RI 9242

REPORT OF INVESTIGATIONS/1989

Surface Fracture Development Over Longwall Panels in South-Central West Virginia

By David K. Ingram

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

Report of Investigations 9242

Surface Fracture Development Over Longwall Panels in South-Central West Virginia

By David K. Ingram

UNITED STATES DEPARTMENT OF THE INTERIOR
Manuel J. Lujan, Jr., Secretary

BUREAU OF MINES
T S Ary, Director

Library of Congress Cataloging in Publication Data:

Ingram, David K.
Surface fracture development over longwall panels in south-central West Virginia.

(Bureau of Mines report of investigations; 9242)

Bibliographies.

Supt. of Docs. no.: I 28.23:9242.

1. Mine subsidences–West Virginia–Raleigh County. 2. Mine subsidences–West Virginia–Boone County. 3. Longwall mining–Environmental aspects–West Virginia–Raleigh County. 4. Longwall mining–Environmental aspects–West Virginia–Boone County. I. Title. II. Series: Report of investigations (United States. Bureau of Mines); 9242.

TN23.U43 [TN319] 622 s [622'.334] 89-600002

CONTENTS

ILLUSTRATIONS

SURFACE FRACTURE DEVELOPMENT OVER LONGWALL PANELS IN SOUTH-CENTRAL WEST VIRGINIA

By David K. Ingram[1]

ABSTRACT

The development of large open surface fractures over mined-out coal longwall panels is the focus of this U.S. Bureau of Mines report. The research concentrates on defining the fractures characteristics and their controlling variables.

The investigation was conducted at two mines in south-central West Virginia. All but one of the fractures are subparallel to the trend of the underlying longwall panel. One fracture is perpendicular to the trend of a longwall panel. Overall length of the fractures ranges from 60 to 900 ft. In cross section they are V-shaped, ranging from a couple of inches to 25 ft in width at the surface, but narrowing as they increase in depth. Fracture depth varies from a few inches to over 50 ft into bedrock. A vertical fracture or joint plane was observed in the bedrock at several open zones along the fractures. All of the fractures vary in elevation and do not parallel surface contours.

The fractures are aligned with local joint trends, they correlate with longwall development, and they are situated in an increased tensional area over the mined out longwall panels. These observations indicate that the fractures are tensional openings along preexisting joint planes possibly triggered by longwall mining.

[1]Geologist, Pittsburgh Research Center, U.S. Bureau of Mines, Pittsburgh, PA.

INTRODUCTION

During the conduct of subsidence monitoring studies in southern West Virginia, large open fractures were observed on the surface. These fractures are in an unpopulated wooded area. They are hundreds of feet long, tens of feet wide, and extend tens of feet deep.

A literature search revealed no reported research on actual field examples of surface fractures over or near active underground longwall mining. However, there are a few reports that mention field examples of surface fractures over retreat pillar mining.[2] It is speculated that such fractures are the result of or are triggered by total extraction mining, but the sequence of development and exact time of fracture initiation are unknown.

The Bureau conducted this research study in an attempt to identify fracture characteristics and to isolate the variables controlling fracture occurrence associated with longwall mining. This work was accomplished by analyzing the local geologic conditions, conducting field inspections, and analyzing previous mining history. The controlling variables were identified by comparing fracture development, mine development, and local geologic conditions.

If the genesis of such fractures could be identified, then it may be possible to take actions to prevent their occurrence. Furthermore, recommendations or guidelines could also be developed such that given similar ground conditions, the mine layout could be altered so that potential fracture zone areas are avoided.

GENERAL GEOLOGY

The two sites that were investigated in this report are located in Raleigh and Boone Counties in south central West Virginia (fig. 1).

The exposed and subsurface major rock units of interest in this study consist predominately of sandstone with interbedded shales, sandy shales, and coalbeds. The two mines studied are extracting the No. 2 Gas (Campbell Creek) Coalbed, which is 1 to 5 ft thick. The topography is mountainous with narrow valleys and ridges. The relief where the study was conducted is about 880 ft with slopes as steep as 40°. Multiple systematic (dominant) fracture or joint trends exist throughout southern West Virginia. As reported by the West Virginia Geological Survey, within Raleigh and Boone Counties there are several varying dominant joint trends.[3] Three of the dominant joint trends within and surrounding the study areas are N 75° E to N 85° E, N 45° W to N 55° W, and N 40° E to N 50° E.

Southern West Virginia lies within the Pocahontas Coal Basin of the Eastern Coal Region. Figure 2 shows the stratigraphic succession of some of the identifiable coalbeds in Raleigh and Boone Counties. Extracting coalbed reserves has been and is being accomplished by strip mining and underground mining. Several strip mining methods are employed in West Virginia, including hilltop and surface contour with auger mining. Underground mining methods include room-and-pillar and/or longwall mining. Both mines discussed in this report employ a combination of room-and-pillar and longwall mining. Strip mining has also occurred in the vicinity of the study areas.

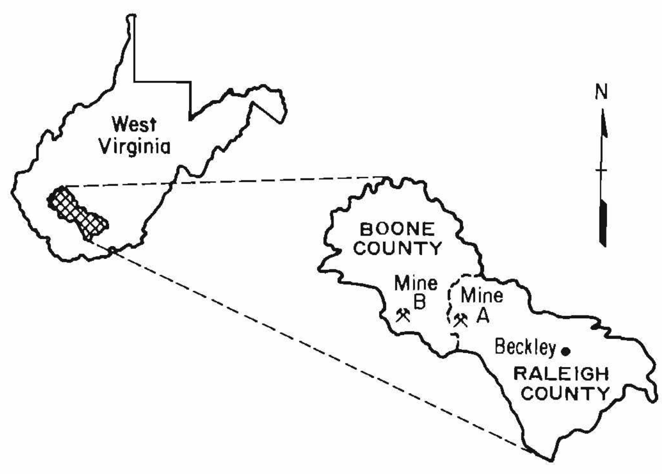

Figure 1.–Location of two study mines in West Virginia.

---

[2]Bauer, R. A., E. M. Gafell, D. W. Barkley. Characterization of Coal Mine Subsidence and Impacts on Bedrock and Near Surface Hydrology Over a Shallow High-Extraction Retreat Mining Operation in Illinois. Paper in Proceedings of the 1987 National Symposium on Mining, Hydrology Sedimentology, and Reclamation, Lexington, KY, Dec. 7-11, 1987. Univ. KY, Lexington, KY, 1987, pp. 197-202.

Dunrud, C. R. Some Engineering Geologic Factors Controlling Coal Mine Subsidence in Utah and Colorado. U.S. Geol. Surv. Prof. Paper 969, 1976, pp. 8-19.

[3]Kulander, B. R., and S. L. Dean. Fracture Trends in the Allegheny Plateau of West Virginia. WV Geol. Surv., Map WV-11, 1980.

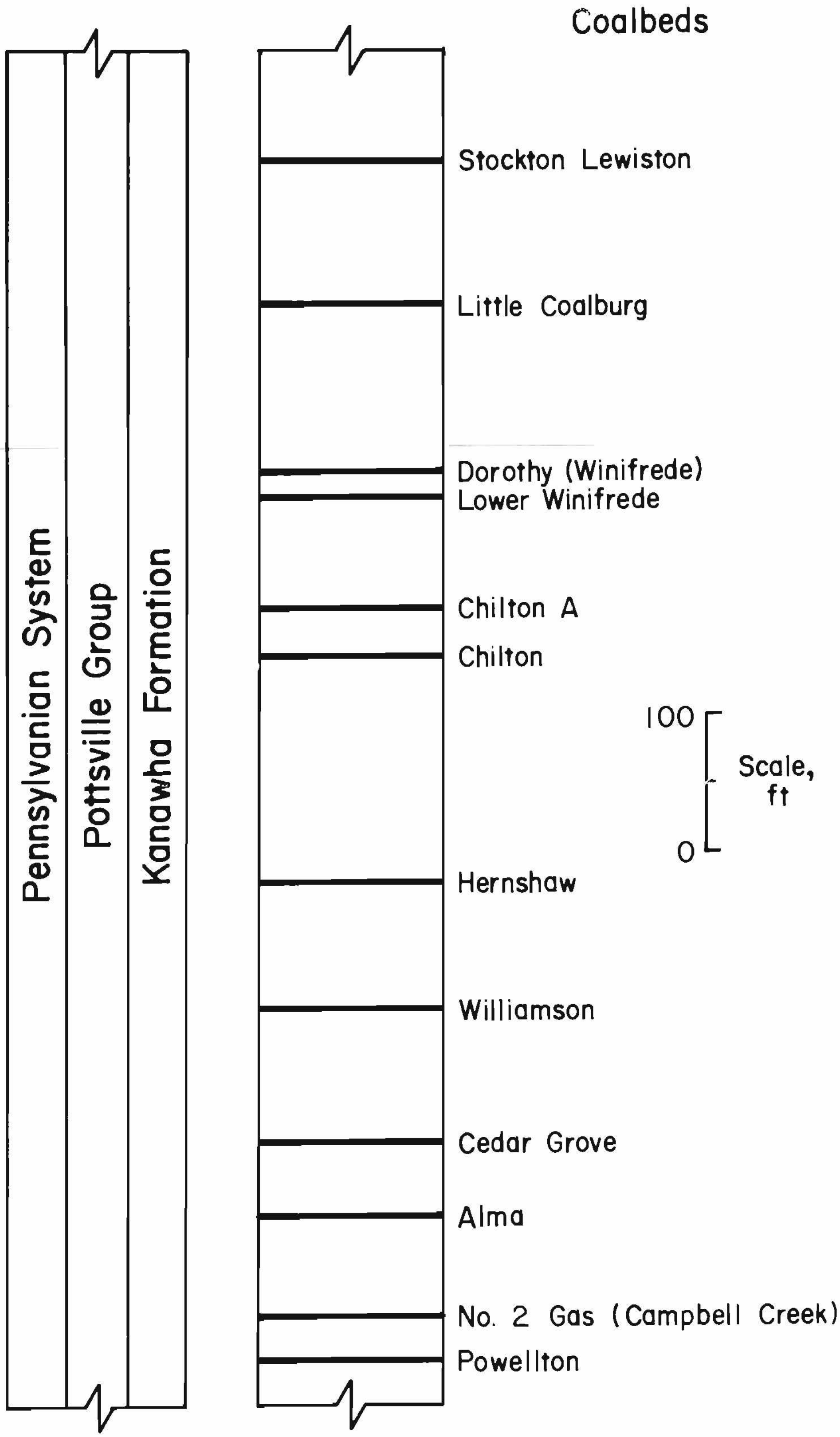

Figure 2.-Generalized stratigraphic column of coalbeds in Raleigh and Boone Counties, WV.

FIELD EXAMPLES OF FRACTURES

Several large open tensional fractures were observed during longwall subsidence monitoring projects at the two mine sites. The fractures exist over or near mined-out longwall panels. They are linear and vary in length, width, and depth. The following is a summary of observations and measurements at each site.

MINE A

The study area at Mine A includes three adjacent longwall panels (fig. 3). The panels are oriented N 45° W, range from 400 to 600 ft wide, and 5,000 to 6,000 ft in length. Mining of these panels begins in the northwest and advances to the southeast. The two fractures that were investigated at this mine are situated over the headgate entries of longwall panel 2 (fig. 3). This panel was 500 ft wide and 5,400 ft long with four entry gate roads on either side. Overburden near the fractures ranged from 600 to 1,100 ft. Mining of this panel required 7 months. The monthly rate of mining for this panel was about 800 ft. One fracture was observed approximately 2 months before completion of the panel. This fracture was detected by the presence of a large linear bare spot in the snow-covered ground. At that time, the longwall panel working face was positioned about 1,500 ft southeast of the reported fracture (fig. 3). The second fracture was observed 3 months later, after the panel was completed.

Field investigations revealed that the two fractures were continuous, parallel, and linear. One fracture measured 900 ft in length, and the other measured 450 ft (fig. 4). Orientation of the fractures varied from N 30° W to N 40° W. In cross section they were V-shaped. The width of the fractures, on the surface, ranged from a few inches at the ends to 25 ft towards the center. The fracture width appeared to narrow with increasing fracture depth. Fracture depth also varied from several inches to more than 50 ft into bedrock. A well-pronounced vertical fracture or joint plane was observed in the bedrock along the wider zone of the fractures (fig. 5). The fracture planes appear to curve toward the northeast about 30 ft below the surface.

The stratigraphy viewed in the largest fracture exhibited unconsolidated surface material varying in thickness from 0 to 35 ft. This zone was composed of strip mine spoil deposits from previous hilltop strip mining operations (fig. 6). The uppermost rock unit was a 1- to 1.5-ft-thick coalbed. This coalbed overlies a claystone deposit about 2 ft thick. Under the claystone was a 3-ft-thick coalbed and then a massive sandstone, over 20 ft thick, as deep as could be seen in the open fracture. Total thickness of the strata between the fractures and the mine ranges from 550 to 900 ft.

During the 4-month field investigations, the fracture characteristics changed somewhat. The first observed and largest fracture extended both in length and width. Fracture length increased approximately 200 ft (on both ends) during the first 2 months. Fracture width, which only widened at the surface, increased as much as 10 ft. This increase in width was due to the strip mine spoil eroding and collapsing into the fracture opening (fig. 7). Such erosion of the mine spoil and in-filling the open fracture void caused a general decrease in fracture depth. It is not known if the smaller fracture developed at the same time as the larger one. However, the characteristics of the smaller fracture also appear to have changed in a similar manner as the larger fracture. The fracture width at the surface was also eroding and collapsing into the void area.

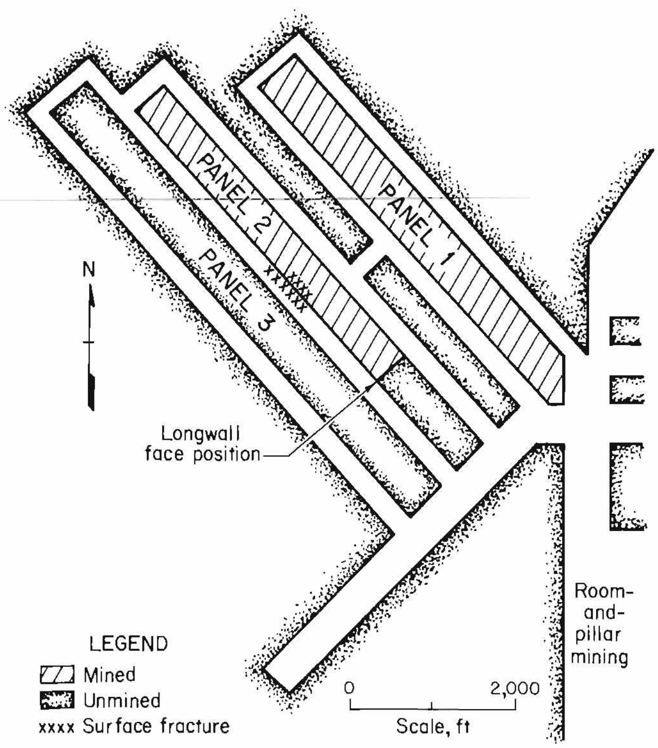

Figure 3.–Location of surface fractures and longwall face position at Mine A.

Figure 4.–Largest fractures over Mine A.

Figure 5.–Joint plane in open zone in fracture at Mine A.

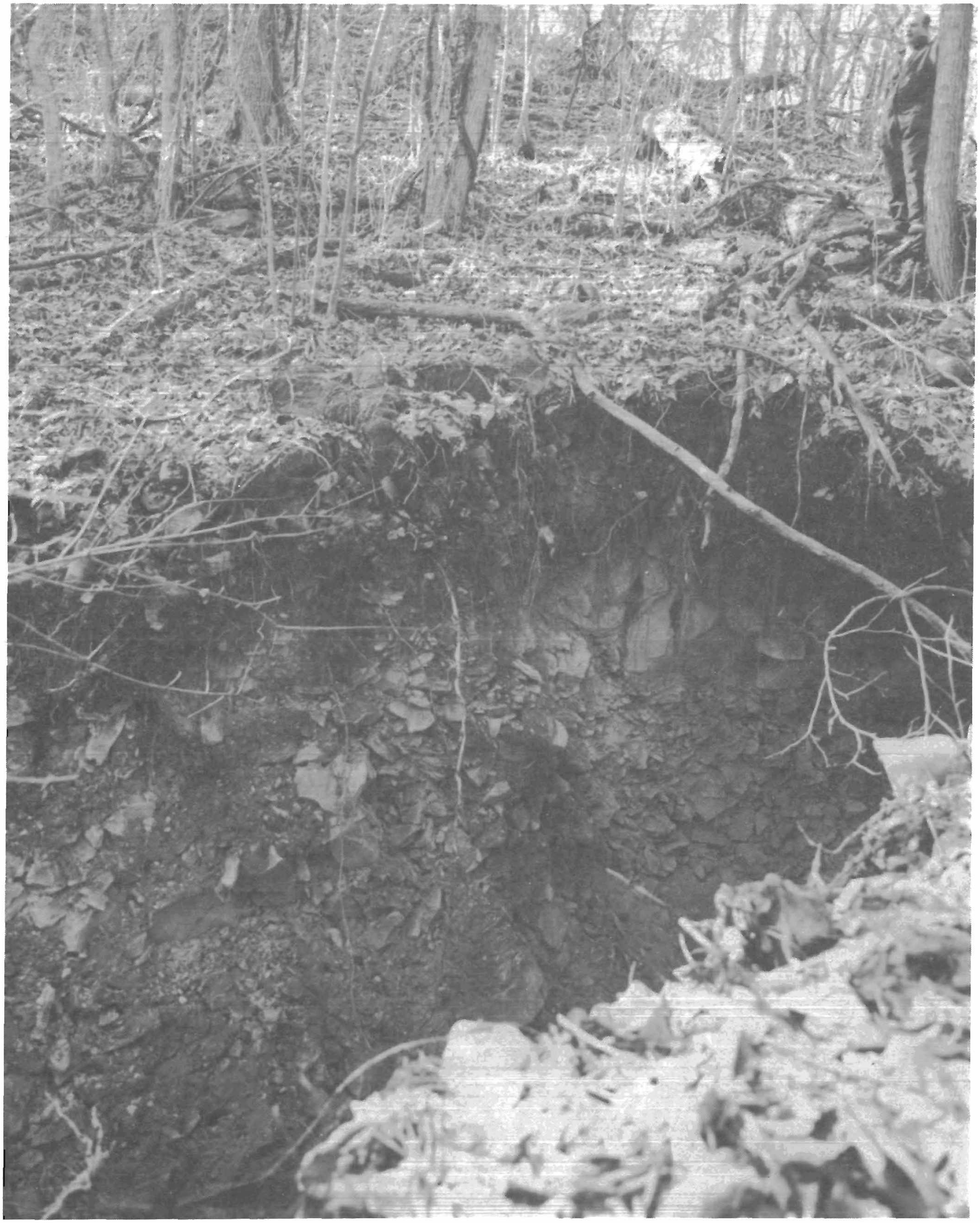

Figure 6.–Strip mine spoil in open zone along fracture at Mine A.

Figure 7–Overburden eroding and washing into open fracture at Mine A.

Both fractures are situated along a hillside closer to the top of the ridge than the valley bottom (fig. 8). The fracture trended subparallel to the valley and ridge. The largest fracture ranged in elevation from 1,860 to 2,040 ft, about 80 to 200 ft below the top of ridge. The smaller parallel fracture was about 80 ft below the larger fracture. It ranged in elevation from 1,680 to 1,860 ft. The relief at this location was about 880 ft with a slope of 39°.

Hilltop and contour-auger strip mining was evident above and below the fractures (fig. 8). Both strip mining operations occurred before the development of the underlying longwall panels. The effects from the hilltop strip

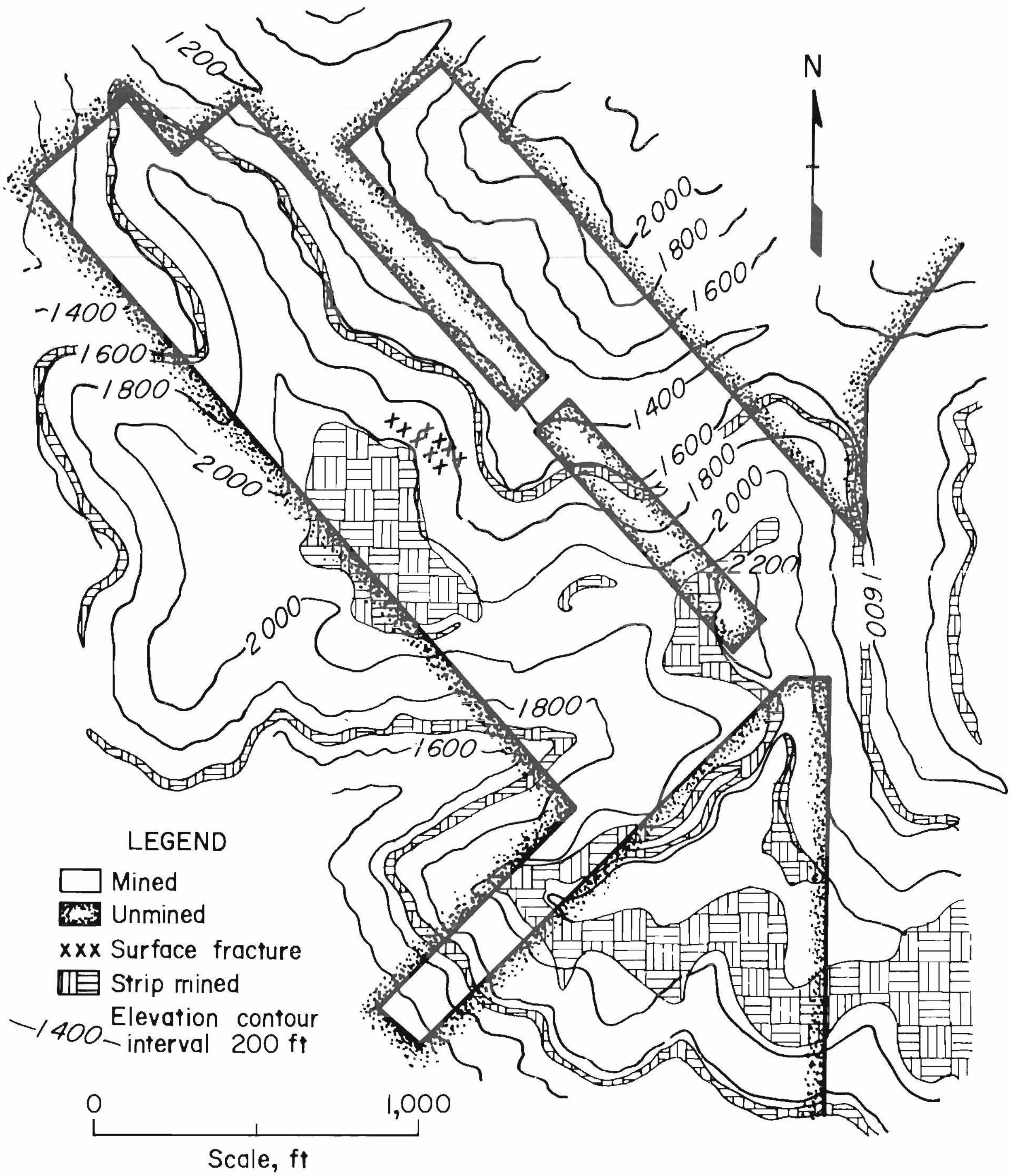

Figure 8.–Topographic map with locations of fractures overlying Mine A.

mining lowered and altered the natural narrow ridge elevation about 180 ft to a flat plateau type of feature. Effects from the contour strip mining left a bench type of feature. The strip bench occurred at an elevation of 1,600 ft. This bench measured about 30 ft wide and 25 ft high.

MINE B

The study site at Mine B included a series of four adjacent longwall panels (fig. 9) orientated N 87° W. The panels were 650 ft wide and ranged from about 2,400 to 5,500 ft in length. Mining of the panels advanced from west to east. Three fractures were observed at Mine B; two were over the gate entries between panels 2 and 3, and one was over the center of panel 3 (fig. 9). Panels 2 and 3 were 4,550 and 5,400 ft long, respectively. Overburden near the fracture area ranged from 650 to 1,000 ft. Mining of panels 2 and 3 required 9 months and 10 months, respectively. The monthly rate of mining for panel 2 was 505 ft and for panel 3 it was 450 ft.

The fractures at this mine, as at Mine A, were first observed by surveyors after snow accumulation. The two paralleling fractures, positioned over the gate entries, were first observed after panel 2 was completed. The working longwall face on panel 3 was positioned about 350 ft west of the two fractures (fig. 9). The single fracture overlying panel 3 was first observed when the longwall face was about 520 east of this fracture (fig. 9). Again as at Mine

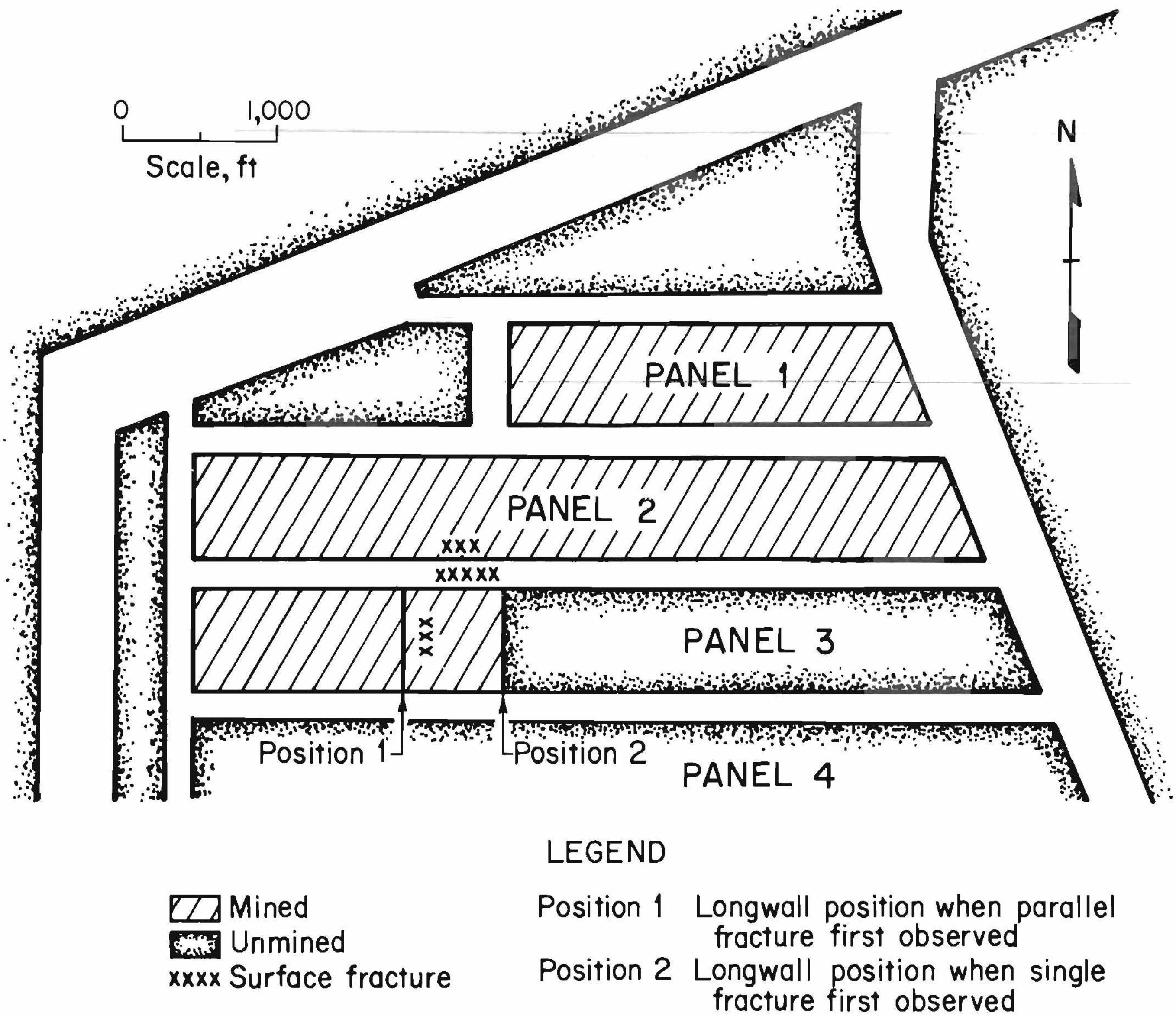

Figure 9.–Location of surface fractures and longwall face positions at Mine B.

A, it is not known if these fractures developed at the same time.

Fractures mapped at Mine B were not as pronounced as the fractures at Mine A. The two parallel linear fractures overlying the gate entries were 245 and 96 ft in length. The single linear fracture in the center of panel 3 was approximately 60 ft in length.

Orientation of the two parallel fractures ranged between N 50° W and N 65° W. Orientation of the single fracture was N 23° W, approximately perpendicular to the two parallel fractures. Only the fractures over the gate entries have open zones (fig. 10). The fracture in the center of panel 3 was only expressed on the surface by a narrow crack several inches wide and deep (fig. 11). The open zones in the two paralleling fractures randomly occurred along the fracture traces. These open zones were connected by a narrow crack only a few inches wide and deep. On the surface, these open zones ranged from about 0.5 to 2 ft in width and from 2 to 15 ft in length (fig. 10). In cross section these open zones were V-shaped. They narrowed in width as they increase in depth. Depth varied from 0.5 to 16 ft.

A vertical fracture or joint plane was observed in the bedrock in several of these open zones. The horizontal offset of these open zones suggests that there may be a series of adjacent parallel fractures instead of a single fracture plane. Stratigraphically, depth to bedrock varied from 0 to 8 ft. The only observed rock unit underlying the overburden was a sandstone. Total thickness of the strata between the fractures and the mine ranged from 1,000 to 1,100 ft. The three fractures have undergone subtle changes from when they were first identified.

All three fractures were situated on or near the top of a mountain ridge (fig. 12). As at Mine A, these fractures do not parallel surface contour elevations. The two parallel fractures ranged in elevations from about 1,920 to 2,000 ft. The longest fracture extended over the top of the ridge and continued down both sides. The single fracture ranged in elevation from approximately 1,920 to 1,980 ft. Elevation at the top of the mountain ridge was about 2,000 ft. The relief in the study area was about 880 ft with slopes of 25°. To date there has been no strip mining in the study area of Mine B.

RELATIONSHIP AMONG FRACTURES, MINING, AND GEOLOGY

There are many similarities among the mine geometries, the characteristics of the fractures, and the local structural geologic conditions. Both Mines A and B are operating in the same coalbed. They both have longwall panels that are similar in size. Orientation of the panels are generally east-northeast to west-southwest. They both develop their panels from east-northeast to west-southwest. Monthly rate of mining between the two mines only varies by about 200 ft. Both mines have similar overburden thicknesses and overlying rock strata. The overlying topography of both mines is mountainous with narrow ridges and valleys. The relief is the same at both mines, with slopes of 39° at Mine A and 25° at Mine B.

The fractures overlying both mines have similar characteristics. All but one of the fractures are subparallel to the trend of the underlying longwall panels. The subparallel fractures appear to occur in pairs and overlie gate entries or rib lines of the longwall panels. All of the fractures are continuous, fairly linear, and do not occur at the same elevation. In cross section they are V-shaped. A well-pronounced fracture or joint plane was observed in all of the open zones of the fractures.

The reason the fractures at Mine A are larger than the fractures at Mine B could be the effects of old strip mine workings located above and below the fractures at Mine A (fig. 8). Both strip mine operations disrupted the natural contouring of the original surface. The lower strip mine bench could have altered the natural stability of the slope before undermining occurred. The slope of the hillside is a steep, 40°. Configuration of the bench and the openings left by augering mining could have removed some of the lower support needed to maintain a stable slope, particularly above the strip mine bench where additional unconsolidated overburden was deposited during the hilltop strip mining operation.

Surface slumping, evidence of a readjustment in the slope stability, was observed along the lower strip mine bench (fig. 13). Several of the slumps had characteristics of being recent. Trees were tilted and freshly exposed soil was observed within the slumps (fig. 14). The older slumps were distinguished from the more recent slumps by occurrence of mature vegetation and vertical trees. Evidence of recent slumping suggests that the fractures could have been influenced by this movement. Slumping may have contributed additional movement during or after the development of the fractures.

There are several correlations among fracture development, longwall mining, and local geologic conditions. All of the fractures had physical features that indicate the fractures developed shortly before they were first observed by the surveyors. When they were first observed, the fractures showed little to no erosion or weathering. The contact of the fractures on the surface looked fresh. The edges along the fractures were sharp and defined. If the fractures were to have closed after they were first observed, they would have left little evidence that they ever existed. During the several months of field investigations it was evident that the fractures were getting wider and

Figure 10.–Open zone in a paralleling fracture overlying Mine B.

Figure 11.–Single hairline fracture overlying center of panel 3 at Mine B.

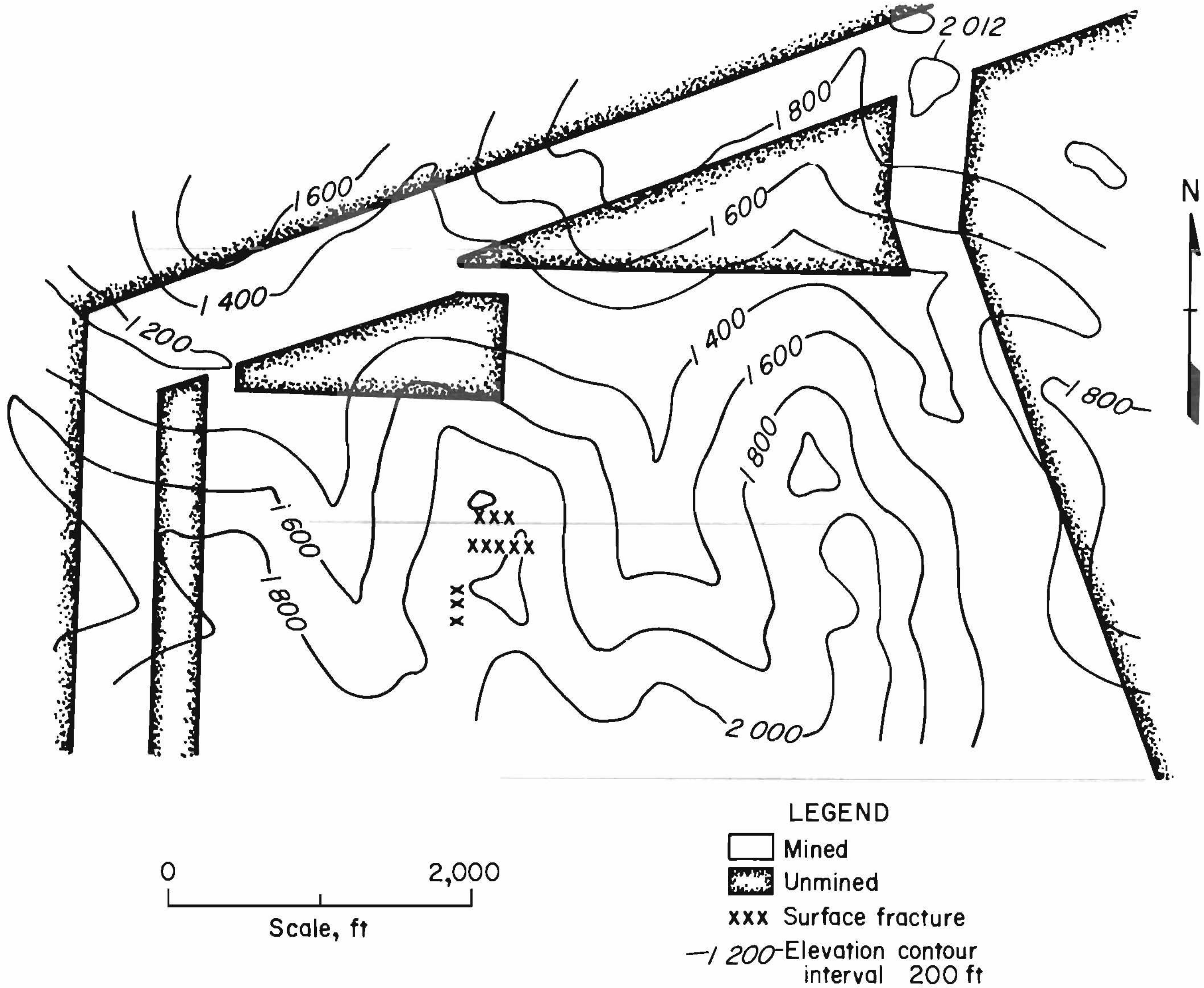

Figure 12.–Topographic map with locations of fractures overlying Mine B.

in-filling was taking place because of the natural weathering process. Furthermore, the vegetation disturbed along the fracture traces was not decomposed or completely dead. This became more pronounced during the spring when the vegetation started to show its foliage.

Field mapping indicates that all of the fractures developed at Mines A and B after longwall mining passed beneath, and only a short period before they were first observed. Also, the occurrence of three of the five fractures observed closely correlated with the time of mining of the underlying longwall panel. The knowledge of when the fractures developed in relation to the longwall face position suggests that fracture development may depend on face position.

The strata above a longwall panel is subjected to changes in stress during mining. The transitional period of these changes occurs as longwall mining advances. The changes in the stress field can cause alterations in the structural integrity as well as a gross displacement in the overlying strata. All of the fractures situated over or near the gate entries appear to be in the zone of increased tension normally created by longwall mining (fig. 15).[4]

The single fracture in the center of the panel at Mine B was also in an area that was influenced by longwall mining. As longwall mining advances there is usually an advancing wave of subsidence occurring perpendicular to the axis of the panel. Generally, this wave occurs directly

[4]U.S. Bureau of Mines, Staff. Mine Subsidence Control. Proceedings: Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, September 19, 1985. IC 9042, 1985, 56 pp.

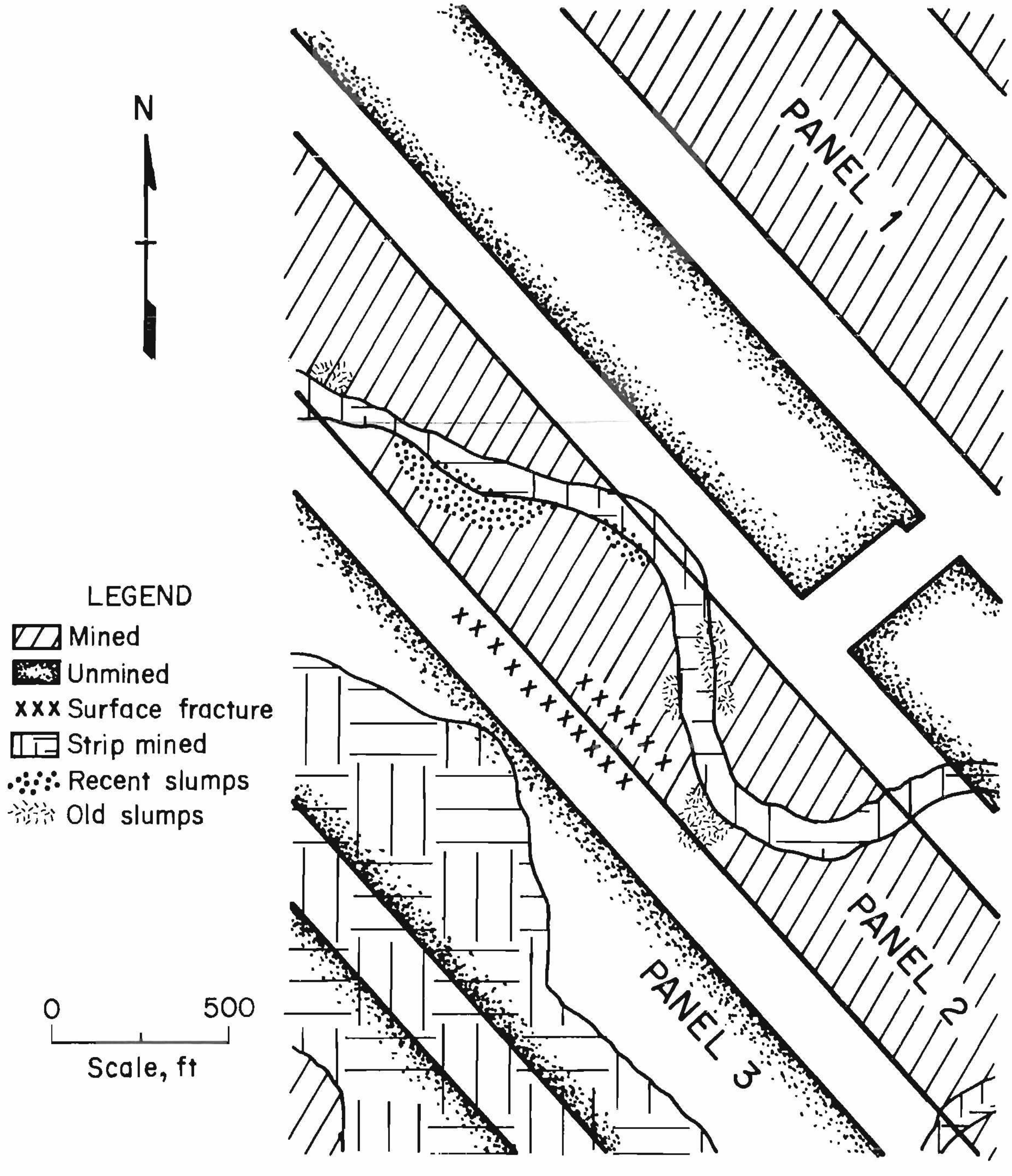

Figure 13.–Locations of fractures, strip mines, and slump features overlying Mine A.

above the advancing working face. This advancing wave creates a tensional force and then changes to a compressional force before maximum subsidence is achieved (fig. 16). The single fracture may be a result of that subsidence wave. The wave may have caused a tensional opening that was closed by the trailing compressional stress as the wave advanced. This would explain why just this fracture has no open zone along its trace.

Figure 14.–Recent slump fractures over Mine A.

Dominant systematic fracture or joint trends were measured at rock outcrops at several different locations over Mines A and B. Outcrop measurements of joints over Mine A indicate a systematic trend oriented northwest to southeast (fig. 17). The fractures and the longwall panels at Mine A align with this northwest-southeast trend. Outcrop measurements of joints over Mine B indicate two systematic trends (fig. 17). One trend is oriented northwest to southeast, the other is oriented north-northeast to south-southwest. Unlike Mine A, only the fractures align with these joint trends at Mine B. The longwall panels are oriented about 35° (N 87 W) west of the northwest to southeast joint trend. The two paralleling fractures over or near the longwall gate entries align with the northwest to southeast joint trend. The single fracture situated over the center of longwall panel aligns with the north-northeast to south-southwest joint trend.

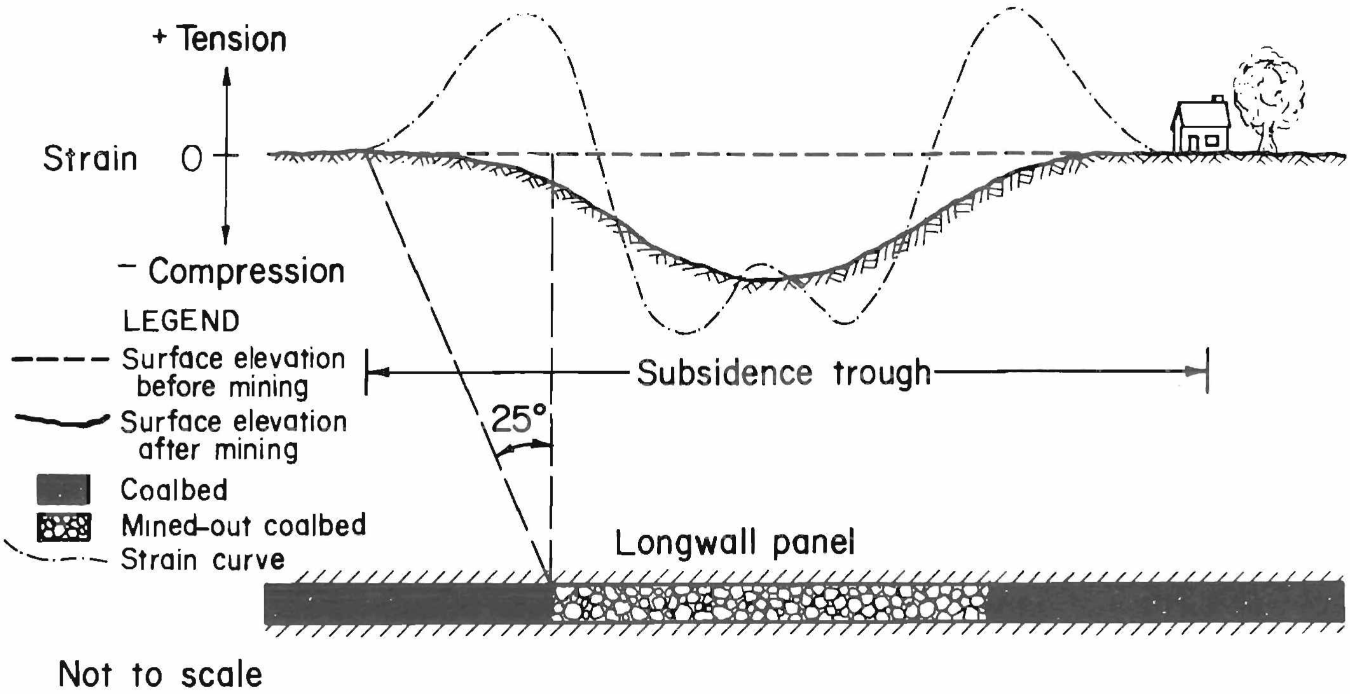

Figure 15.–Subsidence trough and strain distribution on surface caused by longwall mining.

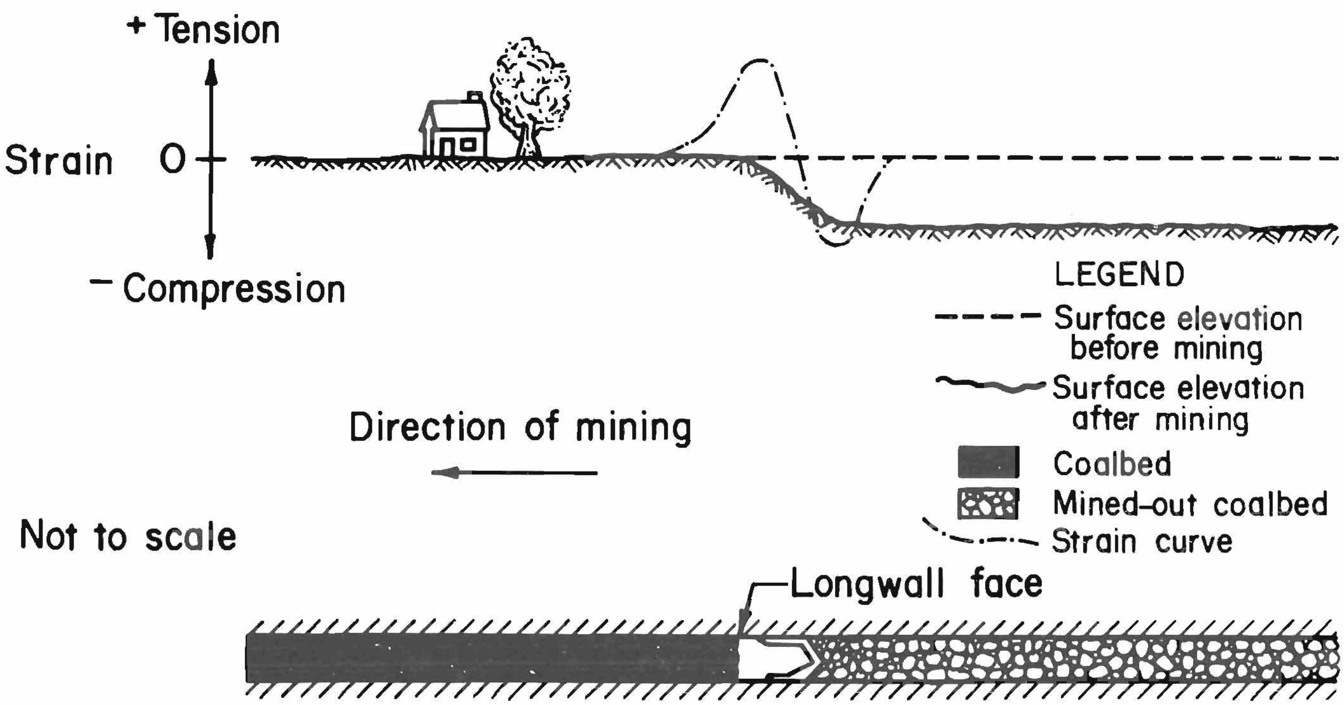

Figure 16.–Strain distribution along wave of subsidence during longwall development.

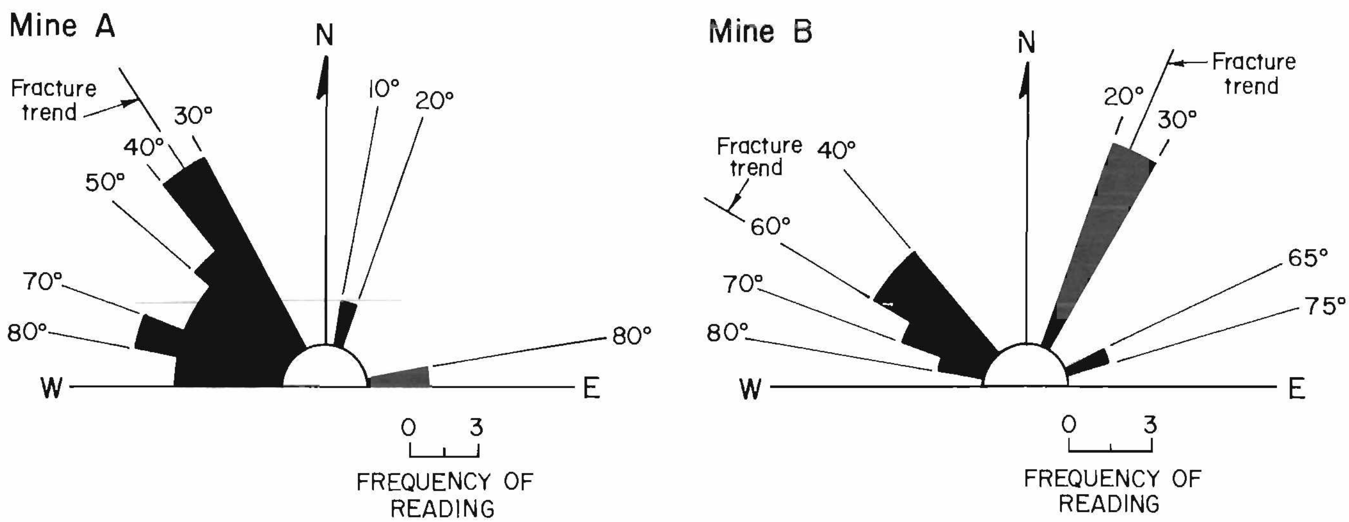

Figure 17.–Rosette diagram of fracture measurements in rock outcrops on surface near fractures at Mines A and B.

CONCLUSIONS

Based on the information collected in this investigation, fractures appear to occur along preexisting joint planes. The tensional separation along these joint planes (fractures) could have been triggered by normal subsidence created by longwall mining. The greater magnitude of the fractures at Mine A could have been caused by additional influence from previous strip mining and topographic relief. If the fractures occur along preexisting joints triggered by longwall mining, then modification in mine layout could be used to control their occurrence. Longwall panels should be oriented 45° to the orientation of the local dominant joint trends. However, orienting panels 45° to joint trends could be difficult if there were several different joint trends occurring in the same local area. Such is the case in southern West Virginia.