

Researching Abandoned Mine Maps in Predicting Subsidence Risk

33rd Professional Engineers in Mining – Kentucky Seminar

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Researching Abandoned Mine Maps in Predicting Subsidence Risk

AGENDA

Review of Mine Mapping Standards and Reporting

Review of Map Drafting Technology and Reproduction

Impact of Mine Maps on Subsidence Risk

Sources of Room and Pillar Mine Maps

Conclusions and Observations

A large yellow excavator is the central focus of the image, positioned on a massive pile of dark, crushed rock. The excavator's arm is extended, and its bucket is positioned over a smaller pile of lighter-colored, angular rocks. In the background, a blue sky and a hazy mountain range are visible. To the left, a vertical structure with a ladder and a blue platform is partially seen. The overall scene depicts an active mining or construction site.

Review of Mine Mapping Standards and Reporting



Reporting of Mine Maps

- > The surveying mine workings and the preparation of underground mine maps are two of the primary functions of the Mining Engineer.
- > In the United States the practice of drawing mine maps was established at a scale of 1 inch equal to 100 feet in the late 1800's.
- > The current Federal standards for the preparation of mine maps and submission of those maps on an semi-annual time period were established in 1969.
- > Prior to 1969, individual state requirements differed depending upon the state and the extent of mining ongoing at the time.



Kentucky Reporting of Mine Maps

- > In Kentucky, KRS. mining regulations setting mapping standards and the annual submission of mine maps were promulgated in 1942.
- > KRS 352.450 established the standards and filing requirements and were amended in 1972, 1976, 2002 and 2006.
- > Prior to 1942, industry accepted standards for surveying and mapping were followed.
- > While theodolites and digital equipment has replaced the miners transit the level of surveying accuracy has not changed. Closed loop underground surveys of mine workings reviewed from the 1930's have closures of 1 in 18,000 which is a level of accuracy consistent with excellent surveying practice.



Mapping Standards have Changed.

- > Although mine maps date back several hundred years, maps of interest today date to the early 1900's and are the quality of those maps were in part a function of the reproductive methods available.
- > In the Early 1800's mine maps, especially coal mines maps were drafted in ink onto
 - Hardbacks or "well seasoned muslin mounted paper" as large as 60" x 240 ", and/or
 - Tracing cloth as large as 54" x 120".
- > Although drawing paper and tracing paper was available, these papers were and still are used primarily for working papers, studies, and temporary copies of plans.

A yellow excavator is the central focus, positioned on a large pile of dark, angular aggregate material. Its arm is extended, and its bucket is positioned over a large pile of light-colored, irregularly shaped rocks. The excavator's cab is visible on the right side, with a person inside. In the background, there are rolling hills under a clear blue sky. On the left side, there is a vertical structure, possibly part of a conveyor system or a support structure for a bridge or dam. The overall scene is a construction or mining site.

Review of Map Drafting Technology and Reproduction



Mapping on Linens

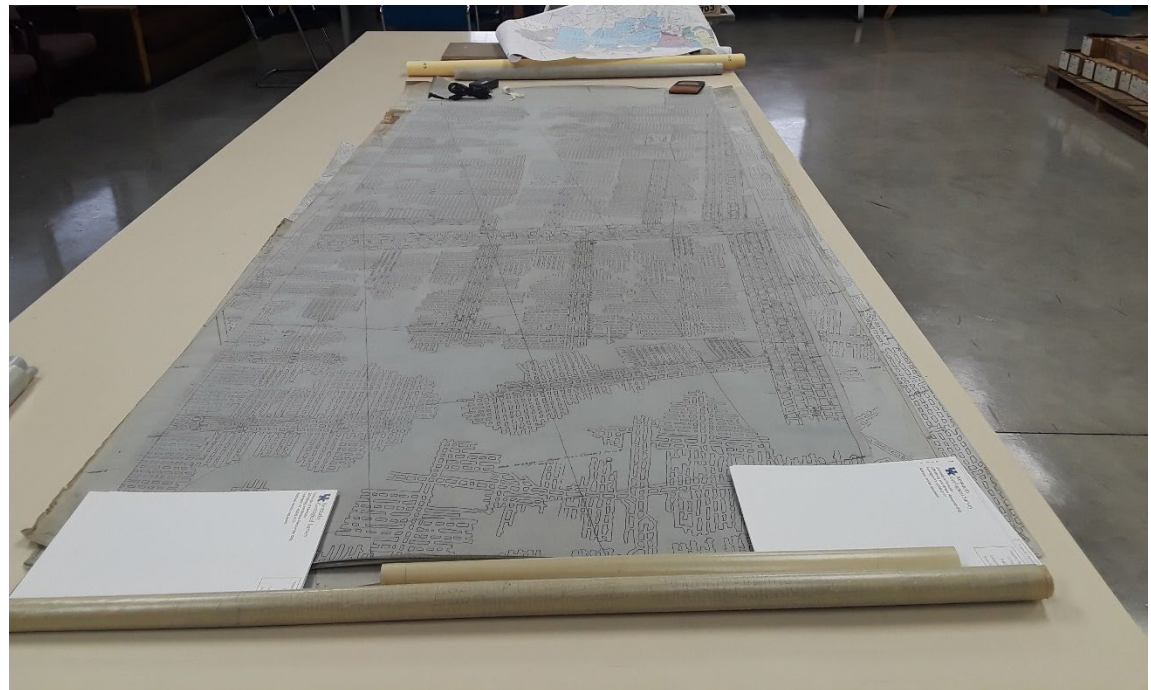
- > Prior to the Civil War, duplicating mine maps required redrawing the map by hand or tracing a copy on paper, which has limited durability.
- > Tracing cloth “Linen” is finely woven linen treated with a chemical wash (sizing) to make it transparent and rubbed with chalk or pumice to make the transparent surface retain ink. Tracing Linen has extreme durability and could be used with wet photocopying methods first developed in 1859.
- > The Linen tracings enabled photocopying using paper treated with light sensitive chemicals and developed in a wet or vapor process (blueprinting). Linen tracings were the primary method used for the drafting of mine maps until the availability of mylar developed during World War II and began use for architectural and map drafting in the 1950’s.



Linen Tracings

- > Tracing cloth was available in roles in varying widths from 24 to 54 inches.
- > There was no standard widths, and a mine engineer would decide on a width for a mine and kept all of the successive Linens the same width but not necessarily the same length.

A Linen tracing 42 inches by 8 feet in length, Circa 1945





Linen Tracings

A linen tracing also 42 inches wide but only 60 inches in length, Circa 1932.



Note the orientation of the mine workings is 90 degrees from the prior photograph.



Photocopying Methods.

The introduction of photocopying in 1859 enabled paper prints to be made from paper tracing and linens of engineering, surveying and architectural drawings. The photocopy method relies upon special paper treated with photosensitive chemicals that when a tracing is laid upon the paper and exposed to light the image of the tracing is formed on the special paper. Developing the image involves exposing the paper to a chemical bath (wet processing) or vapors. The photocopy method quickly gained popularity as evidenced by the light sensitive materials and processing methods available.

- > Ferro Galic (1859 – 1930s)
- > Aniline Print (1864 – 1890s)
- > Blueprint (Cyanotype)(c. 1872 – present; technical uses, c. 1872 - 1950s)
- > Van Dyke Print (c. 1890 – early 1960s)
- > Wash-Off Print (1920s – present)
- > Diazo Print (1923 – present)



Composite Paper Maps

- > Linen mine maps at 1 inch equal to 100 feet tended to be oversize tracings when compared to the standard sizes of mylar and architectural sizes.
- > Although the photocopy methods enabled printing, the developing using wet or vapor exposure often resulted in paper shrinkage during the drying process and/or paper stretch due to mechanical pulling of the paper through the roll contact machines.
- > Compositing paper maps required alignment of the oversize prints and pasting them together. For ease of drafting, tracings were aligned with the rectangular orientation of the mains, panels, or sections being developed, and not true north. The manual task of pasting paper photocopies often resulted in misalignment or adjacent prints due to paper stretch or shrinkage, trimming errors, pasting errors, and carelessness.
- > Such errors persisted through the early 1990s when computer drafting and printing supplanted photocopy printing.

Certified Mine Map - Circa 1967

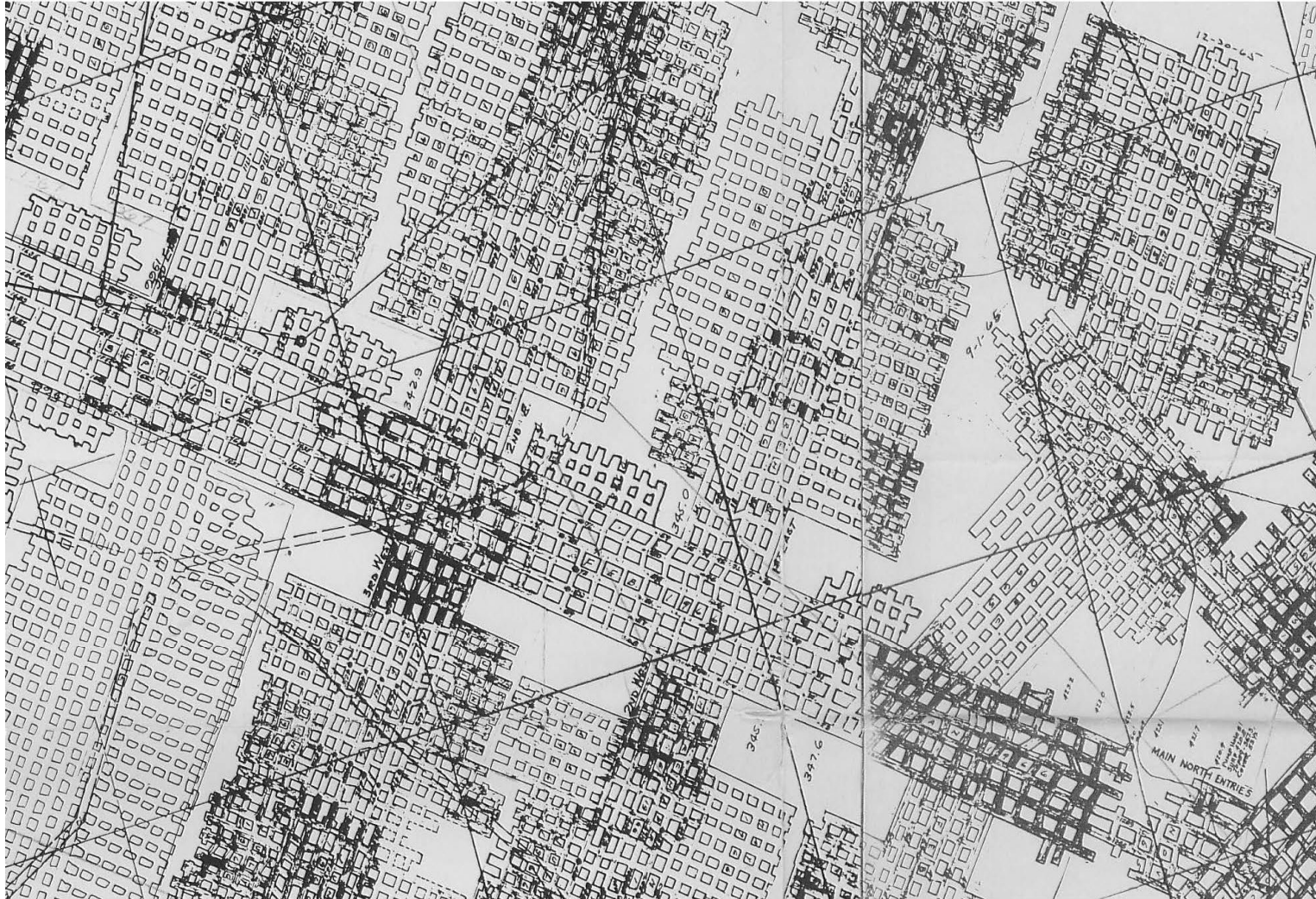


00524-2, 1970F, 1870082
00524-2
NOTE: FINAL MAP - from transmittal -
NOTE: Hopkins County
from annual report -

I, the undersigned, hereby certify that this map is correct and shows to the best of my knowledge and belief all the information required by the Mining Law of this State.
A. J. Smith Engineer
Registration No. 5668
State of Kentucky
Subscribed before me, a Notary Public, this 1 day of
August, 1970.
Joe Raloff
By Notarizer Extraordinary in and for

ISLAND CREEK COAL CO.
ATKINSON MINE NO. 9 SEAM
SCALE 1" = 400' OCT. 1967

Paste Line Miss Match





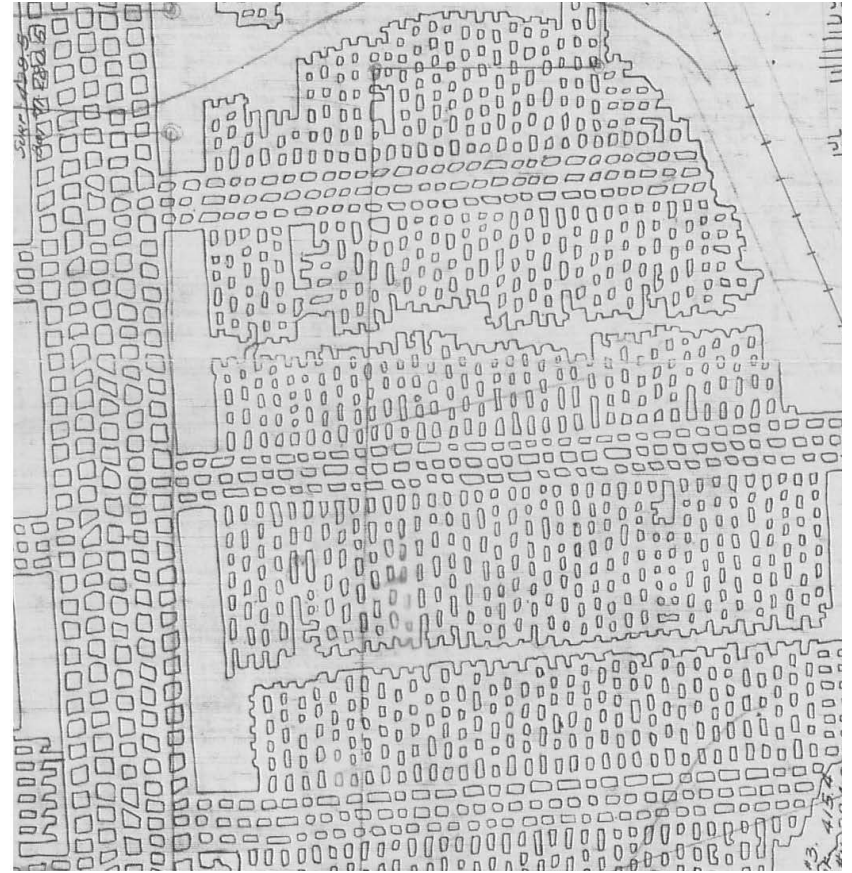
Reduced Scale Maps

- > Reduced scale refers to maps drawn at 1" equal to 400 feet to the inch, and up to 1/10 of the original scale.
- > Prior to the 1960's when wide-spread use of large cameras designed for scaling large maps by photographic methods was introduced, only two means existed for reduced scale maps:
 - > Hand drawing at the reduced scale, or
 - > Using a pantograph to complete a precise tracing of the original 1" = 100' scale mine map.
- > Hand drawing required less time often at sacrificing exact duplication as shown on the next slide.

Hand Drawn Reduced Scale Map



Original 1" = 100'

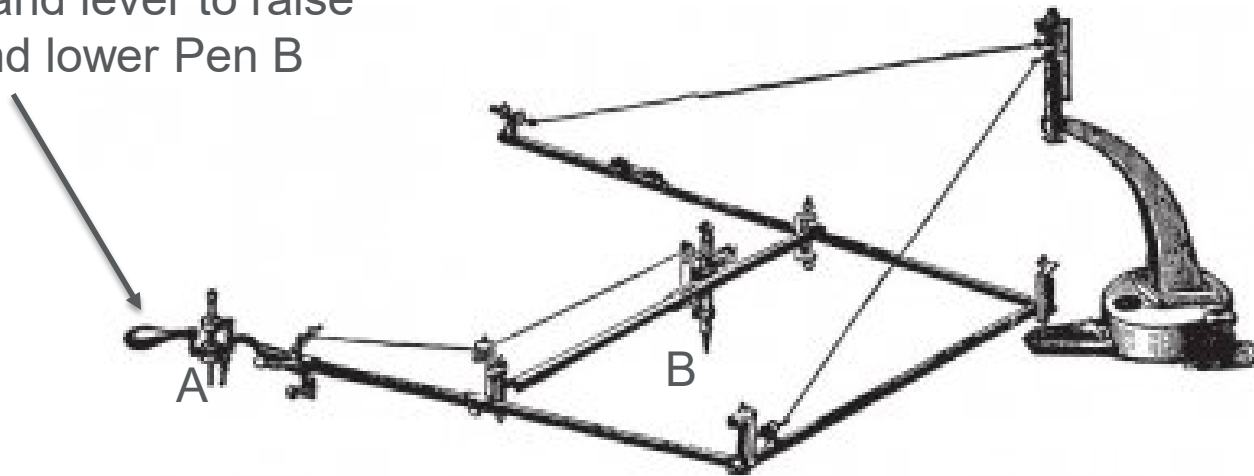


Hand Drawn 1" = 400'

A Long Beam Pantograph

Using the pantograph was expensive and labor intensive.

Hand lever to raise
and lower Pen B



The tracing point A follows the full-size drawing while the Point B draws the exact replica at $1/4$ up to $1/10$ the scale of the original.

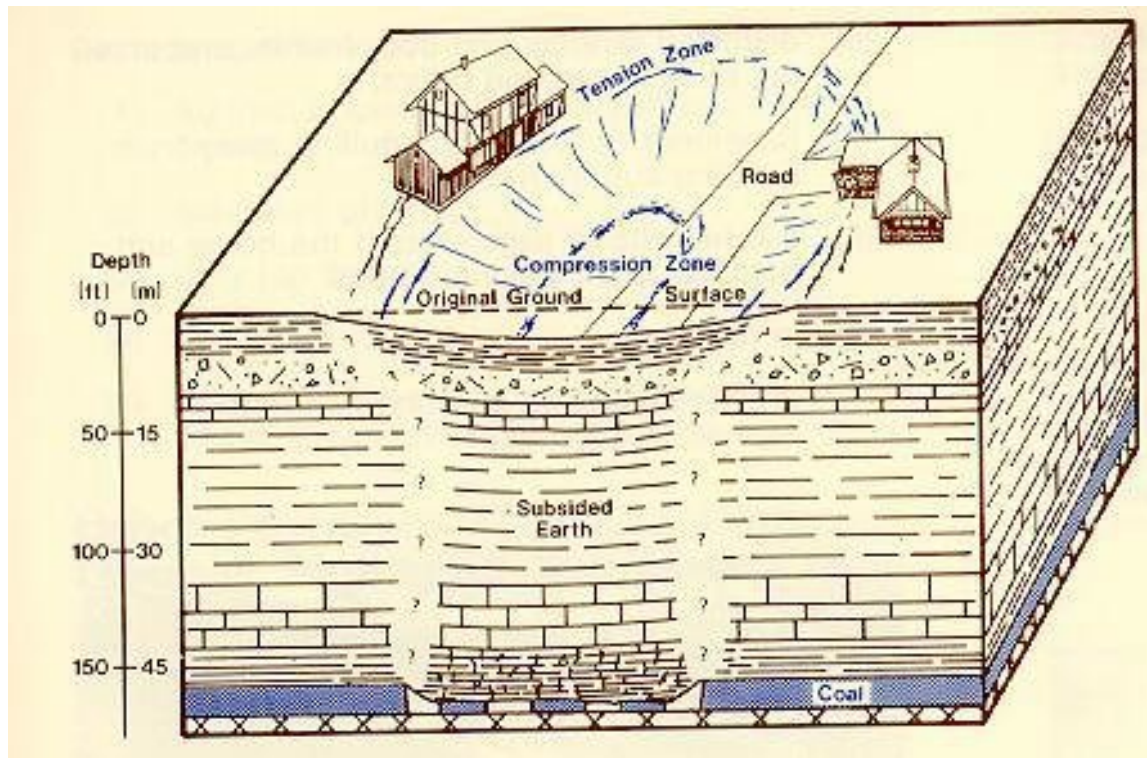


Impact of Mine Maps on Subsidence Risk



Subsidence Risk

Predicting Mine Subsidence above a room and pillar mine requires an accurate depiction of the size and spacing of the pillars beneath the structure(s) from the best version of the original drafted mine map.





Factors to be considered in predicting Mine Subsidence above Room and Pillar Mines

- > Characteristics of the soil zone or other unconsolidated materials above the bedrock.
- > Roof strata type, thickness, and strength properties of the overburden of the room and pillar area (especially in the caved and fracture zones).
- > The strength of the coal in the pillars.
- > The dip and fracture system of the coal and rocks in the room and pillar area of alleged subsidence .
- > Floor strata properties below the room and pillar area of alleged subsidence.
- > Definition of groundwater tables in perched and/or confined zones.
- > **Without the correct size and distribution of the pillars in the alleged subsidence area, prediction is not reliable.**

Historical Depiction of Mine Subsidence Zones

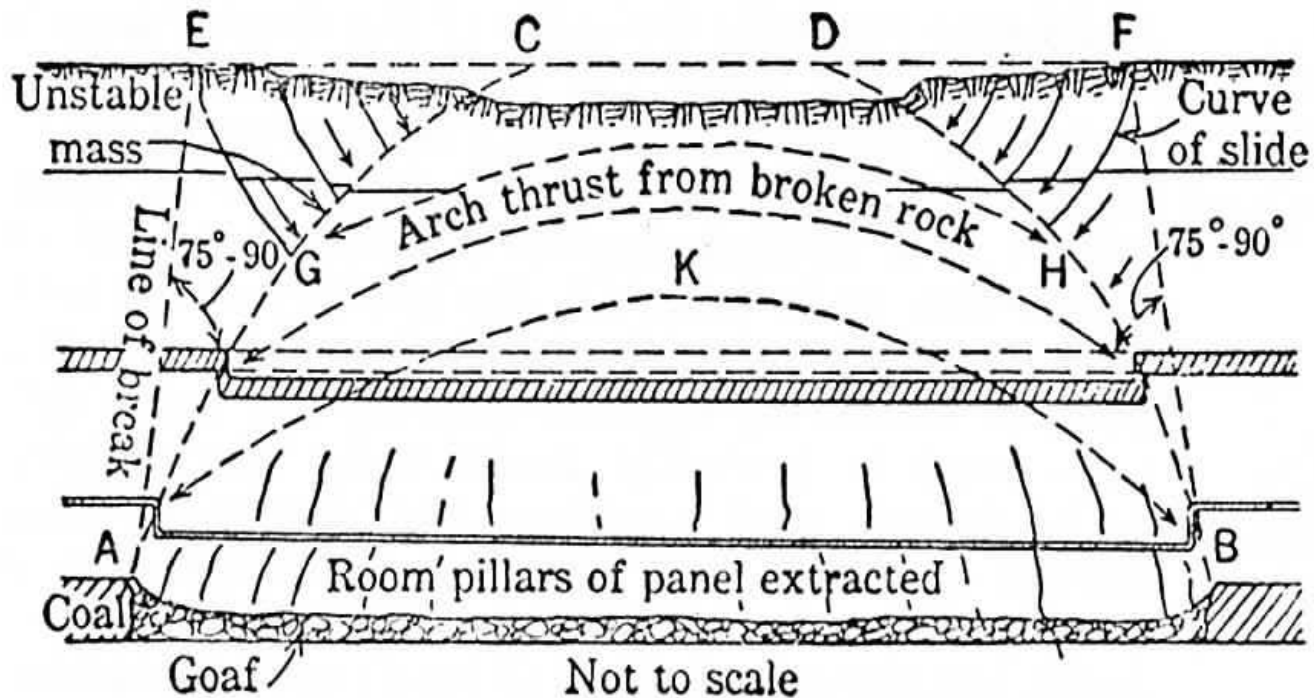
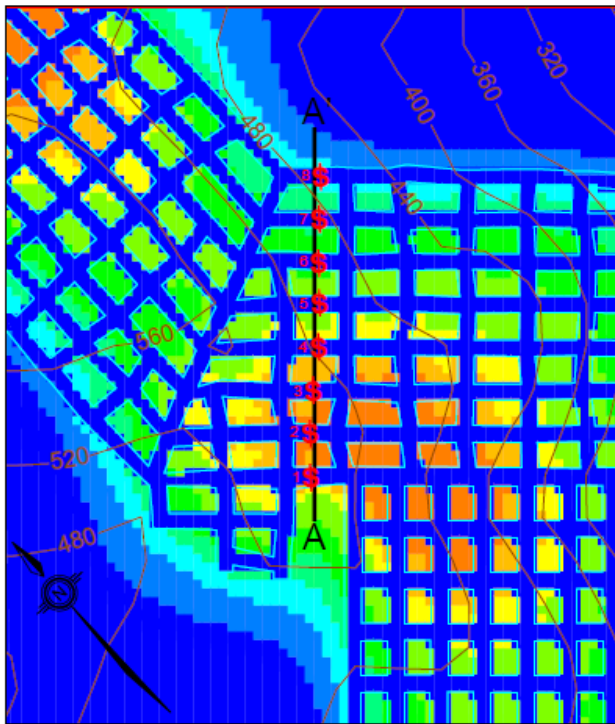
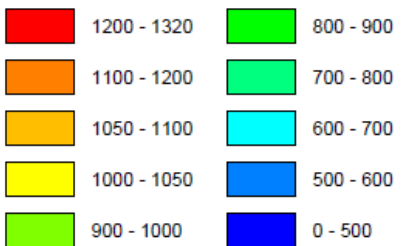


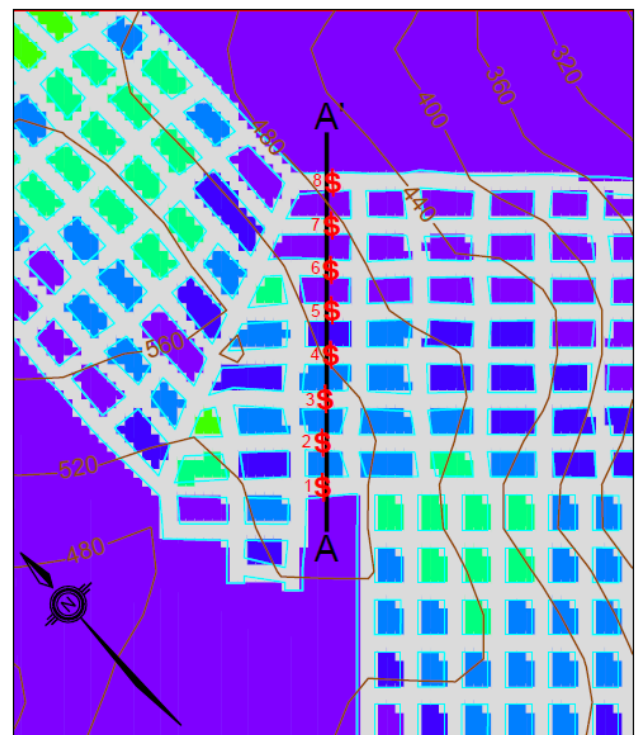
Fig 791. Suggested Mechanics of Room-and-pillar Caving (623)



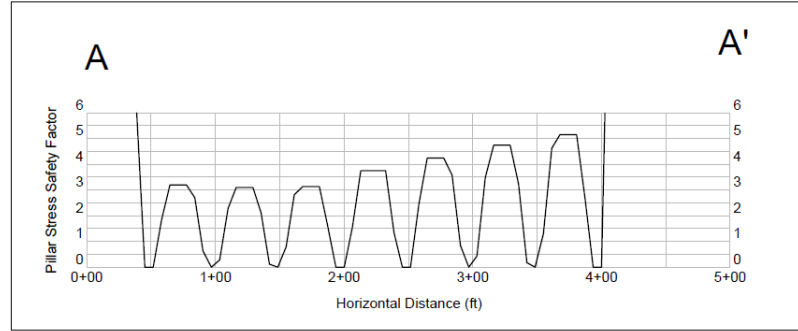
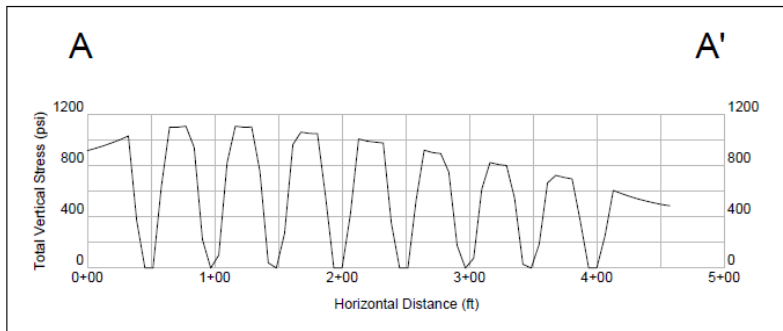
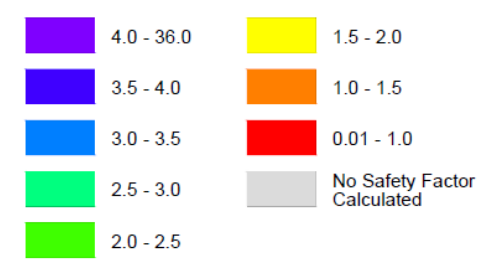
Total Vertical Stress (psi)



The Importance of Reliable Mine Mapping on Subsidence Assessment Using LaModel to Estimate Pillar Stresses and Pillar Stability



Pillar Stress Safety Factor





Sources of Mine Maps



Sources of Room and Pillar Mine Maps

- > The Kentucky Mine Map Repository currently resides at 300 Sower Boulevard in Frankfort, KY. However, so many of the historical maps have been photographed to scale and are available on line in the Kentucky Mine Mapping Information System (minemaps.ky.gov). Consequently many of the original paper backed muslin maps and or the linen tracings that have deteriorated with age have been discarded.
- > The National Mine Map Repository, Office of Surface Mining Reclamation and Enforcement, Department of the Interior, in Pittsburgh, PA. The National Repository is accessible at mmr.osmre.gov or for special searches or requests through direct contact at 412-937-2888. The National Repository has state-of-the-art equipment to provide 200-400dpi images using Cruise Table Scanners up to 60"x 90" and a high DPI Cruise Scanner (80"x120").

Searches at Kentucky Mine Mapping Information System



Available Maps

Selected Mine Details:

State File Name (SFN): 00524-2

Federal Id:

Permit Number:

Company:

Mine Name: Atkinson

Operator:

Nearest Town:

Nearest Stream:

County: Hopkins

Seam Name:

Status: Inactive

Drag a column header and drop it here to group by that column

Map Year	Map Date	Purpose	Name	
1978	04/12/1978	Map	00524-2_1978M_19780412	View Map Images
1970	08/01/1970	Final	00524-2_1970F_19700801	View Map Images
1970	08/01/1970	Final	00524-2_1970F_19700801_T	View Map Images
1970	08/01/1970	Final	00524-2_1970F_19700801_X1OF2	View Map Images
1970	08/01/1970	Final	00524-2_1970F_19700801_X2OF2	View Map Images
1970	01/23/1970	License	00524-2_1970L_19700123	View Map Images
1969	01/31/1969	License	00524-2_1969L_19690131	View Map Images
1968	02/12/1968	License	00524-2_1968L_19680212	View Map Images
1968	05/10/1968	Map	00524-2_1968M_19680510	View Map Images
1968	06/10/1968	Map	00524-2_1968M_19680610	View Map Images

Searches at National Mine Map Repository



OFFICE of SURFACE MINING
RECLAMATION and ENFORCEMENT

U.S. Department of the Interior (<https://www.doi.gov/index.cfm>)

OSMRE Home (<https://mmr.osmre.gov/>)

Web Map (<https://osmre.maps.arcgis.com/apps/webappviewer/index.html?id=2bcf62e9d4984c6d8db4b3bc83ece3de>)

All

SEARCH



(<https://mmr.osmre.gov/>)

National Mine Map Repository

"Preserving Mine Maps for Future Generations"

State ▼	KENTUCKY	▼
County ▼	HOPKINS	▼
Name 🔍	Mine Name...	
Company Name 🔍	Coal Co	
Latitude/Longitude 🔍	Latitude Longitude (decimal degrees)	
	1 mile	▼
Commodity ▼	COAL BITUMINOUS	▼
DocNum 🔍	Document Numbers...	

All Documents

Complete Only

Legacy Only

Search

Start Over

Items Per Page:

25



Results 32

1 2

DocNum	OverView	Year	StateCounties	MineNames	Companies	Commodities	Seams	Latitude/Longitude	WebMap
			KY, HOPKINS		WEST COAL CO	COAL BITUMINOUS	KY UNKNOWN 999	37.3	View Map
		0	KY, HOPKINS	WEST KENTUCKY	WEST COAL CO	COAL BITUMINOUS	KY UNKNOWN 999	37.16	View Map

Header Data for NMMR Mine Maps



National Mine Map Repository: 387060 ATKINSON #54

Map Document Number	387060
Mine Database ID	332664
Mine Company	ISLAND CREEK COAL CO
Mine Name	ATKINSON #54
Commodity	COAL BITUMINOUS
Coal Seam and Bedcode	KY #9 489
Point Description	MINE CENTER
Point Assurance	HIGH CONFIDENCE
Point Longitude	-87.4671
Point Latitude	37.2945
Mining Types on Map	COMBINED SURFACE & UNDERGROUND
MSHA ID	00-00000
Map Cross-Reference Number	02518_1977L_19770131
Map is Final	NO
Map is Certified	YES
Map Year	1977
Map Scale	400.0



Conclusions and Observations



Conclusions and Observations

- > There are numerous mine maps for previously mined areas throughout Kentucky. The precision and accuracy of those mine maps are dependent upon the age, scale and technology available for duplication during the time of mining and may be reliable for subsidence prediction above Room and Pillar mines.
- > For maps prior to 1969 the original 1 inch to 100 feet linen tracings or prints from those tracings are the only source where reliable pillar dimensions and pillar spacing can be determined.
- > Mine maps composited using high dpi scans of the original 1 inch to 100 feet linen tracings or their prints and matched with computer programs are also reliable.



Conclusions and Observations (Continued)

- > Scans of paper copies of maps submitted annually and certified by professional engineers to State and Federal Agencies may be reliable unless pasting or other duplication errors are visible.
- > Reduced scale maps of 1 inch to 400 or 500 feet, or smaller should be carefully reviewed to determine if there were hand drawn or if the scale of such maps are too small for reliably determining pillar dimensions and spacing.