel.

of this draw until another peak of subsidence (6.7 ft) occurred at Monument 1S, located at the top of the next ridge.

As seen in Figure 20 the final face position was only advanced 35 ft past Monument 10S. This resulted in incomplete subsidence for Monuments 7S - 12S. Monuments 5S and 6S, which underwent complete subsidence show less subsidence than for the topographic highs. This indicates that had the panel been mined under the next ridge top there would have been another decrease in measured subsidence for the draw between 5S and 10S.

There are two primary factors which appear to affect the amount of maximum subsidence for a given critical or super-critical area. The first factor deals with overburden depths. Studies have shown a clear tendency for the subsidence factor to decrease with decreasing overburden depths (Wardell and Webster, 1957). Table 1 gives values as observed in 7 cases of super-critical width which had strip packing for goaf support.

Table 1

EFFECT OF DEPTH ON MAXIMUM SUBSIDENCE

(After Wardell and Webster, 1957)

Depth (Yards)	Subsidence Factor
90	0.60
110	0.71

Table 1 (continued)

Depth (yards)	Subsidence Factor
148	0.58
170	0.63
230	0.66
573	0.83
870	0.78

The other factor, which appeared to decrease subsidence over panel 4N was the "piling up" of subsiding overburden moving toward topographic lows as a result of mining. As mining progresses under two opposite facing ridge slopes, caving causes a downslope movement on each side of the valley. This horizontal movement from opposite sides of the valley toward the bottom of the draw causes the overburden to be compressed into the draw. This compression in the draw has enough magnitude to form compression ridges as evidenced by an extensive compression ridge down the bottom of the draw between Monuments 5N and 8N (see Photo 7). Figures 21 and 22 show relative horizontal and vertical movements in two different draws or topographic lows over panel 4N. From these figures it is evident that there must be an accumulation of overburden in the draws. Vertical subsidence is decreased as a result of overburden accumulation and from an arching effect

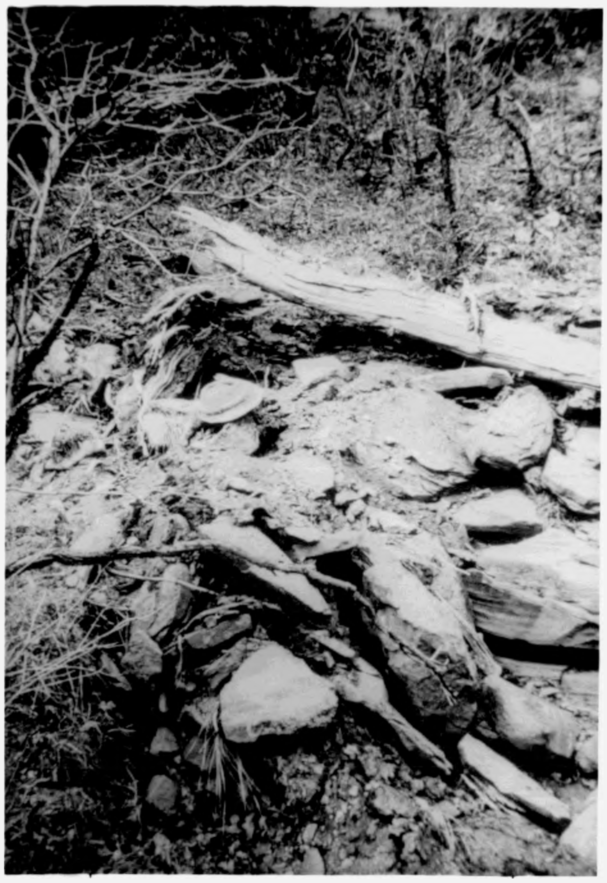


PHOTO 7 COMPRESSION RIDGE IN DRAW BETWEEN MONUMENT 5N and 8N

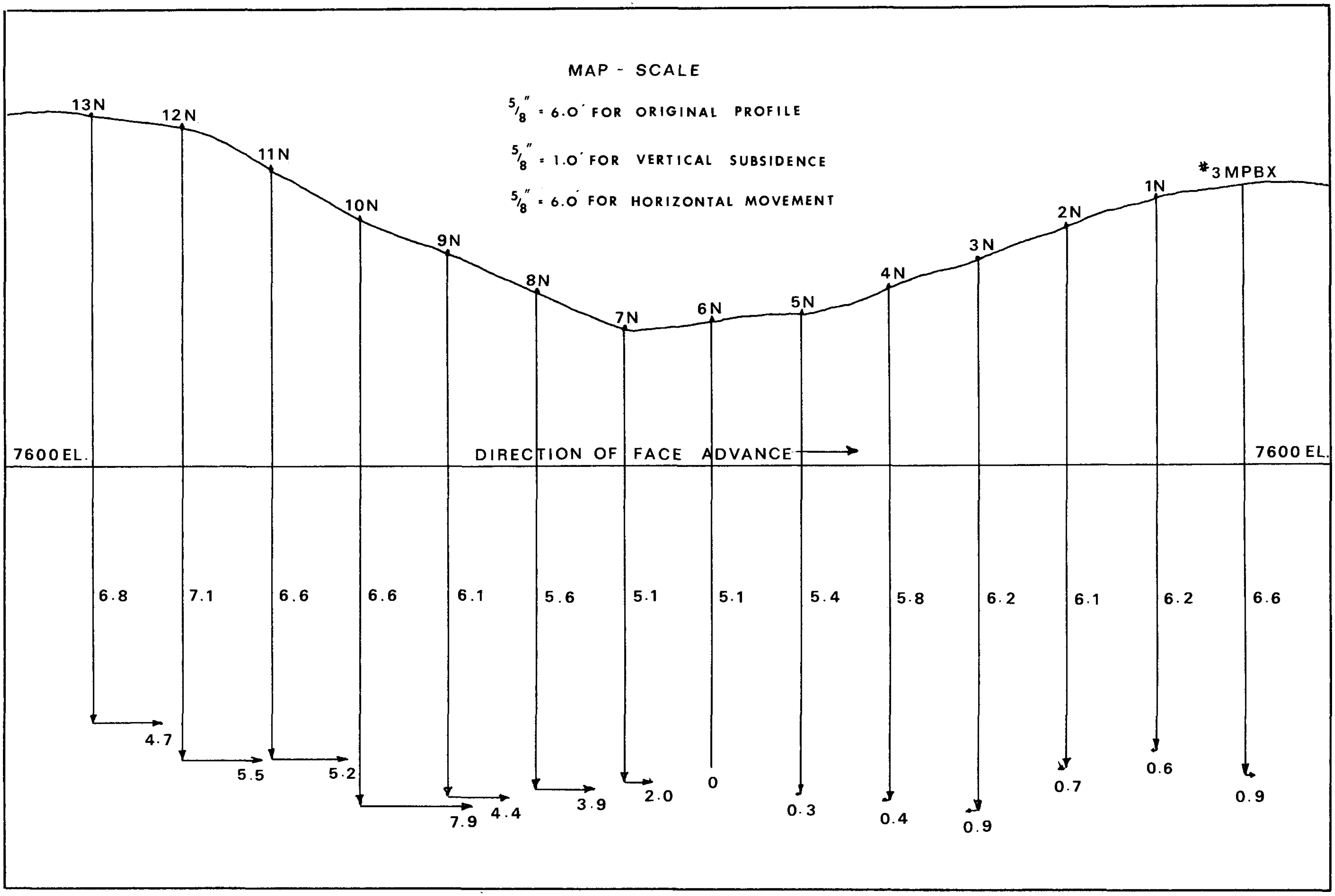


FIG21 HORIZONTAL AND VERTICAL COMPONENTS ALONG CENTERLINE.
York Canyon Mine Test Panel Stabilized Conditions: March, 1976

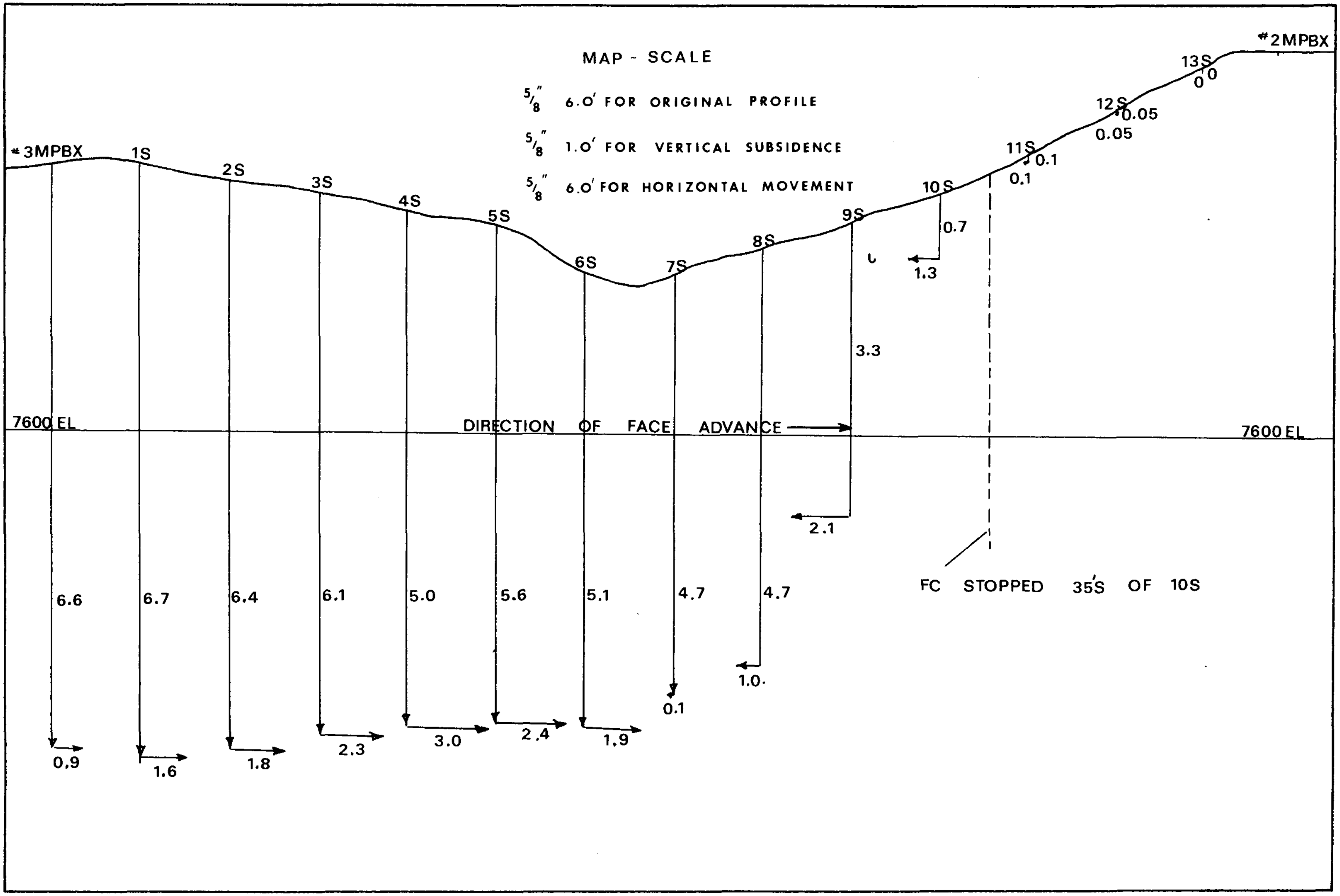


FIG 22 HORIZONTAL AND VERTICAL COMPONENTS ALONG CENTERLINE

York Canyon Mine Test Panel Stabilized Conditions: May 29, 1976.

across the draw caused by the compressional forces present. With these factors in mind, it is easy to see why vertical subsidence decreases in the topographic lows.

Other studies have shown that, with w/h ratios in excess of about 0.7, the transition point, or point of half maximum subsidence, was slightly more than one-tenth of the depth of the seam inside the rib. This study also compares the actual overburden depth to the actual distance of the transition point from the ribside for a number of cases. The average distance to the transition point for an average h of 350 ft and a w/h>1.0 is approximately 70 ft (Hall and Orchard, 1962). This comes very close to the location of half maximum subsidence from the profiles of the 4N longwall panel. Eighty-eight feet is the average distance to the transition point from the ribsides of the north end of the centerline, the south end of the centerline, the headgate side of the perpendicular and the tailgate side of the perpendicular. This value was determined directly from the final subsidence profiles.

Figures 23 thru 26 show the vertical subsidence distribution over the ribsides for super-critical conditions. The data for these figures is compiled in Appendix C. These graphs were drawn in order to correlate subsidence in terms of angles from the vertical (solid-goaf interface). The east-west perpendicular slopes to the west fairly steeply. Figures 24 and 25 show that the subsidence over ribside and also the limit of subsidence (angle of

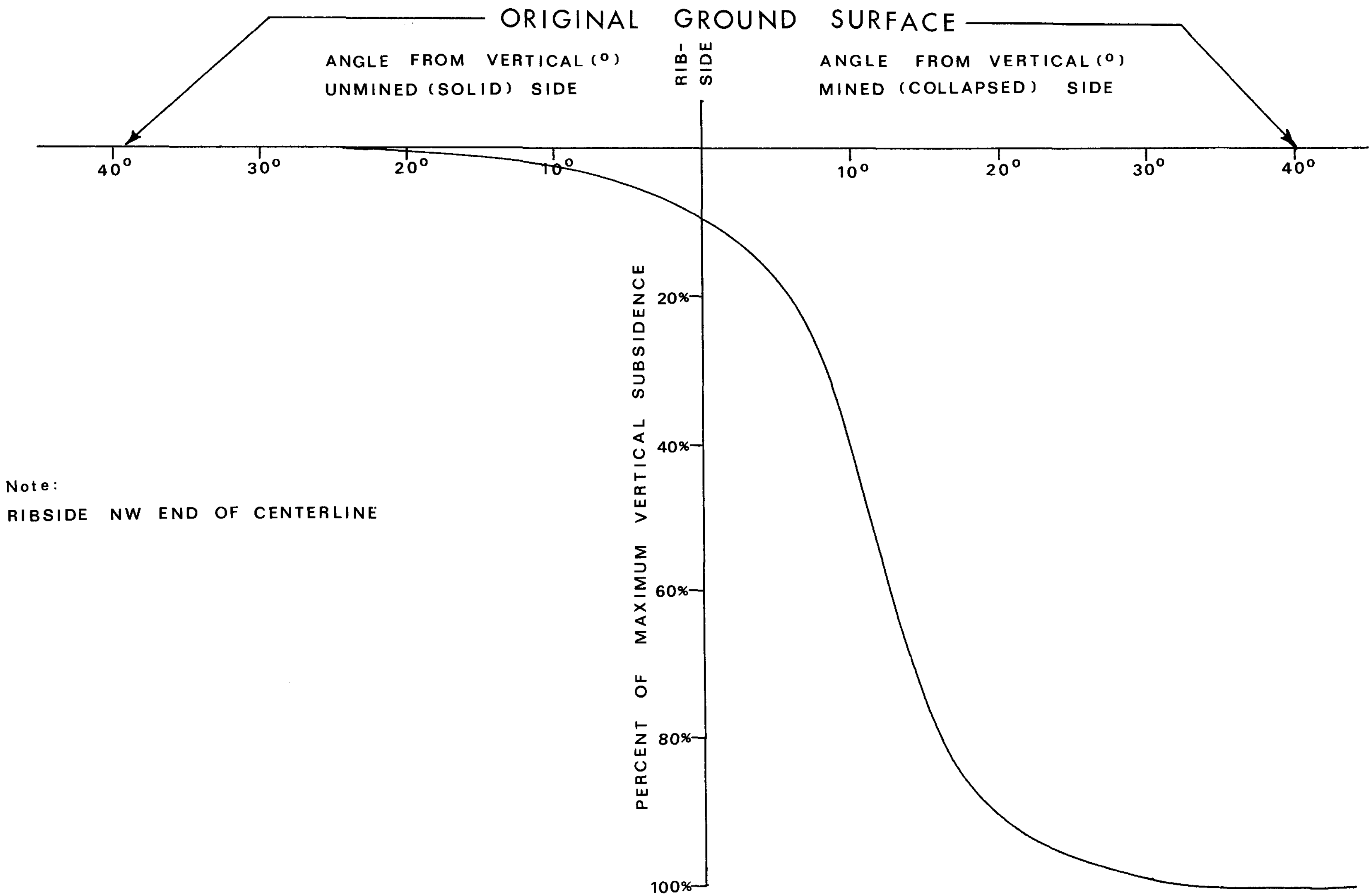


FIG 23 VERTICAL SUBSIDENCE DISTRIBUTION FOR SUPERCRITICAL CONDITIONS (4NLW)

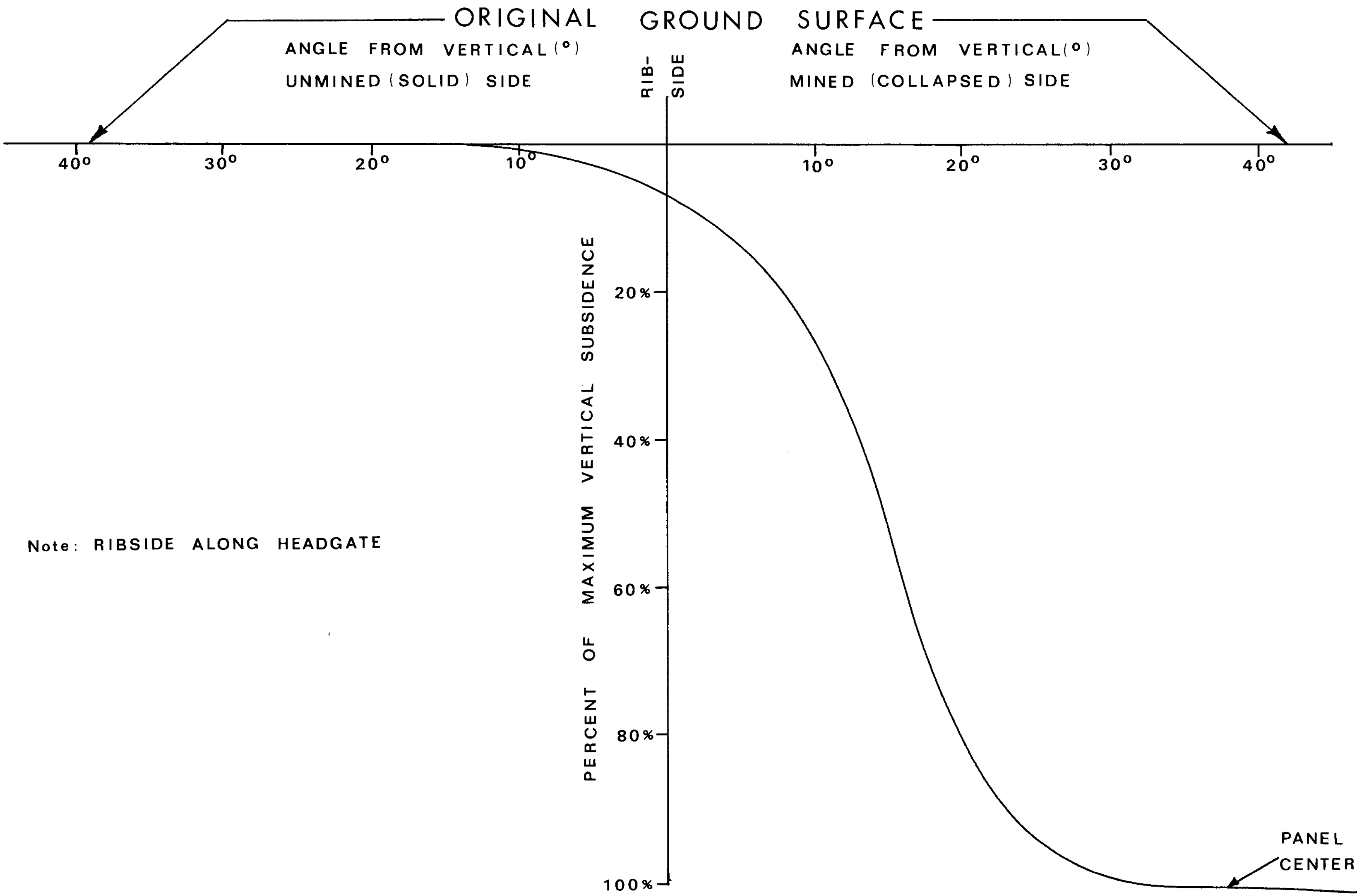


FIG24 VERTICAL SUBSIDENCE DISTRIBUTION FOR SUPERCRITICAL CONDITIONS (4N LW)

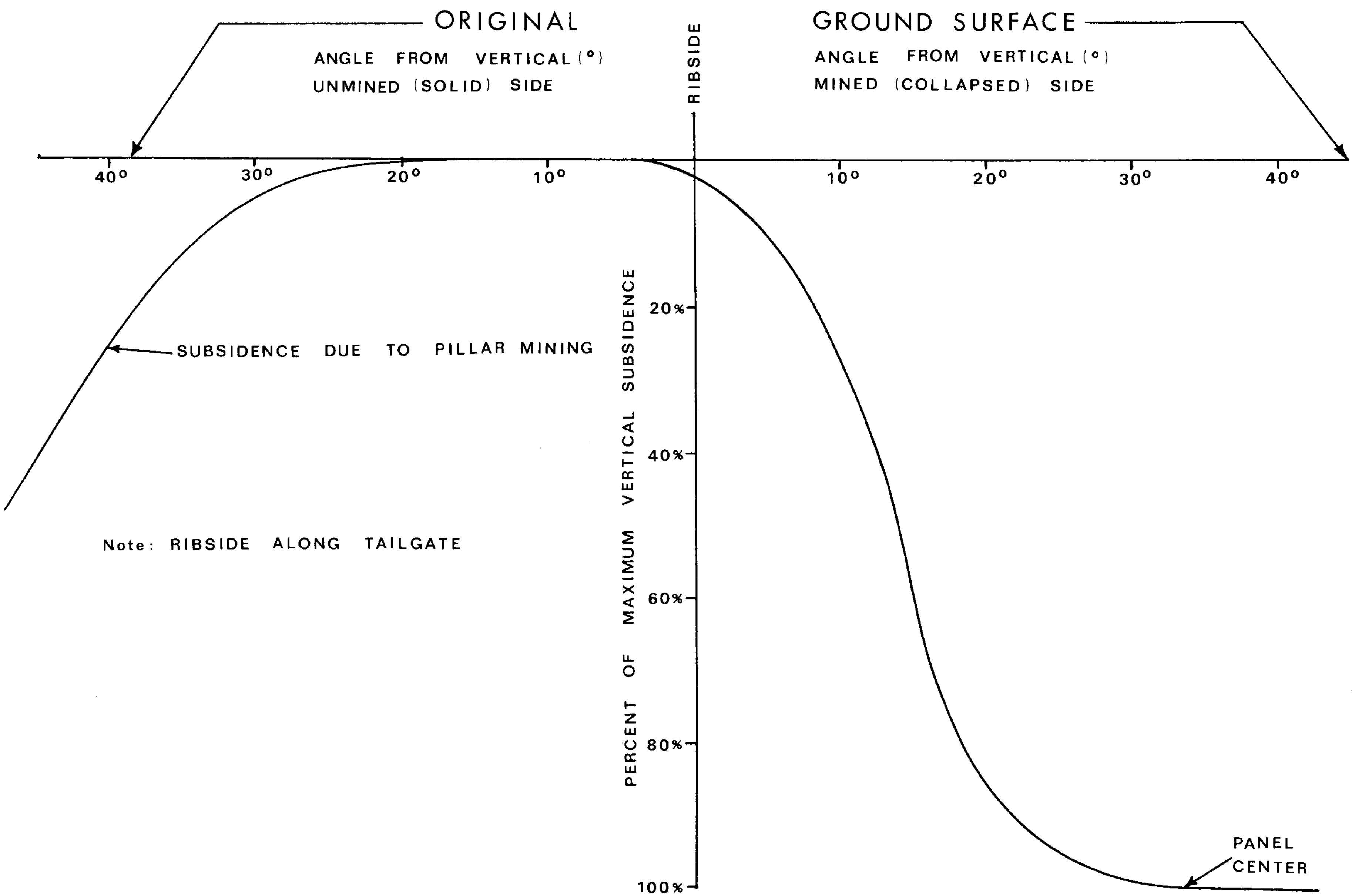


FIG 25 VERTICAL SUBSIDENCE DISTRIBUTION FOR SUPERCRITICAL CONDITIONS (4N LW)

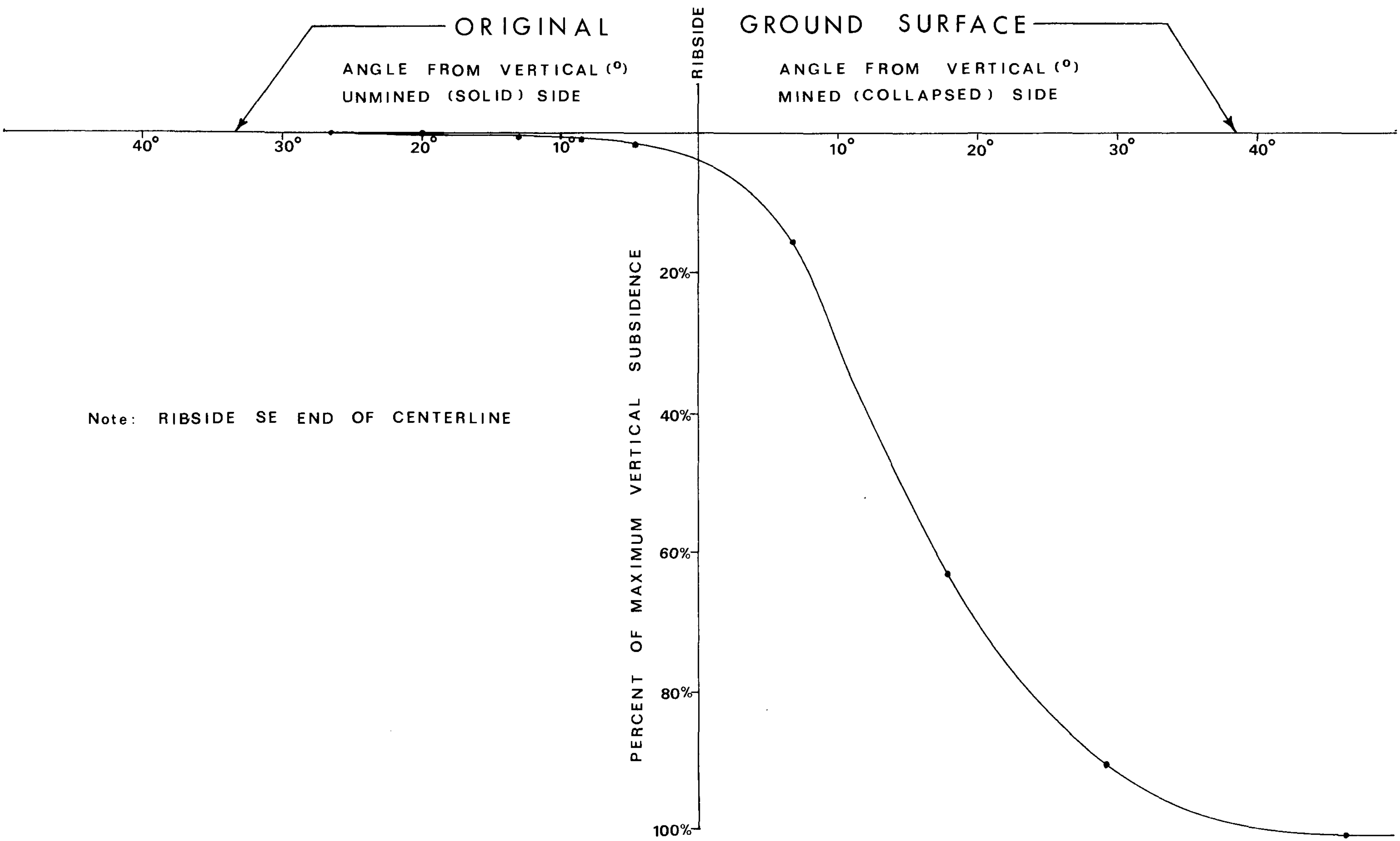


FIG 26 VERTICAL SUBSIDENCE DISTRIBUTION FOR SUPERCRITICAL CONDITIONS (4N LW)

draw) is much greater on the headgate (east) side than on the tailgate (west) side. This indicates that steep slopes facing the panel center increase the subsidence over ribside and steep slopes facing away from the center of the panel decrease the subsidence over ribside. The angle of draw (limit angle) is discussed more fully in the following section titled subsidence development curves.

Subsidence Development Curves:

The definition of "limit angle" as used in this report and other studies is the angle of inclination from the vertical of the line connecting the edge of the workings and the edge of the subsidence area. "Angle of draw" is also used in the same context as limit angle and the two will be used interchangeably throughout this report.

The dimensionless subsidence development curve, developed by the National Coal Board (1966), avoids the use of a limit angle (angle of draw). Since the ordinate and abscissa values are dimensionless these curves are more adaptable to depth and subsidence variations present at the York Canyon Mine.

Figures 27 thru 29 are subsidence development curves for survey Monuments 12N, 2N and 3S respectively. The data for these curves are compiled in Appendix D. These typical subsidence development curves represent the average shape and position

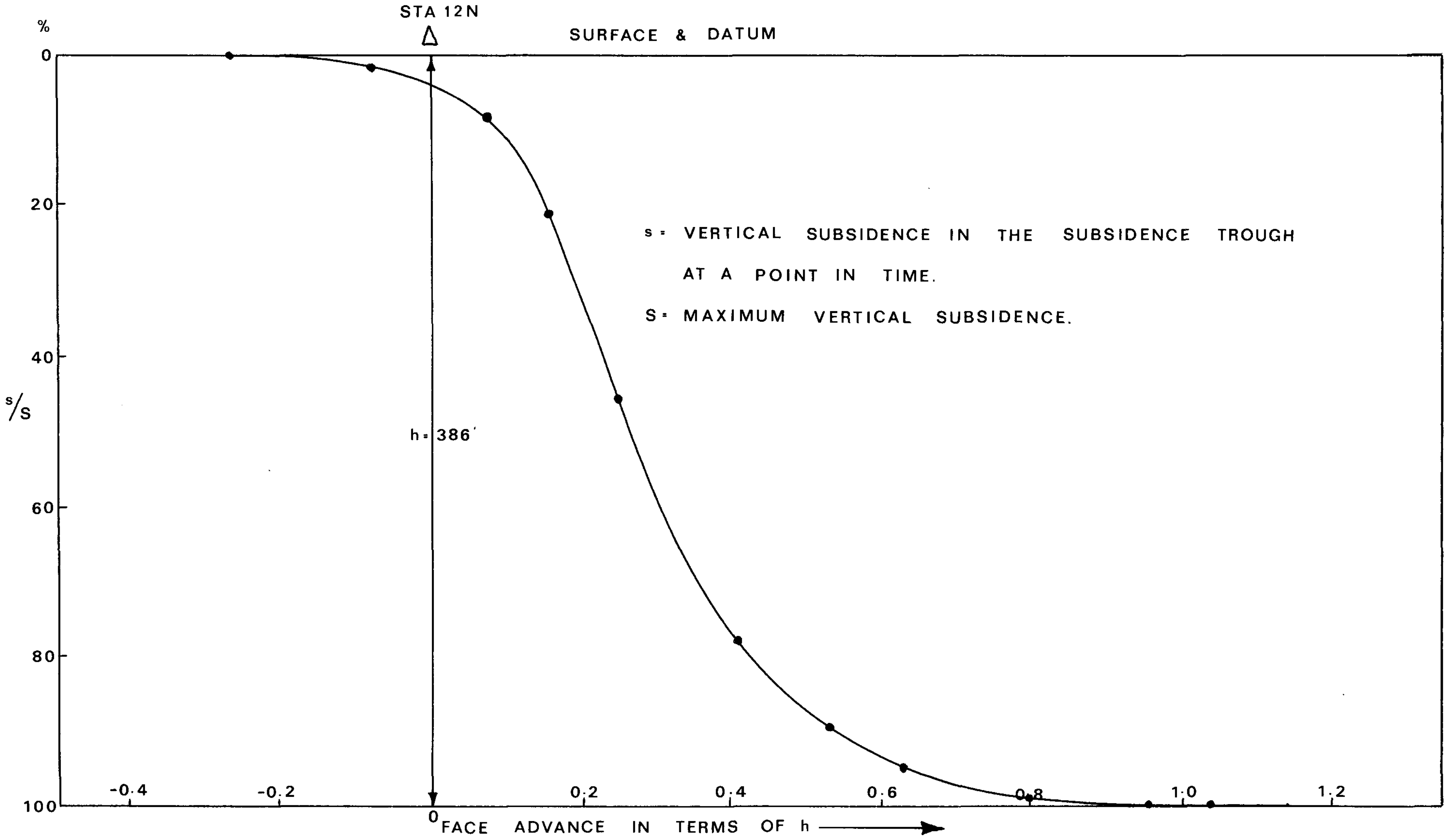


FIG 27 SUBSIDENCE DEVELOPMENT CURVE (4N LW.)

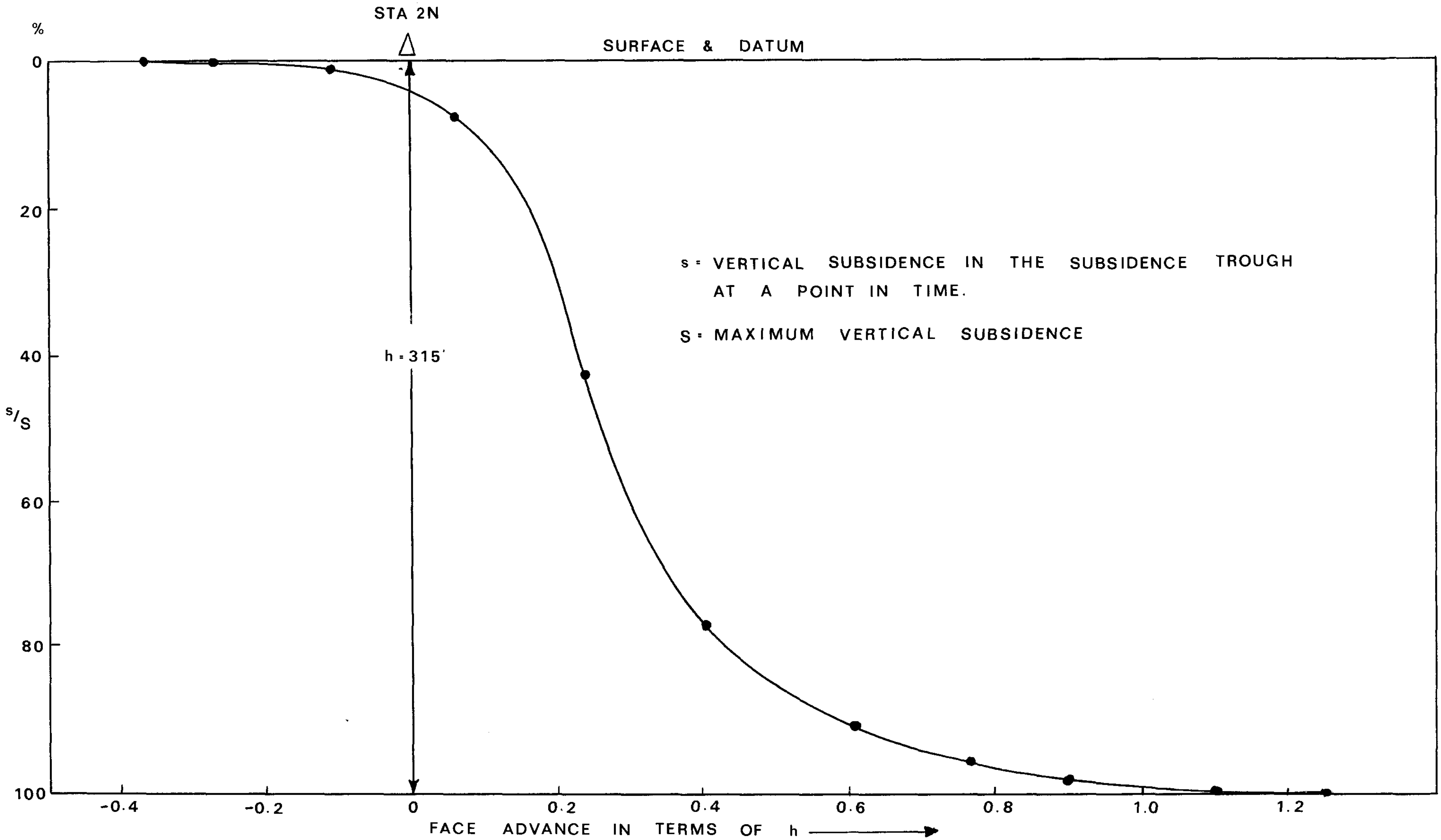


FIG 28 SUBSIDENCE DEVELOPMENT CURVE (4N LW)

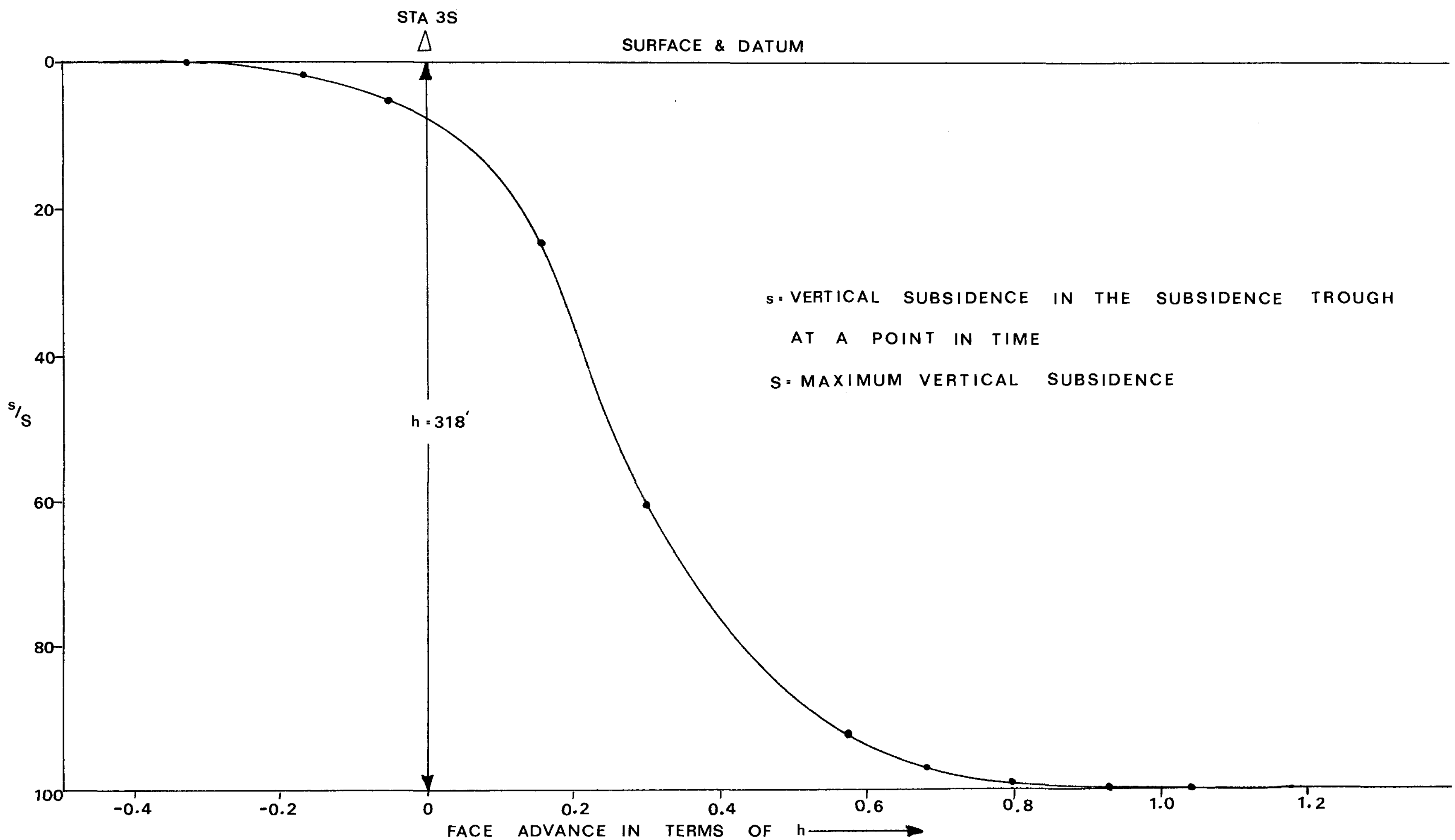


FIG 29 SUBSIDENCE DEVELOPMENT CURVE (4N LW)

of a number of such curves that were plotted for all the survey monuments that underwent complete subsidence. The complete list of these monuments is given in Tables 2 and 3 which tabulate the various subsidence values for each of the development curves. Figures 30 and 31 represent the average subsidence values calculated in Tables 2 and 3 versus face position from monuments and face position in terms of overburden depth. Tables 2 and 3 indicate that subsidence starts (1% subsidence $\approx$ 0.06 ft of vertical movement) when the face is approximately 60 ft from the surface point or 0.19 when expressed in terms of depth. Approximately 5.9% of the surface subsidence occurs by the time the face is directly under the surface monument and 98% of the subsidence has taken place by the time the face is 268 ft past the station or 0.84h in terms of depth beyond the station.

NCB studies for coal seams show that measurable subsidence commences when the face is at a distance of about 0.7h from the surface point; approximately 15% of the total subsidence occurs before the advancing longwall face passes under the surface point; and approximately 95% of the total subsidence occurs before the critical influence area of the advancing face passes beyond the surface point. According to the NCB, active subsidence is effectively complete when the face is 0.8h beyond the point in question. Residual subsidence occurs after this and is generally around 3% of the total subsidence. Values for the more fully developed

TABLE 2

DISTRIBUTION OF TOTAL SUBSIDENCE VALUES IN TERMS
OF FACE POSITION FROM MONUMENTS

Station	Dist.-fc @ 1% Sub.	%Sub. when face directly under station	Dist.-fc @ 10% Sub.	Dist.-fc @ 25% Sub.	Dist.-fc @ 50% Sub.	Dist.-fc @ 75% Sub.	Dist.-fc @ 98% Sub.
2ND	- 59	+ 7.0	+ 26	+ 52	+ 96	+133	+270
3ND	- 45	+ 8.0	+ 11	+ 68	+ 94	+143	+270
13N	- 31	+ 5.0	+ 27	+ 78	+110	+153	+298
12N	- 42	+ 3.5	+ 39	+ 62	+ 97	+151	+293
11N	- 39	+ 5.0	+ 25	+ 60	+103	+142	+291
10N	- 32	+ 5.0	+ 23	+ 61	+ 94	+126	+214
9N	- 60	+ 5.0	+ 32	+ 66	+ 84	+112	+220
8N	- 5	+ 1.0	+ 52	+ 71	+ 88	+121	+238
7N	+ 25	+ 0.0	+ 52	+ 67	+ 92	+126	+213
6N	- 66	+ 3.5	+ 46	+ 79	+ 99	+122	+209
5N	- 15	+ 2.0	+ 39	+ 59	+ 80	+121	+239
4N	- 55	+ 3.5	+ 36	+ 63	+ 91	+118	+292
3N	- 70	+ 5.0	+ 44	+ 64	+ 82	+126	+322
2N	- 41	+ 4.0	+ 32	+ 60	+ 82	+123	+284
1N	- 50	+ 5.5	+ 23	+ 56	+ 83	+139	+312
#3MPBX	- 99	+10.5	- 3	+ 41	+ 82	+136	+340

Table 2 (continued)

Station	Dist.-fc @ 1% Sub.	%Sub. when face directly under station	Dist.-fc @ 10% Sub.	Dist.-fc @ 25% Sub.	Dist.-fc @ 50% Sub.	Dist.-fc @ 75% Sub.	Dist.-fc @ 98% Sub.
2E	- 82	+ 8.0	+ 11	+ 60	+ 92	+160	+341
1E	-100	+11.0	- 3	+ 41	+ 79	+138	+344
1W	-106	+ 9.5	0	+ 33	+ 83	+129	+277
2W	- 75	+ 7.5	+ 9	+ 40	+ 84	+134	+258
1S	- 78	+13.0	- 10	+ 34	+ 75	+122	+278
2S	-104	+ 9.0	+ 3	+ 32	+ 75	+127	+257
3S	- 67	+ 7.0	+ 13	+ 54	+ 79	+127	+242
4S	- 79	+ 4.5	+ 21	+ 49	+ 88	+128	+220
5S	- 77	+ 5.0	+ 27	+ 59	+ 80	+112	+236
6S	-100	+ 6.0	+ 18	+ 39	+ 68	+ 97	+197
MEAN	- 60	5.9	23	56	87	129	268
STND. DEV.	32	3.1	17	13	10	14	43

NOTE: Negative values represent face distance prior to reaching monument.
Positive values represent face position beyond monument.

TABLE 3

DISTRIBUTION OF TOTAL SUBSIDENCE VALUES IN TERMS OF FACE POSITION : OVERBURDEN DEPTH RATIO

Station	Dist.-fc/h @ 1% Sub.	%Sub. when face is directly under sta.	Dist.-fc/h @ 10% Sub.	Dist.-fc/h @ 25% Sub.	Dist.-fc/h % 50% Sub.	Dist.-fc/h % 75% Sub.	Dist.-fc/h @ 98% Sub.
2ND	-0.16	7.0	+0.07	+0.14	+0.26	+0.36	+0.73
3ND	-0.12	8.0	+0.03	+0.18	+0.25	+0.38	+0.72
13N	-0.08	5.0	+0.07	+0.20	+0.28	+0.39	+0.76
12N	-0.11	3.5	+0.10	+0.16	+0.25	+0.39	+0.76
11N	-0.11	5.0	+0.07	+0.17	+0.29	+0.40	+0.82
10N	-0.10	5.0	+0.07	+0.19	+0.29	+0.39	+0.66
9N	-0.20	5.0	+0.11	+0.23	+0.29	+0.39	+0.76
8N	-0.02	1.0	+0.19	+0.26	+0.32	+0.44	+0.87
7N	+0.10	0.0	+0.21	+0.27	+0.37	+0.51	+0.86
6N	-0.26	3.5	+0.18	+0.31	+0.39	+0.48	+0.82
5N	-0.06	2.0	+0.15	+0.23	+0.31	+0.47	+0.93
4N	-0.20	3.5	+0.13	+0.23	+0.33	+0.43	+1.06
3N	-0.24	5.0	+0.15	+0.22	+0.28	+0.43	+1.10
2N	-0.13	4.0	+0.10	+0.19	+0.26	+0.39	+0.90
1N	-0.15	5.5	+0.07	+0.17	+0.25	+0.42	+0.94
#3MPBX	-0.29	10.5	-0.01	+0.12	+0.24	+0.40	+1.00

Table 3 (continued)

Station	Dist.-fc/h @ 1% Sub.	% Sub. when face directly under station	Dist.-fc/h @ 10% Sub.	Dist.-fc/h @ 25% Sub.	Dist.-fc/h @ 50% Sub.	Dist.-fc/h @ 75% Sub.	Dist.-fc/h @ 98% Sub.
2E	-0.23	8.0	+0.03	+0.17	+0.26	+0.45	+0.96
1E	-0.29	11.0	-0.01	+0.12	+0.23	+0.40	+1.00
1W	-0.32	9.5	0.00	+0.10	+0.25	+0.39	+0.84
2W	-0.24	7.5	+0.03	+0.13	+0.27	+0.43	+0.83
1S	-0.23	13.0	-0.03	+0.10	+0.22	+0.36	+0.82
2S	-0.32	9.0	+0.01	+0.10	+0.23	+0.39	+0.79
3S	-0.21	7.0	+0.04	+0.17	+0.25	+0.40	+0.76
4S	-0.26	4.5	+0.07	+0.16	+0.29	+0.42	+0.72
5S	-0.26	5.0	+0.09	+0.20	+0.27	+0.38	+0.80
6S	-0.38	6.0	+0.07	+0.15	+0.26	+0.37	+0.75
MEAN	-0.19	5.9	+0.08	+0.18	+0.28	+0.41	0.84
STND. DEV.	0.11	3.1	0.06	0.05	0.04	0.04	0.11

NOTE: Negative values represent ratio of face distance to overburden depth prior to reaching monument.

Positive values represent ratio of face distance to overburden depth beyond monument.

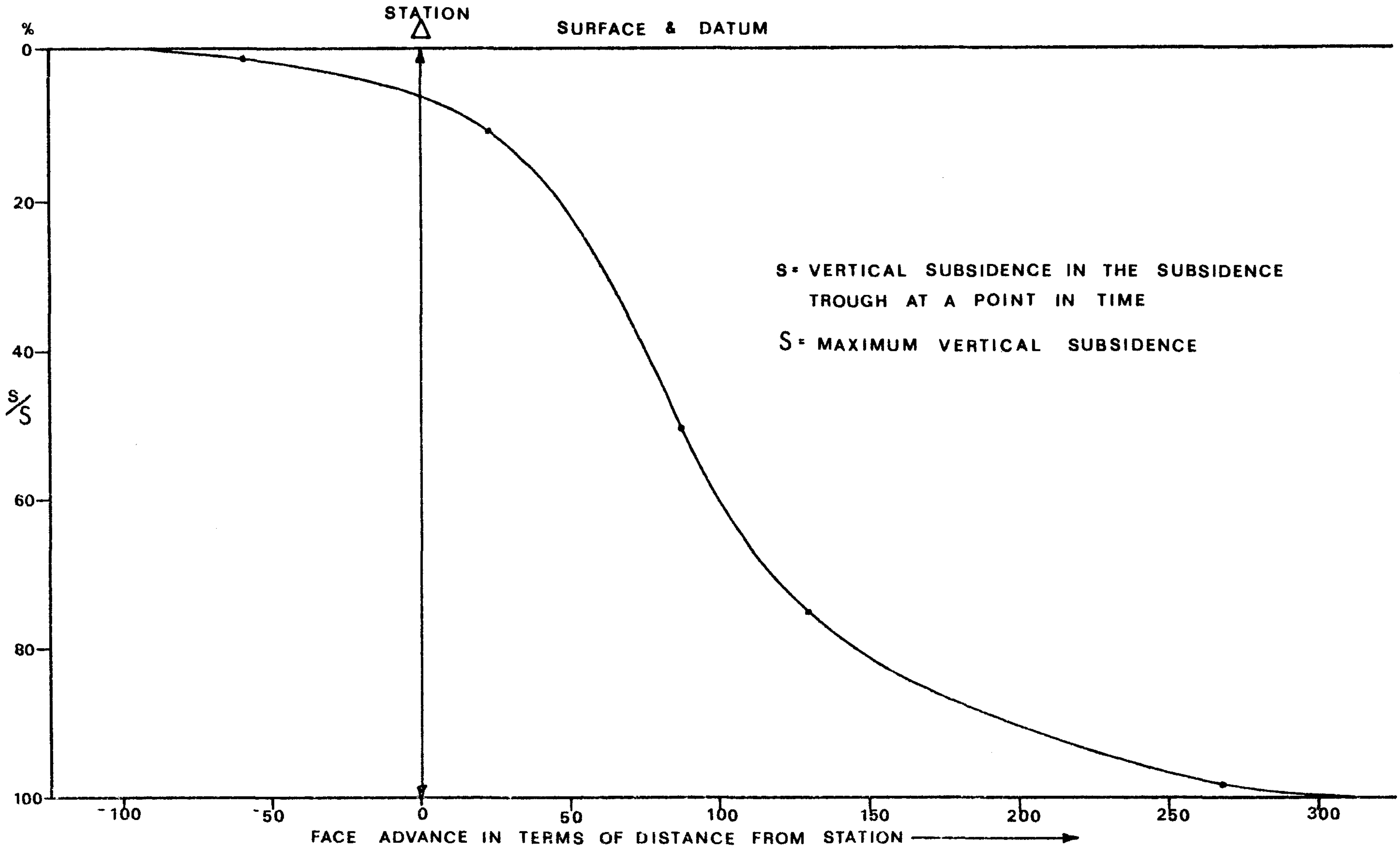


FIG. 30 AVERAGE SUBSIDENCE DEVELOPMENT CURVE (4N LW)

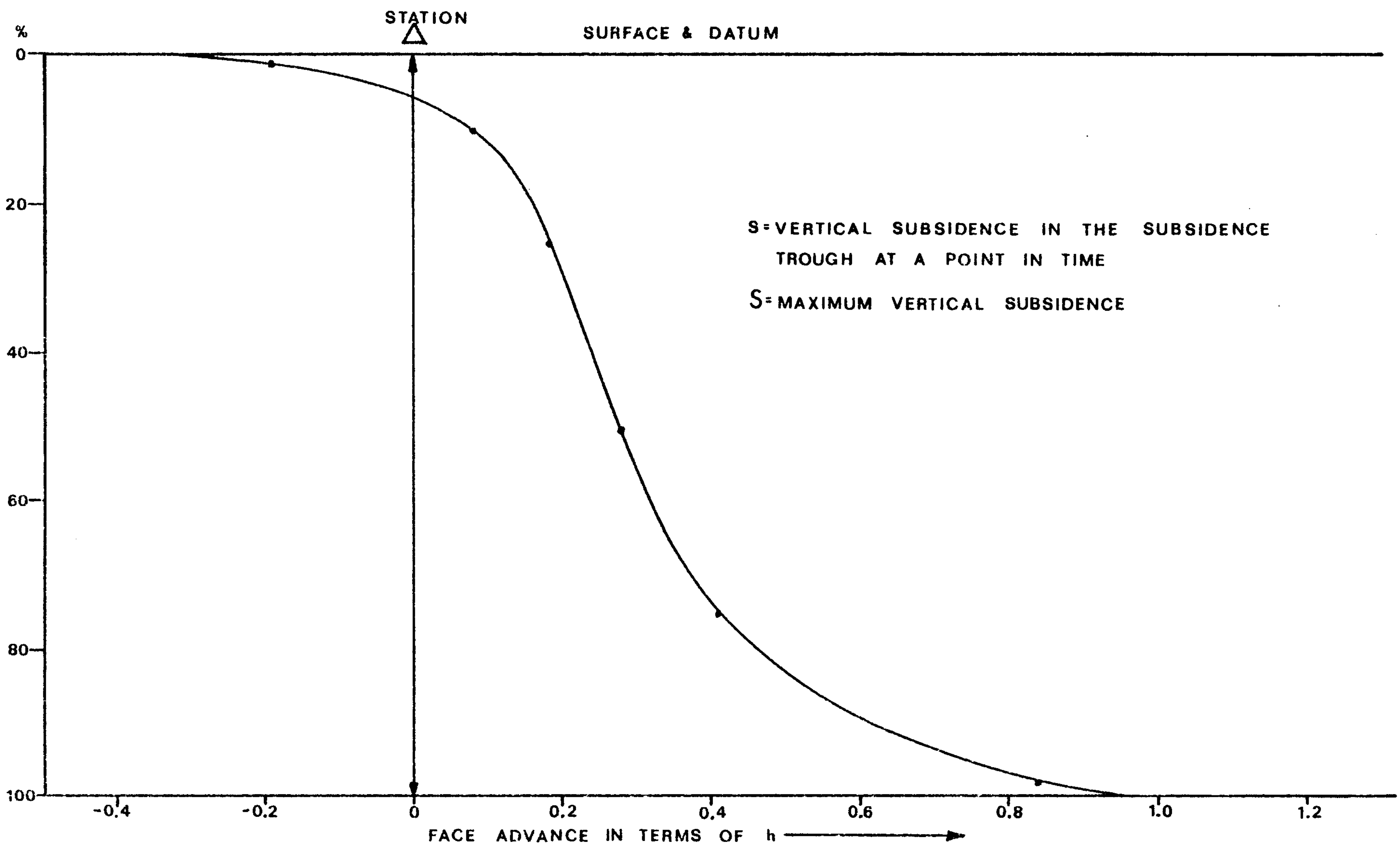


FIG. 31 AVERAGE SUBSIDENCE DEVELOPMENT CURVE (4N LW.).

or later stages of subsidence seem to correlate better with NCB studies than do the initial stages of subsidence.

The average limit angle the NCB uses is approximately 35^{o} (measurable subsidence commencing at 0.7h from surface point). From the final subsidence profiles, Figures 15 and 16, the average angle of draw for both ends of the centerline and both sides of the perpendicular is approximately 15.5^{o}.

The values calculated for the limit angle in a number of observations made in different countries vary significantly. For instance, in Holland values of 35-45 degrees were measured (Drent, 1957); in Great Britain 28-40 degrees (Wardell, K., 1959); in the lower Rhine District 29-39 degrees (Flaschentrager, 1957); and in Poland 19-34 degrees (Knothe, 1959).

Two factors which affect the limit angle are (1) overburden depth and (2) geology of the beds overlying the coal seam. It appears that the limit angle decreases as the depth of cover increases (Hall and Orchard, 1963). Also it is generally accepted that thick sandstone beds above the seam result in low values of the limit angle (Knothe, 1959; Wardell, 1959). The angle of dip of jointing in the rock overburden is another prime factor affecting the ultimate angle of draw (Crane, 1931). Steep angles of dip result in low limit angles.

The 4N longwall panel does not have an unusual depth of overburden (maximum h of 440 ft). Therefore, the low limit angle cannot be attributed to this factor. The geologic information (see Section I) indicates that 30% of the rock overburden consists of sandstone beds with a maximum observed thickness of 20 ft. Sandstone channel deposits of up to 40 ft in thickness are present in the formation. This would support the theory of thick sandstone beds causing low values of the limit angle. The geologic study also established the existance of a steeply dipping, closely spaced joint set having a predominate E-W orientation. This supports Crane's theory that steeply dipping joints result in low limit angles.

In summary, the low limit angles measured above the 4N longwall panel can probably be attributed to the overlying thick sandstone beds and prominent steeply dipping joint sets in the rock overburden.

Table 3 shows that 98% of the subsidence occurs by the time the face is 0.84h past the surface point. This is in close agreement with the NCB's value of 0.8h for 97% completion of subsidence. Evidently there was an initial retardation, as explained above, until the face had progressed well beyond the surface point, Thereafter subsidence developed more or less in accordance with the normal NCB prediction pattern.

Tables 2 and 3 show that there is a greater standard deviation of subsidence values up to 50% subsidence for distance values in terms of "h" than for straight distance values. This would imply that overburden depths are not significant in the initial subsidence development. Conversely, there is a larger standard deviation for subsidence values greater than 50% subsidence for straight distance values as opposed to distance values in terms of "h". This would suggest that overburden does affect final subsidence development. It is logical to assume that with greater overburden depth and stress more time and therefore distance, would be required for the additional compaction to take place.

An attempt was made to correlate the effects topography had on the angle of draw and various subsidence percentages. The first significant change in values occurred in the draw between Monuments 5N and 10N. The face was only 5 ft from being directly under Monument 8N when 1% subsidence had occurred. Monument 7N did not undergo 1% subsidence until the face was 25 ft past the station! This is apparently another effect of the overburden accumulation discussed in the subsidence profile section.

As the face passed under the ridge top between Monuments 2S and 1N another marked change appeared. The distance to the face for 1% subsidence increased from MPBX #3 to Station 6S. The angle of draw might have been increased in this area by the "clearing out" of the overburden from the top of the ridge to the north as it slid into the draw below. The other south facing slope did not experience this "clearing out" process since the panel started under that ridge top. The differences in distances to the face at 1% subsidence for the two south facing slopes (the average distance to the face at 1% subsidence for Monuments 9N-12N is 43 ft, and for Monuments 2S-5S the average distance to the face at 1% subsidence is 82 ft) is probably due to the comparative steepness of the two. The south slope from Monuments 9N to 12N is much steeper than its counterpart along Monuments 2S - 5S. As a result the surface monuments would have to resist more horizontal movement in moving toward the face on the steeper slope than on the more gentle slope. This would cause the initial subsidence to be postponed a little longer on the steeper slope.

Since the face did not progress past the next ridge top to the south, subsidence did not develop fully for the north facing slope between Monuments 8S and 13S. However, initial conditions showed that the distances to the face at estimated 1% subsidence for the monuments on this slope were 20 to 30% greater than for its counterpart between Monuments 1N and 5N.

It can be deduced from the above that the angle of draw increases when the face passes under ridge tops and decreases in gully bottoms and steep slopes facing the direction of advance. Also, the profile for the perpendicular (Figure 16) shows that the angle of draw increases when slopes face toward the center of the subsidence trough and decrease on slopes facing outward from the center of the subsidence trough.

The effect of overburden on final subsidence can be demonstrated by comparing the distances to the face at 98% subsidence to overburden depths > 325 ft and < 325 ft. For overburden depths > 325 ft the average distance to the face at 98% subsidence is 301 ft with a standard deviation of 29 ft. On the other hand, the average distance to the face at 98% subsidence for overburden depths < 325 ft is only 243 ft with a standard deviation of 35 ft.

Subsidence vs. Mining Activity:

The mine was idle from December 24th to January 5th. Surveys were made on December 23rd, 24th, 26th, 29th and January 5th. Figures 32 and 33 show the results of the most actively moving monuments at the time the study was made. The graphs show that major subsidence ceases almost immediately after mining stops and that surface subsidence resumes soon after the mining resumes. When the panel was completed additional surveys were made to determine when the subsidence ceased. The survey data in Appendix E. for Monuments 7S, 8S and 9S (the most actively moving monuments at the completion of the panel) show that subsidence ended soon after mining operations stopped (the shields were stopped on May 14, 1976, with two additional cuts being made without moving the shields). It appears that surface subsidence from the underground workings in the vicinity of panel 4N is transmitted almost instantaneously to the surface, and major subsidence ceases almost as soon as mining ceases.

Subsidence vs. Time:

The time for complete subsidence to occur is directly related

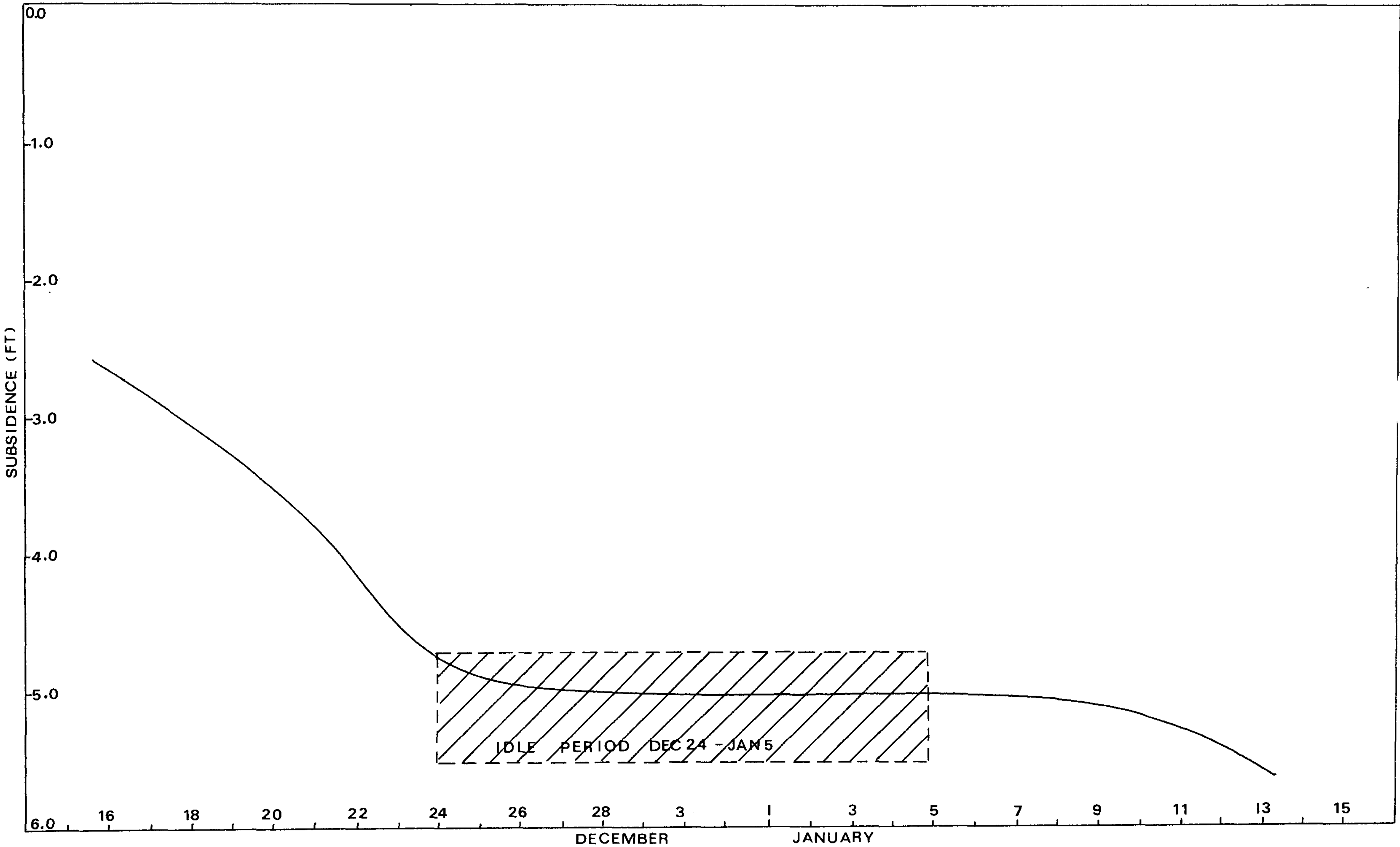


FIG 32 EFFECT OF ACTIVE AND PASSIVE EXTRACTION ON SUBSIDENCE ON STATION IN York Canyon Mine Test Panel.

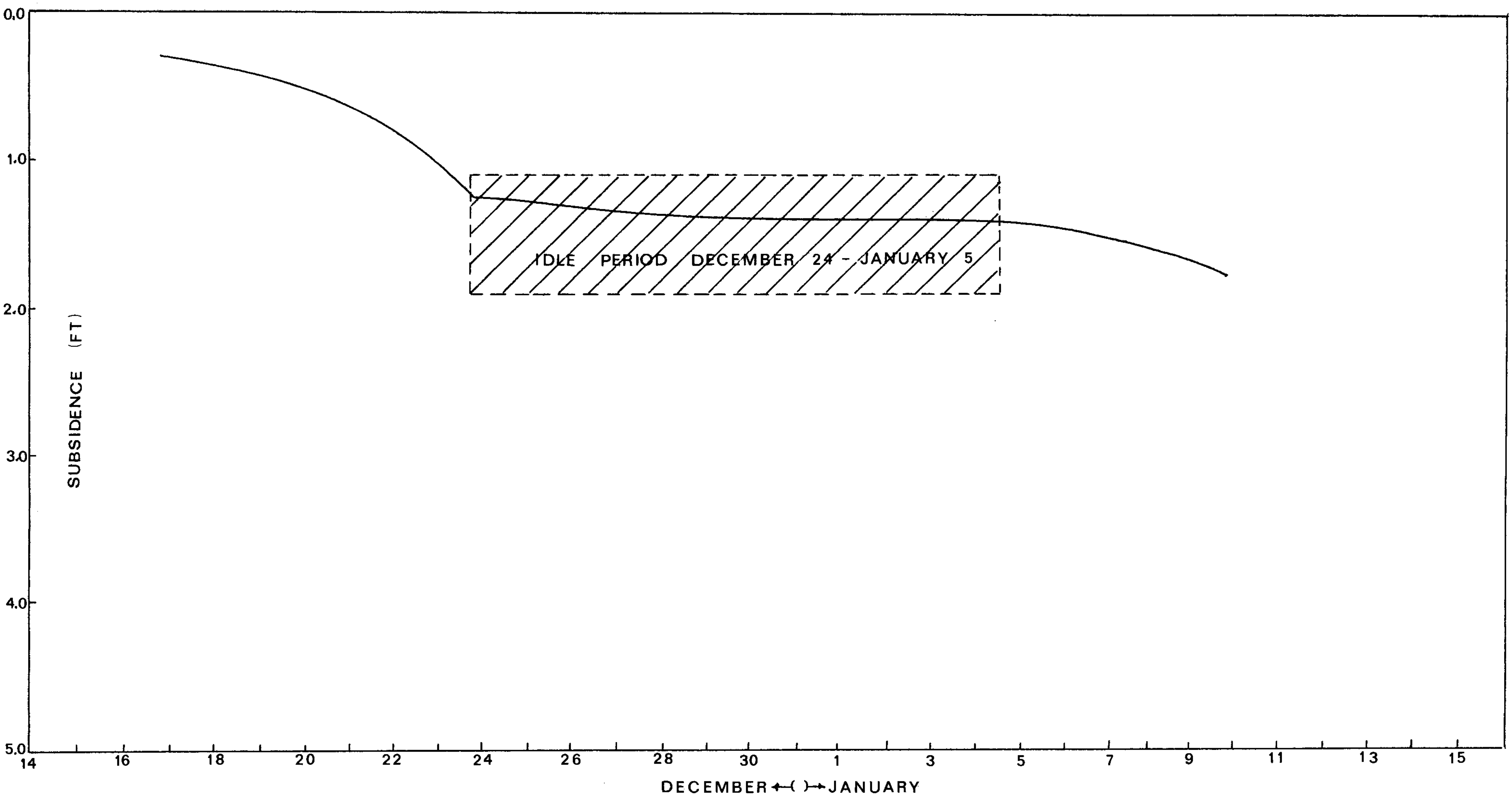


FIG 33 EFFECT OF ACTIVE AND PASSIVE EXTRACTION ON SUBSIDENCE FOR STATION 1S.

York Canyon Mine Test Panel.

to the preceding section. The fact that upward propagation is transmitted almost immediately to the surface and that subsidence ceases almost as soon as mining ceases makes the job of determining when subsidence will be complete relatively easy. As soon as the critical influence area of the face intersects the surface point, subsidence will begin. Subsidence will then increase until the critical influence area of the advancing face passes outside the surface point. The surface subsidence response associated with the critical area for longwall panel 4N appears to start when the face is 0.2h from the surface point in question and is essentially complete when the face is at 0.84h beyond the surface point. Since studies of the 4N longwall panel show that subsidence ends soon after this, the time taken for a point on the surface to undergo complete subsidence is simply the time taken for the face to advance through the critical area.

Surface Subsidence Cracks:

Whenever a large quantity of material is mined underground, the surface will move in response. Movement is transferred through to the surface when the ratio of width of the extracted area to the depth of cover (w/h) exceeds a value which varies from 0.1 to 0.5 (Wardell and Eyon, 1968) and depends primarily on the overlying strata.

The movements observed at the surface can be broadly divided into two groups. One group of movements results in surface fractures, stepped terraces and almost vertical walls. The second group of movements cause a gradual formation of a depression in the surface.

Subsidence troughs usually form over the mining of coal seams or other tabular deposits where the thickness mined is small in relation to the depth of cover. The surface usually does not fracture or fissure extensively where coal seams are relatively thin. However, the average extracted coal seam thickness at the York Canyon Mine was 10.0 ft and surface cracking did occur. Differential subsidence is probably the main cause of surface cracking (Kapp, 1973).

Figures 34 and 35 show the 4N longwall panel and topography with an overlay showing the location and distribution of surface subsidence cracks. From the figures it is evident that the cracks are approximately parallel to the longwall face orientation (perpendicular to the direction of face advance) in the vicinity of the centerline. There is a comparative absence of cracking in the draws. This can be explained by the increased compressional forces present at the bottom of the draws and the overburden accumulations as explained in an earlier section.

At some distance away from the centerline the surface cracks appear to parallel both the subsidence bowl and topography. The southwest side of the panel has very few surface cracks parallel

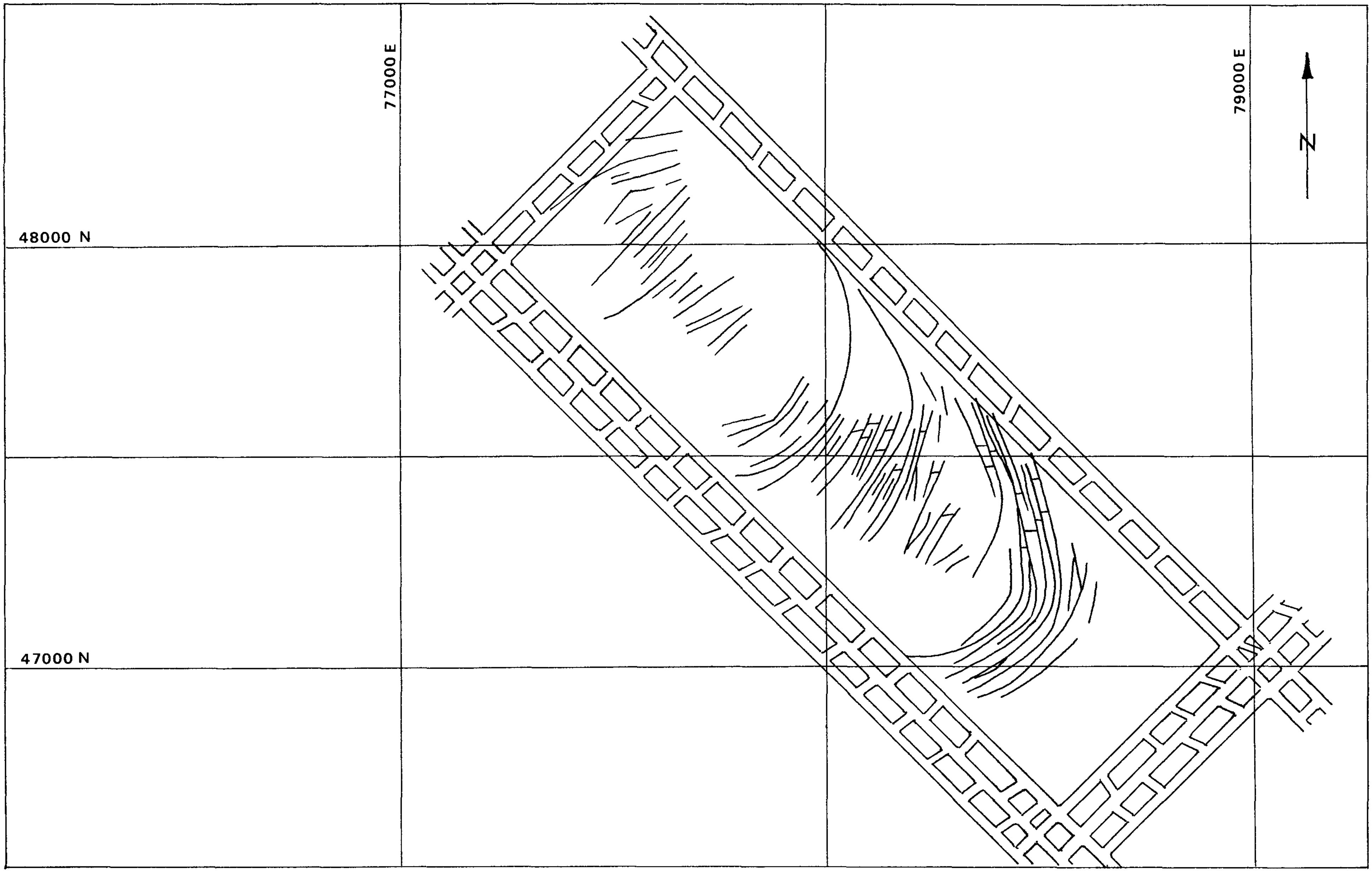


FIG 34 SURFACE CRACKS OVER 4N L.W. PANEL. York Canyon Mine.

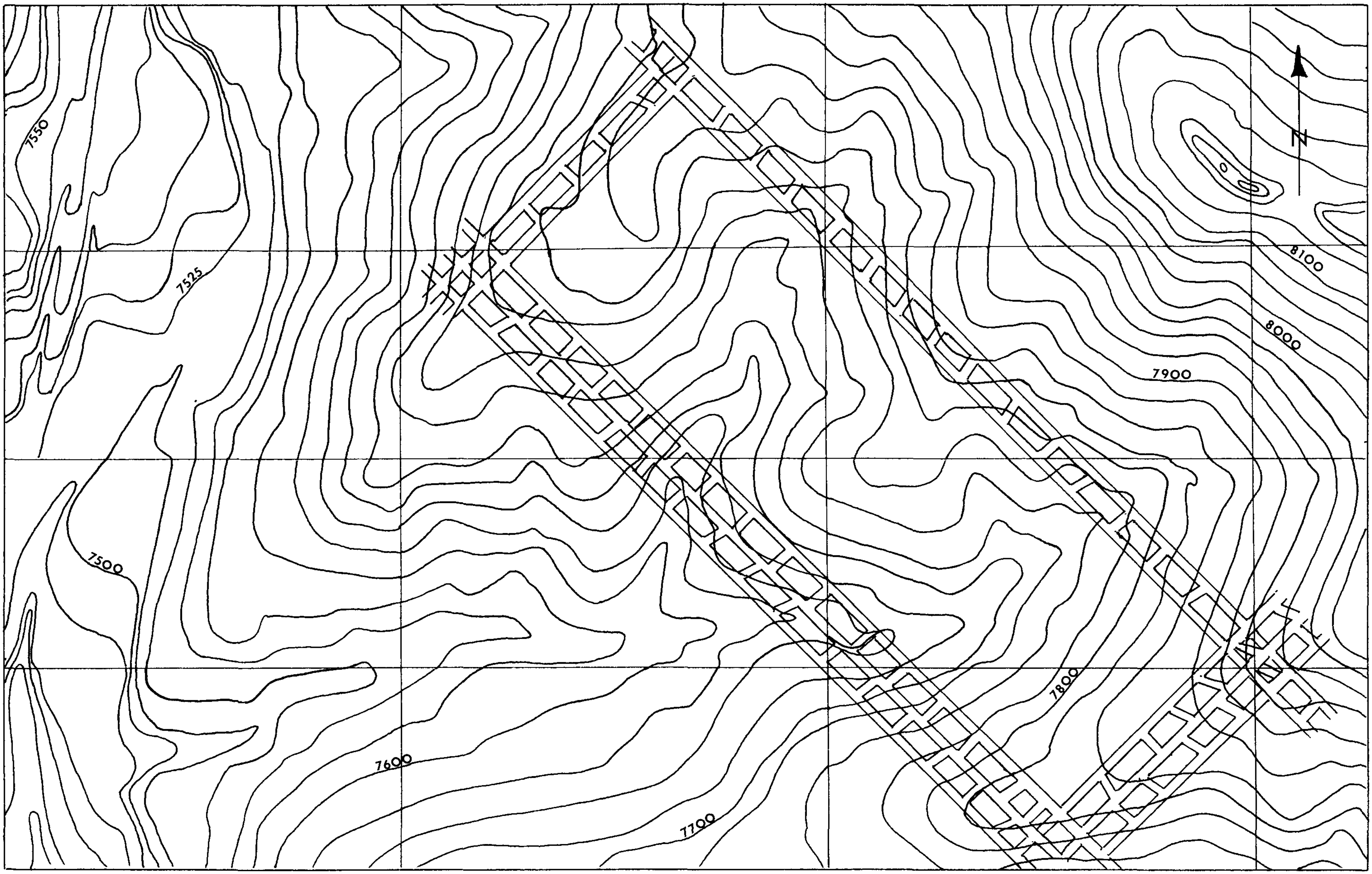


FIG 35 GENERAL TOPOGRAPHY 4N L.W. PANEL. York Canyon Mine.

to the tailgate. Evidently the east-west sloping topography retarded crack development by hindering overburden movement into the subsidence trough.

It may be important to note here that secondary cracks oriented approximately east-west were observed on the high side of the panel. This indicates that the east-west joint system in the rock below the soil overburden is also a controlling factor.

The first sign of surface cracks typically appeared when the face was directly under or a little past (10-20 ft) their location. Specific cracks were monitored on both north-facing and south-facing slopes. Wooden stakes were driven on each side of a crack at its first appearence. Daily measurements were taken of the spread between the stakes and all measurements showed these cracks going from tension into compression when the face was less than 60 ft past the crack.

One of the first surface cracks to form was in the form of a step. This step was located near the northern corner of the panel and intersected a point just south of Monument 6ND (see Figures 20, 32 and 33). This step had about 0.70-ft of vertical displacement, with the high side of the step to the north. The cause of this step was the rapid increase in subsidence from the panel corner inward and also the lack of unconcolidated soil overburden in this area (less than 1.0 ft). This condition is present in block caving operations, only to a larger scale, where soil overburden thickness is small compared to extraction thickness (Obert and Long, 1962). This condition was not found at other locations along the panel probably because a greater depth of non-cohesive soil materials were present. In block caving areas where the surface is overlain by thick non-cohesive materials, slumping develops rather than the near vertical banks characteristic of areas where there is little unconsolidated surface cover (Kapp, 1973).

The only other significant feature associated with the surface cracks was an abnormally wide crack (approximately 0.90 ft wide) located just behind the point where the face was stopped. The maximum width on all the other cracks was around 0.40 ft. This increase in width can probably be attributed to the steep slope facing the point where the face was stopped.

Subsidence Contours:

Subsidence contour maps were constructed using the ratio of total subsidence to seam thickness extracted as contour values. Since subsidence varied depending on location above the panel and/or topography, it was felt that a more rapid determination of the actual subsidence could be made utilizing contoured values. To find the actual subsidence one need only multiply the value of the subsidence contour by 10.0 ft (10.0 ft is the average seam thickness extracted along the 4N longwall panel).

Figures 36 thru 38 show subsidence contours at three different

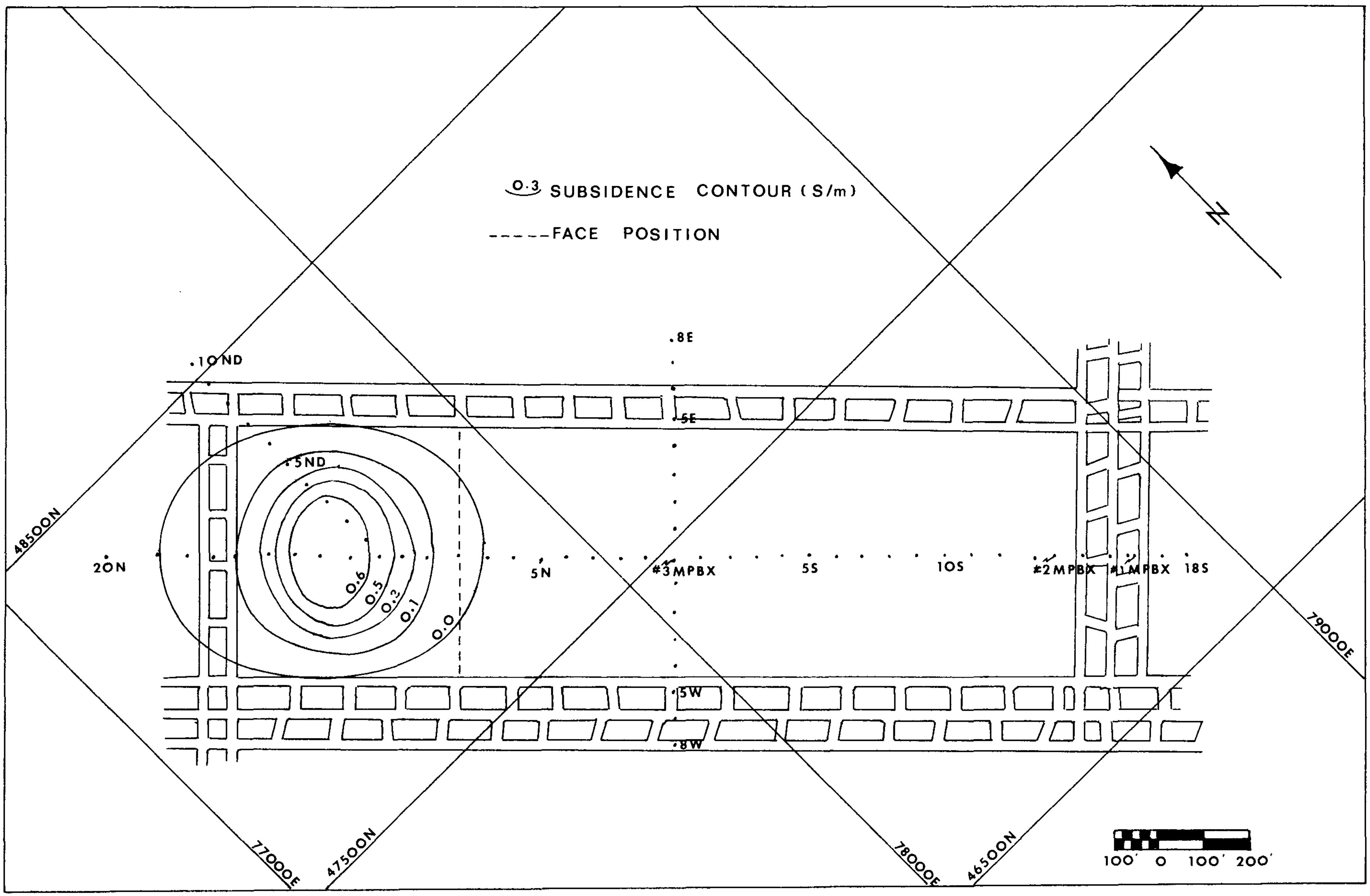


FIG 36 SUBSIDENCE CONTOURS SUB./SEAM THICK. EXTRACTED.

York Canyon Mine Test Panel. Face at 8N: Sept. 9, 1975.

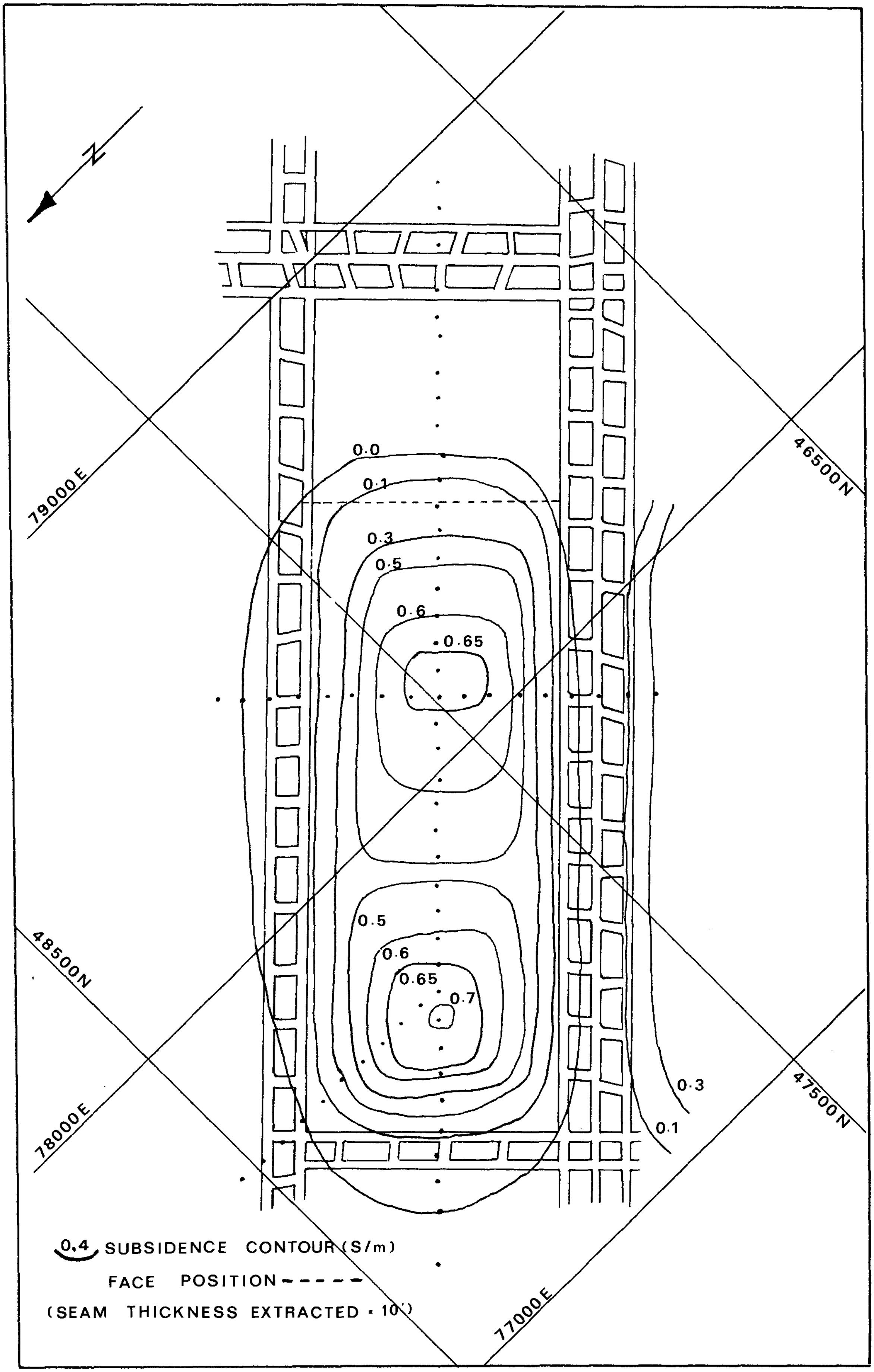


FIG 37 SUBSIDENCE CONTOURS SUB./SEAM THICKNESS EXTR.

York Canyon Mine Test Panel. Face 15'S of 7S: March 15, 1976.

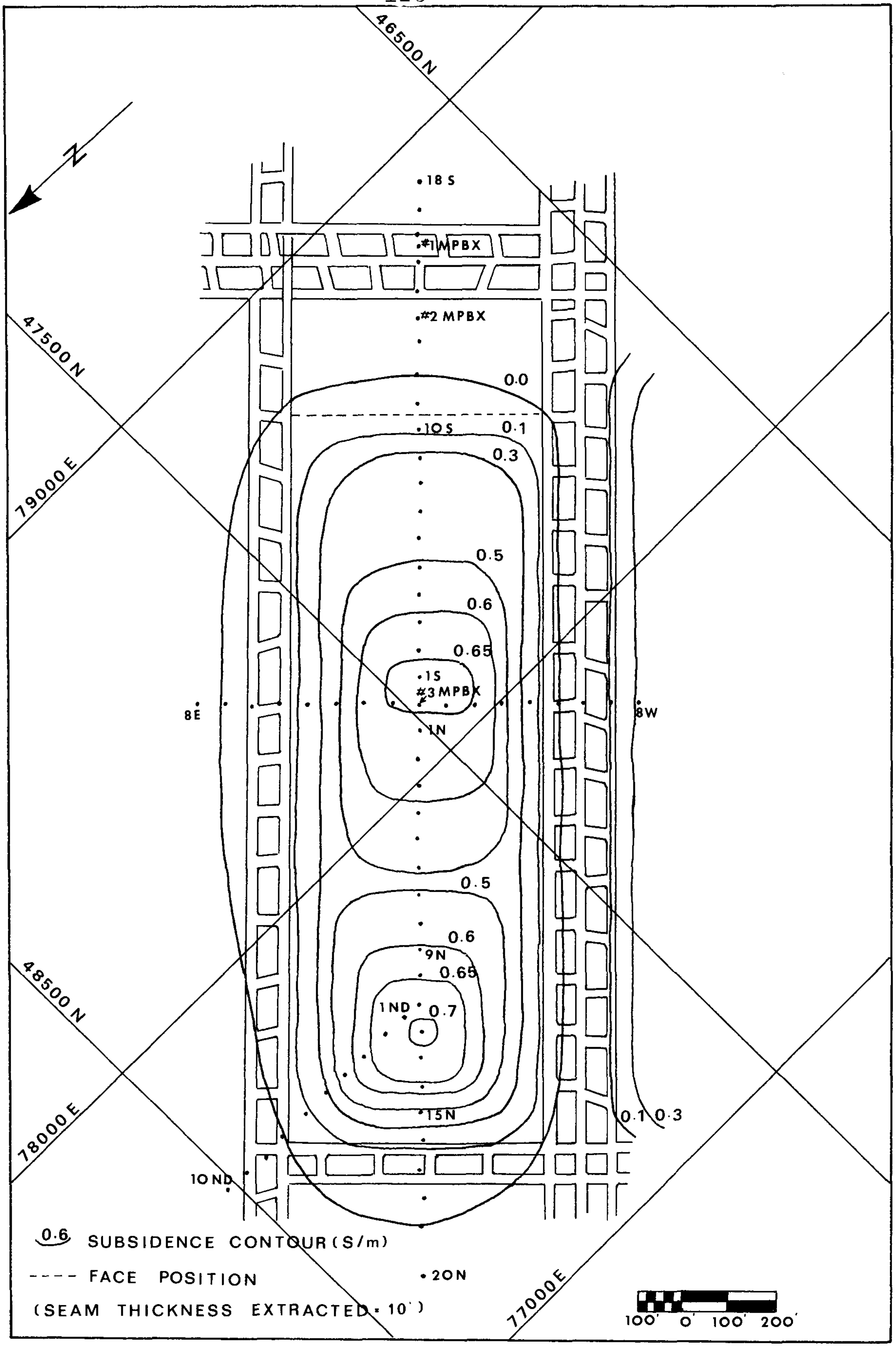


FIG 38 SUBSIDENCE CONTOURS SUB/SEAM THICKNESS EXTR.
York Canyon Mine Test Panel Stabilized Conditions.
Fc 35'S of 10S: May 29, 1975.

stages of panel extraction. When the face was at 8N (Figure 36) the subsidence was fairly uniform. Subsidence went from zero on the edges of the extraction area to a maximum at the center. Very little variation was noted in subsidence since the middle of the extracted area was centered under a ridge top between Monuments 10N and 16N. Figure 37 shows the subsidence after the face had progressed under the next ridge top. Like the travelling subsidence profile map, this subsidence contour map readily shows the effects of topography. Subsidence "highs" are noted in the areas of Monuments 9N - 14N and 3N - 3S. If a topographic map is overlayed on this contour map it shows ridges in these same areas. Conversely, a subsidence "low" is indicated in the area between Monuments 5N and 8N. This area is located in a draw or topographic low. The reasons for this noted decrease of subsidence in topographic lows were given in the section on subsidence profiles.

Figure 38 is the final subsidence contour map based on the final movements above longwall panel 4N after the panel was stopped. Since the face was stopped only 35 ft south of Monument 10S the complete subsidence history of the Monuments (7S- 12S) on the next slope was not developed. As a result this contour map is very similar to the one developed when the face was 15 ft south of Monument 7S. If the face had progressed completely under this slope there would have been another subsidence "low" in the vicinity of Monuments 6S - 8S.

The subsidence contours noted to the southwest of the outside tailgate entry are due to a pillar robbing operation that was accompaning the longwall advance. Undoubtedly more subsidence occurred to the southwest of Monument 8W but because no monuments were constructed this far out no additional information was obtained.

The subsidence contour representing zero subsidence is seen to deviate much farther from the headgate side. Since the general topography slopes from the northeast to the southwest it can be seen that the limit angle increases when the topography slopes toward the center of the subsidence trough and decreases when slopes face opposite the center of the trough.

The subsidence contour map not only gives a "bird's eye" view of how subsidence decreases from the center of the trough outward, but it also shows the relative effect topography has on subsidence.

Strata Separation (MPBX Data):

As mentioned earlier in the report only the northernmost of the three multiple-position borehole extensometers (MPBX No. 3) yeilded any useful information during the extraction of longwall panel 4N.

The MPBX is designed to measure axial strain components in the instrumented drill hole. As the drill hole is axially deformed, the distances between individual down-hole anchors and the instrument head changes, as do the distances between adjacent anchors. These distance changes measured by the MPBX were reduced to the parameters needed to illustrate how the rock mass was affected above the 4N longwall panel.

The relative anchor spacing of MPBX No. 3 is shown in Figure 14 of the section titled "MPBX Installation". The base and reduced data for this MPBX is presented in Appendix F. Two figures were drawn from this data, one to show the tensional development for depth vs. face position, and the other to show the relative strain between anchors (Figures 39 and 40).

Figure 39 shows where, relative to face position, the overlying strata first went into tension at the midway positions between the various anchors. It also shows where bedding and joint separations are likely to first appear and progress versus face position.

Figure 40 is the graph that really describes how the overburden responded to longwall mining. It shows that there was compressive strain between anchors 4 and 5 up until the time they were hit by the coal shearer. This illustrates that they registered the increased face abutment weight the coal seam took on as the face approached. The total convergence indicated by multiplying the maximum strain (350 u-in./in.) by the distance between anchors 4 and 5 (25 ft) was 0.105-in. The convergence underground at this

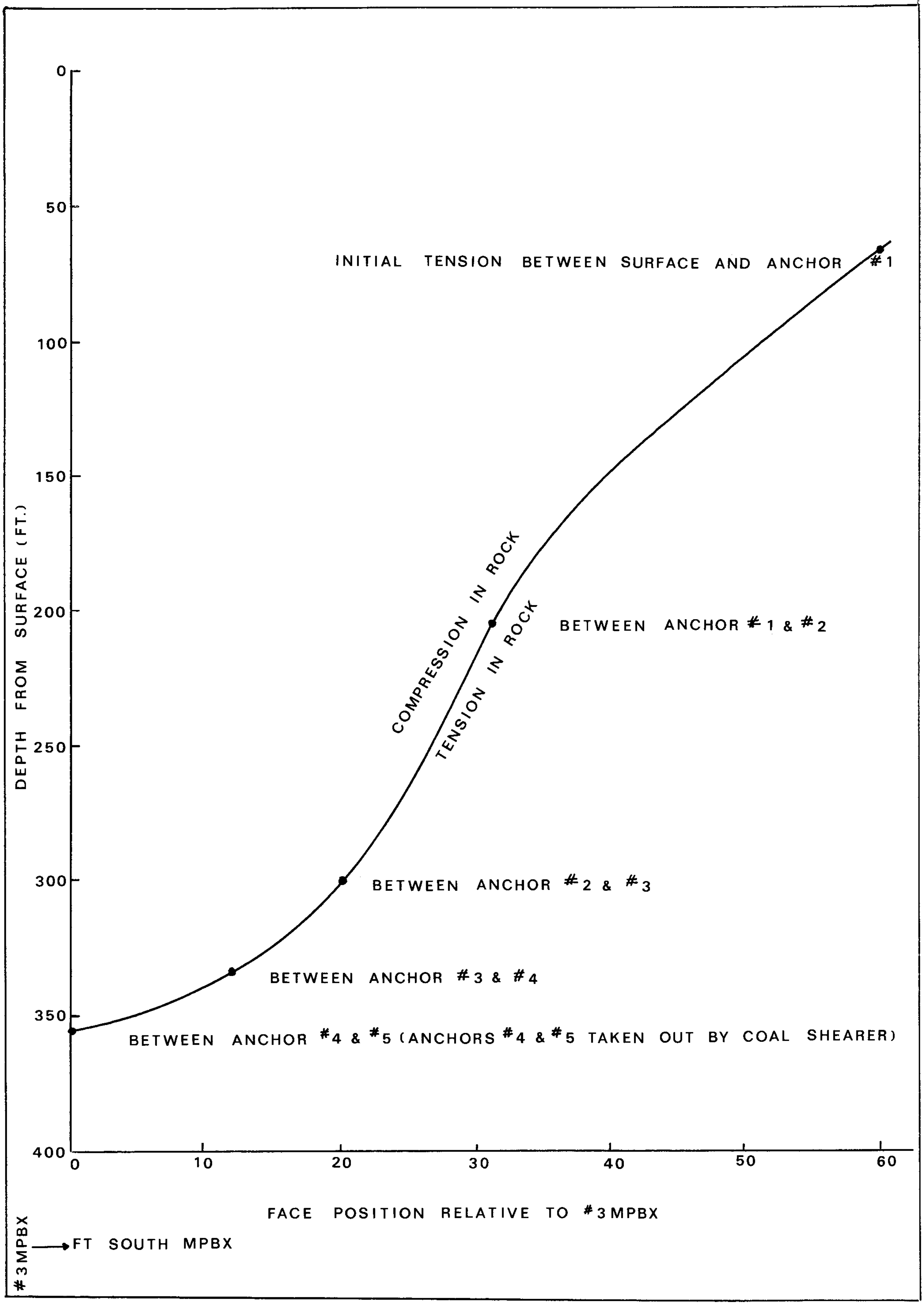


FIG 39 TENSION DEVELOPMENT FOR DEPTH vs FACE POSITION
York Canyon Mine Test Panel

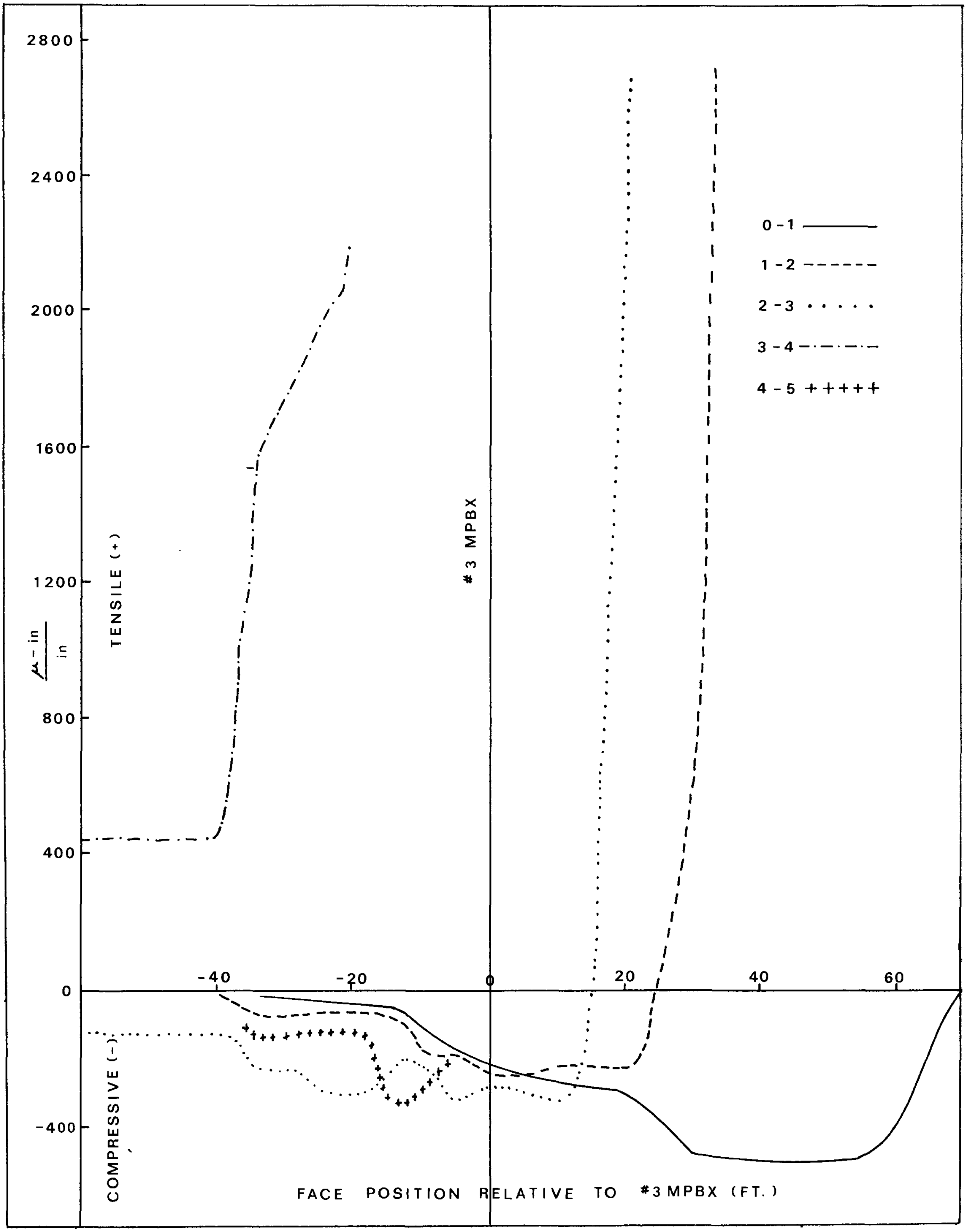


FIG 40 RELATIVE STRAIN BETWEEN ANCHORS
York Canyon Mine Test Panel

time was 0.16-in. recorded at convergence Station B1-5 for the same relative face position. The tensile strain between anchors 3 and 4, when the face was 100 ft from MPBX No. 3, indicates there was initially strata separation between the sandstone bed overlying the coal seam and the shale layer overlying this sandstone bed. When the face reached the anchor string, anchor 4 was not immediately severed indicating that this anchor was just at the bottom of the sandstone bed. The strata separation when the face was 60 ft away was approximately 0.079-in. (440 u-in./in. x 15 ft) between the sandstone and shale beds directly above the coal seam. This tensile strain between anchors #3 and #4, apparently indicating bed separation, may also be the result of lateral movement associated with shear stresses acting along the bedding contact.

Anchors 2 to 3, 1 to 2 and surface to 1, show initial compression and then tension as the overburden deflected into the subsidence trough. Initial compression between these anchors resulted from the overburden sliding into the subsidence trough at differing rates at different depths, starting with the higher anchors first. This is easily visualized if one considers a travelling angle of draw first intersecting the instrument head and lowering it, then intersecting anchor 1 and lowering it, etc.

The first sign of any movement registered by MPBX No. 3 was on November 23, 1975, when the face was about 100 ft from the borehole. Since this registered movement was between the instrument head and anchor 3 only, it was apparently only due to increasing face abutment load on the coal. Surface movement (indicated by registered movement between the instrument head and anchor 5) did not take place until the face was about 75 ft away. This indicates an angle of draw of approximately 12.4^{0} when 0.04-in. of movement had occurred.

It is interesting to note that on December 2, 1975, the movement between the instrument head and anchor 5 was only 0.04-in. whereas the subsidence survey on December 2 showed that the instrument head had dropped over 0.10 ft! This can be explained if one considers the instrument head moving in an arc about anchor 5. This could cause a decrease in instrument head elevation while at the same time keeping the relative distances between anchors and instrument head constant.

Measured Subsidence vs. Predicted Subsidence:

The National Coal Board (NCB), in England, has compiled various graphs and tables from numerous field observations in order that mining induced subsidence can be predicted with a reasonable degree of accuracy. These curves were developed from actual cases in which certain limiting conditions existed. In order for the predications to be valid, these limiting conditions must be met. They are as follows:

(1) The working panels must extend for a distance of

about 0.7 times the depth, or more, in front of and behind, the surface point where subsidence is to be predicted; i.e. the total length of the panel (L) must be about 1.4h or more;

(2) The working panels have no center gates or other zones of special packing apart from those at the headgate and tailgates; and

(3) The average panel width must be used in cases where the sides of the panel are not parallel.

In those cases where the panel length extracted is less than 1.4h, the subsidence predicted by NCB methods must be reduced in proportion to the distance of limited face advance. A partial subsidence curve, as shown in Figure 41, is used to predict the subsidence in these cases. The 4N longwall panel had an extracted length of 1600 ft which greatly exceeds 1.4h.

The first step in predicting subsidence is to determine the parameters of panel width (w), seam thickness to be extracted (m), and overburden depth (h).

The transverse profile along the perpendicular of the 4N longwall panel is used for comparison purposes. The perpendicular was along a ridge top which sloped from the headgate side toward the tailgate side of the panel (see Fig. 16). The width of the panel extended from 10 ft east of Station 5W to 5 ft west of Station 5E. In order to show the effect of different overburden heights

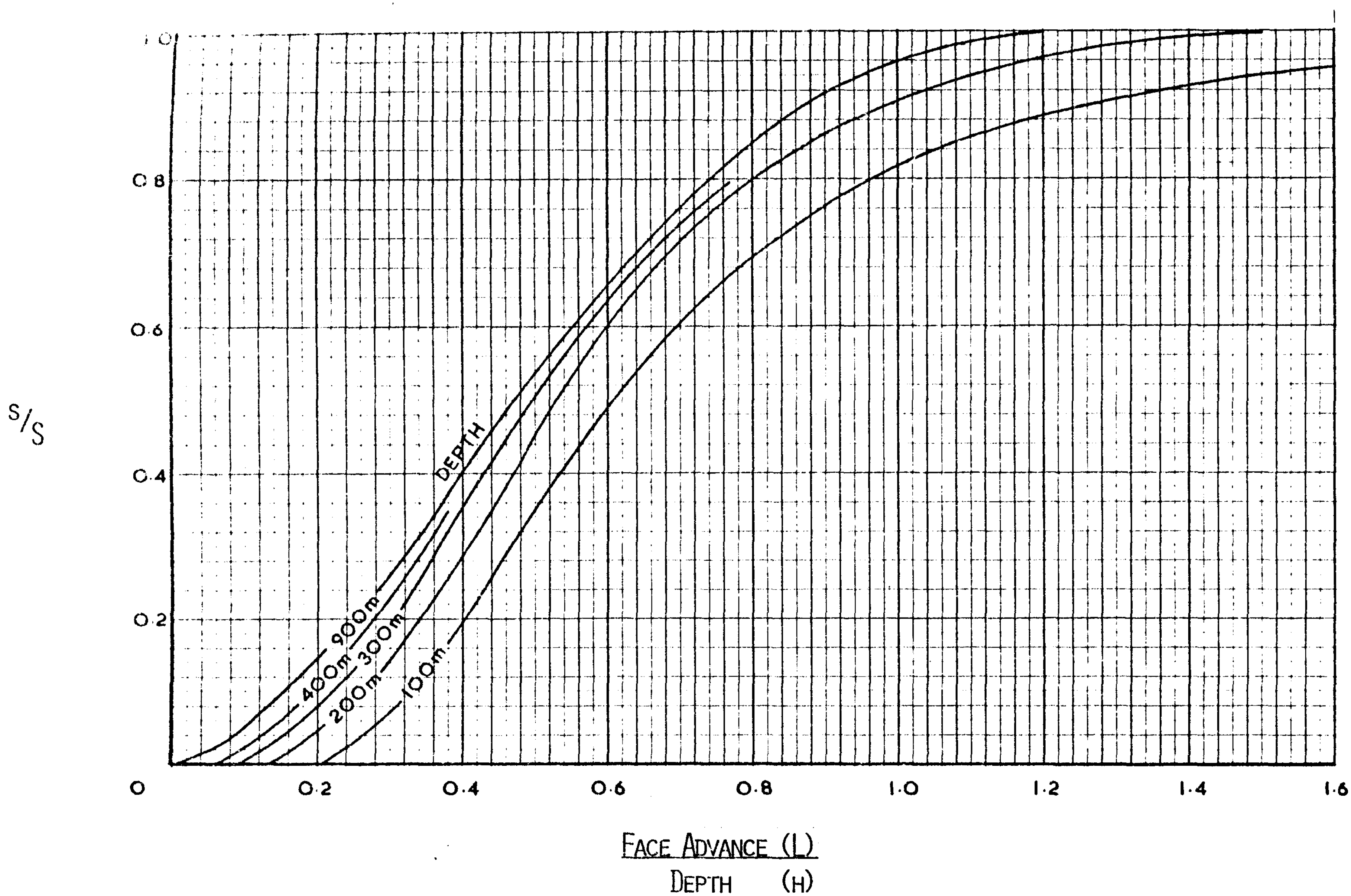


FIG 41 CORRECTION GRAPH FOR LIMITED FACE ADVANCE (NATIONAL COAL BOARD, 1975)

on predicted subsidence profiles the heights of overburden at both 5E and 5W were used. The following parameters were:

Panel width (w)	= 580 ft = 177 m
Seam thickness extracted (m)	= 10.0 ft = 3.05
Overburden height (h) @ 5E	= 393 ft = 120 m
Overburden height (h) @ 5W	= 242 ft = 74 m

To find the subsidence factor (s/m), Figure 42 is used. Thus for a panel width of 177 m and overburden height of 120 m, s/m = 0.86 and for the other extreme (using the overburden height of 74 m at Station 5W), s/m = 0.89. The values used in constructing the prediction curves were derived from cases of multi-seam workings. The NCB recommends a reduction in the subsidence values by a multiplying factor of 0.9 when predicting subsidence in virgin ground. With this factor applied the subsidence factors become 0.77 and 0.80 respectively for panel 4N. To find the maximum subsidence, the subsidence factor is simply multiplied by the seam thickness extracted, which is 10.0 ft for the 4N longwall panel. Figure 43 is a family of curves of "contours" from which subsidence values (s/S) for any profile can be determined. For a more rapid determination of subsidence, Table 4 records the values from which the "contours" are plotted.

In order to predict vertical subsidence for longwall panel 4N, a table was constructed (see Table 5), setting out in line 1 some assumed values of s/S. For convenience the top line of

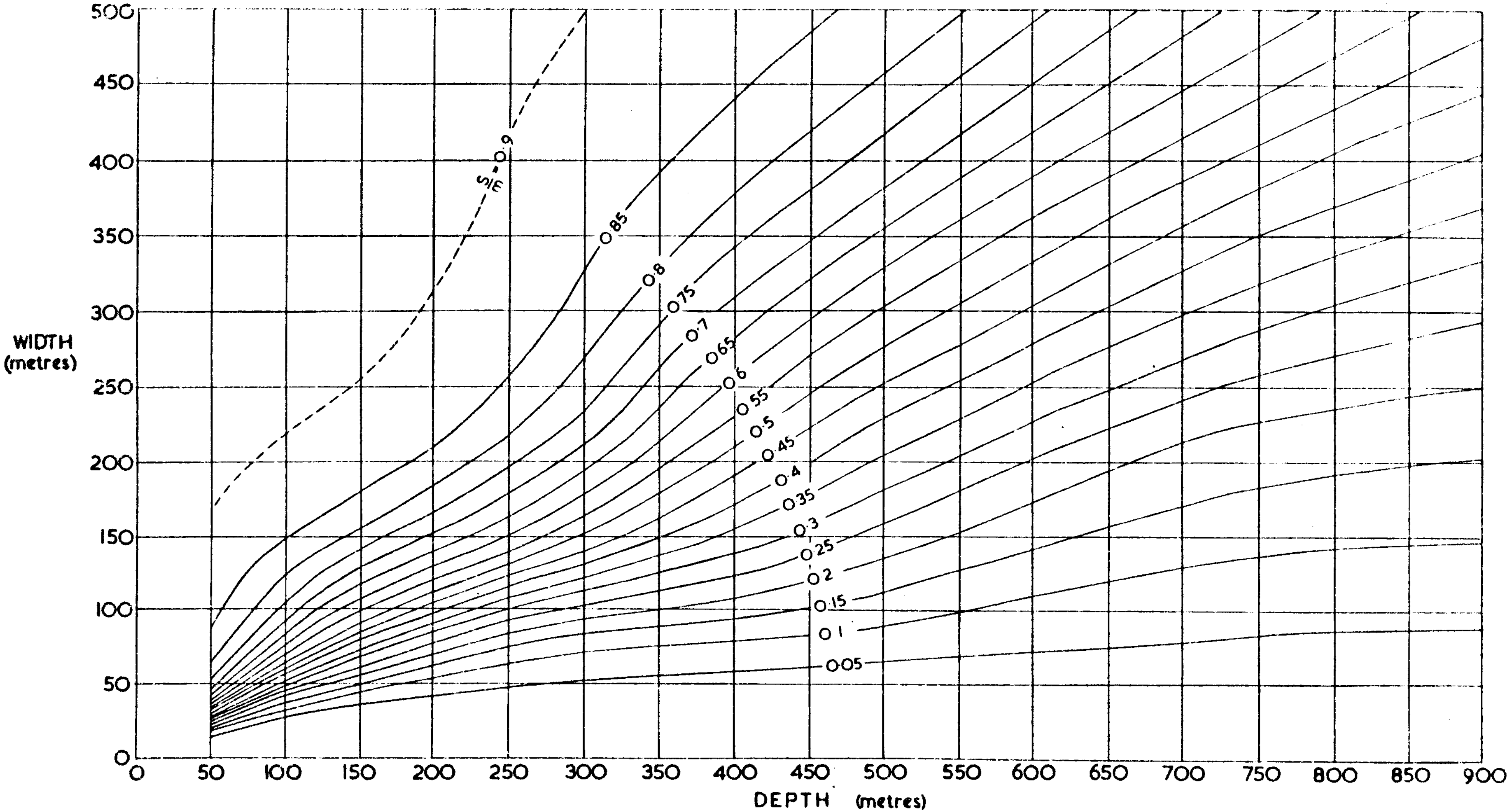


FIG 42 RELATIONSHIP OF SUBSIDENCE TO WIDTH AND DEPTH (NATIONAL COAL BOARD, 1975)

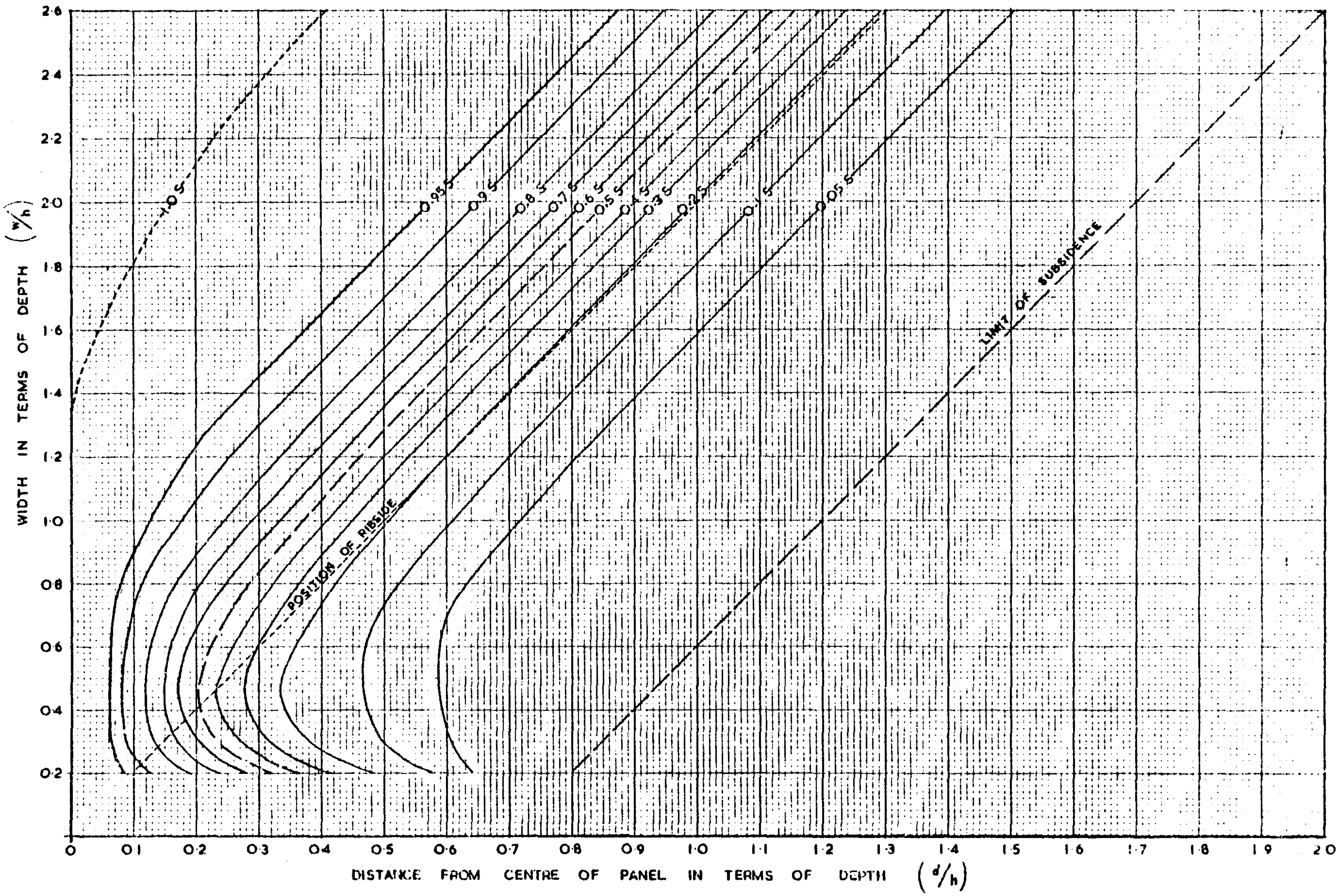


FIG 43 GRAPH FOR PREDICTING SUBSIDENCE PROFILES (NATIONAL COAL BOARD, 1975)

Values of s/S	0	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.95	1.00
w/h RATIO OF PANEL	DISTANCES FROM PANEL CENTRE IN TERMS OF DEPTH												
2.6	2.00	1.51	1.39	1.29	1.24	1.19	1.16	1.12	1.08	1.03	0.95	0.87	0.41
2.4	1.90	1.41	1.29	1.19	1.14	1.10	1.06	1.02	0.98	0.93	0.85	0.77	0.31
2.2	1.80	1.31	1.19	1.09	1.04	1.00	0.96	0.92	0.88	0.83	0.75	0.67	0.23
2.0	1.70	1.21	1.09	0.99	0.94	0.90	0.86	0.82	0.78	0.73	0.65	0.57	0.16
1.8	1.60	1.11	1.00	0.90	0.84	0.80	0.76	0.72	0.68	0.63	0.55	0.47	0.10
1.6	1.50	1.01	0.90	0.80	0.74	0.70	0.66	0.62	0.58	0.53	0.45	0.37	0.05
1.4	1.40	0.91	0.80	0.70	0.64	0.60	0.56	0.52	0.48	0.43	0.35	0.27	0.01
1.3	1.35	0.86	0.75	0.65	0.59	0.55	0.51	0.47	0.43	0.38	0.30	0.23	0
1.2	1.30	0.81	0.70	0.60	0.54	0.50	0.46	0.42	0.38	0.33	0.25	0.19	0
1.1	1.25	0.77	0.65	0.55	0.50	0.45	0.42	0.38	0.34	0.29	0.21	0.16	0
1.00	1.20	0.72	0.61	0.51	0.45	0.41	0.37	0.33	0.29	0.24	0.18	0.13	0
0.98	1.19	0.71	0.60	0.50	0.44	0.40	0.36	0.33	0.28	0.24	0.17	0.12	0
0.96	1.18	0.70	0.59	0.49	0.43	0.39	0.35	0.32	0.27	0.23	0.16	0.11	0
0.94	1.17	0.69	0.58	0.48	0.42	0.38	0.34	0.31	0.26	0.22	0.16	0.11	0
0.92	1.16	0.68	0.57	0.47	0.41	0.37	0.33	0.30	0.26	0.21	0.15	0.10	0
0.90	1.15	0.68	0.57	0.46	0.40	0.36	0.32	0.29	0.25	0.20	0.14	0.10	0
0.88	1.14	0.67	0.56	0.45	0.40	0.36	0.32	0.28	0.24	0.20	0.13	0.10	0
0.86	1.13	0.66	0.55	0.45	0.39	0.35	0.31	0.27	0.23	0.19	0.13	0.09	0
0.84	1.12	0.65	0.54	0.44	0.38	0.34	0.30	0.26	0.22	0.18	0.12	0.09	0
0.82	1.11	0.64	0.53	0.43	0.37	0.33	0.29	0.26	0.21	0.17	0.12	0.08	0
0.80	1.10	0.63	0.52	0.42	0.36	0.32	0.28	0.25	0.21	0.17	0.11	0.08	0
0.78	1.09	0.63	0.52	0.42	0.36	0.32	0.28	0.24	0.20	0.16	0.11	0.08	0
0.76	1.08	0.62	0.51	0.41	0.35	0.31	0.27	0.23	0.20	0.16	0.11	0.07	0
0.74	1.07	0.61	0.50	0.40	0.34	0.30	0.26	0.23	0.19	0.15	0.10	0.07	0
0.72	1.06	0.61	0.50	0.39	0.34	0.30	0.26	0.22	0.18	0.15	0.10	0.07	0
0.70	1.05	0.60	0.49	0.39	0.33	0.29	0.25	0.21	0.18	0.14	0.10	0.07	0
0.68	1.04	0.60	0.49	0.38	0.32	0.28	0.24	0.21	0.17	0.14	0.10	0.07	0
0.66	1.03	0.60	0.48	0.38	0.32	0.28	0.24	0.20	0.17	0.14	0.09	0.06	0
0.64	1.02	0.59	0.48	0.37	0.31	0.27	0.23	0.20	0.17	0.13	0.09	0.06	0
0.62	1.01	0.59	0.47	0.37	0.31	0.27	0.23	0.19	0.16	0.13	0.09	0.06	0
0.60	1.00	0.59	0.47	0.36	0.30	0.26	0.22	0.19	0.16	0.13	0.09	0.06	0
0.58	0.99	0.59	0.47	0.35	0.30	0.25	0.22	0.18	0.16	0.13	0.09	0.06	0
0.56	0.98	0.59	0.47	0.35	0.29	0.25	0.21	0.18	0.15	0.12	0.08	0.06	0
0.54	0.97	0.59	0.47	0.34	0.29	0.25	0.21	0.18	0.15	0.12	0.08	0.06	0
0.52	0.96	0.59	0.47	0.34	0.28	0.24	0.21	0.17	0.15	0.12	0.08	0.06	0
0.50	0.95	0.59	0.47	0.34	0.28	0.24	0.21	0.17	0.15	0.12	0.08	0.06	0
0.48	0.94	0.59	0.47	0.33	0.28	0.23	0.20	0.17	0.15	0.12	0.08	0.06	0
0.46	0.93	0.59	0.47	0.33	0.28	0.23	0.20	0.17	0.15	0.12	0.08	0.06	0
0.44	0.92	0.59	0.47	0.33	0.28	0.23	0.20	0.17	0.15	0.12	0.08	0.06	0
0.42	0.91	0.59	0.47	0.34	0.28	0.24	0.20	0.17	0.15	0.12	0.08	0.06	0
0.40	0.90	0.59	0.47	0.34	0.28	0.24	0.21	0.18	0.15	0.12	0.08	0.06	0
0.38	0.89	0.60	0.48	0.35	0.29	0.24	0.21	0.18	0.15	0.12	0.08	0.06	0
0.36	0.88	0.60	0.48	0.35	0.29	0.25	0.21	0.18	0.15	0.12	0.08	0.06	0
0.34	0.87	0.60	0.49	0.36	0.30	0.25	0.22	0.19	0.16	0.12	0.08	0.06	0
0.32	0.86	0.60	0.49	0.37	0.31	0.26	0.22	0.20	0.16	0.13	0.09	0.06	0
0.30	0.85	0.61	0.50	0.38	0.32	0.27	0.23	0.20	0.17	0.13	0.09	0.06	0
0.28	0.84	0.61	0.51	0.39	0.33	0.28	0.24	0.21	0.18	0.14	0.09	0.07	0
0.26	0.83	0.62	0.52	0.41	0.35	0.30	0.26	0.22	0.19	0.15	0.10	0.07	0
0.24	0.82	0.62	0.53	0.43	0.36	0.32	0.28	0.24	0.20	0.16	0.11	0.07	0
0.22	0.81	0.63	0.55	0.46	0.39	0.34	0.30	0.26	0.21	0.17	0.11	0.08	0
0.20	0.80	0.64	0.57	0.48	0.41	0.37	0.32	0.28	0.23	0.19	0.13	0.08	0

TABLE 4 RELATIONSHIP BETWEEN W/H AND D/H FOR VARIOUS POINTS ON A SUBSIDENCE PROFILE (N.C.B., 1975)

TABLE 5

SUBSIDENCE PREDICTION USING OVERBURDEN HEIGHT OF 120 m = 393 FT w/h = 1.48

1. Subsidence as s/S	0.0	0.05	0.10	0.20	0.20	0.40	0.50	0.60	0.70	0.80	0.90	0.95	1.0
2. Subsidence in Ft	0.0	0.39	0.77	1.54	2.31	2.08	2.85	4.62	5.39	6.16	6.93	7.32	7.70
3. Distance in terms of h	1.44	0.95	0.94	0.74	0.68	0.64	0.60	0.56	0.52	0.47	0.39	0.31	0.03
4. Distance in Ft from centerline	566	373	330	291	267	252	236	220	204	184	153	122	11.8

SUBSIDENCE PREDICTION USING OVERBURDEN HEIGHT OF 74 m = 242 FT w/h = 2.39

1. Subsidence as s/S	0.0	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.95	1.0
2. Subsidence in Ft	0.0	0.40	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	7.6	8.0
3. Distance in terms of h	1.89	1.40	1.28	1.18	1.13	1.09	1.05	1.01	0.97	0.92	0.84	0.76	0.30
4. Distance in Ft from centerline	427	339	210	296	273	264	254	244	235	222	203	184	73

of Table 4 was used. Line 2 is derived by multiplying line 1 by the maximum predicted subsidence found in the preceding paragraph. In line 3 the distance values (d/h) in terms of the overburden depth (h) corresponding to w/h = 1.48 and w/h = 2.39 are recorded. Line 4 is then derived by multiplying the depth by the figure in line 3, e.g. 1.44 x 393 = 566 ft.

Lines 2 and 4 are then used to plot the profile. Since the overburden height of 393 ft was on the headgate side and the overburden height of 242 ft on the tailgate side, the prediction curves were combined. The predicted curve for a overburden height of 393 ft was constructed from the centerline to the headgate side whereas, the predicted curve for an overburden height of 242 ft was constructed from the centerline to the tailgate side. These two half curves were then merged at the center of the panel to give the final predicted subsidence profile. Figure 44 shows the actual measured subsidence profile. Figure 44 provides some interesting information. First, the maximum measured subsidence is somewhat less than either of the predicted profiles. Also, the measured angle of draw is less than that predicted. These lower dimensional values often appear to be associated with the presence of thick, strong, sandstone beds in the overburden (Wardell, 1969). As mentioned in the geology section, thick sandstone beds overlie the coal seam of the 4N longwall panel. The subsidence noted at Stations 7W and 8W was due to a pillar robbing operation which

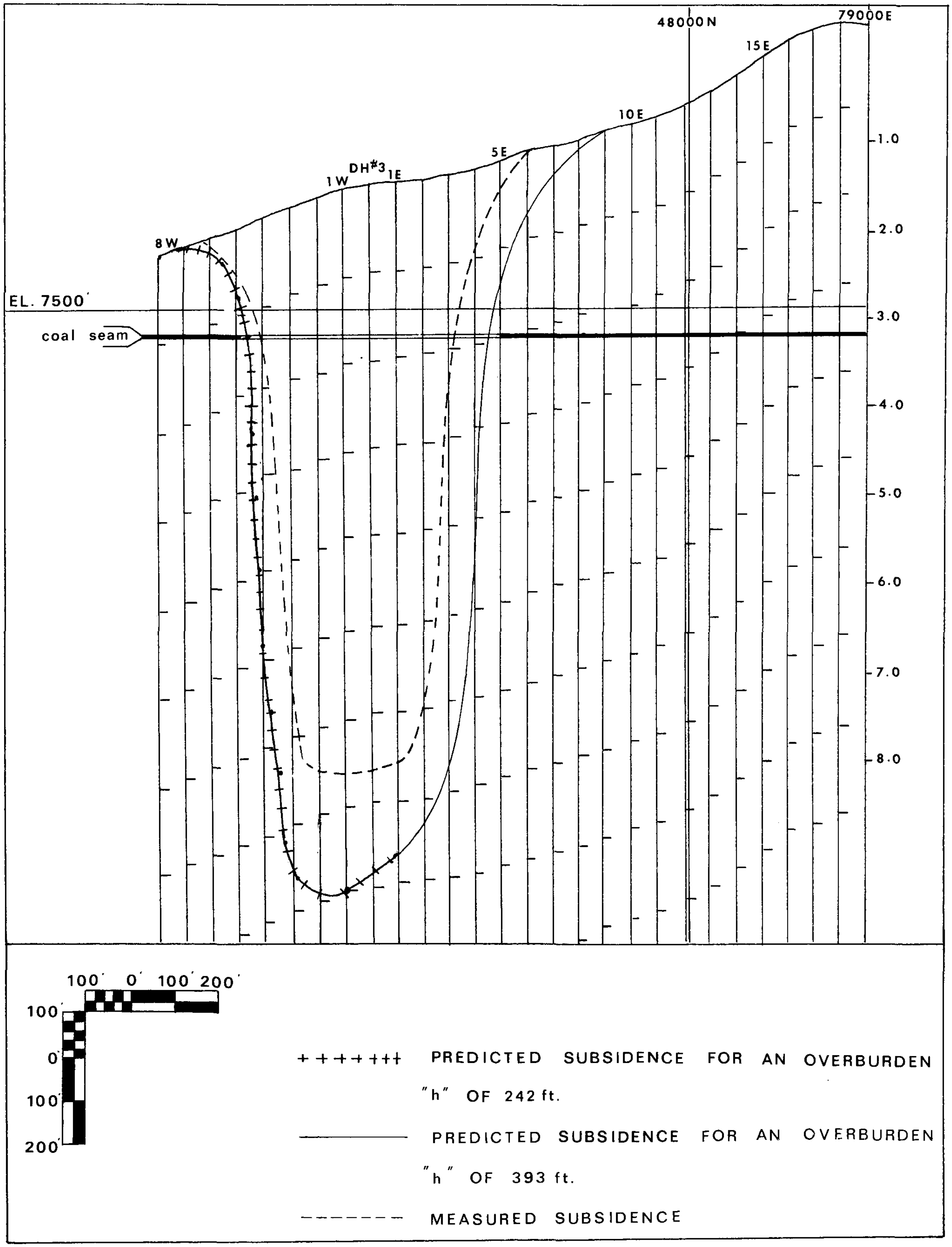


FIG 44 MEASURED VS. PREDICTED TOTAL SUBSIDENCE.

(8W - 22E) York Canyon Mine Test Panel.

closely followed the longwall advance. Thus it was impossible to determine the angle of draw on the tailgate side due to this pillar robbing. The measured subsidence profile of Figure 44 indicates a subsidence factor of approximately 0.66 as compared to the predicted values of 0.77 for h = 393 ft and 0.80 for h = 242 ft. The measured angle of draw on the headgate side is approximately 15.7^{o} ($\mathrm{Tan}^{-1} \frac{120\ \mathrm{ft}}{428\ \mathrm{ft}}$). The predicted angle of draw was approximately 29^{o} on the headgate side.

Horizontal Movement

Horizontal extension and compression are the causes of the most commonly seen type of subsidence damage. For this reason it is particularly important to determine the extent and magnitude of mining induced horizontal strains which may cause structural damage to buildings, etc., in residential and/or industrial environments near areas of mining activity. The following sections present and discuss the horizontal movement data obtained in the area of longwall panel 4N.

Horizontal Strain Profiles:

"Strain" (E), as used in subsidence engineering terminology, is the change in length over a given length of ground or structure. Its dimensions can either be expressed as a change in length over a given length or as a fraction of the unit of length. Thus if a 100 ft building undergoes a 1 ft change in length the strain becomes 1.0 ft in 100 ft, or ten parts per thousand, 10,000 micro-inches per inch, or simply 0.01. In this report strains will be given in terms of micro-inches per inch in order to have larger numbers to facilitate graphing. It has become a convention in subsidence work to describe positive and negative changes in ground length as tensile and compressive ground strains respectively.

For super-critical widths of extraction, according to the NCB, the maximum extension coincides with the position of ribside where the width/depth ratio is greater than 1.35 and two compression zones are developed near the panel center.

Figures 45 thru 48 show the horizontal strain distributions at various locations for super-critical conditions above the 4N longwall panel. The data for Figures 45 thru 48 are compiled in Appendix B. All the figures except Figure 45 show tensile strains going into compressional strains from 10^{o} to 20^{o} inside the mined area. Normal conditions from other studies show that tensile strains usually go to compressive strains, somewhere between 5^{o}-10^{o} from the vertical collapsed side. Figure 45 was evidently altered by the steep ground slope in the direction of face advance. (Station 9N to Station 12N).

Other studies have shown that the change from tensile to compressive strain occurs at or near the transition point (or point of inflexion) where the subsidence is half the maximum (Kapp, 1973). The figures for the vertical subsidence distribution for

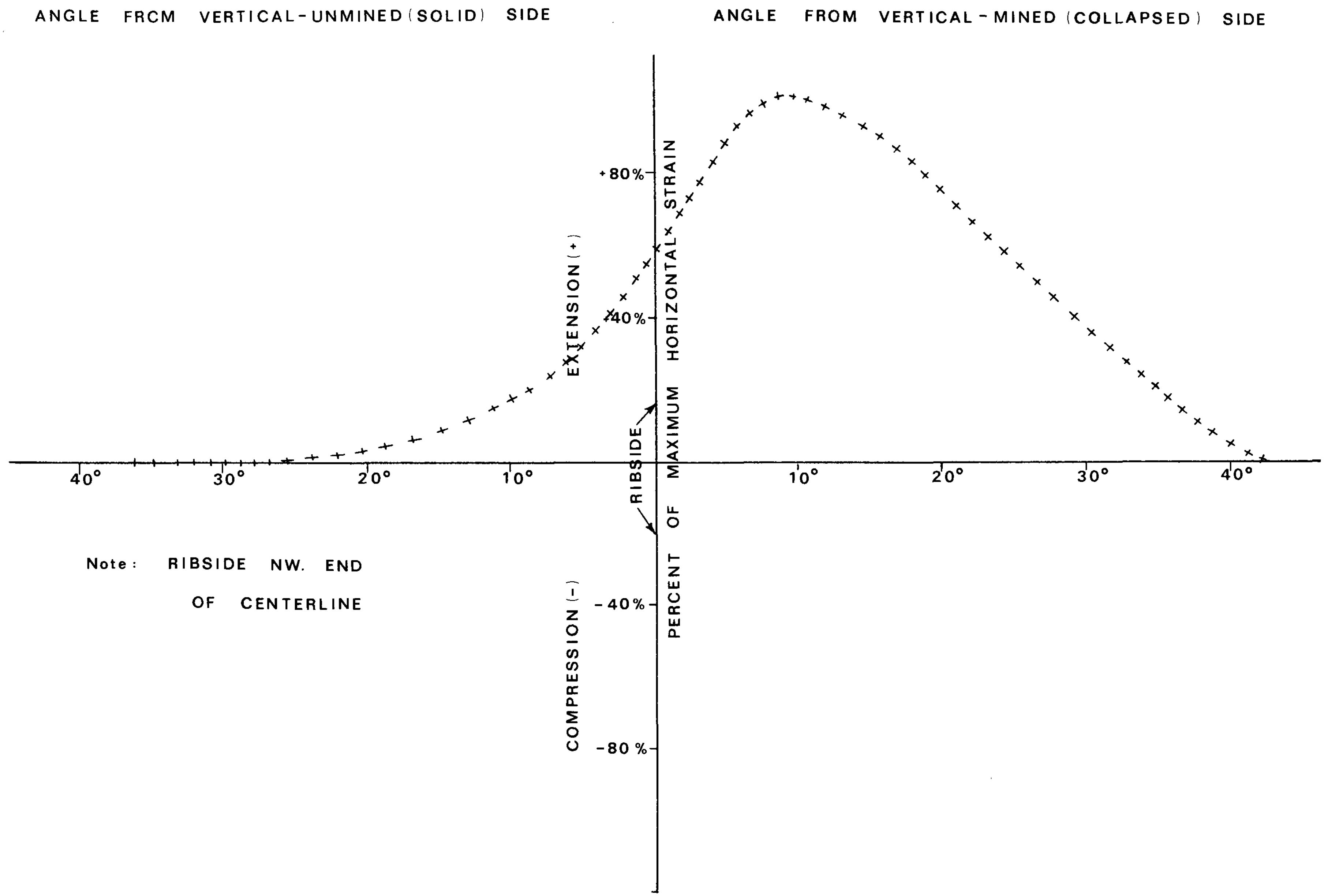


FIG 45 HORIZONTAL STRAIN DISTRIBUTION FOR SUPERCRITICAL CONDITIONS (4N LW)

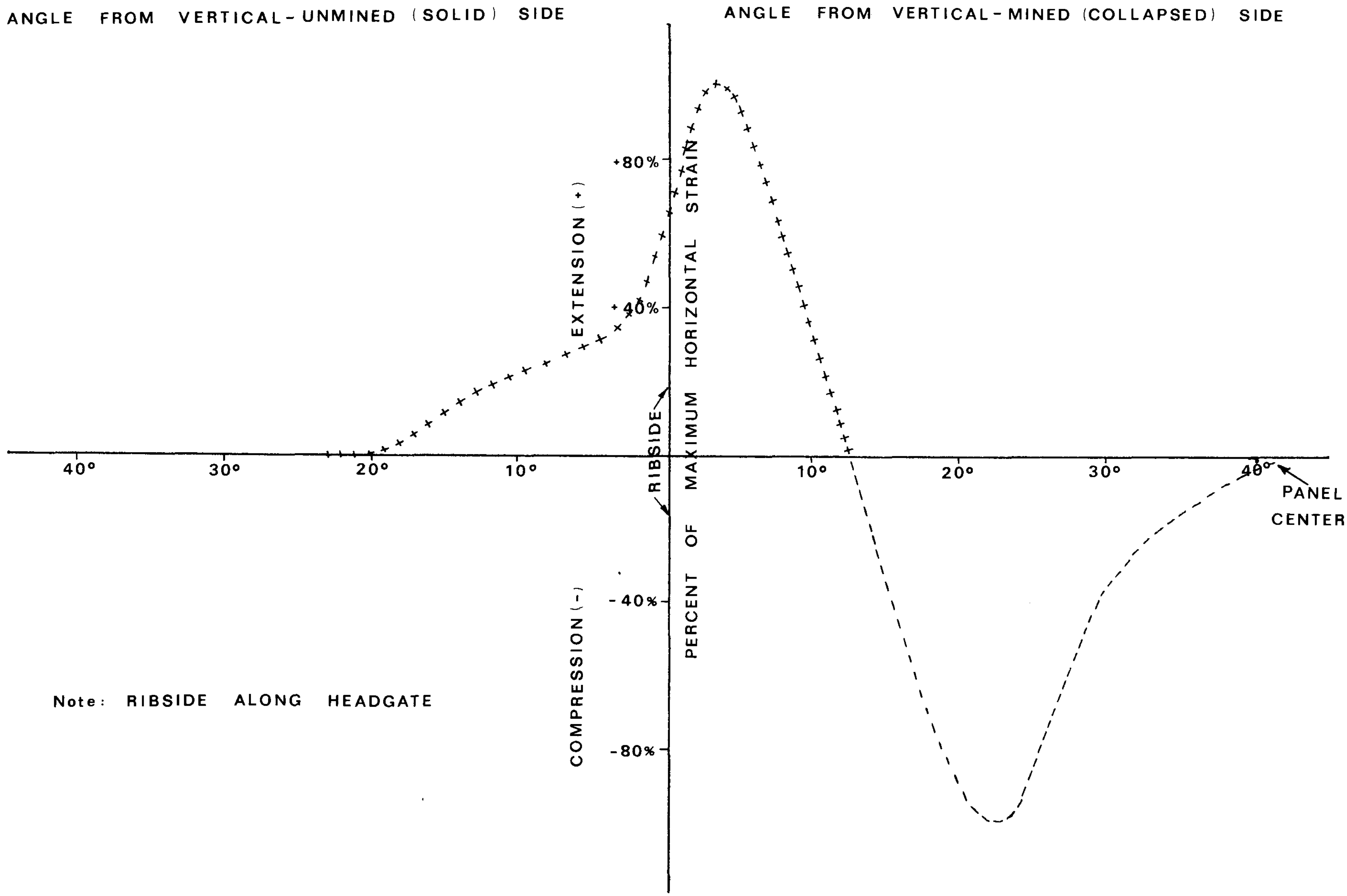


FIG 46 HORIZONTAL STAIN DISTRIBUTION FOR SUPERCRITICAL CONDITIONS (4N LW)

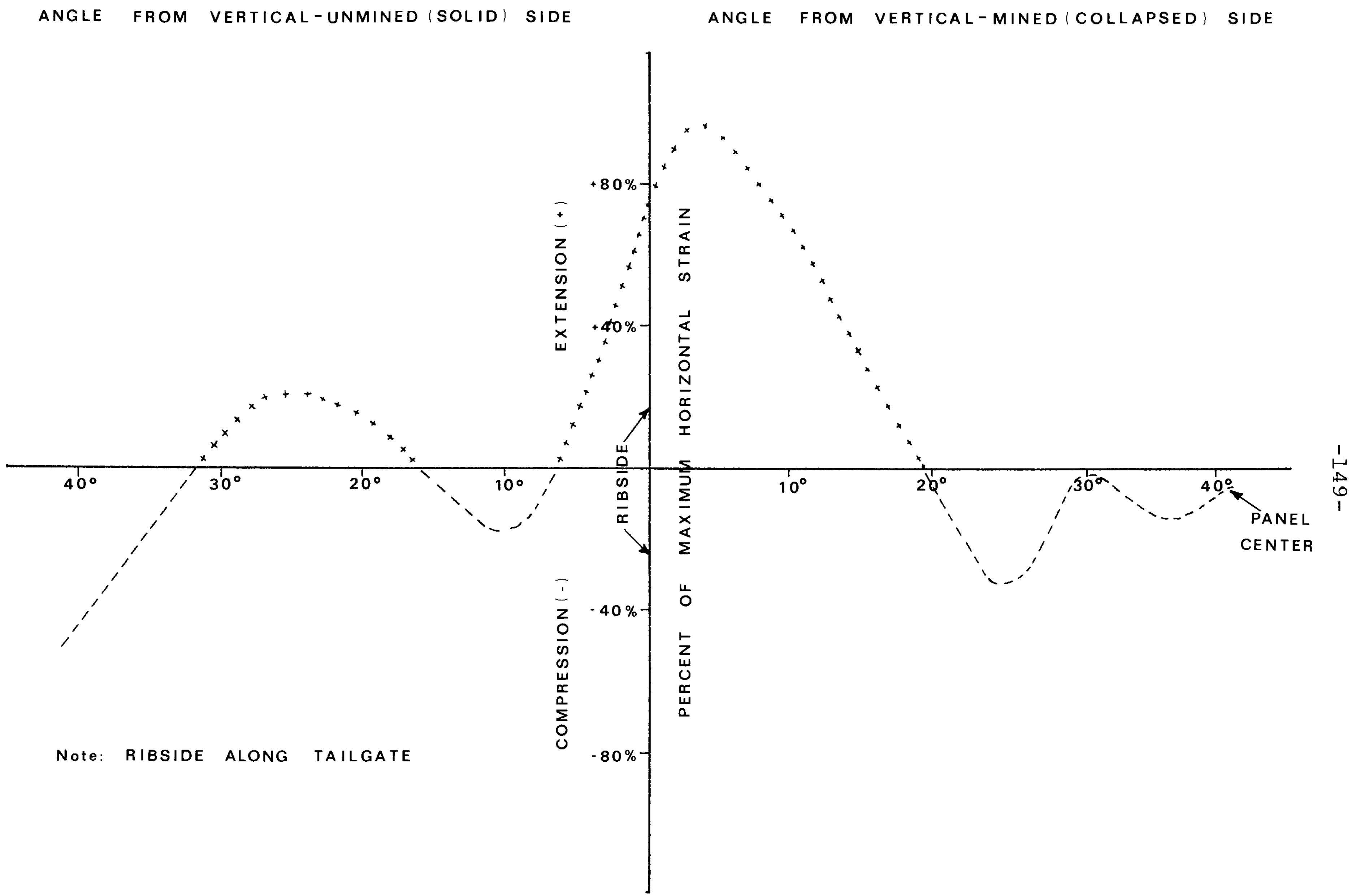
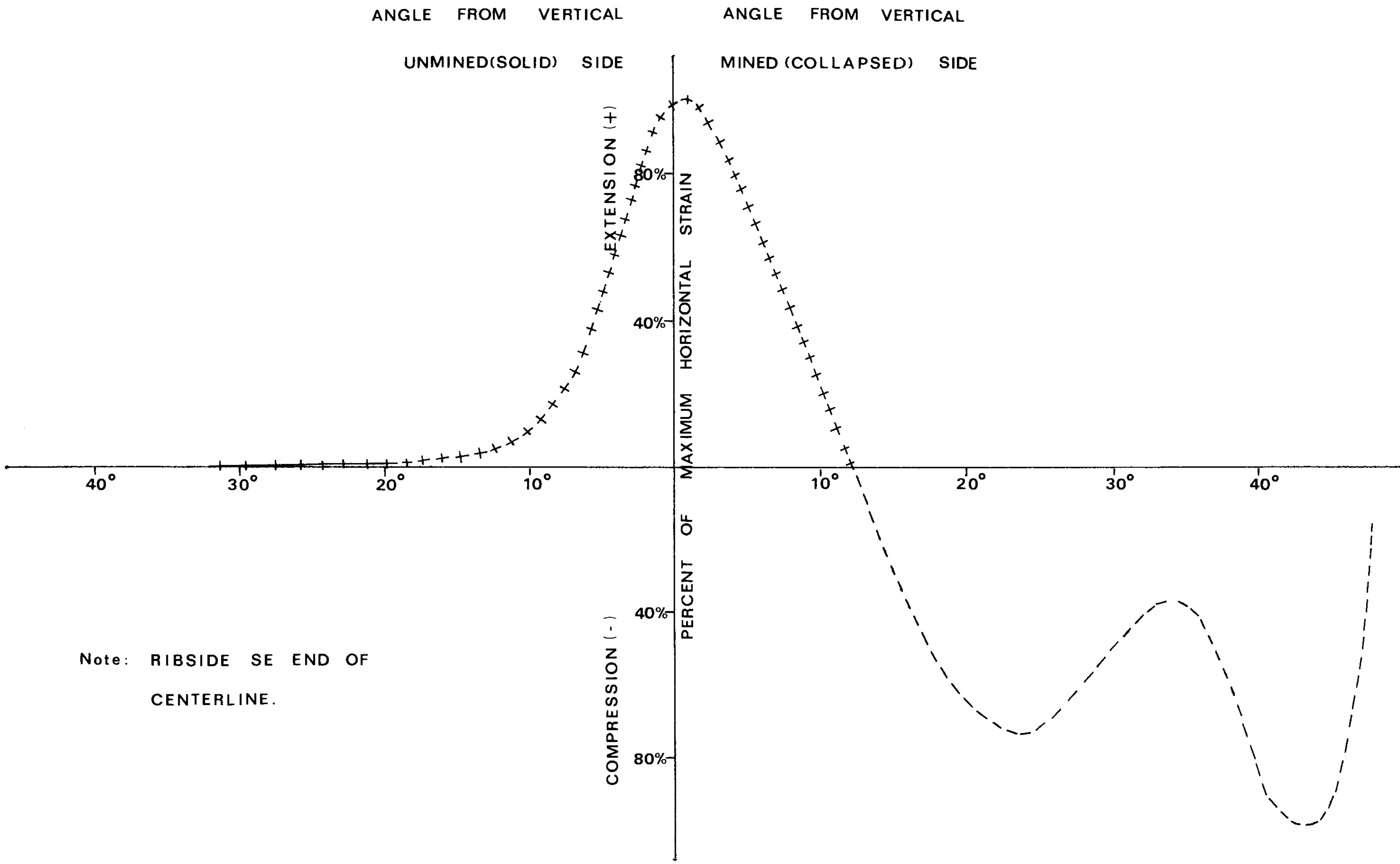


FIG 47 HORIZONTAL STRAIN DISTRIBUTION FOR SUPERCRITICAL CONDITIONS (4N LW)



Note: RIBSIDE SE END OF CENTERLINE.

FIG 48 HORIZONTAL STRAIN DISTRIBUTION FOR SUPERCRITICAL CONDITIONS (4N LW)

super-critical conditions above the 4N longwall panel (Figures 23 thru 26) show that the point of half maximum subsidence is also between 10^{o} and 20^{o} inside the mined area. This indicates that for the 4N longwall panel the transition point can be identified with either the point of half maximum subsidence or the point where the strain profile goes from tension to compression.

Horizontal strain was measured between monuments by computing the component of horizontal movement along the monument line and dividing this component by the station interval which was 60 ft. The fractional strains were then converted to strains in terms of micro-inches per inch by multiplying each fractional strain by 1.0×10^{6}. Since these strains were measured on sloping ground they had to be corrected for ground slope. The method used in doing this is described in the section on measured strain vs. predicted strain

Figures 49 thru 52 show the measured dynamic horizontal strain (corrected for slope) for the centerline, perpendicular and north diagonal for various stages of panel extraction. Data for Figures 49 thru 52 are compiled in Appendix G.

Figures 53 thru 55 show the measured strain profiles for stabilized conditions along the centerline, perpendicular and diagonal. Data for Figures 53 thru 55 are compiled in Appendix H.

When comparing the travelling (dynamic) strains

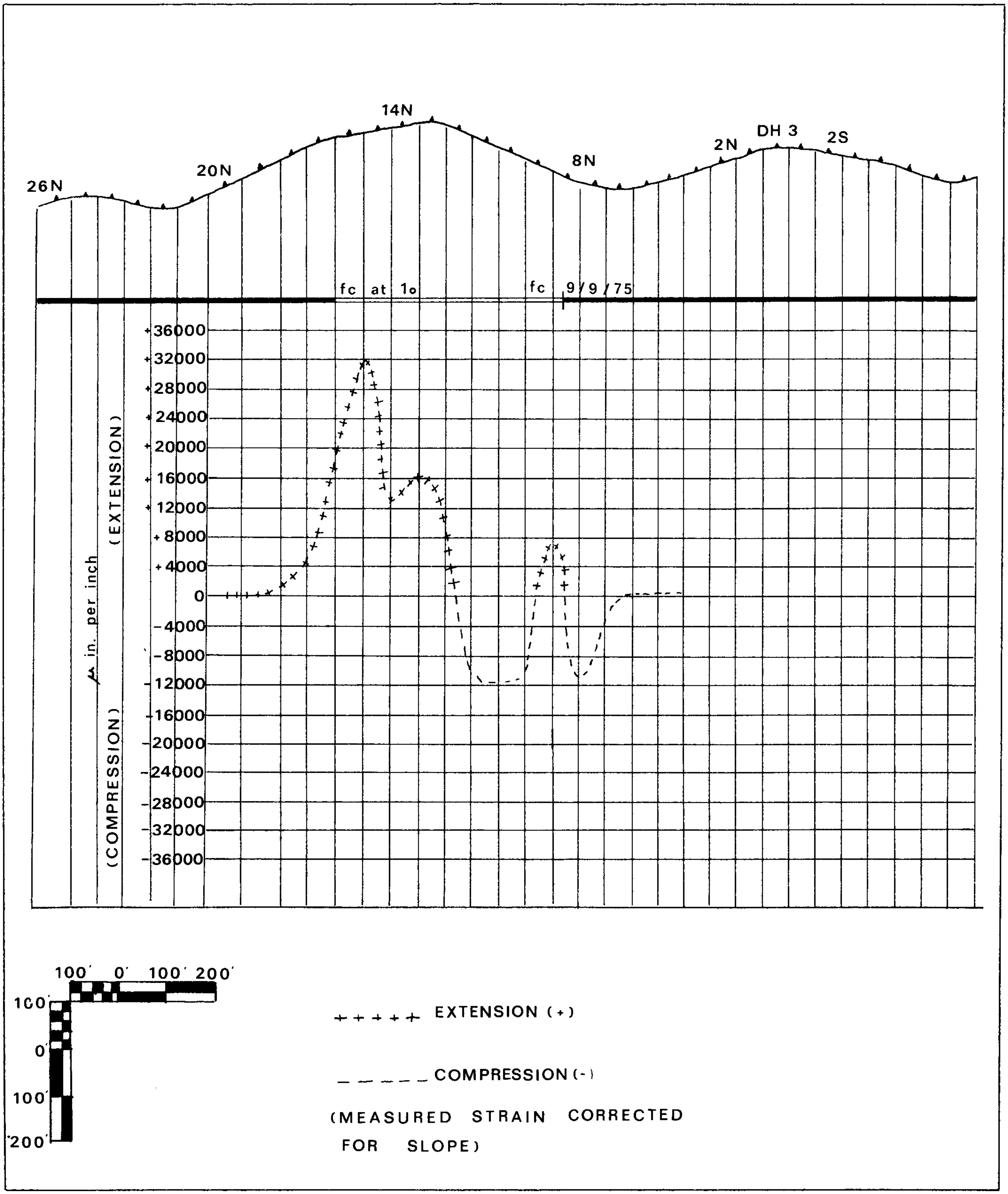


FIG 49 DYNAMIC HORIZONTAL STRAIN - PANEL CENTERLINE

York Canyon Mine Test Panel Fc. at 8N. Sept. 30, 1975.

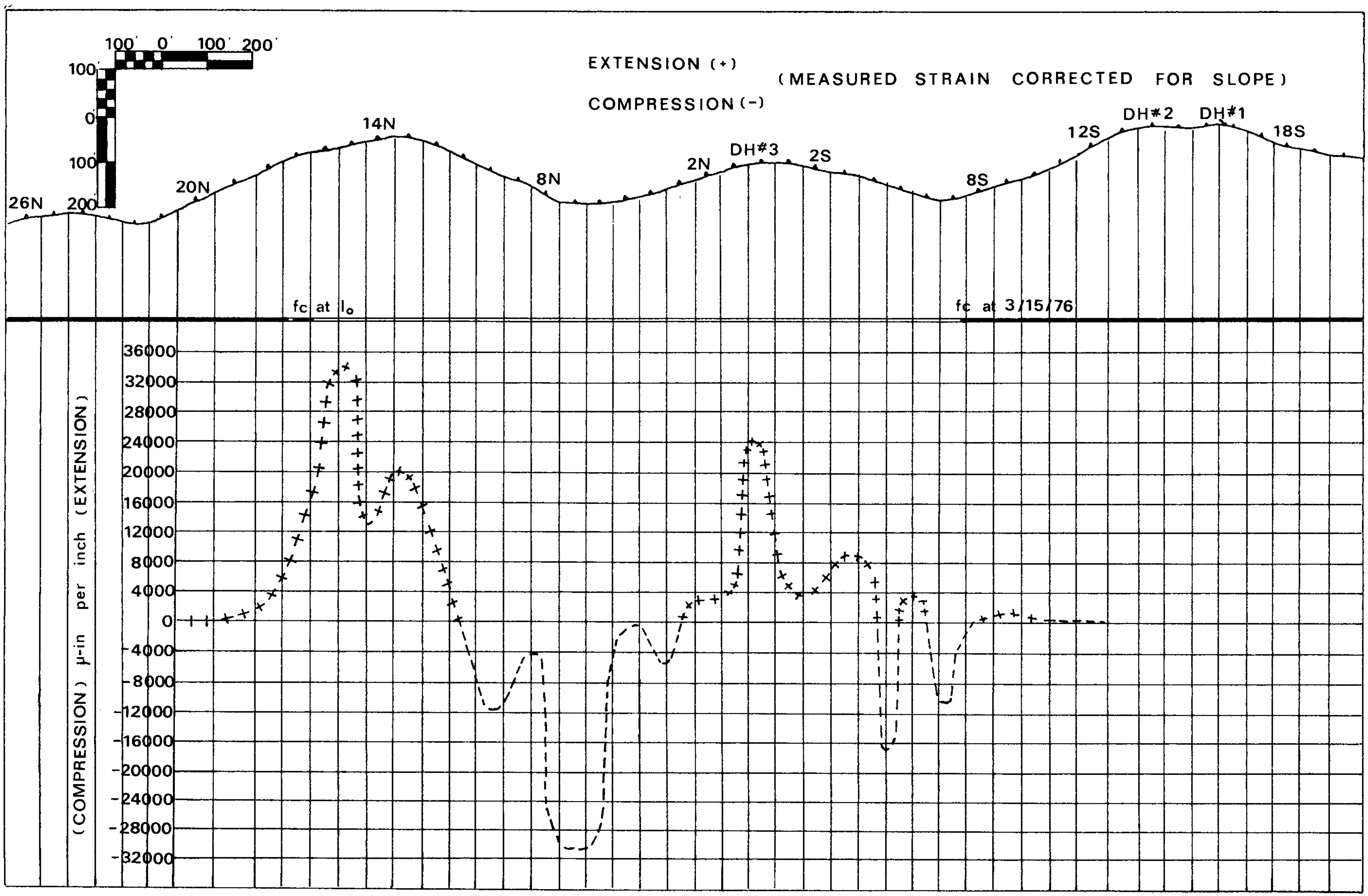


FIG 50 DYNAMIC HORIZONTAL STRAIN - PANEL CENTERLINE

York Canyon Mine Test Panel. Fc. 15'S. of 7S: March 15, 1976.

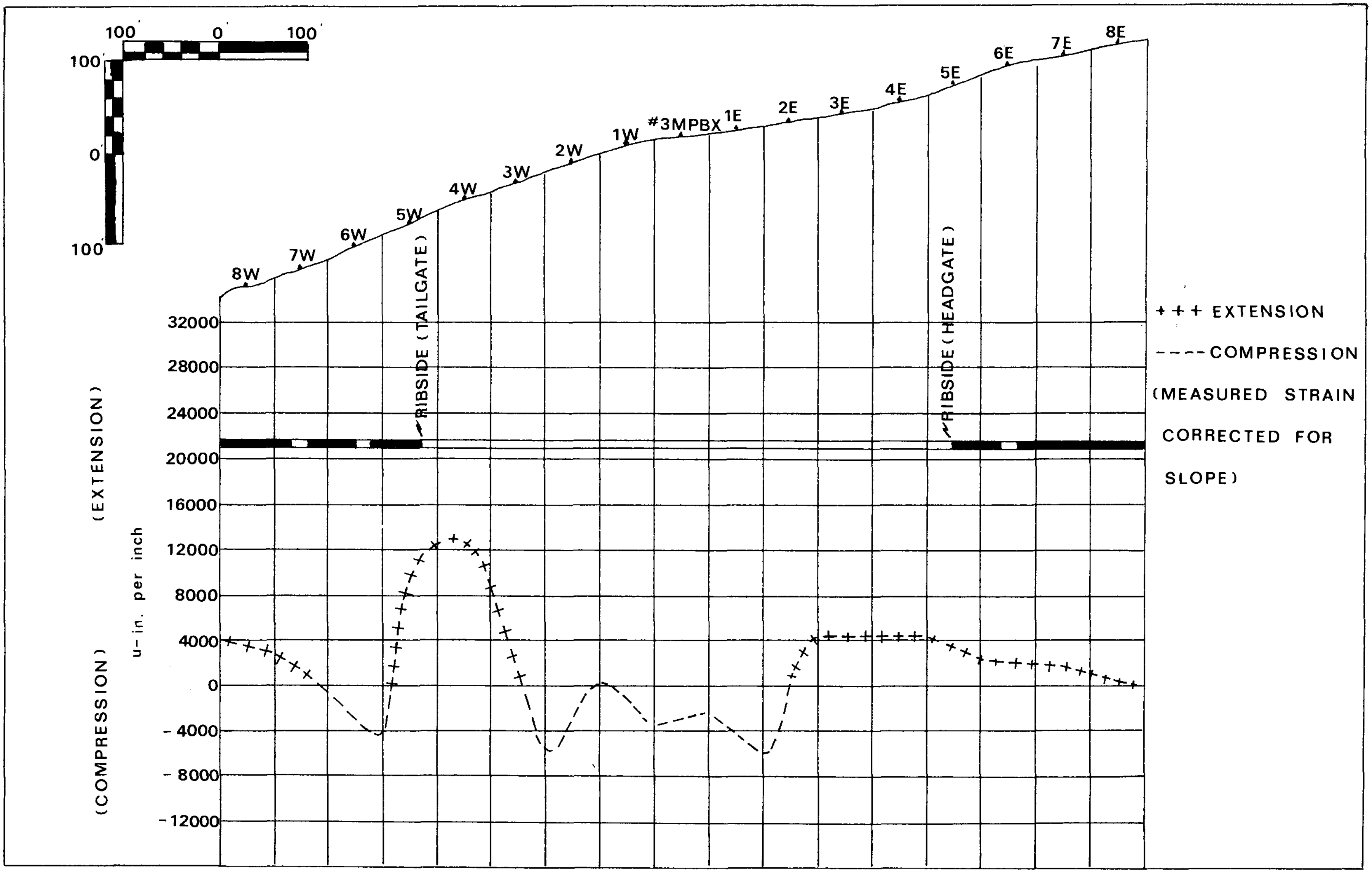


FIG 51 DYNAMIC HORIZONTAL STRAIN - PANEL PERPENDICULAR

York Canyon Mine Test Panel. Fc. 70'S of ⊥. December 24, 1975.

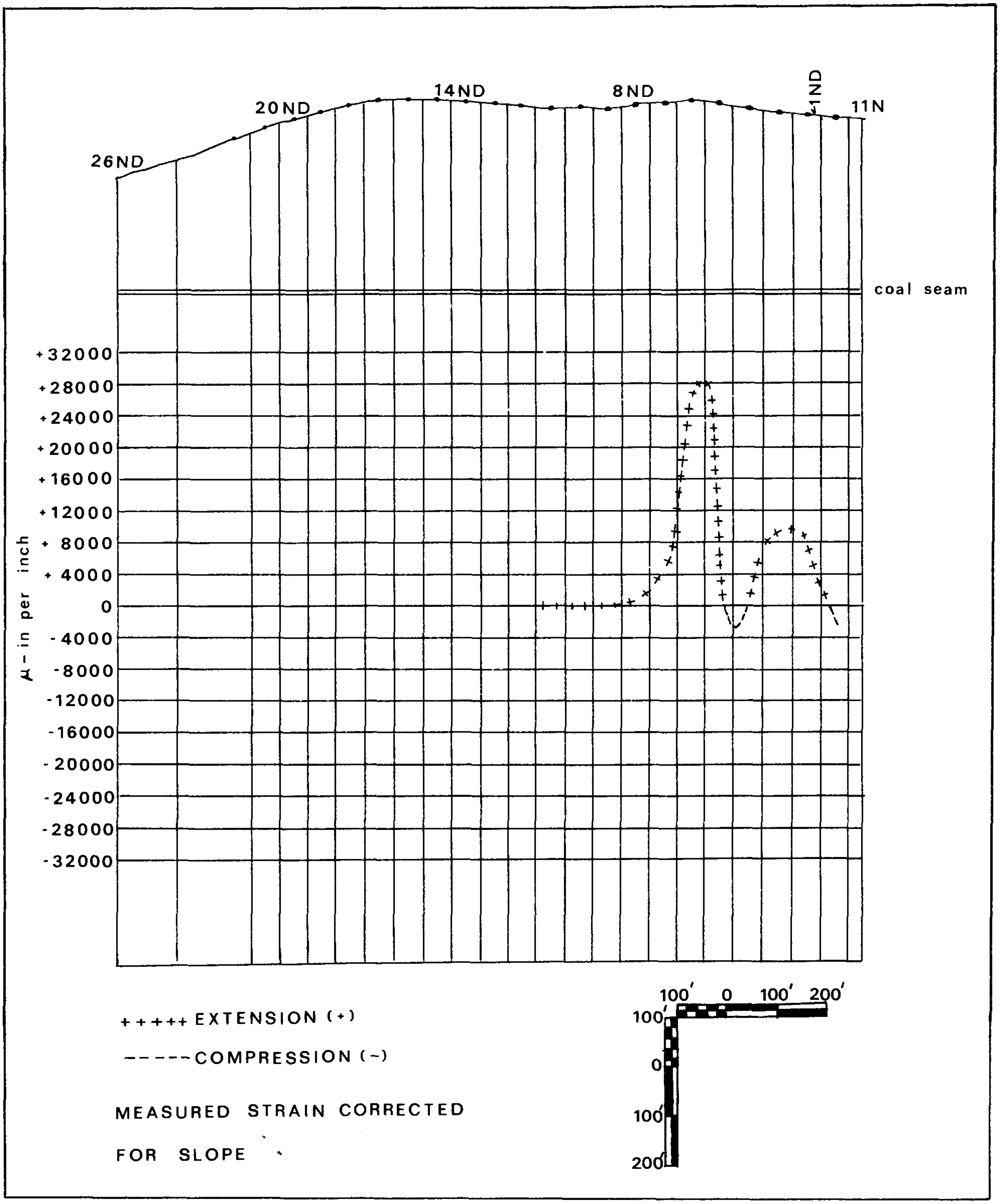


FIG 52 DYNAMIC HORIZONTAL-STRAIN NORTH DIAGONAL

York Canyon Mine Test Panel 4N Fc at 8N Sept. 30, 1975

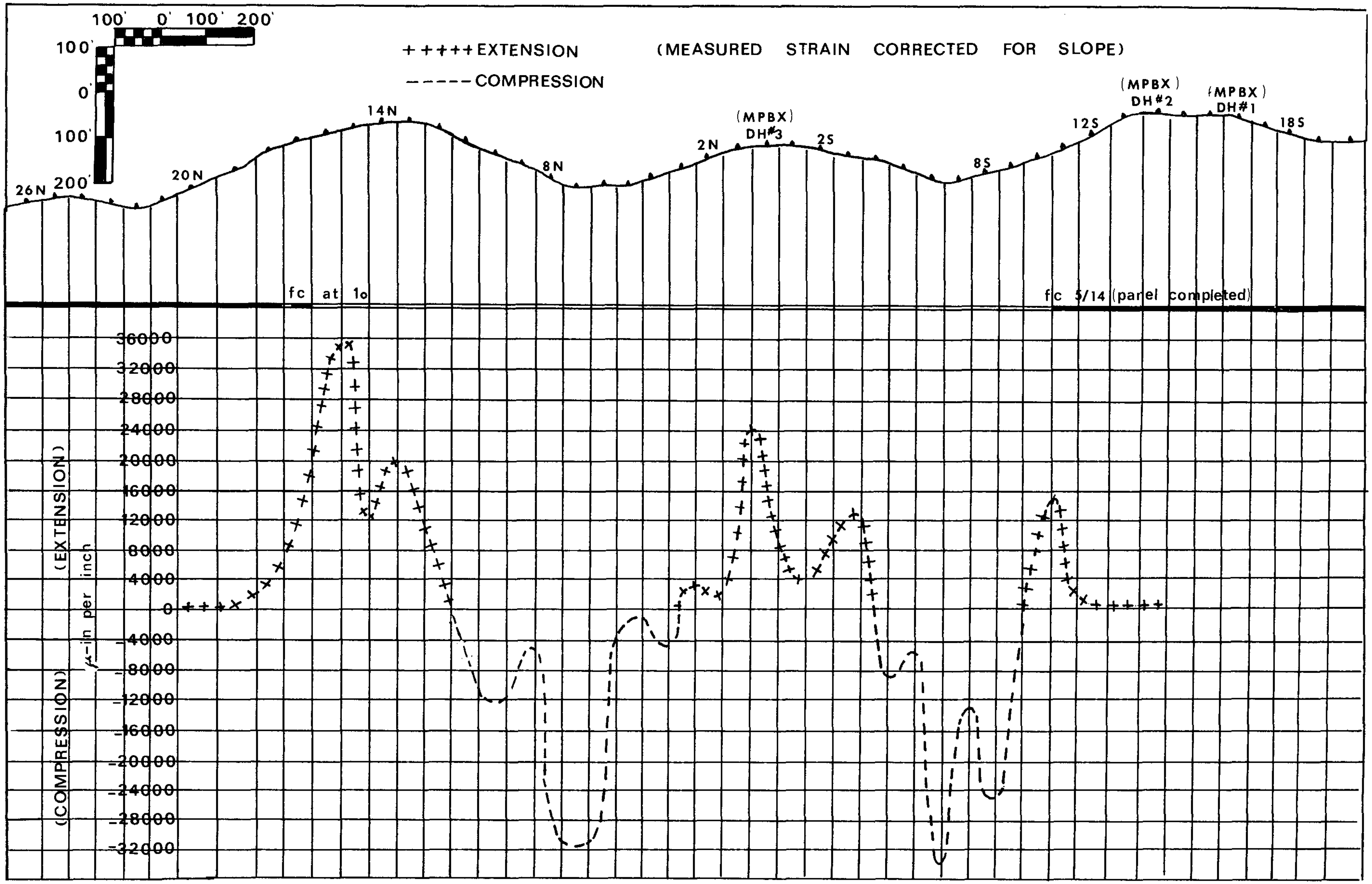


FIG 53 STABILIZED HORIZONTAL STRAIN - PANEL CENTERLINE.

York Canyon Mine Test Panel 4N. Fc. 35'S of 10S. May 28, 1976.

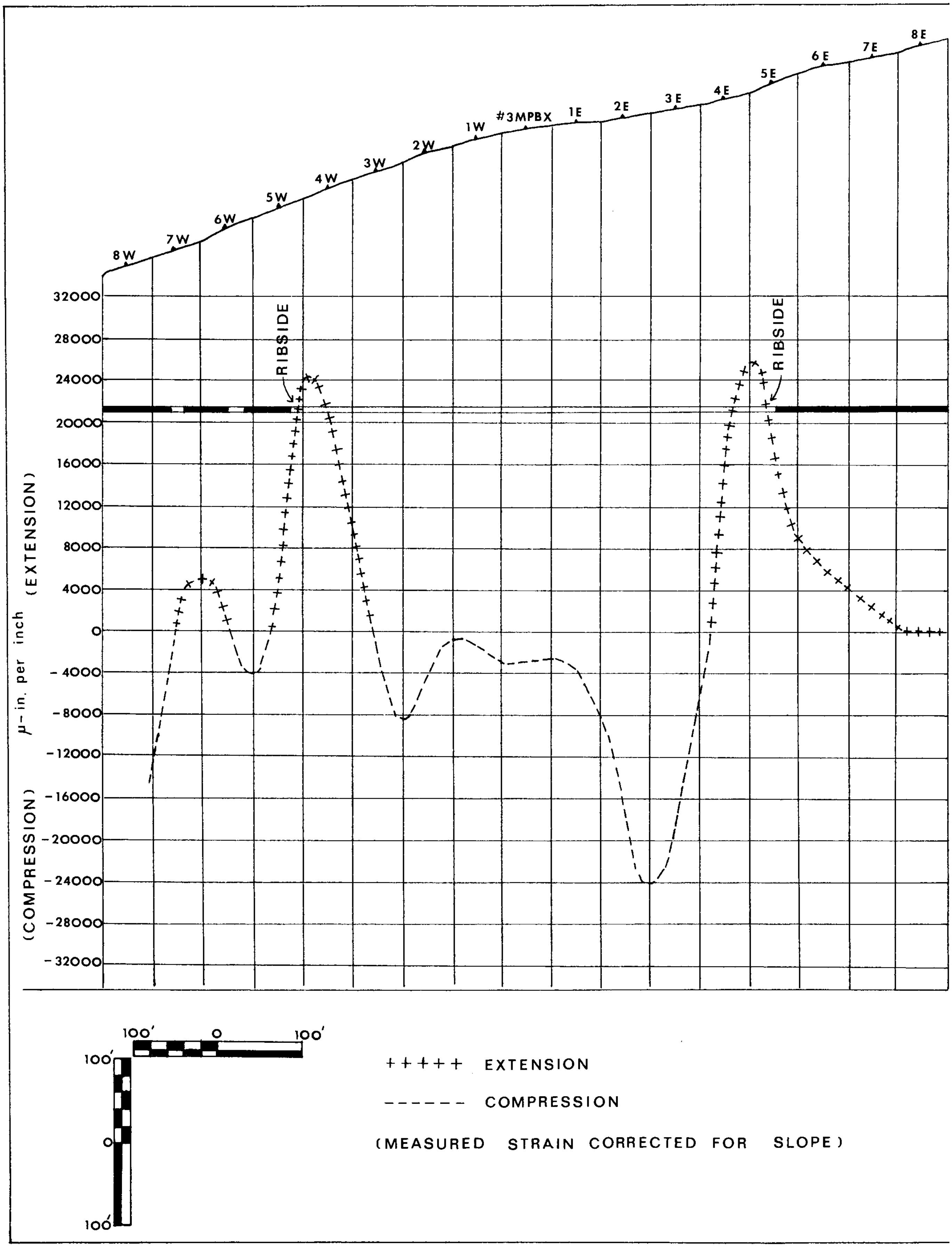


FIG 54 STABILIZED HORIZONTAL STRAIN – PANEL PERPENDICULAR

York Canyon Mine Test Panel Fc 500'S of L; Mar 30 1976

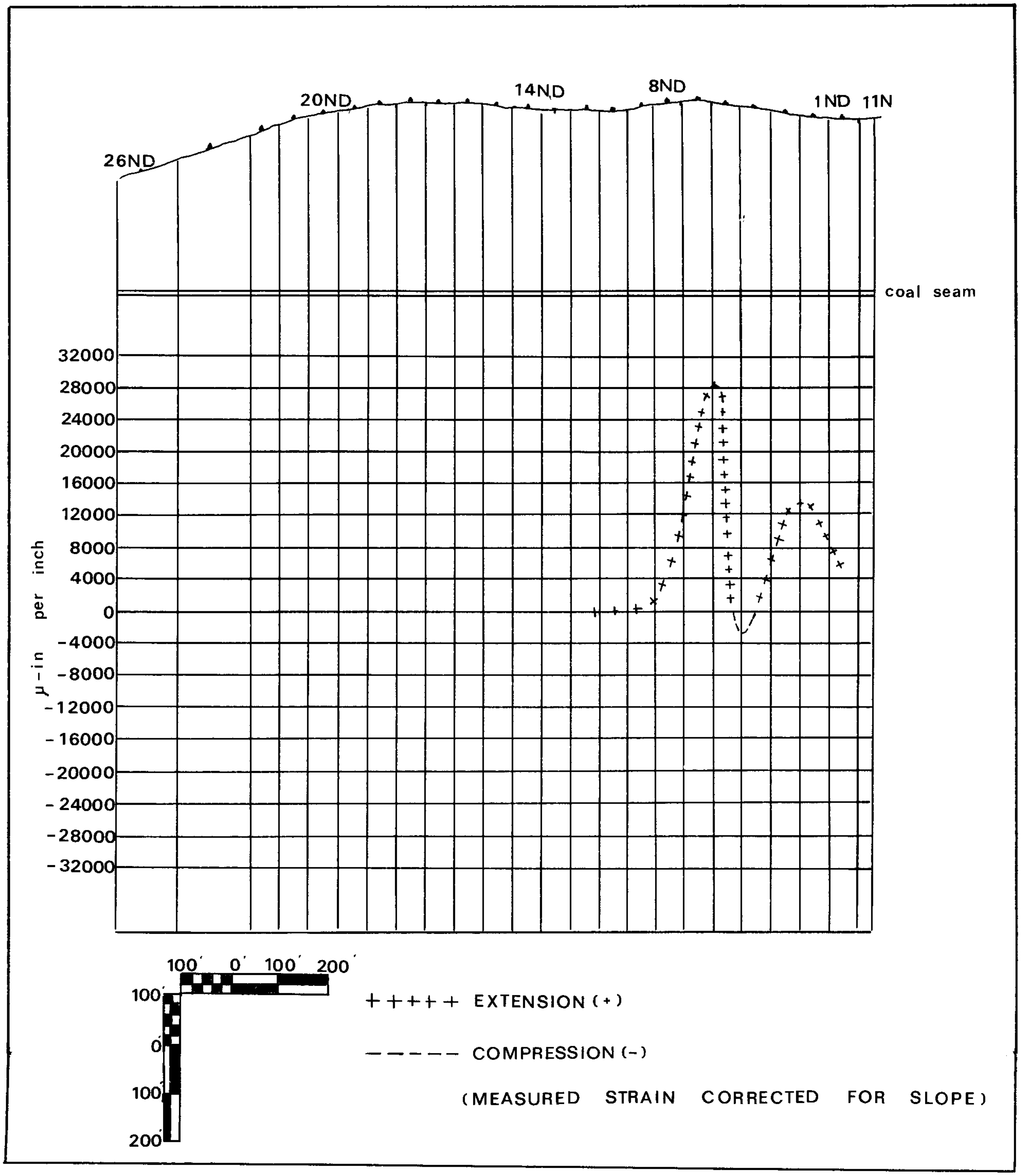


FIG 55 STABILIZED HORIZONTAL STRAIN - NORTH DIAGONAL.
York Canyon Mine Test Panel 4N. Fc.1000′ Past Diagonal. Jan. 1, 1976

to the stabilized strains it is evident that they are somewhat less in the vicinity of the advancing face. This is logical since points just inside the advancing face have not yet reached their maximum horizontal displacements.

Figures 49 thru 55 show that the higher tensional strains develop first over the areas of least overburden under dynamic conditions and after conditions stabilize over areas with the most overburden. Figure 53, showing horizontal strain for stabilized conditions over the centerline, typifies this. The maximum tensional strains occurred below the ridgetop between Monuments 12N and 16N which was the highest ridge over the panel under which complete extraction occurred. Figure 53 also shows that the areas of maximum compression occur under topographic lows. The reason for compressional zones in topographic lows is exemplified in Figures 21 and 22. They show the horizontal and vertical components along the panel centerline in two different draws. More horizontal movement occurs in a downslope direction on each slope. This downslope movement results in the increased compressional forces previously mentioned.

In the section discussing subsidence profiles, an attempt was made to determine if either topography or the direction of face advance was the controlling factor affecting the magnitude of horizontal movement. Because the face was stopped only 35 ft south of Monument 10S, total horizontal movement did not occur at that location. Since Monuments 4N and 9S are approximately in the same realtive positions on the two different south-facing slopes, a comparison can be made between the two. When the face was stopped, it was about 90 to 95 ft past Monument 9S, and the relative downslope component along the centerline was 2.1 ft (See Figure 22).

In comparison, the relative downslope component at Monument 4N was 0.92 ft on November 16, 1975, when the face was 85 ft past the monument. On November 24, with the face 140 ft past Monument 4N, the downslope component was 0.78 ft. From this comparison, it can be deduced that the magnitude of the horizontal movement is principally a function of the steepness of the slope and not the direction of face advance.

The direction of movement is a function of location. Monuments on ridge tops and in the bottom of draws were always displaced from their original plan position in the direction of face advance, while monuments on the slopes were initially displaced horizontally in the downslope direction.

The average final displacement for monuments on ridge tops and and bottoms of the draws was 2.4 ft towards the face with a standard deviation of 1.3 ft. The average for south-facing slopes was 3.5 ft in the direction of face advance. It should be noted that for the steepest south-facing slope (Monuments 8N - 12N) the average displacement toward the direction of face advance was 4.7 ft. Conversely, for the north-facing slopes, the final displacement was opposite the direction of advance and averaged 0.9 ft (Figures 21 and 22).

Studies for flat terrain (Weir, 1966) have shown that, as the face approaches a subsidence station, the station's movement can be considered to have two components. There is a vertical lowering and a horizontal shift towards the face. As the face passes beneath the station, the vertical lowering continues, but the direction of horizontal movement is gradually reversed. Eventually, with a supercritical area in a level seam and a level topographic surface, the station, though lowered, regains its origonal plan position. As mentioned previously, this was not the case for the mountainous terrain in the area of longwall panel 4N.

It appears that topography controls initial horizontal movement on slopes to some extent. Monuments midway on slopes facing opposite to the direction of advance first show a horizontal movement opposite the firection of advance and then subsequent movements toward the direction of advance. However, monuments midway on slopes facing the direction of advance show only horizontal movement in the direction of advance.

Measured Horizontal Strain vs. Predicted Horizontal Strain:

Predicting horizontal strains is accomplished in much the same manner as subsidence prediction. Once the parameters have been established, the same type of tables are used; first to determine the maximum estension (+E) and maximum compression (-E) and then to compile a table to determine the horizontal strain profile.

Horizontal strain along the perpendicular of the 4N longwall panel was predicted using the same parameters as the previous subsidence prediction. That is, two different overburden heights were used (120 m = 373 ft and 74 m = 242 ft). Figure 56 was used to determine the maximum predicted extension and maximum compression. Close examination of the figure reveals that only strain values for w/h = 1.4 are given. According to the National Coal Board (1975), the maximum tensile and compressive strains for critical and super-critical areas are given by $+E_{max} = 0.65\ S_{max}/h$ and $-\ E_{max} = 0.51\ S_{max}/h$. This can be deduced from Figure 56 if one assumes the curves become essentially linear when w/h = 1.4. Thus for an overburden height of 120 m (393 ft) (Table 5):

$$+E_{max} = 0.65(7.7\text{ ft}/393\text{ ft}) = +12{,}735\text{ u-in./in.}$$

$$-E_{max} =-0.51(7.7\text{ ft}/393\text{ ft}) = -\ 9{,}992\text{ u-in./in.}$$

For an overburden height of 74 m (242 ft):

$$+E_{max} = 0.65(8.0\text{ ft}/242\text{ ft}) = +21{,}488\text{ u-in./in. and,}$$

$$-E_{max} = -0.51(8.0/242\text{ ft}) = -16{,}860\text{ u-in./in.}$$

Figure 57 is a graph of strain contours constructed from a family of curves and Table 6 is derived from this graph for more rapid determination of strain values. A new table (Table 7) was constructed from Table 6. Line 1 of this new table was constructed from line 1 of Table 6 for convenience. Line 2 was derived by multiplying line 1 by the maximum predicted strain. In line 3 the distance values d/h, corresponding to w/h = 1.48 and w/h = 2.39, were determined. Line 4 was derived by multiplying the appropriate depth by each figure in line 3 (e.g., 1.44 x 393 ft = 566 ft).

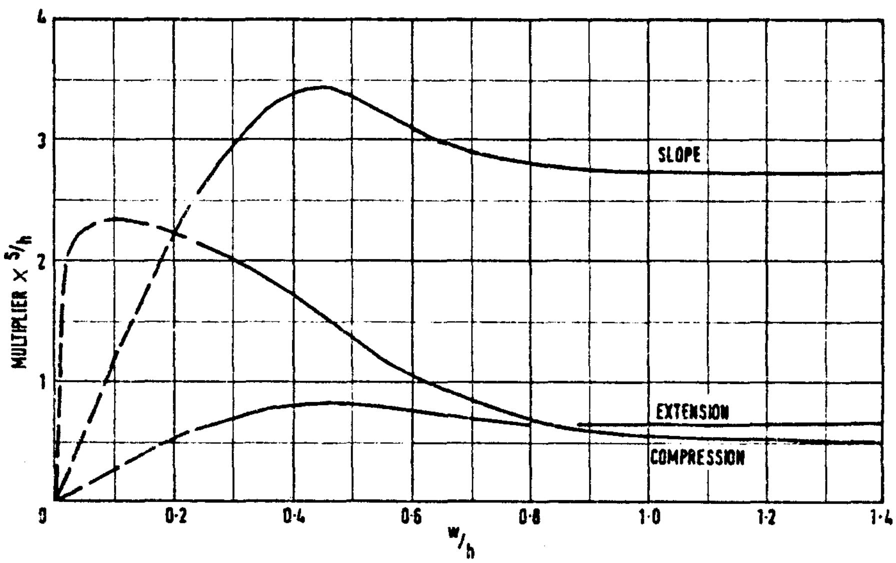


FIG 56 GRAPH FOR PREDICTING MAXIMUM SLOPE AND STRAIN FOR VARIOUS WIDTH/DEPTH RATIOS OF PANEL (NATIONAL COAL BOARD, 1975)

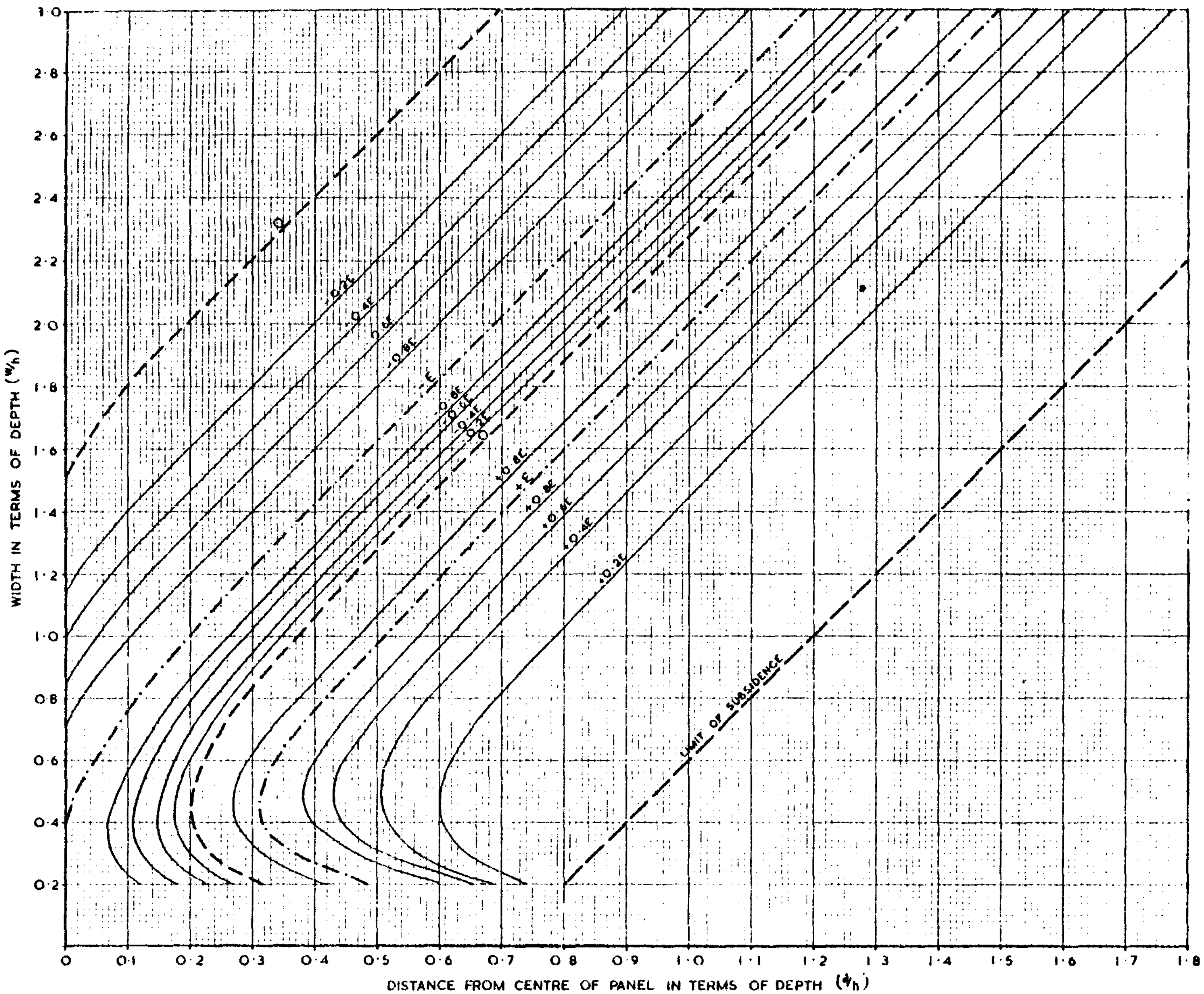


FIG 57 GRAPH FOR PREDICTING STRAIN PROFILES (NATIONAL COAL BOARD, 1975)

Values of e/E	Extension (+E)											Compression (—E)						
	0	0.20	0.40	0.60	0.80	1.00	0.80	0	0.20	0.40	0.60	0.80	1.00	0.80	0.60	0.40	0.20	0
w/h RATIO OF PANEL	DISTANCES FROM PANEL CENTRE IN TERMS OF DEPTH																	
3.0	2.2	1.78	1.67	1.61	1.56	1.50	1.46	1.36	1.34	1.31	1.28	1.25	1.19	1.10	1.03	0.96	0.90	0.70
2 6	2.0	1.58	1.47	1.41	1.36	1.30	1.26	1.16	1.14	1.11	1.08	1.05	0.99	0.90	0.83	0.77	0.70	0.50
2.2	1.8	1.38	1.27	1.21	1.15	1.10	1.06	0.96	0.94	0.91	0.88	0.85	0.79	0.70	0.63	0.57	0.50	0.30
2.0	1.7	1.28	1.17	1.11	1.05	1.00	0.96	0.86	0.84	0.81	0.78	0.75	0.69	0.60	0.53	0.47	0.40	0.20
1.8	1.6	1.17	1.07	1.01	0.95	0.90	0.86	0.76	0.73	0.71	0.68	0.65	0.59	0.50	0.43	0.37	0.30	0.10
1.6	1.5	1.08	0.97	0.91	0.85	0.80	0.76	0.66	0.63	0.61	0.58	0.55	0.49	0.40	0.33	0.27	0.20	0.03
1.4	1.4	0.98	0.87	0.81	0.75	0.70	0.66	0.56	0.53	0.51	0.48	0.45	0.39	0.30	0.23	0.17	0.10	0
1.3	1.35	0.93	0.82	0.76	0.70	0.65	0.61	0.51	0.49	0.46	0.43	0.40	0.34	0.25	0.18	0.12	0.05	0
1.2	1.3	0.88	0.77	0.71	0.66	0.61	0.56	0.46	0.44	0.41	0.38	0.35	0.29	0.20	0.13	0.07	0.02	0
1.1	1.25	0.83	0.72	0.66	0.61	0.56	0.52	0.42	0.39	0.37	0.33	0.31	0.24	0.15	0.09	0.03	0	0
1.0	1.2	0.79	0.68	0.62	0.57	0.51	0.47	0.37	0.35	0.32	0.29	0.26	0.20	0.10	0.05	0	0	0
0.98	1.19	0.78	0.67	0.61	0.56	0.50	0.46	0.36	0.34	0.31	0.28	0.25	0.19	0.09	0.04	0	0	0
0.96	1.18	0.77	0.66	0.60	0.55	0.49	0.45	0.35	0.33	0.30	0.27	0.24	0.18	0.09	0.04	0	0	0
0.94	1.17	0.76	0.65	0.59	0.54	0.48	0.44	0.35	0.32	0.30	0.26	0.23	0.17	0.08	0.03	0	0	0
0.92	1.16	0.75	0.64	0.58	0.53	0.47	0.43	0.34	0.31	0.29	0.25	0.22	0.16	0.07	0.02	0	0	0
0.90	1.15	0.74	0.63	0.57	0.52	0.46	0.42	0.33	0.30	0.28	0.24	0.21	0.15	0.06	0.02	0	0	0
0.88	1.14	0.73	0.62	0.56	0.51	0.46	0.41	0.32	0.29	0.27	0.24	0.21	0.15	0.05	0.01	0	0	0
0.86	1.13	0.72	0.61	0.55	0.50	0.45	0.40	0.31	0.29	0.26	0.23	0.20	0.14	0.05	0	0	0	0
0.84	1.12	0.71	0.60	0.54	0.49	0.44	0.39	0.30	0.28	0.25	0.22	0.19	0.13	0.04	0	0	0	0
0.82	1.11	0.70	0.59	0.53	0.48	0.43	0.38	0.29	0.27	0.25	0.21	0.18	0.12	0.03	0	0	0	0
0.80	1.10	0.69	0.58	0.53	0.48	0.42	0.37	0.29	0.26	0.24	0.20	0.17	0.11	0.02	0	0	0	0
0.78	1.09	0.68	0.57	0.52	0.47	0.41	0.36	0.28	0.26	0.23	0.20	0.17	0.11	0.02	0	0	0	0
0.76	1.08	0.67	0.57	0.51	0.46	0.40	0.36	0.27	0.25	0.22	0.19	0.16	0.10	0.01	0	0	0	0
0.74	1.07	0.67	0.56	0.50	0.45	0.39	0.35	0.26	0.24	0.22	0.18	0.15	0.09	0.01	0	0	0	0
.072	1.06	0.66	0.55	0.49	0.44	0.38	0.34	0.26	0.24	0.21	0.17	0.15	0.09	0	0	0	0	0
0.70	1.05	0.65	0.54	0.48	0.44	0.37	0.33	0.25	0.23	0.20	0.17	0.14	0.08	0	0	0	0	0
0.68	1.04	0.64	0.54	0.47	0.43	0.37	0.32	0.24	0.22	0.20	0.16	0.13	0.07	0	0	0	0	0
0.66	1.03	0.64	0.53	0.47	0.42	0.36	0.31	0.24	0.22	0.19	0.16	0.13	0.07	0	0	0	0	0
0.64	1.02	0.63	0.53	0.46	0.41	0.35	0.31	0.23	0.21	0.19	0.15	0.12	0.06	0	0	0	0	0
0.62	1.01	0.63	0.52	0.45	0.41	0.34	0.30	0.23	0.21	0.18	0.15	0.12	0.05	0	0	0	0	0
0.60	1.00	0.62	0.52	0.45	0.40	0.34	0.29	0.22	0.20	0.18	0.14	0.11	0.05	0	0	0	0	0
0.58	0.99	0.62	0.51	0.44	0.39	0.33	0.29	0.22	0.19	0.17	0.14	0.10	0.04	0	0	0	0	0
0.56	0.98	0.61	0.51	0.44	0.39	0.33	0.28	0.22	0.19	0.17	9.13	0.10	0.03	0	0	0	0	0
0.54	0.97	0.61	0.51	0.43	0.39	0.32	0.28	0.21	0.19	0.16	0.13	0.09	0.03	0	0	0	0	0
0.52	0.96	0.60	0.51	0.43	0.38	0.32	0.27	0.21	0.18	0.16	0.12	0.09	0.02	0	0	0	0	0
0.50	0.95	0.60	0.51	0.43	0.38	0.32	0.27	0.21	0.18	0.16	0.12	0.08	0.02	0	0	0	0	0
0.48	0.94	0.60	0.51	0.43	0.38	0.31	0.27	0.20	0.18	0.15	0.12	0.08	0.01	0	0	0	0	0
0.46	0.93	0.60	0.51	0.43	0.38	0.31	0.27	0.20	0.18	0.15	0.11	0.08	0.01	0	0	0	0	0
0.44	0.92	0.60	0.51	0.43	0.39	0.31	0.27	0.20	0.18	0.15	0.11	0.07	0.01	0	0	0	0	0
0.42	0.91	0.60	0.51	0.44	0.39	0.31	0.27	0.20	0.18	0.15	0.11	0.07	0	0	0	0	0	0
0.40	0.90	0.61	0.52	0.45	0.40	0.32	0.28	0.21	0.18	0.15	0.11	0.07	0	0	0	0	0	0
0.38	0.89	0.61	0.53	0.45	0.41	0.32	0.28	0.21	0.18	0.15	0.11	0.07	0	0	0	0	0	0
0.36	0.88	0.62	0.53	0.46	0.42	0.33	0.29	0.21	0.18	0.15	0.11	0.07	0	0	0	0	0	0
0.34	0.87	0.62	0.54	0.48	0.43	0.34	0.30	0.22	0.19	0.15	0.11	0.07	0	0	0	0	0	0
0.32	0.86	0.63	0.55	0.49	0.45	0.35	0.30	0.22	0.19	0.16	0.12	0.97	0	0	0	0	0	0
0.30	0.85	0.65	0.57	0.51	0.47	0.37	0.32	0.23	0.20	0.16	0.12	0.08	0	0	0	0	0	0
0.28	0.84	0.66	0.58	0.54	0.49	0.39	0.33	0.24	0.21	0.17	0.13	0.08	0	0	0	0	0	0
0.26	0.83	0.68	0.60	0.57	0.51	0.41	0.35	0.26	0.22	0.18	0.14	0.09	0	0	0	0	0	0
0.24	0.82	0.70	0.63	0.60	0.54	0.44	0.37	0.28	0.23	0.20	0.15	0.10	0	0	0	0	0	0
0.22	0.81	0.72	0.66	0.63	0.58	0.47	0.39	0.30	0.25	0.21	0.16	0.11	0	0	0	0	0	0
0.20	0.80	0.74	0.69	0.66	0.61	0.49	0.42	0.32	0.27	0.23	0.18	0.12	0	0	0	0	0	0

TABLE 6 RELATIONSHIP FOR VARIOUS STRAIN VALUES IN A SUBSIDENCE PROFILE (NATIONAL COAL BOARD, 1975)

TABLE 7.

STRAIN PREDICTION USING h=120m393 ft; w/h=1.48

+E=+12,735 micro-in./in.
-E=-9,992 micro-in./in.

EXTENSION (+E) / COMPRESSION (-E)

STRAIN as e/E	0.0	0.20	0.40	0.60	0.80	1.00	0.80	0.0	0.20	0.40	0.60	0.80	1.00	0.80	0.60	0.40	0.20	0.0
STRAIN μ-in/in	0	2547	5094	7641	10188	12735	10188	0	1998	3997	5995	7994	9992	7994	5995	3997	1998	0
DIST. in TERMS of h	1.44	1.02	0.91	0.85	0.79	0.74	0.70	0.60	0.57	0.55	0.52	0.49	0.43	0.34	0.27	0.21	0.14	.01
DIST. in FT	566	401	358	334	310	291	275	236	224	216	204	193	169	134	106	83	55	4.0

STRAIN PREDICTION FOR h=74m=242ft.; w/h= 2.39

+E=+21,483 micro-in./in.
-E=-16,860 micro-in./in.

EXTENSION (+E) / COMPRESSION (-E)

STRAIN as e/E	0.0	0.20	0.40	0.60	0.80	1.00	0.80	0.0	0.20	0.40	0.60	0.80	1.00	0.80	0.60	0.40	0.20	0.0
STRAIN μ-in/in	0	4298	8595	12893	17190	21488	17190	0	3372	6744	10116	13488	16860	13488	10116	6744	3372	0
DIST. in TERMS of h	1.90	1.48	1.37	1.31	1.25	1.20	1.16	1.06	1.04	1.01	0.98	0.95	0.89	0.80	0.73	0.67	0.60	0.40
DIST. in FT.	450	358	332	317	303	290	281	257	252	244	237	230	215	194	177	162	145	97

Lines 2 and 4 were used to plot the horizontal strain profiles

Figure 58 shows the two predicted strain profiles for overburden depths of 393 ft and 242 ft. The figure shows that the tensional and compressional strains for both predicted profiles is less than the measured strains. However, the predicted strain for h = 242 ft is reasonably close to the measured strain profile. This is due to the fact that larger width-to-depth ratios yield greater subsidence which results in more horizontal strain. Since an overburden depth of 242 ft is much lower than the average "h" for the perpendicular (328 ft), it can be said that horizontal strains are apparently greater in those cases where thick sandstone beds with steeply dipping joint sets occur as the roof rock.

The basic components which cause horizontal strain between two points on the surface are (1) differential subsidence, and (2) differential displacement. Figure 59 illustrates two monuments, A and B, which are on sloping terrain. If they are subjected to a differential displacement (dv) and a differential subsidence (ds), then the strain adjustment is $(\sec \alpha_2/\sec \alpha_1) - 1$ when the gradient has been increased. When strains are measured in the field and need to be corrected to horizontal equivalents, the adjustments must be subtracted from tensile strain and added to compressive strain. When the gradient has been decreased, then the strain adjustment is $1 - (\sec \alpha_2/\sec \alpha_1)$ and the corrections are opposite to those under the conditions of gradient increase (NCB, 1975).

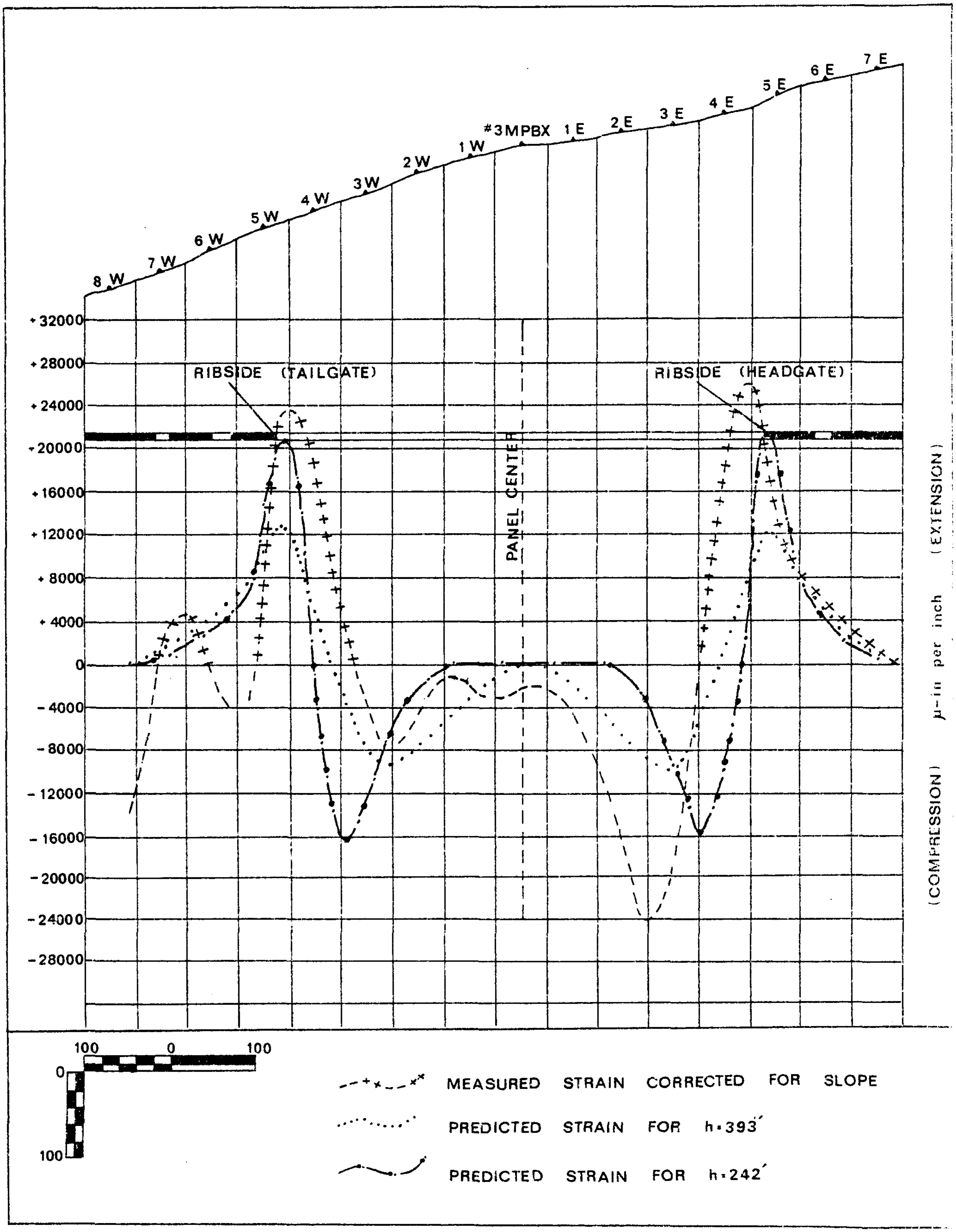
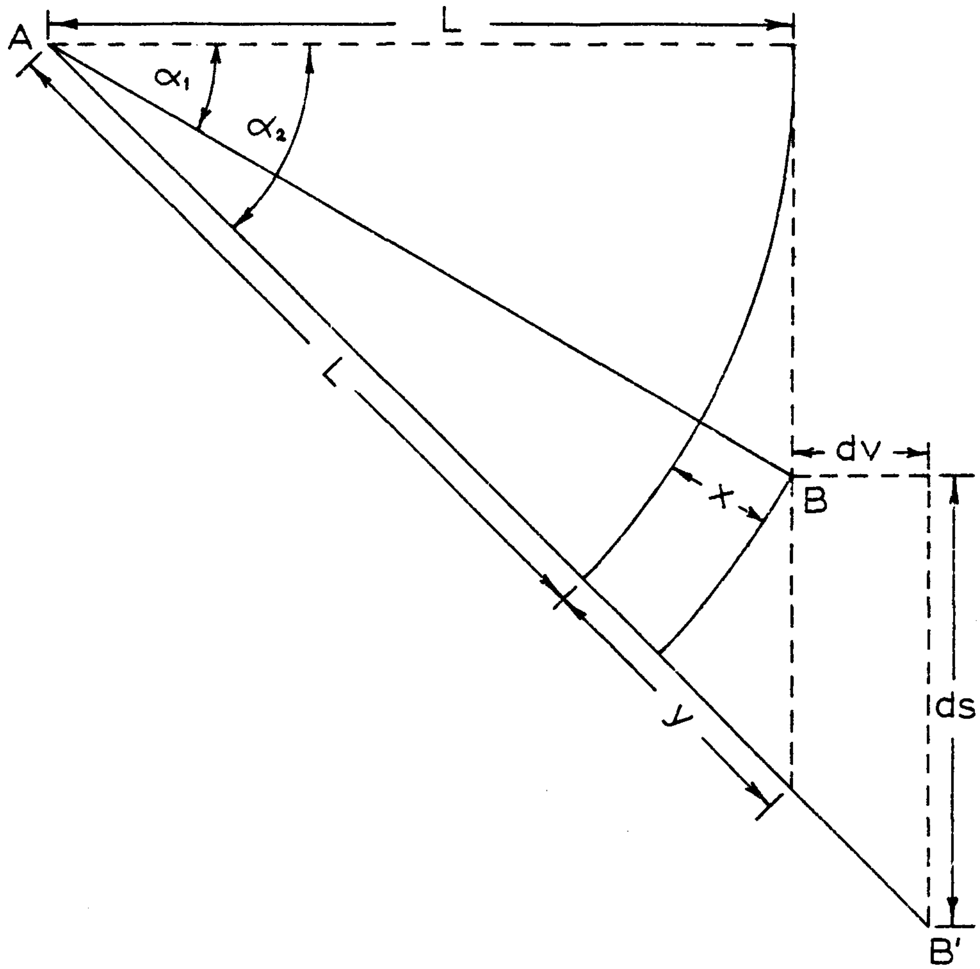


FIG 58 MEASURED VS. PREDICTED STABILIZED HORIZONTAL STRAINS - PANEL PERPENDICULAR.

York Canyon Mine Test Panel. Fc. 500′S of ⊥: Mar. 30, 1975.



$$y = L\sec\alpha_2 - L \qquad x = L\sec\alpha_1 - L$$

$$y - x = (L\sec\alpha_2 - L) - (L\sec\alpha_1 - L)$$

$$= L\sec\alpha_2 - L\sec\alpha_1$$

$$\text{STRAIN ADJUSTMENT} = \frac{L\sec\alpha_2 - L\sec\alpha_1}{AB}$$

$$= \frac{\sec\alpha_2}{\sec\alpha_1} - 1 \qquad (AB = L\sec\alpha_1)$$

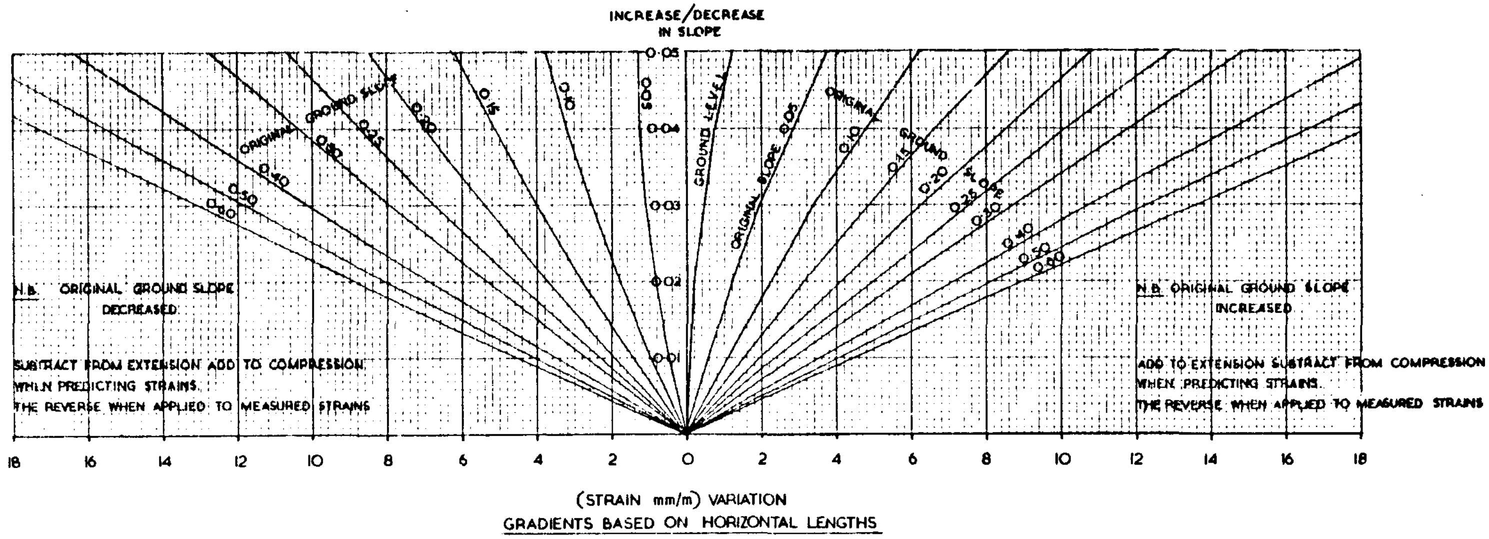
FIGURE 59

EFFECT OF SLOPING SURFACES

To save time and labor, the NCB has constructed a nomogram for calculating the variation in strain due to ground slope (Figure 60). This nomogram was used in correcting all strains measured above the 4N longwall panel. The same precedures used in correcting the measured strains for ground slope were used to correct the predicted strains for ground slope. Tables 8 and 9 were compiled using the distance and subsidence values from Table 5. Original ground slope was calculated from the original surface profile along the perpendicular. Line 4, which is the increase or decrease in ground slope, was obtained by dividing the differential subsidence by the distance between the subsidence values. Strain variation was then obtained from the nomogram and used to adjust the predicted strain values found previously.

The profiles were not plotted for the predicted strain values corrected for slope because of the abnormally high strain variation values for h = 242 ft (e.g. for an interpolation for an original slope of 0.42 and an increase in slope of 0.089 the strain variation would be approximately 33,000 u-in./in.). Evidently the nomogram is only accurate for changes in slope of less than 0.05.

The corrected strains do show greater tensional strains on the headgate side of the panel which is logical since the slope faces toward the center of the panel on the headgate side as compared to the tailgate side. One would think that the greater



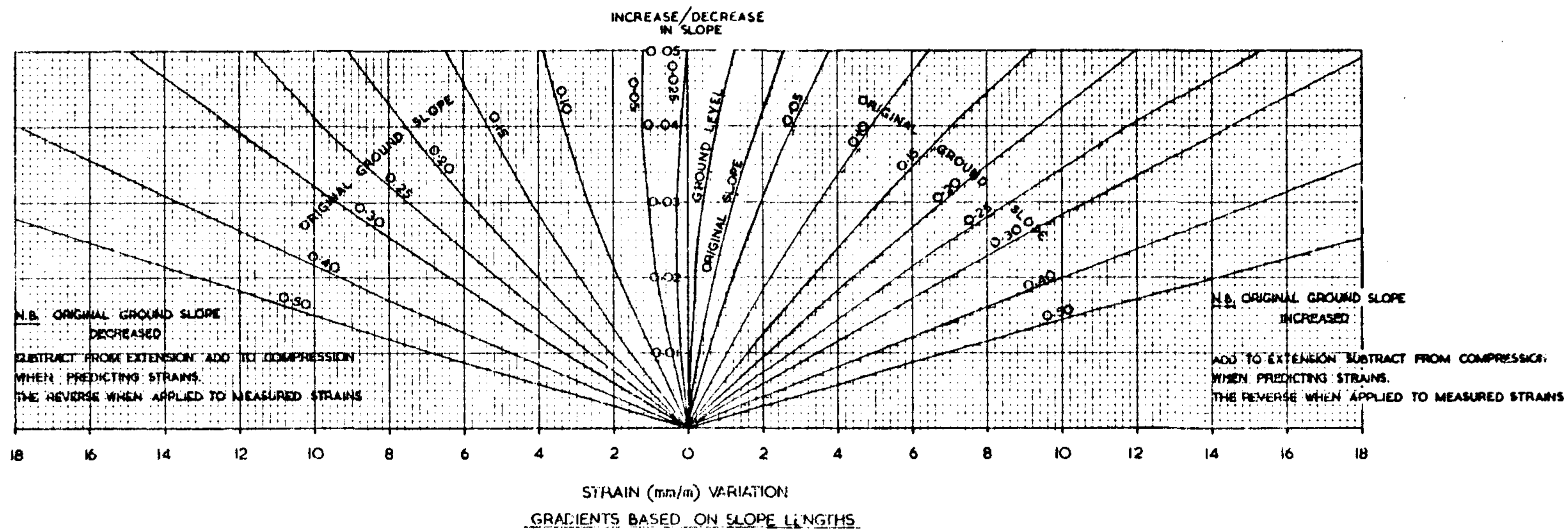


FIG. 60 NOMOGRAM FOR CALCULATING VARIATION IN STRAIN DUE TO GROUND SLOPE (NATIONAL COAL BOARD, 1975)

TABLE 8.

PREDICTED STRAIN CORRECTED FOR GROUD SLOPE FOR h=393 ft.

STRAIN FROM PANEL CENTER TOWARD TAILGATE (μ-in./in.)

DISTANCE in FT.	566	373	330	291	267	252	236	220	204	184	153	122	11.8
SUBSIDENCE IN FT.	0.0	0.39	0.77	1.54	2.31	3.08	3.85	4.62	5.39	6.16	6.93	7.32	7.70

ORIGINAL SLOPE	0.38	0.40	0.41	0.42	0.39	0.37	0.37	0.37	0.36	0.36	0.34	0.22
(+) (-) INC./DEC. IN SLOPE	-0.002	-0.009	-0.020	-0.032	-0.051	-0.048	-0.048	-0.048	-0.039	-0.025	-0.013	-0.003
STRAIN VARIATION	200	3100	7000	11,000	16,400	14,800	14,800	14,800	11,800	7,800	3,800	200
PREDICTED STRAIN	+500	+6000	+11000	+12,000	+7000	+2000	-1500	-4500	-7500	-10,000	-8,000	-2000
STRAIN CORRECTED FOR GROUND SLOPE	+300	+2900	+4000	+1000	-9,400	-12,800	-16,300	-19,300	-19,300	-17,800	-11,800	-2,200

TABLE 8. (continued)

STRAIN FROM PANEL CENTER TOWARD HEADGATE (μ-in./in.) h = 242 ft.

DISTANCE in FT.	566	373	330	291	267	252	236	220	204	184	153	122	11.8
SUBSIDENCE in FT.	0.0	0.39	0.77	1.54	2.31	3.08	3.85	4.62	5.39	6.16	6.93	7.32	7.70
ORIGINAL SLOPE		0.24	0.30	0.35	0.28	0.22	0.20	0.19	0.17	0.16	0.17	0.17	0.13
(+) (-) INC./DEC. in SLOPE		+0.002	+0.009	+0.020	+0.032	+0.051	+0.048	+0.048	+0.048	+0.039	+0.025	+0.013	+0.003
STRAIN VARIATION		200	2600	6400	8800	11,800	10,400	10,000	9200	6600	4400	2200	200
PREDICTED STRAIN		+500	+6000	+11,000	+12,000	+7,000	+2,000	-1500	-4500	-7500	-10,000	-8,000	-2000
STRAIN CORRECTED FOR GROUND SLOPE		+700	+8,600	+17,400	+20,800	+18,800	+12,400	+8,500	+4700	-900	-5600	-5,800	-1800

TABLE 9.

PREDICTED STRAIN CORRECTED FOR GROUND SLOPE FOR h=242 ft.

STRAIN FROM PANEL CENTER TOWARD TAILGATE(μ-in./in.)

DISTANCE in FT.	457	339	310	286	273	264	254	244	235	222	203	184	73
SUBSIDENCE in FT.	0.0	0.40	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	7.60	8.00
ORIGINAL SLOPE	0.40	0.40	0.41	0.42	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.34	
(+) (-) INC./DEC. IN SLOPE	-0.003	-0.014	-0.033	-0.062	-0.088	-0.080	-0.080	-0.089	-0.062	-0.042	-0.021	-0.004	
STRAIN VARIATION	600	4800	11,400	>18,000	>18,000	>18,000	>18,000	>18,000	>18,000	13,000	6,600	1000	
PREDICTED STRAIN	+1000	+10,000	+20,500	+17,000	+10,000	+4,500	-4,000	-8,500	-13,000	-17,500	-13,500	-2000	
STRAIN CORRECTED FOR GROUND SLOPE	+400	+5200	+9100	>-1000	>-8000	>-13,500	>-22,000	>-26,500	>-31,000	-30,500	-20,100	-3000	

TABLE 9. (continued)

STRAIN FROM PANEL CENTER TOWARD HEADGATE (μ -in./in.)

DISTANCE in FT.	457		339		310		286		273		264		254		244		235		222		203		184		73
SUBSIDENCE in FT.	0.0		0.40		0.80		1.60		2.40		3.20		4.00		4.80		5.60		6.40		7.20		7.60		8.00
ORIGINAL SLOPE		0.24		0.42		0.35		0.30		0.28		0.28		0.24		0.20		0.19		0.18		0.17		0.16	
(+) (-) INC./DEC. in SLOPE		+0.003		+0.014		+0.033		+0.062		+0.089		+0.080		+0.080		+0.089		+0.062		+0.042		+0.021		+0.004	
STRAIN VARIATION		400		5200		9000		>18,000		>18,000		>18,000		>18,000		>18,000		≈14,000		8,400		3,800		600	
PREDICTED STRAIN		+1000		+10,000		+20,500		+17,000		+10,000		+4,500		-4,000		-8500		-13000		-17,500		-13500		-2000	
STRAIN CORRECTED FOR GROUND SLOPE		+1400		+15,200		+29,500		>+35,000		>28,000		>22,500		>14,000		>9500		+1000		-9 100		-9700		-1400	

compression would accompany the greater tension. Figure 58 shows that both the measured compressional and tensional strains were greater on the headgate side which is what should be expected. Predicted strains show a point or area of zero compressional strain at the midpoint of the subsidence trough. This predicted area of zero strain for h = 393 ft is only about 24 ft wide. A compressional strain as low as 600 u-in./in. was measured between Stations 1W and 2W. Because this strain was calculated over a distance fo 60 ft, an area of zero strain may have developed over the shorter distance of 24 ft.

Surface Movement vs. Underground Movement

An attempt was made to correlate underground movement with surface movement. The data from convergence stations along the tailgate side of the longwall panel could not be used since a pillar robbing operation accompanied the longwall advance on the tailgate side.

A pressure cell (P8) which was in a pillar along the headgate entry, yielded information on how subsidence on the surface was related to compaction of the cave at seam level. Pressure cell P8 stabilized after the face was approximately 220 ft beyond the instrument. This pressure cell was located on a line parallel to the face that ran midway between Monuments 1N and 2N. The survey data for these monuments (see station coordinates and elevations in Appendix E) indicate that approximately 97% of the surface subsidence had taken place at this time.

Jakobi (1956) attempted to equate surface subsidence with observations of stowing pressure underground and stated that, "The pressure exerted by the overlying strata on the stowed goaf is only attained once all the subsidence movements are completely finished". If this statement is accurate, along with the 98% subsidence at the time pressure in the coal ceased to increase, it can be assumed that residual subsidence is only due to consolidation of the uppermost overburden.

The only convergence stations on the tailgate side were approximately 190 ft from the face when it was stopped due to faulting conditions. They did, however, show an increase in convergence as the face approached the stopping point. This convergence increased after the face stopped until the time surface subsidence ceased. This indicates a one to one relationship between surface movement and transference of underground abutment pressures. Once all surface movement ceases, no additional pressures are apparently exerted or redistributed at seam level.

SUMMARY

The nature of ground movements over mining operations varies according to individual conditions present in every mining district. One of the primary difficulities in relating the various field investigations lies in finding a common basis on which to judge the results.

The surface instrumentation portion of this project attempted to determine the magnitude and extent of surface subsidence resulting from mining a super-critical longwall panel with rapid cross-and along-panel topographic variations in a known geologic environment. The measured vertical and horizontal surface movements were also compared with predicted values found using NCB techniques. Surface subsidence results were presented in both absolute and dimensionless values. This approach was utilized in order that the results could readily be compared and used with other documentation for subsidence prediction in North America.

Conclusions

This report showed that topography does indeed significantly influence the magnitudes and distributions of surface movements resulting from underground extraction. A maximum subsidence of 7.1 ft was measured along the centerline and indicated that the maximum subsidence in topographic lows was between 25% and 30% less than the subsidence noted under ridge tops. This was attributed to three factors: (1) greater overburden depth caused greater subsidence under ridge tops, (2) excess "piling up" of overburden in draws due to horizontal movement of overburden from each opposite facing slope decreased measurable subsidence in topographic lows, and (3) an arching effect, caused by increased compressional forces present in the bottom of draws, decreased subsidence.

The angle of draw was decreased in the areas of topographic lows and also where side panel slopes face outward from the panel centerline. The angle of draw was increased in those cases where: ridges were present, slopes on the sides of the panel faced the centerline, and where steep slopes faced the direction of face advance. For longwall panel 4N, subsidence started when the face was an average distance of 0.2h from a given surface point and was essentially complete when the face was 0.84h beyond the surface point. Initial subsidence was delayed on all subsidence development curves. This is attributed to the influence of thick sandstone bed overlying the coal seam in panel 4N. These results contrast to NCB data which predicts the onset of subsidence when the face is at a distance of about 0.7h from a given surface point.

The average angle of draw for longwall panel 4N was 15.5^{o} as compared to the NCB average of 35^{o}. Thick sandstone beds and steeply dipping joints in the rock overburden were no doubt responsible for the decrease in the average angle of draw.

The results of surveys made during periods of mining activity and over periods of mine holidays indicated that underground activity produced almost instantaneous surface movement and that major surface subsidence ceased almost as soon as mining ceased.

Maximum predicted super-critical subsidence, using NCB values, for the two extremes of overburden depth for prediction parameters was 17% and 21% greater than actual measured subsidence along the perpendicular. When comparing predicted vs. measured subsidence in the draws the percentage is even greater. For example, the average h for monuments 6N and 7N is 251 ft and the measured subsidence at both monuments was 5.1 ft. The predicted subsidence for these conditions is 7.9 ft making the predicted subsidence in the draw about 55% greater than that measured.

Horizontal movement data indicated that tensile strains reverse to compressive strains between 10^{o} and 20^{o} inside the mined area. NCB studies show this average to be somewhere between 5^{o}-10^{o}. The point where measured subsidence was half the maximum measured subsidence was also 10^{o} to 20^{o} inside the mined area. This indicates that for the 4N longwall panel the transition point can be either the point of half maximum subsidence or the point where the strain profile goes from tension to compression.

Higher tensional strains develop first over areas of least overburden under dynamic conditions and after conditions stabilize over areas with the most overburden. The maximum tensional strains occurred just inside the mined-unmined coal interface. The maximum compressional strains occurred under topographic lows along the centerline and had the characteristic "camel's back" in the profile along the perpendicular.

Predicated tensional strains were 15% to 20% less than the measured tensional strains along the perpendicular when an overburden h of 242 ft was used, whereas, predicated compression strains were greater on the tailgate side and less on the headgate side than the corresponding measured compressional strains.

The maximum tensional strain measured over the 4N longwall panel was +35,633 u-in./in. and the maximum compressional strain measured was -33,917 u-in./in. The NCB states that the maximum tensional strain that can develop over a super-critical width of extraction is 0.65 S_{max}/h and the maximum compressional strain is 0.51 S_{max}/h. The minimum overburden "h" along the centerline where these maximum strains were measured was about 250 ft and the maximum subsidence measured along the centerline was 7.1 ft. This gives a maximum +E from NCB formulas of 18,460 u-in./in. and a -E of 14,484 u-in./in. This shows that the maximum strains developed over the 4N longwall panel are almost twice the predicted strains given by NCB formulae for a super-critical width of extraction. This indicates there is a great variation between the numerous NCB studies made in flat to gently rolling terrain and this particular North American study made at the mountainous York Canyon Mine terrain.

SECTION III

SUBSURFACE INSTRUMENTATION

INTRODUCTION

The subsurface instrumentation program at Kaiser Steel Corporation's York Canyon Mine was designed to determine the loads imposed upon the shield supports and upon the rock strata in the vicinity of the coal seam as mining advanced through the longwall panel. The variations in these applied stresses were noted, and an attempt was made to correlate the observed loading histories and rock mass reactions with the geologic structure in the panel area. The subsurface instrumentation program included an instrumentation sequence to determine the response of the shield support systems and the rock mass to mining and a program of laboratory and in situ testing to evaluate physical rock properties.

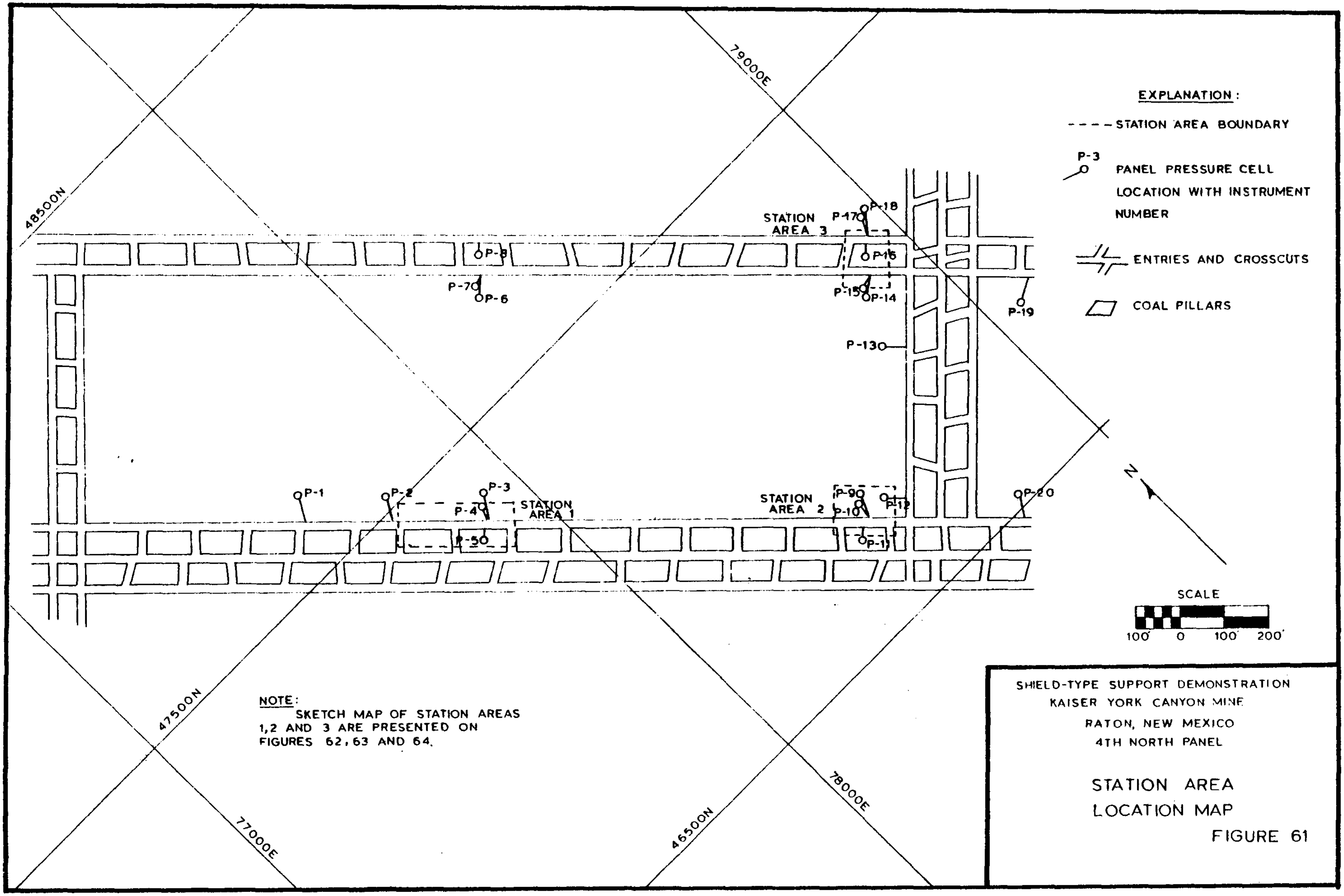
The instrumentation sequence was subdivided into three areas: shield support instrumentation, face instrumentation and entry instrumentation. The shield support instrumentation consisted of eighteen hydraulic pressure recorders installed on selected shield supports along the longwall face. The recorders were utilized to determine the roof loading history across the face. An attempt was made to correlate applied loads, mining activity and geologic structure.

Face instrumentation was installed to relate coal hardness, panel power consumption and support loading. A KVA continuous recorder provided a record of power consumption and coal hardness was determined with a Schmidt hardness hammer.

Intensive instrumentation was installed along the entries adjacent to the longwall panel to determine rock mass response in advance of the longwall face. The instrumentation consisted of four types: hydraulic pressure cells, convergence instrumentation, differential roof-floor horizontal movement instrumentation and double-point extensometers. The twenty panel pressure cells were located throughout the panel area, while the convergence, differential roof-floor horizontal movement and extensometers were grouped into three station areas.

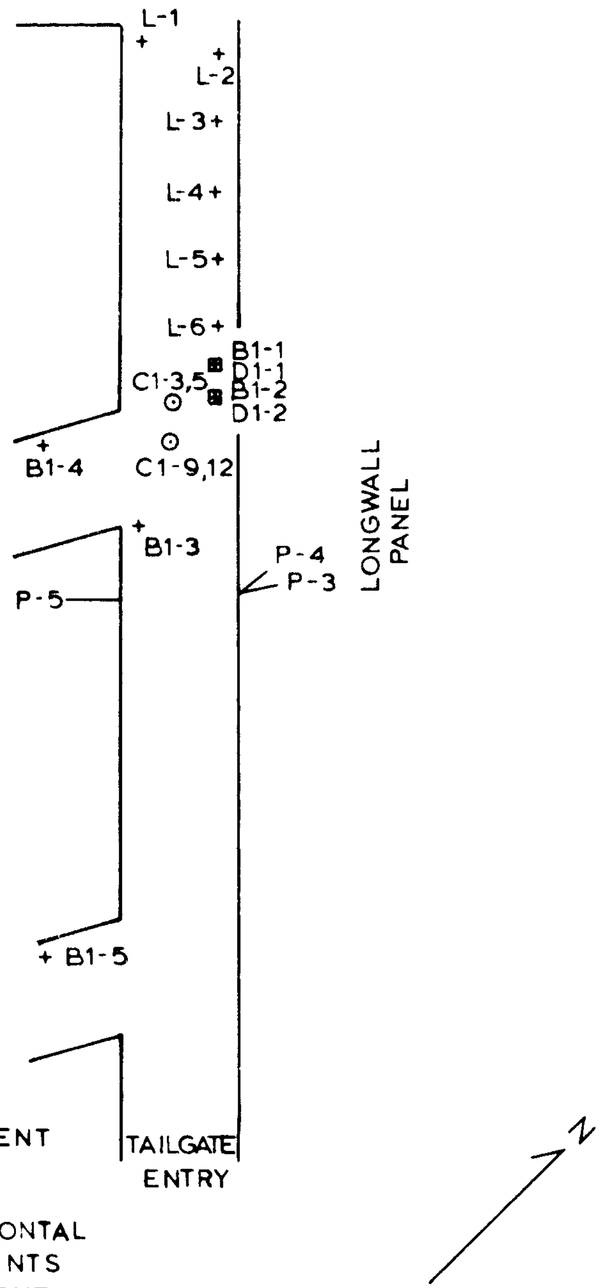
The locations of the panel pressure cells and Station Areas 1, 2 and 3 are shown on Figure 61. Instrument layouts within Station Areas 1, 2 and 3 are shown on Figures 62, 63 and 64, respectively. A tabulation of location and installation data for the panel pressure cells is presented in Table 10. Location data for convergence instrumentation are presented in Table 11 and location data for differential roof-floor horizontal movement instrumentation and roof extensometers are presented in Table 12. Detailed descriptions of the installation and monitoring procedures for each type of instrument are presented in Appendix A.

A program of laboratory and in situ testing was implemented to



SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

STATION AREA
LOCATION MAP
FIGURE 61



EXPLANATION:

+B1-3 CONVERGENCE INSTRUMENT WITH NUMBER

□D3-1 DIFFERENTIAL ROOF-FLOOR HORIZONTAL MOVEMENT INSTRUMENT WITH NUMBER

⊞ CONVERGENCE AND DIFFERENTIAL HORIZONTAL MOVEMENT INSTRUMENTS

⊙C3-3,5 ROOF-SAG INSTRUMENT AND NUMBER

P-17—PANEL PRESSURE CELL WITH NUMBER

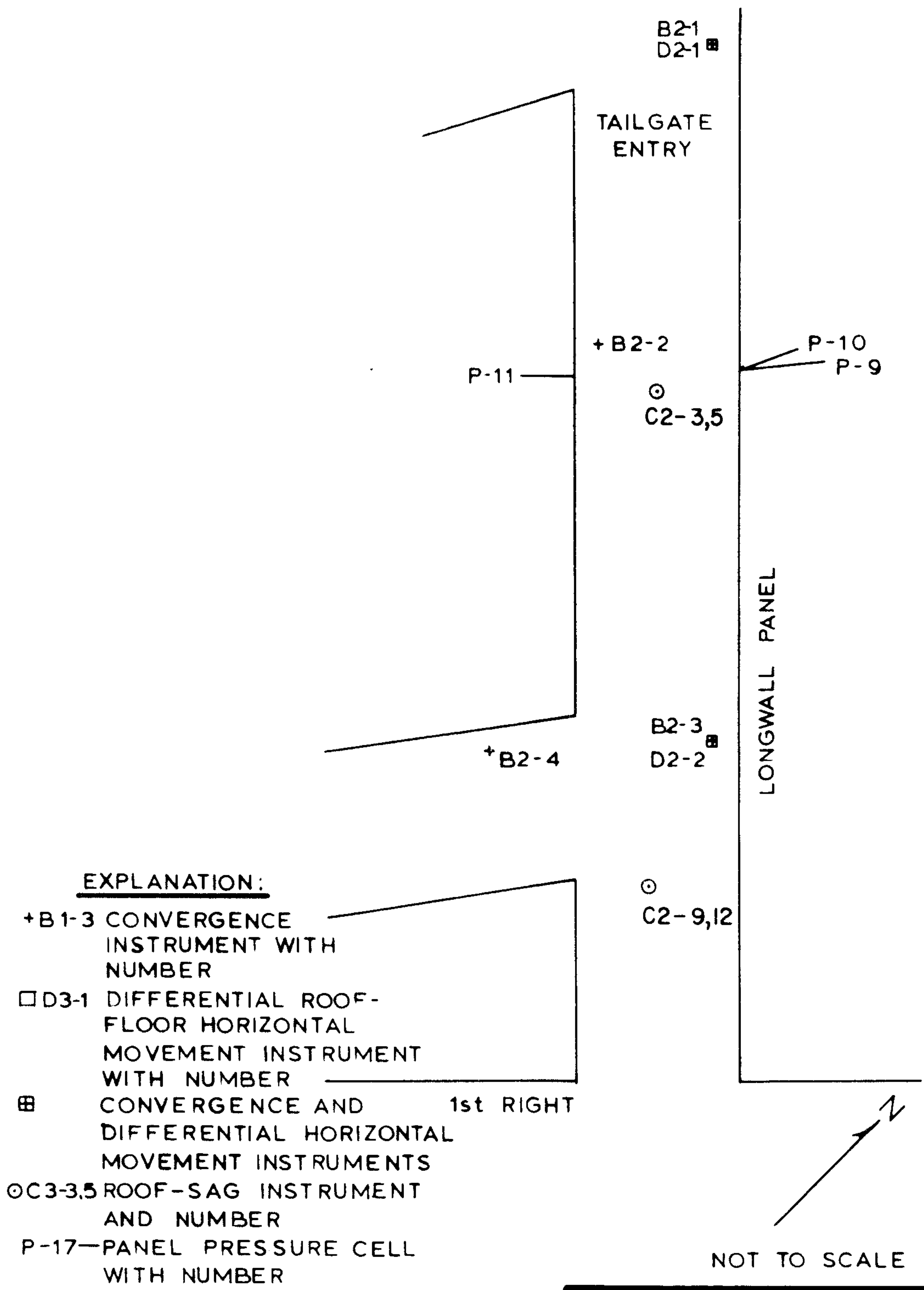
NOTES:

1. Location of Station Area I is shown on Figure 61.
2. Location data is tabulated in the text.

SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

SKETCH MAP STATION AREA 1 INSTRUMENTATION

FIGURE 62



NOTES:

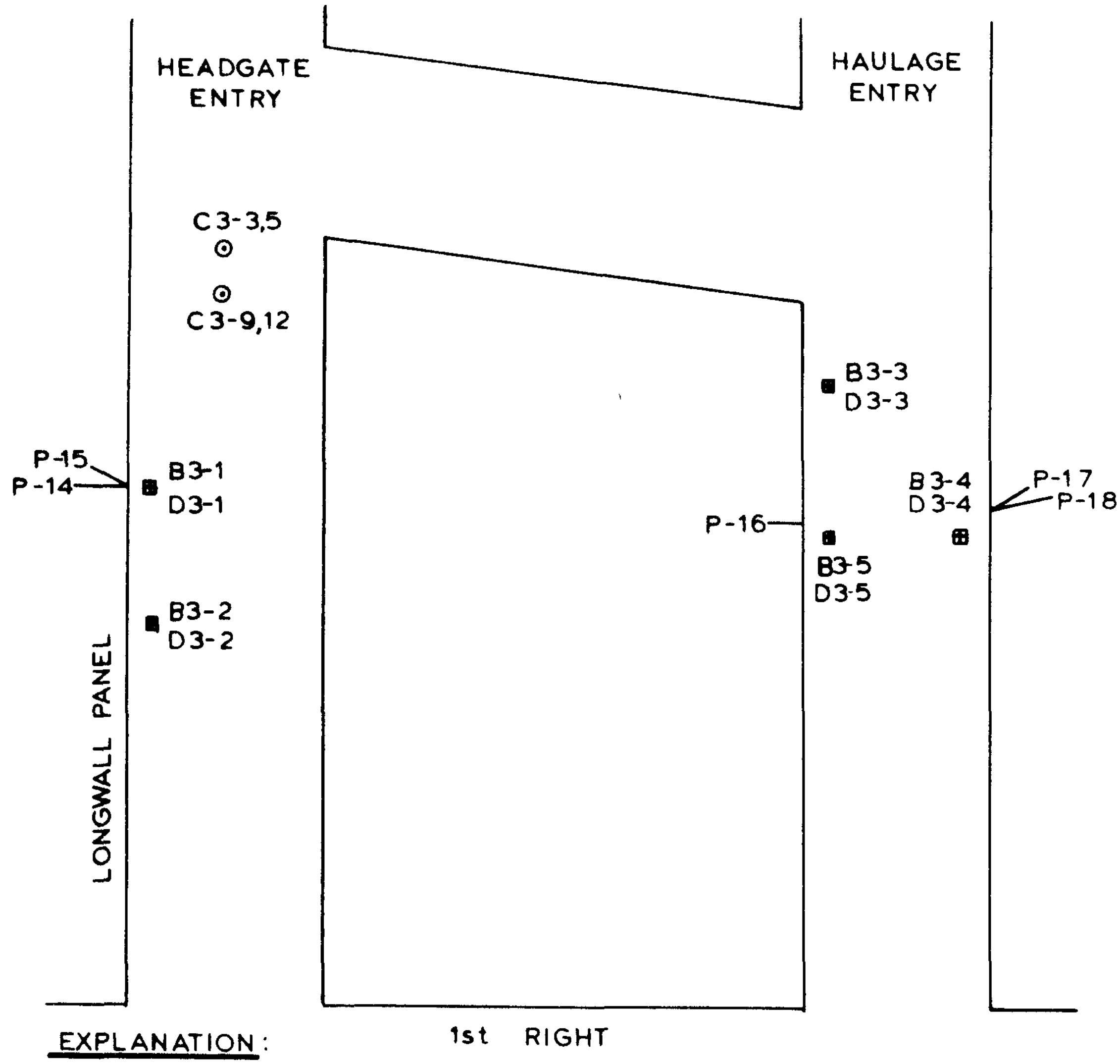
1. Location of Station Area 2 is shown on Figure 61.

2. Location data is tabulated in the text.

SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

SKETCH MAP STATION AREA 2 INSTRUMENTATION

FIGURE 63



EXPLANATION:

+B1-3 CONVERGENCE INSTRUMENT WITH NUMBER

☐D3-1 DIFFERENTIAL ROOF-FLOOR HORIZONTAL MOVEMENT INSTRUMENT WITH NUMBER

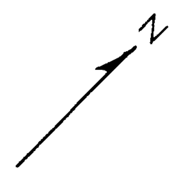
⊞ CONVERGENCE AND DIFFERENTIAL HORIZONTAL MOVEMENT INSTRUMENTS

⊙C3-3,5 ROOF-SAG INSTRUMENT AND NUMBER

P-17—PANEL PRESSURE CELL WITH NUMBER

NOTES:

1. Location of Station Area 3 is shown on Figure 61.
2. Location data is tabulated in the text.



NOT TO SCALE

SHIELD-TYPE SUPPORT
DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

SKETCH MAP STATION
AREA 3 INSTRUMENTATION

FIGURE 64

TABLE 10
LOCATION OF PANEL PRESSURE CELLS,
PANEL 4N, YORK CANYON MINE, NEW MEXICO

Pressure Cell Number	Location Panel Stationing (1, 2)	Depth(3) (ft)	Installation (4) Angle (degrees)	Notes
P-1	W 4+81	50	80	5
P-2	W 6+85	50	80	5
P-3	W 8+79	50	80	5
P-4	W 8+84	30	70	5
P-5	E 8+84	25	90	6
P-6	E 8+90	50	80	5
P-7	E 8+90	30	70	5
P-8	E 8+94	25	90	7
P-9	W 17+41	50	80	5
P-10	W 17+41	30	70	5
P-11	W 17+43	25	90	6
P-12	E/W 18+48	50	90	8
P-13	E/W 18+48	50	90	8
P-14	E 17+67	50	80	5
P-15	E 17+67	30	70	5
P-16	E 17+74	30	90	7
P-17	E 17+75	30	70	9
P-18	E 17+75	50	80	9
P-19	E 21+22	50	80	5
P-20	W 20+89	50	80	5

NOTES:

1. The locations of the panel pressure cells are shown on Figure 61.

2. Station 0+00 corresponds to the starting point for panel 4N.
   E represents the headgate side of the panel.
   W represents the tailgate side of the panel.

TABLE 10 (continued)

3. Horizontal distance into the coal seam at which pressure cell was installed.

4. Horizontal angle from entry centerline at which pressure cell was installed.

5. Installed into the longwall panel.

6. Installed into the barrier pillar adjacent to the longwall panel from tailgate entry.

7. Installed into the barrier pillar adjacent to the longwall panel from the 4N haulage entry.

8. Installed into panel 4N from the First Right entry off of Third North.

9. Installed into panel 5N, adjacent to panel 4N.

TABLE 11
LOCATION OF CONVERGENCE INSTRUMENTATION,
PANEL 4N, YORK CANYON MINE, NEW MEXICO

Convergence Instrument Number	Station Area (1)	Location (Panel Stationing) (2,3)	Distance from Panel (ft)	Notes
L-1	1	W 7+19	13.5	
L-2	1	W 7+19	6.0	
L-3	1	W 7+37	6.0	
L-4	1	W 7+56	6.0	
L-5	1	W 7+74	6.0	
L-6	1	W 7+92	5.5	
B1-1	1	W 8+10	1.5	
B1-2	1	W 8+18	1.5	
B1-3	1	W 8+35	16.0	
B1-4	1	W 8+35	39.0	
B1-5	1	W 9+36	31.5	
B2-1	2	W 16+83	1.5	
B2-2	2	W 17+36	16.0	
B2-3	2	W 17+92	2.0	
B2-4	2	W 18+00	27.0	
B3-1	3	E 17+68	2.0	
B3-2	3	E 18+07	2.0	
B3-3	3	E 17+48	72.0	4
B3-4	3	E 17+77	88.0	4
B3-5	3	E 17+78	72.0	4

NOTES:

1. The locations of Station Areas are shown on Figure 61.

2. Station 0+00 corresponds to the starting point for panel 4N.
E represents the headgate side of the panel.
W represents the tailgate side of the panel.

TABLE 11 (continued)

3. Sketch maps of instrument locations within Station Areas 1,2 and 3 are shown on Figures 62, 63, and 64, respectively.

4. Instrumentation located in 4 North haulage entry.

TABLE 12

LOCATION OF DIFFERENTIAL ROOF-FLOOR HORIZONTAL MOVEMENT INSTRUMENTATION AND ROOF-SAG INSTRUMENTATION, PANEL 4N, YORK CANYON MINE, NEW MEXICO

Instrument Number	Instrument Type (1)	Station Area (2)	Location Panel Stationing (3,4)	Distance from Panel (ft)	Notes
C1-3,5	C	1	W 8+16	8.5	5
C1-9,12	C	1	W 8+22	8.0	6
C2-3,5	C	2	W 17+44	8.0	5
C2-9,12	C	2	W 18+04	8.0	6
C3-3,5	C	3	E 17+20	8.0	5
C3-9,12	C	3	E 17+29	8.0	6
D1-1	D	1	W 8+13	1.5	
D1-2	D	1	W 8+21	1.5	
D2-1	D	2	W 16+86	1.5	
D2-2	D	2	W 17+89	2.0	
D3-1	D	3	E 17+69	2.0	
D3-2	D	3	E 18+06	2.0	
D3-3	D	3	E 17+46	72.0	7
D3-4	D	3	E 17+79	88.0	7
D3-5	D	3	E 17+81	72.0	7

NOTES:

1. Instrument type:
   C denotes roof-sag instrumentation.
   D denotes differential roof-floor horizontal movement instrumentation.

2. The locations of Station Areas are shown on Figure 61.

3. Station 0+00 corresponds to the starting point for panel 4N.
   E represents the headgate side of the panel.
   W represents the tailgate side of the panel.

TABLE 12 (continued)

4. Sketch maps of instrument locations within Station areas 1,2 and 3 are shown on Figures 62, 63, and 64, respectively.

5. Anchors located at 3-and 5- foot depths.

6. Anchors located at 9- and 12- foot depths.

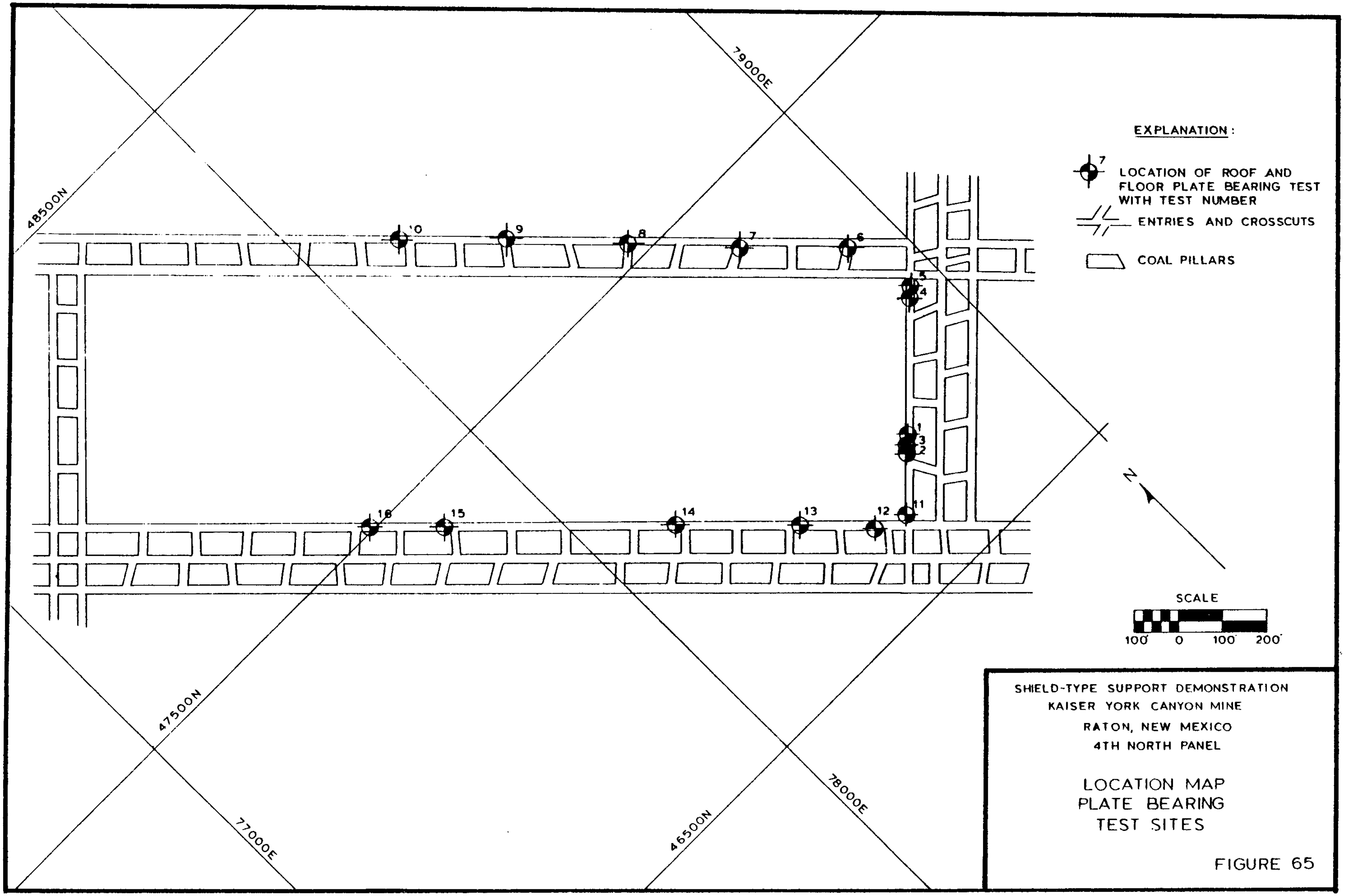
7. Instrument located in 4N haulage entry.

determine the physical characteristics of the coal seam, the immediate roof strata and the immediate floor strata. Physical properties of the roof and floor rock units were determined to a depth of at least one seam thickness.

Laboratory tests were performed on NX-sized core (2 1/8-inch diameter) obtained from test borings adjacent to panel 4N. The locations of these test borings are shown on Figure 8. The in situ testing consisted of plate bearing tests and coal hardness determinations. The locations of the plate bearing tests are shown on Figure 65. Detailed descriptions of the test procedures are presented in Appendix A.

PHYSICAL ROCK PROPERTIES

The estimation of physical properties for the roof sandstone, the coal and the floor sandstone at panel 4N was made by testing 91 specimens. These specimens were gathered in the field from 5 diamond coreholes drilled into the roof and floor and from bulk samples of coal from the face. Over 52 ft of core and over 1/2 ton of coal were returned to the Mining Research Lab of CSM for testing. The breakdown of tests is shown in Table 13.



SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

LOCATION MAP
PLATE BEARING
TEST SITES

FIGURE 65

TABLE 13

PHYSICAL PROPERTY TESTS PERFORMED

Rock Type	Uniaxial Compression	Triaxial Compression	Direct Shear
Roof Sandstone	2	12	9
Coal	9	8	9
Floor Sandstone	5	22	6
Miscellaneous*	___	10	___
	15	52	24

*Note: *Tests performed on unusual geologic conditions and at inclination to bedding.*

The quantitative results of the entire physical testing program are presented in Appendix I, Tables I-1, I-2, I-3 and I-5 for compression and direct shear testing of roof sandstone, coal and floor sandstone. These results are also presented graphically in Appendix I. The average strength parameters measured are given in Table 14.

TABLE 14

PHYSICAL TESTING RESULTS

Rock Type	Uniaxial Compression Strength (psi)	Mean Elastic Modulus $(psi/\frac{u\text{-}in.}{in.})$	Mean Poisson's Ratio	Shear Strength Properties (1)			
				Φp (^{o})	Φr (^{o})	Cp (psi)	Cr (psi)
Roof Sandstone	9840	6.28	0.174	----(2)	26.7^{o}	---(2)	6

TABLE 14 (continued)

Rock Type	Uniaxial Compression Strength (psi)	Mean Elastic Modulus (psi/$\frac{u\text{-in.}}{\text{in.}}$)	Mean Poisson's Ratio	Shear Strength Properties[1] Φp (°)	Φr (°)	Cp (psi)	Cr (psi)
Coal	1640	1.36	0.267	46.0°	24.2°	332	3
Floor Sand-stone	17780	1.95	0.178	32.5°	27.8°	4880	4

Notes:

(1) Φp, Cp - Peak intact rock shear properties

Φr, Cr - Residual intact rock shear properties

(2) Irrational results

The physical test results demonstrate the relative properties of the roof, seam and floor rocks. The roof sandstone was the most variable rock in the vicinity of the coal seam. The variability of the roof sandstone was so great and the scatter of test results so broad that no rational intact rock shear properties could be determined. This variability may well be the result of thin beds of coal locally present in the roof sandstone.

The coal proved to be the most uniform of the three rocks. The coal had the highest intact rock angle of internal friction and Poisson's ratio. The coal had the lowest strength, elastic stiffness and residual shear strength. The coal, in short, was most uniform but least elastic of the rocks tested. It was a relatively low strength and stiffness coal, probably resulting from its recent formation and low rank.

The roof sandstone is, on the average, moderately strong and exhibits a moderate average elastic stiffness. It does, however, exhibit an extremely side scatter of compressive and shear properties. This high variability of the roof sandstone is probably the result of thin coal stringers scattered through the roof sandstones tested. The variation of physical properties should facilitate the collapse and caving of the roof which should benefit longwall mining.

The floor sandstone is the strongest rock tested in compression. It also has the highest overall shear strength. This sandstone has a high compression strength but low elastic stiffness in comparison with the general run of sandstones. This sandstone is more uniform than the roof sandstone, both in properties and in appearance in core samples. The angle of internal friction determined is very low.

It was not possible to test the approximately 1-ft of boney coal at the top of the seam or the approximately 1-ft of carbonaceous shale at the base of the seam. These beds fell apart during drilling or specimen preparation. These beds are in potentially critical locations but can not be tested in the lab. The in situ jacking tests examined properties of these beds.

The 85-ft wide roof span at the time of initial collapse indicates that the rock mass compression strength of the roof sandstone is not less than 1125 psi. This rock mass compression strength of the roof sandstone was calculated assuming the roof sandstone only had to support itself, was fixed-end, was 15 ft thick and at a depth of 360 ft. The rock mass compression strength may approach 5500 psi if the weaker, near-roof, thin-bedded shales and sandstones above were loading the roof sandstone. The thin-bedded near roof members would normally be expected to load the thicker roof sandstones.

Plate Bearing Tests

Plate bearing tests were performed in the entries adjacent to panel 4N at the locations shown in Figure 65. Summaries of the moduli determinations made from the test data are presented in Tables 15 and 16. Sample graphs of deformation vs. load are presented on Figures 66 thru 70. The data from which the graphs were plotted are presented in Appendix J. A contour map of floor deformation modulus values is presented on Figure 71.

Four rock types were encountered during the tests. The floor rock tested was either a silty shale of variable quality and fracture intensity or a fine-grained silty sandstone. Results of tests on both floor rock types indicates a large degree of variability in rock strength. This was expected for the shale but not the sandstone. The variations in sandstone bearing data can be attributed to the presence of thin layers of interbedded shale and siltstone in the upper 2 to 3 ft of the floor sandstone. These

TABLE 15

SUMMARY OF PLATE BEARING TEST RESULTS BY ROCK TYPE

PANEL 4N, YORK CANYON MINE, RATON, NEW MEXICO

Rock Type	Plate Size (in.)	Deformation Modulus (psi/0.001-in.) $\bar{x}$	S_x	Youngs Modulus (psi/μ in./in.) $\bar{x}$
Coal (roof) u = 0.280				
	6x6	8.49	0.77	0.045
	14x14	1.85	0.36	0.023
Shale (floor) u = 0.250				
	6x6	10.74	8.71	0.057
	14x14	6.65	7.07	0.083
Shaley, fine-grained sandstone (floor) u = 0.180				
	6x6	74.37	35.30	4.10
	14x14	8.09	6.71	1.04
Shaley, fine-grained sandstone (roof) u = 0.200				
	6x6	17.17	4.34	0.940
	14x14	2.64	0.60	0.034
Thin coal over shaley, fine-grained sandstone (roof) u = 0.220				
	6x6	9.09	5.11	0.049
	14x14	2.59	1.47	0.033

NOTES:

1. Locations of plate bearing tests are shown on Figure 65 .

2. Table 16 in the text presents a complete tabulation of plate bearing test results.

3. Sample load vs. deformation curves are presented on Figures 66 thru 20 and data for these curves is presented in Appendix J .

TABLE 16

SUMMARY OF PLATE BEARING TEST RESULTS, PANEL 4N
YORK CANYON MINE, NEW MEXICO

Test No.	Type of Test (Roof/Floor)	Bearing Plate Size (in)	Rock Type[4]	Deformation Modulus (psi/0.001-inch)
		TESTS ALONG 1ST RIGHT		
1	FLR	14 x 14	Sh	4.5
2	RF	6 x 6	Ss	16.21
2	FLR	14 x 14	Sh	10.95
3	RF	14 x 14	Ss	2.54
3	FLR	6 x 6	Sh	7.56
4a	RF	14 x 14	C/Ss	4.07
4b	RF	14 x 14	C/Ss	4.02
4a	FLR	8 x 8	Sh	62.5
4b	FLR	6 x 6	Sh	104.3
5	FLR	14 x 14	Sh	6.05
5	RF	6 x 6	C/Ss	16.03
11a	RF	6 x 6	Ss	11.6
11b	RF	14 x 14	Ss	Insufficient Data
11b	FLR	6 x 6	Sh	8.93
11a	FLR	14 x 14	Sh	2.80
		TESTS ALONG 4N ENTRY		
6a	RF	6 x 6	Coal	9.17
6b	RF	14 x 14	Coal	2.26
6b	FLR	6 x 6	Sh	44.4
6a	FLR	14 x 14	Sh	6.67
7a	RF	6 x 6	C/Ss	4.14
7b	RF	14 x 14	C/Ss	1.36
7b	FLR	6 x 6	Sh	53.14
7a	FLR	14 x 14	Sh	20.51
8a	RF	6 x 6	C/Ss	6.74
8b	RF	14 x 14	C/Ss	2.61
8b	FLR	6 x 6	Sh	60.87
8a	FLR	14 x 14	Sh	2.53
9a	RF	6 x 6	Coal	8.64

NOTES:

Refer to Sheet 3

TABLE 16 (continued)

Test No.	Type of Test (Roof/Floor)	Bearing Plate Size (in)	Rock Type[4]	Deformation Modulus (PSI/0.001-inch)
9b	RF	14 x 14	Coal	1.73
9b	FLR	6 x 6	Sh	27.27
9a	FLR	14 x 14	Sh	10.0
10a	RF	6 x 6	Coal	7.66
10b	RF	14 x 14	Coal	1.57
10b	FLR	6 x 6	Sh	141.4
10a	FLR	14 x 14	Sh	Insufficient Data
		TESTS ALONG 3N ENTRY		
12a	RF	6 x 6	C/Ss	9.44
12b	RF	14 x 14	C/Ss	0.89
12b	FLR	6 x 6	Sh	12.26
12a	FLR	14 x 14	Sh	21.05
13	RF	6 x 6	Ss	20.0
13	FLR	14 x 14	Sh	0.67
14a	RF	6 x 6	Ss	20.78
14b	RF	14 x 14	Ss	2.64
14b	FLR	8 x 9	Sh	2.56
14a	FLR	14 x 14	Sh	1.55
15a	RF	6 x 6	Ss	12.66
15b	RF	14 x 14	Ss	3.42
15b	FLR	8 x 8	Sh	5.84
15a	FLR	14 x 14	Sh	5.97
16a	RF	6 x 6	Ss	21.75
16b	RF	14 x 14	Ss	1.96
16b	FLR	6 x 6	Sh	54.0
16a	FLR	14 x 14	Sh	2.21

NOTES:

Refer to Sheet 3

TABLE 16 (continued)

NOTES:

1. Locations of plate bearing tests are shown on Figure 65.

2. Table 15 presents a tabulation of results by rock type.

3. Sample load vs. deformation curves are presented on Figures 66 thru 70.

4. Rock Types

SH	=	Shale
Ss	=	Shaley, fine-grained sandstone
C	=	Coal
C/Ss	=	Thin coal over shaley fine-grained sandstone

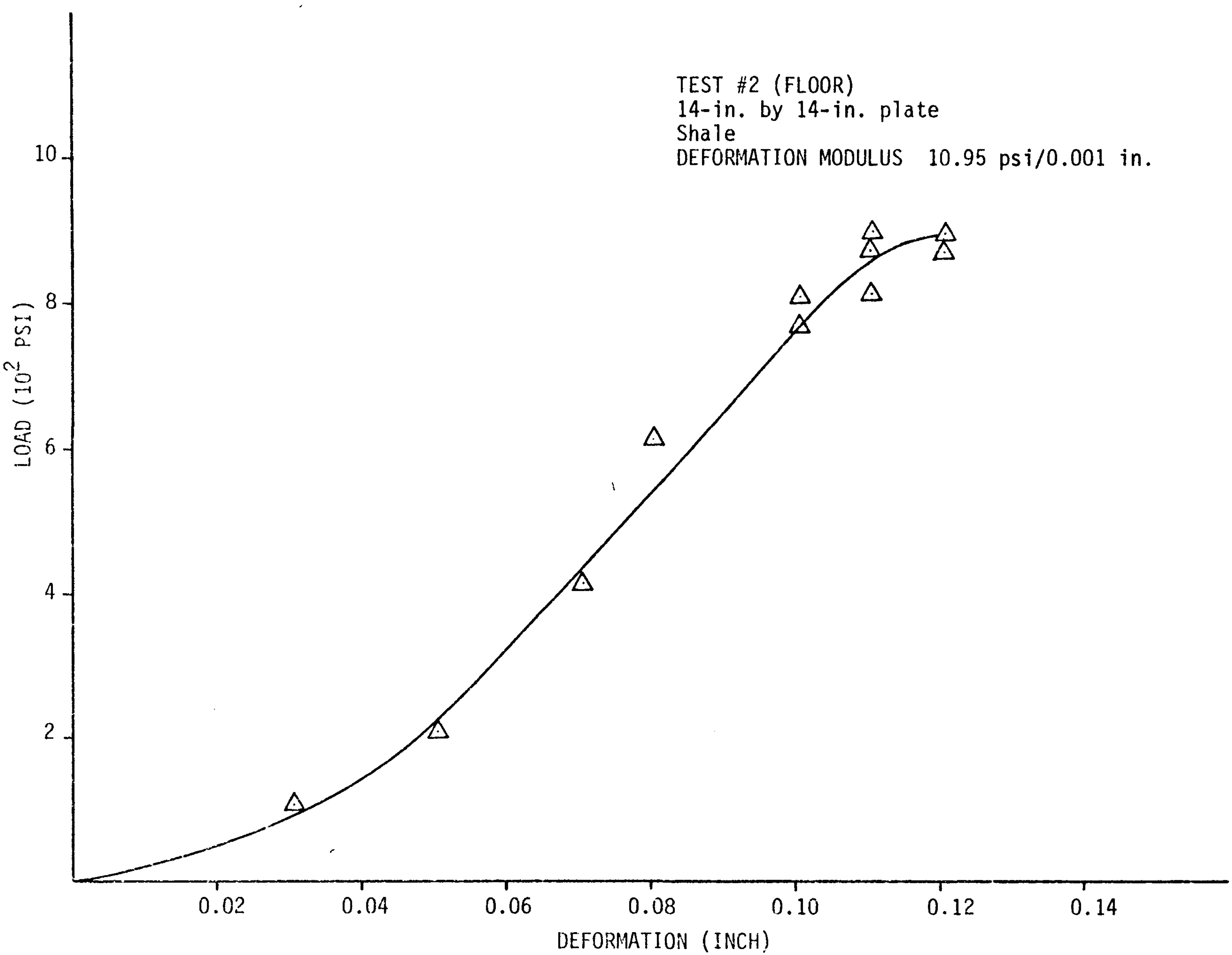


FIG 66 DEFORMATION VS. LOAD, PLATE BEARING TEST 2

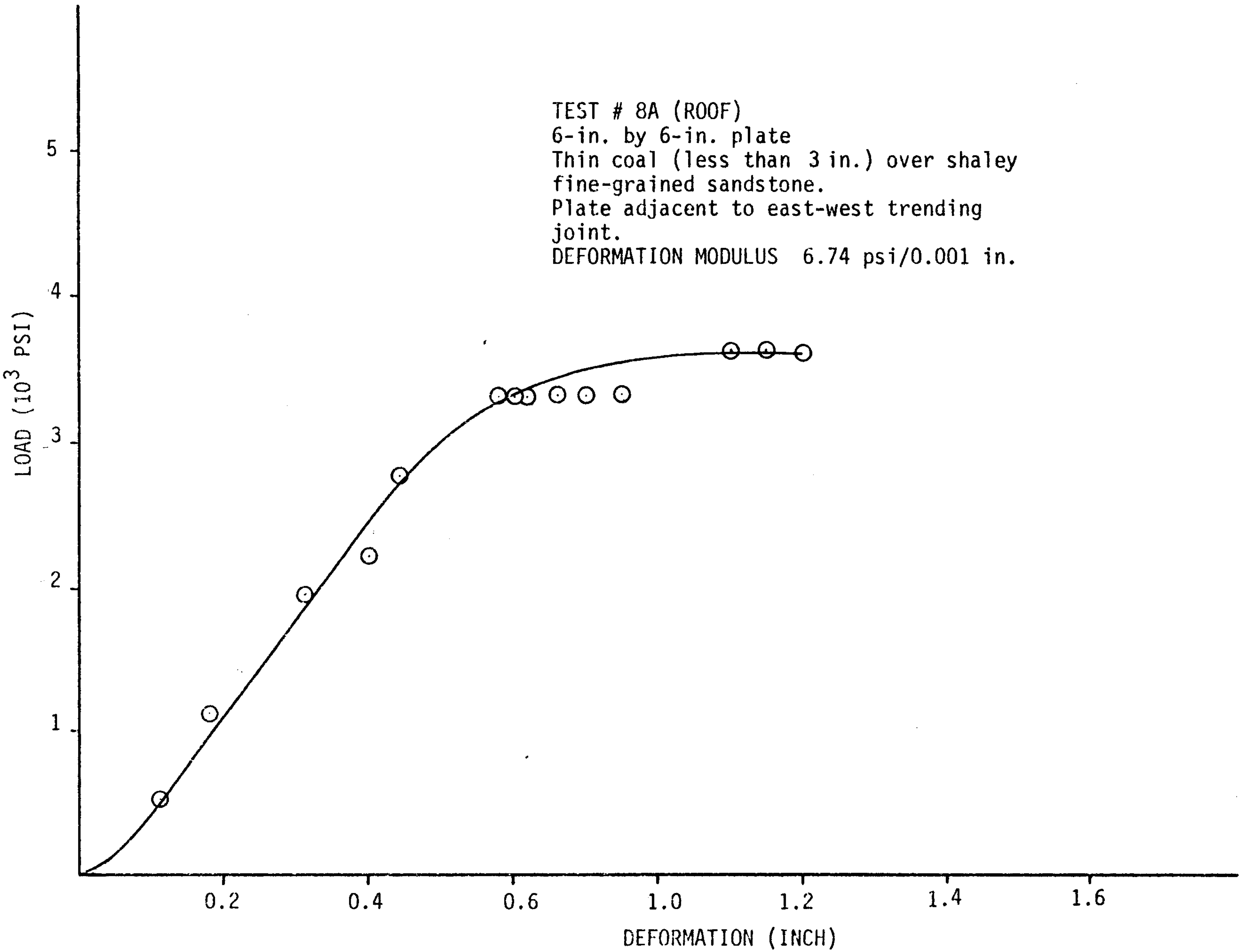


FIG 67 DEFORMATION VS. LOAD, PLATE BEARING TEST 8A

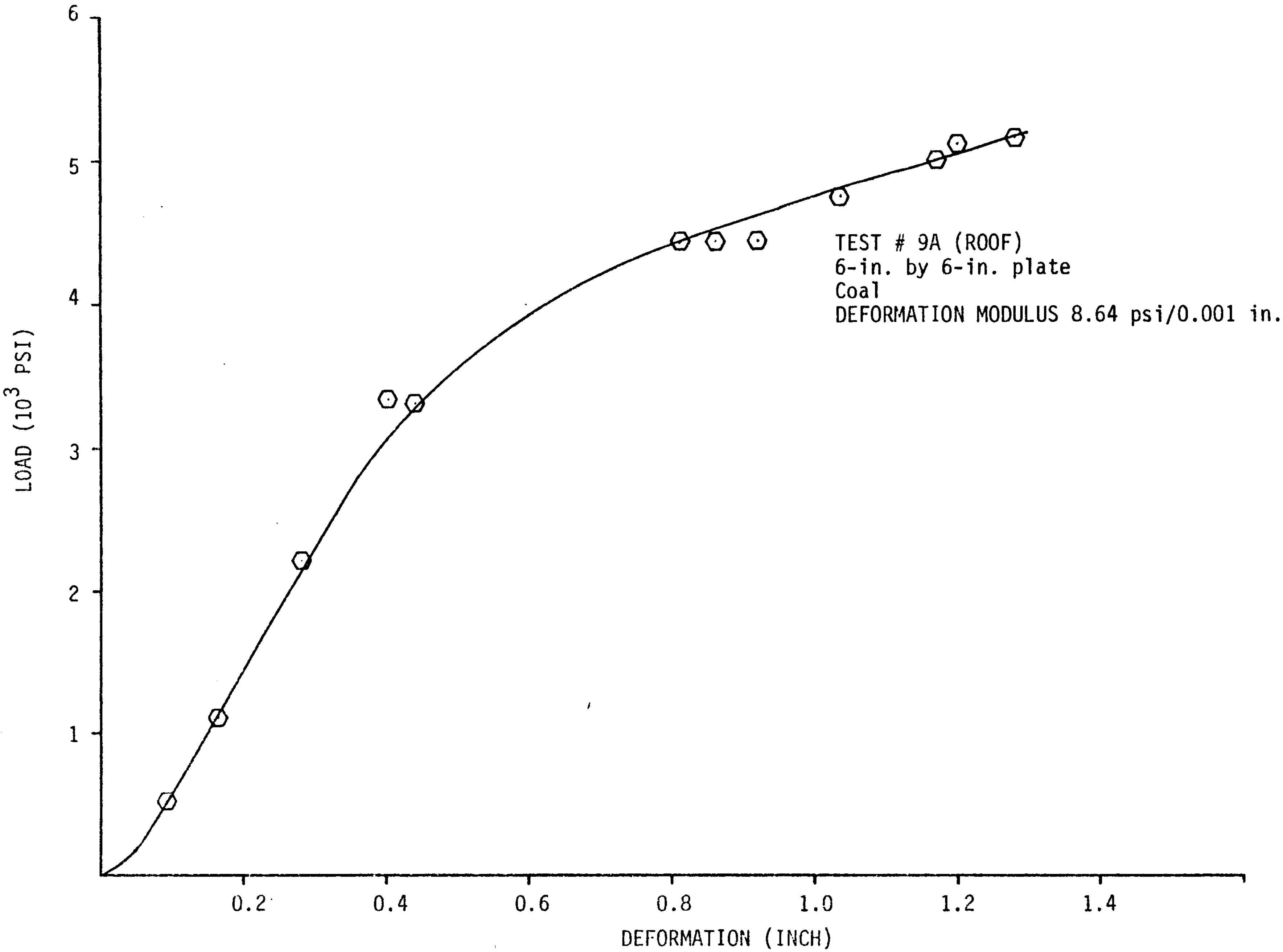


FIG 68 DEFORMATION VS. LOAD, PLATE BEARING TEST 9A

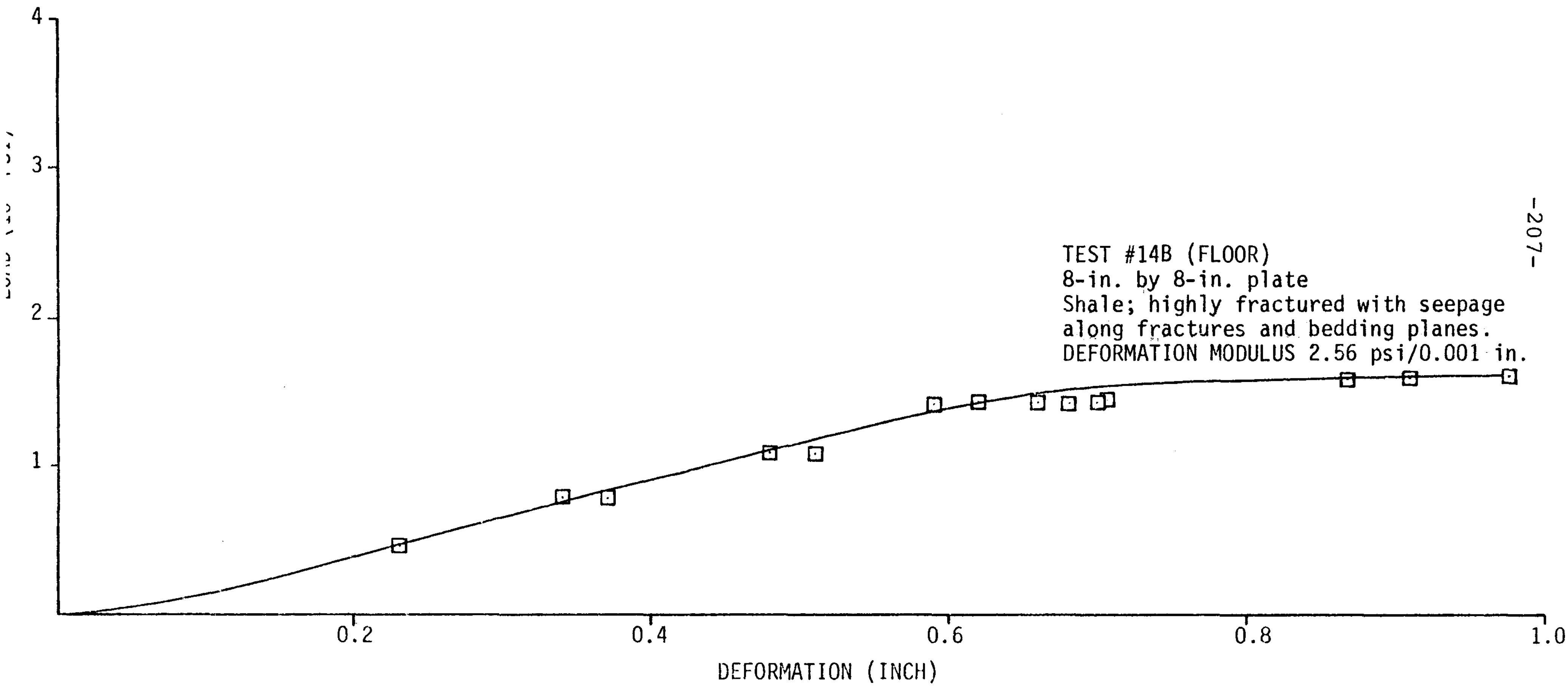


FIG 69 DEFORMATION VS. LOAD, PLATE BEARING TEST 14B

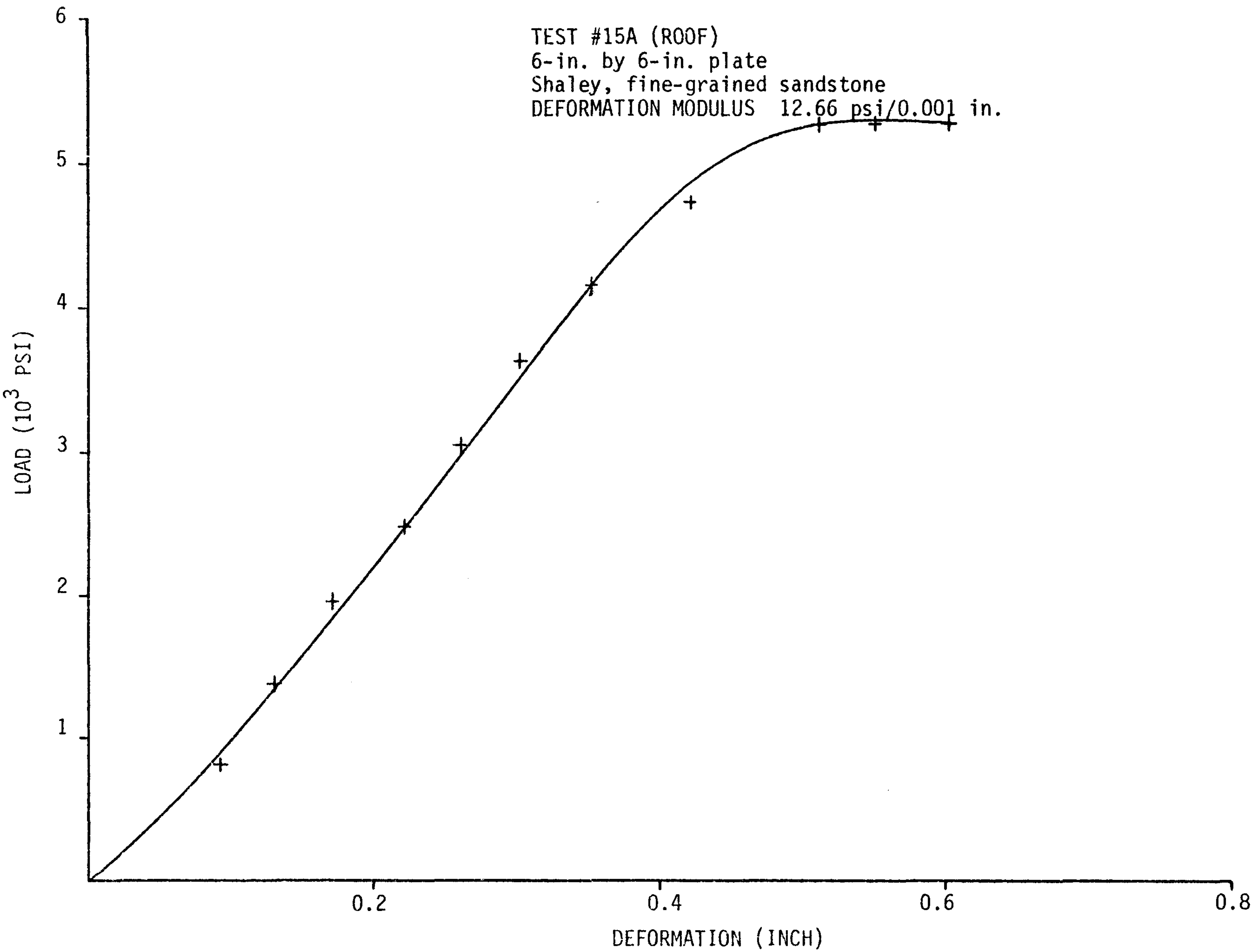
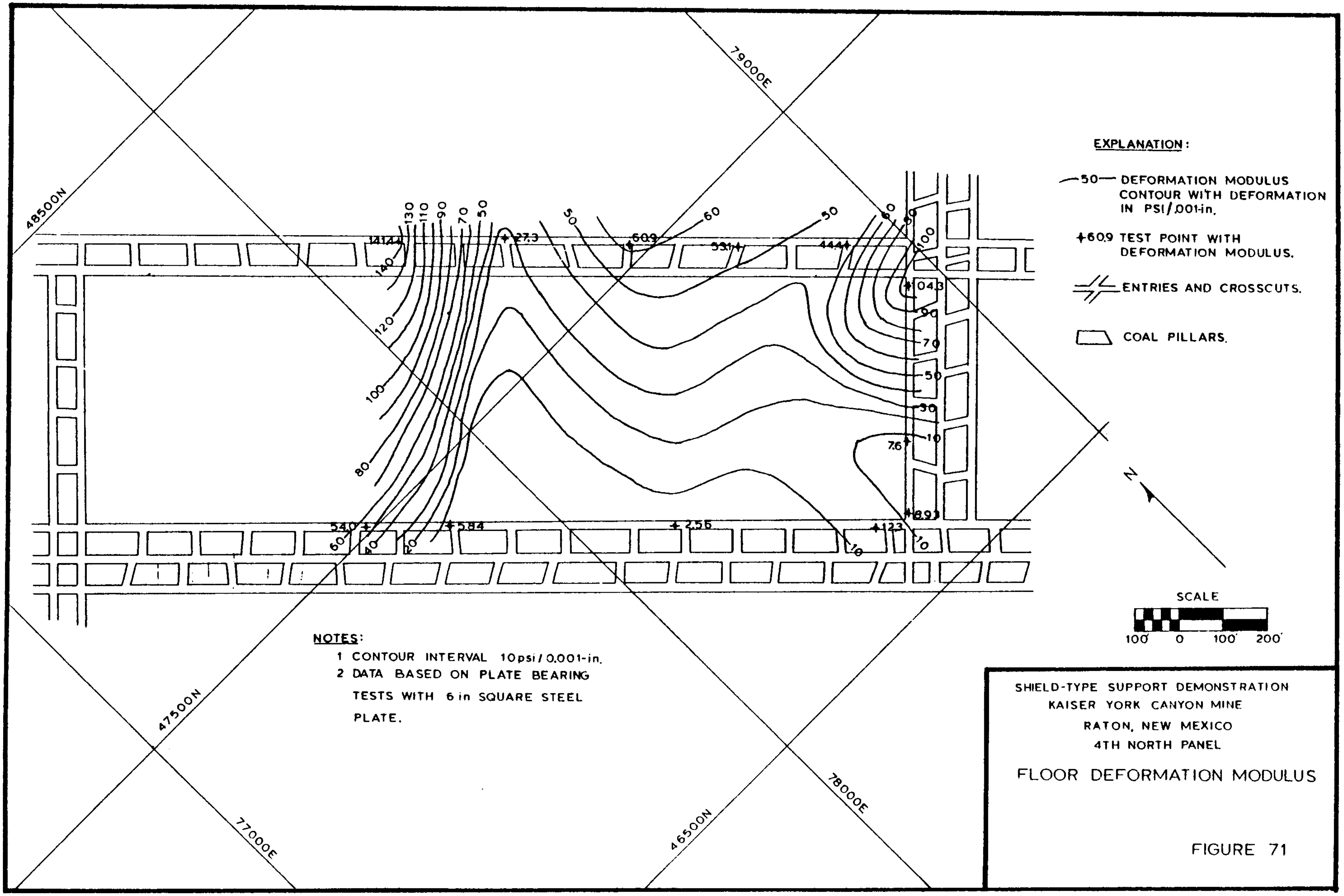


FIG 70 DEFORMATION VS. LOAD, PLATE BEARING TEST 15A



SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

FLOOR DEFORMATION MODULUS

FIGURE 71

interbeds are variable in thickness and lateral extent. As a result, a particular test site may or may not have a significant number of these weaker layers present. Where the rock has 20 per cent or more of these interbeds, the test results tend to show lower deformation moduli.

The roof rock tested consisted of three rock types: a shaley fine-grained sandstone, coal, or a thin coal layer (less than 3-inches) over the sandstone. Moduli determinations for the sandstone and coal were most consistent with standard deviation values of 4.34 and 0.77 respectively. Results from the thin coal over sandstone were extremely variable. In some cases the coal absorbed the total deformation while in other cases the coal crushed out and the sandstone began to pick up some of the load.

The data indicate that the smaller the plate size, the higher the resultant modulus value. Conversely, as plate size increased, a larger number of rock anisotropies were included in the test's sphere of influence, and rock moduli values decreased in magnitude. One advantage to the larger plate size is that it produced more consistant data.

Schmidt Hammer Tests

Rock hardness determinations were performed at selected locations along panel 4N and in entries adjacent to the panel. A summary of the hardness data is presented in Table 17. The data indicate that coal hardness is extremely variable. Within the accuracy of the Schmidt hardness hammer, no discernible trends were noted.

TABLE 17

SUMMARY OF SCHMIDT HAMMER HARDNESS DATA FOR YORK CANYON COAL SEAM, PANEL 4N, YORK CANYON, NEW MEXICO

Test Location (1)	Average Hardness	Tangent Modulus of Deformation (2) (10^6 psi)
E0+60	13.8	
E1+60	13.3	
E2+60	26.7	2.63
E3+60	15.0	
E4+60	21.3	1.23
E5+60	22.8	1.62
E6+60	16.8	0.06
E7+60	25.3	2.26
E8+60	12.3	
E9+60	25.3	2.26
E10+60	27.0	2.70
E11+60	31.0	3.74
E12+60	22.0	1.41
E13+60	28.0	2.96
E14+60	29.3	3.30
E15+60	19.8	0.84
E16+60	31.2	3.80
E17+60	12.5	
E18+50	15.0	
W0+00	25.7	2.37
W1+20	30.3	3.56
W2+40	14.2	
W3+50	28.5	3.09
W4+70	26.7	2.63
W5+90	22.7	1.59
W7+00	23.7	1.85
W8+25	14.0	
W9+50	15.5	
W10+70	10.0	
W12+10	24.3	2.00

TABLE 17 (continued)

Test Location (1)	Average Hardness	Tangent Modulus of Deformation(2) (10^6 psi)
W13+35	22.8	1.62
W14+55	25.5	2.31
W15+80	25.7	2.37
W17+00	16.5	
W18+10	28.0	2.96
W18+50	31.7	3.92

NOTES:

1. Stationing refers to distance from the starting point of the longwall panel. E represents headgate entry and W represents tailgate entry.

2. Calculated as $Et = (.259R-4.29) \times 10^6$
   R=Schmidt Hammer Hardness

ANALYSIS OF SUBSURFACE INSTRUMENT DATA

The subsurface instrumentation program was designed to permit determinations of the loads imposed by longwall mining activity upon the shield type supports, upon the coal seam and adjacent rock strata, and to determine the variations in these applied loads with mining advance. Instrumentation was installed adjacent to panel 4N at three Station Areas (Figure 61). Initially the mining plan included a mined-out panel of over 2000 ft. However, difficulties associated with mining through the face faulting zones resulted in a final mined-out panel length of only 1600 ft. As a result most instrumentation in Station Areas 2 and 3 were never significantly affected by mining operations. The data utilized for analysis in this section is principally from instruments located in Station Area 1. Station Areas 2 and 3 will provide subsequent information when room and pillar mining is conducted in this area.

For the purpose of this discussion, the instrumentation is subdivided into three categories: support load instrumentation, face instrumentation and entry instrumentation. A description of the instruments, installation, and monitoring procedures for the subsurface instrumentation is presented in Appendix A.

Support Load Instrumentation

Selected shield-type roof supports were equipped with hydraulic pressure recorders in an attempt to determine the correlations between mining activity, support load (pressure) history and geologic conditions. A description of the equipment is presented in Appendix A along with a summary of the installation and monitoring procedures utilized during the project. A dual recording system was adopted to determine if the shields were being subjected to differential loading. The recorders were mounted in pairs on each shield to monitor ram pressure on each shield leg because the shield acts as a three point system when loaded with each leg free to act independently. It was felt that roof over-ride related to the higher topography along the headgate (eastern) side of the panel could possibly impose differential loading on the shields.

The pressure recorders were attached to shields number 2, 15, 29, 43, 57, 85, 99 and 115. The numbering system was established such that shield number one was the first shield on the headgate side of the longwall panel, and shield number 116 was the last shield on the tailgate side of the longwall panel. The spacing of every fourteenth shield was adopted to allow the available pressure recorders to be positioned evenly along the face. This spacing was adequate for determining the roof loading pattern along the central portion of the panel.

The data obtained from the shield recorders during the mining of panel 4N are tabulated in Appendix K and summarized in Tables 18 through 22. Table 18 summarizes the mean values of the setting load, the final load and the loading rate for each instrumented shield leg. Figure 72 presents the setting and the final load values graphically. Table 19 summarizes the mean value, standard deviation and standard error of the setting load for each shield leg. Table 20 presents a similar summary for shield leg final loads. Table 21 and 22 indicate the average time required for the leg loads to stablize during two periods of mining inactivity.

These tables and figures are derived from approximately eighty readings selected from over forty weekly charts for each recorder. A weekly chart from each recorder was selected from a period around the first and fifteenth of each month. For each day represented on the charts, the setting pressure for the last set up and the subsequent final pressure were determined and recorded, along with the total time elapsed. Hydraulic pressure readings were converted to applied load values by multiplying the recorded pressure by the cross-sectional area of the piston (58.6 sq in.).

The loading rate was determined by dividing the differential between the setting and final loads by the total time elapsed. By tabulating selected weekly charts, representations of both overnight loading and the longer weekend loading cycles were obtained.

A correction for the inclination of the ram was not applied.

TABLE 18

AVERAGE SETTING LOADS, FINAL LOADS
AND LOADING RATES FOR SHIELDS

Shield Number And Leg (1)	Set Load (Tons)	Final Load (Tons)	Loading Rate (Tons/Hr)
2E	92.0	104.4	0.79
2W	88.2	100.8	0.79
15E	90.5	117.6	2.4
15W	84.4	113.0	2.5
29E	96.1	134.0	4.8
29W	90.0	129.5	4.9
43E	87.9 (2)	119.0 (2)	3.4 (2)
43W	87.8	135.1	8.2
57E	93.9	135.5	7.0
57W	86.4	130.8	9.4
71E	82.3	129.8	12.1
71W	74.1	124.2	6.7
85E	80.3	123.6	5.0
85W	67.4	110.9	4.5
99E	80.1 (2)	87.3 (2)	1.5 (2)
99W	70.8	108.1	4.5
115E	81.2	59.2	-4.9 (3)
115W	81.3	75.3	-1.0 (3)

Notes:

1. E represents headgate ram, and W represents tailgate ram.
2. Recorder malfunction during part of project.
3. Negative number denotes pressure drop.

TABLE 19

SHIELD SETTING LOADS

Shield Number And Leg (1)	n (2)	Mean Value (tons)	Standard Deviation (tons)	Standard Error (tons)
2E	83	92.0	22.3	2.4
2W	83	88.2	22.5	2.5
15E	83	90.5	18.2	2.0
15W	86	84.4	22.7	2.5
29E	86	96.1	19.9	2.1
29W	86	90.0	22.2	2.4
43E	41 (3)	87.9 (3)	25.8 (3)	4.0 (3)
43W	95	87.8	23.4	2.4
57E	85	93.9	18.6	2.0
57W	85	86.4	16.6	1.8
71E	75	82.3	17.8	2.0
71W	83	74.1	19.8	2.2
85E	84	80.3	21.0	2.3
85W	83	67.4	28.9	3.2
99E	66 (3)	80.1 (3)	17.2 (3)	2.1 (3)
99W	72	70.8	19.8	2.3
115E	84	81.2	24.4	2.7
115W	83	81.3	26.4	2.9

Notes:

1. E represents headgate ram, and W represents tailgate ram.
2. Number of data points.
3. Recorder malfunction during part of project.

TABLE 20

SHIELD FINAL LOADS

Shield Number And Leg (1)	n (2)	Mean Value (tons)	Standard Deviation (tons)	Standard Error (tons)
2E	82	104.4	26.1	2.6
2W	82	100.8	24.7	2.7
15E	83	117.6	25.8	2.8
15W	85	113.0	31.4	3.4
29E	85	134.0	30.8	3.3
29W	85	129.5	29.4	3.2
43E	41 (3)	119.0 (3)	30.2 (3)	4.7 (3)
43W	95	135.1	32.4	3.3
57E	84	135.5	21.9	2.4
57W	84	130.8	27.6	3.0
71E	73	129.8	29.9	3.5
71W	81	124.2	31.8	3.5
85E	83	123.6	30.7	3.4
85W	82	110.9	40.4	4.4
99E	23 (3)	87.3 (3)	32.6 (3)	6.8 (3)
99W	71	108.1	37.4	4.4
115E	83	59.2	29.5	3.2
115W	82	75.3	26.8	3.0

Notes:

1. E represents headgate ram, and W represents tailgate ram.
2. Number of data points.
3. Recorder malfunction during part of project.

TABLE 21
TIME FOR SHIELDS TO ASSUME ROOF LOADS,
PANEL 4N, YORK CANYON MINE, NEW MEXICO
CHRISTMAS HOLIDAY 23 DEC - 5 JAN 76

Shield Ram Number	Setting Pressure (psi)	Maximum Pressure Reached (psi)	Time to Reach Maximum Pressure (hrs.) (1)
2E	3400	5300	60.0
2W	3300	5050	134.0
15E	2400	4300	293.0
15W	2500	4200	194.0
29E	3700	5600	3.0
29W	3500	5400	2.0
43E	RECORDER MALFUNCTION		
43W	3200	5200	2.0
57E	3000	5300	2.5
57W	2100	5300	7.5
71E	2900	5100	2.0
71W	2400	5000	3.0
85E	2000	5300	9.5
85W	2300	4300	60.0
99E	RECORDER MALFUNCTION		
99W	2300	5000	31.0
115E	2300	2500	93.0
115W	2500	2300	18.0

NOTES:

1. Time elapsed, set pressure to onset of final (maximum) pressure.

TABLE 22
TIME FOR SHIELDS TO ASSUME ROOF LOADS,
PANEL 4N, YORK CANYON MINE, NEW MEXICO
MINE LAYOFF 1 MAR 76 THROUGH 8 MAR 76

Shield & Ram Number	Setting Pressure (psi)	Maximum Pressure Reached (psi)	Time to Reach Maximum Pressure (hrs) (1)
2E	3800	4500	160.0
2W	3600	4200	160.0
15E	900	3450	157.0
15W	700	2800	157.0
29E	4000	5400	33.0
29W	4000	5150	20.5
43E	RECORDER OFF FOR REPAIRS		
43W	3150	5150	66.5
57E	3500	5100	21.0
57W	3200	5200	24.0
71E	3600	4800	21.0
71W	3700	4900	15.0
85E	2000	5100	66.0
85W	2000	5000	33.0
99E	RECORDER OFF FOR REPAIRS		
99W	2800	5100	9.0
115E	3200	1200	39.0
115W	2400	2100	161.0

NOTES:

1. Time elapsed, set pressure to onset of final (maximum) pressure.

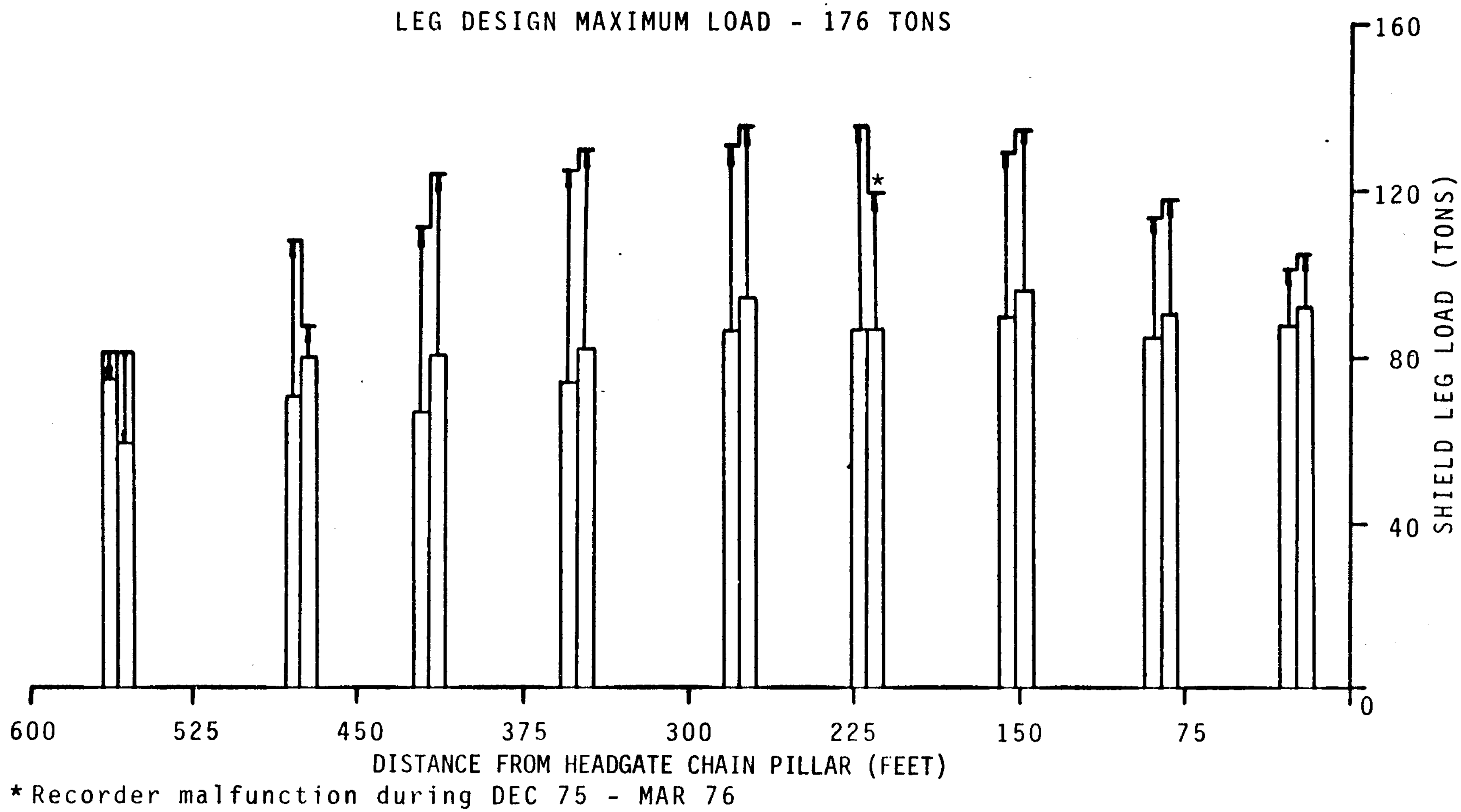


FIG. 72 SHIELD LEG LOADS - SETTING AND FINAL LOADS

At the 10.3 ft extraction height, the ram inclination was approximately 6 degrees. The error that resulted from assuming that total shield load was vertical shield load was less than 1 percent.

In analyzing shield loading data, several factors should be included: amount of roof supported by the shield, shield contact area; and the load at which the shield's hydraulic system is designed to begin yielding.

The amount of roof supported by a single shield is at best an approximation. Geologic structures in the roof and floor, localized zones of weakness and variations in lithology can all alter the load imposed upon a particular shield.

At York Canyon, each shield supported an average face length of 5.1 ft. The roof tended to cave up tightly behind the shields along the face. As a result, the shields were responsible for supporting the roof 10 to 15 ft back from the face. The only exception was at the tailgate where spans of 45 to 55 ft tended to open up, both out from the face and along the face.

The shield contact area was difficult to determine exactly because extendable canopies were in use. The contact area varied from 38 sq ft with the canopy retracted, to 45 sq ft with the canopy extended. The maximum roof support density varied from 8.5 T/ft^2 with the canopy retracted, to 7.2 T/ft^2 with the canopy extended. The relationship between canopy extension and the mining cycle is illustrated on Figure 73.

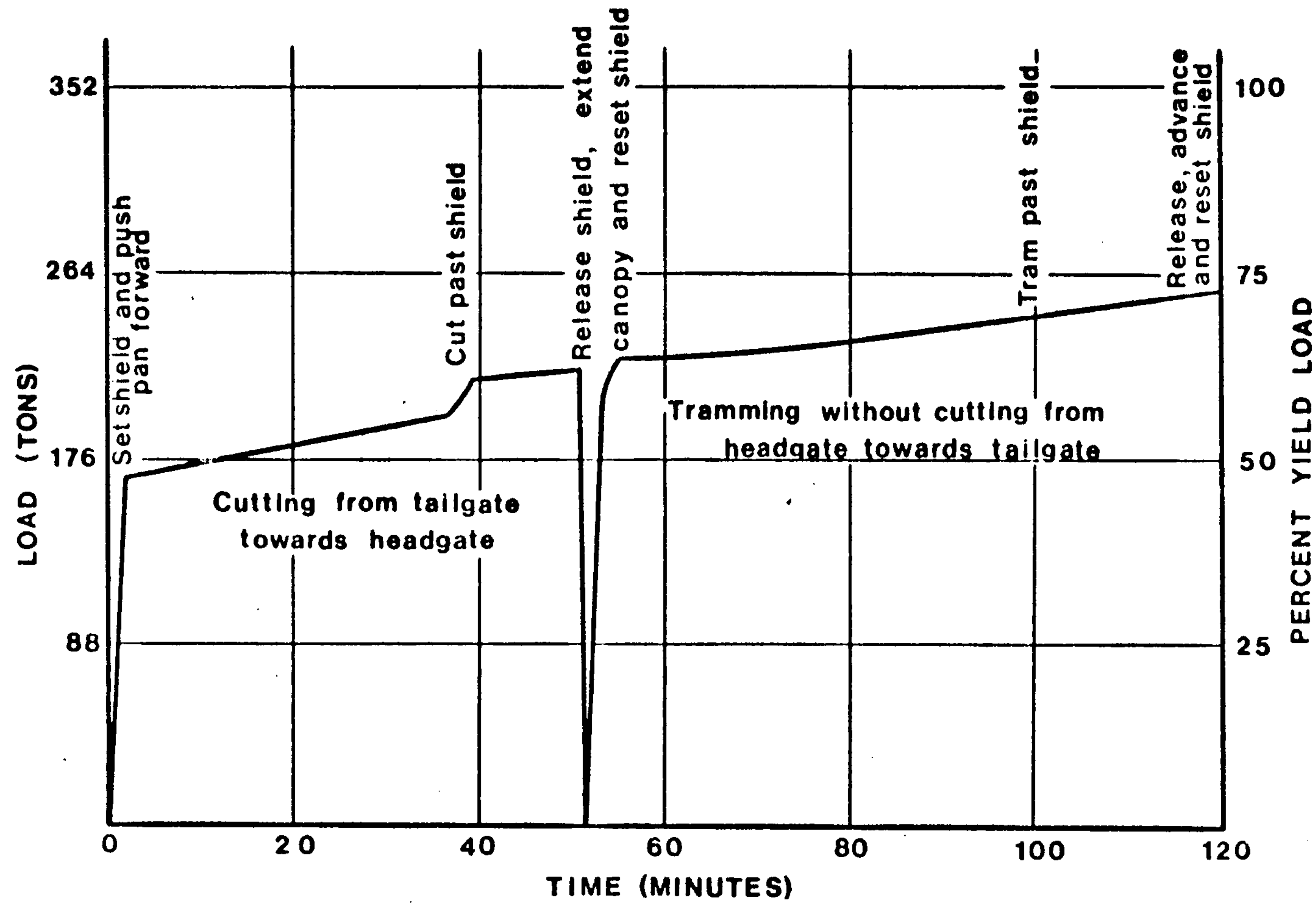


FIG. 73 HYPOTHETICAL SHIELD LOAD CURVE - SINGLE MINING CYCLE

The yield load was controlled by check valves in the hydraulic system for each ram. The shields have a design yield load of 176 tons per leg. However, at York Canyon, the original check valves allowed the shields to yield when the load reached 161 tons per leg. After October 1975, faulty operation of the original spring-operated check valves resulted in their replacement with gas-operated valves designed to yield at about 146 tons per leg.

Figure 73 illustrates the magnitude of the load imposed upon a shield by mining operations during a single cycle of shield advance. It is a hypothetical curve and represents the average behavior observed for the interior shields between supports 29 and 85. Figures 74 through 76 represent typical 24-hour load history curves for three selected shields. Shield 2 (Figure 74) represents loading behavior near the headgate barrier pillar, while shields 57 and 85 (Figures 75 and 76) illustrate loading patterns for the shields in the interior zone where the barrier pillars did not influence shield loads.

The data presented in Tables 18 thru 22 indicate that the shields were subjected to a degree of differential loading. A comparison of shield final pressures (Figure 72 and Tables 18 and 20) shows that the load on the east or headgate, leg was 5.9 tons greater than the load on the tailgate leg. The only exception was shield 115 at the tailgate where the recorders indicated differential loading with the west leg subjected to the higher applied load. Figures 72 and

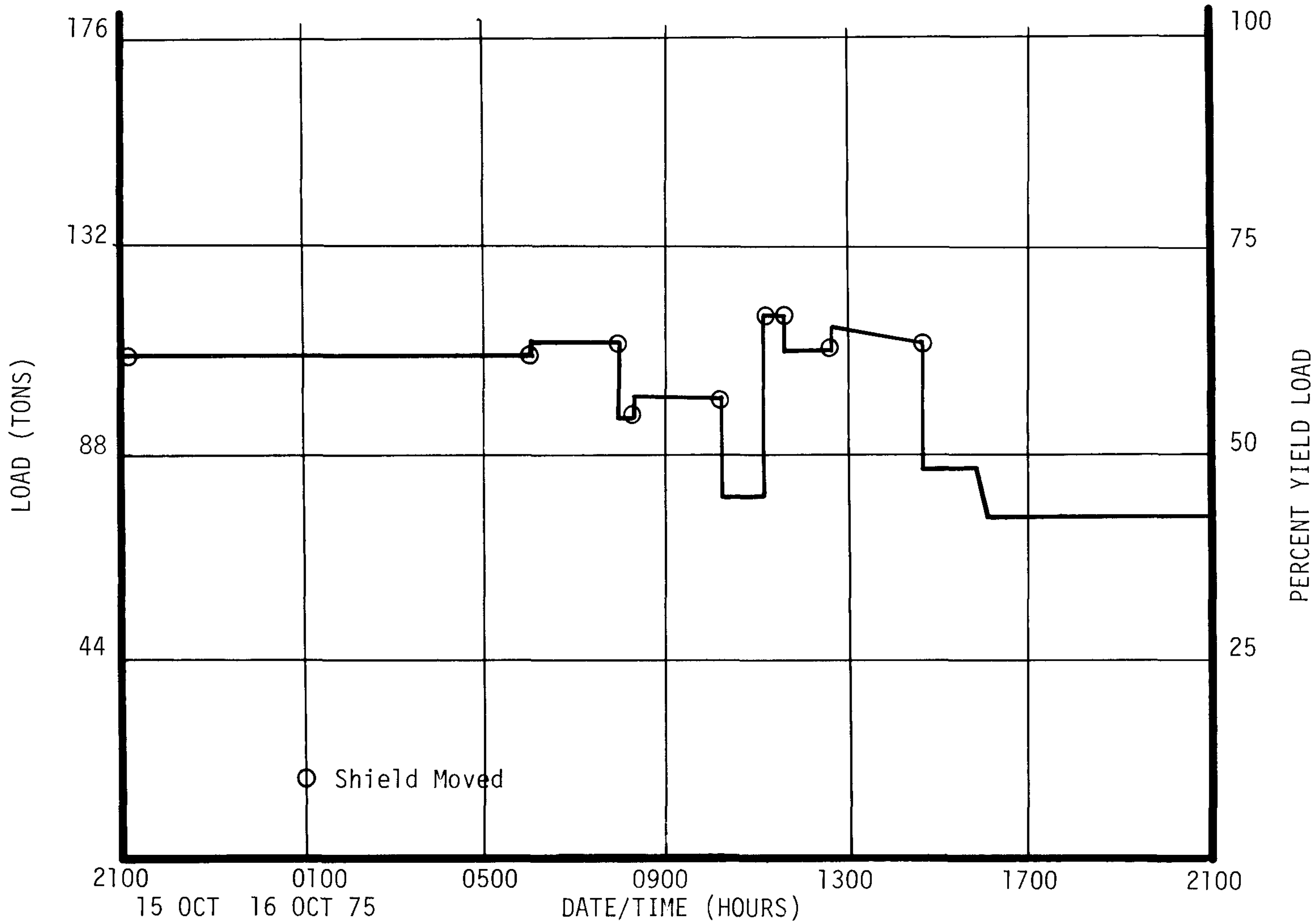


FIGURE 74A EAST LEG LOAD HISTORY, SHIELD 2

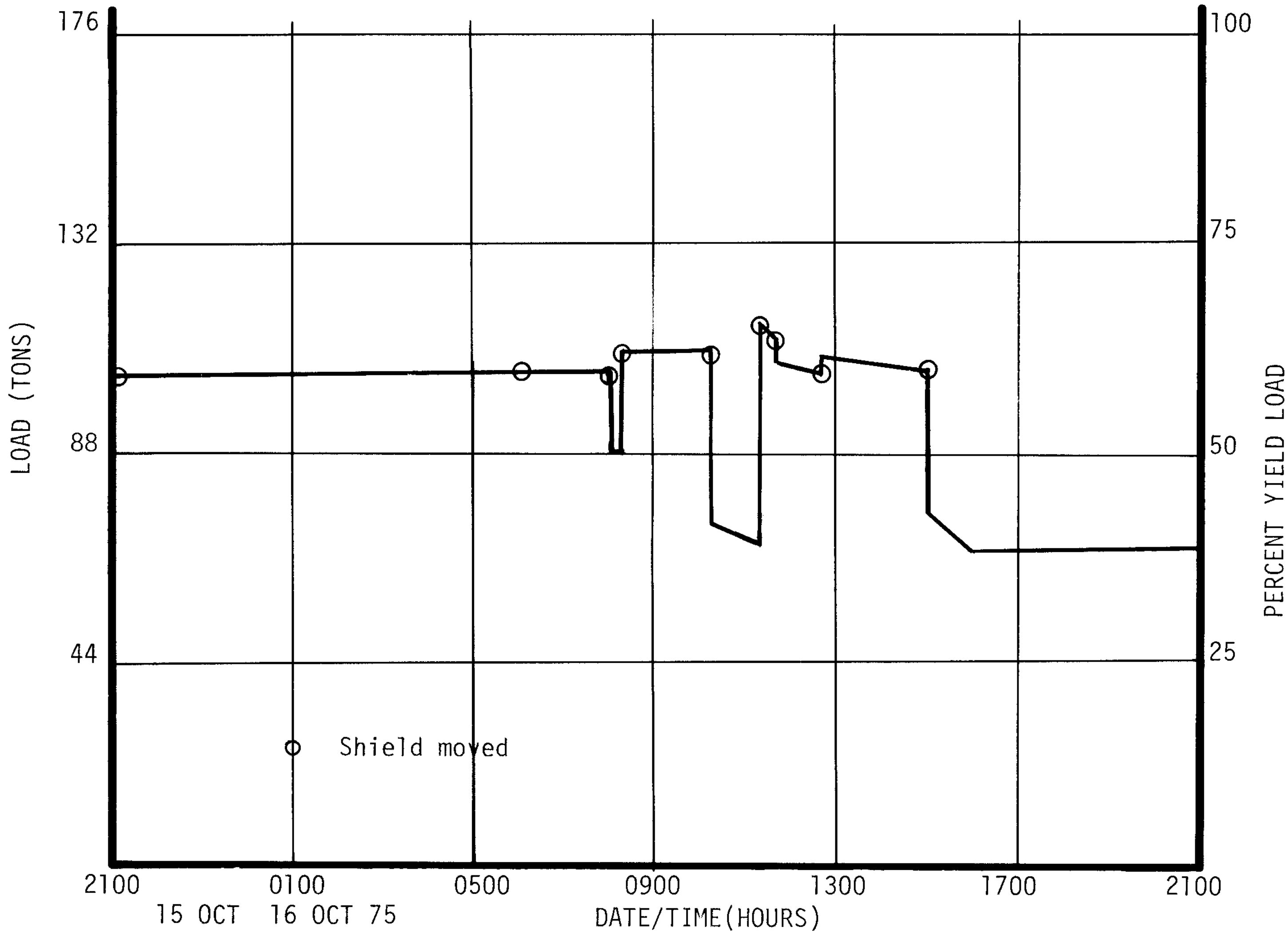


FIGURE 74B WEST LEG LOAD HISTORY, SHIELD 2

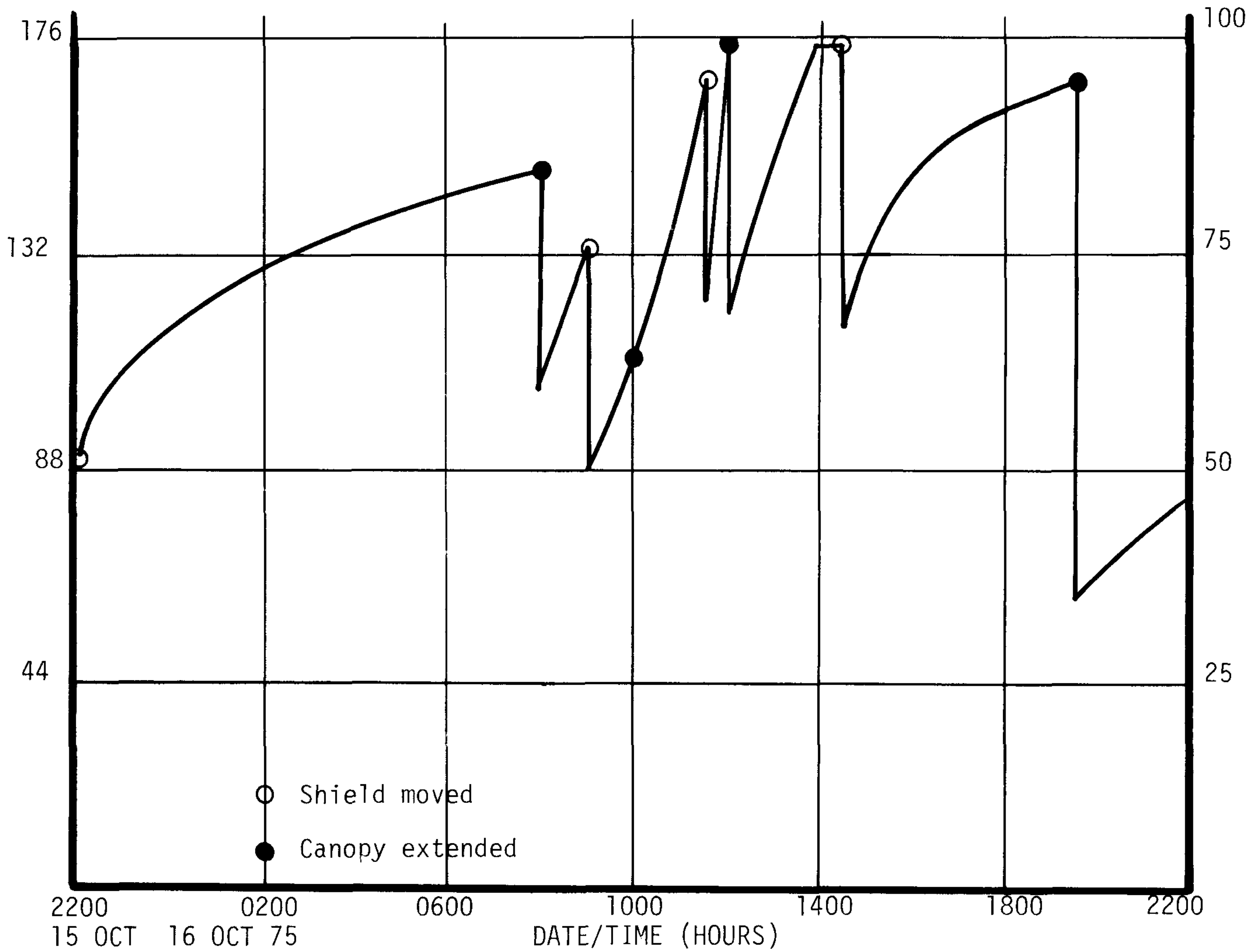


FIGURE 75A EAST LEG LOAD HISTORY, SHIELD 57

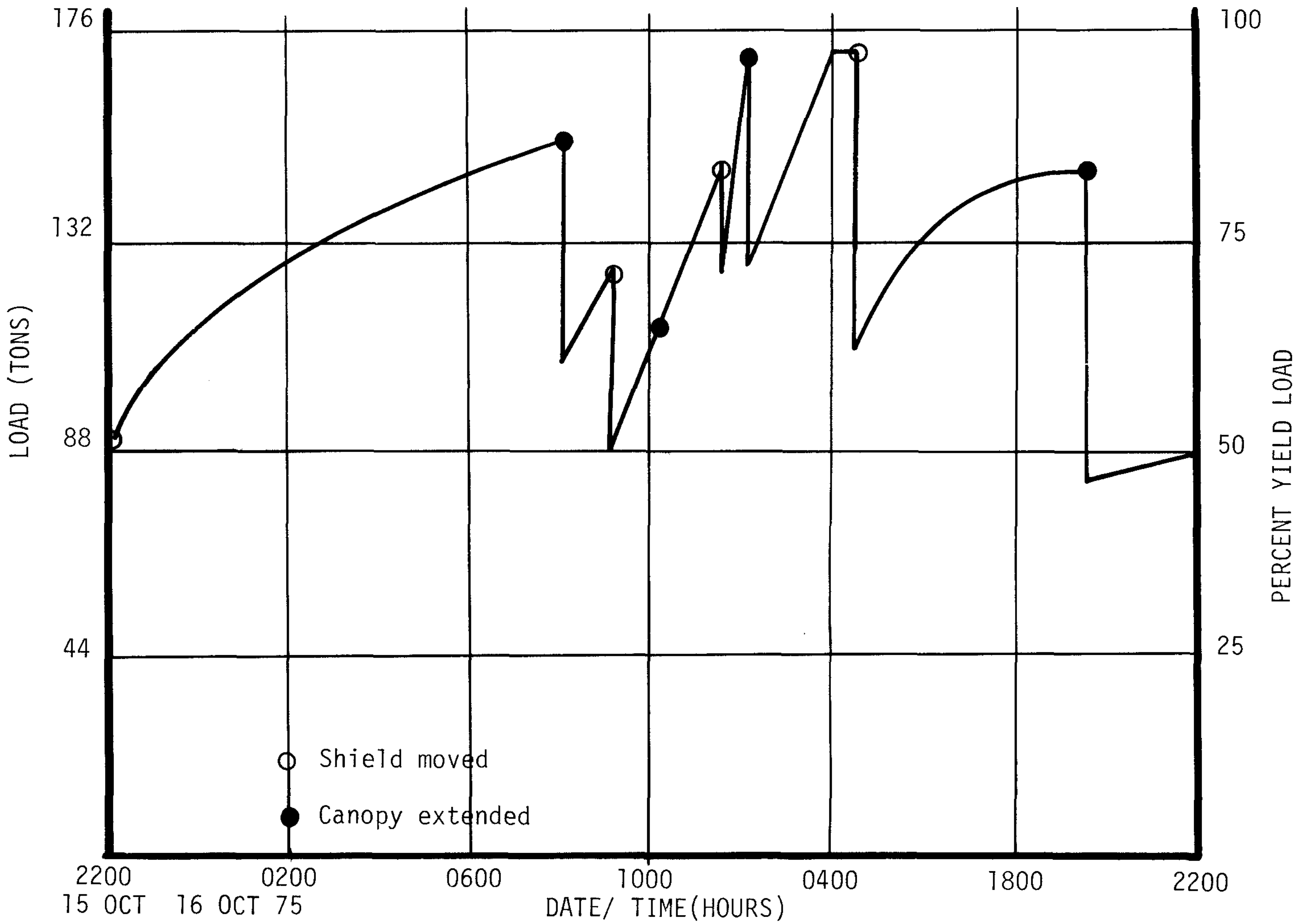


FIGURE 75B WEST LEG LOAD HISTORY, SHIELD 57

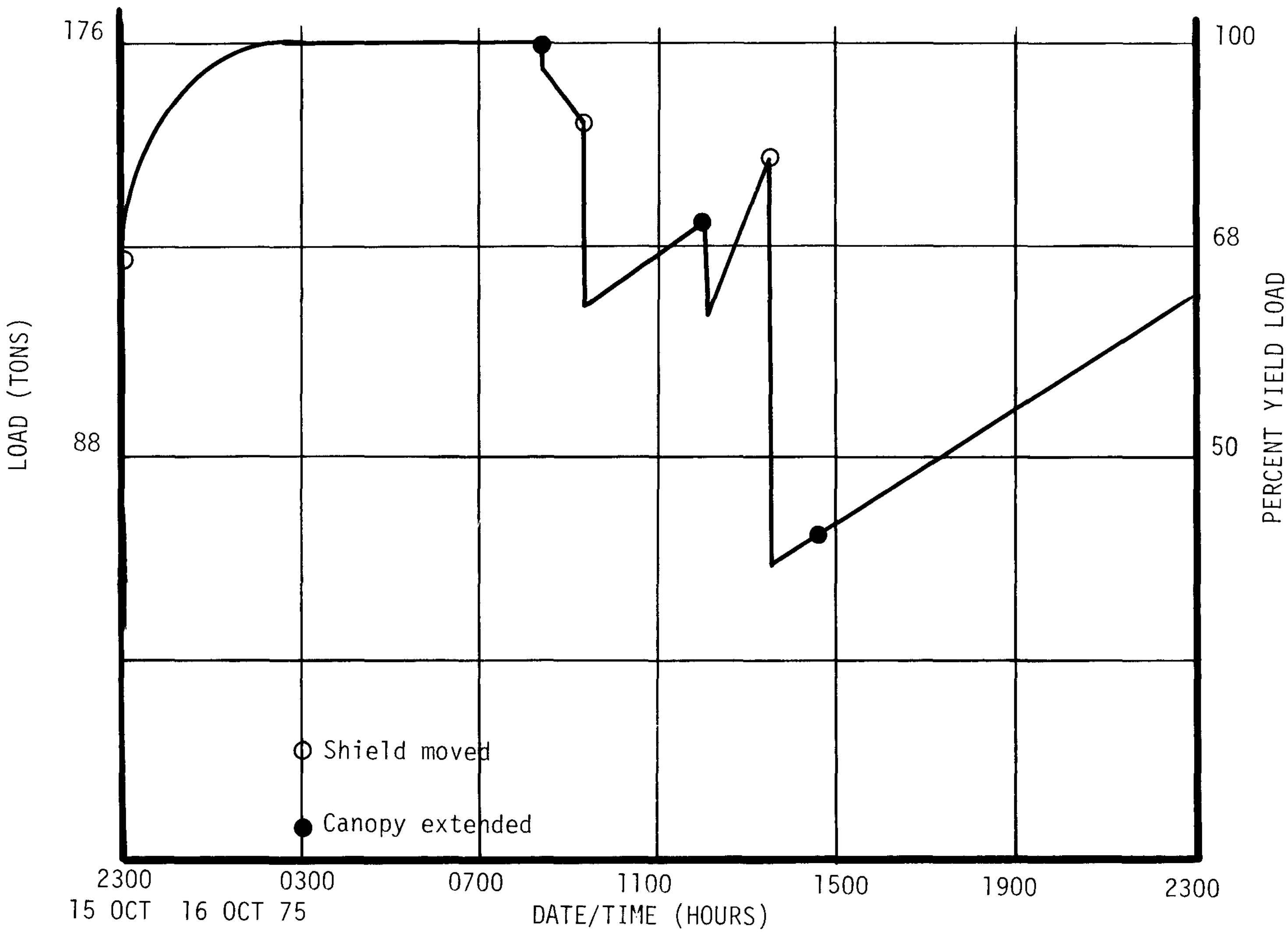


FIGURE 76A EAST LEG LOAD HISTORY, SHIELD 85

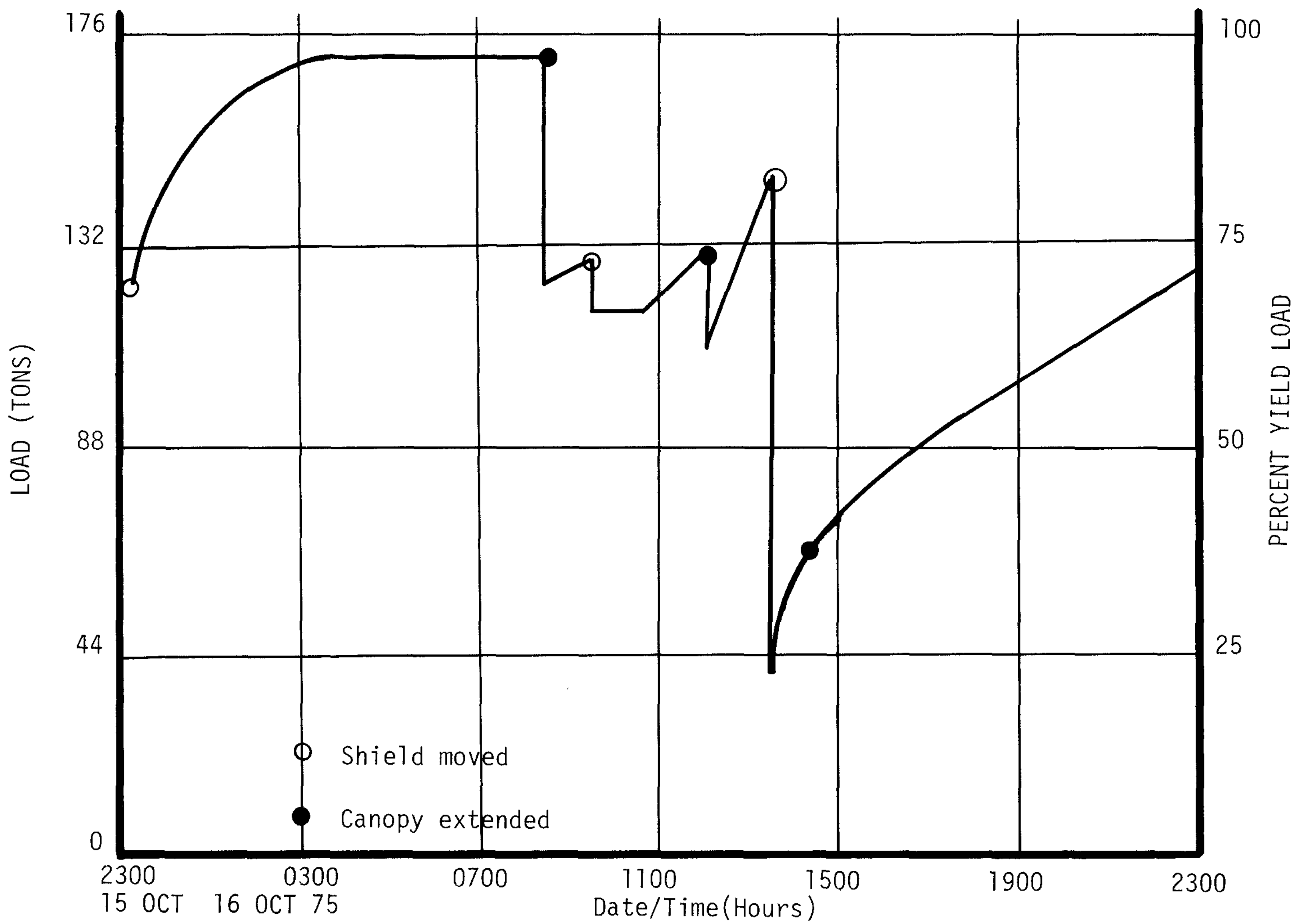


FIGURE 76B WEST LEG LOAD HISTORY, SHIELD 85

Tables 18 and 19 indicate that this load differential was present from the time the shields were initially set. The average setting load on the east leg was generally 7.3 tons greater than the setting load on the west leg.

It is probable that these load differentials were related to the higher topography to the east of the panel area. The shield hydraulic systems were such that the two rams on a shield should have achieved the same setting pressure simultaneously. Variables introduced by operation methods during mining would have yielded scattered data and not the consistent pattern observed. Once a shield was set, no significant differential loads were imposed. Thus the topographically imposed stress field apparently did not vary during periods of mining activity or inactivity.

Tables 21 and 22 indicate the average times elapsed between the setting load and the final stable load for each shield leg during two one-week periods of mining inactivity. The data indicate that the shields in the more heavily loaded center stabilized more rapidly than those shields within the areas influenced by the barrier pillars.

Figure 77 presents a series of shield load contours for panel 4N. The total load (east plus west legs) for each shield was determined for the dates indicated. Records for the one week period, including the indicated date, were reviewed to insure that the data point was not an anomalous value. Points of equal load were connected with load contour lines.

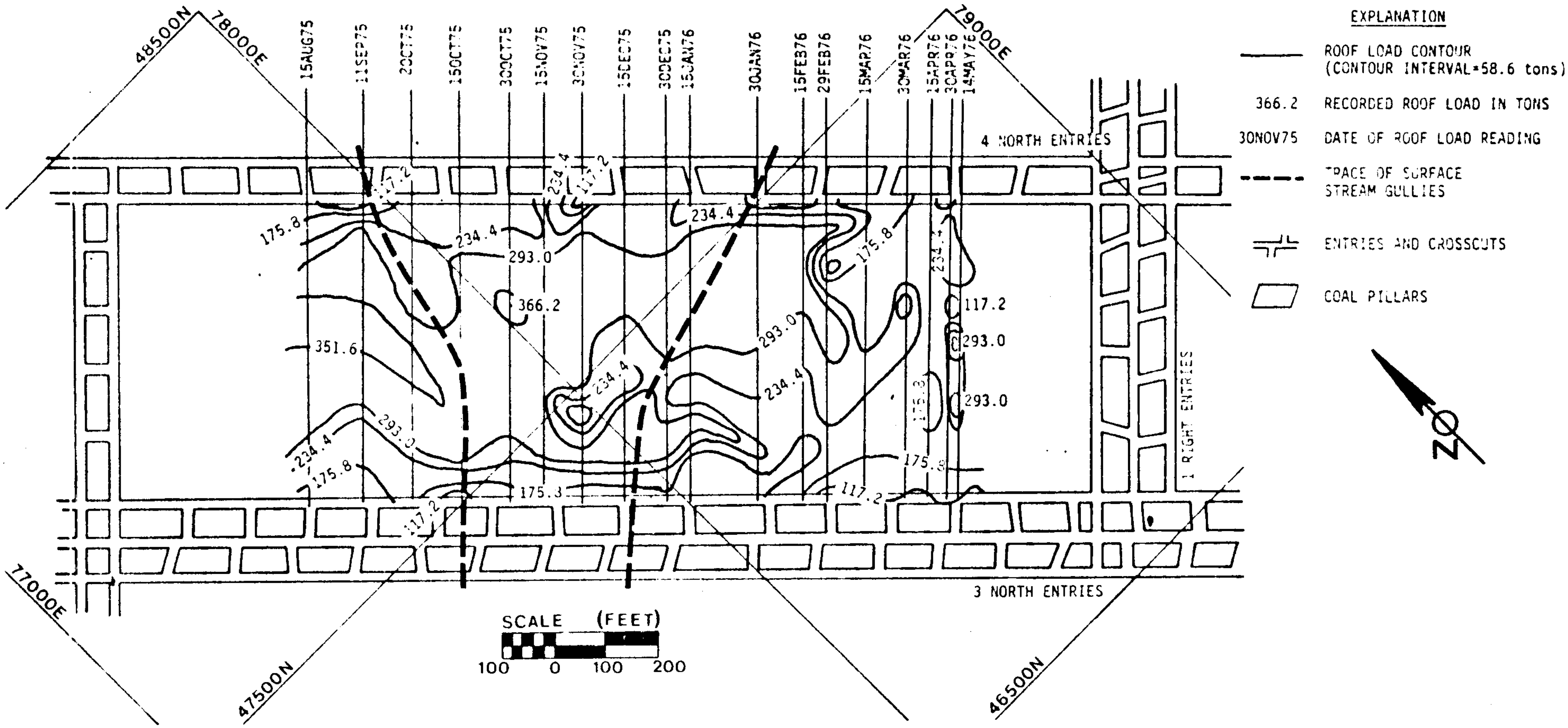


FIG. 77 SHIELD ROOF LOAD HISTORY

Figure 77 illustrates the affects of the barrier pillars on the load distribution. Near the barrier pillars, the shield roof loads were smaller, because the pillars absorbed some of the loads. This zone of pillar influence varied from 75 to 90 ft out from pillar ribside.

The locations of the two surface gullies transecting panel 4N are shown on Figure 77. It appears that these across-panel topographic variations did influence shield loading patterns to some extent. Loads decreased as the panel advanced under the topographic lows. Shield loads tended to be most affected in those areas within the influence zone of the barrier pillars.

The effects of face faulting on roof loading are also illustrated on Figure 77. The face faults were initially encountered during the latter part of March 1976. Prior to that time, roof pressure contour trends tended to parallel the panel centerline. As the face faults were encountered, however, the distributions of roof loads shifted. Roof pressure contours tended to be constructed into zones of high stress separated by fault zones with lower stress values

Face Instrumentation

Instrumentation was installed in an attempt to correlate coal hardness, panel power consumption and support load history during mining operations. Coal hardness was determined with a rock classification hammer that provided Schmidt hardness data. A continuous strip-chart

KVA recorder was installed to provide power consumption data. The hydraulic pressure recorders mounted on selected shields provided support load history records.

An accurate correlation between coal hardness, power consumption and support load histories could not be established. The variations in hardness in the coal seam could not be detected with the sensitivity and accuracy of the KVA recorder. A summary of the coal hardness data is presented in the section on in situ rock property determinations. Descriptions of the equipment and methods utilized to determine coal hardness and panel power consumption are presented in Appendix A.

Entry Instrumentation

Instrumentation was installed in entries adjacent to panel 4N to determine the response of the rock mass to mining advance. Four types of instrumentation were utilized: hydraulic pressure cells, convergence instrumentation, differential roof-floor horizontal movement instrumentation and roof-sag instrumentation. A description of the instrumentation, as well as the installation and monitoring procedures, is presented in Appendix A.

Hydraulic Pressure Cells:

A total of twenty hydraulic pressure cells was installed into the coal seam at various locations within and adjacent to the longwall panel. These pressure cells were patterned after the U. S. Bureau of Mines design developed by Millar and Sporcic (1964). The pressure cells were designed to record changes in the vertical stress component as the mining face advanced. This allowed determinations of the onset of the zone if influenced and, in certain instances, determination of the face abutment pressure peak (Wilson, 1972, p. 410).

Table 10 listed instrument locations. Graphs illustrating typical pressure cell response to longwall mining are presented on Figures 78 through 81. The data from the pressure cells are presented in Appendix L.

Detailed graphs of the last 100 ft of face advance are presented on Figures 82 through 85. These figures indicate the zone of increasing vertical stress related to the onset of the zone of influence or the front abutment of the pressure arch.

The concept of the pressure arch is well developed in the literature, particularly British coal mining literature. Hudspeth, Phillips and Walker (1935, p. 351) indicate that the redistribution of overburden weight above an excavation results in the formation of a pressure arch with a partially destressed central core.

As an opening is excavated, the immediate roof beds deflect slightly, relieving themselves of the overburden load. This overburden load is transferred to the sides of the opening by the pressure arch. As the size of the opening is increased, the width of the pressure arch is also increased, but the pressure abutments still rest on the

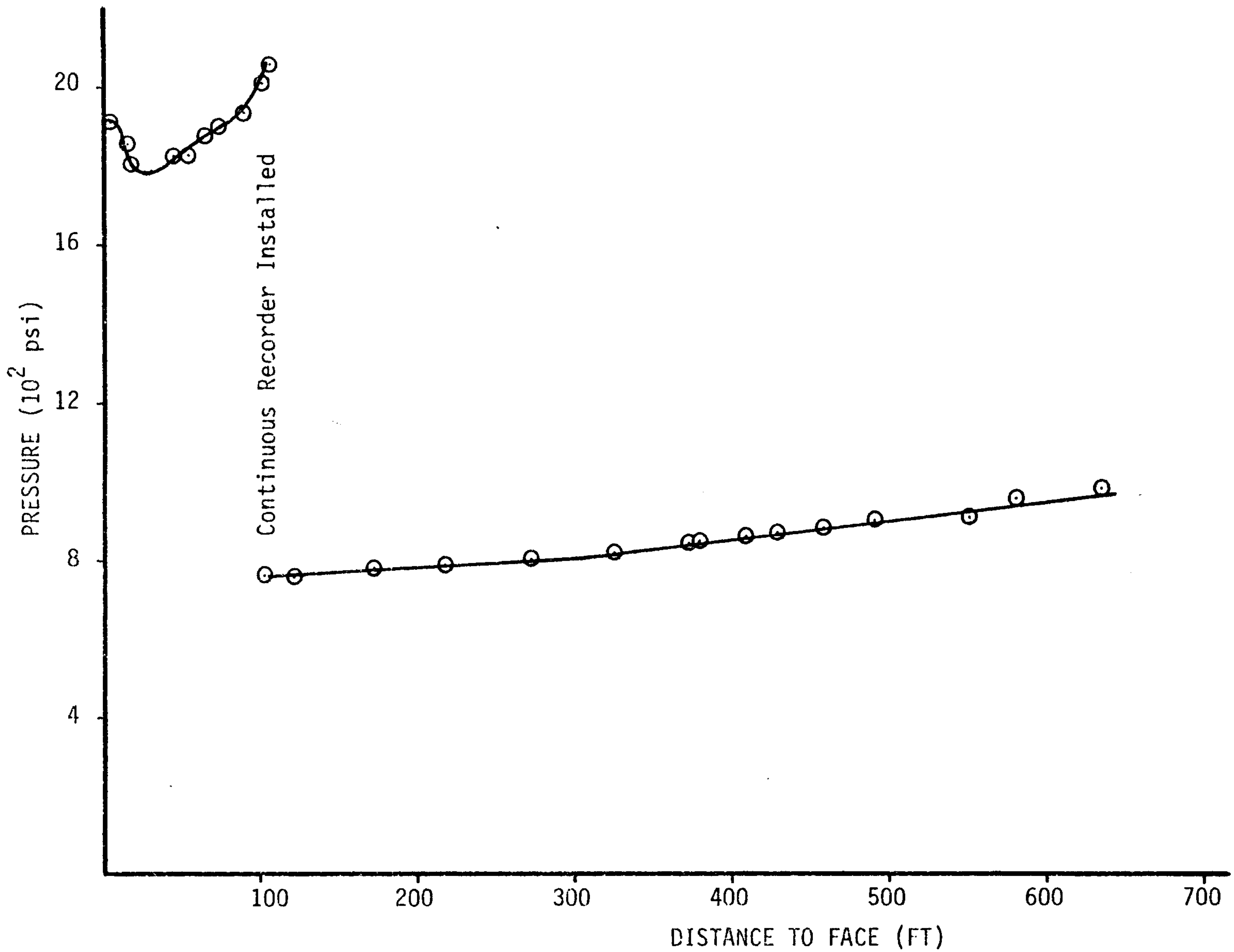


FIG 78 FACE DISTANCE VS. CELL PRESSURE, PANEL CELL P-4

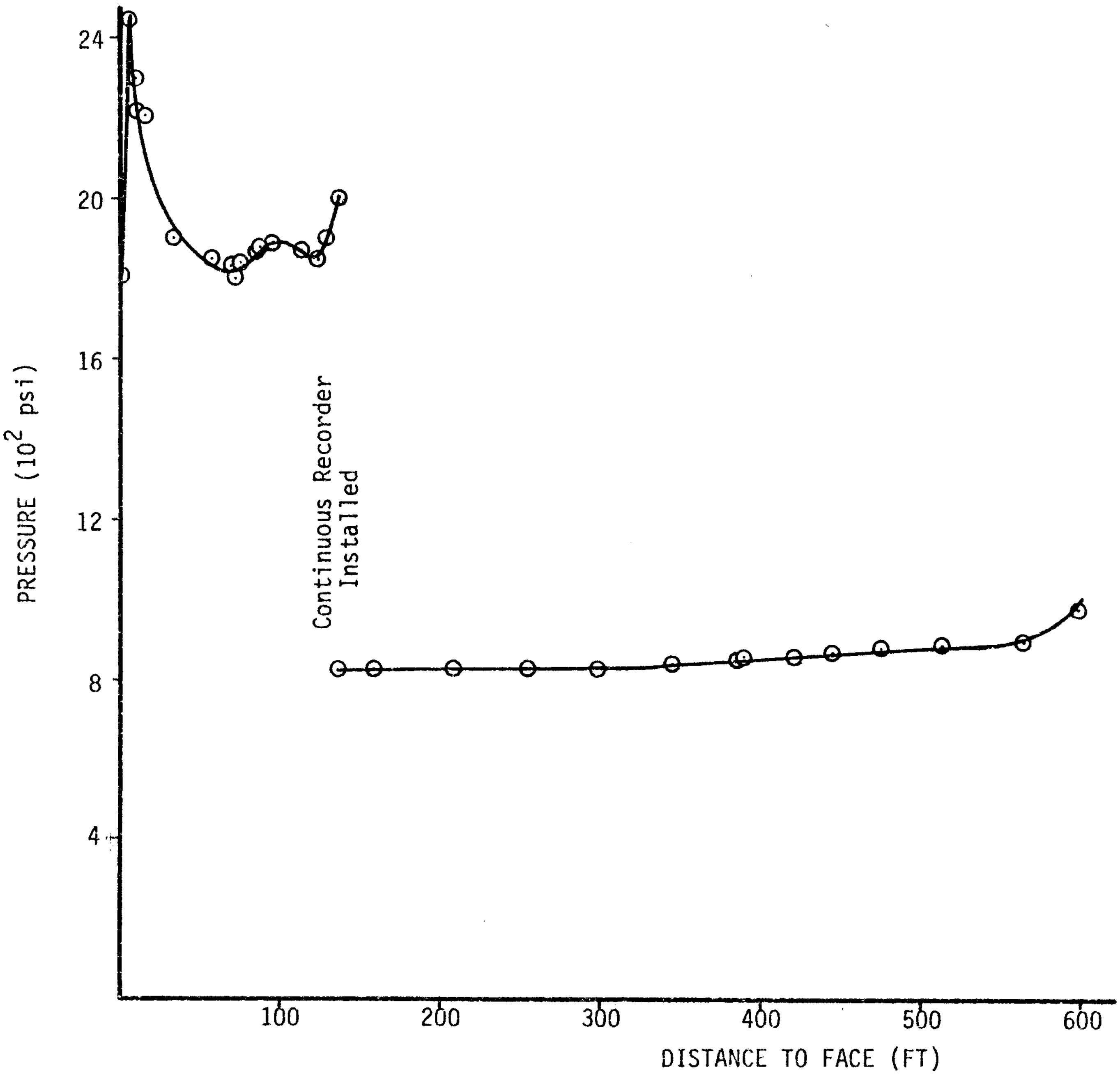


FIG 79 FACE DISTANCE VS. CELL PRESSURE, PANEL CELL P-6

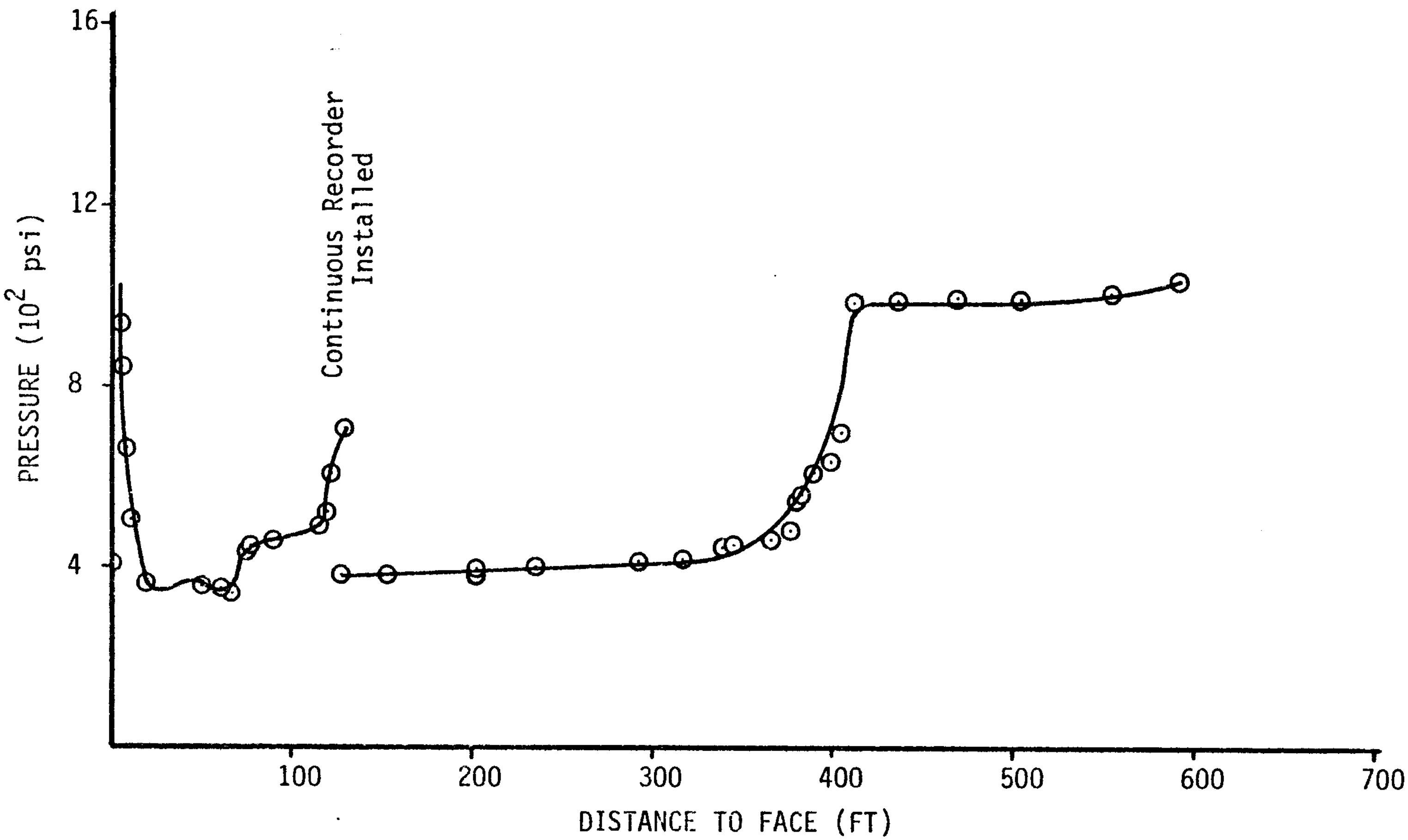


FIG 80 FACE DISTANCE VS. CELL PRESSURE, PANEL CELL P-7

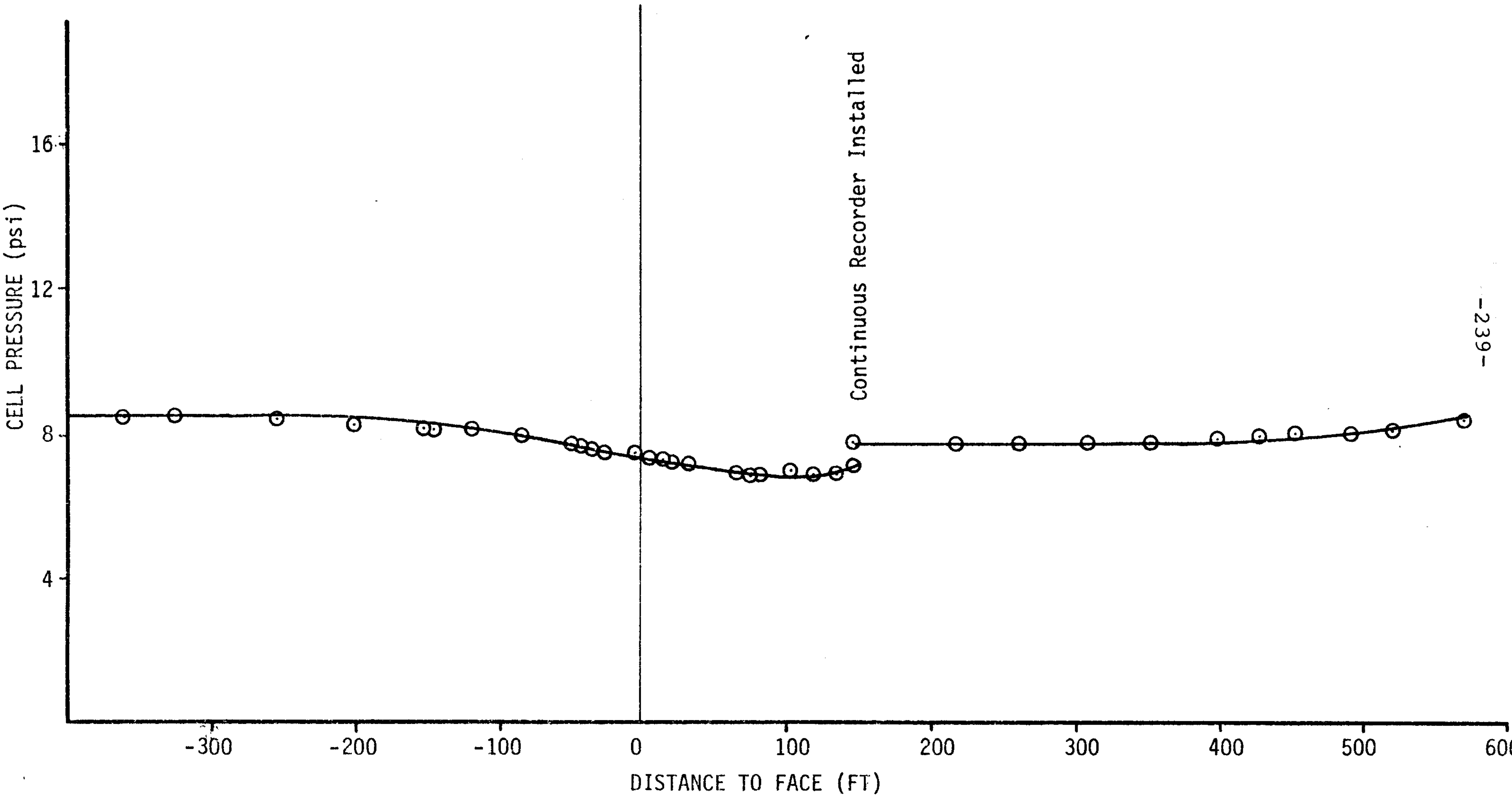


FIG 81 FACE DISTANCE VS. CELL PRESSURE, PANEL CELL P-8

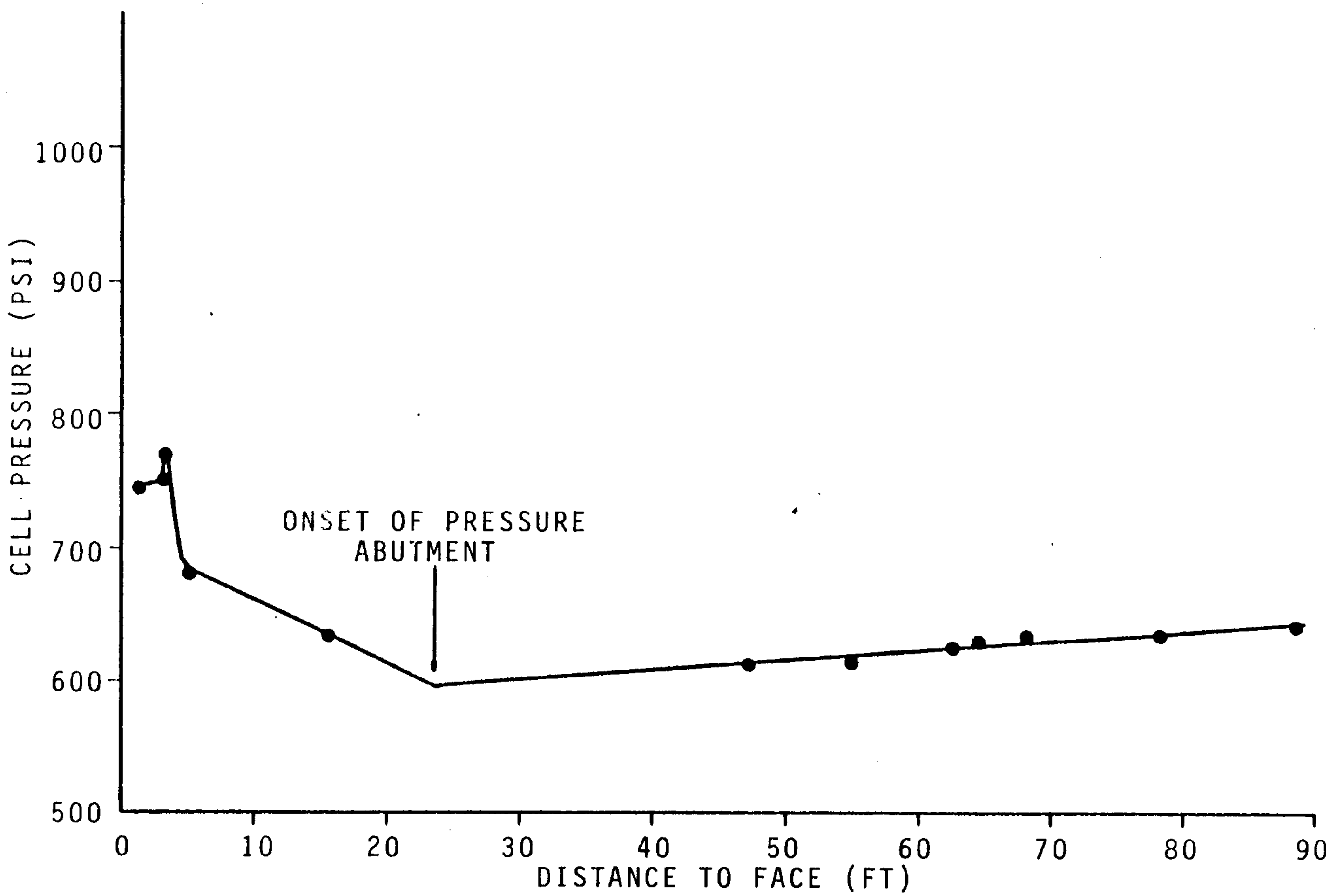


FIG. 82 ONSET OF PRESSURE ABUTMENT - INSTRUMENT P-3

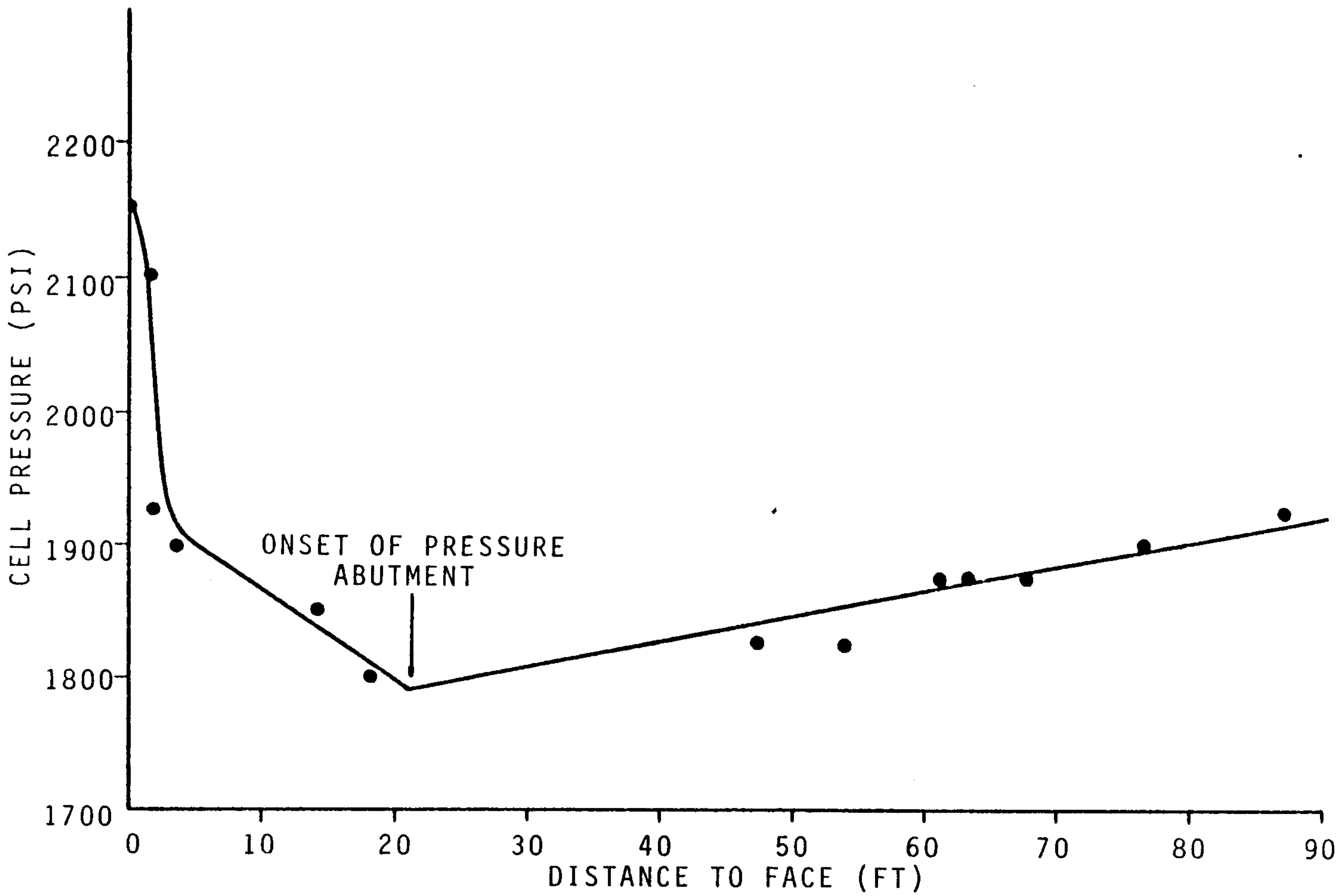


FIG. 83 ONSET OF PRESSURE ABUTMENT - INSTRUMENT P-4

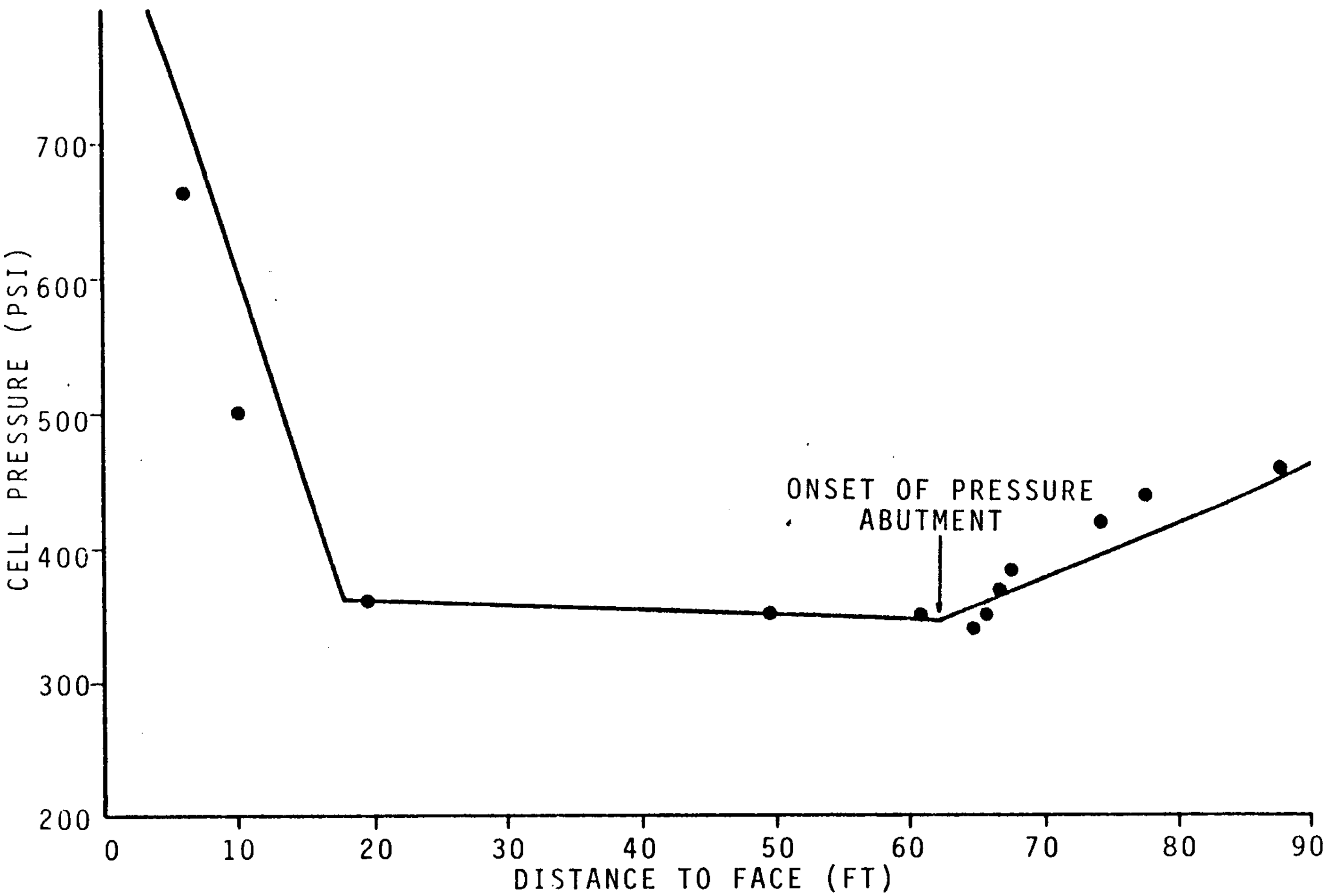


FIG. 84 ONSET OF PRESSURE ABUTMENT - INSTRUMENT P-7

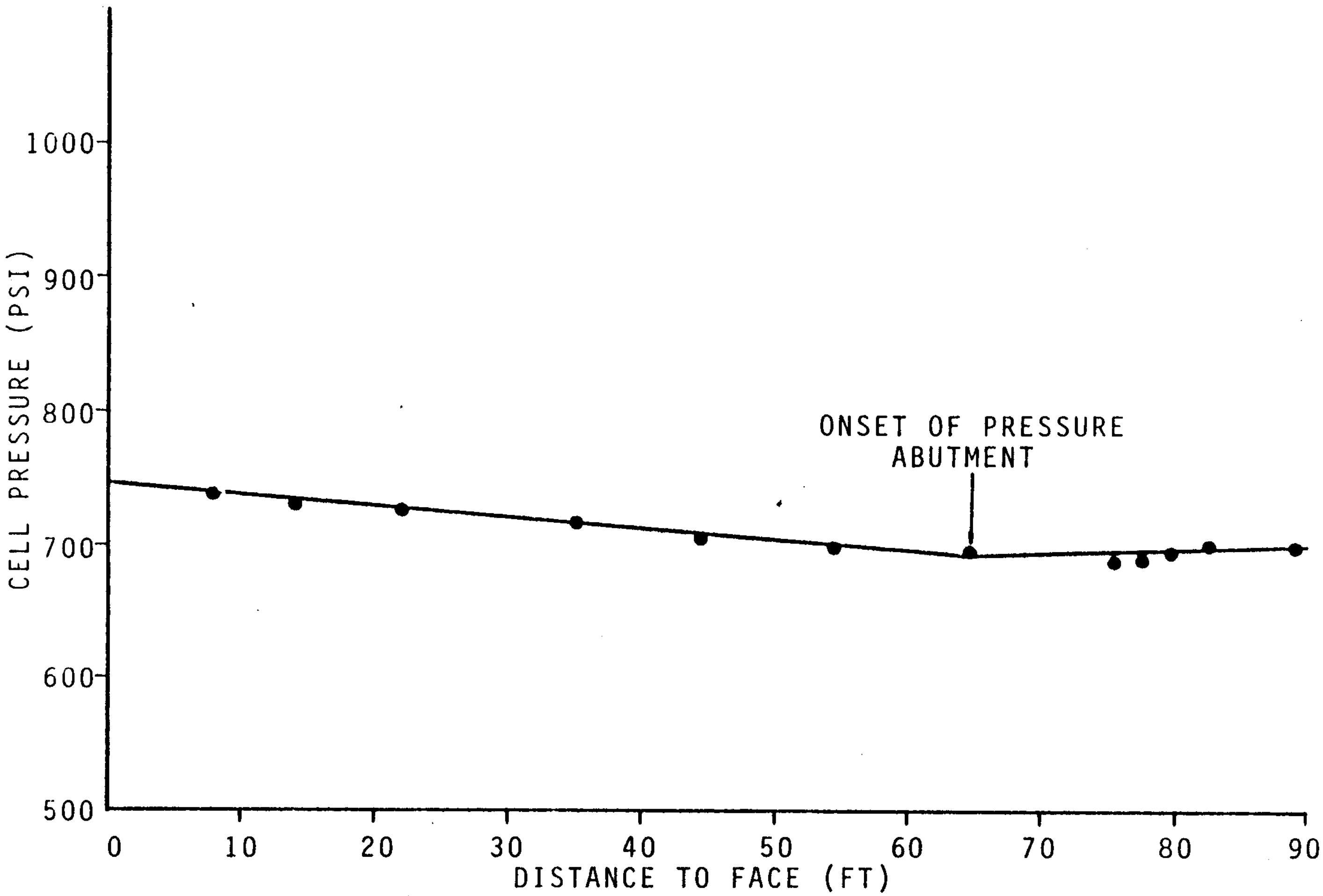


FIG. 85 ONSET OF PRESSURE ABUTMENT - INSTRUMENT P-8

solid material at the sides of the opening. With increasing opening width, a point is eventually reached where the rock mass cannot span and transfer the load to the sides of the opening. The width of the opening just short of this point has been defined as the maximum pressure arch (Divisional Strata Control Research Council, 1953, p. 389). This maximum pressure arch is a measure of the maximum distance that mining activity can transfer load (Divisional Strata Control Research Council, 1950, p. 255) and represents the influence zone. In this paper, the influence zone is defined as the distance within which the panel hydraulic pressure cell instrumentation could detect a rock mass response to mining.

British experience indicates that while the width of the pressure arch is influenced by the overburden strata, the minimum width is principally a function of seam depth (North of England Safety in Mines Committee, 1949, p. 491). This relationship is approximately a straight line of the form (Divisional Strata Control Research Council, 1953, p. 398):

$$W = 0.015D + 60$$

where:

W = width of the pressure arch (ft)

D = depth of seam (ft) ($400 \leq D \leq 2000$)

Abel (1976) combined British data on pressure arch widths and produced an equation of the form:

$$W = 0.257 D + 18.4$$

The data from the hydraulic pressure cells were analyzed to determine the widths of the influence zones and the relationship between width and seam depth. The depth was simply defined as the amount of overburden above an instrument. This was determined from surface topographic maps and coal seam elevation measurements.

The width of the zone of influence was defined as the distance between the pressure cell and the longwall face at the time an increasing vertical stress was noted. The point of increasing vertical stress was determined by performing a linear regression analysis of the data points.

The initial regression model was constructed by utilizing the first three data points. The coefficient of determination was calculated to determine the adequacy of the model (Walpole and Myers, 1972, p. 321). Then the next data point was added, and the analysis was repeated.

In general, the addition of the next data point would yield a better-fitted regression model, and the value of the coefficient of determination would increase. The point of increasing vertical stress was chosen as the point where the regression model resulted in a decreasing coefficient of determination.

The results of the analysis are presented in Table 23 which summarizes the width of the influence zone (face distance) and the depth of the overburden above the coal seam at the instrument location. These data points are plotted on Figure 86 along with British data from the Seventh Progress Report (1949) and the Abel equation (1976).

A linear regression analysis of the 4N data indicated that the width of the zone of influence was related to seam depth by the equation:

$$W = 0.201\ D - 23.7$$

where:

W = width of the zone of influence (ft)

D = depth of the seam (ft)

This equation is shown on Figure 86.

A comparison of the 4N results with previous British experience indicates that the width of the influence zone was approximately 60 percent less than the width that was anticipated from a straight-line projection of the Abel equation. It is apparent that the irregular topography above panel 4N and the shallow depth of overburden significantly affected pressure arch development.

The records of hydraulic cell pressure were analyzed to determine

TABLE 23

SUMMARY OF PANEL PRESSURE CELL PRESSURE ABUTMENT DATA

Panel Pressure, Cell Number	Distance to the Face at Onset of Pressure Increase (ft)	Overburden Thickness (ft)
P-1	25	310
P-2	9	210
P-3	24	270
P-4	21	270
P-5	27	240
P-6	72	365
P-7	18	365
P-8	66	405

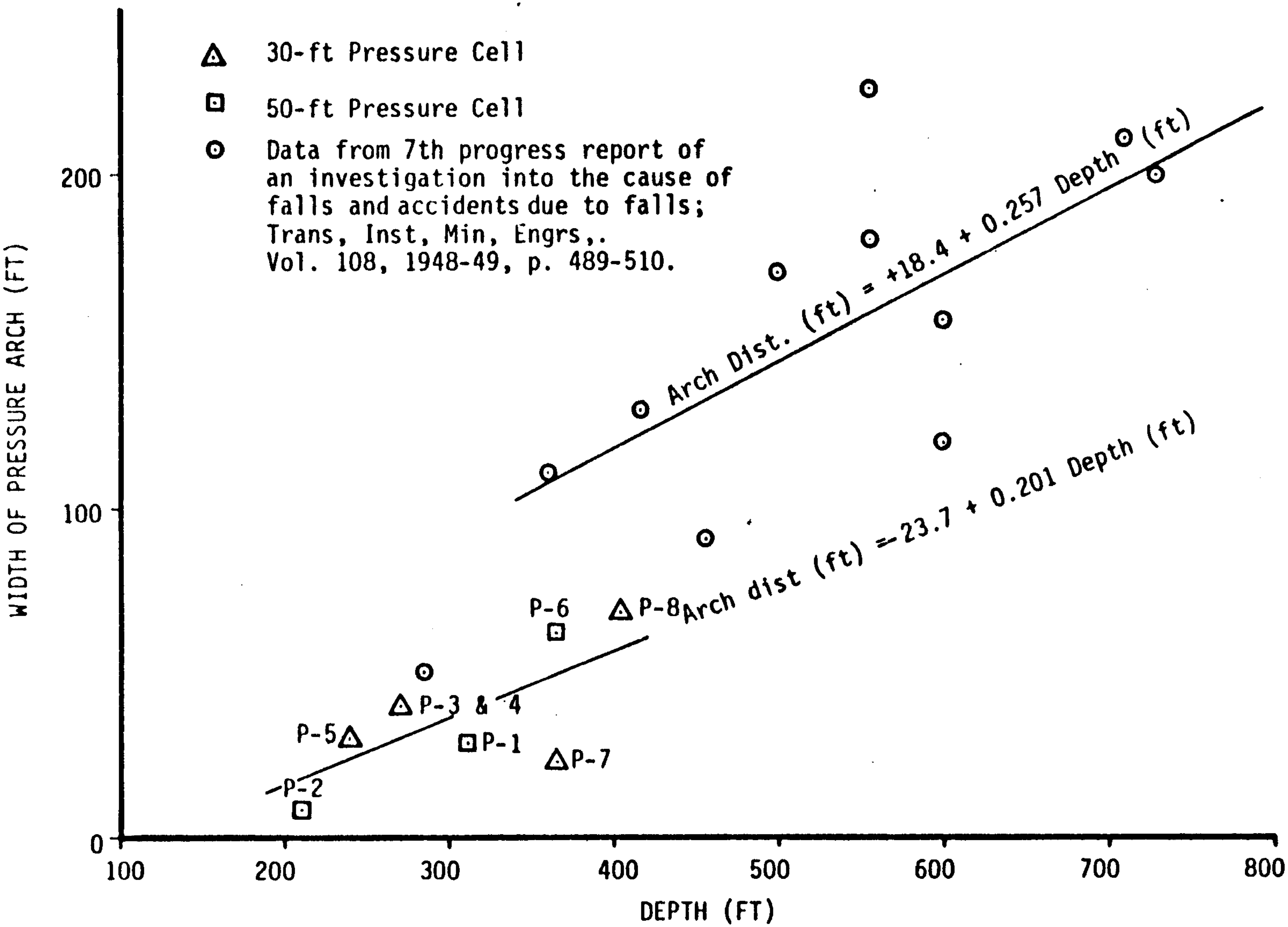


FIG. 86 INFLUENCE ZONE DATA

at what point in advance of the mining face the cells registered a permanent stress decrease. According to Wilson (1972, p. 410), a vertical stress peak should occur at some point behind an exposed ribside. The distance, $\bar{y}$, is related to the peak vertical stress, $\bar{s}_v$, and the overburden depth. According to Wilson (1972, p. 413) the relationship is as follows:

$$\bar{y}\text{ (ft)} = \frac{m}{(\text{Tan } B)^{\frac{1}{2}}(\text{Tan } B-1)} \ln \frac{\bar{s}_v}{\bar{c}}$$

where:

m = face height (ft)

$\text{Tan } B = \frac{1 + \sin \emptyset}{1 - \sin \emptyset}$

$\emptyset$ = angle of internal friction

$\bar{c}$ = cohesion (psi)

$\bar{s}_v$ = peak vertical stress

$= (6.94 \times 10^{-3}\ dH)\ \text{Tan } B + \bar{c}$

d = density of the overburden (psf)

H = depth of overburden (ft)

Table 24 summaries observed pressure release data and presents $\bar{y}$ values calculated with Wilson's formula. The values of $\bar{y}$ were calculated with the peak intact coal shear properties ($\emptyset$ and $\bar{c}$) from Table 14 and overburden depths from Table 23. Peak intact properties were utilized because observations indicated that the coal at the face

TABLE 24

SUMMARY OF PANEL PRESSURE CELL PRESSURE RELEASE DATA

Pressure Cell	Observed $\bar{y}$ (1) (ft)	Calculated $\bar{y}$ (2) (ft)
P-3	3.3	1.4
P-4	0.0	1.4
P-6	4.0	1.7
P-7	2.0	1.7

NOTES:

1. $\bar{y}$ represents distance to the mining face at the time the cell registered a permanent decrease in recorded pressure.

2. Calculated value for distance to peak vertical stress (after Wilson, 1972, p. 413).

was usually intact without any significant deterioration.

Table 24 indicates that there is reasonable agreement between the observed values and the calculated values. It appears that the regular topography and the shallow mining depth affected peak stress locations only so far as they affected overburden thickness.

A single pressure cell, P-8, was located in a position to determine the distance behind the face were the vertical stress stabilized. The pressure cell was located in the barrier pillar along the headgate entry. The pressure cell was installed into the pillar from the haulage entry adjacent to the headgate entry.

Pressure cell P-8 indicated that the overburden loads stabilized at a point 220 ft behind the longwall face. This would indicate that overburden load had essentially been transferred to the gob. Roof caving and gob compaction were essentially complete. The 220 ft distance agrees well with the vertical subsidence data. Surface subsidence measurements indicate that 97 percent of the subsidence had occurred at a point 220 ft behind the face.

Convergence Instrumentation:

A total of twenty roof-floor convergence instruments was installed adjacent to longwall panel 4N. The instrumentation was divided between the three station areas (Figure 61). Table 11 summaries instrument locations, and Figures 62, 63 and 64 show the placement of the convergence instrumentation within each station area.

A summary of convergence instrumentation results is presented in Table 25. Plots of roof-floor convergence with respect to face distance and time are presented on Figures 87 through 93. Convergence data are tabulated in Appendix M.

Table 25 indicates the distance from the instrument to the mining face at the point when the rate of convergence began to accelerate. This point was determined by performing a linear regression analysis of the data points. Starting with the first three readings, a linear regression analysis was applied, and the coefficient of determination was calculated to determine the adequacy of the model (Walpole and Myers, 1972, p. 321). The next data point was added, and the analysis was repeated. In general, the addition of the next data point would yield a better-fitted regression model, and the value of the coefficient of determination would increase. The point of accelerating convergence was chosen as the point where the regression model resulted in a decreasing coefficient of determination.

Analysis of the convergence data in Table 25 indicate that --

1. two types of convergence behavior were observed prior to the onset of the accelerating trend;
2. the magnitude of the convergence observed as the face passed an instrument station did not exceed 0.6 in;
3. the magnitude of convergence in entries, near the face, was less than anticipated;

TABLE 25

CONVERGENCE INSTRUMENTATION RESULTS

Convergence Instrument Number	D (1) (ft)	Overburden Thickness (ft)	Maximum Convergence (2) (in)
L-1	34.5	225	0.500
L-2	78.5	225	0.428
L-3	(3)	235	0.025 (5)
L-4	89.0	245	0.037 (5)
L-5	78.5	245	0.239
L-6	125.5	250	0.294
B1-1	126.0	255	0.544
B1-2	133.5	260	0.581
B1-3	150.5	255	0.380
B1-4	81.0	240	0.723
B1-5	174.5	265	0.161 (5)
B2-1	859.5	365	0.531
B2-2	483.5	390	0.206
B2-3	404.0	410	0.193
B2-4	698.0	415	0.225
B3-1	284.0	400	0.124
B3-2	(4)	420	0.156
B3-3	(4)	405	0.072
B3-4	(4)	420	0.041
B3-5	(4)	415	0.069

Notes:

1. D represents the distance from the instrument to the longwall face at the time accelerating convergence was noted.

2. Maximum convergence recorded prior to the instrument's destruction.

3. Instrument destroyed before entering the influence zone.

4. Instrument not influenced by face advance.

5. Instrument destroyed before the mining face reached it.

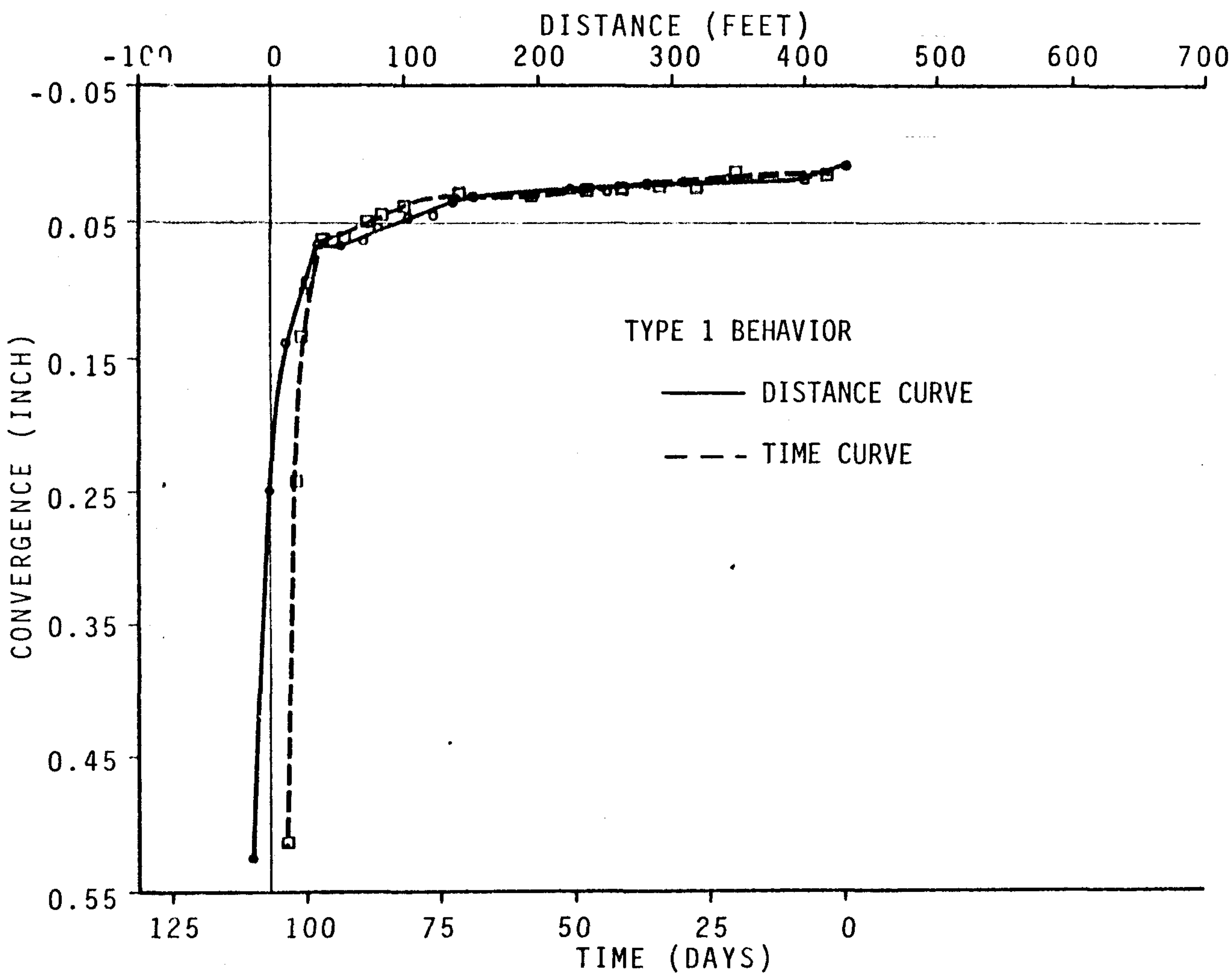


FIG. 87 ENTRY CONVERGENCE - INSTRUMENT L-1

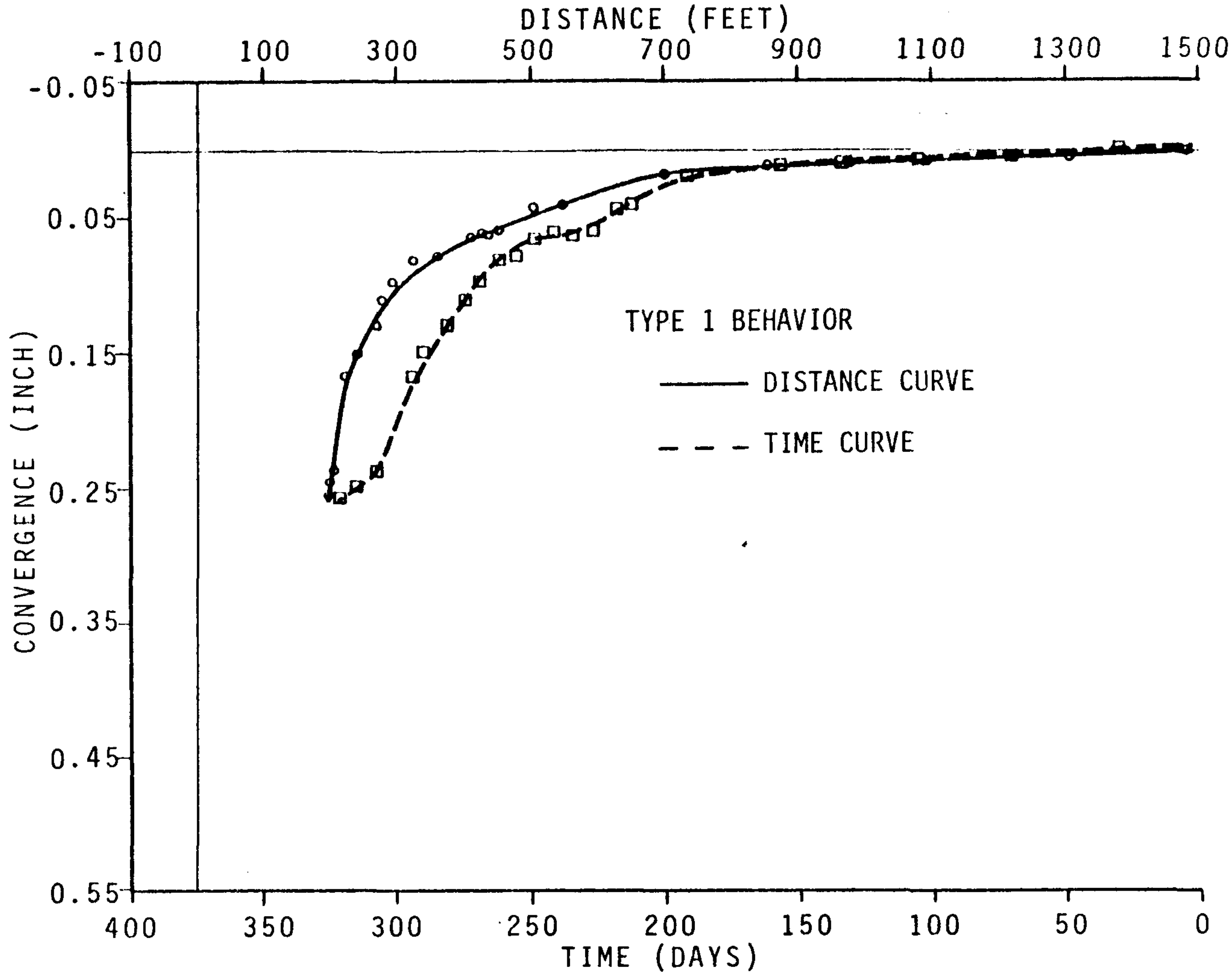
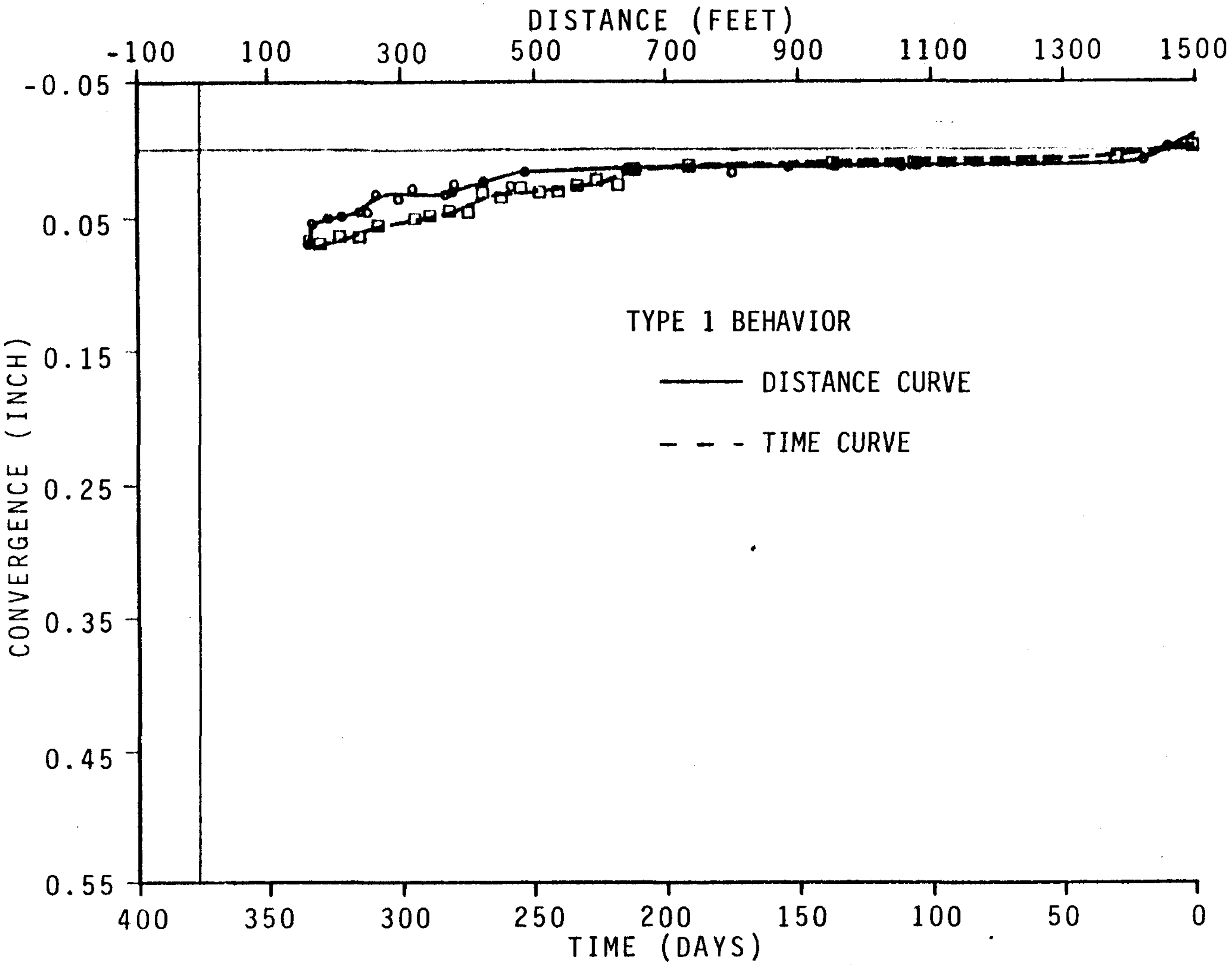


FIG. 88 ENTRY CONVERGENCE - INSTRUMENT B2-4



EIG. 89 ENTRY CONVERGENCE - INSTRUMENT B3-3

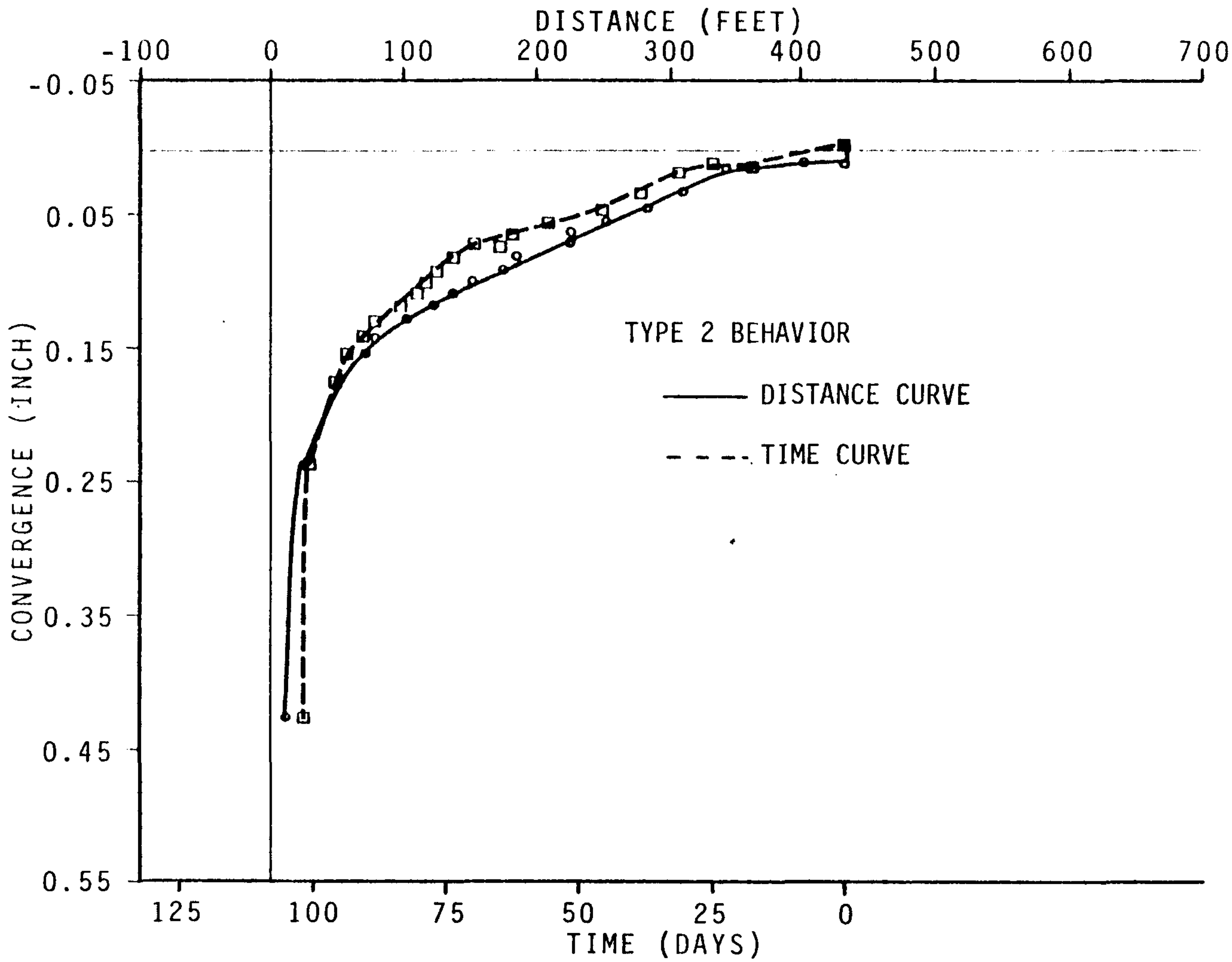


FIG. 90 ENTRY CONVERGENCE - INSTRUMENT L-2

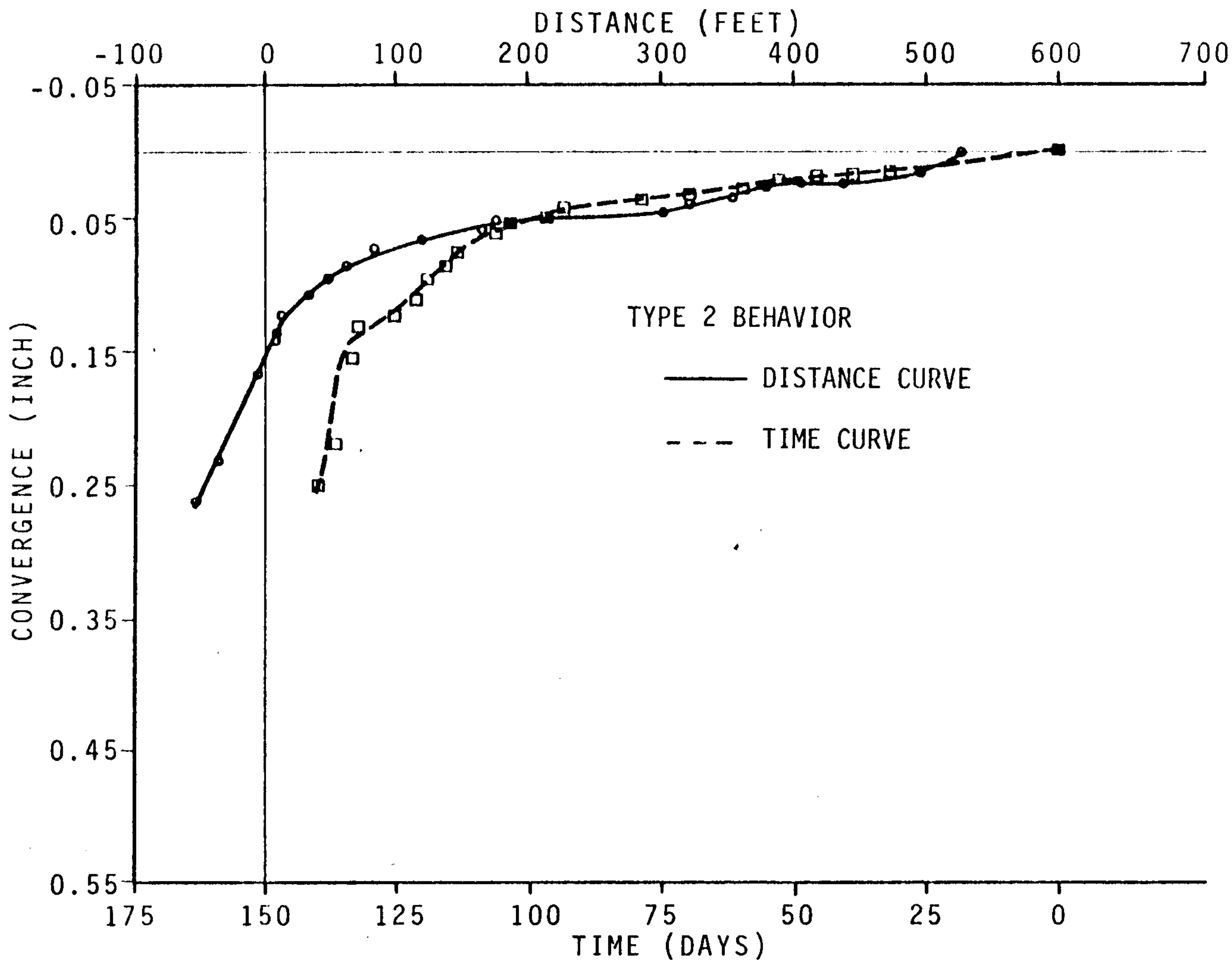


FIG. 91 ENTRY CONVERGENCE - INSTRUMENT B1-4

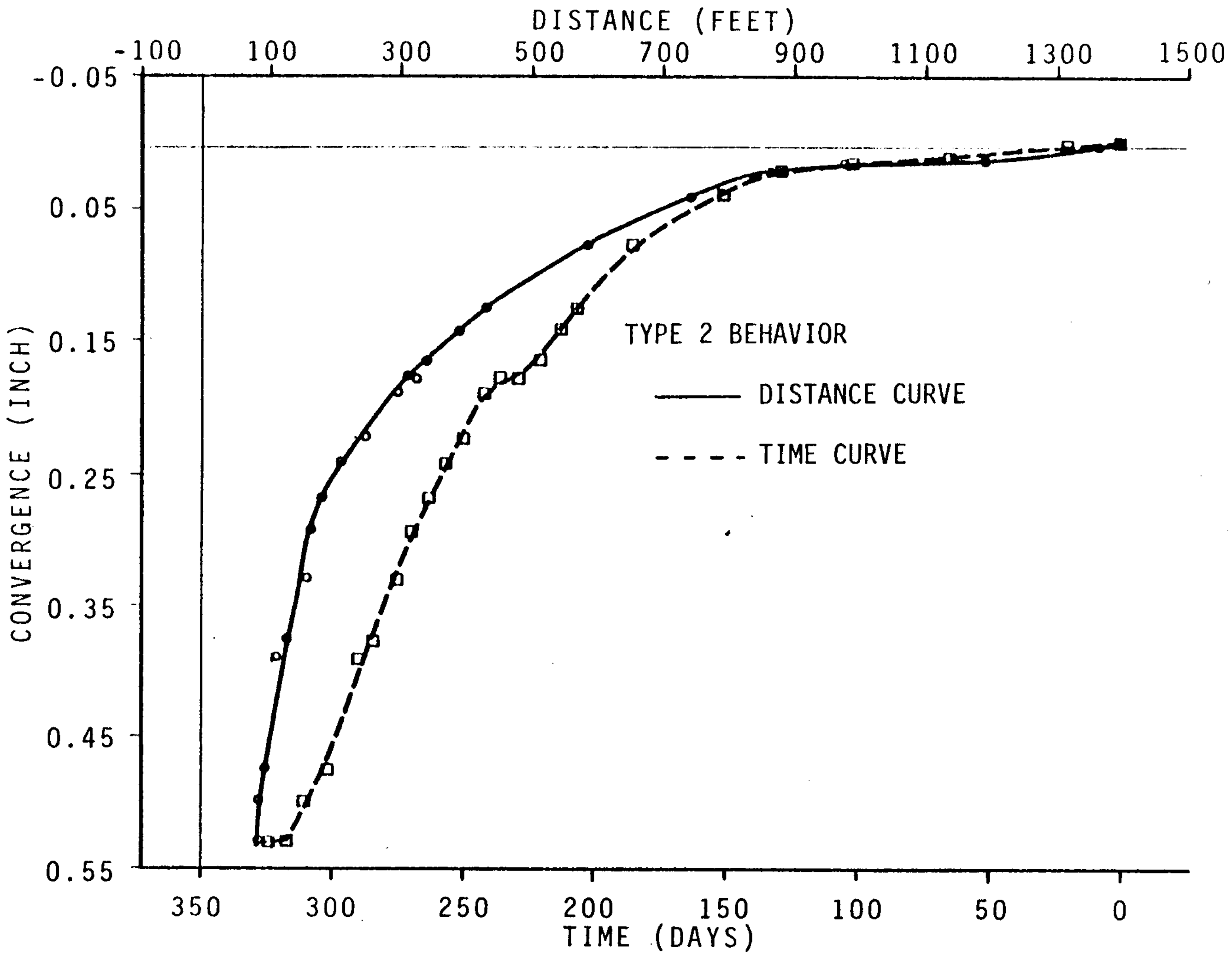


FIG. 92 ENTRY CONVERGENCE - INSTRUMENT B2-1

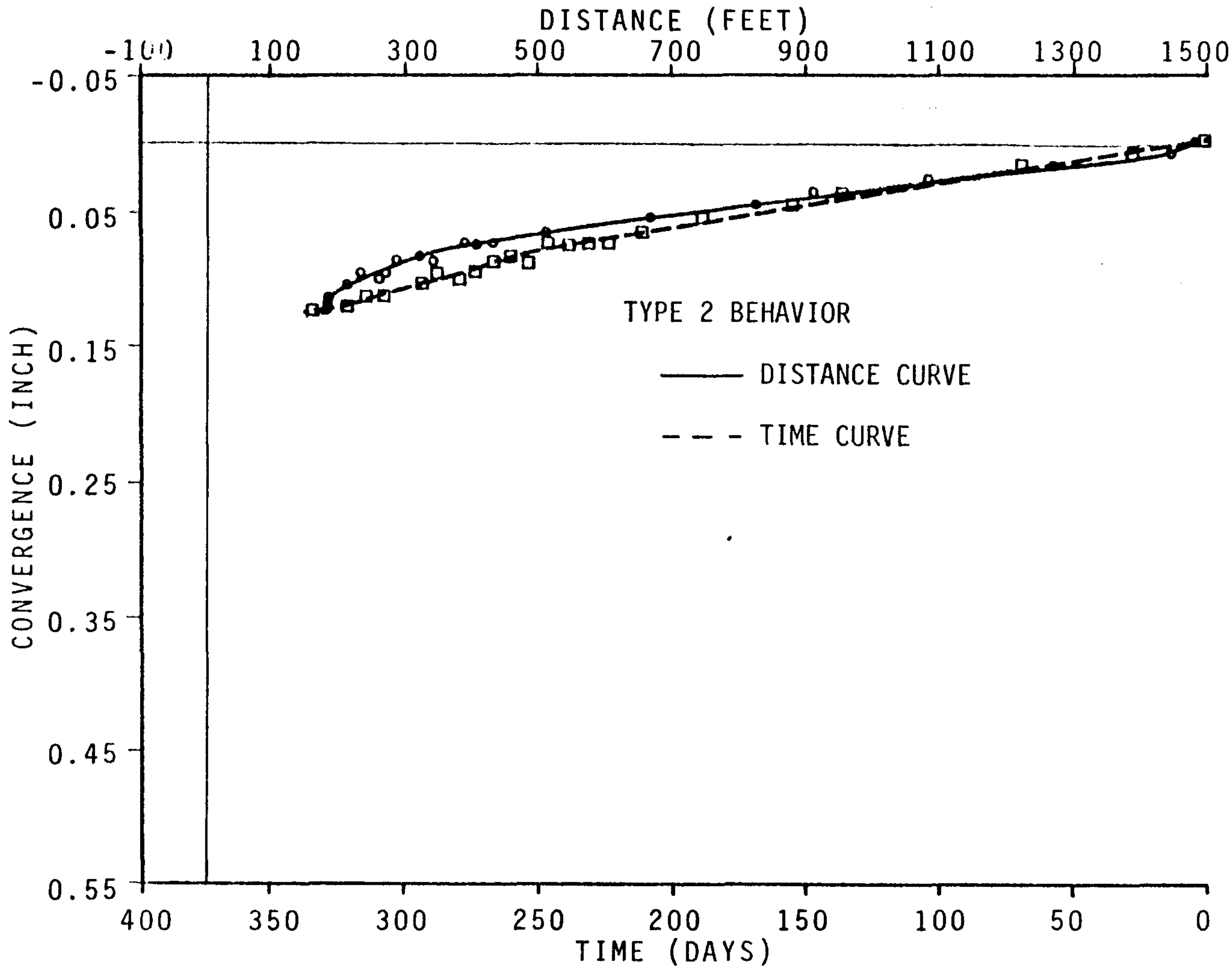


FIG. 93 ENTRY CONVERGENCE - INSTRUMENT B3-1

4. there was no correlation between amount of convergence and overburden depth;
5. the zone of influence ahead of the face, as measured by the onset of accelerating convergence, may have been a function of overburden depth;
6. pillar robbing operations along the 3N entry adjacent to the tailgate side of the panel may have influenced convergence instruments in Station Area 2.

Figures 87 through 93 illustrate the two basic kinds of convergence behavior observed before the onset of accelerating convergence. Type I behavior was characterized by very small amounts of initial convergence prior to the onset of the accelerating trend. The data plot yielded a nearly horizontal line as shown on Figures 87, 88 and 89.

Type II behavior is illustrated on Figures 90 through 93. It was characterized by a constant, positive rate of convergence prior to the onset of the accelerating trend. The data plot yielded on upward-sloping, straight line.

Table 25 indicates that the convergence recorded in entries near the face did not exceed 0.6 in. This was less convergence than had been anticipated.

Schwartz (1960 and 1961) and Chambon and Schwartz (1964) have performed numerous studies of convergence in roadways influenced by longwall faces. According to Schwartz (1961, p. 5), the magnitude of convergence along the face-side of a longwall entry is a function of --

1. the thickness of the seam worked, w;
2. the nature of the roadside pack;
3. the distance from the instrument to the longwall face.

Schwartz (1961, p. 5) indicates that between the time the face is approximately 100 ft from the instrument and the time the face passes the instrument, the convergence should be approximately 5 percent of the thickness of the seam worked.

Utilizing this relationship, the anticipated convergence in entries adjacent to panel 4N was 6.3 in. (based on an extraction height of 10.3 ft). The data in Table 15 indicate that the magnitude of the convergence in entries adjacent to panel 4N was approximately 0.5 percent of the extraction height.

Analysis of the convergence data in Table 25 indicates that no correlation existed between the depth of overburden above an instrument and the amount of convergence recorded as the face passed the instrument. Linear regression of the data yielded a coefficient of determination of 0.006 while logarithmic and exponetial regression yielded coefficients of 0.004 and 0.163, respectively. A power curve fit of the data yielded a coefficient of determination of less than 0.001.

The lack of correlation between overburden and convergence agrees with observations reported in the literature. Barry and

Wojciechowski (1954, p. 8) indicate that, once subsidence into the mined-out area has continued to the surface, convergence at any point in advance of the mining face should be constant. Schwartz (1960 and 1961) and Chambon and Schwartz (1964) do not include overburden thickness as a factor influencing convergence.

The data in Table 25 indicate that there may be a correlation between overburden thickness and the distance to the face at the onset of the accelerating trend. Linear regression of Station Area 1 data yielded a coefficient of determination of 81.8 percent. However, the lack of any significant range in the values for overburden thickness makes the analysis suspect. Additional data are needed to prove or disprove any correlation.

The data in Table 25 indicate that there was a significant difference in the convergence behavior recorded for Station Areas 1, 2 and 3. Station Area 1 instruments indicated that the onset of accelerating convergence occurred 35 to 175 ft out ahead of the face. Station Area 2 instruments indicatd that the onset of accelerating convergence occurred out ahead of the face a distance of 400 to 860 ft. Station Area 3 instruments, located along the headgate side of the panel, had only begun to indicate accelerating convergence when mining ceased with the face at a distance of approximately 190 ft.

The behavior of the Station Area 2 instruments indicates that they may have been influenced by the full-retreat pillar robbing operation conducted along entry 3N adjacent to the tailgate side of panel 4N.

The 3N pillar robbing operation was by full-retreat methods with the roof allowed to cave behind the extraction line. The direction of the retreat was parallel to the direction of longwall face advance. The edge of the extraction area was approximately 150 ft from the tailgate edge of panel 4N. The longwall operation started before the pillar robbing, and during the initial stages of mining, the longwall face was ahead of the pillar extraction line. After the face passed through Station Area 1, equipment problems slowed the progress of the longwall mining operation, and the pillar extraction line passed ahead of the longwall face. Throughout the latter stages of the longwall operation, the pillar extraction line was 200 to 300 ft ahead of the longwall face. Thus instruments in Station Areas 1 and 3 were affected principally by the longwall face while Station Area 2 instruments were influenced initially by the 3N pillar robbing operation.

The effects of the pillar robbing are most apparent when the behavior of Station Areas 2 and 3 are compared. Station Areas 2 and 3 were located on opposite sides of panel 4N at approximately equal distances from the mining face. The overburden above each station was similar in composition, and the thickness averaged 400 ft above each station. Instruments in each station area should have reacted in a similar manner to face advance.

The pillar robbing operation was initially thought to be responsible for the two types of convergence behavior noted. Convergence instruments in Station Areas 1 and 2 generally exhibited the Type II trend with the constant, positive rate of convergence.

However, the reactions of instruments L-1, B2-4 and B3-1 tend to disprove the hypothesis that Type II behavior was associated with the 3N pillar robbing. Instruments L-1 (Figure 87) and B2-4 (Figure 88) were both located along the tailgate side of the panel and exhibit Type I behavior. Instrument B3-1 (Figure 93) was located along the headgate entry but exhibits the Type II behavior initially attributed to the pillar robbing operation. Therefore, the type of initial convergence behavior does not appear to be a consequence of the 3N pillar robbing operation.

The results of convergence instrumentation, surface and roof extensometers and observations in the entries ahead of the face indicate that the recorded roof-floor convergence was a function of strata separation and squeezing of the coal seam.

According to Schwartz (1960, p. 367), the initial convergence in a newly driven entry is caused by strata separation and expansion of the near-seam rock strata. The initial convergence in the entries bounding panel 4N appeared to be related principally to the expansion of the near-seam rock strata. The lack of significant strata separation in the extensometer-instrumented, 12-ft near-roof would indicate that the block sensitive to expansion (Schwartz, 1960, p. 367) was thicker than 12 ft.

Convergence near the face exceeded the amounts of strata separation recorded by roof and surface extensometers. Observations along the headgate entry indicated that increased spalling of coal from the panel began at a point about 50 ft in advance of the face. Convergence in this interval was apparently related to squeezing of the coal seam.

Observations in the entries and along the longwall face indicated that convergence was not accompanied by the formation of "induced cleavage" or "main breaks" (Alder, 1968, p. 61). Alder (1968, p. 62) indicates that the lack of breaks or the minimal roof movements are not unusual in areas with strong roof and in more shallow mines. Panel 4N satisfied both criteria.

Differential Roof-Floor Horizontal Movement Instrumentation:

Nine differential roof-floor horizontal movement instruments were distributed between Station Areas 1, 2 and 3 (Figure 61). They consisted of plum line instrumentation designed to measure roof or floor over-ride and/or lateral displacements induced by mining. Table 12 summarizes instrument locations, and Figures 62, 63 and 64 present plan views of the instrumentation placement within each station area.

The original data, which consisted of a bearing and a distance from the initial zero point, were reduced into components of movement parallel and perpendicular to the orientation of the panel centerline. The reduced data are summarized on Table 26 and are tabulated in Appendix N. Figures 94 through 97 present graphic representations

TABLE 26

SUMMARY OF DIFFERENTIAL ROOF-FLOOR HORIZONTAL MOVEMENT DATA

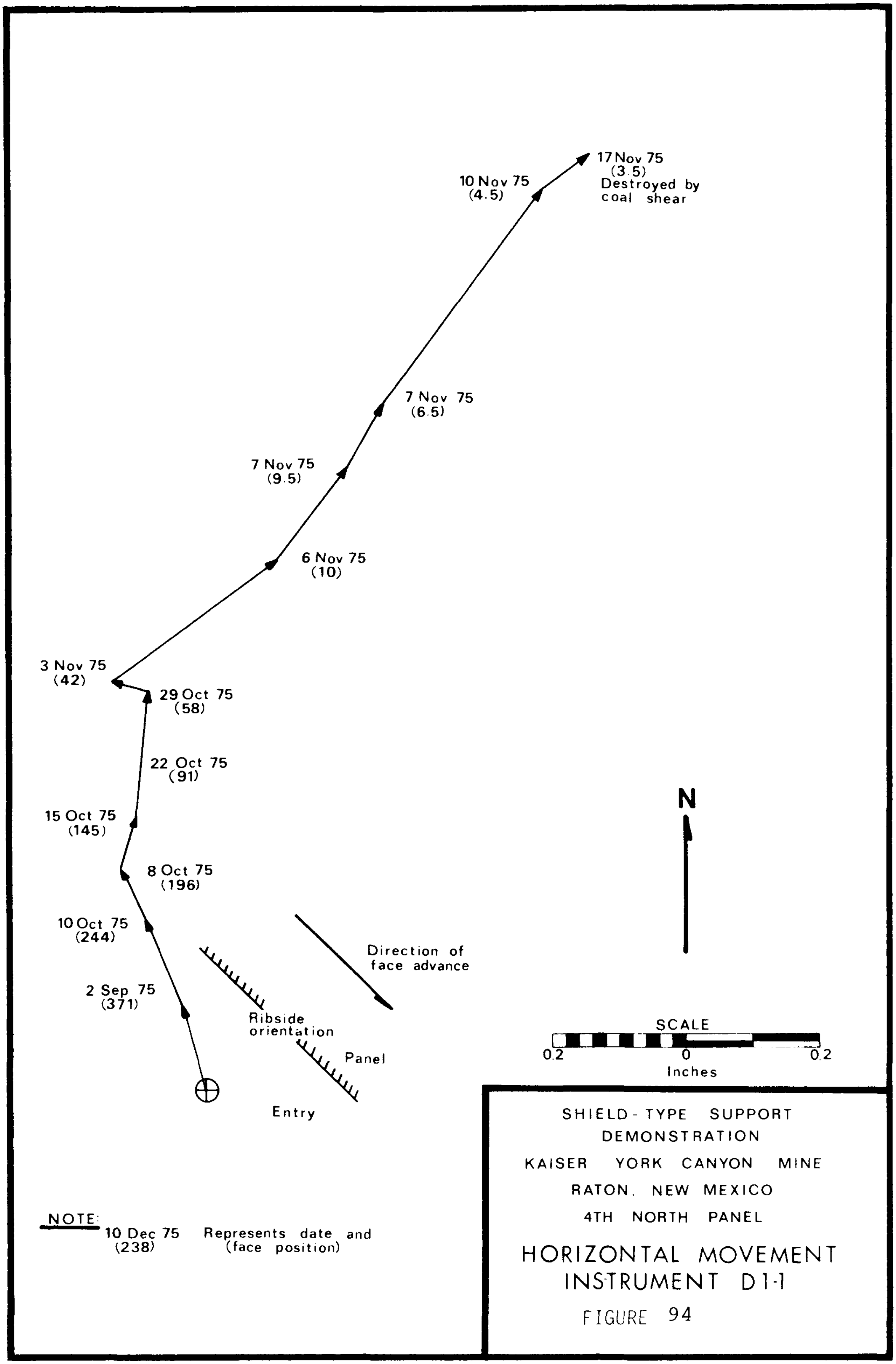
Instrument Number	Final Movement Vectors Para. (1) (in.)	Perp. (2) (in.)	D (3) (ft)
D1-1	+0.59	+1.38	3.5
D1-2	+0.80	-0.29	5.5
D2-1	+0.39	-0.97	84.0
D2-2	+0.74	-0.35	187.0
D3-1	+0.06	+0.24	182.5
D3-2	+0.08	+0.11	701.0
D3-3	+0.06	+0.24	159.5
D3-4	+0.12	+0.40	270.0
D3-5	+0.03	+0.30	194.0

Notes:

1. Component of movement parallel to the direction of face advance.
   + indicates movement towards the longwall face.

2. Component of movement perpendicular to the direction of face advance.
   + indicates movement towards the longwall panel.

3. D represents distance from the differential movement station to the longwall face.



SHIELD-TYPE SUPPORT DEMONSTRATION

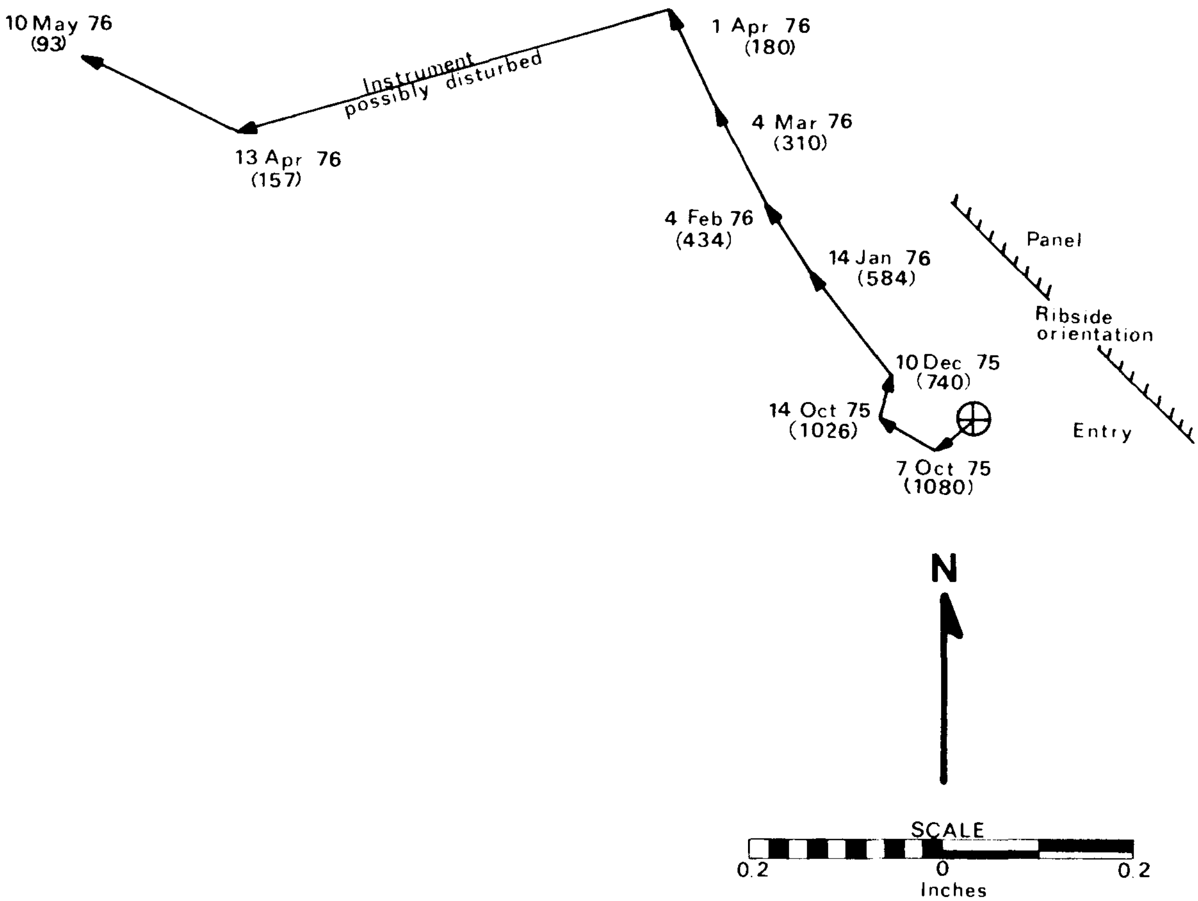
KAISER YORK CANYON MINE

RATON, NEW MEXICO

4TH NORTH PANEL

HORIZONTAL MOVEMENT INSTRUMENT D1-1

FIGURE 94



NOTE: 10 Dec 75 (238) · Represents date and (face position)

SHIELD-TYPE SUPPORT DEMONSTRATION

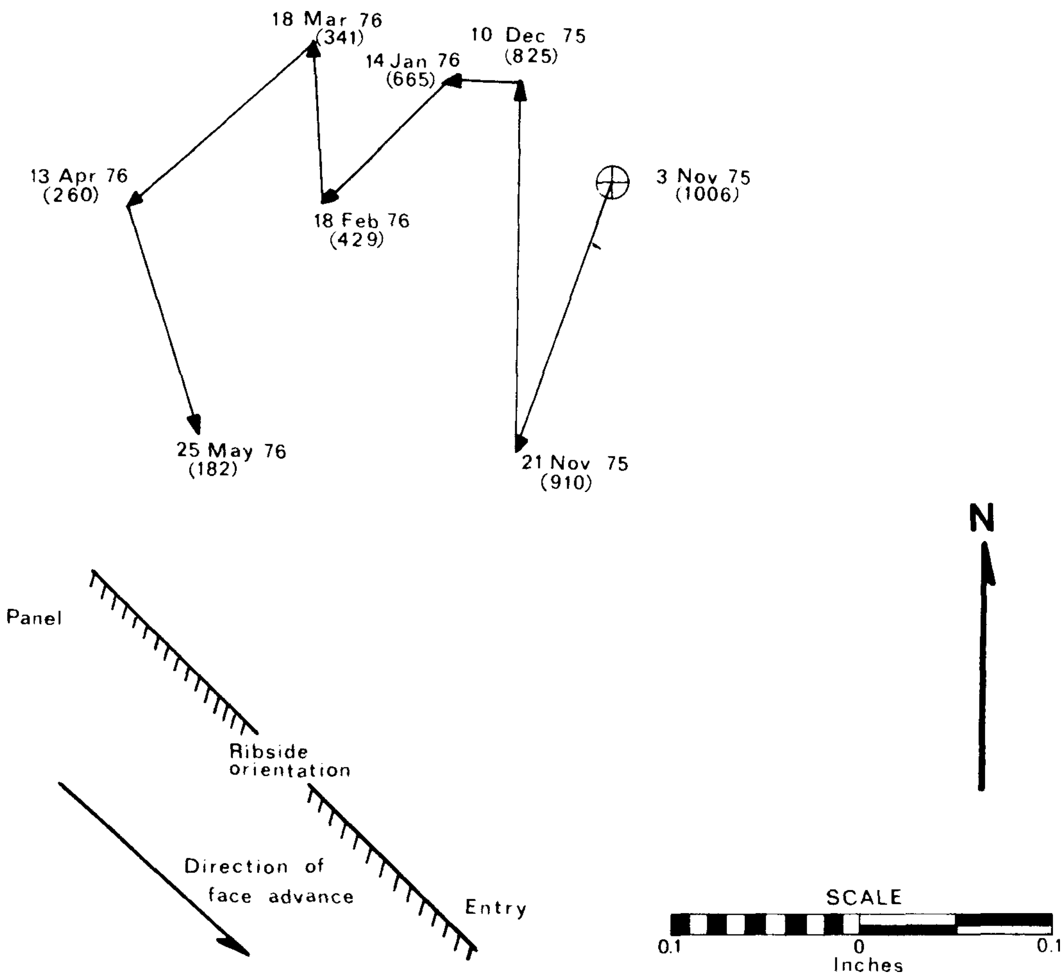
KAISER YORK CANYON MINE

RATON, NEW MEXICO

4TH NORTH PANEL

HORIZONTAL MOVEMENT INSTRUMENT D2-1

FIGURE 95

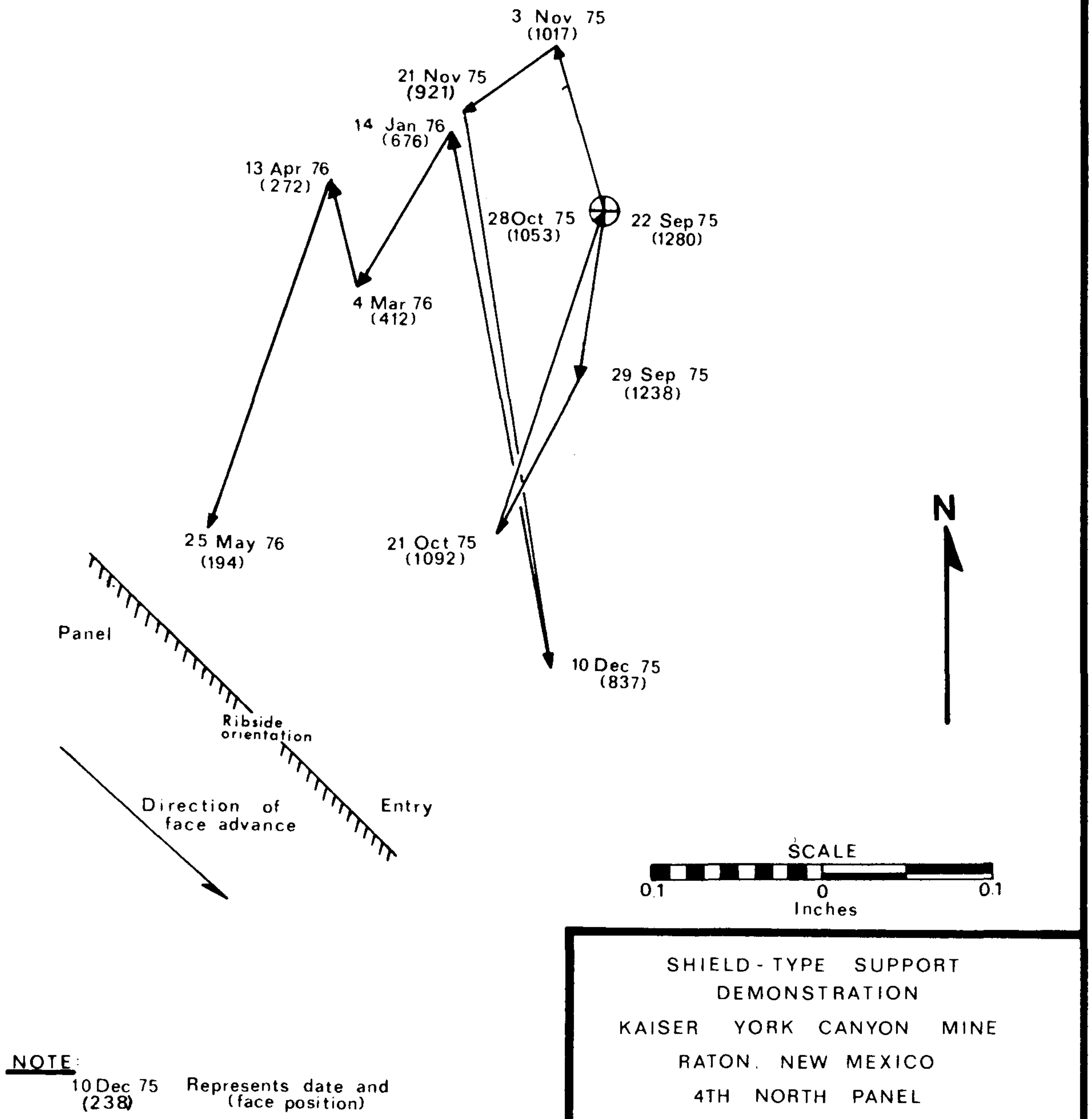


NOTE: 10 Dec 75 (238) Represents date and (face position)

SHIELD-TYPE SUPPORT DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

HORIZONTAL MOVEMENT INSTRUMENT D 3-1

FIGURE 96



SHIELD - TYPE SUPPORT
DEMONSTRATION
KAISER YORK CANYON MINE
RATON, NEW MEXICO
4TH NORTH PANEL

HORIZONTAL MOVEMENT
INSTRUMENT D3-5

FIGURE 97

of the movement histories for selected instruments.

The data in Table 26 indicate that all the instruments registered a component of roof movement towards the mining face in a direction parallel to the panel centerline. The magnitude of the movement was less than 1 in., and the rate of movement was small, averaging less than 0.05 in./hr after the face had advanced to within 10 ft.

The data on lateral roof movement in the direction perpendicular to the panel centerline were inconclusive. Only two instruments, D1-1 and D1-2, were definitely influenced by the mining face. These two instruments, located approximately 8 ft apart, indicated lateral movements that were in opposite directions. Instrument D1-1 indicated 1.38 in. of movement towards the panel while instrument D1-2 indicated 0.29 in. of movement away from the panel.

The data indicate that the higher topography along the headgate side of the panel may have initially influenced the direction of roof over-ride. Table 26 shows that all instruments, except D1-1, had initial movement along the perpendicular orientation directed down-slope from the topographic high along the eastern edge of the panel.

The data indicate that the caving mechanism was principally responsible for roof motion in the direction parallel to the panel centerline. The roof was literally pulled towards the caved zone. Roof movement in the direction perpendicular to the panel centerline was apparently related to topographic over-ride.

Roof-Sag Instrumentation:

Six roof-sag instruments were installed along the headgate and tailgate entries adjacent to panel 4N in Station Areas 1, 2 and 3. The instruments were installed in pairs with anchors at the 3- and 5-ft level and the 9- and 12-ft level. The instruments were designed to indicate the amount of strata separation that occurred in advance of the longwall face.

The only pair of instruments that were influenced by mining activity were located in Station Area 1 (Figure 61). A summary of the data recorded for instruments C1-3, 5 and C1-9, 12 is presented on Figures 98 and 99. Figure 99 represents the recorded roof sag by anchored intervals and Figure 98 represents the total recorded roof sag. The data from which these graphs were plotted are presented in Appendix O.

Several observations can be made from the collected data. The 0- to 3-ft interval was unaffected by mining operations until supplemental roof supports were applied. This interval then remained in compression throughout face advance as long as props or shields were applying supportive roof loads.

The 3- to 5-ft interval was subjected to a constant compressive stress during initial mining operations. The compressive stress began to increase when the face advanced to within 20 ft. When the face reached a point about 5 ft from the instrument, the compressive stress began to decrease until, with the face 5-ft past the instrument, the stresses became tensile. This tensile stress began to increase rapidly ith small changes in the distance to the face.

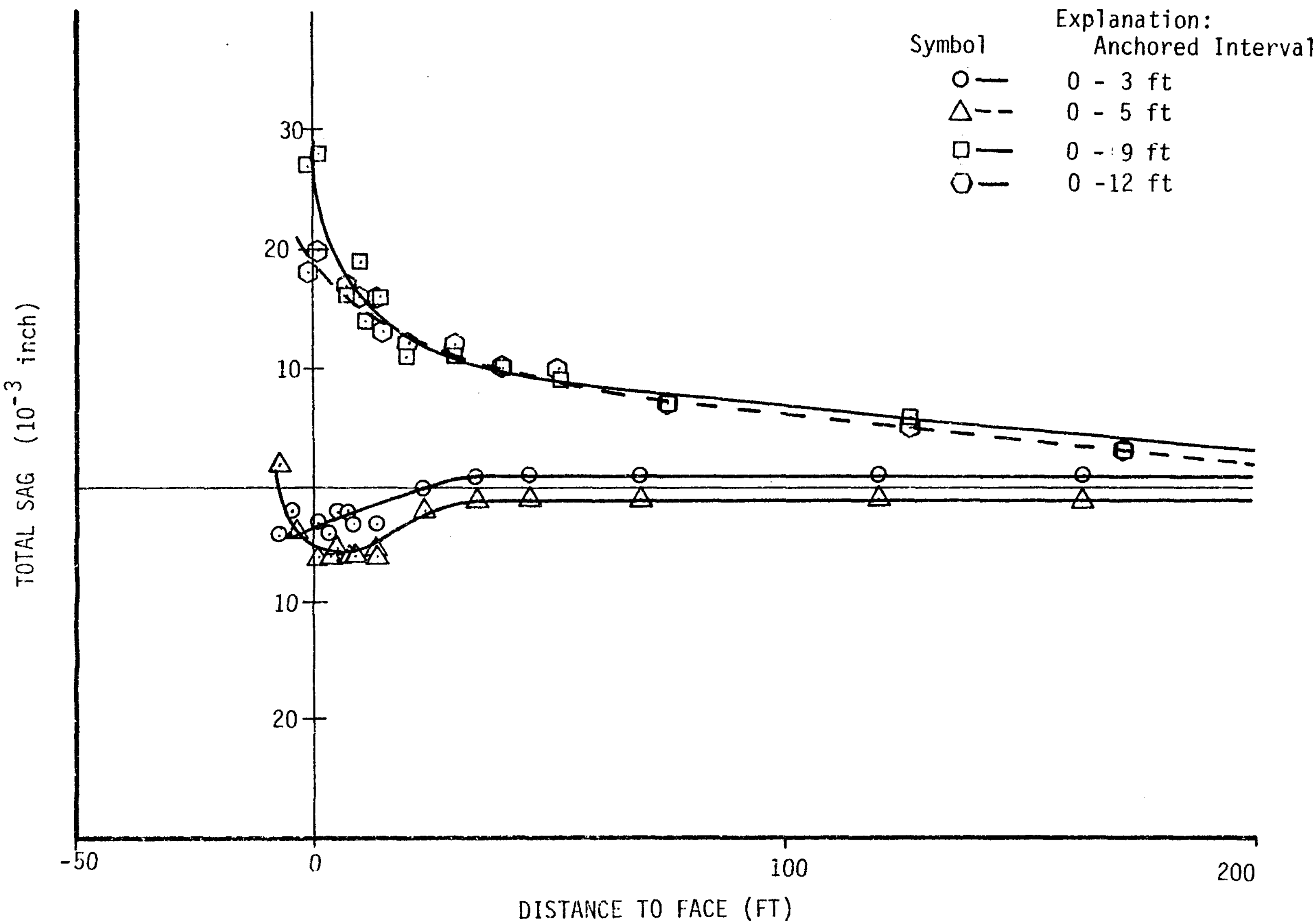


FIG 98 TOTAL RECORDED SAG, STATION AREA I

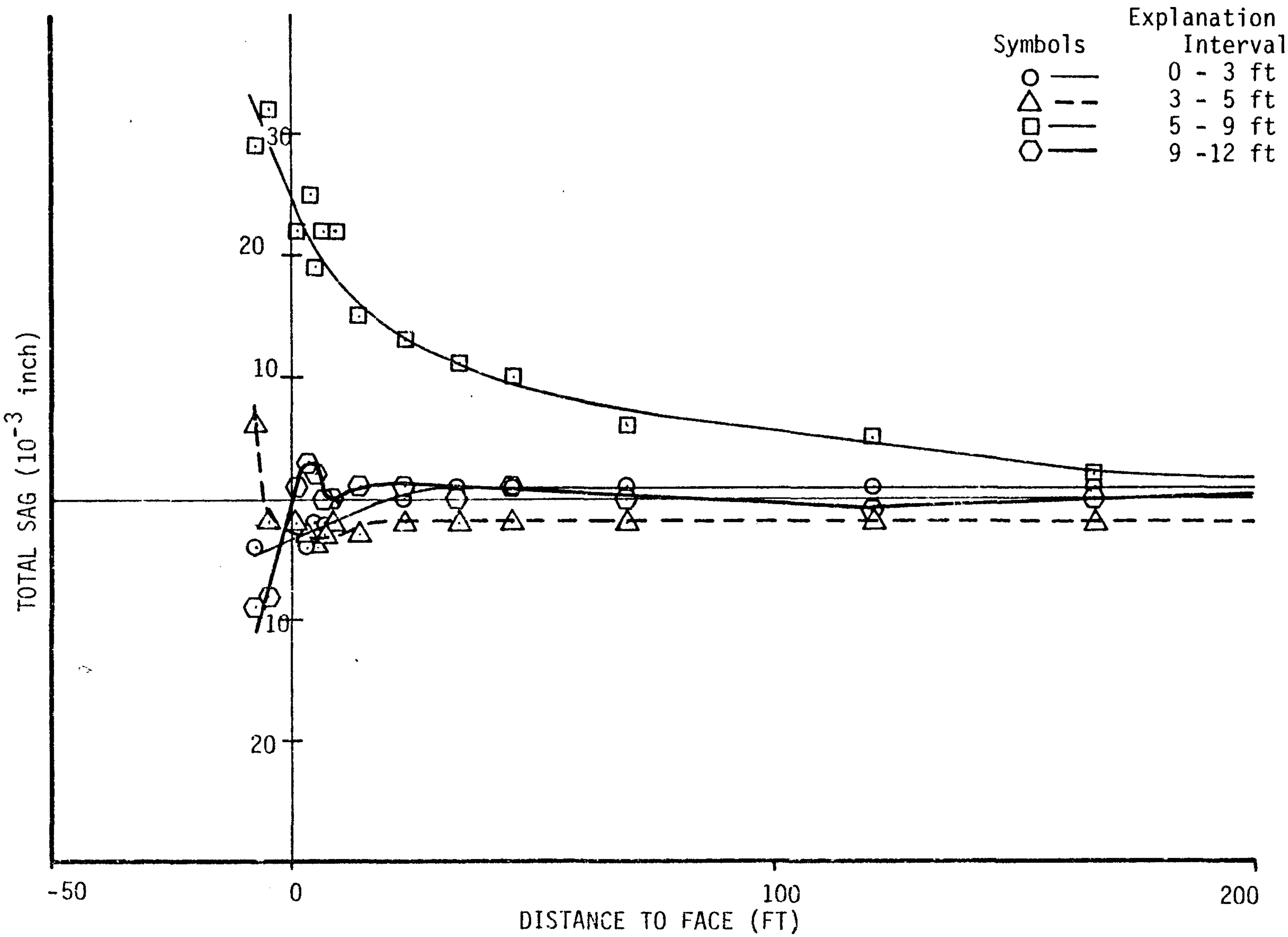


FIG 9.9 TOTAL RECORDED SAG BY INTERVALS STATION AREA I

The 5 to 9 ft interval began to show increased tensile stress with the face at a distance of 172 ft. The stress increased slowly until the face reached a distance of 60 ft. At this point tensile stress began to increase rapidly and continued increasing as long as the instruments could be monitored.

The 9 to 12 ft interval remained unaffected by mining operations until the face reached a distance of 20 ft from the instruments. The tensile stress then decreased to zero as the face approached a distance of 9 ft. At this point tensile stress increased rapidly as the face approached a distance of 3 ft. At 3 ft the tensile stress began a rapid decrease. As the face passed the instruments, stresses became compressive and showed large increases with small changes in face distance.

The data indicate that the instrumented interval behaved in a manner similar to that of a uniformly loaded, cantilever beam. The overburden provides the uniform load and the mined out, uncaved roof behind the shield supports acts as the cantilever beam. The "beam" is anchored by unmined coal and supplementary roof support. In addition the "beam" is apparently subdivided by a zone of weakness between 5 and 9 ft. As failure begins, the "beam" separates along the zone of weakness into two "beams". This results in the compressive stresses noted for the 0 to 3 ft and 9 to 12 ft intervals. In effect these intervals contain the load carrying bases of two separate beams. As failure along the zone of weakness progresses, overburden load is transferred onto the upper beam and the lower beam progressively acts only under its own weight. Data indicate that the neutral axis of this lower beam lies within the 3 to 5 ft interval.

SHIELD AND FACE OPERATIONS

Ground Control Operations

Mining operations on panel 4N were relatively free of roof fall and other ground control problems. Throughout the mining period, only one case involving ground control was encountered. On August 20, 1975, shields 1 and 2 began leaning east in response to rock pressure from the roof. By August 25, shield 1 was leaning against the rib of the barrier pillar and shield 2 was leaning against shield 1. A large amount of cave material had worked in-between shields 2 and 3. The shields were uprighted on August 26. Timber sets, single-leg hydraulic props, wire mesh and steel I-beams were utilized to upright the leaning shields.

Steel I-beams, supported by shield 3, wooden posts and single-leg props, provided supplemental roof support. Wire mesh was placed between shields 2 and 3 and along the roof to prevent additional roof material from caving on to shields 2 and 1. A chain come-along and an air wrench, anchored to shield 3 were used to pull shields 1 and 2 upright.

The instability problem resulted from the combination of a zone of weakness in the roof and a soft floor. The zone of roof weakness allowed a rock slip which provided lateral loading on shields 1 and 2. The soft saturated floor shale did not provide enough strength to resist the applied moment caused by lateral loading.

During mining operations along panel 4N no other problems with roof control were encountered.

Caving Patterns

After the start up of mining on panel 4N, caving did not commence until an unsupported roof span of 85-ft had opened up behind the shield line. Once this span caved, no significant problems with the roof were encountered.

Once caving had been initiated, a cave pattern developed. The roof tended to remain collapsed uptight behind shields along the interior portion of the face (100 ft out from either rib). Along the headgate and tailgate, the roof would open up with spans of 20 to 50 ft before caving occurred. This pattern remained relatively constant throughout mining operations. The only modification occurred at the headgate where the cave began to remain collapsed uptight behind the shields during the latter months of the project.

The caving pattern was controlled by the east-west joint set. Prior to caving, numerous closely-spaced fractures (less than 6-inches), oriented east-west, developed behind the shield face.

On several occassions, the cave behind the tailgate looked like a floor-to-roof sandstone wall where the roof had come down, without breaking up, along an east-west joint.

The cave itself consisted of large blocks and slabs of roof sandstone. These blocks varied in size from less than 2 ft on a side to over 8 ft on a side. The average block size was between 5 and 6 ft. As a result of inter-block voids, the material tended to expand in volume as it caved. Observations of the cave behind the shields indicated that only small amounts of subsequent consolidation occurred after caving was completed. This provided an excellent support base for the upper, undisturbed, rock strata.

Face Operations

The occurrence of large blocks of coal. sloughing off of the face, presented the only major problem to mining operations in this area.

The occurrence of large blocks of coal was principally restricted to the middle one-third of the working face. This represents the zone where the entire roof load is assumed by the face and shields without any supplemental support from the adjacent pillars. The blocks varied in size and reached a maximum of 2 ft by 3 ft by 6 ft. The blocks resulted when load was applied to an area where the two coal cleat directions intersected within 2 to 3 ft of the longwall face.

Face Faulting

Since March 25, 1976, the shield face was negotiating two separate face faults. These faults were characterized by 5 to 6-ft offsets with minimal brecciation of rock within the fault zones.

No significant problems were encountered in negotiating shields through these coal seam displacements. The uneven roof and floor surfaces caused only minor problems when the shields were advanced.

SUMMARY

The subsurface instrumentation program at Kaiser Steel Corporation's York Canyon Mine was designed to determine loads imposed upon the shield supports by longwall mining and the reaction of the rock mass to mining advance and to correlate the observed reactions and loads with the geologic structure in the panel area. The subsurface program included a longwall panel instrumentation sequence and a program of laboratory and in situ physical rock property determinations.

Physical Rock Properties

The laboratory determinations of the physical properties of the roof sandstone, the coal and the floor sandstone were made by testing 91 specimens from 5 diamond coreholes and from bulk samples of coal from the face. A summary of physical testing results is presented in Table 13, p. 196.

These tests indicate that the roof sandstone was extremely variable in physical rock properties. This wide scatter of test results is attributed to the localized presence of thin beds of coal and carbonaceous shale. The coal was the most uniform of the three rock types tested and was characterized as relatively low strength and stiffness coal. The floor sandstone was the most competent rock tested and was characterized by high compression strength with low elastic stiffness.

In situ testing consisted of a series of plate bearing tests and coal hardness determinations. A summary of the moduli values obtained from the plate bearing tests is presented in Table 16, p. 200, and a summary of coal hardness data is presented in Table 17, p. 211.

The plate bearing tests generally paralleled the results of laboratory testing, but recorded rock strengths were smaller as a consequence of in situ anisotropies. In addition to the three rock types tested in the laboratory, plate bearing tests were performed on the boney coal at the top of the seam and the carbonaceous shale at the bottom of the seam. The testing indicated that both were low strength, low elastic stiffness material with variable physical rock properties.

Rock hardness data indicates that coal hardness is extremely variable. No discernable trends were noted.

Subsurface Instrument Data

Subsurface instrumentation was subdivided into three categories: support load instrumentation, face instrumentation and entry instrumentation.

Support Load Instrumentation:

Records of support loads were obtained with hydraulic pressure recorders. Support load data is summarized on Table 18, p. 216.

The data indicates that the shields are subjected to differential loading at the time the shields are set. It was observed that the east, or headgate leg of each shield was subjected to a positive pressure differential of 200 psi. The only exceptions were the tail-gate shields where the effects adjacent barrier pillar over rode the trend.

The pressure differential appears to result from stresses imposed by the higher topography to the east of the panel area.

The data also indicates that the face faulting encountered during mining operations caused a redistribution of roof loads into areas of high stresses separated by low fault zones.

Face Instrumentation:

Face instrumentation was installed in an attempt to correlate support load history, panel power consumption and coal hardness. Because variations in coal hardness exceeded the sensitivity of the power consumption recorder no correlations could be established.

Entry Instrumentation:

Four types of entry instrumentation were utilized; panel pressure cells, convergence instrumentation, differential roof-floor horizontal movement instrumentation and roof-sag instrumentation.

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Panel Pressure Cells: Eight of twenty installed pressure cells were influenced by mining activity. These indicated that the width of the pressure arch is apparently related to the depth of overburden and that the irregular topography above panel 4N yielded pressure arch widths 60% less than the widths predicted from the literature (Alder, Potts and Walker, 1951 and North of England Safety in Mines Research Committee). A graph illustrating the various pressure arch data is presented in Figure 86, p. 248.

Convergence Instrumentation: A summary of convergence instrumentation results is presented in Table 25, p. 253. The convergence recorded during the last 10 ft of face advance was considerably less than that reported in prevous studies. Previous workers (National Coal Board, 1965, p. 5 and Alder, 1968, p. 63-65) indicate that convergence of 1/2-inch per ft of face advance can be expected. Total recorded convergence for panel 4N instruments rarely exceeded 0.4 inches.

Differential Roof-FLoor Horizontal Movement Instrumentation: Table 26, p. 267 summarized observed horizontal movement data. In general, the data indicates that with face advance, the roof tends to move towards the face and towards the panel. The rate of horizontal movement during the last 10 ft of face advance averaged 0.05-inches. This is less than the 1/2-inch rate reported by the National Coal Board (1965, p. 8).

Roof-Sag Instrumentation: Roof-sag instrumentation indicated that the massive roof sandstone behaved like a uniformly-loaded contilever beam prior to caving.

Shield and Face Operations

Only a single ground control problem was encountered during mining of panel 4N. A slip in the roof rock provided lateral loading of the two headgate shields and a soft floor failed to provide any resistance to the induced moment. The two shields were uprighted without difficulty after leaning against the rib at an angle of about 30^{o}. Caving of the roof proceeded well after an initial span of 85 ft opened up behind the shields. The caving pattern behind the headgate and tailgate shields tended to open up with spans of 20 to 50 ft before caving. Along the interior portions of the shield face the roof remained caved uptight behind the shield line.

Caving was controlled by the east-west joint set. The cave consisted of large angular blocks of roof sandstone that varied in size 2 ft to 8 ft on a side.

During the latter part of mining operations, the shield face was negotiating two fault zones without any significant problems.

BIBLIOGRAPHY

Abel, J. F., 1976, Personal communication.

Abel, J. F., and Hoskins, W. N., 1976, "Confined Core Pillar Design for Colorado Oil Shale", 9th Oil Shale Symposium, Colorado School of Mines Quarterly (in press).

Adler, Lawrence, 1968, "Roof Control in Longwall Mining", Mining Congress Journal, March 1968, p. 58-67.

Alder, H., Pott, E.L.J., and Walker, A., 1951, "Research on Strata Control in the Northern Coal Field of Great Britian", International Conference about Rock Pressure and Support in the Workings, Liege, p. 104-113.

Archibald, G.I., and Weir, A.M., 1969, "A Field Study of Subsidence", The Chartered Surveyor, v. 102, No. 4, p. 177-186.

ASTM, 1976, Annual Book of ASTM Standards, Part 19, Natural Building Stones; Soil and Rock; Peats, Mosses, and Humus: Philadelphia, American Society for Testing and Materials, 486 p.

Aynsley, W.J., and Hewitt, G., 1961, "Subsidence Observations Over Shallow Workings; Including Pneumatic Stowing and Rapidly Advancing Faces", Mining Engineer, v. 120, No. 7, April, p. 552-569.

Barrientos, Gonzalo and Parker, Jack, 1974, "Use of the Pressure Arch in Mine Design at White Pine", Trans. Soc. Mining Engineers, AIME, vol. 256, p. 75-82.

Barry, A.J., and Wojciechowski, J.J., 1954, "Roof Movement Study of Retreating Longwall Operation, Lancashire No. 15 Mine, Bakerton, Cambria County, Pa.", United States Bureau of Mines Report of Investigations 5028, 13 p.

Barry, A. J., Zuna, A., Gilley, J. L. and Oitto, Jr., R.H., 1967, "Investigation of Stress Distributions in Burst-Prone Coal Pillars", United States Bureau of Mines Report of Investigations 6971, 11 p.

Barry, A.J., and Nair, O.B., 1970, "Insitu Tests of Bearing Capacity of Roof and Floor in Selected Bituminous Coal Mine, A Progress Report - Longwall Mining", United States Bureau of Mines Report of Investigations 7406, 20 p.

Beevers, C., and Wardell, K., 1955, "Recent Research in Mining Subsidence", Trans. Inst. Mining Engineers, v. 114, p. 223-244.

Blatz, E.H., and Bachman, G.O., 1956, "Notes on the Geology of the Southeastern Sangre de Cristo Mountains, New Mexico", in New Mexico Geological Society Guidebook of Southeastern Sangre de Cristo Mountains, 7th Field Conf., 1956, p. 107-108.

Bolstad, D.D. Alldredge, J.R., and Mahtab, M.A., 1973, "Procedures Used for Sampling Fracture Orientations in an Underground Coal Mine", United States Bureau of Mines Report of Investigations 7763, 9 p.

Boyum, B.H., 1961, "Subsidence Case Histories in Michigan Mines", Proc. Fourth Symposium on Rock Mechanics, April, p. 19-57.

Brauner, Gerhard, 1973, "Subsidence Due to Underground Mining (In Two Parts)", Information Circular, United States Bureau of Mines, No. 8571 and 8572.

Brown, A., and Casey, F.L., 1971, "An Investigation Into Surface Subsidence Associated With the Extraction of Coal Seams"; Mining Research Centre Internal Report MR 71/88-IO, Dept. of Energy, Mines and Resources Mines Branch Ottawa.

Bureau of Mines, 1973, "Rock Mechanics Instrumentation for Mine Design", U. S. Bureau of Mines Information Circular, United States Bureau of Mines, No. 8585.

Chambon, Claude, and Schwartz, Bertrand, 1964, "Study of the Effect of Longwall Faces on Roadways", Int. Conf. Strata Control and Rock Mechanics, 4th, New York, Columbia University, 1964, p. 109-122.

Choi, D.S., Dahl, D.H., and von Schonfeldt, H., "Design of Longwall Development Headings", Trans. Soc. Mining Engineers, AIME, vol. 258, p. 358-363.

Clark, K.F., 1966, "Geology of the Sangre de Cristo Mountains and Adjacent Areas Between Taos and Raton, New Mexico", in New Mexico Geological Society Guidebook, Taos-Raton-Spanish Peaks Country, 17th Field Conf., 1966, Fig. 1 and p. 62-64.

Coates, D.F., and Gyenge, M., 1964, "The Mechanics of Support and Caving in Longwall Top-Slicing", Reprinted from the Proceedings of the Fourth Intl. Conference on Strata Control and Rock Mechanics, Columbia University, New York, May, p. 70-84.

Couetdic, J.M., and Barron, K., 1975, "Plate-Load Testing as a Method of Assessing the Insitu Strength Properties of Western Canadian Coal", Int. J. Rock Mechanics Mining Science and Geomechanics, Abstr., v. 12, p. 303-310.

Crane, W.R., 1931, "Essential Factors Influencing Subsidence and Ground Movement", Information Circular, United States Bureau of Mines, No. 6501.

Corden, C.A.H., and King, H.J., 1965, "A Field Study of the Development of Surface Subsidence", Int. Rock Mechanics, Mining Science, v. 2.

Dahl, H.D. and Parson, R.C., 1972, "Ground Control Studies in the Humphrey No. 7 Mine, Christopher Coal Div., Consolidated Coal Co.", Trans. Soc. Mining Engineers, AIME, vol. 252, p. 211-222.

Deere, D.U., and Miller, R.P., 1965, Engineering Classification and Index Properties of Intact Rock, Clearance House for Federal Scientific and Technical Information, Dept. of Commerce, Washington, D.C.

Deere, D. U., 1968, "Geological Considerations", in Rock Mechanics in Engineering Practice (Stagg, K.G. and Zienkiewicz, O.C. eds.) p. 1-20.

Diamond, W.P., McCulloch, C.M., and Bench, B.M., 1976, Use of Surface Joint and Photolinear Data for Predicting Subsurface Coal Cleat Orientation", United States Bureau of Mines Report of Investigations 8120, 13 p.

Divisional Strata Control Research Council, 1953, "Report on the Effects of Workings in Adjacent Seams Upon New Development", Trans. Inst. Mining Engineers, vol. 113, p. 389-403.

Divisional Strata Control Research Council, 1950, "Memorandum on the Design of Mine-Working to Secure Effective Strata Control", Trans. Inst. Mining Engineers, vol. 110, p. 255.

Drent, S., 1957, "Some Considerations on the Connection Between Time-Curves and the Thickness of the Non-Car-Boniferous Overburden in the South Limburg Coalfield", Proc. European Congress Ground Movement, Leeds, p. 49-57.

Fenneman, N.M., 1931, Physiography of Western United States, New York, McGraw-Hill, p. 1-42.

Fläschenträger, H., 1957, "Considerations in Ground Movement Phenomena Based on Observations Made in the Left Bank Lower Rhine Region", Proc. European Congress Ground-Movement, Leeds, p. 58-73.

Grander, F.P., and Hibberd, G., 1962, "Subsidence-The Transferring of Ground Movement to Surface Structures", Mining Engineer, v. 121, p. 19-36.

Gentry, D.W., and Abel, J.F. Jr., 1976, "Rock Mass Response to Longwall Mining", Mines Magazine, Colorado School of Mines, March.

Gentry, D.W., and Abel, J.F. Jr., 1976, "Surface Response to Longwall Coal Mining in Mountainous Terrain", Coal Mining Activities and Concepts of Multiple Land Use, (in press), AEG, Colorado Geological Survey and APGS, Denver, Colorado.

Grond, G.J.A., 1957, Grond, G.J.A., 1957, Ground Movements Due to Mining", Collifry Engineering, v. 34, p. 157-197.

Hall, M., and Orchard, R.J., 1962, "Subsidence Profile Characteristics", The Chartered Surveyor, v. 95, No. 8, p. 422-428.

Hall, W.J., Newmark, N.W. and Hendron, Jr., A.J., 1974, "Classification, Engineering Properties and Field Exploration of Soils, Intact Rock and In situ Rock Masses", Washington, D.C., Directorate of Regulatory Standards, U.S. Atomic Energy Commission, p. 60-61, 103.

Hendron, A.J., Jr., 1968, "Mechanical Properties of Rock", in Rock Mechanics in Engineering Practice (Stagg, K.G., and Zienkiewicz, D.C., eds.), p. 21-53.

Hudspeth, H.M., Phillips, D.W., and Walker, A., 1935, "Fourth Progress Report of an Investigation Into the Causes of Falls, and Accidents Due to Falls in Bord-and-Pillar Whole Workings", Trans. Inst. Min. Engr., vol. 91, p. 349-367.

Jakobi, O., 1956, "The Pressure on Seam and Goaf", Int'l Strata Control Congress, Essen, October.

Jenkins, J.D., and Storey, I., 1960, "Support Loads at the Coal Face", Trans. Inst. Mining Engineers, v. 119, p. 700-712.

Johnson, R.B., Dixon, G.H., and Wanek, A.A., 1966, Late Cretaceous and Tertiary Stratigraph of the Raton Basin on New Mexico and Colorado", in New Mexico Geological Society Guidebook, Taos - Raton-Spanish Peaks Country; 17th Field Conf., 1966: p. 89-98.

Kapp, W.A., 1973, "Mine Subsidence", Fourth Annual Symposium, Illawarra Branch, Aust, Inst. Min. Met., Paper 1, p. 1-9.

King, H.J., and Whetton, J.T., 1957, Mechanics of Mining Subsidence", Collifry Engineering, v. 35, p. 247-285.

Knothe, S., 1959, "Observations of Surface Movements and their Theoretical Interpretation", Collifry Engineering, v. 36, p. 210-218.

Komar, C.A., Overbey, K.W., Jr., and Pasini III, J. 1973, "Directional Properties of Coal and their Utilization in Underground Gasification Experiments", United States Bureau of Mines Technical Progress Report 73, 11 p.

Lahee, F.H., 1961, Field Geology, McGraw Hill, New York, 926 p.

Laurie, K.P., 1976, "History of Vermejo Park", New Mexico Geol. Soc. Guidebook, 27th Field Conf., p. 87.

Lee, A.J., 1966, "The Effect of Faulting on Mine Subsidence", The Mining Engineer, August, p. 733-745.

Leeman, E.R., 1959, "The Measurement of Changes in Rock Stress Due to Mining", Mine and Quarry Engineering.

Mahtab, M.A., Bolstad, D.D., and Kendorski, F.S., 1973, "Analysis of the Geometry of Fractures in San Manuel Copper Mine, Arizona", United States Bureau of Mines Report of Investigations 7715, 24 p.

Maize, E.R., Thomas, Edward, and Greenwald, H.P., 1941, "Studies of Roof Movement in Coal Mines", Report of Investigations, United States Bureau of Mines, No. 3562.

Marr, J.E., 1959, "A New Approach to the Estimation of Mining Subsidence", Trans. Inst. Mining Engineers, August, v. 118, p. 692-706.

Millar, T.C., and Sporcic, Rudolph, 1964, "Development of a Hydraulic Device for Measuring Relative Pressure Changes in Coal During Mining: A Progress Report", United States Bureau of Mines Report of Investigation 6571, 13 p.

McCulloch, C.M., Diamond, W.P., Bench, B.M., and Duel, Maurice, 1975, "Selected Geologic Factors Affecting Mining of the Pittsburgh Coalbed", United States Bureau of Mines Report of Investigations 8093, 72 p.

McMulloch, C.M., Lambert, S.W., and White, J.R., 1976, "Determining Cleat Orientation of Deeper Coalbeds from Overlying Coals", United States Bureau of Mines Report of Investigations 8116, 19 p.

Mukherjee, K.P., Samanta, S., and Singh, B., 1971, "Strata Control Observations at a Longwall Face in the Pharia Coal Field", Jour. Mines, Metals and Fuels, vol. 19, no. 4, p. 103-111.

National Coal Board, 1963, "Principles of Subsidence Engineering", National Coal Board Mining Department, Information Bulletin 63/240.

National Coal Board, 1965, "Strata Control on Longwall Faces", NCB Mining Research Establishment Bulletin, No. 10, 11 p.

National Coal Board, 1966, Subsidence Engineers' Handbook; National Coal Board Mining Department.

National Coal Board, 1975, Subsidence Engineers' Handbook; National Coal Board Mining Department.

North of England Safety in Mines Research Committee, 1949, "7th Progress Report of an Investigation into the Cause of Falls and Accidents due to Falls", Trans. Inst. Mining Engineers, v. 108, p. 489-410.

Obert, L., and Long, A.E., 1962, "Underground Borate Mining, Kern County, California", Report of Investigations, United States Bureau of Mines, No. 6110.

Ogden, H., and Orchard, R.J., 1960, "Ground Movements in North Staffordshire"; Trans. Inst. Mining Engineers, January, v. 19, p. 259-272.

Orchard, R.J., 1954, Recent Developments in Predicting the Amplitue of Mining Subsidence", JI.R. Instn. Chart. Surv., v. 33, p. 864.

Orchard R.J., 1957, "Prediction of the Magnitude of Surface Movements", Collifry Engineering, v. 34, p. 455.

Orchard, R.J., 1964, "Partial Extraction and Subsidence", Mining Engineer, April, No. 43.

Orchard, R.J., 1964, "Surface Subsidence Resulting from Alternative Treatments of Collify Goaf", Collifry Engineering, October.

Orchard, R.J., 1973, "Some Aspects of Subsidence in the U.K", Aust. Inst. Mining Met. Symposium, February.

Orchard, R.J., and Allen, W.S., 1965, "Ground Curvature Due to Coal Mining", Chartered Surveyor, May, v. 97.

Orchard, R.J., and Allen, W. S., 1970, "Longwall Partial Extraction Systems", Mining Engineer, June, p. 523-535

Orchard, R.J., and Allen, W.G., 1975, "Time Dependence in Mining Subsidence", Inst. Mining Met., March, p. 643-659.

Overbey, W.K., Jr., Komar, C.A. and Pasini III., J., 1973, Predicting Probable Roof Fall Areas in Advance of Mining by Geological Analysis", United States Bureau of Mines Technical Progress Report 70, 17 p.

Parker, Jack, 1974, Practical Rock Mechanics for Miners", Reprinted from a Seven Part Series, E/MJ Publication.

Phillips, D.W., and Jones, T.J., 1941, "Strata Movements Ahead of and Behind Longwall Faces", Trans. Inst. Mining Engineers, vol. 101, p. 348-351, 356-357.

Pillmore, C.L., 1976, "The York Canyon Coal Bed", New Mexico Geol. Soc. Guidebook, 27th Field Conf., p. 250-251.

Pillmore, C.L., 1969, "Geology and Coal Deposits of the Raton Coal Field Colfax County, New Mexico", The Mountain Geologist, v. 6, no. 3, p. 125-142.

Priest, A.V., and Orchard, R.J., "Recent Subsidence Research in the Nottinghamshire and Derby shire Coalfield", Trans. Inst. Mining Engineers, v. 117, p. 499.

Sarkar, S.K., Singh, B. and Sinha, K.N., 1964, "Convergence and Its Implications on Mine Workings", Jour. Mines, Metals and Fuels, vol. 12, no. 7, p. 203.

Savely, J.P., 1972, "Orientation and Engineering Properties of Jointing in the Sierrita Pit", (M.S. Thesis), Tucson, University of Arizona.

Schwartz, Bertrand, 1961, "Movements of the Roof and Floor in Roadways", Proc. Symposium on Rock Mechanics, 4th University Park, Pa., Pennsylvania State University, 1961, Bulletin of the Mineral Industries Experiment Station, p. 1-10.

Schwartz, Bertrand, 1960, "Prediction of Rock Movement in Roadways", Int. Conf, Strata Control, Brd, Paris. May 1960, Reveu de L'Industrie Minerale, p. 363-377.

Singh, T.N., and Singh, B., 1968, "Angle of Draw in Mine Subsidence", Journal of Mines, Metals & Fuels, v. 16, p. 253-258.

Singh, T.N., and Singh, B., 1974, "The Mechanism of Caving of Longwall Faces", Journal of Mines, Metals & Fuels, July 1974, p. 189-201.

Spencer, L.H., 1953, "Subsidence Research Carried Out in the Bestwood Area of Notting-Hamshire", Mining Engineer, December, v. 120, No. 3, p. 201-210.

Spruth, Ing. Fritz, 1951, "Distribution of Pressure Up, On and Near the Coal Face", International Conference About Rock Pressure and Support in the Workings, Liege, April 1951, p. 36 - 44.

Stagg, K.G., 1974, "Insitu Tests on the Rock Mass", in Rock Mechanics in Engineering Practice (Stagg, K.C., and Zienkiewicz, O.C., eds), New York, p. 129-134.

Stateham, R.M., 1974, "Field Studies on an Unsupported Roof, York Canyon Coal Mine, Raton, New Mexico", United States Bureau of Mines Report of Investigations 7886, 17 p.

VanEschen, G.F., 1961, "The Climate of New Mexico, Climatological Summaries for 35 Weather Stations and the State", Business Information Series, No. 37, Albuquerque, College of Business Administration, The University of New Mexico, p. 47.

Walpole, R.E. and Myers, R.H., 1972, "Probability and Statistics for Engineers and Scientists", New York, MacMillian Pub. Co., Inc., p. 321.

Wardell, K., 1953, "Some Observations on the Relationship Between Time and Mining Subsidence", Trans. Inst. Mining Engineers, v. 113, p. 471-483.

Wardell, K., 1957, "The Minimisation of Surface Damage", Collify Engineering, v. 34, p. 361.

Wardell, K., 1959, "The Problems of Analyzing and Interpreting Observed Ground Movement", Collify Engineering, December, p. 529-538.

Wardell, K., 1969, "Ground Subsidence and Control", Mining Congress Journal, January, p. 36-42.

Wardell, K., and Eyon, P., 1968, "Structural Concept of Strata Control and Mine Design", Mining Engineering, v. 127, p. 633-645.

Wardell, K., and Webster, N.E., 1957, "Surface Observations and Strata Movement Underground", Collifry Engineering, v. 34, p. 329-336.

Weir, A. McL., 1966, "Subsidence - The Interpretation of Traveling Strain Observations", Collify Guardiam, May, p. 576-577.

Whetton, J.T., 1957, "A General Survey of the Ground Movement Problem", Collify Engineering, v. 34, p. 153.

Whetton, J.T., and King, H.J., 1961, "The Time Factor in Mining Subsidence", International Symposium on Mining Research, Rolla, Missouri, v. 1, ppr. 31, p. 1-29.

Wilson, A.H., 1972, "Research into the Determination of Pillar Size, pt. 1, A hypothesis concerning Pillar Stability", The Mining Engineer, v. 131, no. 141, p. 409-417.

Woodward, L.A., and Snyder, D.D., 1976, "Structural Framework of the Southern Raton Basin", New Mexico Geol, Soc. Guidebook, 27th Field Conf., map, p. 125-127.

Yi-Fu, Tuan, Everard, C.E., and Widdison, J.G., 1969, Climate of New Mexico, Santa Fe, New Mexico, State Planning Office, p. 18 and 159, Fig. 2.

Zenc, M., 1969, "Comparison of Bals' and Knothe's Methods of Calculating Surface Movements due to Underground Mining", Int. Journal Rock Mechanics Mining Science, March, p. 159-190.

Zuess, Hilaria, 1967, Geology of the Raton Area, Colfax County, Raton Quadrangle, New Mexico, Colorado School of Mines unpub. M.S. thesis, p. 84.

APPENDIX A

FIELD PROCEDURES

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FIELD PROCEDURES

This appendix presents a summary of the instrumentation and field procedures utilized in the subsurface rock mechanics investigation conducted as a part of the shield-type support demonstration at the York Canyon Mine. A brief description of each instrument is provided along with a summary of the testing or monitoring procedure. Where an American Society for Testing and Materials (ASTM) Standard Method or Method of Test applied, only a reference to the Standard is provided.

Field instrumentation and procedures involved three general areas of activity: determination of panel geology, determination of rock properties and subsurface instrumentation.

Geologic Field Methods

The stratigraphy and geologic structure of panel 4N were determined from a field exploration program that included the examination of mine workings and surface outcrops, core test borings and borehole geophysics. The field program was designed to provide a detailed description of the geologic setting of the longwall panel, including the occurrence of faults and other geologic discontinuities. The field program was conducted in accordance with the applicable sections of the ASTM Standard Recommended Practice for Investigation and Sampling Soil and Rock for Engineering Purposes, Designation D 421-69 (1975) (ASTM, 1976, p. 63).

The soils overlying bedrock above panel 4N were examined to determine their thickness and composition. The soils were described and classified in accordance with the ASTM Standard Recommended Practice for Description of Soils (Visual - Manual Procedure), Designation D 2488-69 (1975) (ASTM, 1976, p. 314).

Surface outcrops and mine workings adjacent to panel 4N were examined for selected geologic factors that would affect mining operations (McCulloch and others, 1975). Particular attention was directed at determining rock stratigraphy and lithologies as well as the orientations of the principal directions of joints, faults, and the coal cleat. Geologic field methods outlined by Lahee (1961) were utilized throughout the program.

Joint, fault and cleat orientations were determined by detailed mapping with an induction-damped Brunton compass and a 100-ft tape utilizing methods outlined by Savely (1972). Surface data and maplinear data were utilized to determine the correlations between coal cleat and the regional joint pattern (Diamond and others, 1970).

Savely's (1972) method for determining fracture orientations utilizes measurements along a line across the outcrop or exposed face. The reference line is spray painted across the outcrop at a convenient height. The line can either be horizontal or inclined at a slight angle. A measuring tape, fixed at both ends, is placed along the outcrop coincident with the reference line. Starting at the zero point, a traverse across the outcrop is performed. The following data are recorded for every joint, fracture or other geologic discontinuity that intersects a zone one foot above and below the reference line:

1. Type of feature (joint, fault, etc)
2. Distance from the starting point measured along the tape (where the fracture does not intersect the reference line, its projected intercept is utilized)
3. Strike and dip
4. Trace length
5. Continuity
6. Tightness (open or closed)
7. Character of fracture surface (smooth, slickensided, irregular, etc.)
8. Planarity (planar, curvilinear, etc.)

The strike and dip data were then plotted as poles to the planes on a lower hemisphere projection of a Schmidt Equal Area net. These plots are contoured to determine principal orientations.

Rock core test borings were drilled at selected locations around panel 4N. The holes were drilled vertically and at angles varying from 45^{o} to 51^{o} to delineate the lithology and stratigraphy of the roof and floor strata adjacent to the York Canyon Coal Seam. The drilling program was conducted in accordance with the applicable sections of the ASTM Standard Method for Diamond Core Drilling for Site Investigation, Designation D 2113-70 (1975) (ASTM, 1976, p. 260). A CP-55, air-powered drill was used for the drilling program. The drilling method was rotary wash with 2-, 3- or 5-ft, NX-sized, double-tube core barrels with diamond bits. The drilling was performed by Colorado School of Mines personnel, and the U. S. Bureau of Mines provided the equipment.

The rock core was placed in cardboard core boxes as it was removed from the corebarrel. A geologist logged the core and maintained a record of drilling notes. The core logging included descriptions of rock lithologies and the character, orientation and frequency of jointing. The length of the longest and shortest pieces of recovered core and the rock quality designation (RQD) were determined for each core run. The RQD represents the ratio of recovered pieces of core greater than 4 in. to the length of the interval cored.

Borehole geophysics was performed on the surface borings drilled to install the three multiple position borehole extensometers. Resistivity, density and natural gamma ray count were determined in each test boring. The geophysics was run by Century Geophysics Corporation of Denver, Colorado. Kaiser Exploration of Raton, New Mexico, provided a lithologic interpretation of the geophysical logs.

Surface resistivity measurements and a hammer seismic survey were performed by a team from the U. S. Bureau of Mines in Denver, Colorado, in an attempt to delineate fault trends in the area of panel 4N. As part of this survey, a velocity profile was established which was utilized to determine the depth of overburden and the weathered zone.

Rock Property Determinations

The rock property determinations consisted of laboratory and *in situ* rock testing programs. The testing programs were designed to provide the physical characteristics of the coal seam and adjacent roof and floor strata.

Laboratory Tests:

The laboratory testing program was designed to determine the following rock parameters:

1. Uniaxial compressive strength
2. Elastic modulus
3. Poisson's ratio
4. Peak intact rock properties
    a. cohesion
    b. angle of internal friction
5. Residual intact rock properties
    a. cohesion
    b. angle of internal friction

Test specimens of the roof and floor strata were obtained from NX-sized core samples from the test borings. The coal test specimens were NX-sized cores drilled from large coal blocks obtained at the mining face.

The uniaxial compressive strengths of the specimens were determined by the ASTM Standard Method for the Unconfined Compressive Strength of Intact Rock Core Specimens, Designation D 2938-71a (ASTM, 1976, p. 374).

The elastic modulus and Poisson's ratio for each specimen were determined by the ASTM Standard Method of Test for Elastic Moduli of Rock Core Specimens in Uniaxial Compression, Designation D 3148-72 (ASTM, 1976, p. 404).

The peak intact rock properties of cohesion and internal angle of friction were determined from triaxial compression tests. The tests were performed in accordance with the ASTM Standard Method of Test for Triaxial Compressive Strength of Undrained Rock Core Specimens without Pore Pressure Measurements, Designation D 2664-67, (1974) (ASTM, 1976, p. 326). The angle of internal friction and cohesion were determined by the method described by Hall and others (1974, p. 62-63).

Briefly, the method involves plotting the major stress at failure versus the confining stress and performing a linear regression analysis of the data. The resultant line has the form of:

$$s_1 = S_o + Ks_3$$

where:

s_1 = failure stress

S_o = unconfined compression strength

$$\text{cohesion} = \frac{S_o}{2K^{1/2}}$$

s_3 = confining stress

$$K = \frac{1 + \sin \phi}{1 - \sin \phi}$$

ϕ = angle of internal friction

The residual intact rock properties of cohesion and angle of internal friction were determined by direct shear tests. A test specimen consisted of two NX-sized core discs with planar surfaces placed one on top of the other. The method involved the determination of the failure shear strength at an applied vertical stress. The shear strength was plotted versus the normal stress and a linear regression analysis performed. The resultant line was of the form:

$$T = \bar{c} + Ks$$

where:

T = shear strength

$\bar{c}$ = cohesion

s = normal stress

$$K = \frac{1 + \sin \phi}{1 - \sin \phi}$$

ϕ = angle of internal friction

In Situ Rock Property Tests:

Several tests were performed to determine the physical properties of the *in situ* rock. These tests included plate bearing tests on the roof and floor adjacent to the coal seam and Schmidt hammer hardness determinations along the coal seam.

Relative rebound-hardness values for the coal seam were obtained with a Soil Test, Inc., rock classification hammer. This provided Schmidt hardness values for the coal seam. Coal hardness was determined at selected points along the entries adjacent to panel 4N. Test points were positioned between 5 and 6 ft above the floor of the entry and were spaced 50 ft apart along unmined portions of the panel and 100 ft apart along entries adjacent to mined-out portions of the panel.

The test procedure involved placing the rock hammer perpendicular to a level surface on the coal. With the hammer in place, the plunger was depressed with a gradual increase in applied pressure until it impacted. A reading was then obtained from the scale on the side of the test hammer. This procedure was repeated five times at each test point, and the last three readings were recorded and averaged to obtain the hardness value for that test location. The average hardness value was utilized to determine an approximation of the tangent modulus of deformation, E, by the following formula (Deere and Miller, 1965):

$$E = (0.259\ R - 4.29) \times 10^6$$

where R = Schmidt hardness value.

In Situ jacking tests were performed to determine the bearing capacity of the roof and floor adjacent to the coal seam. Test sites, spaced between 200 and 300 ft apart, were located in entries adjacent to panel 4N. The test equipment was provided by the U. S. Bureau of Mines, Colorado School of Mines and Kaiser Steel Corporation. The actual testing was performed by Colorado School of Mines personnel. A detailed description of the testing equipment and procedures is presented by Barry and Nair (1970). A brief summary follows.

The testing apparatus consisted of the following equipment:

1. A 100-ton capacity hydraulic ram with a stroke of about 8 in.
2. A 10,000 psi hand-operated hydraulic pump with an attached 20,000 psi pressure gauge
3. A T-2 theodolite used as a level sighting device to measure strata penetration and ram extension remotely by observing movement of separately attached scales having 0.02-in. divisions
4. A set of square penetrometer plates of dimensions 4-in. by 4-in., 6-in. by 6-in. and 8-in. by 8-in. The plates were 2 in. thick with rounded edges
5. A 14-in. by 14-in. steel bearing plate with wooden blocking
6. Miscellaneous parts including high-strength steel tubular sectionalized extensions, high-pressure hydraulic lines, high-pressure valves and fittings, and construction tools required for preparation of test sites

The test procedure at a test location involved three phases: the selection and preparation of the test location, the roof bearing capacity test and a floor bearing capacity test.

The test sites were located along the headgate haulage entry and the tailgate entry adjacent to panel 4N in areas that appeared to be representative of normal conditions. Test sites were spaced about 200 ft apart except where abnormal quantities of water precluded testing. In preparing the test site, the roof and floor were cleaned of loose material, and the test surfaces were made relatively flat. The equipment was set up such that the bearing area opposite the penetrometer test plate was much larger that the penetrometer plate area. The graduated scales were attached separately to the ram and casing to measure penetration of the test plate and deformation beneath the bearing plate. The theodolite was set up 10 to 15 ft away from the test assembly and sighted on the two graduated scales.

The test procedure involved applying a load, at a constant rate, until a predetermined stress level was reached. While the constant load was maintained, penetration values for both the bearing plate and the pentration plate were recorded. The elapsed time since the stress level was first reached was also recorded with each corresponding penetration value. Data were taken at a specific stress level until penetration had essentially ceased. At this point, the load was increased to a second stress level and the recording procedure repeated. The test was terminated when the rock failed or the capacity of the ram was reached. Predetermined loads varied from 1000 to 2000 psi increments in zones where failure was not expected, to 500 psi increments in zones where failure was anticipated.

The data was subsequently reduced to yield a graph of applied load vs. recorded deformation. The straight line portion of the graph prior to failure was utilized to provide data to calculate a tangent deformation value, D_t, in psi/0.001 in. The value D_t, along with Poisson's ratio values for the applicable rock type, were used to determine Young's modulus, E_t, according to the following formula:

$$E_t = (0.95)\ (1 - u^2)\ (D_t\ A^{\frac{1}{2}}) \times 10^3$$

where:

0.95 represents a shape factor for a square penetration plate

u = Poisson's ratio

D_t = Deformation value from graph

A = Area of penetration plate

(Formula modified from Stagg, 1974, p. 127).

Subsurface Instrumentation

The subsurface instrumentation was designed to determine the response of the rock mass to longwall mining with shield-type supports. Instrumentation was installed on selected shields, along the face, in entries adjacent to the panel and into the panel. A description of the instrumentation and a summary of the installation and monitoring procedures are presented in this section.

Shield Instrumentation:

Hydraulic pressure recorder were installed on selected shields to determine the loading history of each shield leg. The instruments were 9-in., continuous pressure recorders manufactured by the U.S. Gauge Division of Ametek, Inc. Each recorder was equipped with a 10,000 psi element and a spring-wound chart drive. The chart drive had a seven-day rotation period with an 8-day wind.

Initially each recorder was equipped with a V-type inking pen. This type of recording pen was unsatisfactory because it allowed ink to be thrown out during movement of the shields. This resulted in record charts that were incomplete and illegible because of ink splatters. Two different types of pens, a box-type reservoir pen and a fiber tipped, capillary action, Cannon inking pen, were ordered in an attempt to solve the problem. The box-type pen was plagued with the splattering problems similar to those experienced with the V-type pens. As a result, all shield recorders were equipped with the Cannon inking pens. These pens performed well throughout the project period.

The recorder was attached to the shield with an 3/8 in. bolt installed through a hole drilled in the back of the recorder box and through the base of the shield just below the hinge point for the gob shield. A T-fitting was installed in the hydraulic line to the shield leg, and a connection was made to the recorder's pressure element.

After the recorder was installed and the system checked for leaks, the pressure recorder was calibrated. The following calibration procedure was utilized:

1. An adjustable pressure gauge with a range of 0 to 10,000 psi was calibrated with a dead weight tester
2. This pressure gauge was installed in series with the shield recorder
3. A load of approximately 2000 psi was imposed upon the system
4. The shield pressure recorder was adjusted according to directions in the instruction manual to correspond with the reading on the calibration gauge
5. The system was pressurized to the maximum obtainable pressure (approximately 4500 psi), and the recorder was again adjusted to correspond to the calibration gauge
6. Steps 4 and 5 were repeated with corresponding recorder adjustments until the calibration gauge and pressure recorder agreed throughout the pressure range.

The recorder charts were changed and recorder performance was monitored on a weekly basis. The shield and leg number, date, time and pressure were recorded on each chart as it was removed. The setting pressure, final pressure and time for the leg to assume the final pressure were tabulated for selected dates to provide data for subsequent analysis of shield load history.

The pairs of recorders on shields number 43 and 99 were replaced with dual pen recorders during the latter part of the project. This was to determine durability of the single recorder, dual pen system and the legibility of the records obtained. Both dual pen systems performed well and provided good quality records. The only problem with the dual pen installation was that a recorder malfunction resulted in an incomplete record for both legs.

Face Instrumentation:

An attempt was made to correlate coal hardness and panel power consumption. Coal hardness was determined with a rock classification hammer that provided Schmidt hardness data. Panel power consumption was monitored with a continuous strip chart KVA recorder.

The rock classification hammer was utilized to determine the relative rebound hardness values for the coal seam at selected locations. The test hammer was held perpendicular to the rock surface at the selected testing point. The hammer plunger was depressed with a gradual increase in applied pressure until it impacted. A reading of rock hardness was then obtained from the scale on the side of the test hammer.

This procedure was repeated five times at each test location. The last three hardness values were recorded and averaged to obtain the hardness value recorded for that particular testing location.

The testing locations were spaced 50 ft apart along the headgate and tailgate sides of the unmined longwall panel. In order to delineate large-scale hardness variations within the coal seam, hardness data was also obtained along the entries adjacent to the caved portion of the longwall panel. Testing locations in this area were spaced approximately 100 ft apart. All testing locations were approximately 5.5 ft above the base of the coal seam.

A General Electric Type CH continuous, strip-chart KVA recorder was utilized to record power consumption during mining operations on the longwall panel. The type CH recorder is a direct acting, fast response, inking-type with a two-speed chart drive. It was installed on the air-break in the power line to the longwall panel. The recorder is operated with power taken from the measured circuit.

The KVA power consumption recorder was installed on December 16, 1975. Due to a variety of problems, the instrument was not operational until February 1976. Initial data indicated that the instrument was not accurate enough to delineate variations in power consumption due to coal seam hardness.

Entry Instrumentation:

Instrumentation was installed in entries adjacent to the longwall panel to determine the effects of mining advance upon the rock mass. Three types of instrumentation were installed: differential roof-floor horizontal movement instruments, roof-floor convergence instruments and double-point roof extensometers.

Differential Roof-Floor Horizontal Movement Instrumentation:

Instrumentation was installed to monitor differential roof-floor horizontal movement as mining advanced through the longwall panel. A total of nine instruments was distributed among three station areas.

A horizontal movement instrument consisted of a 4-in., expanding-shell, rock anchor, 1 5/8-in. in diameter. The rock anchor was installed in the roof directly above a 7-in. square, 1/4-in. steel plate grouted into the floor. They were installed by Colorado School of Mines personnel in holes drilled by Kaiser Steel Corporation personnel with a jackleg drill.

The installation procedure consisted of drilling the roof hole and installing a roof anchor. The roof anchor was equipped with a hook to accept a plumb-bob string. A plumb-bob was utilized to establish the floor locations for the steel plate. The floor area was then cleaned of debris and broken rock. A 1-ft square concrete pad was poured and the steel plate laid on top in a level configuration. Once the concrete had set, the plumb-bob was utilized to establish the zero reference point. This was marked with a steel punch to provide a permanent point. A Brunton compass was utilized to establish a north arrow through the zero point, and a line was scribed for permanent reference.

Horizontal movement measurements were obtained by noting the compass bearing and distance between the zero reference point and the tip of the plumb-bob suspended from the roof anchor. Measurements were recorded to the nearest degree and 0.02 in. along with the corresponding date, time and longwall face distance. The readings were taken once a month until either accelerating convergence was noted or large changes in horizontal movement were noted. Readings were then obtained every two weeks until the face position advanced to within 50 ft. Daily readings were then recorded. During the last 10 ft of face advance readings were taken after each cutting cycle.

The horizontal movement data was reduced into components of movement parallel to and perpendicular to the panel centerline. This was in an attempt to determine the amount of roof over-ride as the rock caved into the extracted zone behind the shield face.

Experience during the project indicated that the instrument worked well as designed and installed. The only suggested modification would be to increase protection of the floor plate.

Convergence Instrumentation: Instrumentation was installed to monitor roof-floor convergence as mining advanced through the longwall panel. A total of twenty instruments was grouped into three instrument station areas.

A convergence instrument consisted of 4-in., expanding-shell rock anchors, 1 5/8-in. in diameter, installed on a vertical line in the roof and floor. The anchors were installed in 1 7/8-in. holes drilled 6 to 8 in. deep. The rock anchors were obtained from Terrametrics, Inc., of Golden, Colorado. They were installed by Colorado School of Mines personnel in holes drilled with a jackleg drill by Kaiser Steel Corporation personnel.

The installation procedure consisted of drilling the holes and then clearing the area of broken rock and debris. The anchors were installed and tightened in place with a wrench. Each anchor had a 1/8-in. threaded hole in the tightening net that was used to install a 3/4-in. eyelet. A concrete cinder block was placed over the floor anchor for protection.

Convergence measurements were obtained with a tape extensometer manufactured by Terrametrics, Inc., of Golden, Colorado. The tape extensometer consisted of a 50-ft steel tape with a hooked end to mate with the roof anchor. The tape had holes spaced every 1.5 in. that accepted a pin on a spring-mounted shaft that was connected with a dial micrometer. The micrometer assembly hooked to the floor anchor.

Measurements were recorded to 0.001-in. along with the corresponding date, time and longwall face distance. Convergence readings were obtained every two weeks until an accelerating convergence rate was noted. Readings were then taken weekly. When the face advanced to within 50 ft of the instrument, daily readings were obtained. During the last 10 ft of face advance, readings were taken after each cutting cycle.

Convergence data were plotted vs. elapsed time and face distance to determine the point at which accelerating convergence was first noted. This was tabulated vs. overburden depth in an attempt to predict the effect of overburden thickness on roof-floor convergence in advance of the longwall face.

Experience during the project indicated that several modifications to instrument location and density were desirable. It was apparent that instruments located near the centerline of entries were subject to destruction by mining activity (traffic in the entries) far in advance of the longwall face. The optimum position appeared to be about 2 ft out from the barrier pillar adjacent to the longwall panel. Instruments located here were generally out of the way of mining equipment, and readings could easily be obtained during the final 10 ft of face advance without interference from shearer operations. Readings could also be obtained during the period that the shields were providing supplemental roof support.

The instrument density could also be reduced. Convergence instruments were generally positioned in groups of three to five in a station area. It appeared that three to four instruments, spaced 50 ft apart along alternate sides of an entry, would provide adequate data and would minimize disturbance caused by mining activity.

The installation itself appeared to require two modifications: a longer length (1.5 ft) floor anchor and better instrument protection. The 4 in. anchor length was too short for the floor anchor. It did not allow the anchor to penetrate past the shallow fractured zone created by mining operations. The short anchors had a tendency to break loose or pull out of the floor during convergence measurements. The situation was worse when the floor was saturated by water sprays on the coal shearer as the working face approached the instrument. The holes should be drilled at least 2 ft deep, and the floor anchor point should be cleaned down to competent rock prior to installing the anchor. The anchor should be grouted in place, and the eyelets should be epoxied to the anchors.

Roof Extensometers: Instrumentation was installed to monitor roof-sag as mining advanced through the longwall panel. A total of six instruments was grouped into three instrument station areas.

An instrument installation consisted of a pair of double-point extensometers mounted into the roof along entry centerlines. One extensometer was constructed with anchors at the roof-entry interface, at the 3-ft level and at the 5-ft level. The second instrument had anchors at the 9- and 12-ft levels in addition to the collar anchor. The extensometers were obtained from Terrametrics, Inc., of Golden, Colorado. They were installed by Terrametrics personnel with assistance from Colorado School of Mines personnel. Kaiser Steel Corporation was responsible for drilling the installation holes.

A typical installation sequence follows:

1. Two vertical holes, 1 7/8-in. in diameter, were drilled into the roof at the selected instrument location. The holes were drilled 5 and 12 ft, respectively. All instrument components were delivered to the site unassembled.
2. The long anchor was assembled first. It consisted of a 4-in. rock anchor with a 1/8-in. threaded hole in the hexagonal tightening nut. A section of 1/8-in. stainless steel rod was screwed in place, and the assembly was inserted in the hole. If additional lengths of stainless steel rod were required, they were mated with a threaded brass collar.
3. After the anchor was placed in the hole, it was set with a segmented setting tool. This tool consisted of a "T"-handle, various lengths of pipe with couplings and a short length of pipe with a socket-type end. The socket was designed to fit the hexagonal tightening nut on the rock anchor.
4. After the long anchor was set, the end was trimmed

flush with the hole collar, and a small brass cap was fitted on the end to provide a flat bearing surface.

5. The intermediate anchor consisted of a 4-in. rock anchor with a 3/8-in. hole drilled through the tightening nut and bolt. The instrument was assembled with 3/8-in. galvanized pipe. The same setting tool was utilized to set the intermediate anchor. The 3/8-in. pipe was trimmed so that it extended approximately 1/2-in. past the brass cap on the stainless steel rod. A brass cap was threaded onto the 3/8-in. pipe to provide a flat bearing surface. This cap had a large hole to provide access to the cap on the 1/8-in. rod inside.
6. The collar anchor was then slipped over the entire assembly and positioned so that the brass cap on the 3/8-in. pipe was 1/2-in. inside the collar assembly. The collar anchor was set with the setting tool, and a brass cap with two holes was screwed over the collar anchor to provide a flat surface with access to the brass bearing caps on the 3/8-in. pipe and the 1/8-in. rod.

Roof-sag measurements were taken with a dial micrometer outfitted with stainless steel probes. Measurements were taken of the distance between the collar anchor bearing plate and the respective brass caps on the ends of each anchor assembly. The values were recorded along with the corresponding date, time and face distance. Measurements were taken monthly until the face advanced to within 50 ft. At that point, daily readings were taken after each cutting cycle.

As a result of project experience two modifications are suggested: increased anchor spacing and installation of extensometers in the floor.

It is suggested that anchor spacing be increased to 5, 10, 15 and 20 ft. The project anchor spacing yielded significant results only in the 5- to 9-ft interval. This resulted because all four anchors were within the massive roof sandstone which reacted to mining as a single unit without any significant internal anisotropies. The increased spacing would put anchors within and above this unit and allow determinations of rock mass behavior at the upper sandstone contact.

It is also suggested that an extensometer with an anchor spacing of 7 and 15 ft be installed in the floor to determine the amount of floor heave. It was apparent that the amount of recorded roof-sag was generally less than recorded roof-floor convergence by an order of a magnitude of 10. This can be attributed to either floor heave, seam parting above the instrumented roof zone or both. The suggested modifications should help delineate the relationship between roof-sag, floow-heave and roof-floor convergence.

Panel Instrumentation:

Instrumentation was installed into the longwall panel to determine the reaction of the rock mass to mining advance. The instrumentation consisted of multiple position borehole extensometers installed from the surface and load cells installed from entries adjacent to the longwall panel.

Multiple Position Borehole Extensometers: Instrumentation was installed in the coal seam, below the coal seam and in the overburden above the coal seam to monitor the relationships between face position, strata separation and tensile strain development. A total of three multiple position borehole extensometers (MPBX) was installed into panel 4N.

Each MPBX was installed from the surface in a 4 1/2-in. diameter drill hole. The holes were drilled by Kaiser's exploration group utilizing rotary wash techniques. Logs of cuttings were maintained by Kaiser geologists and each hole was logged geophysically.

The MPBX instrumentation was purchased from Terrametrics, Inc., of Golden, Colorado. Terrametrics personnel installed the instruments with assistance from Colorado School of Mines personnel.

Each MPBX installation consisted of five in-hole anchors. The lowest anchor was positioned about 20 ft below the coal seam. A second anchor was positioned within the coal seam, and the three remaining anchors were placed in the strata above the coal seam.

The installed anchors were Terrametrics type HG, which were designed for use in soft ground. The anchor had a length of 6 in. and consisted of a flattened copper pipe wrapped concentrically around the anchor point and attached to it. One-quarter-in. O.D. nylon tubing (bursting pressure 1500-2000 psi) was connected to the copper pipe through a check valve.

The anchors were laid out on the ground and connected to one another with 3/8-in. flexible, "sealite" conduit. Stainless steel piano wire individually connected each anchor to a separate spring element in the instrument head. The stainless steel piano wire was 0.041 in. in diameter and each spring element had a spring constant of 25 lb/in. The wires from anchors 4 and 5 were placed in a conduit separate from that for anchors 1, 2 and 3. This allowed continued monitoring of anchors 1, 2 and 3 after face advance had destroyed anchors 4 and 5.

Once the MPBX assembly was complete, the instrument was lowered manually into the borehole. Each anchor point was fixed in the hole by hydraulically expanding the copper pipe against the sides of the borehole until the nylon tubing burst. The deepest anchor was fixed first, and then the remaining anchors were inflated sequentially starting with the lowest and finishing with the most shallow.

The instrument head was then grouted in place with a quick setting cement. Each anchor wire was inserted through individual plungers and pulled to a tension of 10 pounds. *In situ* wire elongation tests were made to verify wire lengths and spring constants. These wire elongation factors were later used to reduce the recorded displacement values to true displacement data.

Continuous chart recorders were installed on each MPBX. These recorders were driven by 2-speed clockwork motors, and the drum revolution speed could either be set at one revolution per week or one revolution per day. The charts had a range of 5 in. and a sensitivity of 0.025 in. The actual anchor movement range indicated by the 5-in. chart range varied from 25 in. for the deep anchors to 11 in. for the shallow anchors.

A lockable steel housing was bolted to the concrete pads to protect the chart recorder and instrument head assembly.

Hydraulic Panel Pressure Cells: A total of twenty hydraulic pressure cells was installed at various locations within and adjacent to panel 4N. The design and operation of the pressure cells are described in detail in Miller and Sporcic (1964). The pressure cells used during the project were constructed by the U. S. Bureau of Mines with assistance from Colorado School of Mines personnel. Installation was done by Colorado School of Mines personnel with assistance from U. S. Bureau of Mines and Kaiser Steel Corporation personnel. A brief description of the instrumentation and a summary of the installation and monitoring procedures follow.

The pressure cell consisted of three separate parts: the pressure element, a pressure recording device and a length of copper hydraulic line. The pressure element was constructed of 1-in. I.D. soft copper tubing. The tubing was cut in 10-in. lengths and flattened through the center to leave the edges slightly rounded. A 5/8-in. wide steel ring was placed at each end of the flattened pressure element as reinforcement. The ends of the flattened element were then silver-soldered together with a 1/8-in. O.D. copper hydraulic line soldered in place at one end. The cell was encapsulated with Vitroplast to a final diameter of 2 in. An orienting loop was placed at the end with the hydraulic line to aid in placing the pressure element in the correct position. The system was then filled with low viscosity hydraulic fluid and checked for leaks.

The panel pressure cells were installed by drilling a hole into the coal about 4 ft above the floor. The hole was drilled with a diameter of 2 1/4 in. to the desired installation depth. The final 2 ft of hole was then drilled with a diameter of 2 in. to provide a snug fit for the pressure element. The element was placed into the hole and oriented with the flattened sides in the horizontal plane. After the pressure cell was oriented, the system was prestressed by applying a pressure between 3000 and 5000 psi for about 1 minute. This fractured the Vitroplast and partially opened the element body. After prestressing, the pressure was reduced until it was approximately equal to the estimated load. The twenty panel pressure cells installed around panel 4N were set with a pressure of approximately 1000 psi after prestressing.

The pressure cells installed in the center of the barrier pillars adjacent to panel 4N were oriented at an angle of 90° with the panel centerline and installation depths varied from 25 to 30 ft. The pressure cells installed in the longwall panel were installed in pairs, one at a 30-ft depth and one at a 50-ft depth. The pressure cells were placed at a slight angle so that the pressure element was ahead of the pressure recorder. The 50-ft cells were oriented at an angle of 80° from the panel centerline, and the 30-ft cells were oriented at an angle of 70°. This allowed monitoring of the pressure element up to the time it was destroyed by mining without endangering the pressure recording device.

The panel pressure cells were initially installed with a 3000-psi pressure gauge. Readings were taken daily for about two weeks after the cell was installed to determine the magnitude of the initial pressure drop. Thereafter, readings were taken monthly until the longwall face approached to within 250 to 200 ft of the pressure cell. At this time a continuous pressure recorder, equipped with a spring-wound clock mechanism, was installed. The pressure charts were changed weekly until the pressure element was destroyed by mining.

The pressure records were analyzed to determine the distance from the pressure element to the longwall face at the onset of the pressure abutment (beginning of pressure increase) and the distance to the face at the point pressure release occurred prior to the element's destruction.

The only suggested modification to the procedures used to install panel 4N pressure cells would be to lower the setting pressure from 1000 psi to something approximating overburden loads. The 1000 psi setting pressure resulted in a large amount of initial pressure loss and a continuing gradual pressure decrease that continued for 4 to 6 months. This could be attributed to deformation of the coal immediately adjacent to the pressure element which would cause the element to be less sensitive to pressure changes induced by mining activity.

APPENDIX B

GEOLOGIC STRUCTURAL DATA

TABLE B-1
NOTES TO ACCOMPANY TABLES
OF DETAILED LINE DATA

1. Distance, in feet, from start of tape.

2. Type of discontinuity

   J = Joint

   CJ = Cross-joint

3. Length, in feet, of fracture trace along the outcrop.

4. Continuity

   S = short (less than 5 ft)

   M = medium (5 to 12 ft)

   L = long (greater than 12 ft)

5. Tightness (amount fracture was open)

   O = open

   C = closed

TABLE B-2
DETAILED LINE DATA
LINE 4N-1

Distance[1] (Feet)	Strike (°)	Dip (°)	Type[2]	Length[3] (Feet)	Continuity[4]	Tightness[5]
0.0	N 3W	67SW	J	0.3	S	O
0.0	N63E	70NW	J	0.5	S	C
0.3	N 5E	75NW	J	0.5	S	C
0.3	N59W	90NE	J	0.2	S	O
0.4	N 5E	82SE	J	0.3	S	O
0.4	N88W	83NE	J	0.4	S	O
0.5	N10E	75NW	J	0.4	S	O
0.8	N 6W	74SW	J	1.5	S	C
1.4	N77E	70NW	J	0.5	S	O
1.5	N42W	84SW	J	0.3	S	O
2.3	N65E	74NW	J	2.0	S	O
2.3	N52W	90NE	J	0.3	S	O
2.0	N72E	71NW	J	1.5	S	O
2.3	N41E	77NW	J	0.5	S	O
3.0	N88E	90NW	J	0.5	S	O
3.0	N70W	88NE	J	0.2	S	O
3.0	N62E	68NW	J	2.5	S	O
3.3	N33E	70NW	J	0.5	S	O
3.9	N 6E	66NW	J	0.5	S	O
4.1	N35E	62NW	J	1.0	S	O
4.3	N50W	86NE	J	2.0	S	O
4.7	N40E	69NW	J	1.0	S	O
4.7	N53W	84NE	J	0.5	S	C
5.1	N80[illegible]	83NE	J	0.3	S	O
5.1	N30E	70NW	J	3.0	S	O
5.3	N82W	83NE	J	0.4	S	O

TABLE B-2 (continued)

Distance[1] (Feet)	Strike (°)	Dip (°)	Type[2]	Length[3] (Feet)	Continuity[4]	Tightness[5]
5.3	N68E	76NW	J	2.5	S	O
5.5	N50W	62NE	J	0.4	S	O
5.5	N65E	72NW	J	0.5	S	O
6.2	N54W	83NE	J	0.5	S	C
6.2	N15E	63NW	J	0.5	S	O
6.1	N 3E	61NW	J	0.3	S	C
6.5	N53W	87SW	J	1.0	S	O
6.5	N60E	63NW	J	2.0	S	O
7.1	N72W	85NE	J	1.0	S	O
7.4	N65E	62NW	J	1.5	S	O
7.5	N 3E	59NW	J	0.3	S	O
7.9	N80W	88NE	J	0.3	S	O
7.9	N76E	72NW	J	1.0	S	O
8.0	N10E	56NW	J	0.2	S	C
8.3	N68E	75NW	J	0.5	S	O
8.3	N 2W	66SW	J	0.5	S	C
8.7	N76W	79NE	J	0.2	S	O
8.8	N77W	77NE	J	0.2	S	O
8.9	N55W	90NE	J	1.5	S	O
9.4	N60W	87NE	J	0.5	S	O
9.6	N80W	88NE	J	0.5	S	O
9.6	N15E	80NW	J	0.5	S	O
10.0	N55E	75NW	J	2.0	S	O
10.2	N22W	86SW	J	1.0	S	C
10.3	N52W	85NE	J	0.4	S	C
10.3	N40E	63NW	J	0.4	S	O

TABLE B-2 (continued)

Distance[1] (Feet)	Strike (°)	Dip (°)	Type[2]	Length[3] (Feet)	Continuity[4]	Tightness[5]
10.4	N47W	90NE	J	0.2	S	O
10.8	N70E	78NW	J	0.7	S	C
12.7	N16E	87NW	J	0.5	S	O
14.4	N42W	87NE	J	0.5	S	O
14.4	N 5E	80NW	J	1.0	S	O
14.6	N65E	75NW	J	0.5	S	C
14.6	N53W	88NE	J	0.7	S	C
14.6	N53W	88NE	J	0.7	S	C
14.7	N53W	88NE	J	0.7	S	C
14.9	N32E	79NW	J	0.4	S	O
15.3	N48W	89NE	J	0.3	S	C
15.3	N10W	71SW	J	0.3	S	O
15.5	N27E	78NW	J	0.3	S	O
15.4	N55W	90NE	J	0.4	S	C
15.6	N55W	90NE	J	0.4	S	C
15.6	N55W	90NE	J	0.4	S	C
15.7	N20W	83NE	J	0.3	S	O
15.2	N49E	70NW	J	1.0	S	O
16.3	N20W	88NE	J	0.3	S	O
16.9	N46W	89NE	J	0.2	S	O
17.3	N50W	84NE	J	1.5	S	O
17.3	N 5W	90NE	J	0.5	S	O
17.5	N60E	73NW	J	0.3	S	O
17.6	N74E	77NW	J	0.7	S	O
18.0	N70W	77NE	J	1.0	S	O
18.0	N33E	88SE	J	2.5	S	O

TABLE B-3
DETAILED LINE DATA
LINE PIT

Distance[1] (Feet)	Strike (°)	Dip (°)	Type[2]	Length[3] (Feet)	Continuity[4]	Tightness[5]
0.0	N15W	76NE	J	1.0	S	O
0.0	N90E	89N	J	1.0	S	O
0.1	N 2W	82NE	J	1.0	S	O
0.1	N85W	89NE	J	1.0	S	O
0.1	N66E	83NW	J	1.0	S	O
0.5	N38E	85SE	CJ	0.3	S	O
0.5	N89E	77NW	J	2.0	S	O
2.3	N20W	86NE	J	0.7	S	O
2.7	N16W	80NE	J	3.0	S	O
2.8	N40W	75NE	J	2.0	S	O
2.8	N74W	83NE	J	1.0	S	O
2.8	N86E	89NW	J	1.0	S	O
3.6	N51E	75SE	J	1.0	S	O
4.0	N57E	54SE	J	1.0	S	O
4.0	N55W	65NE	J	1.0	S	O
4.7	N15W	60NE	J	1.0	S	O
4.8	N15W	81NE	J	1.0	S	O
4.9	N33W	77NE	J	3.0	S	O
4.9	N75E	89SE	J	1.0	S	O
5.2	N12E	88SE	J	1.0	S	O
5.3	N57E	69SE	J	1.5	S	O
5.4	N67E	88SE	J	0.3	S	O
5.4	N20W	82NE	J	0.6	S	O
5.8	N21W	81NE	J	0.4	S	O
5.8	N69E	89SE	J	0.2	S	O
5.9	N20W	83NE	J	1.0	S	O
5.9	N75W	88SW	J	1.0	S	O

TABLE B-3 (continued)

Distance[1] (Feet)	Strike (°)	Dip (°)	Type[2]	Length[3] (Feet)	Continuity[4]	Tightness[5]
6.6	N10E	83SE	J	0.5	S	O
6.6	N54E	90SE	J	1.0	S	O
6.9	N23W	77NE	J	3.0	S	O
6.9	N70E	77SE	J	1.0	S	O
6.9	N 8E	77SE	J	0.6	S	O
6.9	N41E	82SE	J	1.0	S	O
8.3	N 3W	83NE	J	4.0	M	O
9.0	N10W	81NE	J	5.0	M	O
9.2	N45E	62SE	J	1.0	S	O
9.4	N45E	90NW	J	2.0	S	O
10.5	N88W	65SW	J	1.0	S	O
11.0	N55E	71SE	J	1.0	S	O
13.3	N79E	84NW	J	6.0	M	O
17.1	N31W	90NE	J	1.0	S	O
17.1	N88W	84SW	J	0.7	S	O
17.8	N 5E	90SE	J	0.5	S	O
17.9	N30W	81NE	J	0.5	S	O
18.0	N88W	85NE	J	0.5	S	O
18.8	N 5W	83NE	J	8.0	M	O
18.8	N86E	86NW	J	1.0	S	O
18.8	N87E	78NW	J	0.7	S	O
18.8	N89E	84SE	J	1.5	S	O
20.4	N19W	83NE	J	8.0	M	O
20.4	N80E	90SE	J	8.0	L	O
20.5	N13W	75NE	J	0.5	S	O
21.1	N ON	86E	J	0.6	S	O
21.8	N 8W	90NE	J	2.0	S	O
22.0	N40W	50NE	J	1.5	S	O

TABLE B-3 (continued)

Distance[1] (Feet)	Strike (°)	Dip (°)	Type[2]	Length[3] (Feet)	Continuity[4]	Tightness[5]
22.0	N 6W	89NE	J	0.7	S	O
22.1	N26W	63NE	J	0.5	S	O
25.3	N42E	88SE	J	0.4	S	O
25.6	N32W	64NE	J	0.4	S	O
25.8	N25W	63NE	J	0.3	S	O
25.7	N20W	84NE	J	1.5	S	O
25.6	N 2W	88SW	J	1.0	S	O
27.8	N 6W	88NE	J	2.0	S	O
28.3	N14W	84NE	J	2.0	S	O
28.8	N15W	89SW	J	4.0	S	O
29.5	N10W	58NE	J	0.3	S	O
29.8	N44E	86SE	J	0.2	S	O
30.7	N37W	54NE	J	0.3	S	O
30.8	N 5W	75NE	J	0.3	S	O
34.3	N20W	79NE	J	5.0	M	O
37.0	N10E	64NW	J	1.0	S	O
38.8	N10W	87NE	J	1.0	S	O
43.3	N20W	88SW	J	2.0	S	O
44.3	N10W	86NE	J	6.0	M	O
45.5	N88E	75NW	CJ	1.5	S	O
45.5	N11W	84NE	J	1.0	S	O
46.6	N65W	79NE	CJ	1.5	S	O
49.0	N88E	87SE	CJ	0.5	S	O
50.0	N83E	84SE	J	8.0	L	O
53.3	N23W	90SW	J	3.0	S	C
55.8	N 4W	86SW	J	2.0	S	C
57.0	N10W	79NE	J	2.5	S	O
57.0	N84E	90SE	J	3.0	M	O

APPENDIX C

RIBSIDE VERTICAL SUBSIDENCE DISTRIBUTION DATA AND HORIZONTAL STRAIN DISTRIBUTION DATA FOR SUPER-CRITICAL CONDITIONS

TABLE C-1

NOTES TO ACCOMPANY
TABLES C-2 THROUGH C-4

1. Distance to ribside represents distance from the station point to the edge of the unmined barrier pillars.

   - station over solid coal

   + station over goaf

2. Depth to coal seam represents the amount of overburden between the measurement station point and the coal seam.

3. Vertical angle

   Angle from vertical between ribside and measurement station point

   - station over solid coal

   + station over goaf

4. S/S-Max = Observed station subsidence/maximum observed panel subsidence.

5. Observed horizontal strain corrected for slope gradient.

6. E/E-Max = Observed horizontal station strain/maximum observed horizontal panel strain.

TABLE C-2

VERTICAL SUBSIDENCE AND HORIZONTAL STRAIN DISTRIBUTION FOR SUPERCRITICAL CONDITIONS

RIBSIDE AT NORTHWEST END OF CENTERLINE

STATION	DISTANCE FROM RIBSIDE (1)	DEPTH TO COAL SEAM (2)	ANGLE FROM SOLID - GOAF INTERFACE (3)	S/S-MAX (%) (4)	CORRECTED HORIZONTAL STRAIN (u-in/in) (5)	E/E-MAX (%) (6)
20N	-268	252	-46.8°	0.0		
	-209 (Midpoint)	278	-36.6°		0	0
19N	-150	304	-26.3°	0.0		
	-120 (Midpoint)	320	-20.3°		1,567	3.3
18N	- 90	335	-15.0°	1.4		
	- 60 (Midpoint)	347	- 9.5		6,133	17.2
17N	- 30	359	- 4.8°	4.3		
	0 (Midpoint)	365	0.0°		+20,100	56.4
16N	+ 30	371	+ 4.6°	17.1		
	+ 61 (Midpoint)	379	+ 9.1°		+35,633	100.0
15N	+ 92	387	+13.4°	64.3		
	+120 (Midpoint)	391	+17.0°		+12,267	34.4
14N	+148	395	+20.5°	91.4		
	+179 (Midpoint)	393	+24.3°		+20,167	56.6
13N	+210	392	+28.2°	97.1		
	+240 (Midpoint)	389	+31.4°		+12,033	33.8

TABLE C-2 (continued)

STATION	DISTANCE FROM RIBSIDE (1)	DEPTH TO COAL SEAM (2)	ANGLE FROM SOLID - GOAF INTERFACE (3)	S/S-MAX (%) (4)	CORRECTED HORIZONTAL STRAIN (u-in/in) (5)	E/E-MAX (%) (6)
12N	+270	386	$+35.0^{\circ}$	100.0		
	+301 (Midpoint)	370	$+39.1^{\circ}$		+1,467	4.1
11N	+332	355	$+43.1^{\circ}$	100.0		
	+362 (Midpoint)	339	$+46.5^{\circ}$			0
10N	+392	323	$+50.5^{\circ}$	100.0	-12,133	

Numbers Refer to Notes on Table C-1.

TABLE C-3

VERTICAL SUBSIDENCE AND HORIZONTAL STRAIN DISTRIBUTION FOR SUPER-CRITICAL CONDITIONS

HEADGATE AND TAILGATE

STATION	DISTANCE FROM RIBSIDE (1)	DEPTH TO COAL SEAM (2)	ANGLE FROM SOLID- GOAF INTERFACE (3)	S/S-MAX (%) (4)	CORRECTED HORIZONTAL STRAIN (u-in/in) (5)	E/E-MAX (%) (6)
8E	-185	442	-22.7°	0.0		
	-155 (Midpoint)	435	-19.6°		0	0
7E	-125	428	-16.3°	0.0		
	- 95 (Midpoint)	423	-12.7°		+ 4,267	+16.4
6E	- 65	418	- 8.8°	1.5		
	- 35 (Midpoint)	406	- 4.9°		+ 8,300	+31.8
5E	- 5	393	- 0.7°	6.1		
	+ 25 (Midpoint)	385	+ 3.7°		+26,067	+100.0
4E	+ 55	376	+ 8.3°	19.7		
	+ 85 (Midpoint)	370	+12.9°		- 3,800	-15.4
3E	+115	364	+17.5°	68.2		
	+145 (Midpoint)	359	+22.0°		-24,600	-100.0
2E	+175	354	+26.3°	92.4		
	+205 (Midpoint)	349	+30.4°		- 8,567	-34.8
1E	+235	343	+34.4°	100.0		
	+264 (Midpoint)	341	+37.7°		- 2,333	- 9.5
#3MPBX	+292	339	+40.7°	100.0		
	+261 (Midpoint)	335	+37.9°		- 1,167	- 4.7

TABLE C-3 (continued)

STATION	DISTANCE FROM RIBSIDE (1)	DEPTH TO COAL SEAM (2)	ANGLE FROM SOLID - GOAF INTERFACE (3)	S/S-MAX (%) (4)	CORRECTED HORIZONTAL STRAIN (u-in/in) (5)	E/E-MAX (%) (6)
1W	+230	330	+34.9°	100.0		
	+200 (Midpoint)	321	+31.9°		- 600	- 2.4
2W	+170	311	+28.7°	98.5		
	+140 (Midpoint)	300	+25.0°		- 8,033	- 32.7
3W	+110	289	+20.8°	87.9		
	+ 80 (Midpoint)	278	+16.1°		+ 7,067	+ 27.1
4W	+ 50	267	+10.6°	28.8		
	+ 20 (Midpoint)	255	+ 4.5°		+24,767	+ 95.0
5W	- 10	242	- 2.4°	0.0		
	- 40 (Midpoint)	230	- 9.9°		- 4,033	- 16.4
6W	- 70	218	-17.8°	0.0		
	-100 (Midpoint)	206	-25.9°		+ 5,300	+ 20.3
7W	-130	193	-34.0°	10.6		
	-160 (Midpoint)	183	-41.2°		-12,633	- 51.4
8W	190 (Midpoint)	172	-47.8°	48.5		

Numbers Refer to Notes on Table C-1.

TABLE C-4

VERTICAL SUBSIDENCE AND HORIZONTAL STRAIN DISTRIBUTION FOR SUPER-CRITICAL CONDITIONS

RIBSIDE AT SE END OF CENTERLINE

STATION	DISTANCE FROM RIBSIDE (1)	DEPTH TO COAL SEAM (2)	ANGLE FROM SOLID - GOAF INTERFACE (3)	S/S-MAX (%) (4)	CORRECTED HORIZONTAL STRAIN (u-in/in) (5)	E/E-MAX (%) (6)
14S	-205	415	-26.3°	0.0		
	-195 (Midpoint)	408	-23.3°		0	0
13S	-145	400	-19.9°	0.0		
	-115 (Midpoint)	385	-16.6°		+1,167	+ 7.7
12S	- 85	371	-12.9°	1.0		
	- 55 (Midpoint)	356	- 8.6°		+1,167	+ 7.7
11S	- 25	341	- 4.2°	1.9		
	- 5 (Midpoint)	327	+ 0.9°		+15,200	+100.0
10S	+ 35	314	+ 6.4°	13.5		
	+ 65 (Midpoint)	305	+12.0°		+33	+ 0.2
9S	+ 95	297	+17.7°	63.5		
	+125 (Midpoint)	288	+23.5°		-24,867	-73.3
8S	+155	278	+29.1°	90.4		
	+185 (Midpoint)	268	+34.6°		-12,367	-36.5
7S	+215	259	+39.7°	90.4		
	+245 (Midpoint)	260	+43.3°		-33,917	-100.0

TABLE C-4 (continued)

STATION	DISTANCE FROM RIBSIDE (1)	DEPTH TO COAL SEAM (2)	ANGLE FROM SOLID - GOAF INTERFACE (3)	S/S-MAX (%) (4)	CORRECTED HORIZONTAL STRAIN (u-in/in) (5)	E/E-MAX (%) (6)
6S	+275	262	$+46.4^{\circ}$	100.0		
	+305 (Midpoint)	278	$+47.7^{\circ}$		- 5,067	-14.9
5S	+335	295	$+48.6^{\circ}$	100.0		
	+365 (Midpoint)	300	$+50.6^{\circ}$		+ 9,400	+61.8
4S	+395	305	$+52.3^{\circ}$	100.0		
	+325 (Midpoint)	311	$+53.8^{\circ}$		+12,833	+84.4
3S	+455	318	+55.1	100.0		

Numbers Refer to Notes on Table C-1.

APPENDIX D

DATA FOR SUBSIDENCE DEVELOPMENT CURVES

MONUMENTS 12N, 2N and 3S

TABLE D- 1

SUBSIDENCE DEVELOPMENT CURVE

FOR STATION 12N h = 386'

DATE	SUB. (ft)	DIST.-FC.	$\frac{\text{DIST.-FC.}}{h}$	% SUBSIDENCE
6/14/75	00'	-105	-.27	0.0
6/30/75	0.1'	- 30	-.08	1.4
7/ 8/75	0.5	+ 30	.08	7.0
7/14/75	1.3	55	.14	18.3
7/30/75	1.5	55	.14	21.1
8/ 7/75	2.3	78	.20	32.4
8/20/75	5.5	160	.41	77.5
8/28/75	6.3	205	.53	88.7
9/ 9/75	6.7	245	.63	94.4
9/17/75	6.8	265	.69	95.8
9/23/75	6.9	280	.73	97.2
9/29/75	7.0	310	.80	98.6
10/ 7/75	7.1	365	.95	100.0
10/14/75	7.1	420	1.1	100.0
10/23/75	7.1	490	1.3	100
10/29/75	7.1	515	1.3	100
11/ 6/75	7.1			

TABLE D - 2

SUBSIDENCE DEVELOPMENT CURVE

FOR STATION 3S h = 318'

DATE	SUB. (ft)	DIST.-FC.	$\frac{\text{DIST.-FC.}}{h}$	% SUBSIDENCE
11/24/75	0.0	-245	-0.77	0.0
12/ 8/75	0.0	-225	-0.71	0.0
12/17/75	0.0	-170	-0.53	0.0
12/23/75	0.0	-105	-0.33	0.0
12/24/75	0.1	-105	-0.33	1.6
12/26/75	0.1	-105	-0.33	1.6
1/13/76	0.1	- 55	-0.17	1.6
1/19/76	0.3	- 15	-0.05	4.9
1/26/76	1.5	+ 50	+0.16	24.6
2/ 3/76	3.7	+ 95	+0.30	60.7
2/16/76	5.6	+185	+0.58	91.8
2/23/76	5.9	+215	+0.68	96.7
3/15/76	6.0	+255	+0.80	98.4
3/22/76	6.1	+295	+0.93	100.0
3/30/76	6.1	+330	+1.04	100.0
4/ 8/76	6.1	+365	+1.15	100.0

TABLE D - 3

SUBSIDENCE DEVELOPMENT CURVE

FOR STATION 2N h = 315'

DATE	SUB. (ft)	DIST.-FC.	$\frac{\text{DIST.-FC.}}{h}$	% SUBSIDENCE
10/23/75	0.0	-115	-0.37	0.0
10/29/75	0.0	- 85	-0.27	0.0
11/ 6/75	0.1	- 34	-0.11	1.6
11/24/75	0.4	+ 21	+0.07	6.6
12/ 8/75	2.6	+ 75	+0.24	42.6
12/16/75	4.7	+130	+0.41	77.0
12/23/75	5.5	+192	+0.61	90.2
1/ 5/76	5.7	+202	+0.64	93.4
1/13/76	5.8	+242	+0.77	95.1
1/19/76	6.0	+282	+0.90	98.4
1/26/76	6.0	+350	+1.11	98.4
2/ 3/76	6.1	+397	+1.26	100.0 fc @ 397'
2/16/76	6.1	+488	+1.55	100.0
2/23/76	6.1	+513	+1.63	100.0

APPENDIX E

COORDINATES AND ELEVATIONS OF SURVEY MONUMENTS AT VARIOUS POINTS IN TIME

STATION 20N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 26, 1975	7688.34	48365.66	77227.07
July 8, 1975	7688.32	48365.65	77227.04
August 28, 1975	7688.32	48365.60	77227.04
September 8, 1975	7688.31	48365.56	77227.06
" 17, "	7688.32	48365.57	77227.06
" 23, "	7688.33	48365.58	77227.06
" 29, "	7688.31	48365.55	77227.08
October 15, 1975	7688.32	48365.60	77227.07
" 31, "	7688.33	48365.58	77227.10
December 2, 1975	7688.33	48365.59	77227.05
February 4, 1976	7688.34	48365.58	77227.09
May 5, 1976	7688.33	48365.57	77227.10

STATION 19N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 26, 1975	7742.77	48281.66	77311.38
July 8, 1975	7742.77	48281.64	77311.31
" 30, "	7742.75	48281.58	77311.31
August 7, 1975	7742.77	48281.58	77311.31
" 19, "	7742.74	48281.56	77311.32
" 28, "	7742.75	48281.58	77311.31
September 8, 1975	7742.74	48281.56	77311.31
" 17, "	7742.74	48281.57	77311.32
" 23, "	7742.75	48281.57	77311.32
" 29, "	7742.75	48281.54	77311.34
October 15, 1975	7742.75	48281.59	77311.34
" 31, "	7742.79	48281.56	77311.35
December 2, 1975	7742.74	48281.60	77311.31
February 4, 1976	7742.77	48281.57	77311.34
May 5, 1976	7742.74	48281.57	77311.35

STATION 18N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 14, 1975	7773.47	48239.50	77353.90
" 26, "	7773.45	48239.55	77353.91
July 8, 1975	7773.45	48239.49	77353.85
" 14, "	7773.46	48239.47	77353.89
" 30, "	7773.47	48239.48	77353.87
August 7, 1975	7773.47	48239.47	77353.85
" 19, "	7773.42	48239.40	77353.89
" 28, "	7773.42	48239.44	77353.86
September 8, 1975	7773.41	48239.42	77353.87
" 17, "	7773.43	48239.43	77353.88
" 23, "	7773.41	48239.43	77353.88
" 29, "	7773.42	48239.35	77353.83
October 15, 1975	7773.44	48239.42	77353.91
" 31, "	7773.43	48239.42	77353.91
December 2, 1975	7773.42	48239.42	77353.87
February 4, 1976	7773.44	48239.40	77353.92
May 5, 1976	7773.43	48239.39	77353.93

STATION 17N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7797.64	48196.81	77396.13
" 14, "	7797.65	48196.85	77396.08
" 26, "	7797.62	48196.90	77396.10
July 8, 1975	7797.57	48196.81	77396.04
" 14, "	7797.53	48196.72	77396.13
" 30, "	7797.54	48196.67	77396.14
August 7, 1975	7797.53	48196.63	77396.16
" 19, "	7797.43	48196.51	77396.23
" 28, "	7797.40	48196.47	77396.24
September 8, 1975	7797.40	48196.43	77396.24
" 17, "	7797.38	48196.45	77396.24
" 23, "	7797.38	48196.41	77396.25
" 29, "	7797.34	48196.39	77396.24
October 15, 1975	7797.35	48196.38	77396.26
" 31, "	7797.37	48196.38	77396.26
December 2, 1975	7797.35	48196.39	77396.23
February 4, 1976	7797.37	48196.36	77396.26
May 5, 1976	7797.33	48196.35	77396.27

STATION 16N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7810.65	48154.55	77438.84
" 14, "	7810.62	48154.54	77438.82
" 26, "	7810.32	48154.45	77438.87
July 8, 1975	7809.93	48154.34	77438.90
" 14, "	7809.79	48154.06	77439.12
" 30, "	7809.79	48153.97	77439.16
August 7, 1975	7809.72	48153.89	77439.26
" 19, "	7809.55	48153.62	77439.60
" 28, "	7809.50	48153.57	77439.68
September 8, 1975	7809.48	48153.52	77439.73
" 17, "	7809.45	48153.50	77439.77
" 23, "	7809.46	48153.51	77439.76
" 29, "	7809.44	48153.51	77439.81
October 15, 1975	7809.44	48153.51	77439.81
" 31, "	7809.42	48153.49	77439.83
December 2, 1975	7809.40	48153.48	77439.77
February 4, 1976	7809.40	48153.49	77439.81
May 5, 1976	7809.39	48153.48	77439.82

STATION 15N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7825.35	48112.14	77481.15
" 14, "	7824.95	48111.99	77481.10
" 26, "	7823.30	48112.40	77481.12
" 30, "	7822.62	48112.30	77481.08
July 8, 1975	7821.92	48111.85	77481.36
" 14, "	7821.54	48111.40	77481.71
" 30, "	7821.47	48111.32	77481.73
August 7, 1975	7821.38	48111.12	77481.93
" 19, "	7821.01	48110.38	77482.63
" 28, "	7820.91	48110.22	77482.78
September 8, 1975	7820.89	48110.13	77482.87
" 17, "	7820.86	48110.11	77482.94
" 23, "	7820.85	48110.08	77482.94
" 29, "	7820.82	48110.00	77482.99
October 15, 1975	7820.81	48109.98	77483.06
" 31, "	7820.82	48109.96	77483.07
December 2, 1975	7820.79	48109.92	77483.06
February 4, 1976	7820.79	48109.92	77483.06
May 5, 1976	7820.77	48109.88	77483.08

STATION 13N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7831.74	48028.48	77566.04
" 14, "	7831.77	48028.54	77566.03
" 30, "	7831.05	48028.63	77565.97
July 8, 1975	7829.51	48028.46	77565.87
" 14, "	7829.07	48027.99	77566.22
" 30, "	7827.90	48027.90	77566.20
August 7, 1975	7827.16	48027.54	77566.53
" 20, "	7825.54	48026.06	77567.92
" 28, "	7825.18	48025.57	77568.40
September 9, 1975	7825.00	48025.25	77568.64
" 17, "	7824.98	48025.25	77568.81
" 23, "	7824.95	48025.14	77568.77
" 29, "	7824.94	48025.15	77568.90
October 7, 1975	7824.94	48025.09	77568.88
" 14, "	7824.91	48025.05	77568.85
December 15, 1975	7824.88	48024.98	77568.92
May 5, 1976	7824.89	48025.00	77568.86

STATION 14N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7833.74	48070.68	77523.04
" 14, "	7833.64	48070.74	77522.99
" 26, "	7832.70	48070.80	77522.97
" 30, "	7831.33	48070.92	77522.74
July 8, 1975	7829.36	48070.51	77523.03
" 14, "	7828.53	48069.98	77523.44
" 30, "	7828.37	48069.87	77523.49
August 7, 1975	7828.01	48069.54	77523.73
" 20, "	7827.40	48068.54	77524.64
" 28, "	7827.30	48068.27	77524.77
September 9, 1975	7827.28	48068.15	77524.89
" 17, "	7827.28	48068.15	77524.95
" 23, "	7827.27	48068.11	77524.96
" 29, "	7827.27	48068.11	77525.06
October 7, 1975	7827.21	48068.06	77525.03
" 14, "	7827.19	48068.05	77525.13
February 4, 1976	7827.19	48067.94	77525.03
May 5, 1976	7827.18	48067.94	77525.04

STATION 11N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 14, 1975	7795.01	47943.03	77651.95
" 30, "	7795.01	47943.01	77651.92
July 8, "	7794.94	47943.17	77651.67
" 14, "	7794.98	47942.94	77652.04
" 30, "	7794.79	47942.79	77651.99
August 7, 1975	7794.64	47942.68	77652.10
" 20, "	7791.89	47942.26	77652.63
" 28, "	7790.19	47941.22	77653.47
September 9, 1975	7789.26	47940.28	77654.32
" 17, "	7788.95	47939.98	77654.79
" 23, "	7788.86	47939.84	77654.81
" 29, "	7788.67	47939.59	77655.08
October 7, 1975	7788.54	47939.47	77655.23
" 14, "	7788.46	47939.36	77655.40
" 23, "	7788.45	47939.32	77655.39
November 6, 1975	7788.42	47939.25	77655.40
" 24, "	7788.43	47939.25	77655.43
May 5, 1976	7788.40	47939.26	77655.34

STATION 10N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
July 8, 1975	7763.52	47902.79	77694.86
" 15, "	7763.51	47902.67	77695.03
August 7, 1975	7763.47	47902.27	77695.37
" 20, "	7762.62	47901.12	77696.78
" 28, "	7760.98	47900.39	77697.44
September 9, "	7758.95	47899.58	77698.21
" 17, "	7758.01	47898.95	77698.86
" 23, "	7757.88	47898.75	77699.00
" 29, "	7757.34	47898.11	77699.70
October 7, 1975	7757.02	47897.71	77700.06
" 14, "	7756.94	47897.49	77700.29
" 23, "	7756.92	47897.36	77700.41
January 26, 1976	7756.94	47897.27	77700.45
May 7, 1976	7756.94	47897.25	77700.46

STATION 9N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
July 8, 1975	7739.05	47859.66	77735.87
" 15, "	7739.10	47859.73	77735.94
August 20, 1975	7738.91	47859.28	77736.13
" 28, "	7738.63	47858.99	77736.36
September 9, 1975	7737.48	47858.84	77736.40
" 17, "	7736.05	47858.56	77736.60
" 23, "	7735.73	47858.45	77736.69
" 29, "	7734.18	47857.70	77737.43
October 7, 1975	7733.29	47856.86	77738.30
" 14, "	7733.09	47856.62	77738.58
" 23, "	7733.04	47856.45	77738.75
November 6, 1975	7733.06	47856.50	77738.67
December 16, 1975	7733.04	47856.37	77738.75
January 26, 1976	7733.07	47856.39	77738.70
May 7, 1976	7733.05	47856.37	77738.73

STATION 8N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
July 8, 1975	7715.04	47817.16	77778.46
" 15, "	7715.03	47817.23	77778.54
August 20, 1975	7715.01	47817.12	77778.60
" 28, "	7715.01	47816.89	77778.76
September 9, 1975	7714.95	47816.52	77779.11
" 17, "	7714.78	47816.26	77779.34
" 23, "	7714.73	47816.22	77779.36
" 29, "	7713.47	47815.92	77779.60
October 7, 1975	7710.69	47815.11	77780.31
" 14, "	7709.78	47814.52	77780.92
" 23, "	7709.48	47814.32	77781.14
November 6, 1975	7709.46	47814.35	77781.08
December 16, 1975	7709.45	47814.24	77781.12
January 26, 1976	7709.43	47814.25	77781.08
May 7, 1976	7709.41	47814.22	77781.09

STATION 7N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
July 8, 1975	7689.58	47780.10	77825.35
" 15, "	7689.62	47780.15	77825.33
August 20, 1975	7689.57	47780.13	77825.43
" 28, "	7689.57	47780.10	77825.47
September 9, 1975	7689.59	47779.97	77825.62
" 17, "	7689.62	47779.89	77825.75
" 23, "	7689.63	47779.86	77825.79
" 29, "	7689.58	47779.85	77825.93
October 7, 1975	7688.28	47779.93	77825.68
" 14, "	7686.03	47779.52	77826.12
" 23, "	7684.72	47779.08	77826.19
" 29, "	7684.59	47779.01	77826.80
November 6, 1975	7684.54	47779.00	77826.76
December 8, 1975	7684.55	47778.92	77826.79
January 26, 1976	7684.46	47778.81	77826.81
May 7, 1976	7684.45	47778.76	77826.85

STATION 6N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
August 20, 1975	7696.89	47735.61	77864.88
" 28, "	7696.87	47735.60	77864.88
September 9, 1975	7696.86	47735.62	77864.88
" 14, "	7696.87	47735.61	77864.89
" 23, "	7696.86	47735.65	77864.85
" 29, "	7696.83	47735.67	77864.85
October 7, 1975	7696.73	47735.70	77864.81
" 14, "	7696.16	47735.83	77864.48
" 23, "	7692.93	47735.65	77864.57
" 29, "	7692.37	47735.49	77864.72
November 6, 1975	7692.04	47735.36	77864.71
" 24, "	7691.94	47735.29	77864.67
December 8, 1975	7691.94	47735.29	77864.56
" 16, "	7691.90	47735.24	77864.55
" 26, "	7691.88	47735.32	77864.47
January 26, 1976	7691.84	47735.18	77864.49
February 23, 1976	7691.84	47735.19	77864.48
May 5, 1976	7691.83	47735.14	77864.51

STATION 5N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
September 17, 1975	7699.32	47691.07	77904.58
" 23, "	7699.33	47691.07	77904.59
" 29, "	7699.31	47691.09	77904.58
October 7, 1975	7699.29	47691.08	77904.57
" 14, "	7699.20	47691.10	77904.51
" 23, "	7697.66	47691.27	77903.83
" 29, "	7696.50	47691.25	77903.76
November 6, 1975	7694.84	47691.02	77903.91
" 24, "	7694.17	47690.83	77903.98
December 8, 1975	7694.04	47690.83	77903.84
" 16, "	7693.97	47690.74	77903.86
" 23, "	7693.96	47690.81	77903.77
" 26, "	7693.95	47690.82	77903.74
January 19, 1976	7693.90	47690.70	77903.74
February 23, 1976	7693.89	47690.66	77903.77
May 5, 1976	7693.90	47690.64	77903.78

STATION 4N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
September 17, 1975	7718.17	47649.25	77947.61
" 23, "	7718.18	47649.25	77947.61
" 29, "	7718.17	47649.25	77947.62
October 7, 1975	7718.15	47649.27	77947.60
" 14, "	7718.13	47649.28	77947.59
" 23, "	7717.99	47649.33	77947.48
" 29, "	7717.71	47649.42	77947.28
November 6, 1975	7715.63	47649.73	77946.65
" 24, "	7713.33	47649.57	77946.76
December 8, 1975	7712.76	47649.47	77946.72
" 16, "	7712.60	47649.31	77946.81
" 23, "	7712.54	47649.35	77946.71
" 29, "	7712.53	47649.34	77946.70
January 5, 1976	7712.51	47649.35	77946.71
" 13, "	7712.48	47649.28	77946.73
" 26, "	7712.45	47649.17	77946.74
February 3, 1976	7712.44	47649.13	77946.76
" 23, "	7712.43	47649.11	77946.77
May 7, 1976	7712.43	47649.09	77946.78

STATION 3N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
September 23, 1975	7736.47	47606.28	77989.41
" 29, "	7736.47	47606.28	77989.43
October 7, 1975	7736.45	47606.31	77989.40
" 14, "	7736.44	47606.30	77989.40
" 23, "	7736.42	47606.30	77989.39
" 29, "	7736.36	47606.34	77989.34
November 6, 1975	7736.06	47606.67	77988.82
" 24, "	7733.41	47607.28	77987.66
December 8, 1975	7731.35	47606.97	77987.84
" 16, "	7730.79	47606.75	77987.94
" 23, "	7730.58	47606.68	77987.89
" 24, "	7730.55	47606.65	77987.90
" 29, "	7730.53	47606.63	77987.90
January 5, 1976	7730.50	47606.62	77987.89
" 13, "	7730.45	47606.52	77987.96
" 19, "	7730.39	47606.41	77987.99
" 26, "	7730.36	47606.34	77988.04
February 3, 1976	7730.34	47606.31	77988.07
" 23, "	7730.33	47606.28	77988.10
May 7, 1976	7730.33	47606.23	77988.14

STATION 2N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 7, 1975	7757.67	47563.98	78032.01
" 14, "	7757.69	47563.95	78032.03
" 23, "	7757.69	47563.97	78032.01
" 29, "	7757.67	47563.98	78032.00
November 6, 1975	7757.64	47564.08	78032.82
" 24, "	7757.27	47564.33	78031.40
December 8, 1975	7755.12	47564.35	78030.68
" 16, "	7752.95	47564.84	78030.08
" 23, "	7752.23	47564.52	78030.19
" 24, "	7752.14	47564.41	78030.25
" 26, "	7752.09	47564.42	78030.24
" 29, "	7752.07	47564.40	78030.25
January 5, 1976	7752.04	47564.39	78030.23
" 13, "	7751.87	47564.17	78030.36
" 19, "	7751.74	47563.95	78030.47
" 26, "	7751.68	47563.85	78030.54
February 3, 1976	7751.64	47563.76	78030.60
" 16, "	7751.61	47563.69	78030.66
" 23, "	7751.62	47563.70	78030.64
March 15, 1976	7751.60	47563.66	78030.67
May 7, 1976	7751.61	47563.63	78030.69

STATION 1N

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 14, 1975	7775.45	47522.31	78074.88
" 23, "	7775.47	47522.30	78074.88
" 29, "	7775.45	47522.34	78074.89
November 6, 1975	7775.49	47522.43	78074.73
" 24, "	7775.39	47522.49	78074.62
December 8, 1975	7774.99	47522.85	78073.96
" 16, "	7772.88	47523.59	78072.71
" 23, "	7770.95	47523.11	78072.84
" 24, "	7770.66	47522.92	78072.96
" 26, "	7770.59	47522.91	78072.97
" 29, "	7770.54	47522.88	78072.98
January 5, 1976	7770.49	47522.88	78072.97
" 13, "	7770.03	47522.42	78073.29
" 19, "	7769.64	47521.89	78073.62
" 26, "	7769.46	47521.57	78073.87
February 3, 1976	7769.36	47521.42	78073.97
" 16, "	7769.32	47521.31	78074.04
" 23, "	7769.32	47521.29	78074.06
March 15, 1976	7769.30	47521.25	78074.08
May 7, 1976	7769.29	47521.23	78074.09

STATION 1S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
November 24, 1975	7782.55	47437.30	78159.70
December 8, 1975	7782.48	47437.34	78159.57
" 17, "	7782.23	47437.38	78159.30
" 23, "	7781.63	47437.74	78158.51
" 24, "	7781.26	47437.84	78158.25
" 26, "	7781.19	47437.86	78158.20
" 29, "	7781.13	47437.86	78158.16
January 5, 1976	7781.08	47437.89	78158.15
" 13, "	7779.80	47437.88	78157.87
" 19, "	7777.89	47437.33	78158.09
" 26, "	7776.62	47436.53	78158.85
February 3, 1976	7776.14	47436.04	78159.25
" 16, "	7775.89	47435.65	78159.57
" 23, "	7775.82	47435.59	78159.60
March 15, 1976	7775.78	47435.50	78159.66
" 22, "	7775.76	47435.47	78159.72
" 30, "	7775.76	47435.42	78159.74
May 7, 1976	7775.76	47435.37	78159.77
" 25, "	7775.77	47435.34	78159.80

STATION 2S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
November 24, 1975	7769.99	47395.87	78203.03
December 8, 1975	7769.95	47395.88	78202.96
" 17, "	7769.91	47395.90	78202.90
" 23, "	7769.83	47395.98	78202.76
" 24, "	7769.79	47396.00	78202.70
" 26, "	7769.77	47396.01	78202.65
" 29, "	7769.77	47396.02	78202.63
January 5, 1976	7769.77	47396.02	78202.64
" 13, "	7769.38	47396.18	78202.04
" 19, "	7767.96	47396.22	78201.46
" 26, "	7765.66	47395.74	78201.75
February 3, 1976	7764.37	47394.93	78202.36
" 16, "	7763.78	47394.17	78202.90
" 23, "	7763.69	47394.02	78203.03
March 15, 1976	7763.61	47393.88	78203.12
" 22, "	7763.56	47393.83	78203.19
" 30, "	7763.56	47393.77	78203.22
May 7, 1976	7763.55	47393.69	78203.26
" 25, "	7763.55	47393.67	78203.30

STATION 3S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
November 24, 1975	7762.40	47353.04	78244.64
December 8, 1975	7762.38	47353.05	78244.61
" 17, "	7762.36	47353.04	78244.57
" 23, "	7762.35	47353.04	78244.55
" 24, "	7762.34	47353.06	78244.53
" 26, "	7762.33	47353.05	78244.52
January 13, 1976	7762.29	47353.03	78244.45
" 19, 1976	7762.08	47353.02	78244.13
" 26, "	7760.86	47353.03	78243.61
February 3, 1976	7758.68	47352.59	78243.72
" 16, "	7756.78	47351.30	78244.71
" 23, "	7756.52	47350.97	78244.97
March 15, 1976	7756.37	47350.76	78245.11
" 22, "	7756.31	47350.67	78245.21
" 30, "	7756.27	47350.61	78245.23
April 8, 1976	7756.28	47350.57	78245.26
May 7, 1976	7756.26	47350.50	78245.31
" 25, "	7756.26	47350.48	78245.32

STATION 4S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
December 8, 1975	7749.89	47310.88	78287.31
" 17, "	7749.88	47310.88	78287.28
" 23, "	7749.88	47310.86	78287.29
" 24, "	7749.87	47310.85	78287.31
" 26, "	7749.87	47310.84	78287.29
January 13, 1976	7749.87	47310.81	78287.28
" 19, "	7749.84	47310.77	78287.14
" 26, "	7749.68	47310.69	78287.02
February 3, 1976	7748.88	47310.56	78286.80
" 16, "	7745.55	47309.59	78287.40
" 23, "	7744.77	47309.09	78287.90
March 15, 1976	7744.33	47308.54	78288.32
" 22, "	7744.17	47308.33	78288.51
" 30, "	7744.12	47308.24	78288.58
April 8, 1976	7744.09	47308.17	78288.62
" 21, "	7744.08	47308.13	78288.64
" 27, "	7744.06	47308.10	78288.67
May 7, 1976	7744.06	47308.08	78288.69
" 25, "	7744.05	47308.07	78288.72

STATION 5S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
December 23, 1975	7739.49	47268.48	78329.72
" 24, "	7739.51	47268.47	78329.74
" 26, "	7739.49	47268.48	78329.71
January 13, 1976	7739.49	47268.44	78329.73
" 19, "	7739.48	47268.42	78329.59
" 26, "	7739.44	47268.34	78329.58
February 3, 1976	7739.32	47268.19	78329.45
" 16, "	7737.66	47267.83	78328.72
" 23, "	7736.04	47267.46	78328.94
March 15, 1976	7734.74	47266.83	78329.66
" 22, "	7734.21	47266.44	78330.22
" 30, "	7734.07	47266.28	78330.40
April 8, 1976	7733.99	47266.21	78330.49
" 21, "	7733.94	47266.16	78330.54
" 27, "	7733.93	47266.13	78330.57
May 7, 1976	7733.90	47266.09	78330.62
" 14, "	7733.90	47266.09	78330.64
" 25, "	7733.88	47266.06	78330.67
" 28, "	7733.89	47266.05	78330.68

STATION 6S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
December 24, 1975	7706.67	47224.98	78370.46
" 26, "	7706.66	47224.99	78370.45
January 13, 1976	7706.68	47224.96	78370.46
" 26, "	7706.66	47224.90	78370.40
February 3, 1976	7706.64	47224.75	78370.40
" 16, "	7706.39	47224.43	78370.38
" 23, "	7705.66	47224.39	78370.24
March 15, 1976	7704.00	47224.13	78370.48
" 22, "	7702.54	47223.77	78370.97
" 30, "	7702.03	47223.55	78371.21
April 8, 1976	7701.77	47223.43	78371.34
" 21, "	7701.65	47223.37	78371.39
" 27, "	7701.59	47223.35	78371.43
May 7, 1976	7701.56	47223.33	78371.47
" 14, "	7701.55	47223.31	78371.48
" 17, "	7701.55	47223.30	78371.49
" 21, "	7701.55	47223.29	78371.49
" 25, "	7701.55	47223.30	78371.50
" 28, "	7701.54	47223.28	78371.52
" 31, "	7701.54	47223.29	78371.49

STATION 7S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
December 26, 1975	7704.53	47182.18	78411.30
January 13, 1976	7704.55	47182.19	78411.30
" 26, "	7704.53	47182.19	78411.22
February 3, 1976	7704.54	47182.14	78411.21
" 16, "	7704.52	47182.15	78411.21
" 23, "	7704.46	47182.17	78411.18
March 15, 1976	7704.33	47182.23	78411.13
" 22, "	7703.37	47182.57	78410.74
" 30, "	7701.88	47182.60	78410.59
April 8, 1976	7700.68	47182.36	78410.82
" 21, "	7700.24	47182.20	78410.95
" 27, "	7700.06	47182.17	78410.96
May 7, 1976	7699.96	47182.15	78410.99
" 14, "	7699.93	47182.15	78411.00
" 17, "	7699.92	47182.14	78411.00
" 21, "	7699.91	47182.14	78411.00
" 25, "	7699.91	47182.13	78411.00
" 28, "	7699.90	47182.14	78411.00
" 31, "	7699.90	47182.13	78410.99

STATION 8S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
January 13, 1976	7724.51	47139.74	78454.03
February 3, 1976	7724.51	47139.74	78453.97
" 16, "	7724.50	47139.75	78453.91
" 23, "	7724.46	47139.78	78453.88
March 15, 1976	7724.42	47139.80	78453.86
" 27, "	7724.28	47139.93	78453.74
" 30, "	7723.84	47140.38	78453.17
April 8, 1976	7722.46	47140.73	78452.50
" 21, "	7721.07	47140.49	78452.73
" 27, "	7720.38	47140.33	78452.92
May 7, 1976	7719.96	47140.21	78453.08
" 14, "	7719.81	47140.17	78453.12
" 17, "	7719.78	47140.17	78453.13
" 18, "	7719.76	47140.19	78453.13
" 21, "	7719.76	47140.16	78453.14
" 25, "	7719.75	47140.16	78453.14
" 28, "	7719.75	47140.14	78453.17
" 31, "	7719.75	47140.14	78453.15

STATION 9S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
January 13, 1976	7743.32	47099.24	78498.14
February 3, 1976	7743.31	47099.23	78498.12
" 16, "	7743.32	47099.23	78498.13
" 23, "	7743.29	47099.24	78498.12
March 15, 1976	7743.28	47099.25	78498.10
" 22, "	7743.23	47099.28	78498.09
" 30, "	7743.17	47099.34	78498.02
April 8, 1976	7742.94	47099.53	78496.76
" 21, "	7742.13	47100.24	78496.73
" 27, "	7741.29	47100.46	78496.42
May 7, 1976	7740.47	47100.51	78496.38
" 14, "	7740.14	47100.48	78496.44
" 17, "	7740.08	47100.46	78496.45
" 18, "	7740.05	47100.48	78496.45
" 19, "	7740.03	47100.48	78496.42
" 21, "	7740.01	47100.47	78496.46
" 25, "	7739.98	47100.47	78496.45
" 28, "	7739.97	47100.46	78496.46
" 31, "	7739.96	47100.47	78496.46

STATION 10S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
January 13, 1976	7760.30	47057.80	78541.52
February 3, 1976	7760.29	47057.79	78541.39
March 15, 1976	7760.29	47057.80	78541.38
" 22, "	7760.27	47057.81	78541.39
" 30, "	7760.25	47057.83	78541.36
April 8, 1976	7760.22	47057.86	78541.32
" 21, "	7760.15	47057.90	78541.26
" 27, "	7760.03	47058.00	78541.14
May 7, 1976	7759.83	47058.34	78540.73
" 14, "	7759.66	47058.54	78540.47
" 17, "	7759.62	47058.57	78540.43
" 18, "	7759.59	47058.61	78540.40
" 21, "	7759.58	47058.61	78540.39
" 25, "	7759.56	47058.65	78540.35
" 28, "	7759.55	47058.64	78540.36
" 31, "	7759.55	47058.64	78540.35

STATION 11S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
February 3, 1976	7786.89	47015.39	78583.87
March 22, 1976	7786.87	47015.40	78583.88
" 30, "	7786.87	47015.41	78583.87
April 8, 1976	7786.85	47015.44	78583.85
" 21, "	7786.84	47015.44	78583.83
" 27, "	7786.81	47015.44	78583.83
May 7, 1976	7786.79	47015.47	78583.81
" 14, "	7786.77	47015.48	78583.80
" 17, "	7786.76	47015.49	78583.78
" 21, "	7786.76	47015.50	78583.78
" 25, "	7786.76	47015.50	78583.77
" 28, "	7786.76	47015.49	78583.78
" 31, "	7786.76	47015.49	78583.77

STATION 12S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
January 13, 1976	7817.48	46973.49	78626.11
February 3, 1976	7817.48	46973.48	78626.08
March 22, 1976	7817.47	46973.47	78626.10
April 8, 1976	7817.48	46973.48	78626.09
" 21, "	7817.47	46973.50	78626.07
" 27, "	7817.45	46973.50	78626.07
May 7, 1976	7817.47	46973.47	78626.09
" 14, "	7817.43	46973.53	78626.04
" 17, "	7817.42	46973.53	78626.03
" 18, "	7817.43	46973.52	78626.05
" 19, "	7817.45	46973.50	78626.05
" 21, "	7817.44	46973.52	78626.04
" 25, "	7817.44	46973.52	78626.04
" 28, "	7817.43	46973.53	78626.04
" 31, "	7817.45	46973.50	78626.05

STATION 13S

DATE	ELEVATION	NORTH COOR.	EAST COOR.
February 3, 1976	7846.48	46931.31	78668.46
March 22, 1976	7846.48	46931.31	78668.46
April 27, 1976	7846.48	46931.31	78668.46
May 7, 1976	7846.51	46931.28	78668.48
" 14, "	7846.49	46931.31	78668.46
" 17, "	7846.49	46931.30	78668.47
" 18, "	7846.49	46931.30	78668.47
" 19, "	7846.50	46931.29	78668.47
" 21, "	7846.49	46931.31	78668.46
" 25, "	7846.49	46931.31	78668.46
" 28, "	7846.49	46931.32	78668.46
" 31, "	7846.49	46931.31	78668.46

STATION 1ND

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7803.38	47990.31	77659.48
" 15, "	7803.40	47990.25	77659.45
" 26, "	7803.37	47990.72	77659.26
July 8, 1975	7803.21	47990.55	77659.08
" 14, "	7802.94	47990.19	77659.56
" 30, "	7802.85	47990.06	77659.59
August 7, 1975	7801.80	47989.35	77659.72
" 20, 1975	Leaning Too Far Over to be of Use		

STATION 2ND

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7808.56	48049.78	77658.77
" 15, "	7808.66	48049.80	77658.70
" 26, "	7808.48	48050.35	77658.47
July 8, 1975	7807.64	48050.06	77658.34
" 14, "	7806.60	48049.85	77658.77
" 30, "	7806.47	48049.78	77658.75
August 7, 1975	7805.57	48049.49	77658.68
" 20, "	7802.74	48048.03	77660.26
" 28, "	7802.33	48047.17	77660.92
September 9, 1975	7802.01	48046.74	77661.25
" 17, "	7801.96	48046.64	77661.40
" 23, "	7801.84	48046.59	77661.41
October 7, 1975	7801.82	48046.52	77661.54
" 14, "	7801.78	48046.43	77661.63
November 24, 1975	7801.77	48046.33	77661.63
January 27, 1976	7801.78	48046.25	77661.56
May 5, 1976	7801.77	48046.35	77661.52

STATION 3ND

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7813.66	48109.82	77658.61
" 15, "	7813.61	48109.83	77658.55
" 26, "	7813.14	48110.30	77658.21
July 8, "	7811.44	48109.99	77658.17
" 14, "	7810 00	18109.73	77658.62
" 30, "	7809.92	48109.68	77658.61
August 7, 1975	7809.19	48109.31	77658.65
" 20, "	7807.60	48108.06	77659.99
" 28, "	7807.42	48107.62	77660.32
September 9, 1975	7807.33	48107.34	77660.45
" 17, "	7807.33	48107.29	77660.55
" 23, "	7807.22	48107.23	77660.55
October 7, 1975	7807.21	48107.17	77660.64
" 14, "	7807.20	48107.14	77660.69
November 24, 1975	7807.20	48107 07	77660.70
January 27, 1976	7807.20	48107.01	77660.63
May 5, 1976	7807.18	48107.08	77660.56

STATION 4ND

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7819.84	48169.76	77658.59
" 15, "	7819.85	48169.75	77658.55
" 26, "	7819.14	48170.19	77658.09
July 8, 1975	7816.87	48169.67	77657.95
" 14, "	7815.73	48169.19	77658.43
" 30, "	7815.58	48169.20	77658.40
August 7, 1975	7815.28	48168.83	77658.50
" 20, "	7814.40	48167.98	77659.37
" 28, "	7814.26	48167.82	77659.49
September 9, 1975	7814.16	48167.72	77659.58
" 17, "	7814.17	48167.72	77659.67
" 23, "	7814.11	48167.63	77659.59
October 7, 1975	7814.06	48167.68	77659.65
" 14, "	7814.03	48167.56	77659.73
November 24, 1975	7814.05	48167.49	77659.79
January 27, 1976	7814.07	48167.43	77659.69
May 5, 1976	7813.98	48167.50	77659.73

STATION 5ND

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7829.76	48229.46	77658.53
" 15, "	7829.80	48229.48	77658.47
" 26, "	7829.40	48229.66	77658.12
July 8, 1975	7828.83	48228.79	77658.08
" 14, "	7828.41	48228.30	77658.34
" 30, "	7828.32	48228.21	77658.32
August 7, 1975	7828.21	48227.95	77658.25
" 20, "	7827.69	48227.43	77658.56
" 28, "	7827.58	48227.28	77658.56
September 9, 1975	7827.60	48227.22	77658.62
" 17, "	7827.53	48227.21	77658.68
" 23, "	7827.54	48227.16	77658.65
October 7, 1975	7827.52	48227.15	77658.65
" 14, "	7827.49	48227.09	77658.71
November 24, 1975	7827.56	48227.02	77658.69
January 27, 1976	7827.56	48227.94	77658.63
May 5, 1976	7827.47	48227.01	77658.62

STATION 6ND

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 2, 1975	7839.06	48289.31	77658.04
" 15, "	7839.16	48289.25	77658.05
" 26, "	7839.03	48289.49	77658.01
July 8, 1975	7838.94	48289.24	77657.93
" 14, "	7838.87	48298.19	77658.01
" 30, "	7838.84	48298.13	77657.98
August 7, 1975	7838.86	48298.06	77657.90
" 20, "	7838.71	48289.00	77658.03
" 28, "	7838.66	48288.87	77658.01
September 9, 1975	7838.68	48288.70	77658.03
" 17, "	7838.62	48288.70	77658.08
" 23, "	7838.62	48288.63	77658.03
October 7, 1975	7838.61	48288.62	77658.04
" 14, "	7838.60	48288.55	77658.05
November 24, 1975	7838.59	48288.51	77658.06
January 27, 1976	7838.65	48288.44	77657.96
May 5, 1976	7838.60	48288.53	77657.96

STATION 7ND

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 26, 1975	7838.49	48349.29	77658.09
July 8, 1975	7838.48	48349.35	77658.04
" 14, "	7838.49	48349.36	77658.08
" 30, "	7838.48	48349.32	77658.05
August 7, 1975	7838.51	48349.30	77658.03
" 20, "	7838.45	48349.27	77658.07
" 28, "	7838.45	48349.23	77658.07
September 8, 1975	7838.46	48349.22	77658.08
" 17, "	7838.45	48349.23	77658.06
" 23, "	7838.45	48349.22	77658.09
" 29, "	7838.45	48349.22	77658.07
October 15, 1975	7838.45	48349.22	77658.07
" 31, "	7838.46	48349.23	77658.10
December 2, 1975	7838.44	48349.19	77658.09
February 4, 1976	7838.46	48349.19	77658.09
May 5, 1976	7838.45	48349.19	77658.09

STATION 8ND

DATE	ELEVATION	NORTH COOR.	EAST COOR.
June 26, 1975	7826.57	48409.59	77657.85
July 8, 1975	7826.55	48409.58	77657.82
" 14, "	7826.57	48409.58	77657.87
" 30, "	7826.58	48409.52	77657.84
August 7, 1975	7826.60	48409.50	77657.86
" 20, "	7826.57	48409.51	77657.87
" 28, "	7826.55	48409.49	77657.84
September 8, 1975	7826.56	48409.48	77657.86
" 17, "	7826.57	48409.50	77657.87
" 23, "	7826.56	48409.50	77657.89
" 29, "	7826.55	48409.50	77657.86
October 15, 1975	7826.57	48409.52	77657.86
" 23, "	7826.56	48409.51	77657.89
December 2, 1975	7826.58	48409.53	77657.85
February 4, 1976	7826.55	48409 53	77657.85
May 5, 1976	7826.56	48409.54	77657.85

STATION 8E

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7886.13	47819.66	78445.38
" 12, "	7886.15	47819.75	78445.36
" 20, "	7886.15	47819.73	78445.27
November 4, 1975	7886.19	47819.70	78445.25
" 24, "	7886.18	47819.67	78445.24
December 2, 1975	7886.17	47819.72	78445.23
" 9, "	7886.15	47819.60	78445.20
" 16, "	7886.16	47819.70	78445.22
" 23, "	7886.15	47819.74	78445.23
" 24, "	7886.16	47819.73	78445.21
" 26, "	7886.18	47819.72	78445.22

STATION 7E

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7871.95	47777.52	78413.64
" 13, "	7871.94	47777.58	78413.56
" 20, "	7871.95	47777.58	78413.54
November 4, 1975	7871.98	47777.56	78413.52
" 24, "	7871.96	47777.51	78413.47
December 2, 1975	7871.95	47777.56	78413.46
" 9, "	7871.93	47777.43	78413.46
" 16, "	7871.94	47777.54	78413.44
" 23, "	7871.92	47777.56	78413.44
" 24, "	7871.93	47777.55	78413.42
" 26, "	7871.96	47777.54	78413.44
January 12, 1976	7871.94	47777.51	78413.45
" 19, "	7871.96	47777.49	78413.46
" 26, "	7871.93	47777.52	78413.43
February 2, 1976	7871.93	47777.50	78413.47
" 16, "	7871.91	47777.48	78413.41
" 23, "	7871.92	47777.49	78413.41
March 15, 1976	7871.90	47777.53	78413.45
" 22, "	7871.91	47777.45	78413.42
" 30, "	7871.89	47777.45	78413.45
May 10,1976	7871.91	47777.44	78413.43

STATION 6E

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7862.02	47734.99	78371.35
" 13, "	7862.02	47735.04	78371.29
" 20, "	7862.05	47735.06	78371.25
November 4, 1975	7862.04	47735.04	78371.23
" 24, "	7862.03	47734.98	78371.16
December 2, 1975	7862.01	47735.04	78371.15
" 9, "	7861.98	47734.93	78371.12
" 16, "	7861.98	47735.01	78371.13
" 23, "	7861.96	47734.99	78371.10
" 24, "	7861.94	47734.98	78371.09
" 26, "	7861.97	47734.97	78371.09
January 12, 1976	7861.96	47734.93	78371.11
" 19, "	7861.93	47734.89	78371.10
" 26, "	7861.92	47734.87	78371.06
February 2, 1976	7861.92	47734.84	78371.08
" 16, "	7861.89	47734.83	78371.03
" 23, "	7861.89	47734.84	78371.03
March 15, 1976	7861.88	47734.83	78371.05
" 22, "	7861.89	47734.79	78371.05
" 30, "	7861.90	47734.78	78371.06
May 10, 1976	7861.88	47734.79	78371.06

STATION 5E

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7836.84	47691.93	78328.88
" 13, "	7836.82	47691.96	78328.81
" 20, "	7836 83	47691.96	78328.79
November 4, 1975	7836.83	47691.93	78328.77
" 24, "	7836.83	47691.98	78328.71
December 2, 1975	7836.80	47692.04	78328.71
" 9, "	7836.78	47691 92	78328.65
" 16, "	7836.76	47691.98	78328.63
" 23, "	7836.69	47691 94	78328.58
" 24, "	7836.70	47691 93	78328.57
" 26, "	7836.72	47691.91	78328.56
January 12, 1976	7836.66	47691 85	78328.56
" 19, "	7836.63	47691.75	78328.49
" 26, "	7836.57	47691.68	78328.40
February 2, 1976	7836.54	47691.59	78328.39
" 16, "	7836.50	47691.49	78328.30
" 23, "	7836.49	47691.49	78328.30
March 15, 1976	7836.48	47691.44	78328.28
" 22, "	7836.47	47691.36	78328.28
" 30, "	7836.46	47691.37	78328.29
May 10, 1976	7836.45	47691.34	78328.26

STATION 4E

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7820.03	47650.13	78286.66
" 13, "	7820.02	47650.18	78286.64
" 20, "	7820.02	47650.18	78286.61
November 4, 1975	7820.02	47650.14	78286.56
" 24, "	7820.01	47650.13	78286.52
December 2, 1975	7819.97	47650.17	78286.47
" 9, "	7819.98	47650.06	78286.39
" 16, "	7819.87	47650.13	78286.34
" 23, "	7819.72	47650.03	78286.13
" 24, "	7819.70	47649.96	78286.00
" 26, "	7819.69	47649.93	78285.96
January 5, 1976	7819.67	47649.93	78285.87
" 12, "	7819.56	47649.75	78285.69
" 19, "	7819.27	47649.22	78285.32
" 26, "	7818.97	47649.64	78285.03
February 2, 1976	7818.86	47649.37	78284.97
" 16, "	7818.75	47648.22	78284.91
" 23, "	7818.72	47648.16	78284.91
March 15, 1976	7818.70	47648.12	78284.93
" 22, "	7818.70	47648.07	78284.93
" 30, "	7818.70	47648.07	78284.93
May 10, 1976	7818.68	47648.04	78284.92

STATION 3E

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7808.49	47607.41	78244.13
" 13, "	7808.48	47607.42	78244.11
" 20, "	7808.48	47607.45	78244.09
November 4, 1975	7808.46	47607.44	78244.03
" 24, "	7808.43	47607.40	78243.96
December 2, 1975	7808.39	47607.45	78243.92
" 9, "	7808.35	47607.36	78243.82
" 16, "	7808.24	47607.45	78243.69
" 23, "	7807.73	47607.42	78243.01
" 24, "	7807.44	47607.38	78242.66
" 26, "	7807.36	47607.36	78242.58
" 29, "	7807.30	47607.34	78242.54
January 5, 1976	7807.24	47607.34	78242.48
" 12, "	7806.36	47607.10	78241.98
" 19, "	7805.10	47606.52	78241.67
" 26, "	7804.43	47605.84	78241.84
February 2, 1976	7804.24	47605.48	78241.97
" 16, "	7804.07	47605.23	78242.01
" 23, "	7804.05	47605.19	78242.00
March 15, 1976	7804.02	47605.14	78242.00
" 22, "	7804.02	47605.11	78242.03
" 30, "	7804.03	47605.08	78242.03
May 10, 1976	7803.99	47605.08	78241.99

STATION 2E

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7798.80	47564.77	78201.35
" 13, "	7798.80	47564.81	78201.37
" 20, "	7798.81	47564.79	78201.32
November 24, 1975	7798.75	47564.81	78201.20
December 2, 1975	7798.70	47564.84	78201.10
" 9, "	7798.62	47564.78	78200.91
" 16, "	7798.62	47565.11	78199.91
" 23, "	7796.72	47565.31	78198.77
" 24, "	7796.26	47565.26	78198.73
" 26, "	7796.18	47565.25	78198.75
" 29, "	7796.11	47565.24	78198.76
January 5, 1976	7796.02	47565.24	78198.72
" 12, "	7795.02	47565.03	78198.91
" 19, "	7793.71	47564.33	78198.43
" 26, "	7793.11	47563.75	78199.86
February 2, 1976	7792.91	47563.43	78199.08
" 16, "	7792.76	47563.26	78200.08
" 23, "	7792.75	47563.20	78200.19
March 15, 1976	7792.74	47563.15	78200.22
" 22, "	7792.73	47563.12	78200.23
" 30, "	7792.72	47563.11	78200.25
May 10, 1976	7792.72	47563.10	78200.25

STATION 1E

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7787.85	47522.77	78159.61
" 13, "	7787.84	47522.77	78159.59
" 20, "	7787.85	47522.82	78159.58
November 4, 1975	7787.83	47522.81	78159.53
" 24, "	7787.78	47522.82	78159.44
December 2, 1975	7787.72	47522.84	78159.33
" 9, "	7787.62	47522.78	78159.17
" 16, "	7787.05	47523.05	78158.38
" 23, "	7785.25	47523.40	78157.33
" 24, "	7784.80	47523.39	78157.30
" 26, "	7784.72	47523.38	78157.31
" 29, "	7784.64	47523.35	78157.31
January 5, 1976	7784.57	47523.36	78157.30
" 12, "	7783.63	47523.14	78158.51
" 19, "	7782.34	47522.38	78158.13
" 26, "	7781.76	47521.80	78158.62
February 2, 1976	7781.56	47521.45	78159.86
" 16, "	7781.38	47521.22	78159.03
" 23, "	7781.36	47521.19	78159.07
March 15, 1976	7781.33	47521.12	78159.09
" 22, "	7781.32	47521.08	78159.13
" 30, "	7781.31	47521.06	78159.15
May 10, 1976	7781.32	47521 05	78159.13

STATION #3 MPBX

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 13, 1975	7783.45	47480.78	78117.27
" 20, "	7783.45	47480.79	78117.25
November 4, 1975	7783.44	47480.81	78117.20
" 24, "	7883.40	47480.83	78117.10
December 2, 1975	7783.33	47480.87	78117.01
" 5, "	7783.29	47480.86	78116.88
" 9, "	7783.21	47480.86	78116.80
" 11, "	7783.12	47480.99	78116.60
" 12, "	7782.99	47481.12	78116.38
" 16, "	7782.55	47481.55	78115.80
" 19, "	7781.54	47481.83	78115.12
" 23, "	7780.62	47481.79	78114.91
" 24, "	7780.16	47481.68	78114.90
" 26, "	7780.09	47481.66	78114.93
" 29, "	7780.03	47481.64	78114.93
January 5, 1976	7779.94	47481.65	78114.92
" 12, "	7779.07	47481.32	78115.20
" 19, "	7777.85	47480.48	78115.90
" 26, "	7777.31	47479.89	78116.45
February 2, 1976	7777.13	47479.60	78116.69
" 16, "	7776.97	47479.36	78116.88
March 15, 1976	7776.93	47479.27	78116.97
" 22, "	7776.92	47479.20	78117.00
" 30, "	7776.91	47479.20	78117.01
May 10, 1976	7776.92	47479.20	78117.02

STATION 1W

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7774.26	47437.25	78075.09
" 13, "	7774.26	47437.23	78075.05
" 20, "	7774.25	47437.26	78075.04
November 4, 1975	7774.25	47437.26	78074.99
" 24, "	7774.20	47437.29	78074.90
December 2, 1975	7774.15	47437.37	78074.83
" 9, "	7774.04	47437.34	78074.65
" 16, "	7773.38	47438.12	78073.59
" 23, "	7771.35	47438.34	78072.88
" 24, "	7770.88	47438.21	78072.89
" 26, "	7770.78	47438.20	78072.90
" 29, "	7770.72	47438.18	78072.91
January 5, 1976	7770.63	47438.18	78072.90
" 12, "	7769.77	47437.83	78073.11
" 19, "	7768.53	47437.04	78073.76
" 26, "	7768.00	47436.52	78074.25
February 2, 1976	7767.84	47436.26	78074.46
" 16, "	7767.70	47436.04	78074.63
" 23, "	7767.68	47435.98	78074.66
March 15, 1976	7767.67	47435.94	78074.70
" 22, "	7767.66	47435.90	78074.73
" 30, "	7767.66	47435.89	78074.75
May 10, 1976	7767.66	47435.87	78074.76

STATION 2W

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7755.10	47394.97	78032.63
" 13, "	7755.11	47394.97	78032.60
" 20, "	7755.11	47995.02	78032.61
November 4, 1975	7755.10	47395.01	78032.55
" 24, "	7755.08	47395.06	78032.45
December 2, 1975	7755.03	47395.11	78032.33
" 9, "	7754.93	47395.12	78032.11
" 16, "	7754.35	47395.75	78031.23
" 23, "	7752.25	47395.73	78030.72
" 24, "	7751.73	47395.62	78030.75
" 26, "	7751.62	47395.60	78030.77
" 29, "	7751.56	47395.60	78030.77
January 5, 1976	7751.48	47395.57	78030.76
" 12, "	7750.55	47395.30	78030.95
" 19, "	7749.31	47394.67	78031.43
" 26, "	7748.84	47394.28	78031.76
February 2, 1976	7748.69	47394.09	78031.95
" 16, "	7748.59	47393.93	78032.12
" 23, "	7748.57	47393.89	78032.12
March 15, 1976	7748.55	47393.85	78032.14
" 22, "	7748.56	47393.83	78032.19
" 30, "	7748.55	47393.81	78032.18
May 10, 1976	7748.54	47393.82	78032.18

STATION 3W

DATE		ELEVATION	NORTH COOR.	EAST COOR.
October	6, 1975	7733.71	47352.38	77990.52
"	13, "	7733.70	47352.44	77990.53
"	20, "	7733.71	47352.44	77990.50
November	4, 1975	7733.69	47352.41	77990.47
"	24, "	7733.68	47352.44	77990.39
December	2, 1975	7733.65	47352.52	77990.34
"	9, "	7733.57	47352.44	77990.15
"	16, "	7733.15	47352.82	77989.72
"	23, "	7731.16	47353.05	77989.41
"	24, "	7730.71	47353.00	77989.43
"	26, "	7730.61	47353.00	77989.44
"	29, "	7730.56	47353.00	77989.44
January	5, 1976	7730.46	47352.98	77989.43
"	12, "	7729.66	47352.82	77989.55
"	19, "	7728.61	47352.39	77989.87
"	26, "	7728.15	47352.10	77990.15
February	2, 1976	7728.03	47351.95	77990.28
"	16, "	7727.92	47351.84	77990.39
"	23, "	7727.89	47351.81	77990.41
March	15, 1976	7727.89	47351.77	77990.44
"	22, "	7727.88	47351.76	77990.44
"	30, "	7727.88	47351.76	77990.46
May	10, 1976	7727.87	47351.75	77990.45

STATION 4W

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7711.43	47309.56	77948.26
" 13, "	7711.43	47309.56	77948.25
" 20 "	7711.42	47309.57	77948.25
November 4, 1975	7711.42	47309.59	77948.23
" 24, "	7711.41	47309.58	77948.16
December 2, 1975	7711.38	47309.57	77948.13
" 9. "	7711.37	47309.50	77948.02
" 16, "	7711.26	47309.58	77947.91
" 23, "	7710.69	47309.76	77947.88
" 24, "	7710.61	47309.78	77947.92
" 26, "	7710.57	47309.78	77947.92
" 29, "	7710.57	47309.78	77947.91
January 5, 1976	7710.51	47309.81	77947.93
" 12, "	7710.28	47309.75	77948.01
" 19, "	7709.89	47309.60	77948.20
" 26, "	7709.68	47309.50	77948.37
February 2, 1976	7709.61	47309.42	77948.49
" 16, "	7709.54	47309.36	77948.58
" 23, "	7709.54	47309.34	77948.60
March 15, 1976	7709.52	47309.33	77948.62
" 22, "	7709.51	47309.32	77948.63
" 30, "	7709.52	47309.30	77948.65
May 10, 1976	7709.50	47309.31	77948.64

STATION 5W

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7685.94	47267.10	77905.92
" 13, "	7685 93	47267.09	77905.90
" 20, "	7685 94	47267.13	77905.92
November 4, 1975	7685.94	47267.14	77905.90
" 24, "	7685.93	47267.12	77905.86
December 2, 1975	7685.91	47267.10	77905.85
" 9, "	7685.96	47267.08	77905.82
" 16, "	7685.93	47266.94	77905.67
" 23, "	7685.92	47266.71	77905.56
" 24, "	7685.94	47266.67	77905.54
" 26, "	7685.95	47266.68	77905.54
January 19, 1976	7685.99	47266.49	77905.44
" 26, "	7685.94	47266.60	77905.53
March 15, 1976	7685.94	47266.42	77905.63
May 10, 1976	7685.89	47266.47	77905.35

STATION 6W

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7661.90	47224.78	77863.34
" 13, "	7661.90	47224.79	77863.34
" 20, "	7661.90	47224.81	77863.36
November 4, 1975	7661.90	47224.80	77863.33
" 24, "	7661.90	47224.78	77863.30
December 2, 1975	7661.88	47224.74	77863.28
" 9, "	7661.93	47224.74	77863.26
" 16, "	7661.89	47224.72	77863.18
" 23, "	7661.88	47224.59	77863.12
" 24, "	7661.91	47224.58	77863.12
" 26, "	7661.90	47224.59	77863.11
January 12, 1976	7661.94	47224.51	77863.06
" 19, "	7661.94	47224.43	77862.99
" 26, "	7661.91	47224.41	77862.91
March 15, 1976	7661.92	47224.26	77863.20
May 10, 1976	7661.88	47224.40	77862.82

STATION 7W

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7637.79	47181.90	77821.51
" 13, "	7637.76	47181.88	77821.49
" 20, "	7637.77	47181.90	77821.52
November 4, 1975	7637.79	47181.91	77821.52
" 24, "	7637.77	47181.85	77821.46
December 2, 1975	7637.77	47181.84	77821.46
" 9, "	7637.80	47181.84	77821.42
" 16, "	7637.77	47181.86	77821.35
" 23, "	7637.67	47181.89	77821.11
" 24, "	7637.68	47181.79	77821.18
" 26, "	7637.68	47181.81	77821.16
January 12, 1976	7637.35	47181.57	77820.96
" 19, "	7637.15	47181.30	77820 80
" 26, "	7637.07	47181.30	77820.74
March 15, 1976	7637.09	47180.96	77820.95
May 10, 1976	7637.01	47180.97	77820.63

STATION 8W

DATE	ELEVATION	NORTH COOR.	EAST COOR.
October 6, 1975	7616.09	47140.26	77778.29
" 13, "	7616.07	47140.24	77778.26
" 20, "	7616.09	47140.28	77778.30
November 4, 1975	7616.10	47140.28	77778.29
" 24, "	7616.09	47140.24	77778.23
December 2, 1975	7616.07	47140.22	77778.23
" 9, "	7616.10	47140.25	77778.18
" 16, "	7616.04	47140.26	77778.13
" 23, "	7615.26	47140.01	77777.57
" 24, "	7615.26	47140.00	77777.58
" 26, "	7615.24	47140.02	77777.56
January 12, 1976	7613.66	47139.67	77777.64
" 19, "	7613.16	47139.54	77777.70
" 26, "	7612.98	47139.51	77777.62
March 15, 1976	7612.93	47139.20	77777.92

APPENDIX F

RAW DATA AND RELATIVE STRAIN BETWEEN ANCHORS FOR MPBX NO. 3

TABLE F - 1

NO. 3 MPBX - RAW DATA

DATE	ANCHOR 1 135 ft	ANCHOR 2 275 ft	ANCHOR 3 325 ft	ANCHOR 4 340 ft	ANCHOR 5 365 ft
6/15-11/15/75	2.30	0.98	1.53	1.43	1.33
11/15-11/23/75	2.30	0.98	1.52	1.43	1.33
11/24/75	2.30	0.98	1.52	1.43	1.33
11/25/75	2.30	0.98	1.51	1.43	1.33
11/26/75	2.30	0.98	1.51	1.43	1.33
11/27/75	2.30	0.98	1.51	1.43	1.33
11/28/75	2.30	0.96	1.49	1.43	1.33
11/29/75	2.30	0.96	1.49	1.43	1.33
11/30/75	2.30	0.96	1.49	1.43	1.33
12/ 1/75	2.29	0.94	1.46	1.43	1.32
12/ 2/75	2.28	0.93	1.45	1.43	1.32
12/ 3/75	2.27	0.93	1.44	1.43	1.32
12/ 4/75	2.27	0.93	1.44	1.43	1.32
12/ 5/75	2.25	0.90	1.43	1.40	1.27
12/ 6/75	2.24	0.86	1.40	1.39	1.26
12/ 7/75	2.23	0.86	1.39	1.38	1.26
12/ 8/75	2.20	0.83	1.35	1.36	1.24
12/ 9/75	2.14	0.77	1.30	0.85	hit - 0.57
12/10/75	2.10	0.75	1.28	3.33	-
12/11/75	2.08	0.73	1.68	4.58/0.46 broken	-
12/12/75	1.95	1.17	2.40/0.53 broken	-	-
12/13/75	1.95	2.04	-	-	-

TABLE F-1 (continued)

DATE	ANCHOR 1 135 ft	ANCHOR 2 275 ft	ANCHOR 3 325 ft	ANCHOR 4 340 ft	ANCHOR 5 365 ft
12/14/75	1.95	2.13	-	-	-
12/15/75	1.94	3.77	-	-	-
12/16/75	1.94	3.89	-	-	-
12/17/75	1.98	-	-	-	-
12/18/75	2.30	-	-	-	-
12/19/75	2.73	-	-	-	-
12/20/75	2.95	-	-	-	-
12/21/75	3.00	-	-	-	-
12/22/75	3.12	-	-	-	-
12/26/75	3.40	-	-	-	-

NO. 3 MPBX

TABLE F-2 RELATIVE STRAIN BETWEEN ANCHORS ($\frac{u\text{-}in}{in}$)

DATE	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	DISTANCE FROM NO. 3 MPBX
11/22/75	0	0	0	0	0	-69
11/23/75	0	0	-67	222	0	-69
11/24/75	0	0	-133	444	0	-64
11/25/75	0	0	-133	444	0	-54
11/26/75	0	0	-133	444	0	-40
11/27/75	0	0	-133	444	0	-37
11/28/75	0	-42	-150	889	0	-37
11/29/75	0	-42	-150	889	0	-37
11/30/75	0	-42	-150	889	0	-37
12/ 1/75	-12	-71	-233	1556	-133	-34
12/ 2/75	-31	-77	-233	1778	-133	-29
12/ 3/75	-43	-65	-300	2000	-133	-24
12/ 4/75	-43	-65	-300	2000	-133	-18
12/ 5/75	-68	-101	-200	1556	-333	-12
12/ 6/75	-86	-172	-150	1944	-300	-10
12/ 7/75	-99	-160	-217	1944	-167	-10
12/ 8/75	-142	-179	-317	2389	-200	- 6
12/ 9/75	-222	-232	-283	-8278	+18000 (hit)	0
12/10/75	-278	-220	-300	+49000 (hit)	-	+12
12/11/75	-309	-232	+2483	-	-	+20
12/12/75	-488	+869	+4683 broken	-	-	+31
12/13/75	-488	+2708	-	-	-	+33

TABLE F-2 (continued)

DATE	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	DISTANCE FROM NO. 3 MPBX
12/14/75	-488	+2898	-	-	-	+33
12/15/75	-500	+6375	-	-	-	+41
12/16/75	-500	+6631 broken	-	-	-	+47
12/17/75	-444	-	-	-	-	+59
12/18/75	0	-	-	-	-	+73
12/19/75	+599	-	-	-	-	+86
12/20/75	+901	-	-	-	-	+90
12/21/75	+975	-	-	-	-	+90
12/22/75	+1142	-	-	-	-	+98
12/26/75	+1531	-	-	-	-	+120

APPENDIX G

DYNAMIC HORIZONTAL STRAIN DATA

FOR

CENTERLINE, PERPENDICULAR AND NORTH DIAGONAL

(corrected for slope)

TABLE G - 1

PANEL CENTERLINE

MEASURED HORIZONTAL STRAIN ON MARCH 15, 1975 FACE 15 FT SOUTH of 7S

Station	N	E	Components from N N (-) S (+)	Along from E W (-) E (+)	HD SE (+) NW (-)	Measured Strain
19N	0.0	0.0	0.00	0.00	0.00	
						+ 1,167
18N	0.1S	0.0	+0.07	0.00	+0.07	
						+ 5,833
17N	0.4S	0.2E	+0.28	+0.14	+0.42	
						+16,500
16N	1.0S	1.0E	+0.71	+0.71	+1.41	
						+24,833
15N	2.2S	1.9E	+1.56	+1.34	+2,90	
						+ 8,167
14N	2.8S	2.0E	+1.98	+1.41	+3.39	
						+20,167
13N	3.6S	2.9E	+2.55	+2.05	+4.60	
						+12,833
12N	4.1S	3.5E	+2.90	+2.47	+5.37	
						- 2,333
11N	3.9S	3.5E	+2.76	+2.47	+5.23	
						+43,667
10N	5.5S	5.6E	+3.89	+3.96	+7.85	
						-59,000
9N	3.3S	2.8E	+2.33	+1.98	+4.31	
						- 7,000

Table G-1 (continued)

Station	N	E	Components from N N (-) S (+)	Along from E W (-) E (+)	HD SE (+) NW (-)	Measured Strain
8N	2.9S	2.6E	+2.05	+1.84	+3.89	-33,000
7N	1.3S	1.4E	+0.92	+0.99	+1.91	-31,833
6N	0.4S	0.4W	+0.28	-0.28	0.00	- 4,667
5N	0.4S	0.8W	+0.28	-0.57	-0.28	- 2,333
4N	0.2S	0.8W	+0.14	-0.57	-0.42	- 8,333
3N	0.0S	1.3W	+0.00	-0.92	-0.92	+ 3,500
2N	0.3S	1.3W	+0.21	-0.92	-0.71	+ 2,333
1N	1.0S	1.8W	+0.71	-1.27	-0.57	+23,667
#3MPBX	1.5S	0.3W	+1.06	-0.21	+0.85	+ 8,167
1S	1.8S	0.1E	+1.27	+0.07	+1.34	+ 2,333
2S	2.0S	0.1E	+1.41	+0.07	+1.48	+ 7,167
3S	2.2S	0.5E	+1.56	+0.35	+1.91	+ 8,167

Table G-1 (continued)

Station	N	E	Components from N: N (-) S(+)	Along from E: W (-) E(+)	HD: SE (+) NW (-)	Measured Strain
4S	2.4S	1.0E	+1.70	+0.71	+2.40	
						-20,000
5S	1.7S	0.0E	+1.20	+0.00	+1.20	
						- 9,333
6S	0.9S	0.0E	+0.64	+0.00	+0.64	
						-13,000
7S	0.0S	0.2W	+0.00	-0.14	-0.14	
						0
8S	0.1N	0.1W	-0.07	-0.07	-0.14	
						+ 1,167
9S	0.1N	0.0W	-0.07	+0.00	-0.07	
						+ 1,167
10S	0.0N	0.0W	0.00	+0.00	+0.00	
						0
11S	0.0N	0.0W	0.00	+0.00	+0.00	

TABLE G - 2

PANEL CENTERLINE

MEASURED HORIZONTAL STRAIN ON SEPTEMBER 9, 1975 fc @ 8N

Station	N	E	Components from N N- S+	Along from E W- E+	HD SE (+) NW(-)	Measured Strain
20N	0.0	0.0	0.00	0.00	0.00	
						0
19N	0.0	0.0	0.00	0.00	0.00	
						+ 1,167
18N	0.1S	0.0	+0.07	0.00	+0.07	
						+ 4,667
17N	0.4S	0.1E	+0.28	+0.07	+0.35	
						+16,667
16N	1.0S	0.9E	+0.71	+0.64	+1.35	
						+21,000
15N	2.0S	1.7E	+1.41	+1.20	+2.61	
						+ 8,333
14N	2.5S	1.9E	+1.77	+1.34	+3.11	
						+16,500
13N	3.2S	2.6E	+2.26	+1.84	+4.10	
						+ 9,500
12N	3.6S	3.0E	+2.55	+2.12	+4.67	
						-17,667

Table G-2 (continued)

Station	N	E	Components Along from N	Components Along from E	HD SW (+) NW (-)	Measured Strain	
11N	2.7S	2.4E	+1.91	+1.70	+3.61		
						+16,500	Strain -21,833
10N	3.2S	3.3E	+2.26	+2.33	+4.60		
						-60,167	
9N	0.9S	0.5E	+0.64	+0.35	+0.99		
						- 1,167	
8N	0.7S	0.6E	+0.49	+0.42	+0.92		
						-11,833	
7N	0.1S	0.2E	+0.07	+0.14	+0.21		
						- 3,500	
6N	0.0	0.0	0.00	0.00	0.00		
						0	
5N	0.0	0.0	0.00	0.00	0.00		

TABLE G - 3

MEASURED HORIZONTAL STRAIN ON SEPTEMBER 9, 1975 Fc @ 8N

STRAIN CORRECTED FOR SLOPE

Station	Original Elevation	Elevation 9/9/95	Original Ground Slope	Inc(+)/Decrease(-) In Slope	Strain Correction	Measured Strain	Strain Correction for Slope
20N	7688.3	7688.3					
	54.5	54.5	0.45	0.000	0	0	0
19N	7742.8	7742.8					
	30.7	30.6	0.51	-0.002	400	+ 1,167	+ 1,567
18N	7773.5	7773.4					
	24.1	24.0	0.40	-0.002	300	+ 4,667	+ 4,967
17N	7797.6	7797.4					
	13.0	12.1	0.22	-0.015	3,200	+16,667	+19,867
16N	7810.6	7809.5					
	14.7	11.4	0.25	-0.055	10,800	+21,000	+31,800
15N	7825.3	7820.9					
	8.4	6.4	0.14	-0.033	4,100	+ 8,333	+12,433
14N	7833.7	7827.3					
	2.0	2.3	0.03	+0.005	200	+16,500	+16,300
13N	7831.7	7825.0					
	6.3	6.3	0.11	0.000	0	+ 9,500	+ 9,500
12N	7825.4	7818.7					
	30.4	29.4	0.51	-0.017	7,100	-17,667	-10,567

Table G-3 (continued)

Station	Original Elevation	Elevation 9/9/75	Original Ground Slope	Inc(+)/Decrease(-) In Slope	Strain Correction	Measured Strain	Strain Correction for Slope
11N	7795.0	7789.3					
	31.5	30.3	0.53	-0.020	8,300	+16,500	+24,800
							-11,733
10N	7763.5	7759.0					
	24.4	21.5	0.41	-0.048	16,500	-60,167	-43,667
9N	7739.1	7737.5					
	24.1	22.6	0.40	-0.025	8,700	- 1,167	+ 7,533
8N	7715.0	7714.9					
	25.4	25.3	0.42	-0.002	800	-11,833	-11,033
7N	7689.6	7689.6					
	7.3	7.3	0.12	0.000	0	- 3,500	- 3,500
6N	7696.9	7696.9					
	2.4		0.04	0.000	0	0	0
5N	7699.3	7699.3					

TABLE G - 4

STRAIN CORRECTED FOR SLOPE ON MARCH 15, 1975

tation	Original Elevation	Elevation 3/15/75	Original Ground Slope	Inc(+)/Decrease(-) in Slope	in/in. Strain Correction	Measured Strain	Strain Corrected for Slope
19N	7742.8 +30.7	7742.8 +30.6	0.51	-0.002	400	+ 1,167	1,567
18N	7773.5 +24.1	7773.4 +24.0	0.40	-0.002	300	+ 5,833	6,133
17N	7797.6 +13.0	7797,4 +12.0	0.22	-0.017	3,600	+16,500	+20,100
16N	7810.6 +14.7	7809.4 +11.4	0.25	-0.055	10,800	+24,833	+35,633
15N	7825.3 + 8.4	7820.8 + 6.4	0.14	-0.033	4,100	+ 8,167	+12,267
14N	7833.7 - 2.0	7827.2 - 2.2	0.03	+0.003	0	+20,167	+20,167
13N	7831.7 - 6.3	7825.0 - 6.7	0.11	+0.007	800	+12,833	+12,033
12N	7825.4 -30.4	7818.3 -29.8	0.51	-0.010	3,800	- 2,333	+ 1,467
11N	7795.0 -31.5	7788.5 -31.6	0.53	+0.002	400	+43,667	+43,267
10N	7763.5 -24.4	7756.9 -23.8	0.41	-0.010	3,600	-15,333 -59,000	-12,133 -55,400
9N	7739.1 -24.1	7733.1 -23.7	0.40	-0.007	2,400	- 7,000	- 4,600

Table G-4(continued)

:ation	Original Elevation	Elevation 3/15/75	Original Ground Slope	Inc(+)/Decrease(-) in Slope	in/in. Strain Correction	Measured Strain	Strain Corrected for Slope
8N	7715.0	7709.4					
	-25.4	-24.9	0.42	-0.008	2,800	-33,000	-30,200
7N	7689.6	7684.5					
	+ 7.3	+ 7.3	0.12	0	0	-31,833	-31,833
6N	7696.9	7691.8					
	+ 2.4	+ 2.1	0.04	-0.005	200	- 4,667	- 4,467
5N	7699.3	7693.9					
	+18.9	+18.5	0.32	-0.007	1,800	- 2,333	- 533
4N	7718.2	7712.4					
	+18.3	+17.9	0.31	-0.007	1,800	- 8,333	- 6,533
3N	7736.5	7730.3					
	+21.2	+21.3	0.35	+0.002	300	+ 3,500	+ 3,200
2N	7757.7	7751.6					
	+17.8	+17.7	0.30	-0.002	250	+ 2,333	+ 2,583
1N	7775.5	7769.3					
	+ 8.0	+ 7.6	0.13	-0.007	800	+23,667	+24,467
MPBX	7783.5	7776.9					
	- 1.0	- 1.1	0.02	+0.002	100	+ 8,167	+ 8,067
1S	7782.5	7775.8					
	-12.5	-12.2	0.21	-0.005	1,000	+ 2,333	+ 3,333
2S	7770.0	7763.6					
	- 7.6	- 7.2	0.13	-0.007	700	+ 7,167	+ 7,867

Table G-4 (continued)

tation	Original Elevation	Elevation 3/15/75	Original Ground Slope	Inc(+)/Decrease(-) in Slope	in/in. Strain Correction	Measured Strain	Strain Corrected for Slope
3S	7762.4	7756.4					
	-12.5	-12.1	0.21	-0.007	1,400	+8,167	+ 9,567
4S	7749.9	7744.3					
	-10.4	-9.6	0.17	-0.013	2,000	-20,000	-18,000
5S	7739.5	7734.7					
	-32.8	-30.7	0.55	-0.035	14,000	- 9,333	+ 4,667
6S	7706.7	7704.0					
	- 2.2	+ 0.3	0.04	-0.042	1,000	-13,000	-12,000
7S	7704.5	7704.3					
	+20.0	+20.1	0.33	+0.002	300	0	+ 300
8S	7724.5	7724.4					
	+18.8	+18.9	0.31	+0.002	250	+ 1,167	+ 1,417
9S	7743.3	7743.3					
	+17.0	+17.0	----	-----	0	+ 1,167	+ 1,167
10S	7760.3	7760.3					
	+26.6	+26.6	-----	-----	0	0	0
11S	7786.9	7786.9					

TABLE G - 5

DYNAMIC HORIZONTAL STRAIN ALONG PERPENDICULAR DECEMBER 24, 1975

FACE 70 FT SOUTH OF PERPENDICULAR

Station	N	E	Components from N N (-) S (+)	Along from E E (-) W (+)	HD SW (+) NE (-)	Measured Strain
8E	0.0	0.0	0.0	0.0	0.0	
						0
7E	0.0	0.0	0.0	0.0	0.0	
						+ 2,333
6E	0.0	0.2W	0.0	+0.14	+0.14	
						+ 2,333
5E	0.1S	0.3W	+0.07	+0.21	+0.28	
						+ 4,833
4E	0.2S	0.6W	+0.14	+0.42	+0.57	
						+ 7,000
3E	0.0	1.4W	0.0	+0.99	+0.99	
						+ 8,167
2E	0.5N	2.6W	-0.35	+1.84	+1.48	
						- 4,667
1E	0.6N	2.3W	-0.42	+1.63	+1.20	
						- 2,333
#3MPBX	0.9N	2.4W	-0.64	+1.70	+1.06	
						- 3,500
1W	0.9N	2.1W	-0.64	+1.48	+0.85	
						0
2W	0.6N	1.8W	-0.42	+1.27	+0.85	
						- 8,333

Table G-5 (continued)

Station	N	E	Components from N N(-)	S(+)	Along from E E(-)	W(+)	HD SW(+)	NE(-)	Measured Strain
3W	0.6N	1.1W	-0.42		+0.78		+0.35		
									- 4,667
4W	0.2N	0.3W	-0.14		+0.21		+0.07		
									+ 8,333
5W	0.4S	0.4W	+0.28		+0.28		+0.57		
									- 4,833
6W	0.2S	0.2W	+0.14		+0.14		+0.28		
									0
7W	0.1S	0.3W	+0.07		+0.21		+0.28		
									+ 7,167
8W	0.3S	0.7W	+0.21		+0.49		+0.71		

TABLE G - 6

DYNAMIC HORIZONTAL STRAIN ALONG PERPENDICULAR CORRECTED FOR SLOPE

tation	Original Elevation	Elevation 12/24/75	Original Ground Slope	Inc(+)/Decrease(-) in Slope	Strain Correction	Measured Strain	Strain Corrected for Slope
8E	7886.2	7886.2					
	14.3	14.3	0.24	0.000	0	0	0
7E	7871.9	7871.9					
	9.9	10.0	0.17	+0.002	400	+ 2,333	+ 1,933
6E	7862.0	7861.9					
	25.2	25.2	0.42	0.000	0	+ 2,333	2,333
5E	7836.8	7836.7					
	16.8	17.0	0.28	+0.003	800	+ 4,833	4,033
4E	7820.0	7819.7					
	11.5	12.3	0.19	+0.012	2,700	+ 7,000	4,300
3E	7808.5	7807.4					
	9.7	11.1	0.16	+0.023	4,000	+ 8,167	4,167
2E	7798.8	7796.3					
	10.9	11.5	0.18	+0.010	1,800	- 4,667	- 6,467
1E	7787.9	7784.8					
	4.4	4.6	0.07	+0.003	200	- 2,333	- 2,533
3MPBX	7783.5	7780.2					
	9.2	9.3	0.15	+0.002	300	- 3,500	- 3,800
1W	7774.3	7770.9					
	19.2	19.2	0.32	0	0	0	0
2W	7755.1	7751.7					
	21.4	21.0	0.36	-0.007	2,300	- 8,333	- 6,033

Table G-6(continued)

Station	Original Elevation	Elevation 12/24/75	Original Ground Slope	Inc(+)/Decrease(-) in Slope	Strain Correction	Measured Strain	Strain Corrected for Slope
3W	7733.7	7730.7					
	22.3	20.1	0.37	-0.037	12,400	- 4,667	+ 7,733
4W	7711.4	7710.6					
	25.4	24.7	0.42	-0.012	4,200	+ 8,333	+12,533
5W	7686.0	7685.9					
	24.1	24.0	0.40	-0.002	500	- 4,833	- 4,333
6W	7661.9	7661.9					
	24.1	24.2	0.40	+0.002	700	0	- 700
7W	7637.8	7637.7					
	21.7	22.4	0.36	+0.012	4,000	+ 7,167	+ 3,167
8W	7616.1	7615.3					

TABLE G - 7

PANEL DIAGONAL

MEASURED HORIZONTAL STRAIN ON SEPTEMBER 9, 1975 FACE AT 8N

Station	N	E	Components from N N(-) S(+)	Along Diagonal from E E & W = 0.0	HD N- S+	Measured Strain
10ND	0.0	0.0	0.00	0.00	0.00	
						0
9ND	0.0	0.0	0.00	0.00	0.00	
						0
8ND	0.0	0.0	00.00	0.00	0.00	
						+ 1,667
7ND	0.1S	0.0	+0.10	0.00	+0.10	
						+ 8,333
6ND	0.6S	0.0	+0.60	0.00	+0.60	
						+28,333
5ND	2.3S	0.1E	+2.30	0.00	+2.30	
						- 3,333
4ND	2.1S	1.0E	+2.10	0.00	+2.10	
						+ 6,667
3ND	2.5S	1.9E	+2.50	0.00	+2.50	
						+10,000
2ND	3.1S	2.5E	+3.10	0.00	+3.10	
						- 3,738
1N	2.7S	2.4E	+2.70	0.00	+2.70	

TABLE G - 8

MEASURED HORIZONTAL STRAIN ON SEPTEMBER 9, 1975 FACE AT 8N

tation	Original Elevation	Elevation 9/9/75	Original Ground Slope	Inc(+)/Decrease(-) In Slope	in/in. Strain Correction	Measured Strain	Strain Correct for Slope
10ND	7822.3 6.2	7822.3 6.2	0.10	0.000	0	0	0
9ND	7816.1 10.5	7816.1 10.5	0.18	0.000	0	0	0
8ND	7826.6 11.9	7826.6 11.9	0.20	0.000	0	+ 1,667	+ 1,667
7ND	7838.5 0.6	7838.5 0.2	0.01	-0.007	0	+ 8,333	+ 8,333
6ND	7839.1 9.3	7838.7 11.1	0.16	+0.030	5,200	+28,333	+23,133
5ND	7829.8 10.0	7827.6 13.4	0.17	+0.057	10,000	- 3,333	-10,333
4ND	7819.8 6.3	7814.2 6.9	0.11	+0.010	1,700	+ 6,667	+ 4,967
3ND	7813.5 4.9	7807.3 5.3	0.08	+0.007	400	+10,000	+ 9,600
2ND	7808.6 13.6	7802.0 12.7	0.13	-0.008	1,000	- 3,738	- 4,738
11N	7795.0	7789.3					

APPENDIX H

STABILIZED HORIZONTAL STRAIN DATA

FOR

CENTERLINE, PERPENDICULAR AND NORTH DIAGONAL

(corrected for slope)

TABLE H - 1

MEASURED HORIZONTAL STRAIN CORRECTED FOR SLOPE

PANEL CENTERLINE (STABILIZED CONDITIONS)

ation	Original Elevation	Elevation May 1976	Original Ground Slope	Inc(+)/Decrease(-) in Slope	in/in. Strain Correction	Measured Strain	Strain Corrected for Slope
19N	7742.8	7742.8					
	+30.7	+30.6	0.51	-0.002	400	+ 1,167	+ 1,567
18N	7773.5	7773.4					
	+24.1	+24.0	0.40	-0.002	300	+ 5,833	+ 6,133
17N	7797.6	7797.4					
	+13.0	+12.0	0.22	-0.017	3,600	+16,500	+20,100
16N	7810.6	7809.4					
	+14.7	+11.4	0.25	-0.055	10,800	+24,833	+35,633
15N	7825.3	7820.8					
	+ 8.4	+ 6.4	0.14	-0.033	4,100	+ 8,167	+12,267
14N	7833.7	7827.2					
	- 2.0	- 2.2	0.03	+0.003	0	+20,167	+20,167
13N	7831.7	7825.0					
	- 6.3	- 6.7	0.11	+0.007	800	+12,833	+12,033
12N	7825.4	7818.3					
	-30.4	-29.8	0.51	-0.010	3,800	- 2,333	+ 1,467
11N	7795.0	7788.5					
	-31.5	-31.6	0.53	+0.002	400	+43,667	+43,667
10N	7763.5	7756.9				-15,333	-12,133
	-24.4	-23.8	0.41	-0.010	3,600	-59,000	-55,400
9N	7739.1	7733.1					
	-24.1	-23.7	0.40	-0.007	2,400	- 7,000	- 4,600

Table H-1(continued)

ation	Original Elevation	Elevation May 1976	Original Ground Slope	Inc(+)/Decrease(-) in Slope	in/in. Strain Correction	Measured Strain	Strain Corrected for Slope
N	7715.0 -25.4	7709.4 -24.9	0.42	-0.008	2,800	-33,000	-30,200
N	7689.6 + 7.3	7684.5 + 7.3	0.12	0	0	-31,833	-31,833
N	7696.9 + 2.4	7691.8 + 2.1	0.04	-0.005	200	- 4,667	- 4,467
N	7699.3 +18.9	7693.9 +18.5	0.32	-0.007	1,800	- 2,333	- 533
N	7718.2 +18.3	7712.4 +17.9	0.31	-0.007	1,800	- 7,142	- 5,342
N	7736.5 +21.2	7730.3 +21.3	0.35	+0.002	300	+ 3,500	+ 3,200
N	7757.7 +17.8	7751.6 +17.7	0.30	-0.002	250	+ 2,500	+ 2,750
N	7775.5 + 8.0	7769.3 + 7.6	0.13	-0.007	800	+23,500	+24,300
3 MPBX	7783.5 - 1.0	7776.9 - 1.1	0.02	+0.002	100	+10,667	+10,567
S	7782.5 -12.5	7775.8 -12.2	0.21	-0.005	1,000	+ 3,500	+ 4,500
S	7770.0 - 7.6	7763.6 - 7.3	0.13	-0.005	600	+ 8,167	+ 8,667

Table H-1 (continued)

:ation	Original Elevation	Elevation May 1976	Original Ground Slope	Inc(+)/Decrease(-) in Slope	in/in. Strain Corrected	Measured Strain	Strain Corrected for Slope
3S	7762.4 -12.5	7756.3 -12.2	0.21	-0.005	1,000	+11,833	12,833
4S	7749.9 -10.4	7744.1 -10.2	0.17	-0.003	100	- 9,500	-9,400
5S	7739.5 -32.8	7733.9 -32.3	0.55	-0.008	3,600	- 8,667	- 5,067
6S	7706.7 - 2.2	7701.6 - 1.7	0.04	-0.008	250	-34,167	-33,917
7S	7704.6 +20.1	7699.9 +19.8	0.34	-0.005	1,800	-14,167	-12,367
8S	7724.5 +18.8	7719.7 +20.3	0.31	+0.025	7,200	-17,667	-24,867
9S	7743.3 +17.0	7740.0 +19.5	0.28	+0.042	11,800	+11,833	+ 33
10S	7760.3 +26.6	7759.5 +27.3	0.44	+0.012	4,800	+20,000	+15,200
11S	7786.9 +30.6	7786.8 +30.65	0.51	+0.001	0	+ 1,167	+ 1,167
12S	7817.5 +29.0	7817.45 29.05	0.48	+0.001	0	+ 1,167	+ 1,167
13S	7846.5	7846.5					

TABLE H - 2

MEASURED HORIZONTAL STRAIN (STABILIZED CONDITIONS)

PANEL CENTERLINE MAY, 1976

Station	N	E	Components from N N(-) S(+)	Along From E W(-) E(+)	HD SE(+) NW(-)	Measured Strain
19N	0.0	0.0	0.00	0.00	0.00	
						+ 1,167
18N	0.1S	0.0	+0.07	0.00	+0.07	
						+ 5,833
17N	0.4S	0.2E	+0.28	+0.14	+0.42	
						+16,500
16N	1.0S	1.0E	+0.71	+0.71	+1.41	
						+24,833
15N	2.2S	1.9E	+1.56	+1.34	+2.90	
						+ 8,167
14N	2.8S	2.0E	+1.98	+1.41	+3.39	
						+20,167
13N	3.6S	2.9E	+2.55	+2.05	+4.60	
						+12,833
12N	4.1S	3.5E	+2.90	+2.47	+5.37	
						- 2,333
11N	3.9S	3.5E	+2.76	+2.47	+5.23	
						+43,667
10N	5.5S	5.6E	+3.89	+3.96	+7.85	
						-59,000
9N	3.3S	2.8E	+2.33	+1.98	+4.31	
						- 7,000
8N	2.9S	2.6E	+2.05	+1.84	+3.89	
						-33,000

Table H-2 (continued)

Station	N	E	Components from N: N(-) S(+)	Along From E: W(-) E(+)	HD: SE(+) NW(-)	Measured Strain
7N	1.3S	1.4E	+0.92	+0.99	+1.91	-31,833
6N	0.4S	0.4W	+0.28	-0.28	0.00	- 4,667
5N	0.4S	0.8W	+0.28	-0.57	-0.28	- 2,333
4N	0.2S	0.8W	+0.14	-0.57	-0.42	- 7,142
3N	0.1S	1.3W	+0.07	-0.92	-0.85	+ 3,500
2N	0.4S	1.3W	+0.28	-0.92	-0.64	+ 2,500
1N	1.1S	1.8W	+0.78	-1.27	-0.49	+23,500
#3 MPBX	1.6S	0.3W	+1.13	-0.21	+0.92	+10,667
1S	2.0S	0.2E	+1.41	+0.14	+1.56	+ 3,500
2S	2.2S	0.3E	+1.56	+0.21	+1.77	+ 8,167
3S	2.5S	0.7E	+1.77	+0.49	+2.26	+11,833
4S	2.8S	1.4E	+1.98	+0.99	+2.97	- 9,500

Table H-2 (continued)

Station	N	E	Components from N: N(-) S(+)	Along From E: W(-) E(+)	HD SE (+) NW(-)	Measured Strain
5S	2.4S	1.0E	+1.70	+0.71	+2.40	
						- 8,667
6S	1.7S	1.0E	+1.20	+0.71	+1.91	
						-34,167
7S	0.1S	0.3W	+0.07	-0.21	-0.14	
						-14,167
8S	0.5N	0.9W	-0.35	-0.64	-0.99	
						-17,667
9S	1.3N	1.6W	-0.92	-1.13	-2.05	
						+11,833
10S	0.9N	1.0W	-0.64	-0.71	-1.34	
						+20,000
11S	0.1N	0.1W	-0.07	-0.07	-0.14	
						+ 1,167
12S	0.0	0.1W	0.00	-0.07	-0.07	
						+ 1,167
13S	0.0	0.0	0.00	0.00	0.00	

TABLE H - 3

HORIZONTAL STRAIN ALONG PERPENDICULAR (MEASURED STRAIN)

MARCH 30, 1976 STABILIZED CONDITIONS

Station	Δ N	Δ E	Components from Δ N N- S+	Along ⊥ from Δ E E- W+	Δ HD SW(+) NE(-)	Measured Strain	
8E	0.0	0.0	0.0	0.0	0.0		
						0	
7E	0.0	0.0	0.0	0.0	0.0		
						+ 4,667	
6E	0.2S	0.2W	+0.14	+0.14	+0.28		
						+ 9,500	
5E	0.6S	0.6W	+0.42	+0.42	+0.85		
						+30,667	
4E	2.1S	1.7W	+1.48	+1.20	+2.69		
						+ 7,000	
3E	2.3S	2.1W	+1.63	+1.48	+3.11		
						-20,000	
2E	1.7S	1.0 W	+1.20	+0.71	+1.91		
						- 7,167	
1E	1.7S	0.4W	+1.20	+0.28	+1.48		
						- 2,333	
#3MPBX	1.6S	0.3W	+1.13	+0.21	+1.34		-1,167 @
						- 3,500	

TABLE H-3

(Continued)

Station	Δ N	Δ E	Components from Δ N N- S+	Along ⊥ from Δ E E- W+	Δ HD SW(+) NE(-)	Measured Strain
1W	1.4S	0.2W	+0.99	+0.14	+1.13	
						0
2W	1.2S	0.4W	+0.85	+0.28	+1.13	
						-11,833
3W	0.6S	0.0W	+0.42	+0.0	+0.42	
						- 9,333
4W	0.3S	0.5E	+0.21	-0.35	-0.14	
						+14,167
5W	0.7S	0.3W	+0.49	+0.21	+0.71	
						- 4,833
6W	0.5S	0.1W	+0.35	+0.07	+0.42	
						+ 9,500
7W	0.9S	0.5W	+0.64	+0.35	+0.99	
						+ 1,167
8W	1.1S	0.4W	+0.78	+0.28	+1.06	

TABLE H - 4

HORIZONTAL STRAIN ALONG ⊥ CORRECTED FOR SLOPE (STABILIZED CONDITIONS)

MARCH 30, 1976 STABILIZED CONDITIONS

Station	Original Elevation	Elevation 3/30/76	Original Ground Slope	Inc(+)/Decrease(-) In Slope	Strain Correction	Measured Strain	Strain Correction for Slope
8E	7886.2 14.3	7886.2 14.3	0.24	0.000	0	0	0
7E	7871.9 9.9	7871.9 10.0	0.17	+0.002	400	+ 4,667	+ 4,267
6E	7862.0 25.2	7861.9 25.4	0.42	+0.003	1,200	+ 9,500	+ 8,300
5E	7836.8 16.8	7836.5 17.8	0.28	+0.017	4,600	+30,667	+26,067
4E	7820.0 11.5	7818.7 14.7	0.19	+0.053	10,800	+ 7,000	- 3,800
3E	7808.5 9.7	7804.0 11.3	0.16	+0.027	4,600	-20,000	-24,600
2E	7798.8 10.9	7792.7 11.4	0.18	+0.008	1,400	- 7,167	- 8,567
1E	7787.9 4.4	7781.3 4.4	0.07	0.000	0	- 2,333	- 2,333
#3MPBX	7783.5 9.2	7776.9 9.2	PANEL ℄ 0.11	PANEL ℄ 0	PANEL ℄ 0	PANEL ℄ - 1,167	PANEL ℄ - 1,167

Table H - 4
(continued)

Station	Original Elevation	Elevation 3/30/76	Original Ground Slope	Inc(+)/Decrease(-) In Slope	Strain Correction	Measured Strain	Strain Correction for Slope
1W	7774.3 19.2	7767.7 19.1	0.32	-0.002	600	0	- 600
2W	7755.1 21.4	7748.6 20.7	0.36	-0.012	3,800	-11,833	- 8,033
3W	7733.7 22.3	7727.9 18.4	0.37	-0.065	16,400	- 9,333	+ 7,067
4W	7711.4 25.4	7709.5 23.6	0.42	-0.030	10,600	+14,167	+24,767
5W	7686.0 24.1	7685.9 24.0	0.40	-0.002	800	- 4,833	- 4,033
6W	7661.9 24.1	7661.9 24.8	0.40	+0.012	4,200	+ 9,500	+ 5,300
7W	7637.8 21.7	7637.1 24.2	0.36	+0.042	13,800	+ 1,167	-12,633
8W	7616.1	7612.9					

TABLE H - 5

PANEL DIAGONAL

MEASURED HORIZONTAL STRAIN (STABILIZED CONDITIONS)

Station	N	E	Components from N N(-) S(+)	Along Diagonal from E E & W = 0.0	HD N(-) S(+)	Measured Strain
10ND	0.0	0.0	0.00	0.00	0.00	
						0
9ND	0.0	0.0	0.00	0.00	0.00	
						0
8ND	0.0	0.0	0.00	0.00	0.00	
						+ 1,667
7ND	0.1S	0.0	+0.10	0.00	+0.10	
						+13,333
6ND	0.9S	0.0	+0.90	0.00	+0.90	
						+28,333
5ND	2.6S	0.2E	+2.60	0.00	+2.60	
						- 3,333
4ND	2.4S	1.2E	+2.40	0.00	+2.40	
						+ 6,667
3ND	2.8S	2.1E	+2.80	0.00	+2.80	
						+13,333
2ND	3.6S	2.8E	+3.60	0.00	+3.60	
						+ 5,000
11N	3.9S	3.5E	+3.90	0.00	+3.90	

TABLE H - 6

PANEL DIAGONAL (STRAIN CORRECTED FOR SLOPE)

MEASURED HORIZONTAL STRAIN (STABILIZED CONDITIONS)

tation	Original Elevation	Elevation 9/9/75	Original Ground Slope	Inc(+)/Decrease(-) in Slope	in/in Strain Correction	Measured Strain	Strain Corrected for Slope
10ND	7822.3	7822.3					
			----	0.000	0	0	0
9ND	7816.1	7816.1					
			----	0.000	0	0	0
8ND	7826.6	7826.6					
			----	0.000	0	+ 1,667	+ 1,667
7ND	7838.5	7838.5					
	0.6	0.1	0.01	-0.008	0	+13,333	+13,333
6ND	7839.1	7838.6					
	9.3	11.1	0.16	+0.030	5,200	+28,333	+23,133
5ND	7829.8	7827.5					
	10.0	13.5	0.17	+0.058	10,200	- 3,333	-10,333
4ND	7819.8	7814.0					
	6.3	6.8	0.11	+0.008	1,000	+ 6,667	+ 4,967
3ND	7813.5	7807.2					
	4.9	5.4	0.08	+0.008	600	+13,333	+12,733
2ND	7808.6	7801.8					
	13.6	13.4	0.13	-0.002	200	+ 5,000	+ 5,200
11N	7795.0	7788.4					

APPENDIX I

LABORATORY TEST RESULTS

TABLE I-1
GEOLOGIC DESCRIPTION OF PHYSICAL TESTING CORE SAMPLES
UNIAXIAL COMPRESSION TESTS

BORING NUMBER	SAMPLE DEPTH (ft)	ROCK DESCRIPTION
COR-1 Floor sandstone	4.5	Medium-to fine-grained sandstone, thin bedded to laminated with 50% carbonaceous laminations
COR-1 Floor sandstone	12.0	Medium-to fine-grained sandstone, thin bedded to laminated with 50% carbonaceous laminations
COR-2 Roof sandstone with bedding planes oriented at 51° with core axis	9.0, 17.5	Medium-to fine-grained sandstone, laminated to medium bedded with 20% carbonaceous laminations
COR-3 Floor sandstone	12.0, 3.0 - 4.0, 8.5	Medium-to fine-grained sandstone, laminated with 20% carbonaceous laminations

TABLE I-2
GEOLOGIC DESCRIPTION OF PHYSICAL
TESTING CORE SAMPLES
TRIAXIAL TESTS

BORING NUMBER	SAMPLE DEPTH (ft)	ROCK DESCRIPTION
COR-2 Roof sandstone with bedding planes oriented at 51^{o} with core axis	8.5, 9.5, 10.0, 11.5, 12.0, 12.5, 13.0	Medium-to fine-grained sandstone, laminated to medium bedded with 20% carbonaceous laminations
COR-3 Floor sandstone	9.5, 10.0, 10.3, 10.7, 11.0, 11.5, 12.0	Medium-to fine-grained sandstone, laminated with 20% carbonaceous laminations
COR-4 Floor sandstone with bedding planes oriented at 45^{o} with core axis	2.0, 2.5, 3.2	Medium-to fine-grained sandstone, laminated with 40% carbonaceous laminations
COR-5 Roof sandstone	0.8	Fine-to very fine-grained very silty sandstone, thin bedded
COR-5 Roof siltstone	12.5	Sandy siltstone, medium bedded with 10% coal partings to 0.01'

TABLE I-2 (continued)

BORING NUMBER	SAMPLE DEPTH (ft)	ROCK DESCRIPTION
COR-2 Roof sandstone with bedding planes oriented at 51° with core axis	4.0, 6.5, 7.0, 7.5	Medium- to fine-grained sandstone, laminated to medium bedded with 20% carbonaceous laminations
COR-3 Floor sandstone	0.5	Medium- to fine-grained sandstone, laminated with 50% carbonaceous laminations
COR-1 Floor sandstone	12.5, 13.0	Medium- to fine-grained sandstone, thin bedded to laminated with 50% carbonaceous laminations
COR-5 Roof sandstone	2.0, 2.5, 3.0	Medium- to fine-grained silty sandstone, laminated to thin bedded
COR-5 Roof siltstone	5.0	Sandy siltstone, medium bedded with 10% coal partings to 0.01'
COR-1 Floor sandstone	0.5, 1.0	Medium- to very fine-grained sandstone, laminated to thin bedded with 25% carbonaceous laminations
COR-1 Floor sandstone	2.5, 6.5, 9.0	Medium- to very fine-grained sandstone, laminated to thin bedded with 25% carbonaceous laminations

TABLE I-2 (continued)

BORING NUMBER	SAMPLE DEPTH (ft)	ROCK DESCRIPTION
COR-3 Floor sandstone	1.0, 1.5	Medium- to fine-grained sandstone, laminated with 50% carbonaceous laminations
COR-3 Floor siltstone	2.0	Carbonaceous siltstone
COR-3 Floor sandstone	6.0	Medium- to fine-grained sandstone, laminated with 10% carbonaceous laminations
COR-3 Floor sandstone	9.0	Medium- to fine-grained sandstone, laminated with 20% carbonaceous laminations
COR-1 Floor sandstone	9.5, 10.0, 11.0, 12.5	Medium- to fine-grained sandstone, thin bedded to laminated with 50% carbonaceous laminations
COR-3 Floor sandstone	3.0 - 4.0	Medium- to fine-grained sandstone, laminated with 10% carbonaceous laminations
COR-1 Floor sandstone	4.5	Medium- to very fine-grained sandstone, laminated with 25% carbonaceous laminations
COR-3 Floor sandstone	8.5, 12.0	Medium- to fine-grained sandstone, laminated with 20% carbonaceous laminations

TABLE I-2 (continued)

BORING NUMBER	SAMPLE DEPTH (ft)	ROCK DESCRIPTION
COR-2 Roof sandstone with bedding planes oriented at 51^{o} with core axis	9.0	Medium- to fine-grained sand-stone, laminated to medium bedded with 20% carbonaceous laminations
COR-1 Floor sandstone	12.0	Medium- to fine-grained sand-stone, thin bedded to laminated with 50% carbonaceous laminations
COR-3 Floor sandstone	12.0	Medium- to fine-grained sand-stone, laminated with 20% carbonaceous laminations
COR-2 Roof siltstone with bedding planes oriented at 51^{o} with core axis	17.5	Shaley siltstone with trace fine sand, thinly laminated

TABLE I-3
FLOOR SANDSTONE
UNIAXIAL COMPRESSION TEST RESULTS
PERPENDICULAR TO BEDDING (CORRECTED FOR W/H RATIO)

UNIAXIAL COMPRESSION STRENGTH (psi)	ELASTIC MODULUS (10^6 psi)	LOAD RANGE (psi)	POISSON'S RATIO	LOAD RANGE (psi)
14650	4.21	(0 - 6520)	0.102	(0 - 6750)
	4.61	(6520 - 13660)	0.185	(6750 - 13380)
	6.40	(13660 - 14620)	0.285	(13380 - 14620)
17470	1.41	(0 - 7740)	0.131	(0 - 4620)
	0.97	(7740 - 15550)	0.197	(4620 - 13130)
	0.50	(15550 - 17470)	0.256	(13130 - 17630)
15170	0.75	(0 - 450)	0.035	(0 - 2750)
	2.09	(450 - 5330)	0.135	(2750 - 6120)
	2.10	(5330 - 13590)	0.214	(6120 - 10450)
	1.37	(13590 - 15170)		
15720	0.46	(0 - 4820)	0.073	(0 - 5500)
	0.54	(4830 - 15720)	0.220	(5500 - 6900)
			0.338	(6900 - 12460)
20550	1.10	(0 - 4970)	0.096	(0 - 4340)
	1.63	(4980 - 13130)	0.153	(4390 - 9820)
	2.12	(13130 - 20550)	0.219	(9820 - 16560)
			0.245	(16560 - 20380)

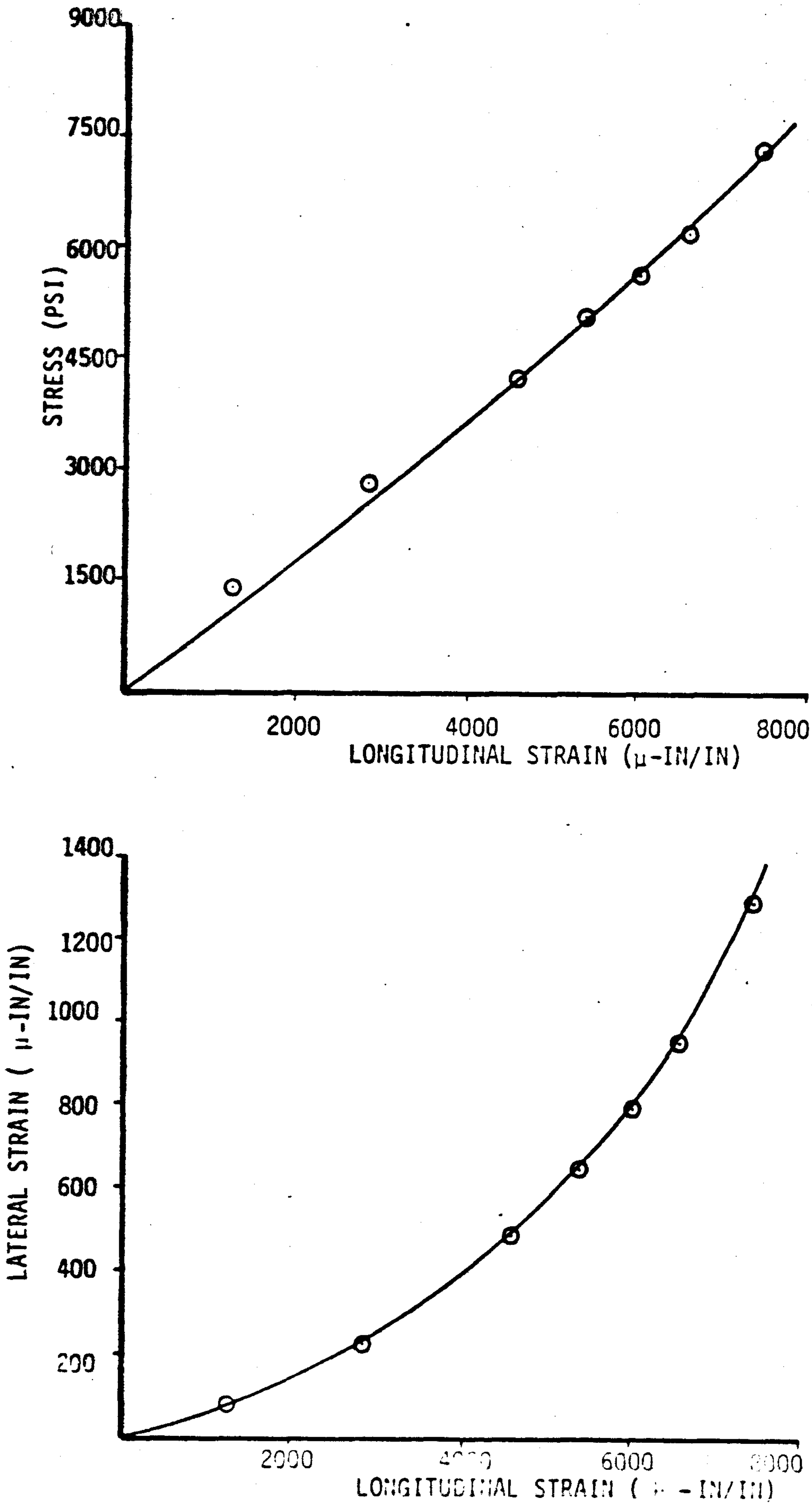


FIG. I-1 UNIAXIAL COMPRESSION TEST RESULTS - FLOOR SANDSTONE

TABLE I-4
FLOOR SANDSTONE
TRIAXIAL TEST RESULTS

CONFINING STRESS (psi)	FAILURE STRENGTH (psi)	CONFINING STRESS (psi)	FAILURE STRENGTH (psi)
100	17050	740	27850
200	31320	800	22560
260	14670	810	19970
300	22960	840	17430
400	18900	900	17190
400	24240	900	18050
410	17000	930	23640
500	14570	940	27290
620	15860	1000	26400
630	14480	1010	22780
680	13260	1130	16880
700	20460		

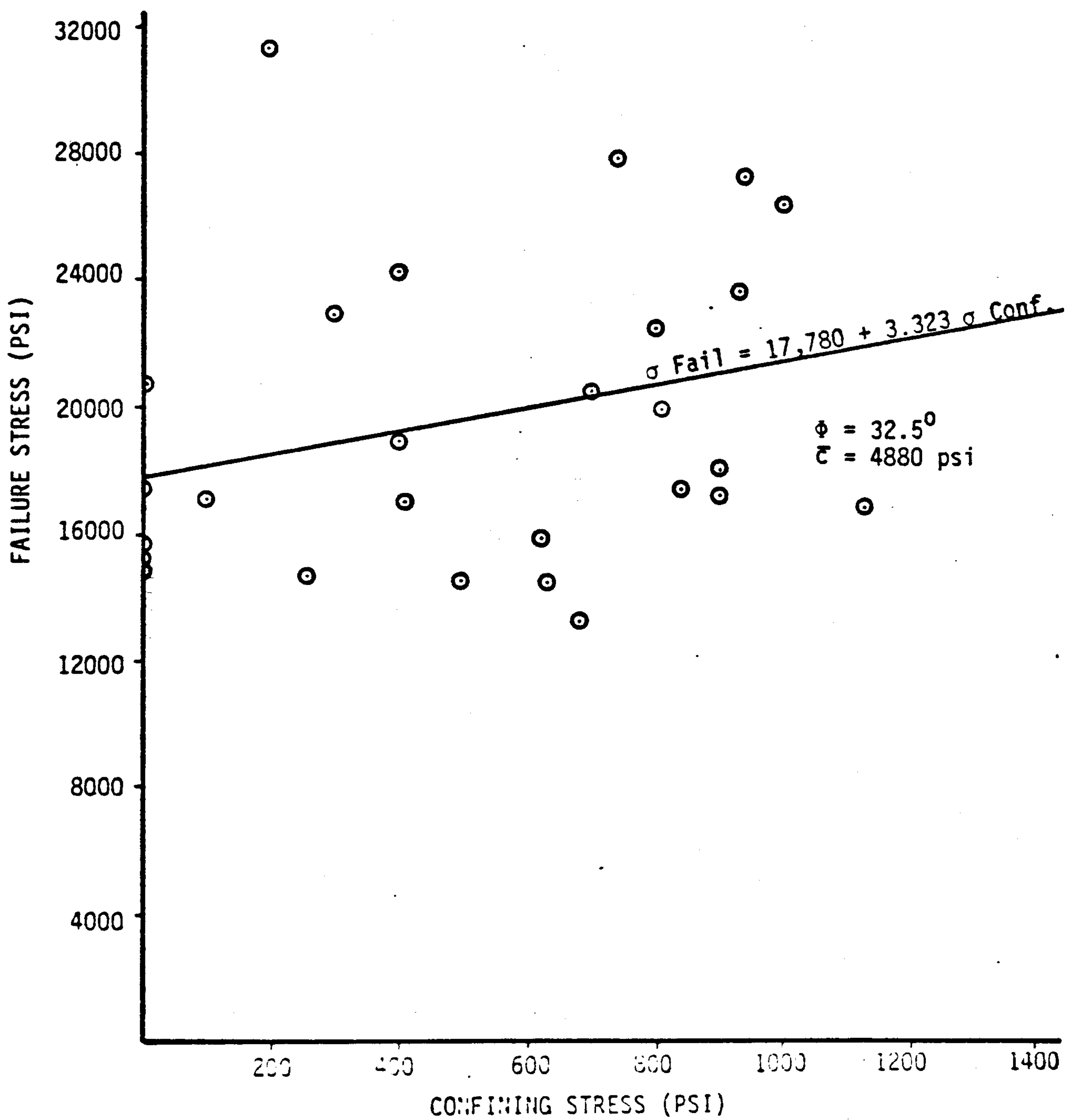


FIG. I-2 TRIAXIAL COMPRESSION TEST RESULTS - FLOOR SANDSTONE

TABLE I-5
COAL
UNIAXIAL COMPRESSION TEST RESULTS
PERPENDICULAR TO BEDDING (CORRECTED FOR W/H RATIO)

UNIAXIAL COMPRESSION STRENGTH (psi)	ELASTIC MODULUS (10^6 psi)	LOAD RANGE (psi)	POISSON'S RATIO	LOAD RANGE (psi)
647	0.15	(0 - 684)	0.275	(0 - 684)
945	1.20	(0 - 622)	0.150	(0 - 249)
			0.427	(373 - 622)
716	0.67	(0 - 249)	NON-LINEAR	
1092	4.20	(0 - 249)	0.220	(0 - 249)
	1.10	(249 - 746)		
652	1.45	(249 - 622)	0.430	(249 - 498)
2392	2.05	(0 - 1119)	0.202	(0 - 1119)
1504	0.29	(124 - 174)	0.400	(298 - 498)
	0.20	(298 - 498)		

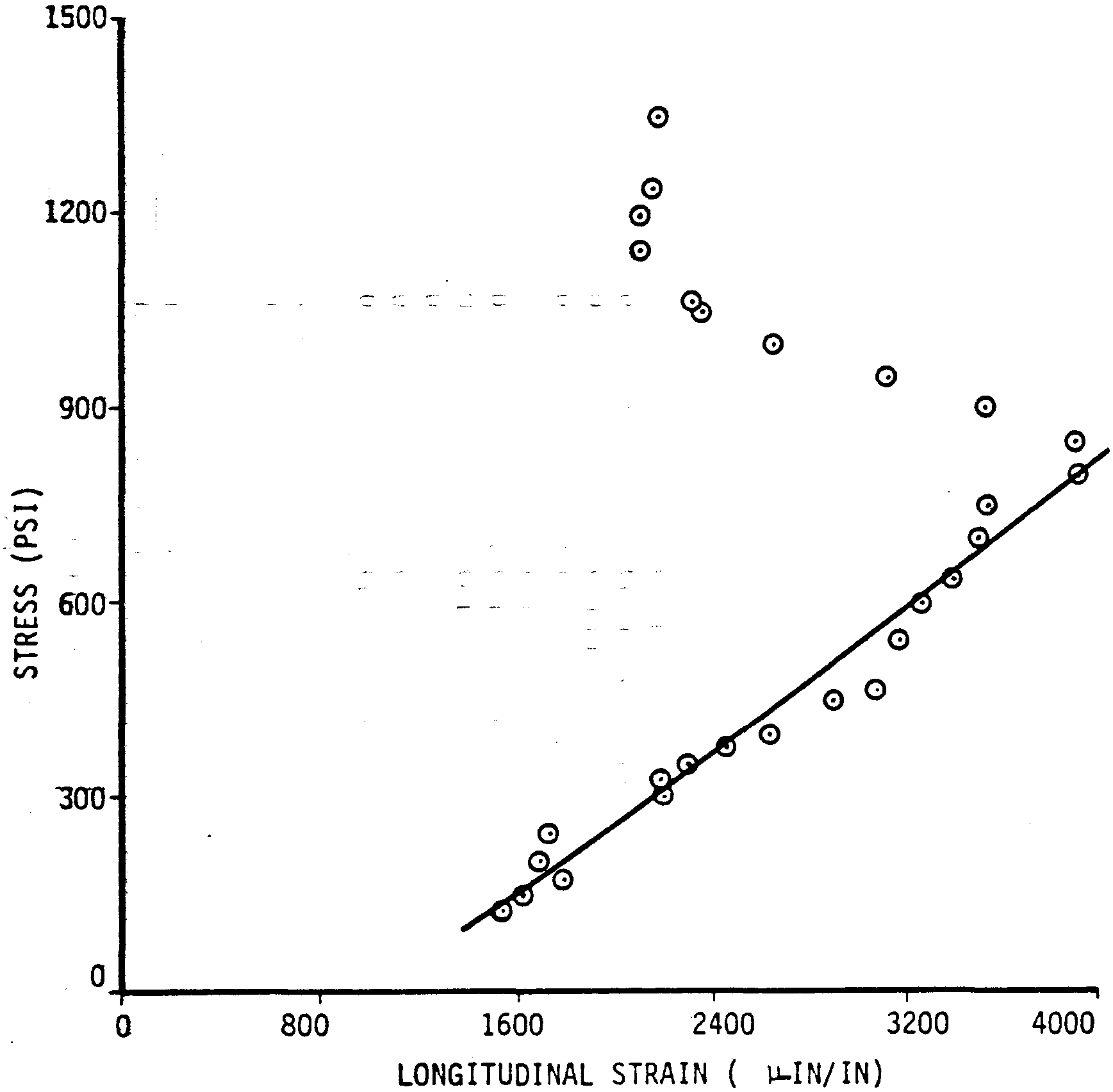


FIG. I-3 UNIAXIAL COMPRESSION TEST RESULTS - COAL

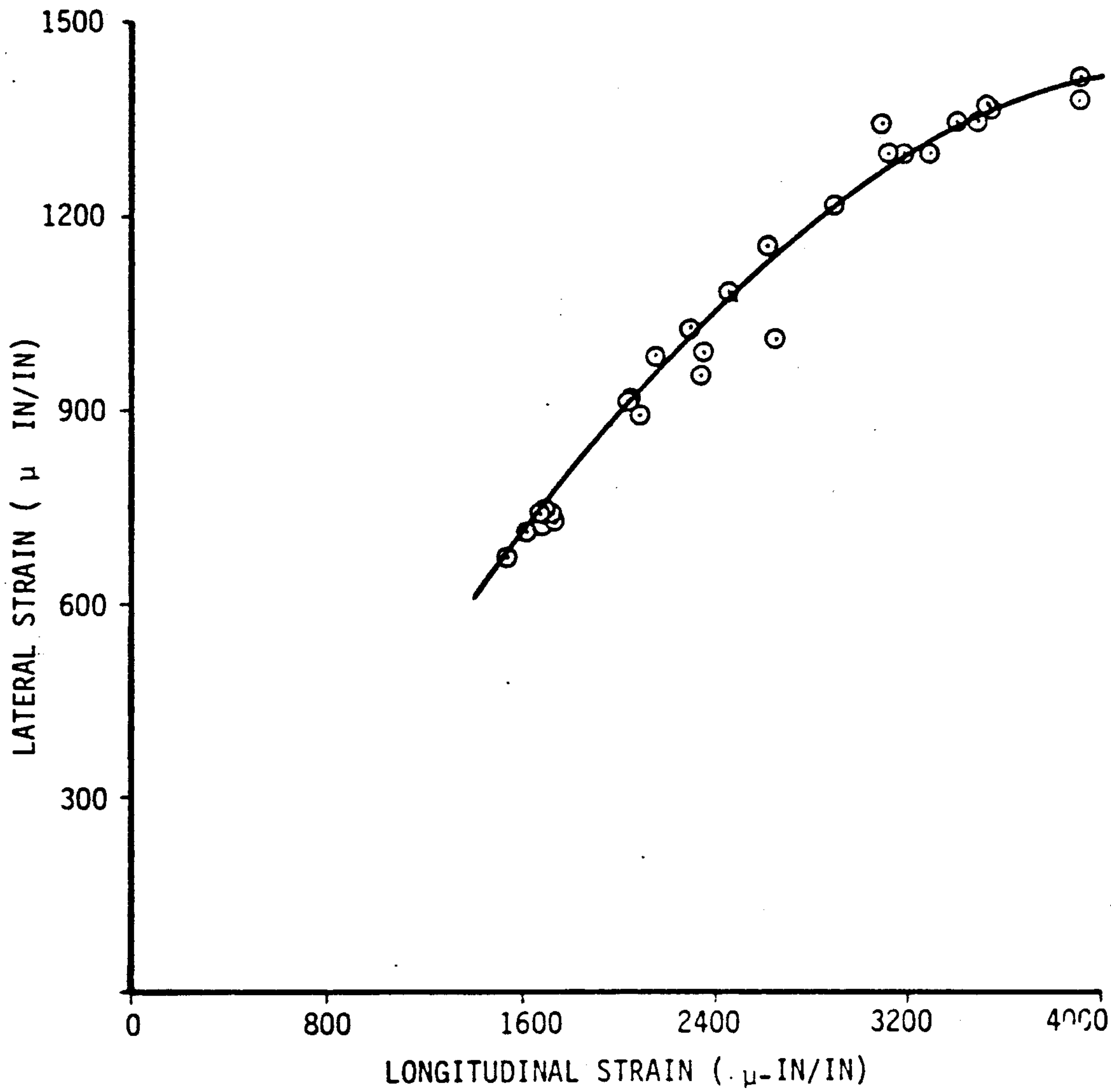


FIG. I-4 UNIAXIAL COMPRESSION TEST RESULTS - COAL

TABLE I-6
COAL
TRIAXIAL TEST RESULTS

CONFINING STRESS (psi)	FAILURE STRENGTH (psi)
300	4670
330	3640
500	8220
830	5880
920	7030
1020	9860
1240	9740
1520	8420

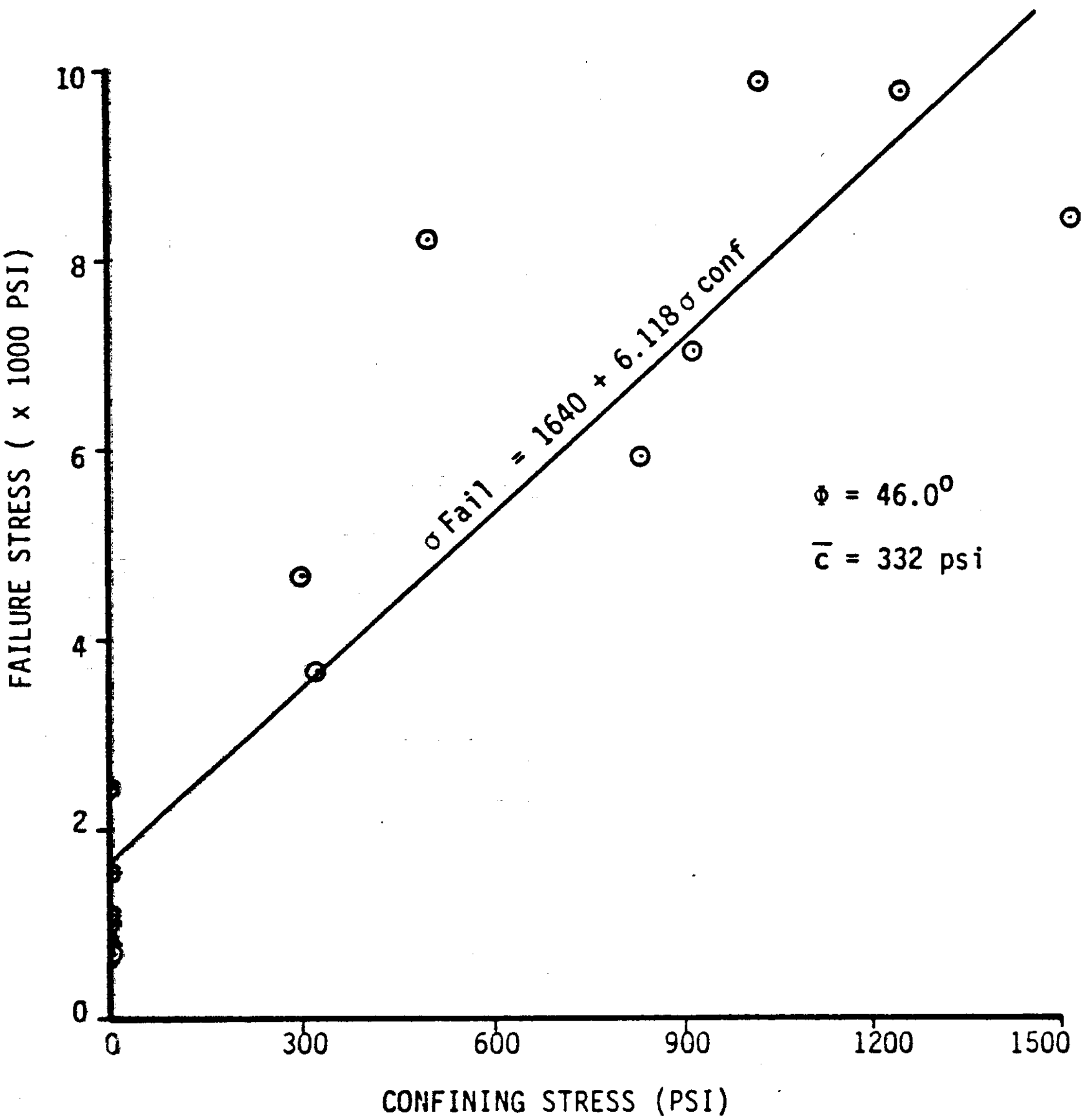


FIG. I-5 TRIAXIAL COMPRESSIVE TEST RESULTS - COAL

TABLE I-7
ROOF SANDSTONE
UNIAXIAL COMPRESSION TEST RESULTS
PERPENDICULAR TO BEDDING (CORRECTED FOR W/H RATIO)

UNIAXIAL COMPRESSION STRENGTH (psi)	ELASTIC MODULUS (10^6 psi)	LOAD RANGE (psi)	POISSON'S RATIO	LOAD RANGE (psi)
7283	1.03	(0 - 2330)	0.077	(0 - 3590)
	0.87	(2330 - 5990)	0.229	(3590 - 6080)
	1.29	(5990 - 7280)	0.395	(6080 - 7280)
11340	7.79	(0 - 2610)	0.148	(0 - 5090)
	6.51	(2610 - 7690)	0.189	(5090 - 10800)
	15.71	(7690 - 11230)		

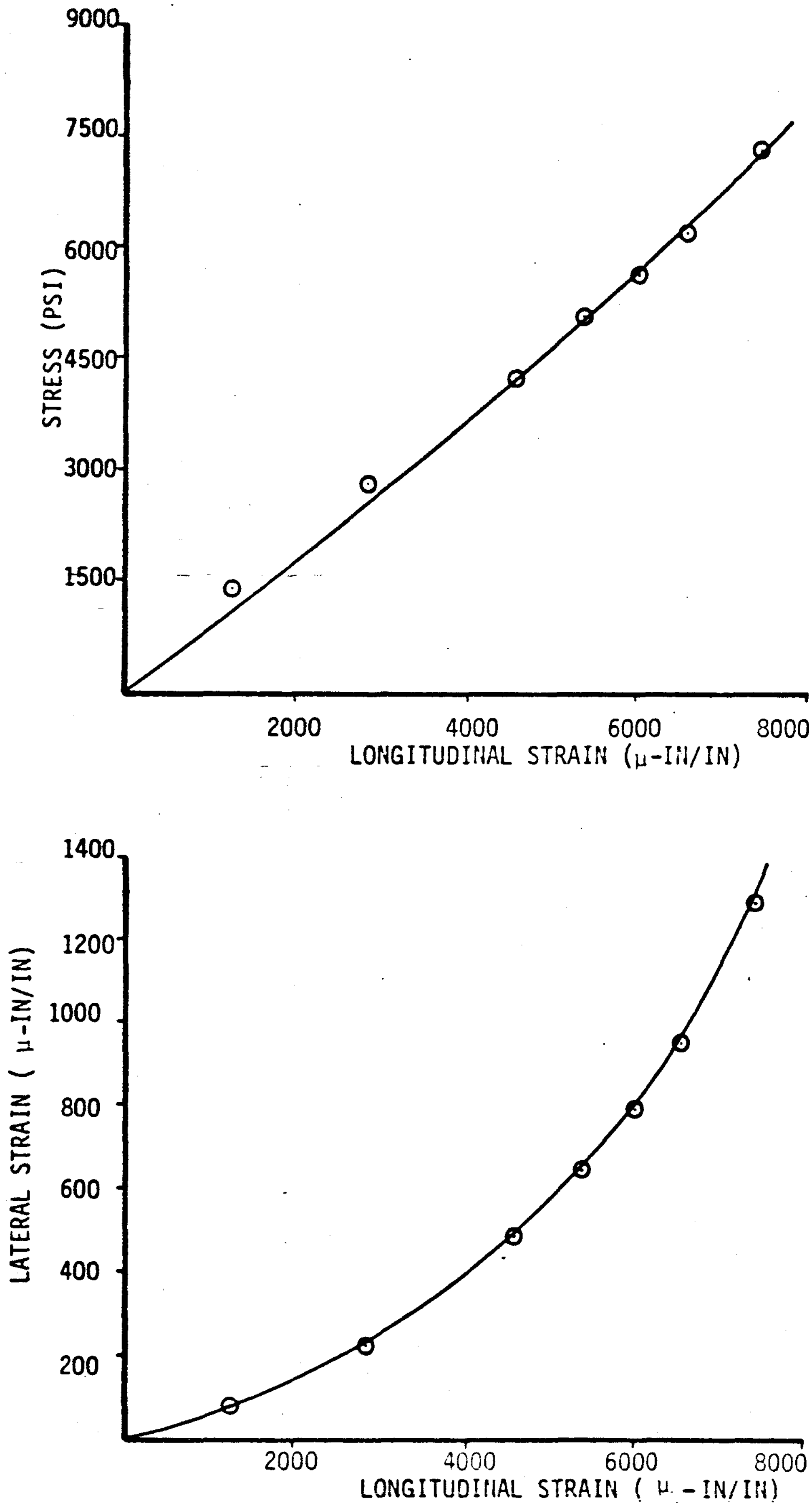
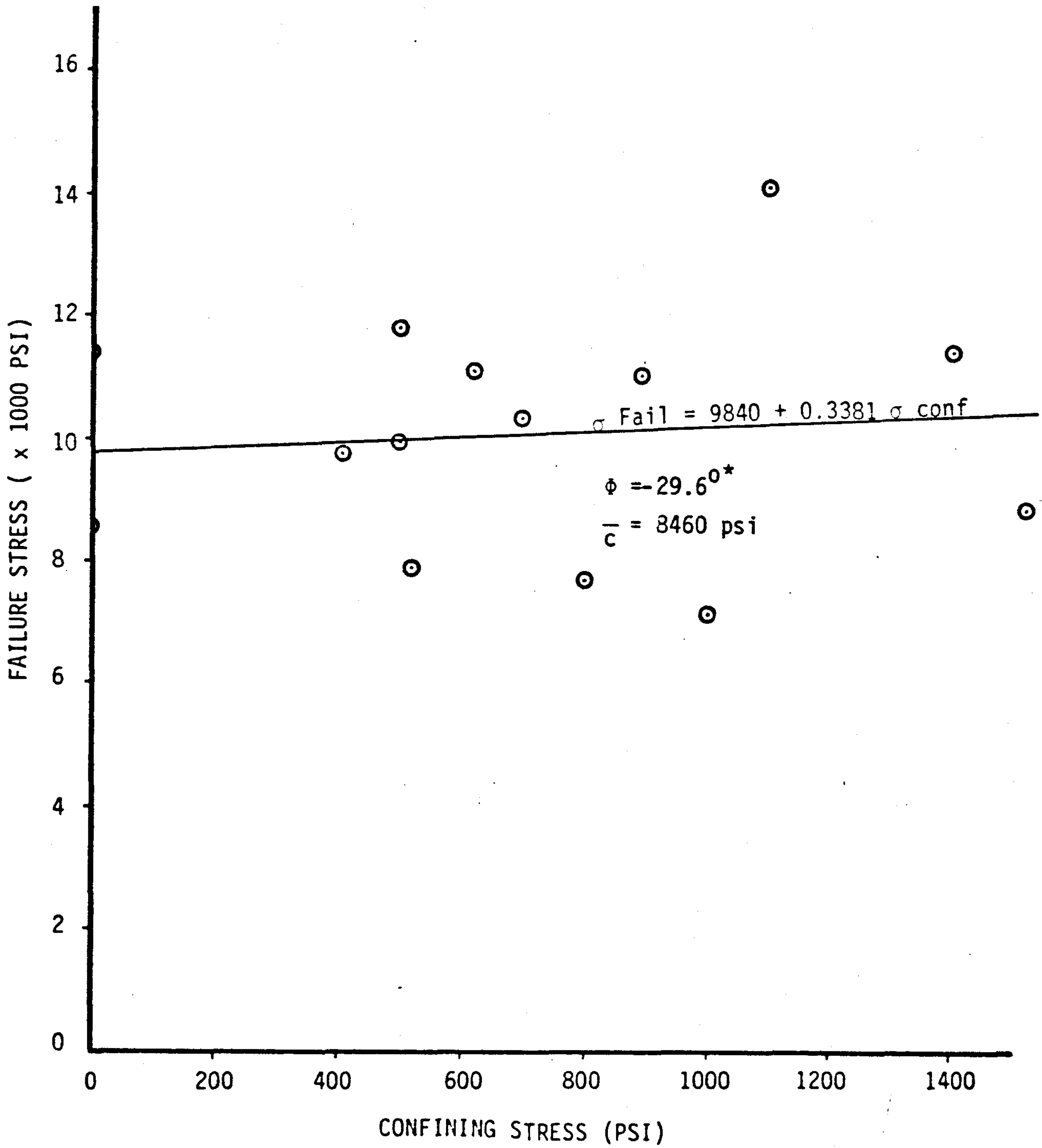


FIG. I-6 UNIAXIAL COMPRESSION TEST RESULTS - ROOF SANDSTONE

TABLE I-8
ROOF SANDSTONE
TRIAXIAL TEST RESULTS

CONFINING STRESS (psi)	FAILURE STRENGTH (psi)
410	9790
500	9960
500	11830
520	7900
620	11130
700	11340
800	7700
890	11040
1000	7150
1100	14110
1400	11440
1520	8870



*NOTE: RESULTS IRRATIONAL, PROBABLY DUE TO ROCK VARIABILITY

FIG. I-7 TRIAXIAL COMPRESSIVE TEST RESULTS - ROOF SANDSTONE

TABLE I-9
MISCELLANEOUS
TRIAXIAL COMPRESSION TEST RESULTS

CONFINING STRESS (psi)	FAILURE STRENGTH (psi)
FLOOR SANDSTONE, BEDDING PLANES 45° TO CORE AXIS	
300	11660
1100	17340
1100	19210
FLOOR SILTSTONE	
1010	22780
ROOF SANDSTONE, WITH CARBONACEOUS LAMINATIONS	
620	19940
810	18270
930	16400
1300	14480
ROOF SILTSTONE, WITH COAL PARTINGS	
550	10100
820	12430

TABLE I-10
DIRECT SHEAR TEST RESULTS

ROCK TYPE	NORMAL STRESS (psi)	FAILURE SHEAR STRESS (psi)
ROOF SANDSTONE	55.5	29.2
	113.2	62.2
	170.4	86.3
	55.5	22.2
	113.2	61.5
	170.4	87.5
	55.5	59.0
	113.2	50.8
	170.4	110.4
COAL	55.5	34.3
	113.2	59.0
	170.4	92.6
	55.5	27.3
	113.2	50.8
	170.4	69.8
	55.5	26.0
	113.2	47.6
	170.4	79.9
FLOOR SANDSTONE	55.5	40.6
	110.7	66.0
	170.4	102.1
	55.5	26.6
	113.2	60.9
	170.4	86.3

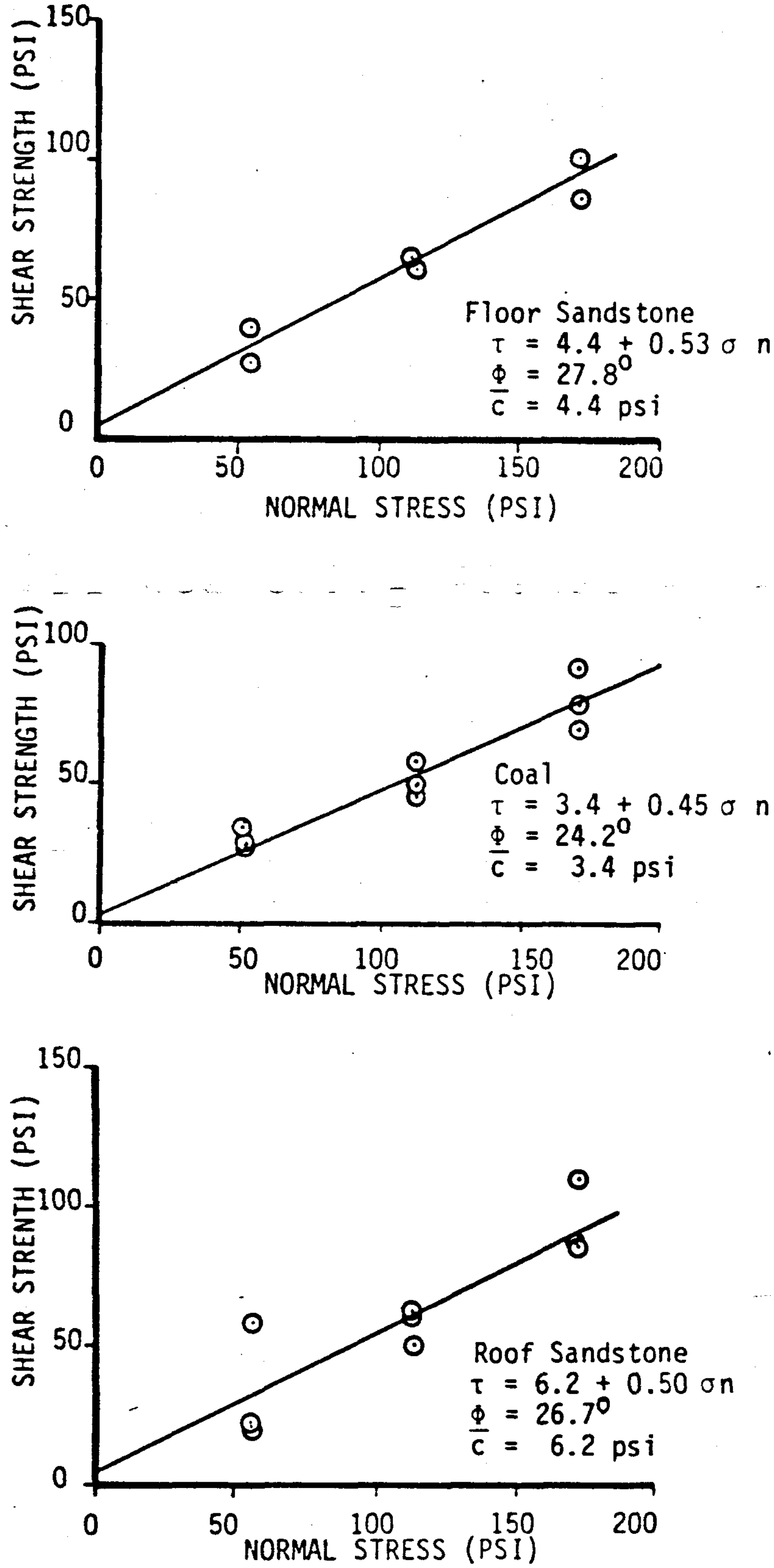


FIG. I-8 DIRECT SHEAR TEST RESULTS

APPENDIX J

IN SITU TEST RESULTS

TABLE J-1
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 1

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
-	25.5	20.92	-	138.9	12.00	-
3.0	112.2	21.04	0.12	611.2	12.12	0.12
4.0	112.2	21.04	0.12	611.2	12.12	0.12
7.0	290.7	21.18	0.26	1583.5	12.35	0.35
9.0	290.7	21.19	0.27	1583.5	12.35	0.35
12.0	561.0	21.32	0.40	3055.8	12.47	0.47
14.0	561.0	21.32	0.40	3055.8	12.48	0.48
22.00	734.4	21.38	0.46	4000.3	12.58	0.58

TEST TERMINATED DUE TO LEAKING HYDRAULIC FITTING

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-2
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 2

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
-	Ø	22.01	-	Ø	12.00	-
1.2	102.0	22.03	0.02	555.6	12.11	0.11
2.3	102.0	22.04	0.03	555.6	12.11	0.11
3.0	204.0	22.06	0.05	1111.2	12.15	0.15
4.0	204.0	22.06	0.05	1111.2	12.15	0.15
5.0	408.0	22.08	0.07	2222.4	12.21	0.21
6.5	408.0	22.08	0.07	2222.4	12.22	0.22
8.0	612.0	22.09	0.08	3333.6	12.29	0.29
9.0	612.0	22.09	0.08	3333.6	12.29	0.29
10.8	805.8	22.11	0.10	4389.2	12.39	0.39
11.2	765.0	22.11	0.10	4167.0	12.40	0.40
12.2	816.0	22.12	0.11	4444.8	12.42	0.42
13.5	816.0	22.12	0.11	4444.8	12.43	0.43
14.8	867.0	22.12	0.11	4722.6	12.44	0.44
15.2	897.6	22.12	0.11	4889.3	12.47	0.47
15.5	897.6	22.12	0.11	4889.3	12.50	0.50
15.8	897.6	22.13	0.12	4889.3	12.52	0.52
16.2	867.0	22.13	0.12	4722.6	12.56	0.56
				FAILURE OF ROOF ROCK		

TABLE J-2 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-3
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 3

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
-	Ø	13.00	-	Ø	19.99	-
0.5	555.6	13.00	Ø	102.0	20.15	0.16
2.5	555.6	13.00	Ø	102.0	20.16	0.17
3.0	1111.2	13.05	0.05	204.0	20.22	0.23
4.2	1111.2	13.05	0.05	204.0	20.27	0.28
5.0	1666.8	13.12	0.12	306.0	20.32	0.33
6.2	1666.8	13.13	0.13	306.0	20.32	0.33
7.0	2222.4	13.22	0.22	408.0	20.36	0.37
7.5	2222.4	13.24	0.24	408.0	20.37	0.38
7.8	2222.4	13.25	0.25	408.0	20.37	0.38
8.5	2222.4	13.26	0.26	408.0	20.37	0.38
9.0	2222.4	13.27	0.27	408.0	20.37	0.38
9.5	2222.4	13.28	0.28	408.0	20.37	0.38
10.0	2222.4	13.29	0.29	408.0	20.37	0.38
10.1	2222.4	13.30	0.30	408.0	20.37	0.38
10.2	2222.4	13.31	0.31	408.0	20.37	0.38
10.4	2222.4	13.33	0.33	408.0	20.37	0.38
10.6	2222.4	13.34	0.34	408.0	20.37	0.38
10.7	2222.4	13.38	0.38	408.0	20.37	0.38
10.8	1944.6	13.40	0.40	357.0	20.36	0.37
10.8	1944.6	13.41	0.41	357.0	20.35	0.36
10.9	1944.6	13.42	0.42	357.0	20.35	0.36
	FAILURE OF FLOOR ROCK					

TABLE J-3 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-4
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 4a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
-	ø	14.00	-	ø	18.00	-
0.8	312.5	14.03	0.03	102.0	18.07	0.07
1.2	625.0	14.04	0.04	204.0	18.11	0.11
2.0	625.0	14.04	0.04	204.0	18.11	0.11
2.2	937.5	14.04	0.04	306.0	18.15	0.15
3.0	937.5	14.04	0.04	306.0	18.15	0.15
3.5	1562.5	14.06	0.06	510.0	18.22	0.22
4.5	1562.5	14.05	0.05	510.0	18.22	0.22
5.2	1875.0	14.06	0.06	612.0	18.24	0.24
6.0	1875.0	14.06	0.06	612.0	18.25	0.25
6.5	2187.5	14.06	0.06	714.0	18.27	0.27
7.5	2187.5	14.06	0.06	714.0	18.27	0.27
8.0	2500.0	14.06	0.06	816.0	18.30	0.30
9.0	2500.0	14.06	0.06	816.0	18.30	0.30
9.8	2812.5	14.07	0.07	918.0	18.32	0.32
10.5	2812.5	14.07	0.07	918.0	18.32	0.32
11.0	3000.0	14.07	0.07	979.2	18.34	0.34

TEST TERMINATED WITHOUT FAILURE

TABLE J-4 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 8-by 8-inch
   Roof 14-by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Thin coal (less than 2 inches) overlying shaley, fine-grained sandstone

TABLE J-5
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 4b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
-	Ø	12.00	-	Ø	18.08	-
0.5	555.6	12.02	0.02	102.0	18.16	0.08
0.8	555.6	12.02	0.02	102.0	18.16	0.08
1.2	1111.2	12.02	0.02	204.0	18.20	0.12
1.8	1111.2	12.02	0.02	204.0	18.20	0.12
2.5	2222.4	12.04	0.04	408.0	18.26	0.18
3.0	2222.4	12.04	0.04	408.0	18.26	0.18
3.8	3333.6	12.04	0.04	612.0	18.31	0.23
4.2	3333.6	12.04	0.04	612.0	18.31	0.23
5.0	4444.8	12.05	0.05	816.0	18.36	0.28
5.5	4444.8	12.05	0.05	816.0	18.36	0.28
6.2	5333.8	12.06	0.06	979.2	18.40	0.32
6.8	5333.8	12.06	0.06	979.2	18.40	0.32

TEST TERMINATED WITHOUT FAILURE

TABLE J-5 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Thin coal (less than 2 inches) overlying shaley, fine-grained sandstone

TABLE J-6
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 5

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
-	Ø	13.98	-	Ø	16.00	-
0.2	102.0	13.99	0.01	555.6	16.05	0.05
1.0	102.0	13.99	0.01	555.6	16.05	0.05
1.5	204.0	14.03	0.05	1111.2	16.08	0.08
2.0	204.0	14.03	0.05	1111.2	16.08	0.08
2.5	408.0	14.06	0.08	2222.4	16.14	0.14
3.0	408.0	14.06	0.08	2222.4	16.14	0.14
3.8	612.0	14.10	0.12	3333.6	16.20	0.20
4.2	612.0	14.10	0.12	3333.6	16.20	0.20
4.5	714.0	14.11	0.13	3889.2	16.22	0.22
5.5	714.0	14.11	0.13	3889.2	16.22	0.22
6.0	816.0	14.12	0.14	4444.8	16.25	0.25
6.5	816.0	14.13	0.15	4444.8	16.25	0.25
7.0	918.0	14.14	0.16	5000.4	16.27	0.27
7.2	918.0	14.15	0.17	5000.4	16.28	0.28
8.0	918.0	14.15	0.17	5000.4	16.28	0.28
8.2	969.0	14.15	0.17	5278.2	16.29	0.29
8.8	969.0	14.15	0.17	5278.2	16.29	0.29
9.0	969.0	14.16	0.18	5278.2	16.29	0.29
9.2	969.0	14.16	0.18	5278.2	16.29	0.29

TEST TERMINATED WITHOUT FAILURE

TABLE J-6 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Thin coal (less than 2 inches) overlying shaley, fine-grained sandstone

TABLE J-7
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 6a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA- TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA- TION (inch)
-	Ø	16.00	-	Ø	15.00	-
0.2	102.0	16.02	0.02	555.6	15.08	0.08
0.8	102.0	16.02	0.02	555.6	15.08	0.08
1.2	204.0	16.03	0.03	1111.2	15.16	0.16
1.8	204.0	16.03	0.03	1111.2	15.16	0.16
2.0	306.0	16.05	0.05	1666.8	15.22	0.22
2.8	306.0	16.05	0.05	1666.8	15.22	0.22
3.2	408.0	16.06	0.06	2222.4	15.28	0.28
4.0	408.0	16.06	0.06	2222.4	15.28	0.28
4.2	510.0	16.07	0.07	2778.0	15.33	0.33
4.8	510.0	16.07	0.07	2778.0	15.34	0.34
5.2	510.0	16.08	0.08	2778.0	15.34	0.34
5.8	510.0	16.08	0.08	2778.0	15.34	0.34
6.2	612.0	16.08	0.08	3333.6	15.39	0.39
6.8	612.0	16.09	0.09	3333.6	15.39	0.39
7.5	612.0	16.09	0.09	3333.6	15.39	0.39
7.8	714.0	16.10	0.10	3889.2	15.44	0.44
8.2	714.0	16.10	0.10	3889.2	15.45	0.45
8.8	714.0	16.10	0.10	3889.2	15.45	0.45
9.0	816.0	16.11	0.11	4444.8	15.49	0.49
9.2	816.0	16.11	0.11	4444.8	15.50	0.50
10.0	816.0	16.11	0.11	4444.8	15.51	0.51
10.8	816.0	16.11	0.11	4444.8	15.51	0.51

TABLE J-7 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
11.2	887.4	16.11	0.11	4833.7	15.57	0.57
11.3	918.0	16.11	0.11	5000.4	15.58	0.58
11.4	918.0	16.11	0.11	5000.4	15.59	0.59
11.7	918.0	16.11	0.11	5000.4	15.60	0.60
11.8	918.0	16.11	0.11	5000.4	15.61	0.61
11.8	918.0	16.12	0.12	5000.4	15.62	0.62
12.2	918.0	16.12	0.12	5000.4	15.64	0.64
12.8	918.0	16.12	0.12	5000.4	15.65	0.65
13.8	918.0	16.12	0.12	5000.4	15.67	0.67
14.2	969.0	16.12	0.12	5278.2	15.70	0.70
14.8	948.6	16.12	0.12	5167.1	15.72	0.72
15.2	969.0	16.12	0.12	5278.2	15.74	0.74
16.2	969.0	16.12	0.12	5278.2	15.76	0.76
16.8	958.8	16.12	0.12	5222.6	15.76	0.76
17.0	969.0	16.12	0.12	5278.2	15.77	0.77
				FAILURE OF COAL IN ROOF		

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Coal with closely-spaced (2-3 inches), smooth joints

TABLE J-8
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 6b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
-	Ø	16.00	-	Ø	17.00	-
0.5	555.6	16.04	0.04	102.0	17.12	0.12
0.9	555.6	16.04	0.04	102.0	17.12	0.12
1.2	1111.2	16.07	0.07	204.0	17.18	0.18
1.8	1111.2	16.08	0.08	204.0	17.18	0.18
2.5	2222.4	16.12	0.12	408.0	17.26	0.26
3.0	2222.4	16.12	0.12	408.0	17.26	0.26
3.8	3333.6	16.15	0.15	612.0	17.33	0.33
4.5	3333.6	16.15	0.15	612.0	17.34	0.34
5.0	3333.6	16.15	0.15	612.0	17.34	0.34
5.5	4444.8	16.17	0.17	816.0	17.40	0.40
6.5	4444.8	16.17	0.17	816.0	17.40	0.40
7.5	4444.8	16.19	0.19	816.0	17.44	0.44
8.5	5278.2	16.19	0.19	969.0	17.44	0.44
9.5	5278.2	16.19	0.19	969.0	17.44	0.44

TEST TERMINATED WITHOUT FAILURE

TABLE J-8 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Coal with closely-spaced (2-3 inches), smooth joints

TABLE J-9
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 7a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
-	Ø	11.30	-	Ø	18.00	-
1.0	102.0	11.32	0.02	555.6	18.21	0.21
2.0	102.0	11.32	0.02	555.6	18.21	0.21
2.5	204.0	11.33	0.03	1111.2	18.36	0.36
4.5	204.0	11.33	0.03	1111.2	18.37	0.37
5.0	204.0	11.33	0.03	1111.2	18.37	0.37
6.8	408.0	11.34	0.04	2222.4	18.64	0.64
8.2	408.0	11.34	0.04	2222.4	18.66	0.66
9.2	408.0	11.34	0.04	2222.4	18.66	0.66
10.8	612.0	11.35	0.05	3333.6	18.86	0.86
11.5	612.0	11.35	0.05	3333.6	18.87	0.87
12.0	612.0	11.35	0.05	3333.6	18.88	0.88
13.2	612.0	11.35	0.05	3333.6	18.89	0.89
15.2	612.0	11.35	0.05	3333.6	18.90	0.90
17.5	612.0	11.35	0.05	3333.6	18.90	0.90
18.2	714.0	11.35	0.05	3889.2	19.04	1.04
18.5	714.0	11.35	0.05	3889.2	19.05	1.05
18.7	714.0	11.35	0.05	3889.2	19.06	1.06
18.8	714.0	11.35	0.05	3889.2	19.07	1.07
19.0	714.0	11.35	0.05	3889.2	19.08	1.08
19.5	714.0	11.35	0.05	3889.2	19.10	1.10
				FAILURE OF COAL IN ROOF		

TABLE J-9 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Thin coal (less than 2 inches) overlying shaley, fine-grained sandstone

TABLE J-10
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 7b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
-	Ø	14.25	-	Ø	20.00	-
0.8	555.6	14.25	Ø	102.0	20.20	0.20
1.8	555.6	14.26	0.01	102.0	20.20	0.20
2.2	555.6	14.26	0.01	102.0	20.20	0.20
2.5	1111.2	14.28	0.03	204.0	20.26	0.26
3.5	1111.2	14.28	0.03	204.0	20.26	0.26
4.0	2222.4	14.31	0.06	408.0	20.36	0.36
5.5	2222.4	14.31	0.06	408.0	20.36	0.36
6.2	3333.6	14.33	0.08	612.0	20.46	0.46
7.2	3333.6	14.33	0.08	612.0	20.47	0.47
8.0	3333.6	14.33	0.08	612.0	20.47	0.47
9.2	4444.8	14.37	0.12	816.0	20.56	0.56
10.0	4444.8	14.38	0.13	816.0	20.56	0.56
11.2	4444.8	14.39	0.14	816.0	20.56	0.56
12.5	4444.8	14.39	0.14	816.0	20.56	0.56
13.2	5278.2	14.42	0.17	969.0	20.60	0.60
14.2	5278.2	14.42	0.17	969.0	20.60	0.60
14.8	5278.2	14.43	0.18	969.0	20.60	0.60
15.2	5278.2	14.43	0.18	969.0	20.60	0.60

TEST TERMINATED WITHOUT FAILURE

TABLE J-10 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Thin coal (less than 2 inches) overlying shaley, fine-grained sandstone

TABLE J-11
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 8a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	15.40	-	Ø	16.00	-
0.5	102.0	15.48	0.08	555.6	16.11	0.11
1.5	102.0	15.48	0.08	555.6	16.11	0.11
2.0	204.0	15.52	0.12	1111.2	16.17	0.17
2.8	204.0	15.52	0.12	1111.2	16.18	0.18
3.5	204.0	15.57	0.17	1111.2	16.18	0.18
4.2	357.0	15.58	0.18	1944.6	16.30	0.30
5.5	357.0	15.58	0.18	1944.6	16.31	0.31
6.0	357.0	15.58	0.18	1944.6	16.31	0.31
6.2	408.0	15.60	0.20	2222.4	16.34	0.34
7.2	408.0	15.60	0.20	2222.4	16.40	0.40
8.0	510.0	15.64	0.24	2778.0	16.42	0.42
8.8	510.0	15.65	0.25	2778.0	16.43	0.43
10.2	510.0	15.65	0.25	2778.0	16.44	0.44
11.2	510.0	15.65	0.25	2778.0	16.44	0.44
12.5	612.0	15.71	0.31	3333.6	16.58	0.58
12.8	612.0	15.71	0.31	3333.6	16.60	0.60
12.8	612.0	15.71	0.31	3333.6	16.61	0.61
13.0	612.0	15.71	0.31	3333.6	16.62	0.62
13.2	612.0	15.72	0.32	3333.6	16.64	0.64
13.5	612.0	15.72	0.32	3333.6	16.65	0.65
13.6	612.0	15.72	0.32	3333.6	16.66	0.66
14.1	612.0	15.72	0.32	3333.6	16.68	0.68

TABLE J-11 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
14.9	612.0	15.72	0.32	3333.6	16.70	0.70
15.5	612.0	15.72	0.32	3333.6	16.72	0.72
16.0	612.0	15.72	0.32	3333.6	16.73	0.73
16.5	612.0	15.72	0.32	3333.6	16.74	0.74
17.5	612.0	15.72	0.32	3333.6	16.76	0.76
18.0	612.0	15.72	0.32	3333.6	16.77	0.77
19.0	663.0	15.74	0.34	3611.4	16.90	0.90
19.5	663.0	15.74	0.34	3611.4	16.95	0.95
19.8	663.0	15.75	0.35	3611.4	16.96	0.96
20.2	663.0	15.75	0.35	3611.4	16.98	0.98
20.8	663.0	15.75	0.35	3611.4	17.00	1.00
				FAILURE OF COAL IN ROOF		

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Coal overlying shaley, fine-grained sandstone

TABLE J-12
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 8b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	15.99	-	Ø	18.00	-
0.5	555.6	16.03	0.04	102.0	18.12	0.12
1.5	555.6	16.03	0.04	102.0	18.12	0.12
2.0	1111.2	16.03	0.04	204.0	18.18	0.18
3.0	1111.2	16.03	0.04	204.0	18.18	0.18
3.8	2222.4	16.06	0.07	408.0	18.28	0.28
4.5	2222.4	16.08	0.09	408.0	18.29	0.29
5.5	2222.4	16.08	0.09	408.0	18.29	0.29
6.5	3333.6	16.10	0.11	612.0	18.38	0.38
7.5	3333.6	16.10	0.11	612.0	18.38	0.38
8.5	4444.8	16.15	0.16	816.0	18.48	0.48
9.2	4444.8	16.16	0.17	816.0	18.48	0.48
10.2	4444.8	16.16	0.17	816.0	18.48	0.48
11.5	5278.2	16.20	0.21	969.0	18.55	0.55
12.2	5278.2	16.21	0.22	969.0	18.55	0.55
12.8	5278.2	16.22	0.23	969.0	18.55	0.55
14.0	5278.2	16.22	0.23	969.0	18.55	0.55

TEST TERMINATED WITHOUT FAILURE

TABLE J-12 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Coal overlying shaley, fine-grained sandstone

TABLE J-13
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 9a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	12.56	-	Ø	18.00	-
1.0	102.0	12.74	0.18	555.6	18.09	0.09
5.0	102.0	12.75	0.19	555.6	18.09	0.09
5.5	204.0	12.77	0.21	1111.2	18.16	0.16
6.5	204.0	12.77	0.21	1111.2	18.16	0.16
7.0	408.0	12.79	0.23	2222.4	18.28	0.28
8.0	408.0	12.79	0.23	2222.4	18.28	0.28
8.8	612.0	12.80	0.24	3333.6	18.40	0.40
9.2	612.0	12.80	0.24	3333.6	18.41	0.41
9.5	612.0	12.80	0.24	3333.6	18.42	0.42
10.5	612.0	12.80	0.24	3333.6	18.43	0.43
11.5	612.0	12.80	0.24	3333.6	18.44	0.44
12.5	612.0	12.80	0.24	3333.6	18.44	0.44
15.0	816.0	12.81	0.25	4444.8	18.81	0.81
15.1	816.0	12.81	0.25	4444.8	18.82	0.82
15.3	816.0	12.81	0.25	4444.8	18.84	0.84
15.8	816.0	12.81	0.25	4444.8	18.86	0.86
16.2	816.0	12.81	0.25	4444.8	18.88	0.88
17.0	816.0	12.81	0.25	4444.8	18.90	0.90
18.2	816.0	12.81	0.25	4444.8	18.92	0.92
19.0	867.0	12.81	0.25	4722.0	19.03	1.03
20.5	918.0	12.81	0.25	5000.4	19.17	1.17
21.1	938.4	12.81	0.25	5111.5	19.20	1.20
22.0	948.5	12.81	0.25	5167.1	19.28	1.28

TEST TERMINATED WITHOUT FAILURE

TABLE J-13 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Coal overlying shaley, fine-grained sandstone

TABLE J-14
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 9b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	14.54	-	Ø	16.00	-
0.5	555.6	14.57	0.03	102.0	16.14	0.14
1.5	555.6	14.57	0.03	102.0	16.15	0.15
2.5	555.6	14.57	0.03	102.0	16.15	0.15
3.0	1111.2	14.59	0.05	204.0	16.22	0.22
4.0	1111.2	14.59	0.05	204.0	16.22	0.22
5.2	2222.4	14.62	0.08	408.0	16.32	0.32
6.0	2222.4	14.63	0.09	408.0	16.33	0.33
7.0	2222.4	14.63	0.09	408.0	16.33	0.33
7.5	3333.6	14.66	0.12	612.0	16.42	0.42
8.5	3333.6	14.66	0.12	612.0	16.44	0.44
9.0	3333.6	14.67	0.13	612.0	16.44	0.44
10.0	3333.6	14.67	0.13	612.0	16.44	0.44
10.2	3889.2	14.69	0.15	714.0	16.49	0.49
11.2	3889.2	14.69	0.15	714.0	16.50	0.50
12.2	3889.2	14.69	0.15	714.0	16.50	0.50
12.5	4444.8	14.70	0.16	816.0	16.54	0.54
13.5	4444.8	14.70	0.16	816.0	16.54	0.54
13.8	5000.4	14.72	0.18	918.0	16.58	0.58
14.5	5000.4	14.72	0.18	918.0	16.59	0.59
15.2	5000.4	14.72	0.18	918.0	16.60	0.60
16.2	5000.4	14.72	0.18	918.0	16.60	0.60
17.2	5278.2	14.73	0.19	969.0	16.62	0.62

TABLE J-14 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
17.5	5278.2	14.73	0.19	969.0	16.62	0.62
18.5	5278.2	14.73	0.19	969.0	16.62	0.62
TEST TERMINATED WITHOUT FAILURE						

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Coal overlying shaley, fine-grained sandstone

TABLE J-15
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 10a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
Ø	Ø	10.37	-	Ø	19.00	-
0.5	102.0	10.39	0.02	555.6	19.11	0.11
1.0	102.0	10.39	0.02	555.6	19.11	0.11
1.2	204.0	10.39	0.02	1111.2	19.19	0.19
2.0	204.0	10.39	0.02	1111.2	19.20	0.20
3.0	408.0	10.39	0.02	2222.4	19.32	0.32
4.0	408.0	10.39	0.02	2222.4	19.32	0.32
5.0	612.0	10.40	0.03	3333.6	19.48	0.48
5.5	612.0	10.40	0.03	3333.6	19.50	0.50
6.4	612.0	10.40	0.03	3333.6	19.52	0.52
7.2	612.0	10.40	0.03	3333.6	19.53	0.53
8.0	612.0	10.40	0.03	3333.6	19.53	0.53
9.0	714.0	10.40	0.03	3889.2	19.70	0.70
9.2	714.0	10.40	0.03	3889.2	19.72	0.72
9.5	714.0	10.40	0.03	3889.2	19.74	0.74
10.0	714.0	10.40	0.03	3889.2	19.76	0.76
10.5	714.0	10.40	0.03	3889.2	19.78	0.78
11.8	714.0	10.40	0.03	3889.2	19.80	0.80
13.5	816.0	10.40	0.03	4444.8	20.06	1.06
13.8	816.0	10.40	0.03	4444.8	20.08	1.08
14.0	816.0	10.40	0.03	4444.8	20.10	1.10
14.5	816.0	10.40	0.03	4444.8	20.12	1.12
14.8	816.0	10.40	0.03	4444.8	20.14	1.14

TEST TERMINATED WITHOUT FAILURE

TABLE J-15 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Coal overlying shaley, fine-grained sandstone

TABLE J-16
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 10b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	12.00	-	Ø	18.00	-
0.5	555.6	12.01	0.01	102.0	18.14	0.14
1.2	555.6	12.01	0.01	102.0	18.14	0.14
1.5	1111.2	12.02	0.02	204.0	18.22	0.22
2.5	1111.2	12.02	0.02	204.0	18.22	0.22
3.0	2222.4	12.02	0.02	408.0	18.32	0.32
4.0	2222.4	12.02	0.02	408.0	18.32	0.32
4.5	3333.6	12.03	0.03	612.0	18.39	0.39
5.5	3333.6	12.03	0.03	612.0	18.39	0.39
6.0	4444.8	12.04	0.04	816.0	18.46	0.46
7.0	4444.8	12.04	0.04	816.0	18.46	0.46
7.5	5222.6	12.04	0.04	958.8	18.51	0.51
7.8	5278.2	12.04	0.04	969.0	18.52	0.52
8.8	5278.2	12.04	0.04	969.0	18.52	0.52

TEST TERMINATED WITHOUT FAILURE

TABLE J-16 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Coal overlying shaley, fine-grained sandstone

TABLE J-17
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 11a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	10.11	-	Ø	19.00	-
0.8	102.0	10.20	0.09	555.6	19.23	0.23
1.8	102.0	10.20	0.09	555.6	19.23	0.23
2.2	204.0	10.25	0.14	1111.2	19.27	0.27
3.0	204.0	10.25	0.14	1111.2	19.28	0.28
3.5	204.0	10.25	0.14	1111.2	19.28	0.28
4.2	408.0	10.31	0.20	2222.4	19.37	0.37
5.5	408.0	10.31	0.20	2222.4	19.37	0.37
6.0	612.0	10.34	0.23	3333.6	19.48	0.48
7.0	612.0	10.34	0.23	3333.6	19.48	0.48
7.2	714.0	10.36	0.25	3889.2	19.52	0.52
7.7	714.0	10.36	0.25	3889.2	19.53	0.53
8.7	714.0	10.36	0.25	3889.2	19.54	0.54
9.2	714.0	10.36	0.25	3889.2	19.54	0.54
9.5	816.0	10.38	0.27	4444.8	19.58	0.58
10.5	816.0	10.38	0.27	4444.8	19.58	0.58
11.1	918.0	10.40	0.29	5000.4	19.62	0.62
11.5	918.0	10.40	0.29	5000.4	19.63	0.63
11.8	918.0	10.40	0.29	5000.4	19.64	0.64
12.3	918.0	10.40	0.29	5000.4	19.64	0.64
13.8	958.8	10.41	0.30	5222.6	19.66	0.66
14.8	958.8	10.41	0.30	5222.6	19.66	0.66

TEST TERMINATED WITHOUT FAILURE

TABLE J-17 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Rock -Shaley, fine-grained sandstone

TABLE J-18
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 11b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	10.00	-	Ø	20.00	-
0.5	555.6	10.07	0.07	102.0	20.16	0.16
1.3	555.6	10.07	0.07	102.0	20.16	0.16
2.0	1111.2	10.12	0.12	204.0	20.21	0.21
3.2	1111.2	10.12	0.12	204.0	20.21	0.21
5.0	1389.0	10.69	0.69	255.0	20.21	0.21
5.5	1389.0	10.72	0.72	255.0	20.21	0.21
5.8	1389.0	10.74	0.74	255.0	20.21	0.21
6.0	1389.0	10.76	0.76	255.0	20.21	0.21
	FAILURE OF FLOOR ROCK					

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-19
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 12a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	14.97	-	Ø	14.00	-
0.5	102.0	15.07	0.10	555.6	14.12	0.12
1.5	102.0	15.07	0.10	555.6	14.12	0.12
1.8	204.0	15.10	0.13	1111.2	14.18	0.18
2.8	204.0	15.10	0.13	1111.2	14.18	0.18
3.2	408.0	15.13	0.16	2222.4	14.31	0.31
4.3	408.0	15.13	0.16	2222.4	14.31	0.31
5.0	612.0	15.15	0.18	3333.6	14.40	0.40
5.8	612.0	15.15	0.18	3333.6	14.41	0.41
7.0	612.0	15.15	0.18	3333.6	14.42	0.42
7.8	714.0	15.16	0.19	3889.2	14.48	0.48
8.5	714.0	15.16	0.19	3889.2	14.49	0.49
9.2	714.0	15.16	0.19	3889.2	14.50	0.50
10.2	714.0	15.16	0.19	3889.2	14.50	0.50
11.0	816.0	15.17	0.20	4444.8	14.60	0.60
11.8	816.0	15.17	0.20	4444.8	14.62	0.62
12.1	816.0	15.17	0.20	4444.8	14.64	0.64
13.0	816.0	15.17	0.20	4444.8	14.68	0.68

TEST TERMINATED WITHOUT FAILURE

TABLE J-19 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Thin coal (less than 1 inch) overlying shaley, fine-grained sandstone

TABLE J-20
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 12b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
Ø	Ø	14.01	-	Ø	16.00	-
0.2	555.6	14.04	0.03	102.0	16.09	0.09
1.0	555.6	14.04	0.03	102.0	16.10	0.10
1.5	555.6	14.04	0.03	102.0	16.11	0.11
2.0	1111.2	14.08	0.07	204.0	16.24	0.24
2.8	1111.2	14.09	0.08	204.0	16.24	0.24
3.8	1111.2	14.09	0.08	204.0	16.24	0.24
4.5	2222.4	14.17	0.16	408.0	16.45	0.45
5.0	2222.4	14.18	0.17	408.0	16.46	0.46
5.5	2222.4	14.20	0.19	408.0	16.46	0.46
6.2	2222.4	14.22	0.21	408.0	16.46	0.46
7.5	2222.4	14.23	0.22	408.0	16.46	0.46
9.2	2222.4	14.23	0.22	408.0	16.46	0.46
9.8	2778.0	14.33	0.32	510.0	16.56	0.56
10.2	2778.0	14.35	0.34	510.0	16.56	0.56
10.5	2778.0	14.36	0.35	510.0	16.56	0.56
11.0	2778.0	14.38	0.37	510.0	16.56	0.56
11.5	2778.0	14.40	0.39	510.0	16.56	0.56
12.0	2778.0	14.42	0.41	510.0	16.56	0.56
12.2	2778.0	14.43	0.42	510.0	16.56	0.56
	FAILURE OF FLOOR ROCK					

TABLE J-20 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-21
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 13

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
Ø	Ø	16.35	-	Ø	16.00	-
1.8	102.0	16.82	0.47	555.6	16.08	0.08
2.5	102.0	16.84	0.49	555.6	16.08	0.08
4.0	102.0	16.86	0.51	555.6	16.08	0.08
5.2	102.0	16.86	0.51	555.6	16.08	0.08
5.8	153.0	16.94	0.59	833.4	16.10	0.10
6.8	153.0	16.96	0.61	833.4	16.10	0.10
7.8	153.0	16.97	0.62	833.4	16.10	0.10
9.5	153.0	16.97	0.62	833.4	16.10	0.10
9.8	204.0	17.02	0.67	1111.2	16.12	0.12
11.0	204.0	17.04	0.69	1111.2	16.13	0.13
12.5	204.0	17.05	0.70	1111.2	16.13	0.13
13.5	204.0	17.05	0.70	1111.2	16.13	0.13
13.8	255.0	17.09	0.74	1389.0	16.15	0.15
14.8	255.0	17.11	0.76	1389.0	16.15	0.15
15.8	255.0	17.12	0.77	1389.0	16.15	0.15
17.0	255.0	17.12	0.77	1389.0	16.15	0.15
17.2	306.0	17.16	0.81	1666.8	16.17	0.17
18.2	306.0	17.17	0.82	1666.8	16.17	0.17
19.2	306.0	17.18	0.83	1666.8	16.17	0.17
20.2	306.0	17.19	0.84	1666.8	16.17	0.17
21.2	306.0	17.20	0.85	1666.8	16.17	0.17
22.2	306.0	17.20	0.85	1666.8	16.17	0.17

TABLE J-21 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
22.8	408.0	17.26	0.91	2222.4	16.20	0.20
22.8	408.0	17.27	0.92	2222.4	16.20	0.20
23.8	408.0	17.30	0.95	2222.4	16.20	0.20
24.8	408.0	17.32	0.97	2222.4	16.20	0.20
25.8	408.0	17.34	0.99	2222.4	16.20	0.20
26.8	408.0	17.35	1.00	2222.4	16.20	0.20
27.8	408.0	17.35	1.00	2222.4	16.20	0.20
28.5	510.0	17.42	1.07	2778.0	16.22	0.22
29.8	510.0	17.45	1.10	2778.0	16.22	0.22
30.8	510.0	17.46	1.11	2778.0	16.23	0.23
31.8	510.0	17.48	1.13	2778.0	16.23	0.23
32.2	61[illegible].0	17.48	1.13	3333.6	16.23	0.23
32.8	612.0	17.55	1.20	3333.6	16.25	0.25
33.8	612.0	17.56	1.21	3333.6	16.25	0.25
34.8	612.0	17.60	1.25	3333.6	16.25	0.25
35.8	612.0	17.63	1.28	3333.6	16.25	0.25
36.8	612.0	17.65	1.30	3333.6	16.25	0.25
37.8	612.0	17.68	1.33	3333.6	16.25	0.25
38.8	612.0	17.73	1.38	3333.6	16.25	0.25
39.8	612.0	17.81	1.46	3333.6	16.25	0.25
40.2	612.0	17.88	1.53	3333.6	16.25	0.25
40.8	530.4	17.92	1.57	2889.1	16.25	0.25
	FAILURE OF FLOOR ROCK					

TABLE J-21 (continued)

NOTES:

1. Time elapsed from initial reading.

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Rock -Shaley, fine-grained sandstone

TABLE J-22
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 14a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	14.95	-	Ø	16.00	-
0.5	102.0	15.18	0.23	555.6	16.13	0.13
1.5	102.0	15.19	0.24	555.6	16.13	0.13
2.5	102.0	15.19	0.24	555.6	16.13	0.13
3.0	204.0	15.24	0.29	1111.2	16.16	0.16
4.0	204.0	15.26	0.31	1111.2	16.17	0.17
5.0	204.0	15.26	0.31	1111.2	16.17	0.17
5.3	306.0	15.32	0.37	1666.8	16.20	0.20
6.0	306.0	15.33	0.38	1666.8	16.20	0.20
6.8	306.0	15.34	0.39	1666.8	16.20	0.20
7.8	306.0	15.34	0.39	1666.8	16.20	0.20
8.0	408.0	15.39	0.44	2222.4	16.24	0.24
9.0	408.0	15.40	0.45	2222.4	16.24	0.24
10.0	408.0	15.40	0.45	2222.4	16.24	0.24
10.2	510.0	15.44	0.49	2778.0	16.26	0.26
10.5	510.0	15.45	0.50	2778.0	16.27	0.27
11.0	510.0	15.45	0.50	2778.0	16.27	0.27
12.0	510.0	15.46	0.51	2778.0	16.27	0.27
13.0	510.0	15.46	0.51	2778.0	16.27	0.27
13.8	714.0	15.50	0.55	3889.2	16.30	0.30
14.0	714.0	15.52	0.57	3889.2	16.30	0.30
15.0	714.0	15.52	0.57	3889.2	16.31	0.31
15.8	714.0	15.52	0.57	3889.2	16.31	0.31

TABLE J-22 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
16.0	816.0	15.56	0.61	4444.8	16.34	0.34
17.0	816.0	15.56	0.61	4444.8	16.36	0.36
17.8	816.0	15.57	0.62	4444.8	16.38	0.38
18.0	816.0	15.58	0.63	4444.8	16.38	0.38
19.0	816.0	15.58	0.63	4444.8	16.39	0.39
19.8	816.0	15.59	0.64	4444.8	16.40	0.40
20.5	816.0	15.59	0.64	4444.8	16.41	0.41
21.0	816.0	15.59	0.64	4444.8	16.42	0.42
22.0	816.0	15.59	0.64	4444.8	16.42	0.42
22.8	918.0	15.62	0.67	5000.4	16.45	0.45
24.0	918.0	15.63	0.68	5000.4	16.48	0.48
25.0	918.0	15.64	0.69	5000.4	16.48	0.48
25.5	918.0	15.64	0.69	5000.4	16.49	0.49
26.0	918.0	15.64	0.69	5000.4	16.50	0.50
27.0	918.0	15.64	0.69	5000.4	16.50	0.50
27.5	969.0	15.66	0.71	5278.2	16.53	0.53
28.0	969.0	15.66	0.71	5278.2	16.53	0.53
28.5	969.0	15.67	0.72	5278.2	16.54	0.54
29.0	969.0	15.67	0.72	5278.2	16.54	0.54
29.8	969.0	15.67	0.72	5278.2	16.54	0.54
30.0	969.0	15.68	0.73	5278.2	16.54	0.54
30.5	969.0	15.68	0.73	5278.2	16.54	0.54

TEST TERMINATED WITHOUT FAILURE

TABLE J-22 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-23
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 14b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
Ø	Ø	16.67	-	Ø	16.00	-
1.5	468.8	16.89	0.22	153.0	16.14	0.14
2.0	468.8	16.90	0.23	153.0	16.12	0.12
3.0	468.8	16.90	0.23	153.0	16.14	0.14
3.8	781.2	17.01	0.34	255.0	16.20	0.20
5.0	781.2	17.03	0.36	255.0	16.20	0.20
6.0	781.2	17.04	0.37	255.0	16.20	0.20
7.0	781.2	17.04	0.37	255.0	16.20	0.20
7.5	1093.8	17.13	0.46	357.0	16.24	0.24
8.0	1093.8	17.15	0.48	357.0	16.24	0.24
9.0	1093.8	17.16	0.49	357.0	16.24	0.24
9.8	1093.8	17.17	0.50	357.0	16.24	0.24
11.0	1093.8	17.18	0.51	357.0	16.24	0.24
12.0	1093.8	17.18	0.51	357.0	16.24	0.24
12.8	1406.2	17.26	0.59	459.0	16.27	0.27
14.0	1406.2	17.29	0.62	459.0	16.28	0.28
15.0	1406.2	17.30	0.63	459.0	16.28	0.28
16.0	1406.2	17.32	0.65	459.0	16.28	0.28
17.0	1406.2	17.33	0.66	459.0	16.28	0.28
18.0	1406.2	17.34	0.67	459.0	16.28	0.28
19.0	1406.2	17.35	0.68	459.0	16.28	0.28
20.0	1406.2	17.36	0.69	459.0	16.28	0.28
21.0	1406.2	17.37	0.70	459.0	16.28	0.28
22.0	1406.2	17.38	0.71	459.0	16.28	0.28

TABLE J-23 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER PRESSURE (inch)	ROOF DEFORMA-TION (inch)
23.0	1406.2	17.38	0.71	459.0	16.28	0.28
24.0	1562.5	17.54	0.87	510.0	16.30	0.30
24.2	1562.5	17.58	0.91	510.0	16.30	0.30
24.8	1562.5	17.64	0.97	510.0	16.30	0.30
25.2	1406.2	17.72	1.05	459.0	16.30	0.30
25.5	1406.2	17.74	1.07	459.0	16.30	0.30
25.8	1250.0	17.76	1.09	408.0	16.30	0.30
	FAILURE OF FLOOR ROCK					

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 8- by 8-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-24
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 15a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
Ø	Ø	16.36	-	Ø	15.00	-
0.5	153.0	16.47	0.11	833.4	15.08	0.08
1.5	153.0	16.47	0.11	833.4	15.09	0.09
2.5	153.0	16.48	0.12	833.4	15.09	0.09
3.5	153.0	16.48	0.12	833.4	15.09	0.09
3.8	255.0	16.51	0.15	1389.0	15.13	0.13
4.8	255.0	16.52	0.16	1389.0	15.13	0.13
5.8	255.0	16.52	0.16	1389.0	15.13	0.13
6.8	255.0	16.52	0.16	1389.0	15.13	0.13
7.0	357.0	16.55	0.19	1944.6	15.17	0.17
8.0	357.0	16.55	0.19	1944.6	15.17	0.17
8.8	459.0	16.58	0.22	2500.2	15.21	0.21
9.8	459.0	16.58	0.22	2500.2	15.22	0.22
10.8	459.0	16.58	0.22	2500.2	15.22	0.22
11.2	561.0	16.60	0.24	3055.8	15.25	0.25
12.0	561.0	16.60	0.24	3055.8	15.26	0.26
13.0	561.0	16.60	0.24	3055.8	15.26	0.26
13.2	663.0	16.62	0.26	3611.4	15.29	0.29
14.0	663.0	16.62	0.26	3611.4	15.30	0.30
15.0	663.0	16.62	0.26	3611.4	15.30	0.30
15.2	765.0	16.64	0.28	4167.0	15.34	0.34
16.0	765.0	16.64	0.28	4167.0	15.35	0.35
17.0	765.0	16.64	0.28	4167.0	15.35	0.35
17.5	867.0	16.65	0.29	4722.0	15.42	0.42

TABLE J-24 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
18.0	867.0	16.65	0.29	4722.0	15.43	0.43
18.2	867.0	16.65	0.29	4722.0	15.44	0.44
19.0	867.0	16.65	0.29	4722.0	15.44	0.44
20.0	867.0	16.65	0.29	4722.0	15.44	0.44
20.5	969.0	16.67	0.31	5278.2	15.51	0.51
21.0	969.0	16.67	0.31	5278.2	15.52	0.52
21.5	969.0	16.67	0.31	5278.2	15.53	0.53
22.0	969.0	16.67	0.31	5278.2	15.54	0.54
23.0	969.0	16.67	0.31	5278.2	15.55	0.55
24.0	969.0	16.67	0.31	5278.2	15.56	0.56
25.0	969.0	16.67	0.31	5278.2	15.57	0.57
25.5	96[illegible].0	16.67	0.31	5278.2	15.58	0.58
25.8	969.0	16.67	0.31	5278.2	15.60	0.60

TEST TERMINATED WITHOUT FAILURE

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-25
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 15b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
Ø	Ø	18.29	-	Ø	14.00	-
0.5	468.8	18.32	0.03	153.0	14.08	0.08
2.0	468.8	18.32	0.03	153.0	14.08	0.08
2.5	781.2	18.34	0.05	255.0	14.16	0.16
3.0	781.2	18.34	0.05	255.0	14.16	0.16
3.5	781.2	18.34	0.05	255.0	14.16	0.16
4.0	1093.8	18.37	0.08	357.0	14.20	0.20
5.0	1093.8	18.37	0.08	357.0	14.20	0.20
5.5	1406.2	18.41	0.12	459.0	14.23	0.23
6.0	1406.2	18.41	0.12	459.0	14.23	0.23
6.5	1406.2	13.42	0.13	459.0	14.23	0.23
7.5	1406.2	18.42	0.13	459.0	14.23	0.23
8.0	1718.8	18.46	0.17	561.0	14.26	0.26
9.0	1718.8	18.47	0.18	561.0	14.26	0.26
10.0	1718.8	18.47	0.18	561.0	14.26	0.26
10.5	2031.2	18.53	0.24	663.0	14.28	0.28
12.0	2031.2	18.56	0.27	663.0	14.28	0.28
13.0	2031.2	18.56	0.27	663.0	14.29	0.29
14.0	2031.2	18.58	0.29	663.0	14.29	0.29
15.0	2031.2	18.58	0.29	663.0	14.29	0.29
15.5	2343.8	18.66	0.37	765.0	14.30	0.30
16.0	2343.8	18.68	0.39	765.0	14.30	0.30
17.0	2343.8	18.70	0.41	765.0	14.30	0.30

TABLE J-25 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
18.0	2343.8	18.71	0.42	765.0	14.30	0.30
19.0	2343.8	18.72	0.43	765.0	14.30	0.30
20.0	2343.8	18.73	0.44	765.0	14.30	0.30
21.0	2343.8	18.74	0.45	765.0	14.30	0.30
22.0	2343.8	18.74	0.45	765.0	14.30	0.30
22.5	2656.3	18.90	0.61	867.0	14.30	0.30
	FAILURE OF FLOOR ROCK					

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 8- by 8-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-26
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 16a

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
Ø	Ø	16.00	-	Ø	13.00	-
0.5	163.2	16.03	0.03	889.0	13.18	0.18
1.0	163.2	16.03	0.03	889.0	13.18	0.18
1.5	163.2	16.03	0.03	889.0	13.19	0.19
2.5	163.2	16.03	0.03	889.0	13.19	0.19
2.8	265.2	16.07	0.07	1444.6	13.24	0.24
3.8	26 .2	16.08	0.08	1444.6	13.24	0.24
4.8	265.2	16.08	0.08	1444.6	13.24	0.24
5.0	367.2	16.12	0.12	2000.2	13.28	0.28
6.0	367.2	16.13	0.13	2000.2	13.28	0.28
7.0	367.2	16.13	0.13	2000.2	13.29	0.29
8.0	367.2	16.13	0.13	2000.2	13.29	0.29
8.2	469.2	16.16	0.16	2555.8	13.32	0.32
9.0	469.2	16.16	0.16	2555.8	13.32	0.32
9.5	469.2	16.17	0.17	2555.8	13.32	0.32
11.0	469.2	16.17	0.17	2555.8	13.32	0.32
11.2	571.2	16.20	0.20	3111.4	13.34	0.34
12.0	571.2	16.20	0.20	3111.4	13.35	0.35
13.0	571.2	16.21	0.21	3111.4	13.35	0.35
14.0	571.2	16.22	0.22	3111.4	13.35	0.35
15.0	571.2	16.22	0.22	3111.4	13.35	0.35
15.2	673.2	16.23	0.23	3667.0	13.37	0.37
16.0	673.2	16.24	0.24	3667.0	13.37	0.37

TABLE J-26 (continued)

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMATION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMATION (inch)
17.0	673.2	16.24	0.24	3667.0	13.37	0.37
17.2	775.2	16.26	0.26	4222.6	13.40	0.40
18.0	775.2	16.26	0.26	4222.6	13.40	0.40
19.0	775.2	16.27	0.27	4222.6	13.40	0.40
20.0	775.2	16.27	0.27	4222.6	13.40	0.40
20.2	877.2	16.28	0.28	4778.2	13.43	0.43
21.0	877.2	16.29	0.29	4778.2	13.44	0.44
22.0	877.2	16.29	0.29	4778.2	13.44	0.44
22.8	969.0	16.30	0.30	5278.2	13.48	0.48
23.2	969.0	16.30	0.30	5278.2	13.50	0.50
24.0	969.0	16.30	0.30	5278.2	13.51	0.51
24.2	969.0	16.30	0.30	5278.2	13.52	0.52
25.0	969.0	16.30	0.30	5278.2	13.54	0.54
26.0	969.0	16.30	0.30	5278.2	13.54	0.54
27.0	969.0	16.30	0.30	5278.2	13.54	0.54

TEST TERMINATED WITHOUT FAILURE

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 14- by 14-inch
   Roof 6- by 6-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

TABLE J-27
SUMMARY OF PLATE BEARING TEST DATA
TEST NUMBER 16b

ELAPSED TIME (1) (min)	FLOOR BEARING PRESSURE (psi)	FLOOR RULER READING (inch)	FLOOR DEFORMA-TION (inch)	ROOF BEARING PRESSURE (psi)	ROOF RULER READING (inch)	ROOF DEFORMA-TION (inch)
Ø	Ø	14.02	-	Ø	17.00	-
0.5	1111.2	14.15	0.13	204.0	17.04	0.04
1.5	1111.2	14.15	0.13	204.0	17.04	0.04
2.2	2222.4	14.19	0.17	408.0	17.16	0.16
3.5	2222.4	14.19	0.17	408.0	17.16	0.16
4.0	3333.6	14.21	0.19	612.0	17.26	0.26
4.5	3333.6	14.21	0.19	612.0	17.28	0.28
5.5	3333.6	14.21	0.19	612.0	17.28	0.28
6.0	4444.8	14.23	0.21	816.0	17.36	0.36
6.5	4444.8	14.23	0.21	816.0	17.36	0.36
7.5	4444.8	14.24	0.22	816.0	17.36	0.36
8.5	4444.8	14.25	0.23	816.0	17.36	0.36
9.5	4444.8	14.25	0.23	816.0	17.36	0.36
10.2	5222.6	14.25	0.23	958.8	17.44	0.44
11.2	5278.2	14.25	0.23	969.0	17.45	0.45
13.0	5278.2	14.25	0.23	969.0	17.45	0.45

TEST TERMINATED WITHOUT FAILURE

TABLE J-27 (continued)

NOTES:

1. Time elapsed from initial reading

2. Plate sizes (2-inch thick square steel plates):
   Floor 6- by 6-inch
   Roof 14- by 14-inch

3. Rock type:
   Floor-Shale
   Roof -Shaley, fine-grained sandstone

APPENDIX K

SHIELD SUPPORT LOAD DATA

TABLE K-1
NOTES TO ACCOMPANY TABLES K-2 THROUGH K-10

1. Shields are numbered from the headgate towards the tailgate starting with shield number one.

2. Data represent values selected from weekly recorder charts. The set pressure value represents the initial ram pressure for the last shield move and set-up for the operating day. The final pressure value represents the subsequent ram pressure prior to the next shield move after the resumption of mining operations.

3. Elapsed time is the time from the setting of the shield to the onset of the final ram pressure value.

4. The shield's ram hydraulic system has entered a yielding phase under the applied roof load.

5. Factor to convert psi pressure to load tons is based upon the cross-sectional area of a ram piston (58.57 in^2).

TABLE K-2
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 2

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)		EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)		WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
15 OCT-16 OCT	3700/3700		9.0	3600/3700		9.0
16 OCT-17 OCT	2900/1800		16.0	2700/1700		16.0
17 OCT-20 OCT	3900/4350		63.0	3800/3800		63.0
20 OCT-21 OCT	4000/4000		10.0	4100/4000		10.0
21 OCT-22 OCT	4200/4000		12.0	4300/3850		12.0
5 NOV- 6 NOV	2900/3500		11.5	3300/3700		11.5
6 NOV- 7 NOV	2900/2450		10.0	2300/2300		10.0
7 NOV-17 NOV	2700/5400	(4)	189.0	2500/4150		227.0
17 NOV-18 NOV	3400/4000		11.5	3400/4100		11.5
18 NOV-19 NOV	3300/4200		10.5	3000/4050		10.5
19 NOV-20 NOV	3350/3500		10.0	3300/3200		10.0
20 NOV-21 NOV	3600/3500		11.0	3600/3500		11.0
21 NOV-24 NOV	3700/3800		60.0	3700/3700		60.0
17 DEC-18 DEC	2900/1850		10.5	3150/3300		10.5
18 DEC-19 DEC	1800/3400		10.0	2000/3500		10.0
19 DEC-22 DEC	1100/5400	(4)	47.0	1200/5100	(4)	42.0
22 DEC-23 DEC	4000/4800		9.5	3300/4200		9.5
6 JAN- 8 JAN	3800/5200		42.5	3600/4700		42.5
8 JAN- 9 JAN	3900/4400		13.0	4100/4200		13.0
9 JAN-12 JAN	3100/4100		59.0	3000/4100		59.0
12 JAN-13 JAN	3200/3300		9.5	2800/3100		9.5
13 JAN-14 JAN	3900/4000		11.5	3800/3600		11.5
14 JAN-15 JAN	3200/3400		12.0	3500/3500		12.0
15 JAN-16 JAN	3700/3500		10.0	3500/3400		10.0

TABLE K-2 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
16 JAN-19 JAN	2200/2500	54.5	1200/1800	54.5
19 JAN-20 JAN	3000/3000	9.0	3300/3200	9.0
3 FEB- 4 FEB	2700/2500	16.0	3000/2500	16.0
4 FEB- 5 FEB	3200/3700	16.5	3000/3200	16.5
5 FEB- 6 FEB	3200/4200	10.5	3400/4400	10.5
6 FEB- 9 FEB	3000/3800	64.0	3500/4600	64.0
9 FEB-10 FEB	2800/3100	18.5	2600/2850	18.5
10 FEB-11 FEB	3000/3300	15.5	2700/3400	15.5
11 FEB-12 FEB	3250/3600	13.0	3250/3800	13.0
12 FEB-13 FEB	2800/3200	12.0	2800/3800	12.0
13 FEB-16 FEB	1550/2250	58.0	1500/2700	58.0
16 FEB-17 FEB	3700/4200	10.5	3500/4100	10.5
17 FEB-18 FEB	3600/3800	26.0	3400/4100	26.0
18 FEB-19 FEB	3400/3400	11.5	3400/3400	11.5
19 FEB-20 FEB	3300/3050	9.5	2900/2800	9.5
20 FEB- 1 MAR	3500/3400	228.0	3200/3300	228.0
1 MAR- 8 MAR	3800/4500	160.0	3600/4200	160.0
8 MAR-10 MAR	3700/4100	45.0	3700/4200	45.0
10 MAR-11 MAR	3900/3800	10.0	3650/3700	10.0
11 MAR-12 MAR	3700/3550	10.5	3600/3500	10.5
12 MAR-15 MAR	3100/3700	60.0	3000/3900	60.0
15 MAR-16 MAR	2800/3000	12.5	2700/2900	12.5
16 MAR-17 MAR	3100/4500	12.0	3200/4600	12.0
17 MAR-18 MAR	3300/3600	11.0	3200/3800	11.0
18 MAR-22 MAR	3800/5100	82.0	3600/4500	82.0
22 MAR-23 MAR	3100/3700	18.5	3200/3700	18.5
23 MAR-24 MAR	3100/3300	11.0	3000/3100	11.0
24 MAR-25 MAR	3200/4200	14.5	3000/4100	14.5

TABLE K-2 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
25 MAR-29 MAR	2900/3800	85.5	2900/4000	85.5
29 MAR-30 MAR	2600/3350	10.5	2700/3800	10.5
30 MAR-31 MAR	3500/2800	11.0	2800/1750	11.0
31 MAR- 5 APR	3200/3700	108.0	2900/3450	108.0
5 APR- 6 APR	2900/2700	19.0	2600/2800	19.0
6 APR- 7 APR	3800/3600	10.0	3300/3100	10.0
7 APR- 8 APR	3200/3200	4.0	2900/3000	4.0
8 APR-12 APR	3200/3700	111.0	2900/3700	111.0
12 APR-13 APR	2300/2200	5.5	2300/2100	5.5
13 APR-14 APR	3450/3450	10.0	3500/3400	10.0
14 APR-15 APR	3400/3200	13.0	3200/3250	13.0
15 APR-19 APR	3200/4100	91.0	2800/3900	91.0
19 APR-20 APR	Ø/ Ø	16.0	100/ Ø	16.0
20 APR-21 APR	3000/3000	13.0	2800/2700	13.0
21 APR-22 APR	3100/3300	13.5	2850/3400	13.5
22 APR-23 APR	2400/2700	13.0	2100/2900	13.0
23 APR-26 APR	3700/4100	60.0	3600/3900	60.0
26 APR-27 APR	4000/4000	15.5	4000/3900	15.5
27 APR-28 APR	4100/4500	17.0	4000/4300	17.0
28 APR-29 APR	1500/2500	22.0	1600/2600	22.0
29 APR-30 APR	3500/4800	27.0	3300/4800	27.0
30 APR- 4 MAY	3300/5300	90.5	3200/4400	90.5
4 MAY- 5 MAY	1550/3000	23.0	900/1800	23.0
5 MAY- 6 MAY	1000/2000	21.0	1100/1950	21.0
6 MAY- 7 MAY	3600/4000	25.5	3500/3500	25.5
7 MAY-10 MAY	3550/4500	53.0	3250/3400	53.0
10 MAY-10 MAY	3300/3500	10.0	2200/2100	10.0
10 MAY-11 MAY	1800/1900	12.5	2100/2300	12.5

TABLE K-2 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
11 MAY-12 MAY	4100/3950	23.0	4000/3800	23.0
12 MAY-13 MAY	3700/3950	16.0	3400/3500	16.0

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

TABLE K-3
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 15

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
8 OCT- 9 OCT	3800/3900	11.5	3500/2900	11.5
9 OCT-10 OCT	3500/3900	8.5	2500/3000	8.5
10 OCT-13 OCT	2250/3350	58.0	2200/3100	58.0
13 OCT-14 OCT	2500/3300	12.0	2400/3500	12.0
14 OCT-15 OCT	2550/3100	9.0	2600/3400	9.0
5 NOV- 6 NOV	3300/3500	8.0	3400/3750	8.0
6 NOV- 6 NOV	3100/4100	11.0	3000/4250	11.0
6 NOV- 7 NOV	3200/3400	11.5	3400/4000	11.5
7 NOV- 7 NOV	3400/3800	9.0	3400/3800	9.0
7 NOV-17 NOV	2600/4100	226.5	2700/4100	226.5
17 NOV-18 NOV	3700/5400 (4)	4.0	3700/5500 (4)	3.0
18 NOV-19 NOV	2700/4250	9.5	2600/4100	9.5
19 NOV-20 NOV	3600/4800	10.0	3600/4100	10.0
20 NOV-21 NOV	3000/5200	12.5	2800/5250	12.5
21 NOV-24 NOV	3200/5350 (4)	16.5	3300/5350 (4)	23.0
9 DEC-10 DEC	3200/5100	11.0	2700/5400	11.0
10 DEC-11 DEC	1700/2100	9.5	1700/2000	9.5
11 DEC-12 DEC	3300/3200	11.0	3900/3900	11.0
12 DEC-15 DEC	2800/4000	63.0	2500/3100	63.0
15 DEC-16 DEC	3200/4800	16.5	3050/4300	16.5
6 JAN- 8 JAN	3300/3700	40.0	3200/3700	40.0
8 JAN- 9 JAN	3000/3800	13.5	2800/3800	13.5
9 JAN-12 JAN	3300/4200	52.0	3300/4050	52.0
12 JAN-13 JAN	2800/3700	9.5	2500/3200	9.5

TABLE K-3 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
13 JAN-14 JAN	3900/4000	9.5	2300/2800	9.5
14 JAN-14 JAN	3700/5400 (4)	2.5	2600/5400 (4)	3.5
15 JAN-16 JAN	3200/3500	11.0	3300/3600	11.0
16 JAN-19 JAN	2150/3000	60.0	1900/2100	60.0
19 JAN-20 JAN	1100/2400	11.0	1000/1800	11.0
3 FEB- 4 FEB	2700/4000	16.0	2600/4200	16.0
4 FEB- 5 FEB	3400/4000	15.0	3300/4100	15.0
5 FEB- 6 FEB	3100/4850	11.5	3200/5150	11.5
6 FEB- 9 FEB	2500/4500	59.0	2400/5100	59.0
9 FEB-10 FEB	2950/3200	14.0	2600/4000	14.0
10 FEB-11 FEB	3200/4900	14.5	3300/5400	14.5
11 FEB-12 FEB	4000/5000	11.0	3400/4400	11.0
12 FEB-13 FEB	3950/5400	11.5	3900/5400 (4)	5.0
13 FEB-16 FEB	4400/5400 (4)	3.0	3900/5350 (4)	12.0
16 FEB-17 FEB	3500/5000	11.0	3700/5400 (4)	9.5
17 FEB-18 FEB	3700/4850	22.0	3700/5300	32.0
18 FEB-19 FEB	CHART LOOSE ON HUB		3200/3800	13.0
19 FEB-20 FEB	CHART LOOSE ON HUB		4300/5400 (4)	2.5
20 FEB- 1 MAR	CHART LOOSE ON HUB		3000/5250	224.0
1 MAR- 8 MAR	900/3450	157.0	700/2800	157.0
8 MAR-10 MAR	3700/4500	44.5	3600/4300	44.5
10 MAR-11 MAR	4200/4900	10.0	4100/4600	10.0
11 MAR-12 MAR	3350/4300	11.0	3000/3800	11.0
12 MAR-15 MAR	3000/4100	59.5	2850/4200	59.5
15 MAR-16 MAR	3600/3000	13.5	3800/2300	13.5
16 MAR-17 MAR	3700/5400 (4)	3.5	Ø/1600	11.5
17 MAR-18 MAR	3500/5300 (4)	5.5	Ø/ Ø	10.0
18 MAR-22 MAR	3400/4600	88.0	3600/4500	88.0

TABLE K-3 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
22 MAR-23 MAR	3000/3500	19.5	2200/3600	19.5
23 MAR-24 MAR	2200/2600	11.0	2100/2500	11.0
24 MAR-25 MAR	3200/3500	10.5	3100/3300	10.5
25 MAR-29 MAR	2600/3900	84.5	2300/3700	84.5
29 MAR-30 MAR	3100/5200 (4)	6.5	3000/5250 (4)	6.5
30 MAR-31 MAR	3300/3300	8.0	3400/3400	8.0
31 MAR- 5 APR	3000/4000	103.5	3000/3850	103.0
5 APR- 6 APR	2150/1850	18.5	2000/2150	18.5
6 APR- 7 APR	2700/2650	10.5	2500/2600	10.5
7 APR- 8 APR	2550/2550	2.0	2600/2850	2.0
8 APR-12 APR	3400/4400	116.5	3300/4600	116.5
12 APR-13 APR	2600/3000	6.0	2600/3300	6.0
13 APR-14 APR	3800/4400	20.0	2800/4500	20.0
14 APR-15 APR	3300/3700	13.0	2900/3000	13.0
15 APR-19 APR	2800/5100	83.5	2800/4700	83.5
19 APR-20 APR	3700/4000	11.0	3850/4250	11.0
20 APR-21 APR	2900/3400	13.5	2900/3500	13.5
21 APR-22 APR	2100/1900	4.0	2000/1900	4.0
22 APR-23 APR	3400/4150	5.0	3400/4400	10.0
23 APR-26 APR	2800/3200	51.5	2700/3100	51.5
26 APR-27 APR	3600/4000	5.0	3400/3900	5.0
27 APR-28 APR	3400/4300	14.5	3300/4300	14.5
28 APR-29 APR	3400/4400	22.5	3600/4700	22.5
29 APR-30 APR	3500/4900	27.0	3500/4950	27.0
30 APR- 3 MAY	3300/4650	75.5	3100/4800	75.5
3 MAY- 4 MAY	3500/5100	19.5	3200/5100	19.5
4 MAY- 5 MAY	2600/3400	20.5	2500/3400	20.5
5 MAY- 6 MAY	2100/3250	21.0	2000/3300	21.0

TABLE K-3 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
6 MAY- 7 MAY	3100/3900	25.5	2900/3800	25.5
7 MAY-10 MAY	2300/3100	51.0	2600/3650	51.0
10 MAY-10 MAY	3000/3450	8.0	2700/3150	8.0
10 MAY-11 MAY	3900/4000	12.5	3500/3100	12.5
11 MAY-13 MAY	3200/4300	60.5	2700/3300	60.5

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

TABLE K-4
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 29

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
1 OCT- 2 OCT	3200/4250	9.5	3800/5000	9.5
2 OCT- 3 OCT	3200/5400	10.5	3200/5600	10.5
3 OCT- 6 OCT	4100/6100	59.0	4300/5600	4.0
6 OCT- 7 OCT	3500/5800	10.5	3500/5600	10.5
7 OCT- 8 OCT	4400/5550	10.5	4000/5450	10.5
6 NOV- 6 NOV	3400/5000	11.0	3100/4100	11.0
6 NOV- 7 NOV	4000/5500	9.5	3800/5300	9.5
7 NOV-17 NOV	3600/5600 (4)	10.0	3500/5300 (4)	7.0
17 NOV-18 NOV	3400/5700 (4)	5.0	3000/5800 (4)	5.0
18 NOV-19 NOV	2900/4050	10.0	2700/4100	10.0
19 NOV-20 NOV	3700/5600 (4)	6.0	3700/5800 (4)	8.5
20 NOV-21 NOV	3800/5600 (4)	4.0	4000/5850 (4)	4.5
21 NOV-24 NOV	2800/4200	58.5	2300/3550	58.5
16 DEC-17 DEC	2700/5200	11.0	2800/4900	11.0
17 DEC-18 DEC	3100/5700 (4)	2.0	3000/5400 (4)	2.0
18 DEC-19 DEC	2400/3600	11.5	2400/3500	11.5
19 DEC-22 DEC	4000/5600 (4)	4.5	3900/5400 (4)	4.5
22 DEC-23 DEC	3100/5500 (4)	5.5	2900/5100	9.0
6 JAN- 8 JAN	3000/5100	42.0	3000/4700	42.0
8 JAN- 9 JAN	3500/5400	11.0	3500/5200	11.0
9 JAN-12 JAN	3200/5500 (4)	6.0	3050/5200 (4)	5.5
12 JAN-13 JAN	3400/5600 (4)	2.5	3800/5300 (4)	4.0
13 JAN-14 JAN	3300/5500 (4)	7.0	3200/5300 (4)	2.0
14 JAN-15 JAN	3600/5500 (4)	4.0	3500/5300 (4)	2.0

TABLE K-4 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
15 JAN-16 JAN	3000/5500 (4)	8.0	2300/4100	10.5
16 JAN-19 JAN	3700/5500 (4)	7.0	3600/5300 (4)	7.0
19 JAN-20 JAN	2800/5500 (4)	9.0	2750/5200 (4)	7.5
3 FEB- 4 FEB	3500/4000	20.0	3300/4000	20.0
4 FEB- 5 FEB	2900/4300	15.0	2900/4200	15.0
5 FEB- 6 FEB	3300/4500	9.5	3200/4200	9.5
6 FEB- 9 FEB	4800/5500	58.5	4150/4000	58.5
9 FEB-10 FEB	2500/3200	11.5	2300/4400	11.5
10 FEB-11 FEB	3000/4550	11.0	3100/4300	11.0
11 FEB-12 FEB	2200/2400	10.5	1800/2100	10.5
12 FEB-13 FEB	3000/3900	9.5	2750/3550	9.5
13 FEB-16 FEB	3700/5450 (4)	37.0	3300/5100	59.0
16 FEB-17 FEB	4100/5150	10.0	3900/5200 (4)	7.0
17 FEB-18 FEB	4000/5500 (4)	22.0	3600/5200 (4)	26.0
18 FEB-19 FEB	3200/5300	12.5	3100/5150	12.5
19 FEB-20 FEB	3200/3900	10.5	3700/4400	10.5
20 FEB- 1 MAR	3400/3100	224.5	2800/2900	224.5
1 MAR- 3 MAR	4000/5400 (4)	33.0	4000/5150 (4)	20.5
8 MAR- 9 MAR	2600/4500	38.0	2700/4200	38.0
9 MAR-10 MAR	3400/4400	9.5	3500/4300	9.5
10 MAR-11 MAR	3300/4000	4.0	3500/5000	10.0
11 MAR-12 MAR	3200/5500 (4)	5.5	3300/5300 (4)	2.5
12 MAR-15 MAR	3800/5400 (4)	14.0	800/3600	60.0
15 MAR-16 MAR	3500/3200	11.0	3800/3750	6.0
16 MAR-17 MAR	4700/5500 (4)	2.5	1300/2900	11.5
17 MAR-18 MAR	4800/5500 (4)	1.0	1400/3300	10.0
18 MAR-22 MAR	2700/3800	87.5	2700/3900	87.5
22 MAR-23 MAR	3700/4700	19.0	3900/5000	19.0

TABLE K-4 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
23 MAR-24 MAR	3600/5200	10.5	3150/5200 (4)	10.5
24 MAR-25 MAR	4000/5400	11.5	4400/5200	11.5
25 MAR-29 MAR	4450/5400 (4)	26.0	4000/5200 (4)	8.5
29 MAR-30 MAR	2700/3000	2.0	2500/3000	2.0
30 MAR-31 MAR	3400/3400	8.0	3350/3800	8.0
31 MAR- 1 APR	3800/5400 (4)	15.0	3800/5250 (4)	7.0
5 APR- 6 APR	1700/1400	21.5	1700/1300	21.5
6 APR- 7 APR	3500/4400	11.0	3350/4000	11.0
7 APR-12 APR	2800/5100	114.5	2500/5000	114.5
12 APR-13 APR	2800/3700	5.5	2700/3300	5.5
13 APR-14 APR	3500/4800	23.5	3400/3900	23.5
14 APR-15 APR	2900/3350	7.0	3100/3450	13.0
15 APR-16 APR	3900/5400 (4)	11.5	3700/5100	83.0
19 APR-20 APR	4000/4600	10.5	3600/4250	10.5
20 APR-21 APR	3400/4800	13.5	3200/4200	13.5
21 APR-22 APR	2700/2750	1.5	2600/3400	11.5
22 APR-23 APR	3000/4100	9.5	2400/3400	9.5
23 APR-26 APR	3000/4550	56.5	2800/4000	56.5
26 APR-27 APR	3800/3800	8.5	3800/3750	8.5
27 APR-28 APR	3700/4900	14.0	3300/4500	14.0
28 APR-29 APR	2600/4500	23.0	2600/4400	23.0
29 APR-30 APR	3500/4550	14.0	3150/4700	27.0
30 APR- 3 MAY	2650/3900	76.0	2100/4000	76.0
3 MAY- 4 MAY	3200/4100	19.0	3200/4900	19.0
4 MAY- 5 MAY	2600/3900	22.0	3000/5200	22.0
5 MAY- 6 MAY	1800/3000	20.0	1500/3300	20.0
6 MAY- 7 MAY	3000/3450	21.0	3150/3600	21.0
7 MAY-10 MAY	2600/3500	52.5	3200/4900	52.5

TABLE K-4 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
10 MAY-10 MAY	3300/4200	10.0	3400/5100	10.0
10 MAY-11 MAY	3700/4800	12.5	3400/5000	12.5
11 MAY-12 MAY	2500/3400	26.0	2300/3100	26.0
12 MAY-13 MAY	2700/4100	31.0	2600/4000	27.5
13 MAY-14 MAY	400/ 400	3.0	300/ 300	3.0

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

TABLE K-5
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 43

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
8 OCT- 9 OCT	RECORDER MALFUNCTION		3700/5000	11.5
9 OCT-10 OCT			2850/6100 (4)	10.0
10 OCT-13 OCT			3200/6000 (4)	14.0
13 OCT-14 OCT			3600/6000 (4)	5.0
14 OCT-15 OCT			3400/5000	9.5
15 OCT-16 OCT			3700/5100	2.5
16 OCT-16 OCT			3800/4100	4.0
16 OCT-17 OCT			3900/6100 (4)	3.0
17 OCT-20 OCT			4000/6200 (4)	1.5
20 OCT-21 OCT			4500/6150 (4)	3.0
21 OCT-22 OCT			2800/6150 (4)	3.0
29 OCT-30 OCT			3200/6100 (4)	1.5
30 OCT- 3 NOV			3300/6100 (4)	6.5
3 NOV- 4 NOV			3200/3700	9.5
4 NOV- 5 NOV			3500/5500 (4)	3.0
5 NOV- 6 NOV			4200/5500 (4)	1.5
6 NOV- 7 NOV			3700/4800	6.0
7 NOV-17 NOV			4200/5500 (4)	2.0
25 NOV-26 NOV			3800/5400 (4)	4.5
26 NOV- 1 DEC			3700/5450 (4)	2.5
1 DEC- 2 DEC			4200/5500 (4)	2.0
2 DEC- 3 DEC			3000/5500	16.5
3 DEC- 4 DEC			3700/5400 (4)	3.0

TABLE K-5 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
4 DEC- 5 DEC	RECORDER MALFUNCTION		3300/5500 (4)	3.0
5 DEC- 8 DEC			2750/4600	59.0
8 DEC- 9 DEC			2700/5500	12.0
16 DEC-17 DEC			2300/5800	13.5
17 DEC-18 DEC			3000/5600 (4)	4.0
18 DEC-19 DEC			2900/5600 (4)	5.5
19 DEC-22 DEC			2800/5700 (4)	4.5
22 DEC-23 DEC			2900/5500	11.0
6 JAN- 7 JAN			2700/5600 (4)	19.0
8 JAN- 9 JAN			2800/5600 (4)	6.0
9 JAN-10 JAN			2700/5700 (4)	3.0
12 JAN-13 JAN			2800/5000	14.0
14 JAN-15 JAN			3800/5500 (4)	1.0
15 JAN-16 JAN			3300/5400 (4)	2.5
16 JAN-17 JAN			3000/5400 (4)	13.0
19 JAN-20 JAN			2200/4900	10.5
3 FEB- 4 FEB			2500/3600	15.5
4 FEB- 5 FEB			2900/3700	13.5
5 FEB- 6 FEB			1700/2700	10.0
6 FEB- 9 FEB			3500/5600	58.0
9 FEB-10 FEB			2900/5400 (4)	4.0
10 FEB-11 FEB			2800/5000	11.0
11 FEB-12 FEB			3000/4250	11.0
12 FEB-13 FEB			3100/4200	10.0
13 FEB-16 FEB			2200/4700	59.0
16 FEB-17 FEB			3500/5300	10.5
17 FEB-18 FEB			3600/4300	21.0
18 FEB-19 FEB			4150/4400	10.0

TABLE K-5 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
19 FEB-20 FEB	RECORDER MALFUNCTION		2350/3100	10.0
20 FEB-21 FEB			3600/5400 (4)	16.0
8 MAR- 9 MAR	1800/2500	6.0	1700/2800	6.0
9 MAR-10 MAR	3200/4000	23.5	3500/3800	23.5
10 MAR-11 MAR	3500/4000	9.5	4000/4400	9.5
11 MAR-12 MAR	5000/5900 (4)	0.5	1600/5000	10.5
12 MAR-15 MAR	4400/5500 (4)	11.0	600/3500	59.0
15 MAR-16 MAR	2400/2800	10.0	3100/3400	10.0
16 MAR-17 MAR	4400/5400 (4)	7.0	1500/3700	11.0
17 MAR-18 MAR	4800/5400	11.0	Ø/1200	11.0
18 MAR-22 MAR	3400/5400	87.0	3000/4250	87.0
22 MAR-23 MAR	1800/2900	17.0	2100/2900	17.0
23 MAR-24 MAR	3500/4500	11.0	400/1600	11.0
24 MAR-25 MAR	4100/4500	10.0	3700/4650	10.0
25 MAR-29 MAR	4100/4200	83.0	3600/4900	83.0
29 MAR-30 MAR	3750/4200	8.0	3200/3600	8.0
30 MAR-31 MAR	3200/5900 (4)	8.0	2600/5500 (4)	4.0
31 MAR- 5 APR	3200/4500	108.5	4000/5500 (4)	17.5
5 APR- 6 APR	2800/5500	20.5	2600/5300	20.5
6 APR- 7 APR	3900/4600	10.0	2900/4000	10.0
7 APR- 8 APR	2800/5000	10.0	4000/5150	10.0
8 APR-12 APR	3200/5800	143.0	3100/5500	143.0
12 APR	RECORDER DAMAGED BY BLASTING ALONG FACE		RECORDER DAMAGED BY BLASTING ALONG FACE	
13 APR-14 APR	2600/3900	10.0	3300/4900	10.0
14 APR-15 APR	2600/3600	12.5	2800/3800	12.5
15 APR-19 APR	2500/2300	81.0	3300/3300	81.0
19 APR-20 APR	2200/2900	11.0	2800/3400	11.0

TABLE K-5 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
20 APR-21 APR	2700/3250	18.5	2300/2700	18.5
21 APR-22 APR	2700/3500	11.5	3000/4200	11.5
22 APR-23 APR	2800/4200	9.5	3100/4300	9.5
23 APR-26 APR	2500/3600	52.0	3200/4000	52.0
26 APR-27 APR	3700/3700	8.0	3750/3750	8.0
27 APR-28 APR	2300/2700	9.5	2400/2600	9.5
28 APR-29 APR	1600/4500	22.5	2100/4700	22.5
29 APR-30 APR	1300/2200	21.0	1800/2400	21.0
30 APR- 3 MAY	3400/4900	71.0	3600/4700	71.0
3 MAY- 4 MAY	2500/3300	18.0	2800/3300	18.0
4 MAY- 5 MAY	2200/2600	14.0	2500/2900	14.0
5 MAY- 6 MAY	1850/3300	15.5	2400/3700	15.5
6 MAY- 7 MAY	2100/4100	25.0	2500/3700	25.0
7 MAY-10 MAY	2200/3800	62.0	2600/3800	62.0
10 MAY-10 MAY	3000/3500	10.0	2800/3500	10.0
10 MAY-11 MAY	3100/3800	11.0	2800/3350	11.0

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

TABLE K-6
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 57

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
15 OCT-16 OCT	2700/5150	9.5	2800/5200	9.5
16 OCT-17 OCT	2200/4000	10.5	2500/4000	10.5
17 OCT-18 OCT	3500/5700 (4)	7.5	3500/5700 (4)	5.5
20 OCT-21 OCT	4000/5700 (4)	2.5	3800/5700 (4)	3.0
21 OCT-22 OCT	3400/5200	11.0	3350/5600	11.0
5 NOV- 5 NOV	4000/5400 (4)	1.0	3500/5400 (4)	1.0
6 NOV- 7 NOV	3700/5300 (4)	6.0	3600/5300 (4)	7.0
7 NOV- 7 NOV	3000/5200 (4)	0.5	3000/5300 (4)	2.0
17 NOV-18 NOV	3700/5300 (4)	2.5	3700/5400 (4)	3.0
18 NOV-19 NOV	3900/5200	7.0	3000/5400 (4)	2.5
19 NOV-20 NOV	3500/5300 (4)	1.5	3900/5400 (4)	3.0
20 NOV-21 NOV	2500/5300 (4)	3.0	3200/5400 (4)	3.0
21 NOV-22 NOV	3500/5300 (4)	5.0	3500/5400 (4)	3.0
16 DEC-17 DEC	3000/4750	10.5	3050/5300 (4)	9.5
17 DEC-18 DEC	3600/5300 (4)	1.5	3600/5300 (4)	3.5
18 DEC-19 DEC	4000/5300 (4)	1.0	3500/5300 (4)	4.0
19 DEC-20 DEC	3200/5200 (4)	7.5	3000/5250 (4)	10.5
22 DEC-23 DEC	3600/4900	9.5	3700/5200	9.0
6 JAN- 7 JAN	3450/4900	8.0	3250/4850	8.0
7 JAN- 8 JAN	3000/5100	35.0	2400/4300	35.0
8 JAN- 9 JAN	3200/4900	11.5	2850/3900	11.5
9 JAN-11 JAN	2600/5100 (4)	37.0	2500/5200	58.5
12 JAN-13 JAN	2800/4300	10.0	2300/3850	10.0
13 JAN-14 JAN	3200/5300 (4)	2.5	2850/5300 (4)	7.0

TABLE K-6 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
14 JAN-15 JAN	4000/5200 (4)	5.0	3500/5250 (4)	9.0
15 JAN-16 JAN	2850/4400	10.0	2700/4100	10.0
16 JAN-17 JAN	3350/5200 (4)	9.0	3150/5250 (4)	15.0
19 JAN-20 JAN	2000/3250	7.0	1900/2800	7.0
3 FEB- 4 FEB	2200/3200	14.0	2300/3850	14.0
4 FEB- 5 FEB	3400/4700	9.0	3200/4800	9.0
5 FEB- 6 FEB	3800/5300 (4)	2.0	3800/5300 (4)	2.0
6 FEB- 9 FEB	3800/5100 (4)	17.0	3200/5200	58.0
9 FEB-10 FEB	3800/4000	9.5	3200/4100	9.5
10 FEB-11 FEB	3700/5000	11.5	3600/4800	11.5
11 FEB-12 FEB	3600/4750	10.0	2700/3700	10.0
12 FEB-13 FEB	2800/5200	11.0	2750/5300	11.0
13 FEB-16 FEB	3200/4450	58.0	3350/4900	58.0
16 FEB-17 FEB	3400/5100 (4)	10.0	3400/5100	10.0
17 FEB-18 FEB	3450/4100	24.0	3400/4100	24.0
18 FEB-19 FEB	2100/3000	11.5	1850/2500	11.5
19 FEB-20 FEB	2500/3750	9.5	2000/3250	9.5
20 FEB-28 FEB	3400/5100 (4)	75.0	3200/5200	171.0
1 MAR- 2 MAR	3500/5100 (4)	21.0	3200/5200 (4)	24.0
8 MAR- 9 MAR	3600/5100 (4)	16.0	3500/5200 (4)	18.0
10 MAR-11 MAR	3800/3000	4.0	3700/3450	3.0
11 MAR-11 MAR	4000/5100 (4)	1.5	700/3200	10.5
12 MAR-15 MAR	3800/5100 (4)	22.0	1500/4100	139.5
15 MAR-16 MAR	2800/4200	12.0	2300/3000	12.0
16 MAR-17 MAR	3300/3900	2.5	700/1600	4.5
17 MAR-18 MAR	4500/5200 (4)	0.5	1200/3600	11.0
18 MAR-19 MAR	3500/5100 (4)	5.0	3300/5100 (4)	13.5
22 MAR-23 MAR	3800/5100 (4)	13.5	3900/5100 (4)	11.0

TABLE K-6 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
23 MAR-24 MAR	3200/4900	11.0	3400/4000	3.5
24 MAR-25 MAR	2900/3400	10.0	2900/3100	10.0
25 MAR-27 MAR	4000/5100 (4)	0.5	3100/5100 (4)	1.0
29 MAR-30 MAR	3000/4250	10.0	3000/4300	10.0
30 MAR-31 MAR	2800/4850	9.5	2300/4600	9.5
31 MAR- 1 APR	3900/5100 (4)	4.5	3700/5100 (4)	3.5
5 APR- 6 APR	2500/4100	16.0	2900/5000	16.0
6 APR- 7 APR	3400/4800	8.0	3300/5100	8.0
7 APR-11 APR	3800/4650	9.5	3700/4200	9.5
8 APR-12 APR	3100/5100 (4)	67.0	3000/5100	105.0
12 APR-13 APR	2900/4200	11.5	2800/3800	11.5
13 APR-14 APR	2700/4900	20.0	2600/4900	20.0
14 APR-15 APR	1900/3500	12.5	1800/3300	12.5
15 APR-19 APR	3600/4800	82.5	3600/5100	82.5
19 APR-20 APR	2700/3900	13.5	2500/2600	13.5
20 APR-21 APR	3200/4200	13.0	2900/3700	13.0
21 APR-22 APR	4400/5150 (4)	5.0	4200/5200 (4)	4.5
22 APR-23 APR	1800/3000	10.0	1900/3000	10.5
23 APR-26 APR	4000/5100 (4)	6.0	3800/5100 (4)	21.0
26 APR-27 APR	3100/5100	14.5	3200/4900	14.5
27 APR-28 APR	3300/5100	15.0	2500/4500	15.0
28 APR-29 APR	2400/3600	23.0	2400/4000	23.0
29 APR- 3 MAY	3300/5050 (4)	35.0	3200/5100 (4)	34.0
3 MAY- 4 MAY	3000/5100 (4)	22.0	3300/5200 (4)	19.0
4 MAY- 5 MAY	2500/3300	14.0	1800/2800	13.5
5 MAY- 6 MAY	1500/3700	19.0	1600/3700	19.0
6 MAY- 7 MAY	3000/3600	21.5	2700/3700	21.5
7 MAY-10 MAY	1700/2700	66.0	2000/4400	66.0
10 MAY-10 MAY	3100/3500	9.0	2900/2700	9.0

TABLE K-6 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
10 MAY-11 MAY	3700/4700	12.0	3000/3800	12.0
11 MAY-12 MAY	2000/3100	25.0	1600/2700	25.0
12 MAY-13 MAY	3000/4000	25.5	3000/3400	25.5

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

TABLE K-7
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 71

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
8 OCT- 9 OCT	3700/6200 (4)	7.0	3500/5150 (4)	5.0
9 OCT-10 OCT	2400/4750	10.5	2350/4850	10.5
10 OCT-13 OCT	2350/4850	67.5	3300/5400	67.5
13 OCT-14 OCT	2600/5700	11.0	2500/5600	11.0
14 OCT-15 OCT	3150/5500	10.0	2800/4800	10.0
15 OCT-16 OCT	2700/6000	10.0	2500/5600	10.0
16 OCT-17 OCT	2100/5600	17.5	2000/5100	17.5
17 OCT-17 OCT	3400/6200 (4)	1.5	3300/5700 (4)	1.5
20 OCT-21 OCT	3100/4000	3.5	NO READING	
21 OCT-22 OCT	3200/6100 (4)	0.5	3900/5700 (4)	2.0
5 NOV- 6 NOV	4600/5200 (4)	0.5	4250/5100 (4)	2.0
6 NOV- 7 NOV	3750/5300 (4)	6.5	3400/5000	10.0
7 NOV- 8 NOV	3500/5200 (4)	8.0	3200/5100 (4)	32.0
24 NOV-25 NOV	3300/5150 (4)	3.0	3200/5000 (4)	7.5
25 NOV-26 NOV	2500/4300	9.5	2000/5050	12.0
26 NOV-27 NOV	2300/5050 (4)	16.0	2500/5000 (4)	22.5
1 DEC- 2 DEC	2200/5200 (4)	4.0	2200/5100 (4)	4.0
16 DEC-17 DEC	2250/5000 (4)	8.5	2150/5000 (4)	8.0
17 DEC-18 DEC	3300/5300 (4)	3.0	2900/5100 (4)	2.0
18 DEC-19 DEC	3000/5000 (4)	1.0	3500/5000 (4)	1.5
19 DEC-20 DEC	3000/5200 (4)	2.0	2800/5000 (4)	3.0
22 DEC-23 DEC	3300/5100 (4)	4.5	3100/4900 (4)	4.0
6 JAN- 7 JAN	2400/5000 (4)	9.0	2100/5000 (4)	8.5

TABLE K-7 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
7 JAN- 8 JAN	3000/5200	33.0	2000/5000 (4)	33.5
8 JAN- 9 JAN	3600/5150 (4)	5.0	3000/4800	10.5
9 JAN-10 JAN	2500/4900 (4)	17.0	2200/4950 (4)	26.5
12 JAN-13 JAN	3000/5000 (4)	10.5	2600/4950 (4)	11.0
3 FEB- 4 FEB	INKING PEN MALFUNCTION		1400/2600	12.5
4 FEB- 5 FEB			1500/3800	13.5
5 FEB- 6 FEB			2100/3200	10.0
6 FEB- 9 FEB			1600/4000	58.5
9 FEB-10 FEB			2300/3700	12.0
10 FEB-11 FEB			2200/2800	11.5
11 FEB-12 FEB			3600/5000 (4)	2.5
12 FEB-13 FEB			2700/4950 (4)	7.0
13 FEB-16 FEB			2600/3800	57.0
16 FEB-17 FEB			3400/4900 (4)	9.0
17 FEB-18 FEB			2300/2900	24.0
18 FEB-19 FEB	2900/4000	11.5	2400/3250	11.5
19 FEB-20 FEB	2400/4900	11.5	2800/5000	11.5
20 FEB- 1 MAR	1700/4900	229.0	1200/4850	229.0
1 MAR- 2 MAR	3600/4800 (4)	21.0	3700/4900 (4)	15.0
8 MAR-10 MAR	2900/4200	36.5	2800/4200	37.0
10 MAR-11 MAR	2700/2850	9.0	2000/1450	9.0
11 MAR-12 MAR	2650/5000 (4)	7.0	1650/4900	10.5
12 MAR-13 MAR	2700/4900 (4)	1.0	2500/4900 (4)	2.0
15 MAR-16 MAR	2900/4700	13.0	2600/4100	13.0
16 MAR-17 MAR	2300/4700	12.5	2400/3800	12.5
17 MAR-18 MAR	3000/5150 (4)	0.5	2600/4900 (4)	3.5
18 MAR-22 MAR	2500/4900 (4)	24.5	2200/4900	87.5
22 MAR-23 MAR	3200/2600	19.5	2600/2400	19.5

TABLE K-7 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
23 MAR-24 MAR	2600/3800	11.5	2700/4850 (4)	7.5
24 MAR-25 MAR	2200/3000	9.5	1800/4100	9.5
25 MAR-27 MAR	4100/4900 (4)	2.0	3100/4800 (4)	30.5
29 MAR-30 MAR	2600/3900	11.5	2800/4600	11.5
30 MAR-31 MAR	3150/3400	8.0	3000/3800	8.0
31 MAR- 3 APR	2200/4750	51.0	2400/4800 (4)	18.5
5 APR- 6 APR	3700/4900 (4)	3.0	3200/4850 (4)	10.0
6 APR- 6 APR	3500/4900 (4)	1.5	2700/4900 (4)	3.0
7 APR-12 APR	3000/4900	115.0	2500/3700	115.0
13 APR-14 APR	2900/3500	13.0	2600/3400	13.0
14 APR-15 APR	1900/2350	11.0	2000/2400	11.0
15 APR-16 APR	3400/4900 (4)	7.5	3200/4800 (4)	17.5
19 APR-20 APR	1200/2200	11.0	1300/2300	11.0
20 APR-21 APR	2250/2700	20.5	2200/2800	20.5
21 APR-22 APR	2500/4900 (4)	10.0	1600/4500	13.0
22 APR-23 APR	1700/3100	13.0	1900/4200	13.0
23 APR-26 APR	1900/2600	69.0	1600/2400	61.0
26 APR-27 APR	3000/4700	15.0	2500/4750	15.0
27 APR-28 APR	3500/5000 (4)	15.0	4300/4850 (4)	4.0
28 APR-29 APR	2500/3300	18.0	2200/3100	18.0
29 APR- 3 MAY	2500/4750	94.0	2500/4800 (4)	43.0
3 MAY- 4 MAY	2000/2400	18.0	1300/1850	18.0
4 MAY- 5 MAY	3000/3500	13.5	2600/2700	13.5
5 MAY- 6 MAY	2900/3500	20.5	1900/3000	20.5
6 MAY- 7 MAY	3300/4600	24.0	2500/4700	24.0
7 MAY-10 MAY	3700/4900 (4)	31.0	3500/4800	63.0
10 MAY-10 MAY	2000/2500	15.0	1400/1650	15.0
10 MAY-11 MAY	2800/3500	16.0	2100/2400	16.0

TABLE K-7 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
11 MAY-12 MAY	2300/3000	12.5	1500/1900	12.5
12 MAY-13 MAY	3000/3300	15.5	2000/2600	15.5

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

TABLE K-8
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 85

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
15 OCT-16 OCT	4200/6100 (4)	3.0	4000/5900 (4)	4.0
16 OCT-17 OCT	2800/6000	17.5	1600/5100	19.0
17 OCT-18 OCT	3200/6050 (4)	5.5	3300/5850 (4)	5.5
20 OCT-21 OCT	4500/6050 (4)	3.0	4000/5850	5.0
21 OCT-22 OCT	1500/5100	10.0	1800/4400 (4)	10.0
5 NOV- 6 NOV	3300/5450 (4)	6.5	3000/5200	8.0
6 NOV- 7 NOV	3000/4800	10.0	2500/4550	10.0
7 NOV- 8 NOV	3700/5450 (4)	13.0	3000/5150 (4)	8.0
17 NOV-18 NOV	4100/5500 (4)	5.0	4100/5250 (4)	3.5
18 NOV-19 NOV	3000/5400	9.5	2800/5200 (4)	6.0
19 NOV-20 NOV	4100/4600	10.0	4200/4600	3.0
20 NOV-21 NOV	3500/5500 (4)	1.5	3200/5300 (4)	2.5
21 NOV-22 NOV	3300/5400 (4)	6.0	3300/5200 (4)	6.0
16 DEC-17 DEC	2150/2400	10.0	1900/2100	10.0
17 DEC-18 DEC	2700/3600	10.0	2600/3750	10.0
18 DEC-19 DEC	2400/5400	8.0	2100/5200	8.0
19 DEC-20 DEC	2800/5350 (4)	7.0	2000/5200 (4)	5.0
22 DEC-23 DEC	1850/1800	9.0	2000/4750	9.0
5 JAN- 6 JAN	1400/2200	10.0	100/ 800	10.0
6 JAN- 8 JAN	1800/3650	44.5	1700/3650	44.5
8 JAN- 9 JAN	2500/3800	11.0	2300/3000	11.0
9 JAN-11 JAN	2400/5300 (4)	32.0	2200/5100	37.0
12 JAN-13 JAN	2300/4500	10.0	1800/2350	10.0

TABLE K-8 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
13 JAN-14 JAN	2000/2850	10.0	2100/2300	10.0
14 JAN-15 JAN	2900/5300 (4)	3.0	3050/5100 (4)	4.0
15 JAN-16 JAN	2500/5100	9.5	1800/3700	9.5
16 JAN-16 JAN	5000/5500 (4)	0.5	3800/5100 (4)	2.0
19 JAN-20 JAN	2750/3050	9.0	2800/5000	9.0
3 FEB- 4 FEB	3050/3500	9.0	2900/3450	9.0
4 FEB- 5 FEB	2700/4600	15.0	2300/4200	15.0
5 FEB- 6 FEB	2400/4800	10.0	2200/4150	10.0
6 FEB- 9 FEB	2800/5000	57.0	2700/4900	57.0
9 FEB-10 FEB	2400/3700	11.0	2300/3300	11.0
10 FEB-11 FEB	2500/3700	12.0	2500/3800	12.0
11 FEB-12 FEB	2500/2900	9.5	2400/3000	9.5
12 FEB-13 FEB	3300/3900	11.0	3000/4250	11.0
13 FEB-16 FEB	2600/3400	59.0	2600/3700	59.0
16 FEB-17 FEB	2900/4300	10.5	2800/4500	10.5
17 FEB-18 FEB	2700/3200	23.0	2800/4100	23.0
18 FEB-19 FEB	2300/2400	11.0	2100/2500	11.0
19 FEB-20 FEB	2700/3300	10.0	2000/2200	10.0
20 FEB-23 FEB	2800/5100 (4)	42.0	2700/5000	52.0
1 MAR- 3 MAR	2000/5100 (4)	66.0	2000/5000 (4)	33.0
8 MAR-10 MAR	3000/4950	44.5	2900/4900	30.0
10 MAR-11 MAR	3800/5150 (4)	7.0	200/ 800	10.0
11 MAR-12 MAR	2100/3000	10.0	Ø/1500	10.5
12 MAR-15 MAR	3800/5100 (4)	3.0	1150/3600	58.5
15 MAR-16 MAR	1900/2850	12.0	2600/3500	12.0
16 MAR-17 MAR	3500/5200 (4)	4.0	300/2000	9.0
17 MAR-18 MAR	2800/4100	10.0	100/1000	10.0
18 MAR-22 MAR	2300/5000	84.5	700/4300	30.0

TABLE K-8 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)		EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)		WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
22 MAR-23 MAR	1500/1250		12.5	Ø/ Ø		-
23 MAR-24 MAR	1400/2250		11.0	Ø/ Ø		-
24 MAR-25 MAR	2900/2500	(4)	11.5	200/ 600		3.0
25 MAR-29 MAR	2500/5200		50.0	2000/4300		83.0
29 MAR-30 MAR	2500/3100		11.0	2350/3100		11.0
30 MAR-31 MAR	3150/3400		8.0	3100/3400		8.0
31 MAR- 5 APR	2550/4700		103.0	2400/3800		103.0
5 APR- 6 APR	3200/4900	(4)	9.0	3300/5100	(4)	10.5
6 APR- 7 APR	3200/4900		9.5	3300/4900		9.5
7 APR- 8 APR	2500/3400		10.5	2150/3500		10.5
8 APR-12 APR	2950/5050		104.0	3100/4650		104.0
13 APR-14 APR	1900/2900		18.5	1900/3400		18.5
14 APR-15 APR	2400/2700		11.5	2200/2500		11.5
15 APR-19 APR	2400/5050		85.0	2300/4800		85.0
19 APR-20 APR	1800/3000		10.0	1100/2600		10.0
20 APR-21 APR	1700/2700		12.5	PEN NOT INKING		12.5
21 APR-22 APR	2200/3800		9.0	2000/3600		9.0
22 APR-23 APR	2000/2900		11.0	1900/2600		11.0
23 APR-24 APR	3600/5000	(4)	22.0	3550/4850	(4)	23.5
26 APR-27 APR	3000/3600		14.0	2850/3600		14.0
27 APR-28 APR	2700/4100		14.0	2700/3800		14.0
28 APR-29 APR	2900/3650		17.5	2500/4950	(4)	11.0
29 APR-29 APR	3700/5100	(4)	5.0	3300/4900	(4)	3.5
3 MAY- 4 MAY	3200/4900		19.0	3250/4300		19.0
4 MAY- 5 MAY	2700/4500		22.0	2300/3850		22.0
5 MAY- 6 MAY	4000/4900		20.0	3700/4850		20.0
6 MAY- 7 MAY	2800/4900		23.5	2500/3700		23.5
7 MAY-10 MAY	1500/2650		56.0	1350/1950		56.0

TABLE K-8 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
10 MAY-10 MAY	3200/3500	8.5	3000/3150	8.5
10 MAY-11 MAY	2400/3700	15.0	1800/2900	15.0
11 MAY-12 MAY	2000/3700	16.0	1900/3600	16.0
12 MAY-13 MAY	2400/3100	14.0	2100/2700	14.0

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

TABLE K-9
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 99

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
8 OCT- 9 OCT	RECORDER MALFUNCTION		1850/5700	12.0
9 OCT-10 OCT			2500/2600	9.0
10 OCT-13 OCT			2400/5800	69.0
13 OCT-14 OCT			1400/1900	10.0
14 OCT-14 OCT			2550/5400	8.5
14 OCT-15 OCT			2650/5700	12.5
29 OCT-30 OCT	3000/4800	10.0	2900/4400	10.0
30 OCT- 3 NOV	3000/5400	61.5	3100/5600	61.5
3 NOV- 4 NOV	2900/4500	5.0	2500/5900	11.5
4 NOV- 5 NOV	RECORDER MALFUNCTION		3000/4100	6.0
17 NOV-18 NOV			3200/5200 (4)	5.0
18 NOV-19 NOV			3250/4400	10.0
19 NOV-20 NOV			2700/5200 (4)	6.0
20 NOV-21 NOV			3300/5300 (4)	1.0
21 NOV-22 NOV			3200/5200 (4)	6.0
16 DEC-17 DEC			3000/5350	12.0
17 DEC-18 DEC			2200/4000	11.5
18 DEC-19 DEC			2900/5200 (4)	2.5
19 DEC-20 DEC			2500/5150 (4)	12.0
22 DEC-23 DEC			2200/3000	9.5
5 JAN- 6 JAN			2750/4300	9.5
6 JAN- 8 JAN			2100/4200	45.0
9 JAN-12 JAN			1800/4200	61.0
12 JAN-13 JAN			2600/5150 (4)	7.5

TABLE K-9 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
13 JAN-14 JAN	RECORDER MALFUNCTION		Ø/2500	14.5
14 JAN-15 JAN			1500/3000	13.5
15 JAN-16 JAN			1900/5200	10.5
16 JAN-19 JAN			1000/2700	60.5
19 JAN-20 JAN			2600/3650	9.5
3 FEB- 4 FEB			2500/2850	10.0
4 FEB- 5 FEB			2400/3700	16.0
5 FEB- 6 FEB			1800/3500	11.0
6 FEB- 9 FEB			2100/5400	58.0
9 FEB-10 FEB			3000/3600	12.0
10 FEB-11 FEB			2500/2900	13.0
11 FEB-12 FEB			1600/2900	11.5
12 FEB-13 FEB			2500/3200	9.0
13 FEB-16 FEB			2400/2800	59.0
16 FEB-17 FEB			1700/2350	11.5
17 FEB-18 FEB			2800/4200	23.0
18 FEB-19 FEB			3500/4150	8.0
19 FEB-20 FEB			1200/1100	9.5
20 FEB-22 FEB			3000/5000 (4)	48.0
1 MAR- 2 MAR			2800/5100 (4)	9.0
8 MAR- 9 MAR			2800/5100 (4)	15.0
10 MAR-11 MAR			3000/2600	11.5
11 MAR-12 MAR			2500/2900	6.5
12 MAR-15 MAR			2500/5050	59.5
15 MAR-16 MAR			2300/2800	4.0
16 MAR-17 MAR			2900/3200	12.0
17 MAR-18 MAR			1100/1150	9.5
13 APR-14 APR	1650/1200	18.0	2000/2850	18.0
14 APR-15 APR	2850/ -	-	2700/ -	-

TABLE K-9 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
15 APR-19 APR	2800/3000	83.0	3000/3300	83.0
19 APR-20 APR	2000/2550	10.0	2000/2500	10.0
20 APR-21 APR	1500/1950	4.0	1700/2150	4.0
21 APR-22 APR	2500/3200	10.0	1800/2950	10.0
22 APR-23 APR	3000/2550	11.5	3100/2750	11.5
23 APR-26 APR	3000/3100	70.0	2850/3800	70.0
26 APR-27 APR	3500/3350	10.0	3600/3350	10.0
27 APR-28 APR	2000/2200	15.5	1700/1900	15.5
28 APR-29 APR	2500/2350	12.5	2600/2500	12.5
29 APR- 3 MAY	3000/3100	84.5	2700/3350	84.5
3 MAY- 4 MAY	3200/3350	26.5	3050/3350	26.5
4 MAY- 5 MAY	2600/2600	13.0	2500/2700	13.0
5 MAY- 6 MAY	2400/2600	17.5	2500/2700	17.5
6 MAY- 7 MAY	900/1000	16.0	800/ 700	16.0
7 MAY- 7 MAY	2100/2000	8.5	2100/2000	8.5
7 MAY-10 MAY	2200/2900	63.0	2150/2900	63.0
10 MAY-11 MAY	4300/5100	22.5	3600/4500	22.5
11 MAY-12 MAY	2300/2650	19.0	2100/2650	19.0
12 MAY-14 MAY	2400/3100	45.0	2800/3450	45.0

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

TABLE K-10
SUMMARY OF SHIELD SUPPORT LOAD DATA
SHIELD NUMBER 115

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
15 OCT-16 OCT	3100/1900	10.5	3100/2750	10.5
16 OCT-17 OCT	3000/ Ø	2.0	900/ 900	17.0
17 OCT-20 OCT	2700/ 850	2.5	3100/3000	58.5
20 OCT-21 OCT	4000/ 250	3.0	3800/3600	10.0
21 OCT-22 OCT	4200/3900	10.5	4200/3850	10.5
5 NOV- 6 NOV	3800/3500	4.0	4000/1300	4.5
6 NOV- 7 NOV	2400/2500	15.0	1700/1700	15.0
7 NOV- 8 NOV	3100/3000	14.5	3200/2900	2.0
17 NOV-18 NOV	2500/ 500	1.0	3600/3500	13.0
18 NOV-19 NOV	3500/2800	1.5	3800/3700	11.0
19 NOV-20 NOV	3300/2650	11.0	3400/3300	11.0
20 NOV-21 NOV	2500/2450	9.0	2700/2700	9.0
21 NOV-22 NOV	2500/2300	4.0	3800/3500	8.5
16 DEC-17 DEC	2200/2100	12.5	2500/2300	4.0
17 DEC-18 DEC	2100/1700	10.5	2400/2200	10.5
18 DEC-19 DEC	700/ Ø	1.0	1800/1200	3.0
19 DEC-22 DEC	2150/2100	0.5	2500/2500	58.0
22 DEC-23 DEC	2800/2250	1.5	3000/2300	1.0
5 JAN- 6 JAN	2700/ Ø	5.0	2700/2700	9.5
6 JAN- 8 JAN	3500/ Ø	8.5	3800/3500	46.0
8 JAN- 9 JAN	1200/1200	12.0	900/ 900	12.5
9 JAN-12 JAN	2700/ Ø	26.0	2400/2400	61.5
12 JAN-13 JAN	3200/1750	9.0	3700/3450	10.5
13 JAN-14 JAN	2900/2300	11.0	3200/2900	10.5

TABLE K-10 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
14 JAN-15 JAN	3800/1550	5.5	3900/3850	10.0
15 JAN-16 JAN	3000/2600	10.5	3400/3200	10.5
16 JAN-19 JAN	3700/3400	59.0	3800/3700	59.0
19 JAN-20 JAN	2500/2200	8.0	2800/2600	8.0
3 FEB- 4 FEB	2700/ Ø	8.0	2600/2400	11.0
4 FEB- 5 FEB	2500/ Ø	3.0	1800/1200	12.0
5 FEB- 6 FEB	2700/2400	10.5	2750/2600	10.5
6 FEB- 9 FEB	3000/ Ø	10.5	3050/2650	58.5
9 FEB-10 FEB	1100/1000	10.5	1900/1700	10.5
10 FEB-11 FEB	3000/2100	12.0	3100/3100	12.0
11 FEB-12 FEB	800/4000	4.0	900/ 600	4.0
12 FEB-13 FEB	2000/1150	2.0	1300/1200	2.0
13 FEB-16 FEB	4000/2400	56.0	4000/3600	56.0
16 FEB-17 FEB	2800/2400	11.5	2200/1800	11.5
17 FEB-18 FEB	2700/ 500	19.0	2500/2000	19.0
18 FEB-19 FEB	3300/3000	15.5	3300/3100	15.5
19 FEB-20 FEB	3900/2500	9.5	4000/4000	9.5
20 FEB-23 FEB	2200/1800	69.0	2300/1800	72.0
1 MAR- 8 MAR	3200/1200	39.0	2400/2100	161.0
8 MAR-10 MAR	3700/2700	44.5	2900/2700	16.5
10 MAR-11 MAR	4100/3700	12.0	4000/4000	-
12 MAR-12 MAR	1900/1800	11.0	2800/2600	11.0
13 MAR-15 MAR	3000/2400	10.5	3100/2800	60.0
15 MAR-16 MAR	2100/1500	13.0	2800/2650	4.0
17 MAR-17 MAR	3100/2600	12.0	2500/2550	12.0
18 MAR-18 MAR	2500/2350	11.5	2150/2400	11.5
18 MAR-20 MAR	2200/1850	18.0	2000/1600	35.0
22 MAR-23 MAR	2500/2100	13.0	2300/2200	13.0

TABLE K-10 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
23 MAR-24 MAR	1600/1400	11.5	1600/1400	11.5
24 MAR-25 MAR	2000/2000	10.5	1900/1800	10.5
25 MAR-26 MAR	2700/2000	2.0	2800/2600	13.0
29 MAR-30 MAR	2700/2000	11.5	2800/3250	11.5
30 MAR-31 MAR	2000/1750	11.0	2000/1850	11.0
31 MAR- 5 APR	1100/1100	110.0	3500/3300	110.0
5 APR- 6 APR	2700/1800	21.5	2700/2500	21.5
6 APR- 7 APR	3500/2900	10.5	3500/3400	10.5
7 APR- 8 APR	4000/3050	13.0	4000/3600	13.0
8 APR-12 APR	4700/3000	3.5	4700/4600	103.5
13 APR-14 APR	1700/1750	23.5	1700/ 850	23.5
14 APR-15 APR	2400/2200	12.5	2400/2350	12.5
15 APR-19 APR	2400/2300	87.0	2400/1900	87.0
19 APR-20 APR	1200/1150	13.0	900/ 800	13.0
20 APR-21 APR	3100/2800	16.5	3000/1500	16.5
21 APR-22 APR	3100/2950	11.5	3000/2800	11.5
22 APR-23 APR	2500/2200	12.0	1800/1700	12.0
23 APR-26 APR	3500/3300	60.0	3500/3300	60.0
26 APR-27 APR	3600/3200	15.5	3600/3600	15.5
27 APR-28 APR	2900/2700	15.5	3050/3000	15.5
28 APR-29 APR	4000/3800	39.0	4150/4100	39.0
29 APR-30 APR	3500/1500	4.0	3600/3550	4.0
30 APR- 3 MAY	3800/2850	77.5	3800/3700	77.5
3 MAY- 5 MAY	3900/3500	36.0	3400/3200	36.0
5 MAY- 6 MAY	2000/2000	28.0	2000/1950	28.0
6 MAY- 7 MAY	2500/2200	15.5	2400/2150	15.5
7 MAY-10 MAY	1700/1400	78.0	1500/1300	78.0
10 MAY-11 MAY	2500/2300	21.5	2350/2400	21.5

TABLE K-10 (continued)

DATE	EAST (HEADGATE) LEG PRESSURE SET/FINAL (psi)	EAST (HEADGATE) LEG ELAPSED TIME (hrs) (3)	WEST (TAILGATE) LEG PRESSURE SET/FINAL (psi)	WEST (TAILGATE) LEG ELAPSED TIME (hrs) (3)
11 MAY-12 MAY	3500/2700	20.0	3400/3200	20.0
12 MAY-14 MAY	2300/2400	45.5	1400/1450	45.5

NOTES:

Numbers in parentheses refer to notes presented in Table K-1.

To convert psi pressure to tons load, multiply table values by 2.92×10^{-2}.

APPENDIX L

PANEL PRESSURE CELL DATA

TABLE L-1
SUMMARY OF PANEL PRESSURE CELL DATA
PRESSURE CELL P-1

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
18 JUN	0900	900	Ø	326.8	141.5
30 JUN	1400	1000	12.2	263.8	209.0
11 JUL	1430	1000	23.2	182.8	288.8
8 AUG	1045	1000	51.1	151.8	322.2
15 AUG	0851	990	58.0	93.8	376.2
19 AUG	1111	990	62.1	92.8	381.2
20 AUG	1403	1000	63.2	82.8	391.2
21 AUG	0915	1000	64.0	72.8	401.2
22 AUG	0906	1000	65.0	61.8	411.5
25 AUG	1032	1005	68.1	53.8	420.2
26 AUG	0935	1005	69.0	49.8	423.2
27 AUG	0952	1005	70.0	44.3	427.5
28 AUG	1535	1010	71.3	34.3	440.0
29 AUG	1014	1010	72.0	32.3	441.8
2 SEP	0952	1010	76.0	30.3	444.0
3 SEP	1015	1015	77.0	24.8	449.8
4 SEP	1116	1040	78.1	17.3	457.5
5 SEP	0952	1060	79.0	10.8	463.8
8 SEP	1217	1120	82.1	4.3	471.5
9 SEP	0900	DESTROYED BY COAL SHEAR			

NOTES:

1. Pressure cell was installed at an angle of 80 degrees with ribside at a depth of 50 ft.

2. Time elapsed since initial reading.

3. Distance from the pressure cell to the face corrected for the installation angle and depth.

4. Length of the mined-out span.

TABLE L-2
SUMMARY OF PANEL PRESSURE CELL DATA
PRESSURE CELL P-2

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
18 JUN	0930	1000	Ø	531.3	141.5
1 JUL	1700	980	13.3	462.3	214.2
11 JUL	1430	980	23.2	387.3	288.8
8 AUG	1045	960	51.1	356.3	322.2
8 SEP	1215	960	82.1	208.8	471.5
1 OCT	1520	950	105.2	108.3	565.5
2 OCT	1130	950	106.1	98.8	572.5
CONTINUOUS RECORDER INSTALLED					
2 OCT	1145	500	106.1	98.8	572.5
3 OCT	0805	475	106.9	93.3	577.8
6 OCT	1400	460	110.2	78.8	593.0
8 OCT	1045	450	112.1	59.8	610.2
9 OCT	0815	450	112.9	48.3	620.8
10 OCT	0900	450	114.0	35.8	634.0
13 OCT	1330	445	117.2	26.8	641.8
14 OCT	1340	440	118.2	16.3	652.0
15 OCT	1230	440	119.1	9.3	658.8
16 OCT	1130	450	120.1	Ø	668.1
16 OCT	1130	DESTROYED BY COAL SHEAR			

NOTES:

1. Pressure cell was installed at an angle of 80 degrees with ribside at a depth of 50 ft.
2. Time elapsed since initial reading.
3. Distance from the pressure cell to the face corrected for the installation angle and depth.
4. Length of the mined-out span.

TABLE L-3
SUMMARY OF PANEL PRESSURE CELL DATA
PRESSURE CELL P-3

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
24 JUN	1030	925	Ø	-	-
30 JUN	1415	900	6.2	662.8	209.0
11 JUL	1430	880	17.2	581.8	288.8
14 JUL	1255	870	20.1	581.8	288.8
22 JUL	1425	860	28.2	581.8	288.8
28 JUL	1325	850	34.1	581.8	288.8
7 AUG	1240	840	44.1	581.8	288.8
15 AUG	0905	820	51.9	492.8	376.2
21 AUG	0906	800	57.9	471.8	401.2
25 AUG	1028	790	62.0	452.8	420.3
28 AUG	1610	780	65.2	433.3	440.0
4 SEP	1110	780	72.0	416.3	457.5
5 SEP	0958	770	73.0	409.8	463.8
12 SEP	1303	760	80.1	382.3	493.0
24 SEP	1120	750	92.0	357.8	514.0
26 SEP	1335	740	94.1	336.8	534.8
29 SEP	1650	730	97.3	325.8	544.0
1 OCT	1510	720	99.2	302.8	565.5
8 OCT	0955	710	106.0	254.3	610.2
10 OCT	0845	705	108.0	230.3	634.0
17 OCT	1045	700	115.0	186.3	675.8
28 OCT	0955	690	126.0	123.8	737.5
30 OCT	0935	700	128.0	107.3	757.5
CONTINUOUS RECORDER INSTALLED					
30 OCT	1005	690	128.0	107.3	757.5
31 OCT	1130	655	129.0	101.8	763.8
3 NOV	1135	645	132.0	100.8	767.0
4 NOV	1120	640	133.0	88.8	778.8
5 NOV	1310	635	134.1	78.3	792.5
6 NOV	1255	635	135.1	68.3	802.5
7 NOV	1505	630	136.2	64.8	806.0
10 NOV	1020	625	139.0	62.8	810.2
17 NOV	1040	615	146.0	55.3	817.5
18 NOV	1130	610	147.0	47.3	827.0
21 NOV	1325	635	150.1	15.8	857.5
24 NOV	1250	680	153.1	5.3	867.2
24 NOV	1600	770	153.2	3.3	869.2
24 NOV	1600	750	153.2	3.3	869.2
24 NOV	1900	745	153.4	1.3	871.2
24 NOV	1900	DESTROYED BY COAL SHEAR			

TABLE L-3 (continued)

NOTES:

1. Pressure cell was installed at an angle of 80 degrees with ribside at a depth of 50 ft.

2. Time elapsed since initial reading.

3. Distance from the pressure cell to the face corrected for the installation angle and depth.

4. Length of the mined-out span.

TABLE L-4
SUMMARY OF PANEL PRESSURE CELL DATA
PRESSURE CELL P-4

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
24 JUN	1030	800	Ø	-	-
3 JUL	1315	980	9.1	633.7	237.0
11 JUL	1430	950	17.2	580.2	288.8
8 AUG	1025	910	45.0	549.2	322.2
15 AUG	0904	900	51.9	491.2	376.2
22 AUG	0858	880	58.9	459.2	411.5
29 AUG	1010	870	66.0	429.7	441.8
5 SEP	0959	860	73.0	408.2	463.8
12 SEP	1304	840	80.1	380.7	493.0
22 SEP	0908	840	89.9	374.2	498.2
29 SEP	1650	820	97.3	324.2	544.0
6 OCT	1530	805	104.2	271.7	593.0
13 OCT	1335	790	111.1	219.7	641.8
20 OCT	1135	780	118.1	173.7	687.2
28 OCT	0955	760	126.0	122.2	737.5
30 OCT	0935	760	128.0	105.7	757.5
CONTINUOUS RECORDER INSTALLED					
30 OCT	0955	2050	128.0	105.7	757.5
31 OCT	1130	2000	129.0	100.2	763.8
3 NOV	1135	1925	132.0	99.2	767.0
4 NOV	1120	1925	133.0	87.2	778.8
5 NOV	1310	1900	134.1	76.7	792.5
6 NOV	1255	1875	135.1	66.7	802.5
7 NOV	1505	1875	136.2	63.2	806.0
10 NOV	1020	1875	139.0	61.2	810.2
17 NOV	1040	1825	146.0	53.7	817.5
18 NOV	1130	1825	147.0	45.7	827.0
21 NOV	1325	1800	150.1	18.2	853.5
21 NOV	1800	1850	150.3	14.2	857.5
24 NOV	1250	1900	153.1	3.7	867.2
24 NOV	1600	1925	153.2	1.7	869.3
24 NOV	1600	2100	153.2	1.7	869.3
24 NOV	1900	2150	153.4	Ø	871.1
24 NOV	1900	DESTROYED BY COAL SHEAR			

TABLE L-4 (continued)

NOTES:

1. Pressure cell was installed at an angle of 70 degrees with ribside at a depth of 30 ft.

2. Time elapsed since initial reading.

3. Distance from the pressure cell to the face corrected for the installation angle and depth.

4. Length of the mined-out span.

TABLE L-5
SUMMARY OF PANEL PRESSURE CELL DATA
PRESSURE CELL P-5

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
24 JUN	1100	925	Ø	-	-
30 JUN	1430	920	6.2	676.0	209.0
11 JUL	1430	910	17.2	595.0	288.8
8 AUG	1025	900	45.0	564.0	322.2
15 AUG	0903	890	51.9	506.0	376.2
29 AUG	1011	880	66.0	444.5	441.8
12 SEP	1305	880	80.1	395.5	493.0
29 SEP	1650	875	97.2	339.0	544.0
13 OCT	1330	860	111.1	234.5	641.8
30 OCT	0925	860	127.9	120.5	757.5
CONTINUOUS RECORDER INSTALLED					
30 OCT	0950	670	127.9	120.5	757.5
31 OCT	1140	660	129.0	115.0	763.8
3 NOV	1135	655	132.0	114.0	767.0
4 NOV	1120	655	133.0	102.0	778.8
5 NOV	1315	655	134.1	91.5	792.5
6 NOV	1300	650	135.1	81.5	802.5
7 NOV	1505	650	136.2	78.0	806.0
10 NOV	1025	650	139.0	76.0	810.2
17 NOV	1040	640	146.0	68.5	817.5
18 NOV	1030	640	147.0	60.5	827.0
21 NOV	1325	640	150.1	29.0	857.5
24 NOV	1900	645	153.3	14.5	871.2
25 NOV	1500	645	154.2	9.0	878.0
25 NOV	1750	650	154.3	7.0	880.0
25 NOV	1950	655	154.4	5.0	882.0
25 NOV	2200	655	154.5	3.0	884.0
26 NOV	2300	660	154.5	-9.0	896.0
1 DEC	0700	635	159.8	-9.0	896.0
1 DEC	1330	650	160.1	-13.0	900.0
1 DEC	1330	PRESSURE RECORDER REMOVED AS IT WAS ABOUT TO PASS BEHIND THE SHIELDS.			

NOTES:

1. Pressure cell was installed at an angle of 90 degrees with ribside at a depth of 25 ft.

2. Time elapsed since initial reading.

3. Distance from the pressure cell to the face corrected for the installation angle and depth.

4. Length of the mined-out span.

TABLE L-6
SUMMARY OF PANEL PRESSURE CELL DATA
PRESSURE CELL P-6

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
26 JUN	1300	975	Ø	-	-
30 JUN	1430	800	4.1	677.0	209.0
11 JUL	1300	980	15.0	598.5	288.8
8 AUG	1105	900	42.9	562.5	322.2
15 AUG	0933	895	49.9	512.5	376.2
22 AUG	1013	880	56.9	474.0	411.5
29 AUG	0927	870	63.8	443.0	441.8
5 SEP	1225	860	71.0	420.5	463.8
12 SEP	1253	860	78.0	389.5	493.0
22 SEP	0947	850	87.9	385.5	498.2
29 SEP	1440	840	95.1	344.0	544.0
6 OCT	1555	830	102.1	298.5	593.0
13 OCT	1405	830	109.0	253.0	641.8
20 OCT	1255	830	116.0	208.0	687.2
28 OCT	1015	830	123.9	159.0	737.5
30 OCT	1315	830	126.0	135.5	757.5
CONTINUOUS RECORDER INSTALLED					
30 OCT	1330	2000	126.0	135.5	757.5
31 OCT	1230	1900	127.0	128.5	763.8
3 NOV	1405	1850	130.0	123.0	767.0
4 NOV	1205	1870	131.0	111.5	778.8
5 NOV	1335	1890	132.0	94.5	792.5
6 NOV	1135	1875	132.9	84.5	802.5
7 NOV	1445	1860	134.1	81.0	806.0
10 NOV	0845	1840	136.8	74.5	810.2
13 NOV	1200	1820	140.0	73.5	811.3
15 NOV	1200	1800	142.0	72.5	812.4
17 NOV	1000	1800	143.9	71.5	813.5
17 NOV	1445	1840	144.1	67.5	817.5
18 NOV	1350	1850	145.0	56.5	827.0
21 NOV	1125	1900	147.9	31.0	857.5
24 NOV	1835	2200	151.2	14.0	871.2
25 NOV	0800	2220	151.8	10.0	874.0
25 NOV	1010	2300	151.9	8.0	876.0
25 NOV	1430	2275	152.1	6.0	878.0
25 NOV	1500	2250	152.1	6.0	878.0
25 NOV	1745	2200	152.2	4.0	880.0
25 NOV	1800	2400	152.2	4.0	880.0
25 NOV	1930	2450	152.3	4.0	880.0
25 NOV	2000	2275	152.3	2.0	882.0
25 NOV	2200	1800	152.4	Ø	884.0
25 NOV	2200	DESTROYED BY COAL SHEAR			

TABLE L-6 (continued)

NOTES:

1. Pressure cell was installed at an angle of 80 degrees with ribside at a depth of 50 ft.

2. Time elapsed since initial reading.

3. Distance from the pressure cell to the face corrected for the installation angle and depth.

4. Length of the mined-out span.

TABLE L-7
SUMMARY OF PANEL PRESSURE CELL DATA
PRESSURE CELL P-7

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
26 JUN	1300	1075	Ø	-	-
11 JUL	1300	1030	15.0	591.7	288.8
8 AUG	1105	1000	42.9	555.7	322.2
15 AUG	0935	995	49.9	505.7	376.2
22 AUG	1014	990	56.9	467.2	411.5
29 AUG	0928	990	63.9	436.2	441.8
5 SEP	1226	980	71.0	413.7	463.8
8 SEP	1233	695	74.0	404.7	471.5
9 SEP	1338	630	75.0	397.7	478.5
10 SEP	0940	605	75.9	388.7	485.2
12 SEP	1254	560	78.0	382.7	493.0
15 SEP	1104	515	80.9	378.7	498.2
22 SEP	0947	480	87.9	378.7	498.2
24 SEP	1005	460	89.9	365.2	514.0
26 SEP	1240	450	92.0	344.7	534.8
29 SEP	1440	440	95.1	337.2	544.0
1 OCT	1530	420	97.1	317.2	565.5
6 OCT	1550	410	102.1	291.7	593.0
14 OCT	1320	400	110.0	236.2	652.0
17 OCT	1230	395	113.0	213.2	675.8
20 OCT	1255	390	116.0	201.2	687.2
22 OCT	1000	385	117.9	179.2	711.0
28 OCT	1015	380	123.9	152.2	737.5
29 OCT	1200	380	125.0	137.7	748.5
30 OCT	1315	380	126.0	128.7	757.5
CONTINUOUS RECORDER INSTALLED					
30 OCT	1345	710	126.0	128.7	757.5
31 OCT	1230	600	127.0	121.7	763.8
3 NOV	1405	485	130.0	116.2	767.0
4 NOV	1230	465	131.1	104.7	778.8
5 NOV	1335	460	132.0	87.7	792.5
6 NOV	1130	440	132.9	77.7	802.5
7 NOV	1445	420	134.1	74.2	806.0
10 NOV	0845	385	136.8	67.7	810.2
11 NOV	1553	370	138.1	66.7	811.3
14 NOV	1930	350	141.3	65.7	812.4
17 NOV	1000	340	143.9	64.7	813.5
17 NOV	1445	350	144.1	60.7	817.5
18 NOV	1350	350	145.0	49.7	827.0
19 NOV	1350	350	146.0	39.7	837.0
20 NOV	1350	340	147.0	29.7	847.0
21 NOV	1130	360	147.9	19.7	857.8
24 NOV	1835	500	151.2	10.0	870.0
25 NOV	0800	665	151.8	6.0	874.0

TABLE L-7 (continued)

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
25 NOV	1010	760	151.9	4.0	876.0
25 NOV	1330	840	152.0	4.0	876.0
25 NOV	1430	940	152.1	2.0	878.0
25 NOV	1500	900	152.1	2.0	878.0
25 NOV	1750	400	152.2	Ø	880.0
25 NOV	1750	DESTROYED BY COAL SHEAR			

NOTES:

1. Pressure cell was installed at an angle of 70 degrees with ribside at a depth of 30 ft.

2. Time elapsed since initial reading.

3. Distance from the pressure cell to the face corrected for the installation angle and depth.

4. Length of the mined-out span.

TABLE L-8
SUMMARY OF PANEL PRESSURE CELL DATA
PRESSURE CELL P-8

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
30 JUN	1500	800	Ø	-	-
10 JUL	1430	REPRESSURED			
10 JUL	1430	1010	10.0	618.5	276.8
11 JUL	1300	910	10.9	606.5	288.8
14 JUL	1345	900	14.0	570.5	322.2
8 AUG	1105	840	38.8	570.5	322.2
29 AUG	0925	810	59.8	451.0	441.8
5 SEP	1222	800	66.9	428.5	463.8
12 SEP	1250	790	73.9	397.5	493.0
22 SEP	0940	790	83.9	393.5	498.2
29 SEP	1440	780	91.0	352.0	544.0
6 OCT	1550	780	98.0	306.5	593.0
13 OCT	1410	780	105.0	261.0	641.8
20 OCT	1255	780	111.9	216.0	687.2
30 OCT	1230	780	121.9	143.5	757.5
CONTINUOUS RECORDED INSTALLED					
30 OCT	1300	710	121.9	143.5	757.5
31 OCT	1220	700	122.9	136.5	763.8
3 NOV	1405	695	126.0	131.0	767.0
4 NOV	1230	695	126.9	119.5	778.8
5 NOV	1330	700	127.9	102.5	792.5
6 NOV	1120	700	128.8	92.5	802.5
7 NOV	1455	700	130.0	89.0	806.0
10 NOV	0840	700	132.5	82.5	810.2
12 NOV	0718	695	134.7	79.5	813.4
16 NOV	1200	690	138.9	77.5	815.5
17 NOV	1500	690	140.0	75.5	817.5
18 NOV	1345	695	141.0	64.5	827.0
19 NOV	1345	700	142.0	54.5	837.3
20 NOV	1345	705	143.0	44.5	847.5
21 NOV	1100	715	143.8	35.0	857.5
24 NOV	1830	725	147.2	22.0	871.2
25 NOV	0900	730	147.8	14.0	878.0
26 NOV	0900	740	148.8	8.0	884.0
27 NOV	0900	750	149.8	-3.0	896.5
2 DEC	1600	755	155.0	-9.5	903.0
5 DEC	1115	765	157.8	-24.5	918.8
8 DEC	1210	770	160.9	-30.5	925.8
9 DEC	1410	775	162.0	-42.0	936.2
10 DEC	1225	780	162.9	-49.5	945.0
16 DEC	1335	800	168.9	-83.0	979.5
19 DEC	0100	817	171.4	-119.5	1018.0
23 DEC	1530	814	176.0	-144.5	1043.8
23 DEC	2230	820	176.3	-150.0	1049.2

TABLE L-8 (continued)

DATE	TIME	PRESSURE (psi)	TIME (2) (days)	DISTANCE (ft) (3)	SPAN (4) (ft)
5 JAN	1315	803	188.9	-152.5	1051.5
13 JAN	1145	830	196.9	-201.0	1093.5
20 JAN	1005	845	203.8	-253.0	1148.8
27 JAN	1400	855	211.0	-324.5	1209.8
3 FEB	1130	855	217.8	-360.5	1248.0
10 FEB	1245	855	224.9	-403.5	1297.0
18 FEB	1330	855	232.9	-445.5	1343.8
CONTINUOUS RECORDER REMOVED, PRESSURE GAUGE INSTALLED					
18 FEB	1330	900	232.9	-445.5	1343.8
26 FEB	1330	860	240.9	-472.5	1364.0
4 MAR	1550	860	248.0	-474.0	1372.0
11 MAR	1100	860	254.8	-487.5	1385.2
18 MAR	1045	850	261.8	-534.0	1434.2
25 MAR	0915	850	268.8	-554.5	1462.5
21 APR	1030	850	295.8	-642.5	1548.0
27 MAY	1410	CELL LEAKING			

NOTES:

1. Pressure cell was installed at an angle of 90 degrees with ribside at a depth of 25 ft.

2. Time elapsed since initial reading.

3. Distance from the pressure cell to the face corrected for the installation angle and depth.

4. Length of the mined-out span.

APPENDIX M

CONVERGENCE INSTRUMENT DATA

TABLE M-1
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT L-1

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
11 JUL	1400	INITIAL READING		430.0	288.8
14 JUL	1300	0.002	3.0	430.0	288.8
1 AUG	0820	0.001	20.8	430.0	288.8
8 AUG	1000	0.011	27.8	399.0	322.2
15 AUG	0805	0.011	34.8	341.0	376.2
22 AUG	0830	0.012	41.8	309.0	411.5
29 AUG	1107	0.013	48.9	281.5	440.8
8 SEP	1135	0.018	58.9	251.5	471.5
22 SEP	0837	0.017	72.8	224.0	501.5
1 OCT	1510	0.023	82.0	151.0	568.8
3 OCT	0700	0.025	83.7	136.0	581.0
6 OCT	1410	0.032	87.0	121.5	596.2
8 OCT	0910	0.033	88.8	102.5	613.5
10 OCT	0850	0.040	90.8	78.5	637.2
13 OCT	1305	0.049	94.0	69.5	645.0
15 OCT	1100	0.052	95.9	52.0	662.0
17 OCT	0935	0.050	97.8	34.5	679.0
20 OCT	1155	0.084	100.9	23.5	690.5
21 OCT	1030	0.122	101.8	10.5	702.0
22 OCT	0850	0.229	102.8	-2.0	714.3
23 OCT	1125	0.500	103.9	-15.0	726.0
23 OCT		INSTRUMENT PASSED BEHIND SHIELDS			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-2
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT L-2

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
11 JUL	1400	INITIAL READING		430.0	288.8
1 AUG	0820	0.013	17.8	430.0	288.8
8 AUG	1000	0.011	24.9	399.0	322.2
15 AUG	0810	0.016	31.8	341.0	376.2
22 AUG	0830	0.033	38.8	309.0	411.5
29 AUG	1109	0.045	45.9	281.5	440.8
8 SEP	1138	0.056	56.0	251.5	471.5
15 SEP	0950	0.064	62.9	224.0	501.5
17 SEP	1345	0.073	65.0	224.0	501.5
22 SEP	0840	0.072	69.9	224.0	501.5
26 SEP	1248	0.082	74.0	185.0	538.0
29 SEP	1705	0.092	77.2	174.0	547.2
1 OCT	1512	0.101	79.1	151.0	568.8
3 OCT	0700	0.109	80.8	136.0	581.0
6 OCT	1415	0.118	84.0	121.5	596.2
8 OCT	0915	0.129	88.8	102.5	613.5
10 OCT	0850	0.141	90.8	78.5	637.2
13 OCT	1305	0.154	94.0	69.5	645.0
15 OCT	1105	0.173	95.9	52.0	662.0
20 OCT	1155	0.236	100.9	23.5	690.5
21 OCT	1030	0.428	101.8	10.5	702.0
21 OCT		DESTROYED BY COAL SHEAR			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-3
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT L-3

DATE	TIME	CONVER-GENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
11 JUL	1400	INITIAL READING		448.0	288.8
8 AUG	1005	0.008	27.8	417.0	322.2
22 AUG	0835	0.003	41.8	327.0	411.5
5 SEP	1046	-	55.9	276.0	463.8
15 SEP	0950	0.003	65.8	242.0	501.5
26 SEP	1251	0.010	77.0	203.0	538.0
29 SEP	1710	0.010	80.1	192.0	547.2
1 OCT	1515	0.010	82.0	169.0	568.8
3 OCT	0705	0.015	83.7	154.0	581.0
6 OCT	1415	0.018	87.0	139.5	596.2
8 OCT	0915	0.014	88.8	120.5	613.5
10 OCT	0855	0.020	90.8	96.5	637.2
13 OCT	1305	0.025	94.0	87.5	645.0
15 OCT	1105	0.025	95.9	70.0	662.0
16 OCT		DESTROYED BY A SCOOP TRAM			

NOTES:
1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M -4
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT L-4

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
11 JUL	1400	INITIAL READING		467.0	288.8
8 AUG	1005	0.003	27.8	436.0	322.2
15 AUG	0815	0.002	34.8	378.0	376.2
29 AUG	1117	0.003	48.9	318.5	440.8
12 SEP	1103	0.002	62.9	267.5	496.2
1 OCT	1515	0.001	82.0	188.0	568.8
3 OCT	0710	0.003	83.7	173.0	581.0
6 OCT	1415	0.007	87.0	158.5	596.2
8 OCT	0920	0.004	88.8	139.5	613.5
10 OCT	0855	0.006	90.8	115.5	637.2
13 OCT	1310	0.011	94.0	106.5	645.0
15 OCT	1105	0.011	95.9	89.0	662.0
17 OCT	1015	0.019	97.8	71.5	679.0
20 OCT	1205	0.028	100.9	60.5	690.5
21 OCT	1030	0.028	101.8	47.5	702.0
22 OCT	0855	0.037	102.8	35.0	714.2
23 OCT	1115	FLOOR ANCHOR DESTROYED			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-5
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT L-5

DATE	TIME	CONVER-GENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
11 JUL	1400	INITIAL READING		485.0	288.8
8 AUG	1005	0.003	27.8	454.0	322.2
15 AUG	0820	0.004	34.8	396.0	376.2
21 AUG	0840	-	40.8	375.0	401.2
28 AUG	1550	0.002	48.1	336.5	440.0
12 SEP	1105	0.002	62.9	285.5	493.0
22 SEP	0848	-0.003	72.8	279.0	498.2
29 SEP	1715	-0.002	80.1	229.0	544.0
10 OCT	0855	-	90.8	133.5	634.0
20 OCT	1210	0.006	100.9	78.5	687.2
21 OCT	1030	0.014	101.8	65.5	698.8
22 OCT	0855	0.020	102.8	53.0	711.0
23 OCT	1110	0.033	104.9	40.0	722.8
28 OCT	0940	0.067	108.8	27.0	737.5
29 OCT	1430	0.089	110.0	19.5	748.5
30 OCT	1445	0.146	111.0	10.5	757.5
31 OCT	1200	0.205	111.9	5.0	763.8
3 NOV	0805	0.212	114.8	5.0	764.8
3 NOV	1430	0.226	115.0	4.0	767.0
3 NOV	1645	0.240	115.1	2.5	768.8
3 NOV	1700	0.239	115.1	2.5	768.8
3 NOV		DESTROYED BY COAL SHEAR			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-6
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT L-6

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
11 JUL	1400	INITIAL READING		503.5	288.8
8 AUG	1005	0.001	27.8	472.5	322.2
15 AUG	0824	0.003	34.8	414.5	376.2
21 AUG	0840	0.003	40.8	393.5	401.2
28 AUG	1552	0.003	48.1	355.0	440.0
5 SEP	1055	0.002	55.9	331.5	463.8
12 SEP	1107	0.006	62.9	304.0	493.0
22 SEP	0850	0.004	72.8	297.5	498.2
29 SEP	1715	0.006	80.1	247.5	544.0
6 OCT	1420	0.009	87.0	195.0	593.0
15 OCT	1110	0.014	95.9	125.5	658.8
20 OCT	1210	0.022	100.9	97.0	687.2
21 OCT	1030	0.025	101.8	84.0	698.8
22 OCT	0855	0.033	102.8	71.5	711.0
23 OCT	1110	0.039	104.9	58.5	722.8
28 OCT	0940	0.056	108.8	45.5	737.5
29 OCT	1430	0.067	110.0	38.0	748.5
30 OCT	1450	0.088	111.0	29.0	757.5
31 OCT	1200	0.106	111.9	23.5	763.8
3 NOV	0810	0.111	114.8	22.5	767.0
4 NOV	1130	0.159	115.9	10.5	778.8
5 NOV	0820	0.230	116.8	6.5	788.2
5 NOV	0930	0.242	116.8	4.5	790.2
5 NOV	1110	0.246	116.9	4.5	790.2
5 NOV	1500	0.294	117.0	2.5	792.2
5 NOV		DESTROYED BY COAL SHEAR			

NOTES:
1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-7
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B1-1

DATE	TIME	CONVER-GENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1300	INITIAL READING		521.5	288.8
11 JUL	1400	-0.001	4.0	521.5	288.8
8 AUG	1010	-0.002	31.9	490.5	322.2
15 AUG	0829	-0.001	38.8	432.5	376.2
21 AUG	0845	0.002	44.8	411.5	401.2
29 AUG	1125	0.004	52.9	371.0	441.8
12 SEP	1109	0.008	66.9	322.0	493.0
29 SEP	1025	0.010	84.2	265.5	544.0
6 OCT	1032	0.017	91.0	213.0	593.0
17 OCT	1030	0.023	100.9	126.0	675.8
20 OCT	1215	0.035	104.0	115.0	687.2
22 OCT	0900	0.043	105.8	89.5	711.0
23 OCT	1135	0.051	107.0	76.5	722.8
28 OCT	0945	0.066	112.9	63.5	737.5
29 OCT	1435	0.069	114.1	56.0	748.5
30 OCT	1450	0.082	115.1	47.0	757.5
31 OCT	1200	0.087	116.0	41.5	763.8
3 NOV	0820	0.090	118.8	40.5	767.0
4 NOV	1140	0.118	119.9	28.5	778.8
5 NOV	0930	0.142	120.8	18.0	792.5
6 NOV	1225	0.233	122.0	8.0	802.5
7 NOV	0950	0.288	122.9	7.0	803.5
7 NOV	1355	0.319	123.0	4.5	806.0
10 NOV	0935	0.544	125.9	2.5	810.2
17 NOV		DESTROYED BY COAL SHEAR			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-8
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B1-2

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1300	INITIAL READING		529.0	288.8
11 JUL	1400	0.001	4.0	529.0	288.8
8 AUG	1010	0.004	31.9	498.0	322.2
15 AUG	0833	0.005	38.8	440.0	376.2
22 AUG	0845	0.004	45.8	408.0	411.5
29 AUG	1127	0.007	52.9	378.5	441.5
5 SEP	1021	0.005	59.9	357.0	463.8
12 SEP	1110	0.010	66.9	329.5	493.0
22 SEP	0856	0.006	76.8	323.0	498.2
29 SEP	1720	0.011	84.2	273.0	544.0
6 OCT	1440	0.016	91.1	220.5	593.0
15 OCT	1115	0.018	98.9	151.0	658.8
17 OCT	1030	0.021	100.9	133.5	675.8
20 OCT	1215	0.029	104.0	122.5	687.2
22 OCT	0900	0.035	105.8	97.0	711.0
23 OCT	1135	0.040	107.0	84.0	722.8
28 OCT	0945	0.049	112.9	71.0	737.5
29 OCT	1435	0.055	114.1	63.5	748.5
30 OCT	1455	0.061	115.1	54.5	757.5
31 OCT	1205	0.068	116.0	49.0	763.8
3 NOV	0835	0.068	118.8	48.0	767.0
4 NOV	1145	0.087	120.0	36.0	780.2
5 NOV	0930	0.101	120.8	25.5	792.5
6 NOV	1225	0.160	122.0	15.5	802.5
7 NOV	1205	0.191	123.0	15.5	802.5
7 NOV	1355	0.210	123.0	12.0	806.0
10 NOV	0940	0.259	125.9	10.0	810.2
17 NOV	0825	0.282	132.8	8.5	811.5
17 NOV	1120	0.307	132.9	6.5	813.5
17 NOV	1340	0.330	133.0	4.5	815.5
17 NOV	1520	0.359	133.1	2.5	817.5
17 NOV		DESTROYED BY COAL SHEAR			

NOTES:
1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-9
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
. CONVERGENCE INSTRUMENT B1-3

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1300	INITIAL READING		546.0	288.8
8 AUG	1010	0.006	31.9	515.0	322.2
15 AUG	0835	0.009	38.8	457.0	376.2
22 AUG	0850	0.011	45.8	425.0	411.5
29 AUG	1133	0.016	53.0	395.5	441.8
5 SEP	1025	0.024	59.9	374.0	463.8
15 SEP	1004	0.030	69.9	340.0	498.2
22 SEP	0900	0.033	76.8	340.0	498.2
24 SEP	1335	0.040	79.0	322.0	514.0
26 SEP	1304	0.042	81.0	301.0	534.8
29 SEP	1725	0.042	84.2	290.0	544.0
1 OCT	1526	0.044	86.1	267.0	565.5
3 OCT	0720	0.051	87.8	252.0	577.8
6 OCT	1515	0.054	91.1	237.5	593.0
8 OCT	0930	0.055	92.8	218.5	610.2
10 OCT	0910	0.064	93.8	194.5	634.0
13 OCT	1320	0.069	97.0	185.5	641.8
15 OCT	1115	0.072	98.9	168.0	658.8
17 OCT	1035	0.077	100.9	150.5	675.8
20 OCT	1220	0.088	104.0	139.5	687.2
22 OCT	0905	0.095	105.8	114.0	711.0
23 OCT	1140	0.104	107.0	101.0	722.8
28 OCT	0945	0.120	112.9	88.0	737.5
30 OCT	1455	0.127	115.1	71.5	757.5
31 OCT	1205	0.137	116.0	66.0	763.8
3 NOV	1000	0.144	118.9	65.0	767.0
4 NOV	1155	0.156	120.0	53.0	778.8
5 NOV	0940	0.160	120.9	42.5	792.5
6 NOV	1230	0.194	122.0	32.5	802.5
7 NOV	1400	0.209	123.0	29.0	806.0
10 NOV	0940	0.229	125.9	27.0	810.2
17 NOV	0900	0.240	132.8	19.5	817.5
18 NOV	1250	0.318	134.0	11.5	827.0
21 NOV	1325	INSTRUMENT PASSED BEHIND SHIELDS			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-10
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B1-4

DATE	TIME	CONVER-GENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1300	INITIAL READING		526.0	288.8
8 AUG	1015	0.015	31.9	495.0	322.2
15 AUG	0838	0.017	38.8	437.0	376.2
22 AUG	0850	0.019	45.8	405.0	411.5
29 AUG	1137	0.020	53.0	375.5	441.8
5 SEP	1035	0.028	59.9	354.0	463.8
15 SEP	1006	0.032	69.9	320.0	498.2
24 SEP	1335	0.037	79.0	302.0	514.0
10 OCT	0905	0.042	93.8	174.5	634.0
13 OCT	1325	0.049	97.0	165.5	641.8
20 OCT	1220	0.054	104.0	119.5	687.2
23 OCT	1140	0.062	107.0	81.0	722.8
29 OCT	1450	0.075	114.1	60.5	748.5
31 OCT	1210	0.085	116.0	46.0	763.8
4 NOV	1200	0.095	120.0	33.0	778.8
6 NOV	1230	0.111	122.0	12.5	802.5
7 NOV	1400	0.116	123.0	9.0	806.0
10 NOV	0940	0.123	125.9	7.0	810.2
17 NOV	0900	0.130	132.8	6.0	811.0
18 NOV	1250	0.155	134.0	-8.5	827.0
21 NOV	1320	0.220	137.0	-40.0	857.5
24 NOV	1850	0.250	140.2	-54.5	871.2
24 NOV	1850	FINAL READING. ROOF NOT STABLE.			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-11
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B1-5

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1300	INITIAL READING		649.0	288.8
8 AUG	1020	0.015	31.9	618.0	322.2
15 AUG	0844	0.015	38.8	560.0	376.2
22 AUG	0855	0.018	45.8	528.0	411.5
29 AUG	1142	0.019	53.0	498.5	441.8
5 SEP	1040	0.023	59.9	477.0	463.8
22 SEP	0905	0.026	76.8	443.0	498.2
29 SEP	1725	0.029	84.1	393.0	544.0
6 OCT	1525	0.034	91.1	340.5	593.0
13 OCT	1330	0.039	97.0	288.5	641.8
20 OCT	1225	0.046	104.0	242.0	687.2
28 OCT	0955	0.051	112.9	191.0	737.5
30 OCT	1500	0.056	115.1	174.5	757.5
4 NOV	1205	0.062	120.0	156.0	778.8
7 NOV	1405	0.067	123.6	132.0	806.0
10 NOV	0945	0.069	125.9	130.0	810.2
17 NOV	0905	0.073	132.8	129.0	811.0
18 NOV	1245	0.072	134.0	114.5	827.0
21 NOV	1335	0.092	137.0	83.0	857.5
24 NOV	1855	0.111	140.2	68.5	871.2
25 NOV	1650	0.114	141.2	63.0	878.0
1 DEC	1450	0.155	147.1	41.0	898.2
2 DEC	1625	0.161	148.1	36.5	903.0
5 DEC		DESTROYED BY A SCOOP TRAM			

NOTES:
1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-12
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B2-1

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
11 JUL	1215	INITIAL READING		1394.0	288.8
1 AUG	0750	0.002	20.8	1363.0	322.2
15 SEP	1143	0.013	66.0	1188.0	498.2
21 OCT	0830	0.017	101.8	974.5	698.8
18 NOV	0940	0.022	129.9	859.5	827.0
10 DEC	1100	0.040	152.0	737.5	945.0
14 JAN	1145	0.077	187.0	581.5	1103.2
4 FEB	1300	0.125	208.0	430.5	1256.0
10 FEB	1100	0.142	214.0	387.5	1297.0
18 FEB	1735	0.165	222.2	336.0	1343.8
26 FEB	1440	0.178	230.1	322.0	1364.2
4 MAR	1225	0.177	237.0	307.5	1372.2
11 MAR	0830	0.189	243.8	295.0	1385.2
18 MAR	1440	0.223	251.1	243.5	1434.2
25 MAR	1000	0.241	257.9	207.5	1462.5
1 APR	0835	0.268	264.9	177.0	1495.2
7 APR	0900	0.293	270.9	161.5	1511.0
13 APR	1230	0.330	277.0	154.0	1519.2
21 APR	1900	0.376	285.3	124.5	1548.0
27 APR	1105	0.390	291.0	106.0	1567.2
10 MAY	0855	0.476	303.3	90.5	1586.0
18 MAY	1120	0.499	312.0	81.0	1594.8
25 MAY	1225	0.531	319.0	81.0	1594.8
1 JUN	1000	0.531	325.9	81.0	1594.8
8 JUN	1045	INSTRUMENT DESTROYED BY A SCOOP TRAM			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-13
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B2-2

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1530	INITIAL READING		1447.0	288.8
4 AUG	1230	0.009	28.0	1416.0	322.2
15 SEP	1140	0.010	69.9	1241.0	498.2
21 OCT	0830	0.016	104.7	1027.5	698.8
18 NOV	0940	0.020	133.8	912.5	827.0
10 DEC	1100	0.020	155.8	790.5	945.0
14 JAN	1045	0.026	190.8	634.5	1103.2
4 FEB	1300	0.038	211.9	483.5	1256.2
10 FEB	1100	0.045	217.8	440.5	1297.0
18 FEB	1735	0.060	226.1	389.0	1343.8
26 FEB	1440	0.060	234.0	375.0	1364.2
4 MAR	1225	0.060	240.9	360.5	1372.2
11 MAR	0830	0.069	247.7	348.0	1385.2
18 MAR	1440	0.075	255.0	296.5	1434.2
25 MAR	1000	0.078	261.8	260.5	1462.5
1 APR	0835	0.089	268.7	230.0	1495.2
7 APR	0900	0.108	274.7	214.5	1511.0
13 APR	1230	0.117	280.9	207.0	1519.2
21 APR	1900	0.131	289.2	177.5	1548.0
27 APR	1105	0.142	294.3	159.0	1567.2
10 MAY	0845	0.178	307.7	143.5	1586.0
18 MAY	1120	0.193	315.3	134.0	1594.8
25 MAY	1225	0.199	322.9	134.0	1594.8
1 JUN	1000	0.199	329.8	134.0	1594.8
8 JUN	1045	0.206	336.8	134.0	1594.8

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-14
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B2-3

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1530	INITIAL READING		1503.0	288.8
4 AUG	1240	0.012	28.0	1472.0	322.2
15 SEP	1135	0.028	70.0	1297.0	498.2
28 OCT	1125	0.030	112.8	1045.0	737.5
18 NOV	0940	0.032	133.8	968.5	827.0
10 DEC	1100	0.030	155.8	846.5	945.0
14 JAN	1045	0.034	190.8	690.5	1103.2
4 FEB	1300	0.038	211.9	539.5	1256.2
10 FEB	1100	0.037	217.8	496.5	1297.0
18 FEB	1735	0.046	226.1	445.0	1343.8
26 FEB	1440	0.045	234.0	431.0	1364.2
4 MAR	1225	0.043	240.9	416.5	1372.2
11 MAR	0830	0.047	247.7	404.0	1385.2
18 MAR	1440	0.059	255.0	352.5	1434.2
25 MAR	1000	0.064	261.8	316.5	1462.5
1 APR	0835	0.073	268.7	286.0	1495.2
7 APR	0900	0.076	274.7	270.5	1511.0
13 APR	1230	0.083	280.9	263.0	1519.2
21 APR	1900	0.093	289.2	233.5	1548.0
27 APR	1105	0.105	294.3	215.0	1567.2
10 MAY	0845	0.146	307.7	199.5	1586.0
18 MAY	1120	0.147	315.3	190.0	1594.8
25 MAY	1225	0.195	322.9	190.0	1594.8
8 JUN	1045	0.193	336.8	190.0	1594.8

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-15
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B2-4

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1530	INITIAL READING		1510.5	288.8
5 AUG	1300	0.001	28.9	1479.5	322.2
15 SEP	1137	0.006	69.8	1304.5	498.2
21 OCT	0835	0.009	104.7	1091.0	698.8
18 NOV	0945	0.011	133.8	976.0	827.0
10 DEC	1100	0.013	155.8	854.0	945.0
14 JAN	1045	0.020	190.8	698.0	1103.2
4 FEB	1300	0.040	211.9	547.0	1256.2
10 FEB	1100	0.043	217.8	504.0	1297.0
18 FEB	1735	0.059	226.1	452.5	1343.8
26 FEB	1440	0.063	234.0	438.5	1364.2
4 MAR	1225	0.061	240.9	424.0	1372.2
11 MAR	0830	0.065	247.7	411.5	1385.2
18 MAR	1440	0.079	255.0	360.0	1434.2
25 MAR	1000	0.082	261.8	324.0	1462.5
1 APR	0835	0.098	268.7	293.5	1495.2
7 APR	0900	0.111	274.7	278.0	1511.0
13 APR	1230	0.130	280.9	270.5	1519.2
21 APR	1900	0.150	289.2	241.0	1548.0
27 APR	1105	0.167	294.3	222.5	1567.2
10 MAY	0845	0.237	307.7	207.0	1586.0
18 MAY	1120	0.247	315.3	197.5	1594.8
25 MAY	1225	0.255	322.4	197.5	1594.8
1 JUN	1000	DESTROYED BY A SCOOP TRAM			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-16
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B3-1

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1615	INITIAL READING		1480.0	288.8
5 AUG	1020	0.008	28.8	1444.0	322.2
15 SEP	1115	0.016	69.8	1267.0	498.2
21 OCT	1220	0.027	104.8	1079.5	698.8
21 NOV	1255	0.038	136.9	908.5	857.5
10 DEC	1140	0.045	155.8	824.0	945.0
14 JAN	1000	0.055	190.7	663.5	1103.2
4 FEB	1245	0.065	211.8	508.5	1256.2
18 FEB	1515	0.074	226.0	428.0	1343.8
26 FEB	1400	0.074	233.9	401.0	1364.2
4 MAR	1445	0.075	240.9	399.5	1372.2
11 MAR	0910	0.074	247.7	386.0	1385.2
18 MAR	1125	0.088	254.8	339.5	1434.2
25 MAR	0915	0.084	261.7	319.0	1462.5
1 APR	0900	0.087	268.7	284.0	1495.2
7 APR	1035	0.095	274.8	268.0	1511.0
13 APR	0940	0.101	280.7	259.0	1519.2
21 APR	1830	0.096	289.1	231.0	1548.0
27 APR	1010	0.104	294.7	211.0	1567.2
11 MAY	1105	0.114	308.8	186.5	1589.2
18 MAY	1135	0.115	315.8	181.0	1594.8
25 MAY	1315	0.121	322.9	181.0	1594.8
1 JUN	1140	0.126	329.8	181.0	1594.8
8 JUN	1430	0.124	336.9	181.0	1594.8

NOTES:

1. Time elasped since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-17
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B3-2

DATE	TIME	CONVER-GENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1615	INITIAL READING		1519.5	288.8
5 AUG	1015	0.005	28.8	1483.5	322.2
21 OCT	0920	0.022	104.8	1119.0	698.8
21 NOV	1250	0.036	136.9	948.0	857.5
10 DEC	1140	0.045	155.8	863.5	945.0
14 JAN	1000	0.056	190.7	703.0	1103.2
4 FEB	1245	0.072	211.8	548.0	1256.2
18 FEB	1515	0.097	226.0	467.5	1343.8
26 FEB	1400	0.117	233.9	440.5	1364.2
4 MAR	1445	0.114	240.9	439.0	1372.2
11 MAR	0910	0.114	247.7	425.5	1385.2
18 MAR	1125	0.125	254.8	379.0	1434.2
25 MAR	0915	0.129	261.7	358.5	1462.5
1 APR	0900	0.130	268.7	323.5	1495.2
7 APR	1035	0.128	274.8	307.5	1511.0
21 APR	1830	0.134	289.1	270.5	1548.0
27 APR	1010	0.136	294.7	250.5	1567.2
11 MAY	1105	0.145	308.8	226.0	1589.2
18 MAY	1135	0.151	315.8	220.5	1594.8
25 MAY	1315	0.155	322.9	220.5	1594.8
1 JUN	1140	0.151	329.8	220.5	1594.8
8 JUN	1430	0.156	336.9	220.5	1594.8

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-18
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B3-3

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1715	INITIAL READING		1460.5	288.8
5 AUG	1130	0.008	28.8	1424.5	322.2
21 OCT	0945	0.013	104.8	1060.0	698.8
21 NOV	1235	0.013	136.8	889.0	857.5
10 DEC	1220	0.017	155.8	804.5	945.0
14 JAN	0905	0.015	190.7	644.0	1103.2
4 FEB	1200	0.016	211.8	489.0	1256.2
10 FEB	1200	0.026	217.8	470.0	1297.0
18 FEB	1450	0.024	225.9	428.0	1343.8
26 FEB	1345	0.026	233.8	381.5	1364.2
4 MAR	1615	0.031	241.0	380.0	1372.2
11 MAR	0900	0.032	247.7	366.5	1385.2
18 MAR	1035	0.029	254.7	320.0	1434.2
25 MAR	0900	0.036	261.7	299.5	1462.5
1 APR	0925	0.033	268.7	264.5	1495.2
7 APR	1050	0.046	274.7	248.5	1511.0
13 APR	0915	0.046	280.7	239.5	1519.2
21 APR	1810	0.049	289.0	211.5	1548.0
27 APR	1015	0.051	294.7	191.5	1567.2
11 MAY	1055	0.055	308.7	167.0	1589.2
18 MAY	1150	0.065	315.8	161.5	1594.8
25 MAY	1400	0.065	322.9	161.5	1594.8
1 JUN	1130	0.069	324.8	161.5	1594.8
8 JUN	1430	0.072	336.9	161.5	1594.8

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-19
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B3-4

DATE	TIME	CONVERGENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1715	INITIAL READING		1460.5	288.8
5 AUG	1130	0.009	28.8	1424.5	322.2
21 OCT	0945	0.003	104.7	1060.0	698.8
21 NOV	1235	0.005	136.8	889.0	857.5
10 DEC	1220	0.004	155.8	804.5	945.0
20 JAN	0955	0.008	196.7	601.0	1148.8
27 JAN	1340	0.005	203.8	529.5	1209.8
4 FEB	1200	-0.001	211.8	489.0	1256.2
10 FEB	1210	0.007	217.8	479.5	1297.0
18 FEB	1450	0.002	225.9	437.5	1343.8
26 FEB	1345	0.003	233.8	410.5	1364.2
4 MAR	1615	0.002	241.0	409.0	1372.2
11 MAR	0900	-0.002	247.7	395.5	1385.2
25 MAR	0900	0.004	261.7	328.5	1462.5
1 APR	0935	0.010	268.7	293.5	1495.2
7 APR	1050	0.010	274.7	277.5	1511.0
13 APR	0915	0.020	280.7	268.5	1519.2
21 APR	1810	0.029	289.0	240.5	1548.0
27 APR	1015	0.025	294.7	220.5	1567.2
3 MAY	1100	0.022	300.7	210.0	1575.0
11 MAY	1055	0.038	308.7	196.0	1589.2
18 MAY	1150	0.041	315.8	190.5	1594.8
8 JUN		INSTRUMENT DESTROYED BY A SCOOP TRAM			

NOTES:

1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

TABLE M-20
SUMMARY OF ENTRY ROOF-FLOOR CONVERGENCE DATA
CONVERGENCE INSTRUMENT B3-5

DATE	TIME	CONVER-GENCE (in)	TIME (1) (days)	FACE DISTANCE (ft) (2)	SPAN (3) (ft)
7 JUL	1715	INITIAL READING		1460.5	288.8
5 AUG	1300	0.008	28.8	1425.5	322.2
22 SEP	1200	0.007	76.7	1247.5	498.2
21 OCT	0945	0.007	104.7	1060.0	698.8
21 NOV	1235	0.004	136.8	889.0	857.5
10 DEC	1220	0.010	155.8	804.5	945.0
14 JAN	0905	0.011	190.7	644.0	1103.2
27 JAN	1340	0.022	203.8	529.5	1209.8
4 FEB	1200	0.022	211.8	489.0	1256.2
10 FEB	1210	0.025	217.8	480.0	1297.0
18 FEB	1450	0.024	225.9	438.0	1343.8
26 FEB	1345	0.028	233.8	411.0	1364.2
4 MAR	1615	0.027	241.0	409.5	1372.2
11 MAR	0900	0.024	247.7	396.0	1385.2
18 MAR	1035	0.041	254.7	349.5	1434.2
25 MAR	0900	0.037	261.7	329.0	1462.5
1 APR	0925	0.040	268.7	294.0	1495.2
7 APR	1050	0.039	274.7	278.0	1511.0
13 APR	0915	0.046	280.7	269.0	1519.2
21 APR	1810	0.054	289.0	241.0	1548.0
27 APR	1015	0.054	294.7	221.0	1567.2
3 MAY	1100	0.052	300.7	210.5	1575.0
11 MAY	1055	0.063	308.7	196.5	1589.2
18 MAY	1150	0.060	315.8	191.0	1594.8
25 MAY	1400	0.063	322.9	191.0	1594.8
1 JUN	1130	0.064	329.8	191.0	1594.8
8 JUN	1430	0.069	336.9	191.0	1594.8

NOTES:
1. Time elapsed since initial reading.
2. Distance from the convergence instrument to the face.
3. Length of mined-out span.

APPENDIX N

DIFFERENTIAL ROOF-FLOOR HORIZONTAL MOVEMENT DATA

TABLE N-1

NOTES TO ACCOMPANY TABLES N-2 THROUGH N-10

1. The movement vector represents the direction (azimuth) and length of a line between the initial point and the plumb-bob at time, t.

2. Represents components of horizontal movement relative to the orientation of the panel centerline (azimuth 135 degrees).

   Para: Component of movement parallel to the panel centerline. Positive value indicates movement towards the mining face.

   Perp: Component of movement perpendicular to the panel centerline. Positive value indicates movement towards the center of the longwall panel.

3. Distance from the instrument to the mining face.

4. Length of the mined-out span.

TABLE N-2
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D1-1

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
4 AUG	1130	INITIAL READING				523.5	288.8
2 SEP	0925	344	0.14	0.12	0.07	371.0	444.0
15 SEP	1020	335	0.22	0.21	0.08	317.5	498.2
1 OCT	1500	340	0.28	0.25	0.12	244.5	565.5
15 OCT	1040	346	0.42	0.36	0.22	145.5	658.8
20 OCT	1145	350	0.47	0.39	0.27	117.0	687.2
22 OCT	0830	349	0.50	0.41	0.28	91.5	711.0
28 OCT	0820	351	0.60	0.49	0.35	65.5	737.5
29 OCT	1420	351	0.60	0.49	0.35	58.0	748.5
31 OCT	1125	342	0.55	0.49	0.25	43.5	763.8
3 NOV	1050	347	0.62	0.53	0.33	42.5	767.0
4 NOV	1210	342	0.65	0.58	0.30	30.5	778.8
5 NOV	1115	348	0.67	0.56	0.36	20.0	792.5
6 NOV	1250	007	0.80	0.49	0.63	10.0	802.5
7 NOV	1000	012	0.95	0.52	0.80	9.5	802.8
7 NOV	1400	014	1.05	0.54	0.90	6.5	805.8
10 NOV	0950	020	1.42	0.60	1.29	4.5	810.2
17 NOV	0830	022	1.50	0.59	1.38	3.5	811.0
17 NOV		DESTROYED BY COAL SHEAR					

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

TABLE N-3
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D1-2

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
4 AUG	1130	INITIAL READING				500.5	322.2
2 SEP	0930	285	0.12	0.10	-0.06	379.0	444.0
15 SEP	1024	304	0.20	0.20	-0.04	325.5	498.2
1 OCT	1505	330	0.25	0.24	0.06	252.5	565.5
15 OCT	1055	292	0.40	0.37	-0.16	153.5	658.8
20 OCT	1145	292	0.50	0.46	-0.20	125.0	687.2
22 OCT	0830	290	0.55	0.50	-0.23	99.5	711.0
28 OCT	0825	290	0.65	0.59	-0.27	73.5	737.5
29 OCT	1420	290	0.65	0.59	-0.27	66.0	748.5
30 OCT	1440	285	0.70	0.61	-0.35	57.0	757.5
31 OCT	1125	290	0.65	0.59	-0.27	51.5	763.8
3 NOV	1050	287	0.75	0.66	-0.35	50.5	767.0
4 NOV	1215	288	0.70	0.62	-0.32	38.5	778.8
5 NOV	1115	288	0.75	0.67	-0.34	28.0	792.5
6 NOV	1245	288	0.75	0.67	-0.34	18.0	802.5
7 NOV	1135	285	0.85	0.74	-0.42	17.5	803.0
7 NOV	1400	285	0.85	0.74	-0.42	14.5	805.8
10 NOV	0955	292	0.85	0.78	-0.33	12.5	810.2
17 NOV	0840	295	0.85	0.80	-0.29	11.5	811.0
17 NOV	1120	295	0.85	0.80	-0.29	9.5	813.0
17 NOV	1340	295	0.85	0.80	-0.29	7.5	815.0
17 NOV	1515	295	0.85	0.80	-0.29	5.5	817.0
17 NOV		DESTROYED BY COAL SHEAR					

TABLE N-3 (continued)

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

TABLE N-4
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D2-1

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	MOVEMENT VECTOR (1) LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	MOVEMENT (2) PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
22 SEP	0945	INITIAL READING				1191.0	498.2
14 OCT	1255	270	0.10	0.07	-0.07	1026.0	652.0
3 NOV	1530	270	0.10	0.07	-0.07	916.0	767.0
18 NOV	1000	270	0.07	0.05	-0.05	862.5	827.0
10 DEC	1110	296	0.10	0.09	-0.03	740.5	945.0
14 JAN	1045	312	0.23	0.23	-0.01	584.5	1103.2
4 FEB	1335	316	0.32	0.32	0.01	433.5	1256.2
18 FEB	1725	325	0.35	0.34	0.06	339.0	1343.8
4 MAR	1235	320	0.42	0.42	0.04	310.5	1372.2
18 MAR	1425	317	0.45	0.45	0.02	246.5	1434.2
1 APR	0845	323	0.53	0.52	0.07	180.0	1495.2
13 APR	1230	291	0.82	0.75	-0.33	157.0	1519.2
21 APR	1950	288	0.85	0.76	-0.39	127.5	1548.0
10 MAY	0900	292	1.00	0.92	-0.39	93.5	1586.0
25 MAY	1245	247	1.05	0.39	-0.97	84.0	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

TABLE N-5
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D2-2

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
4 AUG	1200	INITIAL READING				1500.0	288.8
15 SEP	0940	-	-	-	-	1294.0	498.2
29 SEP	1410	-	-	-	-	1244.0	544.0
14 OCT	1255	-	-	-	-	1129.0	652.0
3 NOV	1530	-	-	-	-	1019.0	767.0
18 NOV	1000	-	-	-	-	965.5	827.0
10 DEC	1110	234	0.15	0.02	-0.15	843.5	945.0
14 JAN	1045	241	0.15	0.04	-0.14	687.5	1103.2
4 FEB	1335	272	0.27	0.20	-0.18	536.5	1256.2
18 FEB	1725	276	0.35	0.27	-0.22	442.0	1343.8
4 MAR	1235	265	0.40	0.26	-0.31	413.5	1372.2
18 MAR	1425	277	0.45	0.35	-0.28	349.5	1434.2
1 APR	0845	286	0.58	0.51	-0.28	283.0	1495.2
13 APR	1230	284	0.58	0.50	-0.30	260.0	1519.2
21 APR	1950	286	0.85	0.74	-0.41	230.5	1548.0
10 MAY	0900	295	0.72	0.68	-0.25	196.5	1586.0
25 MAY	1245	290	0.82	0.74	-0.35	187.0	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

TABLE N-6
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D3-1

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	MOVEMENT VECTOR (1) LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	MOVEMENT (2) PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
7 JUL	1715	INITIAL READING				1481.5	288.8
5 AUG	1130	-	-	-	-	1481.5	288.8
15 SEP	1135	-	-	-	-	1268.5	498.2
29 SEP	1550	-	-	-	-	1227.0	544.0
14 OCT	1215	-	-	-	-	1126.0	652.0
3 NOV	1330	-	-	-	-	1006.0	767.0
21 NOV	1240	199	0.15	-0.07	0.13	910.0	857.5
10 DEC	1135	317	0.07	0.07	-	825.5	945.0
14 JAN	1010	303	0.10	0.10	0.02	665.0	1103.2
4 FEB	1240	263	0.13	0.08	0.10	510.0	1256.2
18 FEB	1510	265	0.15	0.10	0.11	429.5	1343.8
4 MAR	1445	267	0.15	0.10	0.11	401.0	1372.2
18 MAR	1120	295	0.17	0.16	0.06	341.0	1434.2
1 APR	0910	257	0.20	0.11	0.17	285.5	1495.2
13 APR	0940	267	0.25	0.17	0.19	260.5	1519.2
21 APR	1830	265	0.20	0.13	0.15	232.0	1548.0
10 MAY	1105	267	0.20	0.13	0.15	190.5	1586.0
25 MAY	1325	239	0.25	0.06	0.24	182.5	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

TABLE N-7
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D3-2

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
7 JUL	1715	INITIAL READING				1518.0	288.8
5 AUG	1130	-	-	-	-	1518.0	288.8
15 SEP	1135	-	-	-	-	1305.0	498.2
29 SEP	1550	-	-	-	-	1263.5	544.0
14 OCT	1215	-	-	-	-	1162.5	652.0
3 NOV	1330	-	-	-	-	1042.5	767.0
21 NOV	1240	216	0.07	-0.01	0.07	946.5	857.5
10 DEC	1135	-	-	-	-	862.0	945.0
14 JAN	1010	261	0.13	0.08	0.11	701.5	1103.2
4 FEB		DESTROYED BY A SCOOP TRAM					

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

TABLE N-8
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D3-3

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
22 SEP	1100	INITIAL READING				1245.5	498.2
14 OCT	1145	360	0.05	0.04	-0.04	1103.0	652.0
3 NOV	1300	007	0.05	0.03	-0.04	983.0	767.0
21 NOV	1225	237	0.05	0.01	0.05	887.0	857.5
10 DEC	1205	247	0.10	0.04	0.09	802.5	945.0
14 JAN	0920	233	0.15	0.02	0.15	642.0	1103.2
4 FEB	1205	081	0.20	-0.12	-0.16	487.0	1256.2
4 FEB		INSTRUMENT POSSIBLY DISTURBED					
13 FEB	1440	220	0.20	-0.02	0.20	406.5	1343.8
4 MAR	1600	250	0.20	0.14	0.14	378.0	1372.2
13 MAR	1025	230	0.25	0.02	0.25	318.0	1434.2
1 APR	0945	228	0.20	0.01	0.20	262.5	1495.2
13 APR	0915	258	0.22	0.12	0.18	237.5	1519.2
21 APR	1805	256	0.20	0.10	0.17	209.5	1548.0
11 MAY	1055	245	0.25	0.09	0.23	165.0	1589.2
25 MAY	1420	240	0.25	0.06	0.24	159.5	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

TABLE N-9
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D3-4

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	MOVEMENT VECTOR (1) LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	MOVEMENT (2) PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
22 SEP	1100	INITIAL READING				1278.0	498.2
14 OCT	1145	-	-	-	-	1135.5	652.0
3 NOV	1300	290	0.05	0.05	0.02	1015.5	767.0
21 NOV	1225	270	0.05	0.04	0.03	919.5	857.5
10 DEC	1205	270	0.10	0.07	0.07	835.0	945.0
14 JAN	0920	217	0.20	-0.03	0.20	674.5	1103.2
14 JAN		INSTRUMENT POSSIBLY DISTURBED					
4 FEB	1205	250	0.25	0.11	0.23	519.5	1256.2
18 FEB	1440	228	0.22	0.01	0.22	439.0	1343.8
4 MAR	1600	235	0.25	0.04	0.25	410.5	1372.2
18 MAR	1025	258	0.30	0.16	0.25	350.5	1434.2
1 APR	0945	259	0.35	0.20	0.29	295.0	1495.2
13 APR	0915	242	0.42	0.12	0.40	270.0	1519.2
21 APR		DESTROYED BY A SCOOP TRAM					

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

TABLE N-10
SUMMARY OF DIFFERENTIAL ROOF-FLOOR
HORIZONTAL MOVEMENT DATA
INSTRUMENT D3-5

DATE	TIME	MOVEMENT VECTOR (1) AZIMUTH (degrees)	LENGTH (inch)	MOVEMENT (2) PARALLEL (inch)	PERP. (inch)	DISTANCE (ft) (3)	SPAN (4) (ft)
22 SEP	1100	INITIAL READING				1280.0	498.2
10 OCT	1315	180	0.15	-0.11	0.11	1186.0	600.5
3 NOV	1300	345	0.10	0.09	-0.05	1017.5	767.0
21 NOV	1225	335	0.10	0.10	-0.02	921.5	857.5
10 DEC	1205	185	0.27	-0.17	0.21	837.0	945.0
14 JAN	0920	298	0.20	0.19	0.06	676.5	1103.2
14 JAN		INSTRUMENT POSSIBLY DISTURBED					
4 FEB	1205	310	0.17	0.17	0.01	521.5	1256.2
18 FEB	1440	310	0.15	0.15	0.01	441.0	1343.8
4 MAR	1600	252	0.15	0.07	0.13	412.5	1372.2
18 MAR	1025	257	0.25	0.13	0.21	352.5	1434.2
1 APR	0945	243	0.15	0.05	0.14	297.0	1495.2
13 APR	0915	276	0.25	0.19	0.16	272.0	1519.2
13 APR		INSTRUMENT POSSIBLY DISTURBED					
21 APR	1805	263	0.25	0.15	0.20	244.0	1548.0
11 MAY	1055	258	0.20	0.11	0.17	199.5	1589.2
25 MAY	1420	230	0.30	0.03	0.30	194.0	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table N-1.

APPENDIX O

ROOF-SAG INSTRUMENT DATA

TABLE O-1
NOTES TO ACCOMPANY TABLES F-2 THROUGH F-13

1. Total sag represents the change in the length of the instrumented interval. A positive value indicates elongation (or tensile strain). A negative value indicates shortening (or compressive strain).

2. Time elapsed since initial reading.

3. Distance from the roof sag extensometer to the mining face.

4. Length of the mined-out span.

5. Data represents results from two-point extensometers, installed in pairs. One extensometer was installed with anchors at Ø, 3 and 5 ft depths. A second extensometer had anchors at Ø, 9 and 12 ft depths. Length of anchored interval is indicated in each table.

TABLE O-2
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C1-3 ANCHORED INTERVAL Ø TO 3 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		527.0	288.8
8 AUG	1040	0.001	28.9	496.0	322.2
29 AUG	1055	0.001	50.0	376.5	441.8
22 SEP	0912	0.001	73.9	321.0	498.2
13 OCT	1250	0.001	95.0	166.5	641.8
3 NOV	1100	0.001	116.0	46.0	767.0
6 NOV	1240	-0.003	119.0	13.5	802.5
7 NOV	1115	-0.003	120.0	13.5	802.5
10 NOV	1000	-0.003	122.9	8.0	810.2
17 NOV	0845	-0.002	129.9	7.0	811.0
17 NOV	1150	-0.002	130.0	5.0	813.0
17 NOV	1355	-0.004	130.1	3.0	815.0
17 NOV	1515	-0.003	130.1	0.5	817.5
18 NOV	1240	-0.002	131.0	-5.0	824.5
18 NOV	1330	-0.004	131.1	-7.5	827.0
19 NOV		INSTRUMENT PASSED BEHIND SHIELDS			

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-3
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C1-5 ANCHORED INTERVAL Ø TO 5 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		527.0	288.8
8 AUG	1040	-	28.9	496.0	322.2
29 AUG	1055	-0.001	50.0	376.5	441.8
22 SEP	0912	-0.001	73.9	321.0	498.2
13 OCT	1250	-0.001	95.0	166.5	641.8
3 NOV	1100	-0.001	116.0	46.0	767.0
6 NOV	1240	-0.006	119.0	13.5	802.5
7 NOV	1115	-0.005	120.0	13.5	802.5
10 NOV	1000	-0.006	122.9	8.0	810.2
17 NOV	0845	-0.006	129.9	7.0	811.0
17 NOV	1150	-0.005	130.0	5.0	813.0
17 NOV	1355	-0.006	130.1	3.0	815.0
17 NOV	1515	-0.006	130.1	0.5	817.5
18 NOV	1240	-0.004	131.0	-5.0	824.5
18 NOV	1330	0.002	131.1	-7.5	827.0
19 NOV		INSTRUMENT PASSED BEHIND SHIELDS			

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-4
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C1-9 ANCHORED INTERVAL Ø TO 9 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		533.0	288.8
8 AUG	1035	0.002	28.9	502.0	322.2
29 AUG	1100	0.002	50.0	382.5	441.8
22 SEP	0915	-	73.9	327.0	498.2
13 OCT	1255	0.003	95.0	172.5	641.8
3 NOV	1100	0.009	116.0	52.0	767.0
6 NOV	1235	0.011	119.0	19.5	802.5
7 NOV	1135	0.008	120.0	19.0	803.2
10 NOV	0955	0.016	122.9	14.0	810.2
17 NOV	0845	0.016	129.9	13.0	811.0
17 NOV	1150	0.014	130.0	11.0	813.0
17 NOV	1400	0.019	130.1	9.0	815.0
17 NOV	1510	0.016	130.1	6.5	817.5
18 NOV	1245	0.028	131.0	1.0	824.5
18 NOV	1330	0.027	131.1	-1.5	827.0
19 NOV		INSTRUMENT PASSED BEHIND SHIELDS			

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-5
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C1-12 ANCHORED INTERVAL Ø TO 12 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		533.0	288.8
8 AUG	1035	0.003	28.9	502.0	322.2
29 AUG	1100	0.002	50.0	382.5	441.0
22 SEP	0915	0.002	73.9	327.0	498.2
13 OCT	1255	0.003	95.0	172.5	641.8
3 NOV	1100	0.010	116.0	52.0	767.0
6 NOV	1235	0.012	119.0	19.5	802.5
7 NOV	1135	0.008	120.0	19.0	803.2
10 NOV	0955	0.013	122.9	14.0	810.2
17 NOV	0845	0.016	129.9	13.0	811.0
17 NOV	1150	0.016	130.0	11.0	813.0
17 NOV	1400	0.016	130.1	9.0	815.0
17 NOV	1510	0.017	130.1	6.5	817.5
18 NOV	1245	0.020	131.0	1.0	824.5
18 NOV	1330	0.018	131.1	-1.5	827.0
18 NOV		INSTRUMENT PASSED BEHIND SHIELDS			

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-6
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C2-3 ANCHORED INTERVAL Ø TO 3 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		1454.5	288.8
4 AUG	1245	-	25.0	1454.4	288.8
22 SEP	1003	-	73.9	1248.5	498.2
14 OCT	1250	-0.001	96.0	1083.5	652.0
3 NOV	1530	-0.001	116.1	973.5	767.0
18 NOV	0950	-	130.9	920.0	827.0
10 DEC	1120	-0.001	153.0	798.0	945.0
14 JAN	1100	-0.001	188.0	642.0	1103.2
18 FEB	1745	-0.002	223.2	396.5	1343.8
18 MAR	1455	-0.002	252.1	304.0	1434.2
21 APR	2010	-0.002	286.3	185.0	1548.0
25 MAY	1440	-0.001	320.1	141.5	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O- 7
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C2-5 ANCHORED INTERVAL Ø TO 5 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		1454.5	288.8
4 AUG	1245	0.003	25.0	1454.5	288.8
22 SEP	1003	-	73.9	1248.5	498.2
14 OCT	1250	-	96.0	1083.5	652.0
3 NOV	1530	-0.001	116.1	973.5	767.0
18 NOV	0950	-	130.9	920.0	827.0
10 DEC	1120	-0.001	153.0	789.0	945.0
14 JAN	1100	-0.003	188.0	642.0	1103.2
18 FEB	1745	-0.005	223.2	396.5	1343.8
18 MAR	1455	-0.005	252.1	304.0	1434.2
21 APR	2010	-0.006	286.3	185.0	1548.0
25 MAY	1-40	-0.005	320.1	141.5	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-8
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C2-9 ANCHORED INTERVAL Ø TO 9 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		1514.5	288.8
4 AUG	1250	0.002	25.0	1514.5	288.8
22 SEP	1005	0.005	73.9	1308.5	498.2
14 OCT	1250	0.005	96.0	1143.5	652.0
3 NOV	1530	0.007	116.1	1033.5	767.0
18 NOV	0950	0.007	130.9	980.0	827.0
10 DEC	1120	0.008	153.0	858.0	945.0
14 JAN	1100	0.010	188.0	702.0	1103.2
18 FEB	1745	0.011	223.2	456.5	1343.8
18 MAR	1455	0.014	252.1	364.0	1434.2
21 APR	2015	0.015	286.3	245.0	1548.0
25 MAY	1435	0.018	320.1	201.5	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-9
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C2-12 ANCHORED INTERVAL Ø TO 12 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		1514.5	288.8
4 AUG	1250	0.002	25.0	1514.5	288.8
22 SEP	1005	0.006	73.9	1308.5	498.2
14 OCT	1250	0.006	96.0	1143.5	652.0
3 NOV	1530	0.008	116.1	1033.5	767.0
18 NOV	0950	0.008	130.9	980.0	827.0
10 DEC	1120	0.008	153.0	858.0	945.0
14 JAN	1100	0.010	188.0	702.0	1103.2
18 FEB	1745	0.011	223.2	456.5	1343.8
18 MAR	1455	0.011	252.1	364.0	1434.2
21 APR	2015	0.013	286.3	245.0	1548.0
25 MAY	1435	0.013	320.1	201.5	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-10
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C3-3 ANCHORED INTERVAL Ø TO 3 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		1432.0	288.8
4 AUG	1340	-	25.1	1432.0	288.8
22 SEP	1016	-	73.9	1219.0	498.2
14 OCT	1210	-	96.0	1076.5	652.0
3 NOV	1345	-	116.1	956.5	767.0
21 NOV	1330	-	134.1	860.5	857.5
10 DEC	1150	0.001	153.0	776.0	945.0
14 JAN	1020	-	187.9	615.5	1103.2
18 FEB	1700	0.001	223.2	380.0	1343.8
18 MAR	1110	0.001	252.0	291.5	1434.2
21 APR	1825	0.001	286.3	183.0	1548.0
25 MAY	1330	0.002	320.1	133.0	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-11
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C3-5 ANCHORED INTERVAL Ø TO 5 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		1432.0	288.8
4 AUG	1340	0.003	25.1	1432.0	288.8
22 SEP	1016	0.009	73.9	1219.0	498.2
14 OCT	1210	0.011	96.0	1076.5	652.0
3 NOV	1345	0.014	116.1	956.5	767.0
21 NOV	1330	0.012	134.1	860.5	857.5
10 DEC	1150	0.012	153.0	776.0	945.0
14 JAN	1020	0.012	187.9	615.5	1103.2
18 FEB	1700	0.012	223.2	380.0	1343.8
18 MAR	1110	0.012	252.0	291.5	1434.2
21 APR	1825	0.013	286.3	183.0	1548.0
25 MAY	1330	0.014	320.1	133.0	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-12
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C3-9 ANCHORED INTERVAL Ø TO 9 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		1441.0	288.8
4 AUG	1345	-	25.1	1441.0	288.8
22 SEP	1015	0.008	73.9	1228.0	498.2
14 OCT	1215	0.008	96.0	1085.5	652.0
3 NOV	1350	0.008	116.1	965.5	767.0
21 NOV	1300	0.009	134.1	869.5	857.5
10 DEC	1150	0.008	153.0	785.0	945.0
14 JAN	1020	0.008	187.9	624.5	1103.2
18 FEB	1700	0.008	223.2	389.0	1343.8
18 MAR	1110	0.008	252.0	300.5	1434.2
21 APR	1825	0.008	286.3	192.0	1548.0
25 MAY	1330	0.009	320.1	142.0	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.

TABLE O-13
SUMMARY OF DIFFERENTIAL ROOF-SAG DATA
INSTRUMENT C3-12 ANCHORED INTERVAL Ø TO 12 FEET

DATE	TIME	TOTAL SAG (1) (inch)	TIME (2) (days)	FACE DISTANCE (ft) (3)	SPAN (4) (ft)
10 JUL	1200	INITIAL READING		1441.0	288.8
4 AUG	1345	0.003	25.1	1441.0	288.8
22 SEP	1015	0.012	73.9	1228.0	498.2
14 OCT	1215	0.011	96.0	1085.5	652.0
3 NOV	1350	0.012	116.1	965.5	767.0
21 NOV	1300	0.013	134.1	869.5	857.5
10 DEC	1150	0.012	153.0	785.0	945.0
14 JAN	1020	0.012	187.9	624.5	1103.2
18 FEB	1700	0.011	223.2	389.0	1343.8
18 MAR	1110	0.011	252.0	300.5	1434.2
21 APR	1825	0.012	286.3	192.0	1548.0
25 MAY	1330	0.012	320.1	142.0	1594.8

NOTES:
Numbers in parentheses refer to notes presented in Table O-1.