RI 9338

REPORT OF INVESTIGATIONS/1991

Subsidence Over the End of a Longwall Panel

By Paul W. Jeran and Vladimir Adamek

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

Mission: As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.

Report of Investigations 9338

Subsidence Over the End of a Longwall Panel

By Paul W. Jeran and Vladimir Adamek

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

BUREAU OF MINES
T S Ary, Director

Library of Congress Cataloging in Publication Data:

Jeran, P. W.

Subsidence over the end of a longwall panel / by Paul W. Jeran and Vladimir Adamek.

p. cm. — (Report of investigations; 9338)

Includes bibliographical references.

Supt. of Docs. no.: I 28.23:9338.

1. Mine subsidences—Appalachian Region. 2. Longwall mining Environmental aspects—Appalachian Region. I. Adamek, Vladimir, 1925- . II. Title. III. Series: Report of investigations (United States. Bureau of Mines); 9338.

TN23.U43 [TN319] 622 s—dc20 [622'.334] 90-2634 CIP

CONTENTS

Page

ILLUSTRATIONS

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ft	foot
pct	percent

SUBSIDENCE OVER THE END OF A LONGWALL PANEL

By Paul W. Jeran[1] and Vladimir Adamek[2]

ABSTRACT

Subsidence was monitored by the U.S. Bureau of Mines over the ends of longwall panels operating in the Pittsburgh, Kittanning, and No. 2 Gas Coalbeds of the northern Appalachian Coal Basin. The final subsidence over the finishing ends of three panels in the Pittsburgh Coalbed are compared with the subsidence measured over the rib at these panels. The characteristics of subsidence are different. At Mine A, data over the start of a longwall panel shows similar characteristics to the subsidence measured over the rib. Subsidence over the finishing ends of panels in the Kittanning and No. 2 Gas Coalbeds are also different from the subsidence over the rib. The use of a subsidence prediction model based on data gathered over the rib of a panel will not yield accurate results if it is applied to the finishing end of a longwall panel. Acceptable results may be obtained along the centerline over the starting end of a panel.

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

INTRODUCTION

The mining of a long rectangular block of coal by longwall method results in the development of a trough-shaped depression of the surface above the extracted area. Figure 1 is an isometric sketch of half of the subsidence trough that was developed as a result of longwall mining. The projection of the underlying panel to the trough is shown by heavier line.

The subsidence trough can be divided into three zones based upon subsidence characteristics: start, central, and finish. The central zone, where maximum subsidence occurs, is the largest of the three. Subsidence in this zone varies only across the width of the panel and remains constant along the length. Subsidence within the remaining two zones varies both across the width of the panel and along the length. References to the profile in this report refer to the transverse (or lateral) profile across the width of the longwall panel. Reference to the centerline refer to the longitudinal profile along the length of the panel centerline.

Practically all subsidence monitoring and research has been conducted in the central zone. There are several reasons for this. The central zone usually covers more than half of the disturbed surface. It also contains the maximum deformation of the surface (S_{max}). Monitoring of subsidence is simpler than for the start and finish zones. Figure 2 shows a typical array of points used in monitoring subsidence in the central zone as well as arrays that could be used to monitor subsidence over the ends of a longwall panel. The arrays over the ends have over twice the number of points used in the central zone array. The data from the end array are of unique points since each differs with respect to its distance from the rib and end. Those from the central array are duplicated because they only differ in their distance from the rib. If the trough is symmetrical, as would occur with a flat-lying, uniform coal bed, relatively level topography, and constant geology and mine geometry, then the two profiles, in the central zone, would yield four sets of comparable data from one panel; the end array would yield only one set. Data from the central area are usually easier to analyze since variance is only in one direction, and the multiple data sets from a single site permit the isolation of anomalous measurements and the use of simpler statistics for analysis.

The lack of data from the start and finish zones and the difficulty of obtaining complete sets of data in these areas leads to the assumption of subsidence characteristics of the entire area based upon data gathered in the central zone. These may be valid only if the

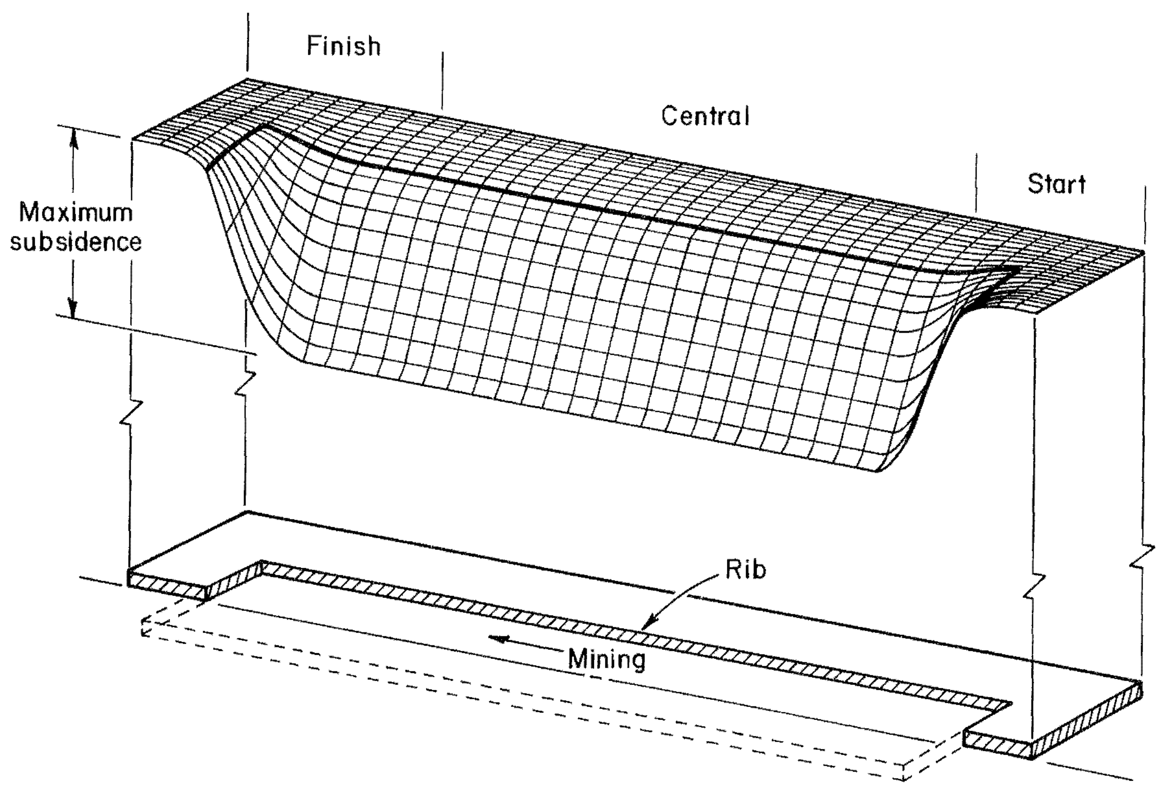

Figure 1.—Isometric sketch of subsidence trough. NOTE: Subsidence is exaggerated.

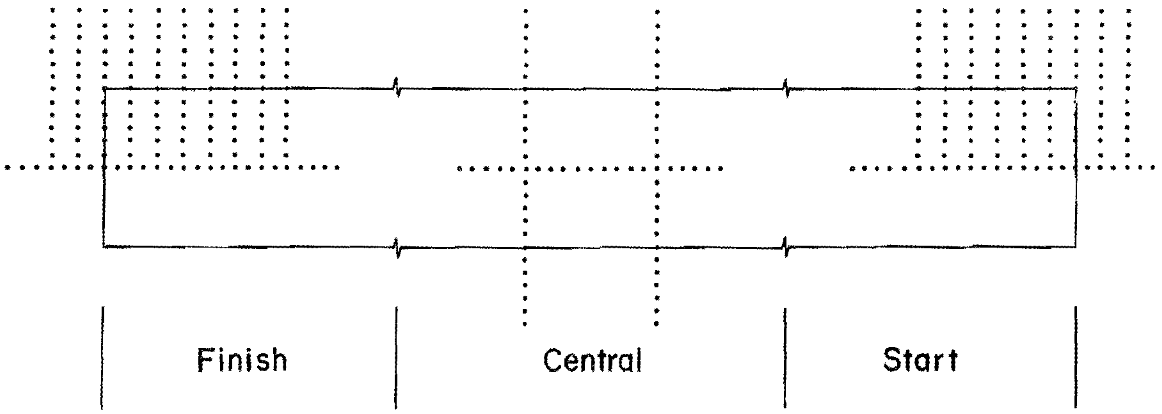

Figure 2.—Typical monitoring arrays for center and ends of subsidence trough.

characteristics of subsidence over the entire area is similar to what is known or measured from the central zone.

Whenever possible, the U.S. Bureau of Mines has tried to obtain some data within the start and finish zones. These data have been from the extension of the centerline over the end of the panel. Along this line, the effect of the lateral ribs are balanced, and the effect of the end of the panel can be studied. To date, five such data sets have been obtained.

The mining industry must submit, as part of the permit application process, an estimate of the subsidence that will result from the proposed mining. There are several models available[3] that predict subsidence over high extraction mining. To the best of the authors knowledge, all of these models are based upon data gathered in the central portion of the trough. The application of these models to the ends of a longwall panel is valid only if the subsidence at the ends closely follows that which occurs in the central portion of the trough.

[3] Ingram, D. K., M. A. Trevits, and J. S. Walker. A Comparison of Subsidence Prediction Models for Longwall and Room-and-Pillar Conditions. Paper in Proceedings of AMC/Longwall USA Conference, Pittsburgh, PA, June 1989, 16 pp.

SITE DESCRIPTIONS

Data have been gathered at five panels in the northern Appalachian Coal Basin (fig. 3). At each site, the monitoring array was installed prior to any disturbance by mining. Since each of these was a subsidence monitoring site, data were also obtained over the central portion of the trough. Three of these are from longwall panels in the Pittsburgh Coalbed. These panels, ranging from 600 to 630 ft wide, were several thousand feet long and had differing overburden thicknesses (figs. 4-5).

At Mine A, subsidence was measured over both the start and finish of the panel. This panel is 600 ft wide. Overburdens ranged from 460 to 681 ft over the start, from 428 to 575 ft over the finish, and from 517 to 579 ft over the profile. The final subsidences are plotted (fig. 6) relative to the rib and ends of the panel (positive locations are within the limits of the panel). The maximum subsidence over the start of the panel is less than that which occurred over the profile and finish of the panel. This probably resulted from a change in extracted thickness and does not reflect a difference in subsidence characteristics.

At Mine B, subsidence was measured over the finishing end of the panel. This panel is 625 ft wide. Overburdens

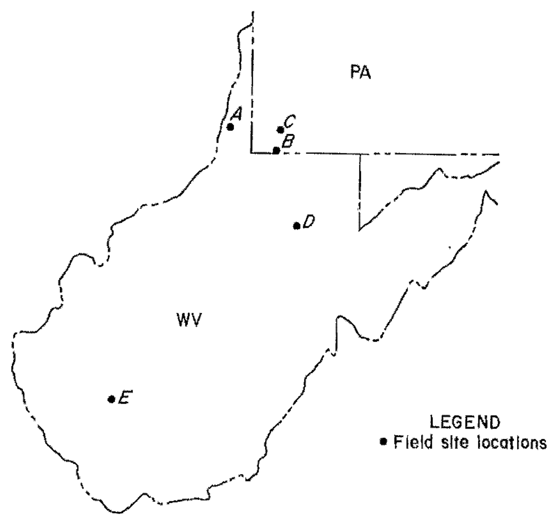

Figure 3.—Location of subsidence monitoring sites.

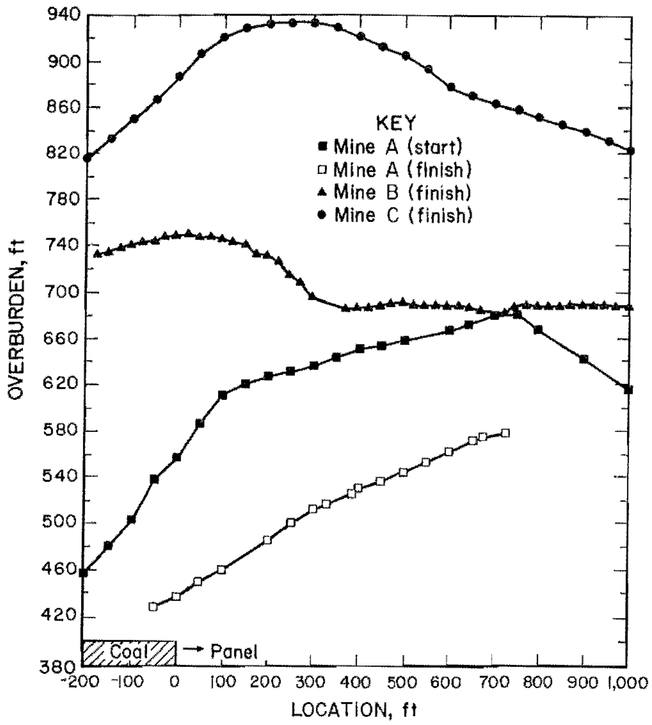

Figure 4.—Overburdens above ends of panels.

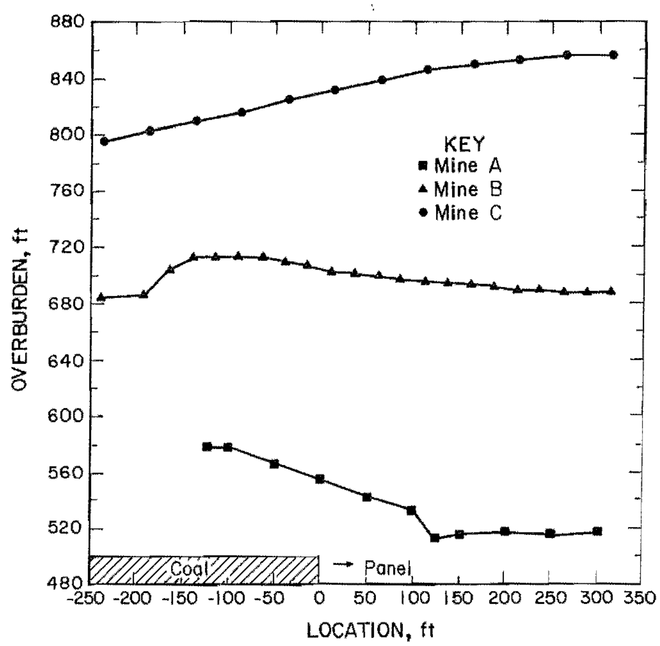

Figure 5.—Overburdens above profiles.

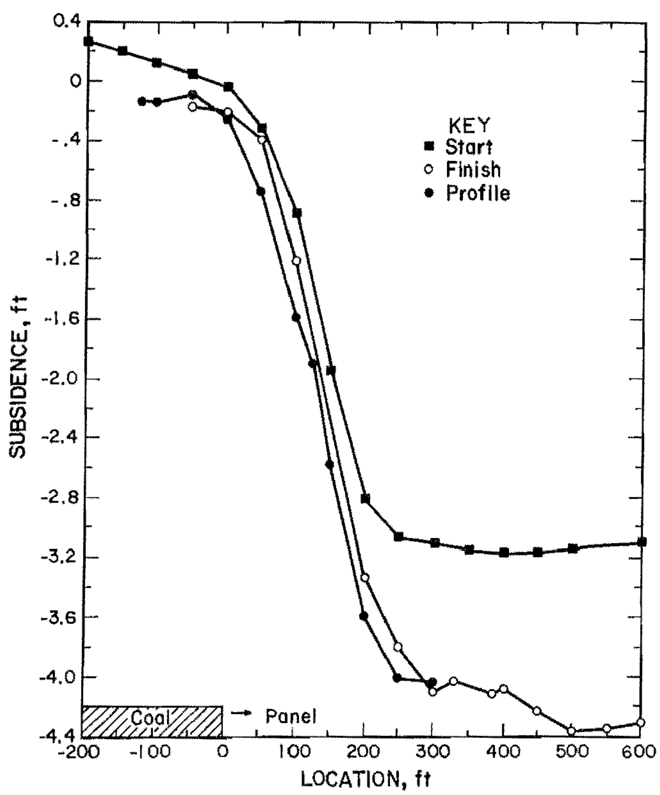

Figure 6.—Mine A—Subsidence over start, finish, and rib.

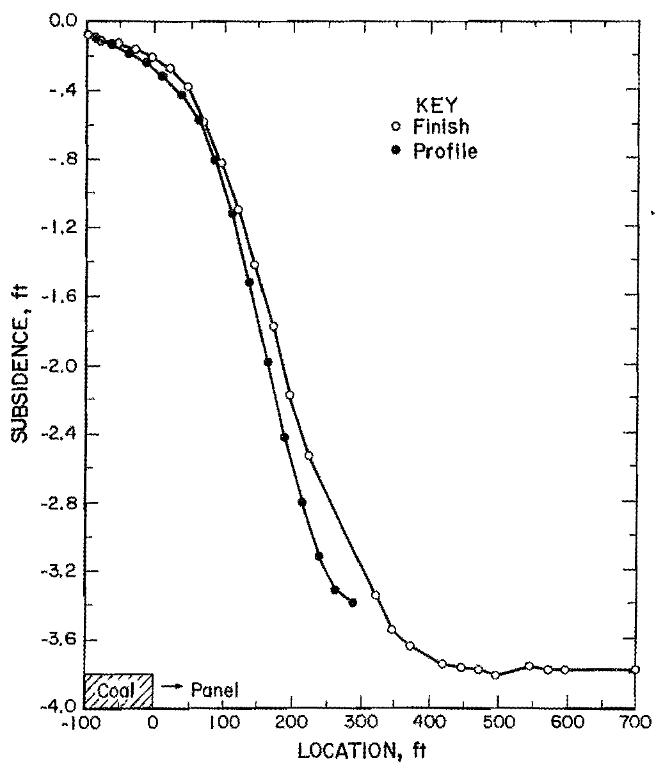

Figure 7.—Mine B—Subsidence over finish and rib.

ranged from 683 to 750 ft over the end and from 683 to 715 ft for the profile. The final subsidences are plotted in figure 7 following the same convention as Mine A.

At Mine C, the panel is 630 ft wide, and overburdens ranged from 795 to 935 ft over the centerline and from 776 to 839 ft over the profile. The final subsidence over the finishing end of the panel and profile are shown in figure 8.

DISCUSSION

The process of subsidence is dynamic during active mining and for a short time thereafter. Jeran and Barton[4] have reported that, in the northern Appalachian Basin, movement in the central portion of the trough is generally 90 pct or more completed when the face has mined past a surface point a distance equal to the thickness of the local overburden. When mining is initiated, there is no movement at the surface until the gob has developed. Surface movement then begins and continues until some maximum displacement has occurred; the magnitude of which is controlled primarily by the extracted thickness, the width of panel, and the overburden thickness and type. As mining progresses and the length of the gob increases, the zone of maximum subsidence lengthens along the centerline of the panel. This process continues until mining stops. Shortly after, the cessation of mining equilibrium is reached and surface deformations due to subsidence become static.

The graphs of the final subsidence measured at each of the monitored sites show that the subsidence relative to the rib in the central portion of the trough differs from that observed over the finishing end of the panel. The degree of difference varies among the sites. In general, the distance from the rib to the first point of maximum subsidence along the profile (at the center of the panel) is less than the distance from the end to the first point of maximum subsidence along the centerline. The distance from the finishing end to the first point of maximum subsidence appears to increase with overburden thickness.

To remove some of the effects of differing extraction thickness and overburden variation, the data were normalized by dividing by maximum subsidence to obtain percent of maximum subsidence. This permits comparison among the sites. Figure 9 shows the profile data and their similarity. Figure 10 shows that there is no such similarity for the subsidence over the ends of these longwall panels. The curve Mine A (start) reaches maximum subsidence closest to the end of the panel, and curve Mine C reaches maximum subsidence furthest from the end. These curves come from the sites with the thinnest and thickest overburdens.

If the location of each point is divided by the overburden thickness and the data replotted (fig. 11), the curves from the finishing ends are brought into agreement. This shows that the subsidence over the finishing ends of the longwall panels is significantly affected by overburden thickness. The curve over the starting end does not match those over the finishing end. If the percent of subsidence over the start is compared with the percent of subsidence over the rib at this site (fig. 12), then subsidence over the start of this longwall panel correlates to the subsidence over the rib. If this relationship holds after future investigation, then subsidence prediction models based on rib data may be applied to the centerline over the start of a longwall panel, but not over the finishing end.

At the initiation of subsidence, the surface is moving toward the gob as the overburden fills the created void. The strata above the rubbelized zone bend and bridge over the ribs, face, and starting end. As the face advances, the zone of movement follows leaving the strata draped over the starting end in a static state similar to that existing over the ribs when the central portion of the trough adjacent to them has reached maximum subsidence. The zone of active movement has solid coal to retard movement on three sides: the face and two ribs. The curve of subsidence differs from that developed where four sides retard movement. Jeran and Barton[5] have shown that the curves of dynamic subsidence from two dissimilar longwall panels are almost identical when plotted against face position expressed in terms of overburden thickness. The dynamic curves for the three sites were developed and showed similar results (fig. 13). Comparing these to the curves over the finishing ends of the panels shows agreement. This indicates that the subsidence over the finishing end of a longwall panel is related to the dynamic process of subsidence and not the static condition developed over the rib in the central portion of the trough. Since available models are based upon rib data and the subsidence over the end is different, their use to predict subsidence over the finishing end of a longwall panel is not valid.

For comparison, the subsidence data obtained over the finishing ends of a 1,000-ft-wide panel in the Kittanning Coalbed (Mine D, fig. 2) and a 530 ft-wide panel in the No. 2 Gas Coalbed (Mine E, fig. 2), were used to plot the percent of maximum subsidence verses the distance from the end and rib for each panel (figs. 14-15). These data show the same kind of differences in subsidence characteristics as observed for the Pittsburgh Coalbed.

[4]Jeran, P. W., and T. M. Barton. Comparison of the Subsidence Over Two Different Longwall Panels. Paper in Proceedings. Mine Subsidence Control. BuMines IC 9042, 1985, pp. 25-33.

[5]Work cited in footnote 4.

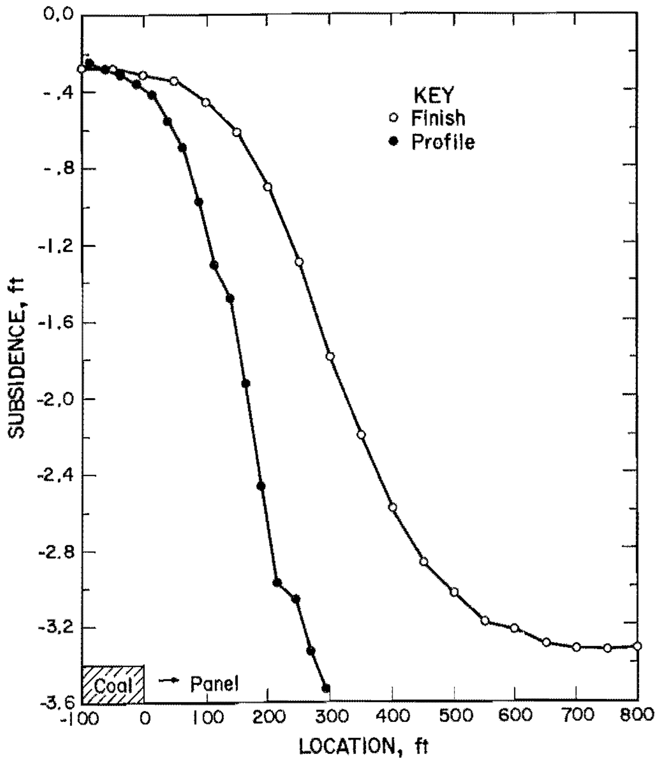

Figure 8.—Mine C—Subsidence over finish and rib.

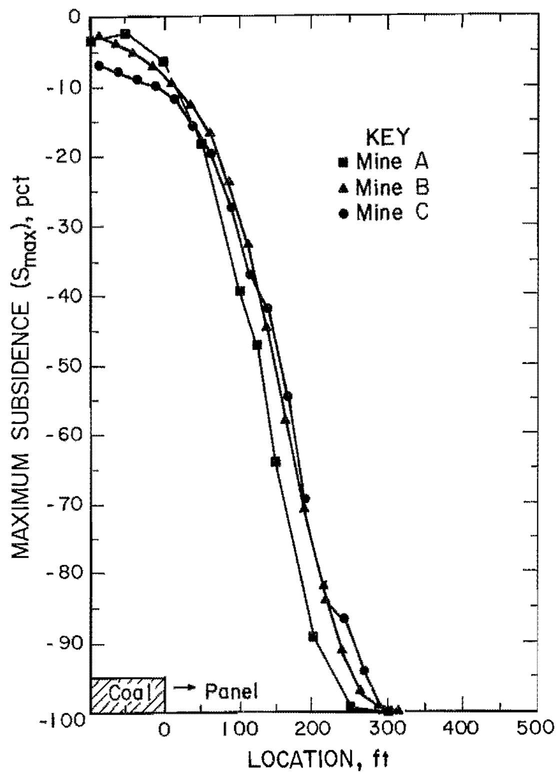

Figure 9.—Percent maximum subsidence—profiles.

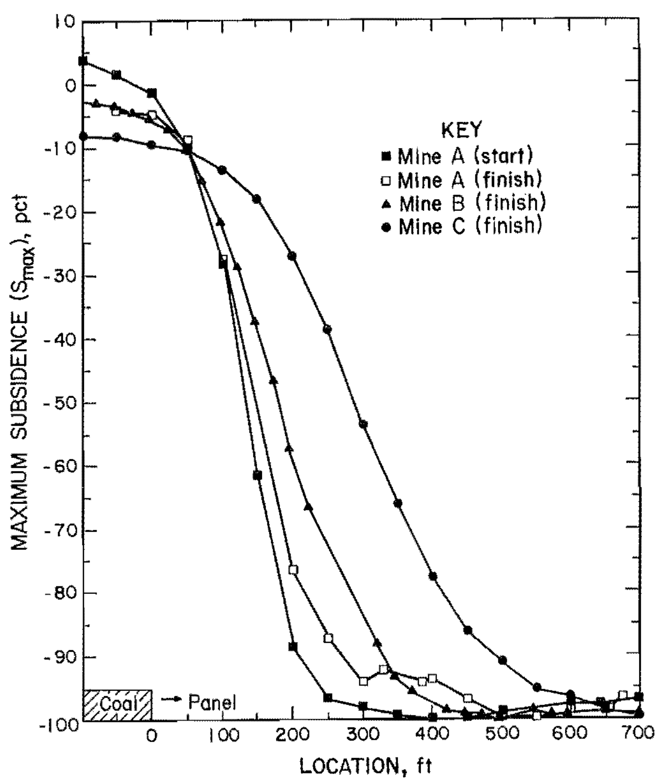

Figure 10.—Percent maximum subsidence—ends.

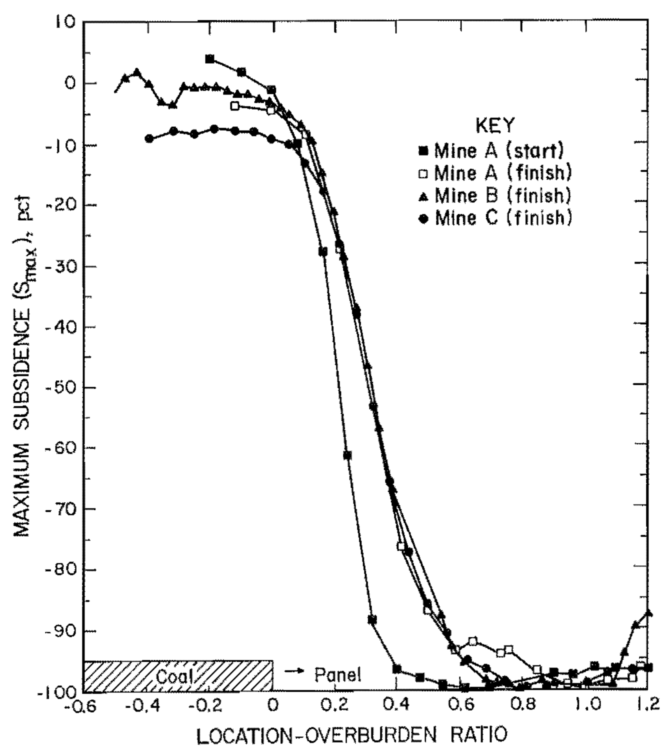

Figure 11.—Percent maximum subsidence versus location-overburden.

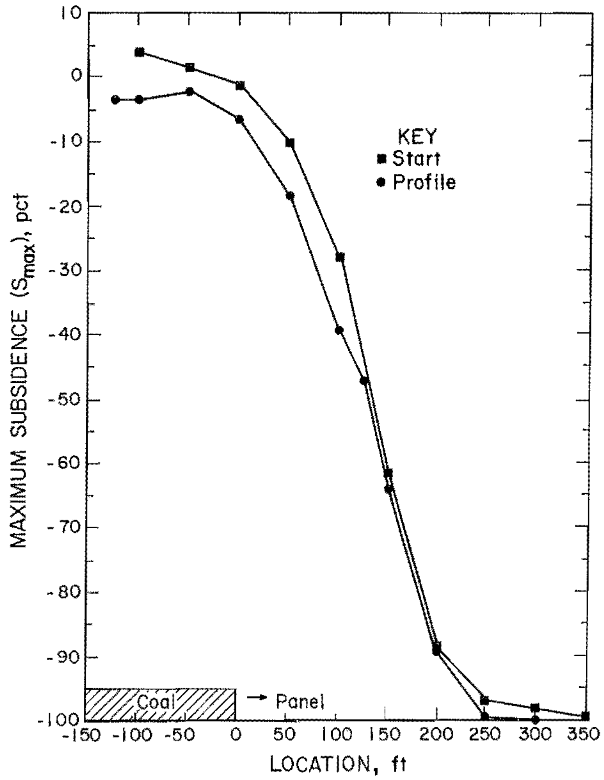

Figure 12.—Mine A—Percent subsidence start and rib.

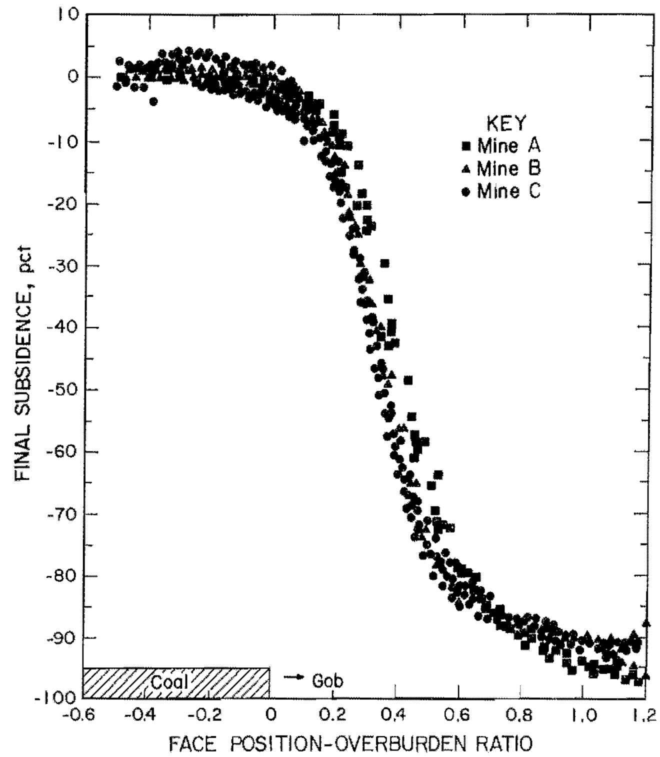

Figure 13.—Dynamic subsidence.

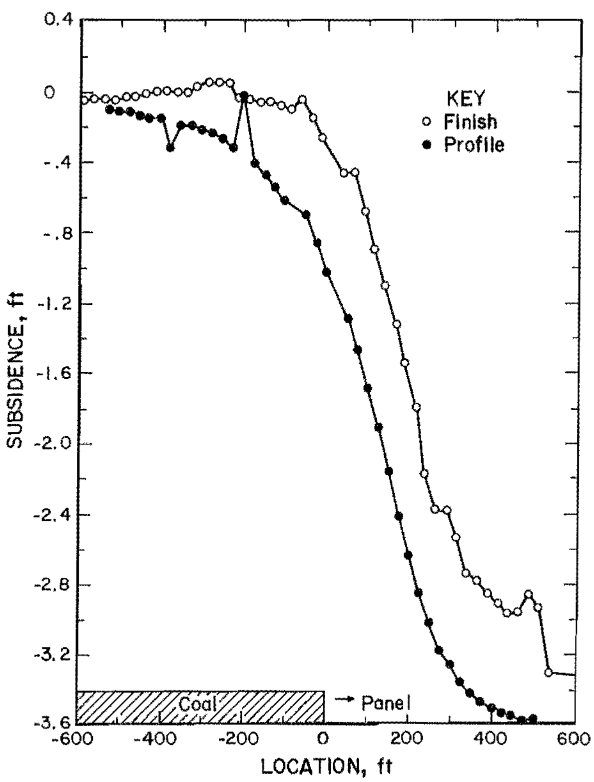

Figure 14.—Mine D—Percent maximum subsidence over finish and rib.

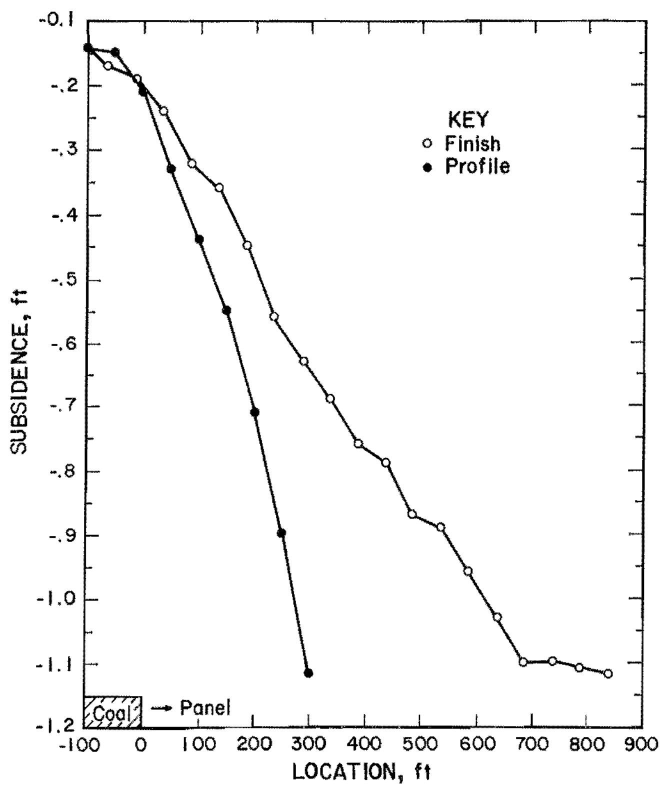

Figure 15.—Mine E—Percent maximum subsidence over finish and rib.

This analysis was limited to the centerline of the panel. The bridging of strata over the rib significantly affects subsidence in the northern Appalachian Coal Basin.[6] As the ends are approached the bridging is affected from two directions and there is little data to assess its effect on the resulting subsidence. The little data available indicate the effect is not arithmetic and are insufficient, at this time in the author's opinion, to attempt a more robust analysis.

SUMMARY AND CONCLUSIONS

Subsidence was measured over the finishing ends of three longwall panels operating in the Pittsburgh Coalbed of the northern Appalachian Coal Basin. At one of these sites, data were also obtained over the starting end of the panel. At each site, the characteristics of the subsidence over the finishing end of the panel differs from that measured over the rib. While these data are insufficient to develop a predictive model for the ends of a longwall panel, some general observations can be noted. The shape of the subsidence curve along the centerline over the finishing end appears more closely related to the dynamic subsidence curve than to the static curve developed relative to the rib. Data obtained from monitoring sites over the Kittanning and No. 2 Gas Coalbeds agree with these observations. The one set of data over the starting end differs from what was observed over the finishing end of the same panel in that the subsidence more closely resembles the static rib curve measured in the central portion of the panel. All of this indicates that the use of a model developed to predict subsidence relative to the rib in the central portion of a subsidence trough will not yield valid results when applied to the finishing end of a longwall panel, but may be applicable to the starting end.

Additional data will have to be obtained over both ends of longwall panels to expand the data base and provide a sound basis for development of a model capable of predicting subsidence throughout the subsidence trough. Since the overburden appears to have a significant affect it must be considered in the selection of the monitoring sites. In addition, data will have to be obtained over the corners where the effects of both the rib and the end are greatest.

[6]Adamek, V., P. W. Jeran, and M. A. Trevits. Prediction of Surface Deformations Over Longwall Panels in the Northern Appalachian Coalfield. BuMines RI 9142, 1987, 19 pp.

INT.BU.OF MINES,PGH.,PA 29293