Subsidence Prediction Using SDPS

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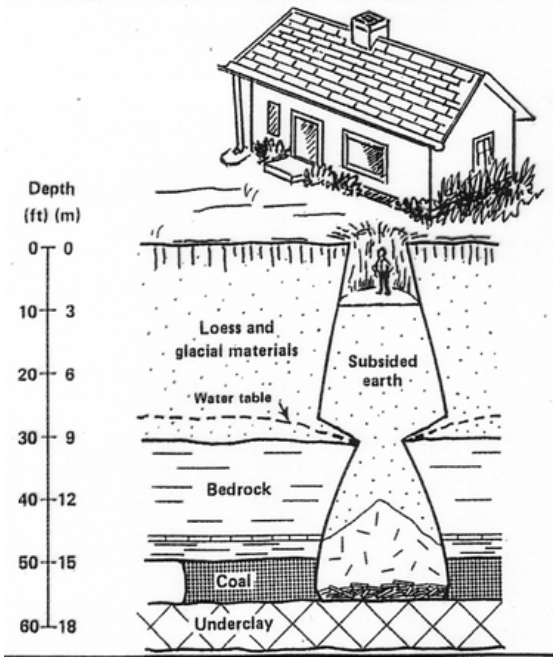
Presentation Outline

- Basic concepts on subsidence / ground deformation prediction
- The SDPS Package
- Using the Influence Function Method
- New developments in ground deformation assessment (Calibration, Dynamic Deformations, Prediction of Movements on Streams)

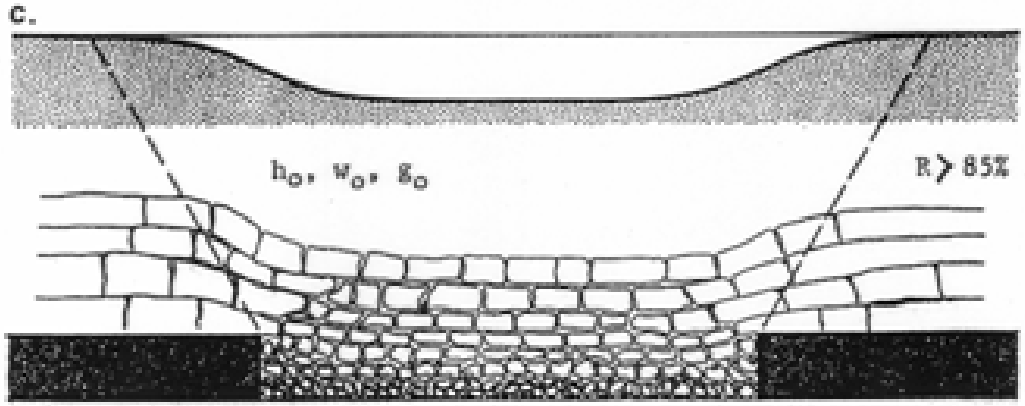
Introduction

- The impacts of underground mining on the surface are important environmental considerations in the permission, planning and monitoring of coal mining operations
- The development of rigorous and well-accepted ground deformation prediction techniques and damage criteria for assessing mining impacts on surface structures and facilities, is the foundation of subsidence engineering and control

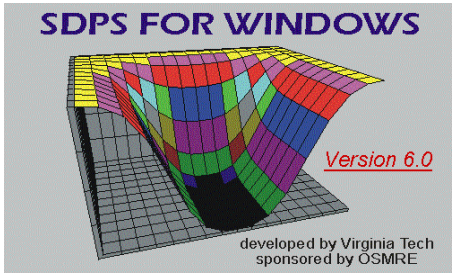


Ground Movement Predictions

- A complex task, due to the number and nature of the parameters affecting ground deformation induced by underground mining
- Important parameters include: subsidence characteristics, surface morphology, mine plan, mining sequence, coal structure characteristics, overburden lithology.



Surface Deformation Prediction Software System (SDPS)

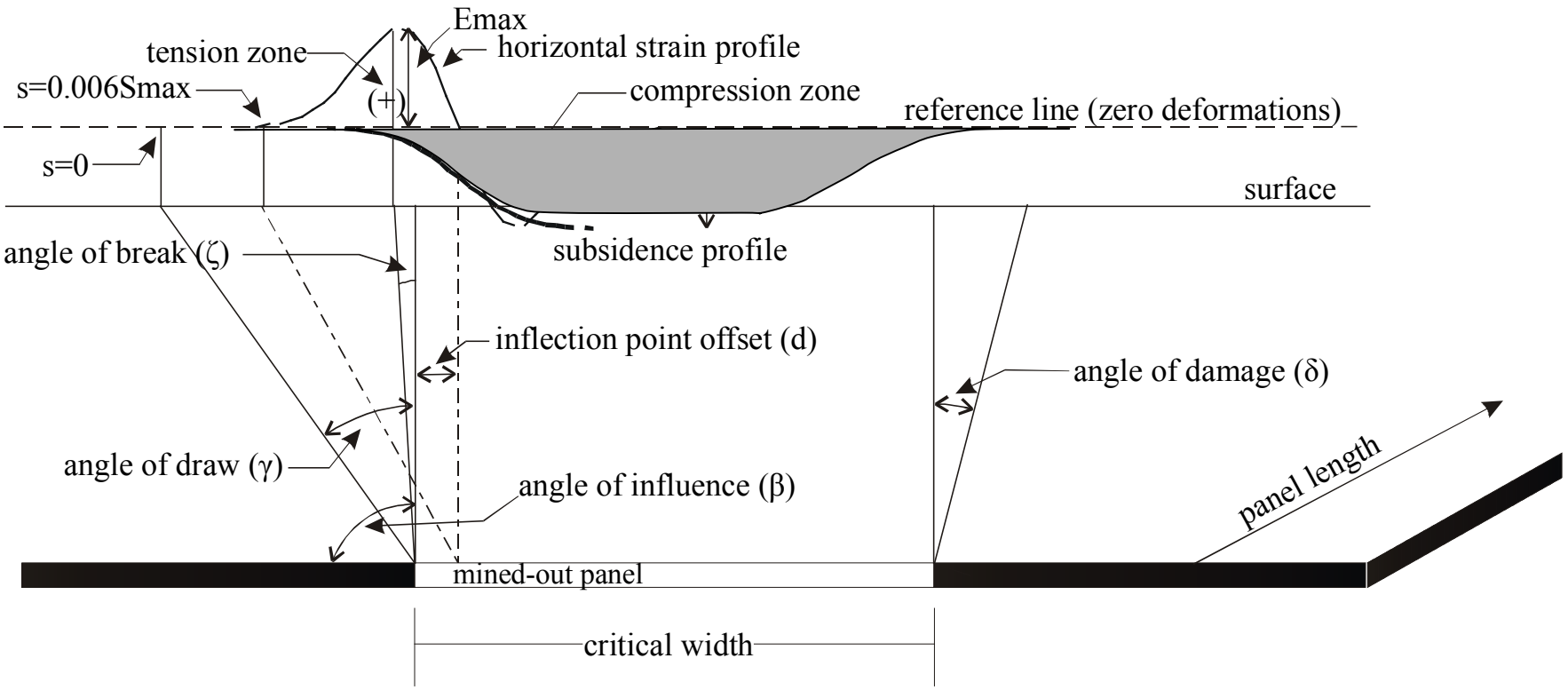


- The Surface Deformation Prediction Software System (SDPS) is an integrated package for calculating a variety of surface deformation indices, using both the profile function and the influence function methods.
- Calculations are based on several empirical relationships, developed through the statistical analysis of data from a number of case studies (VPI & SU, 1987 & 1999; Karmis et al., 1989, 1990 & 1992).
- SDPS has been updated to version 6.2B (Feb 2015)

Basic Concepts in Subsidence Prediction

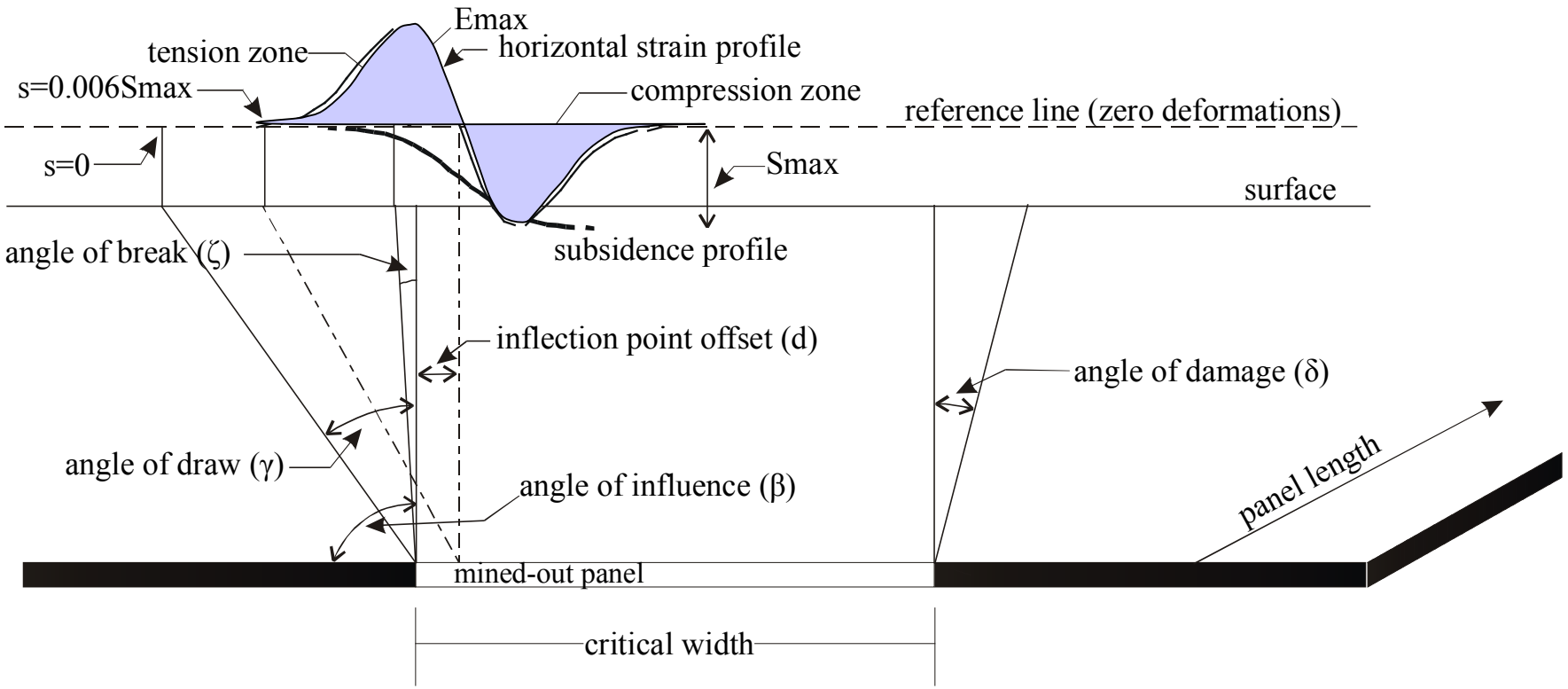
- Maximum Possible Subsidence (supercritical extraction)
- Maximum Strain
- Angle of Influence / Angle of Draw
- Inflection Point
- Edge Effect Offset

Subsidence Parameters



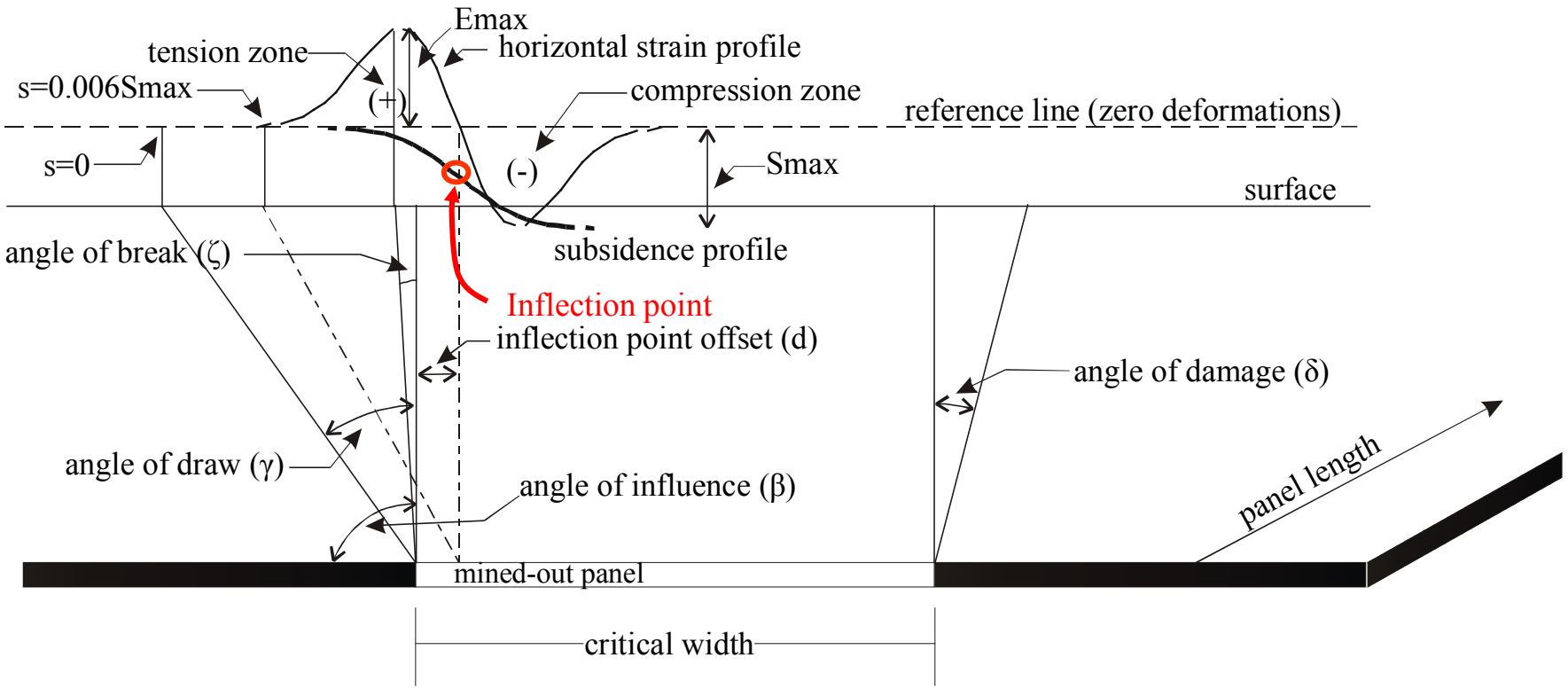
The maximum subsidence (Smax)

Subsidence Parameters



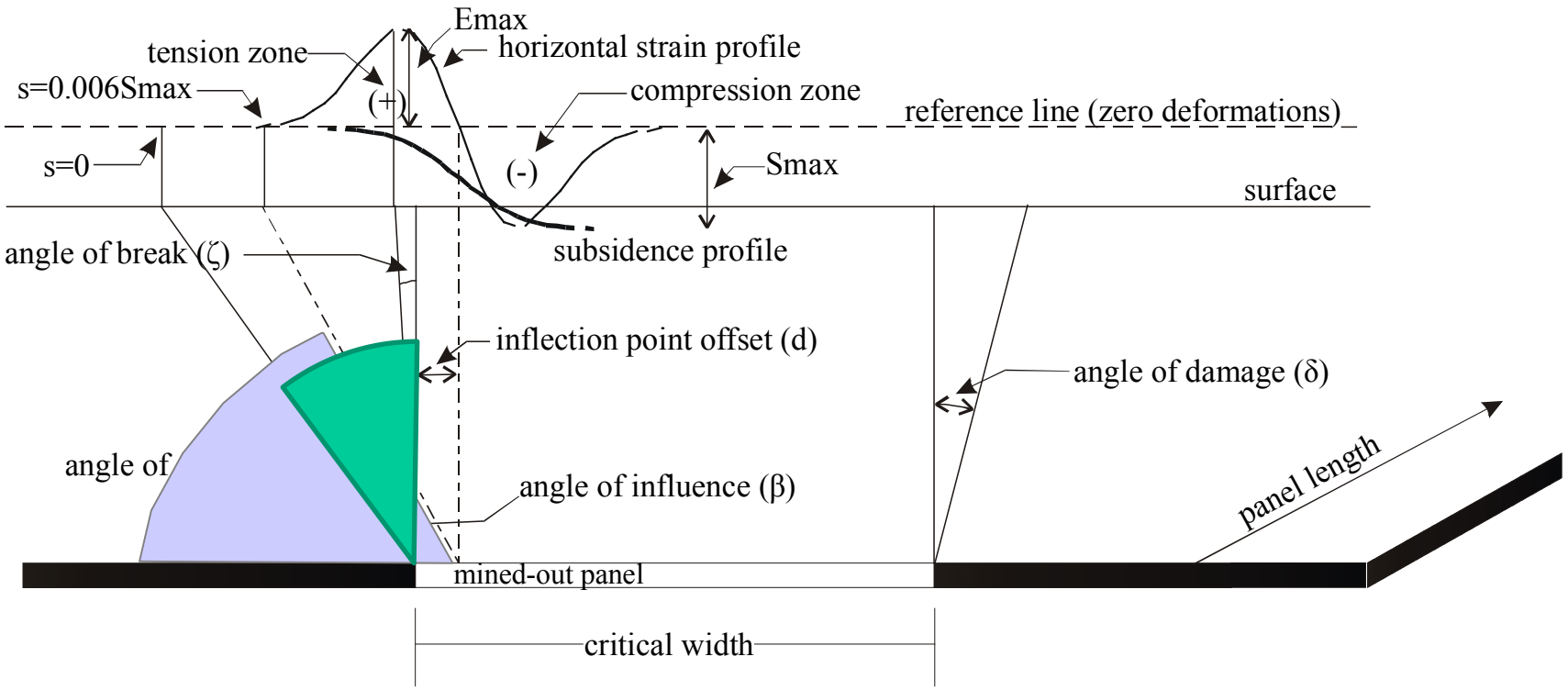
The maximum tensile and compressive strains (Emax)

Subsidence Parameters



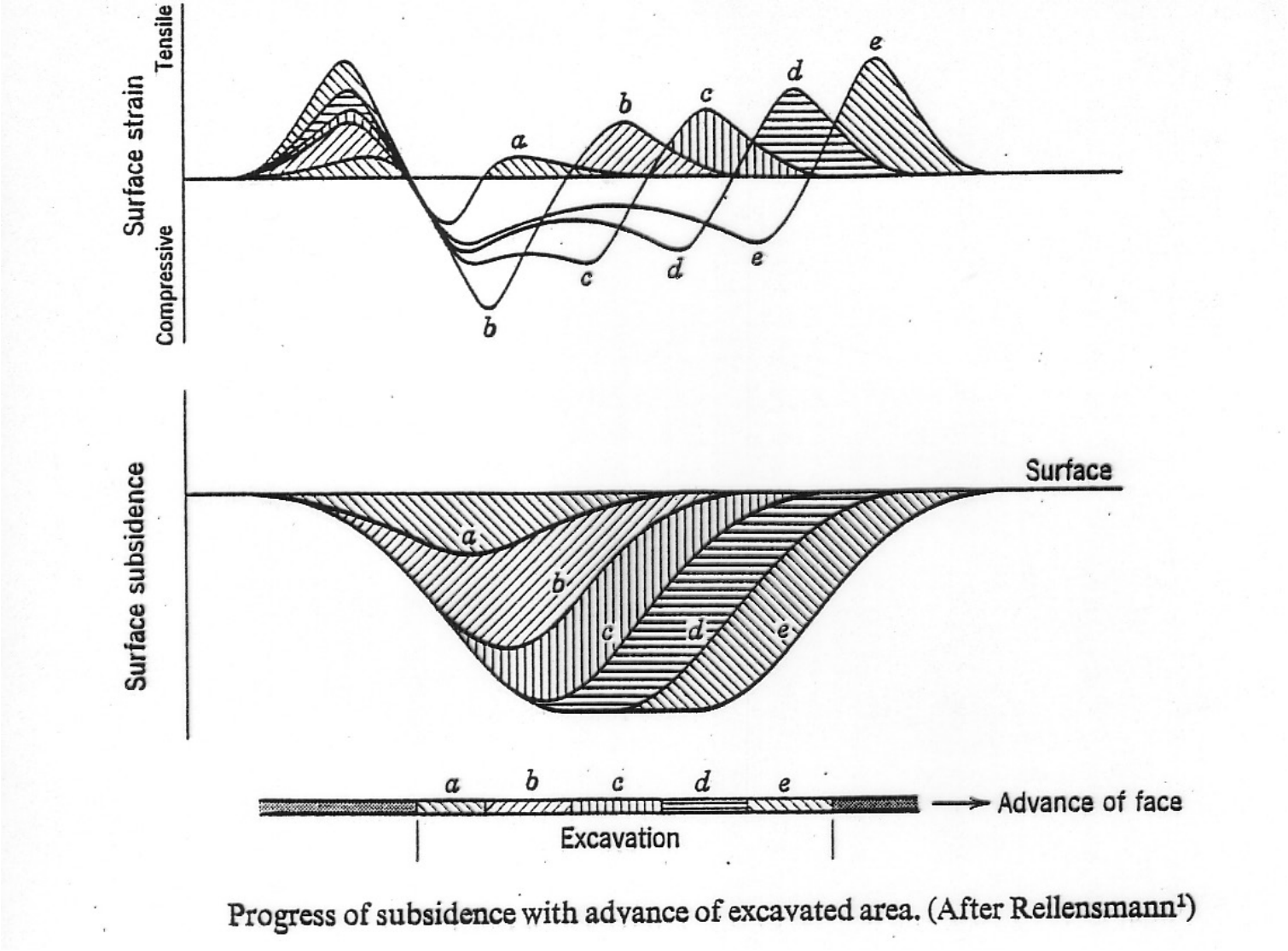
The inflection point corresponds to s = Smax/2 on the subsidence profile or zero curvature. This point is usually displaced from the rib of the excavation at a distance, (d) towards the panel center.

Subsidence Parameters



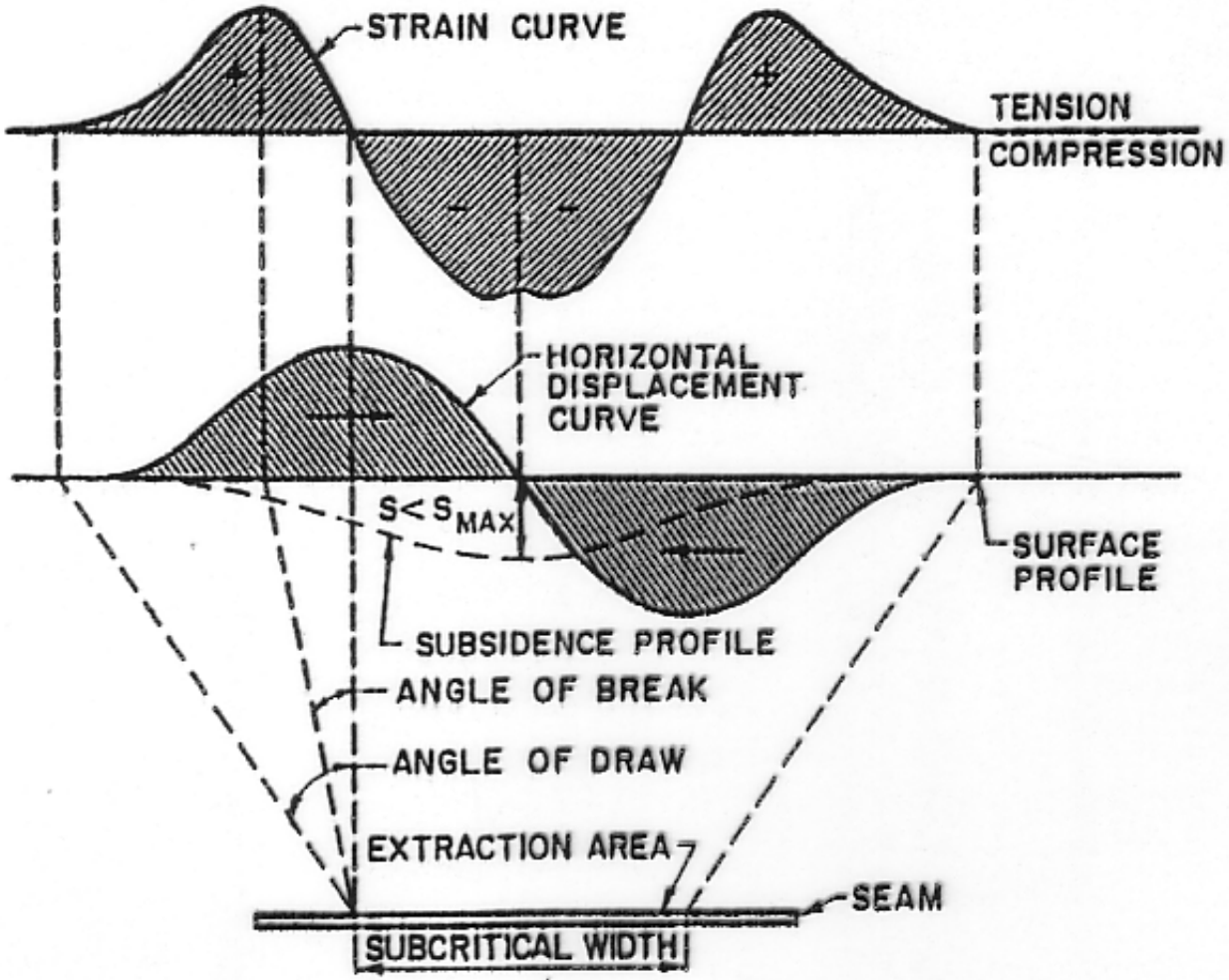
Angle of Influence: the angle between the horizontal and the line connecting the projection of the inflection point position of the subsidence trough, at the seam level, with the surface point of "zero influence"

Mining Progress

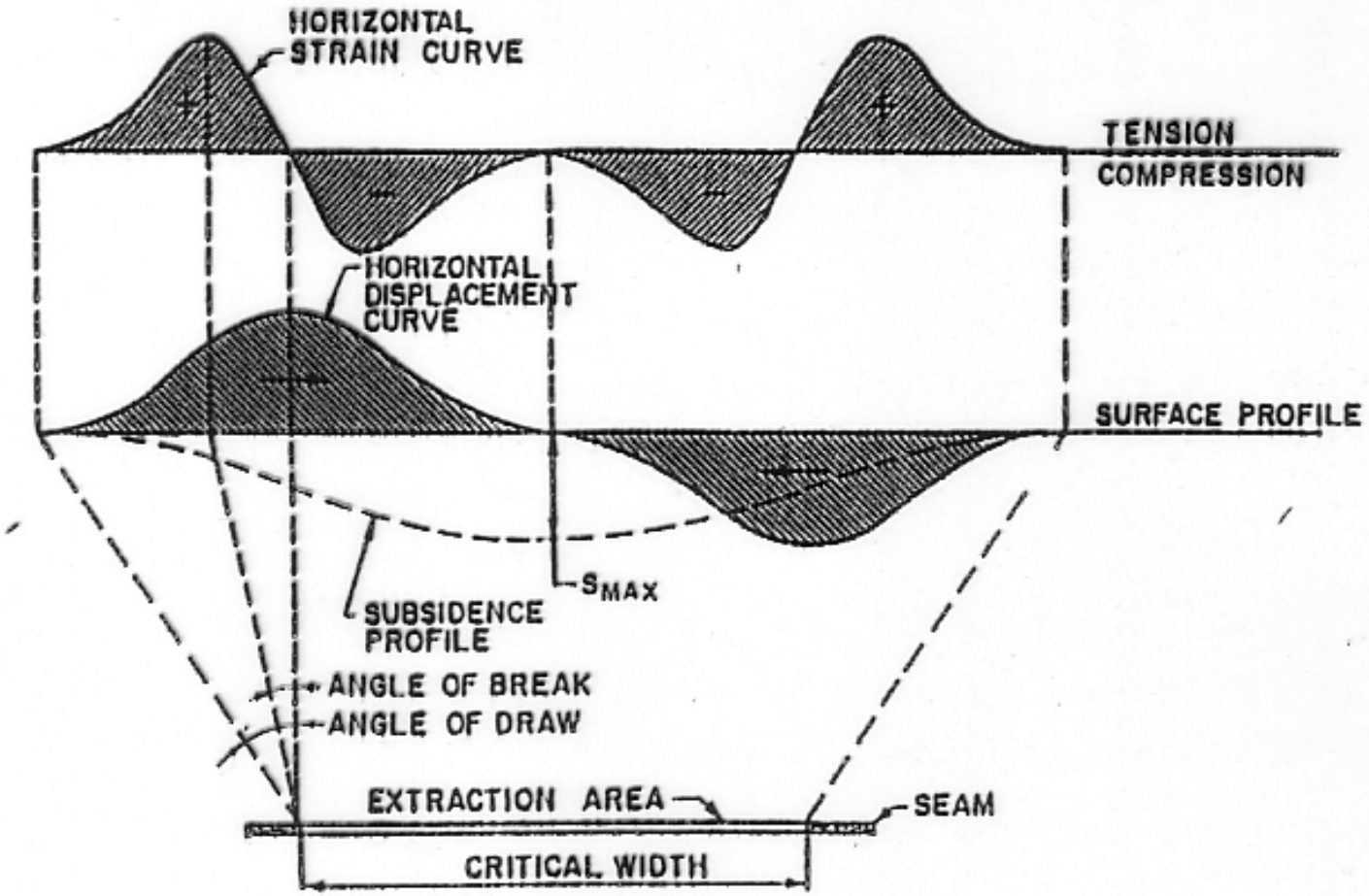


Progress of subsidence with advance of excavated area. (After Rellensmann[1])

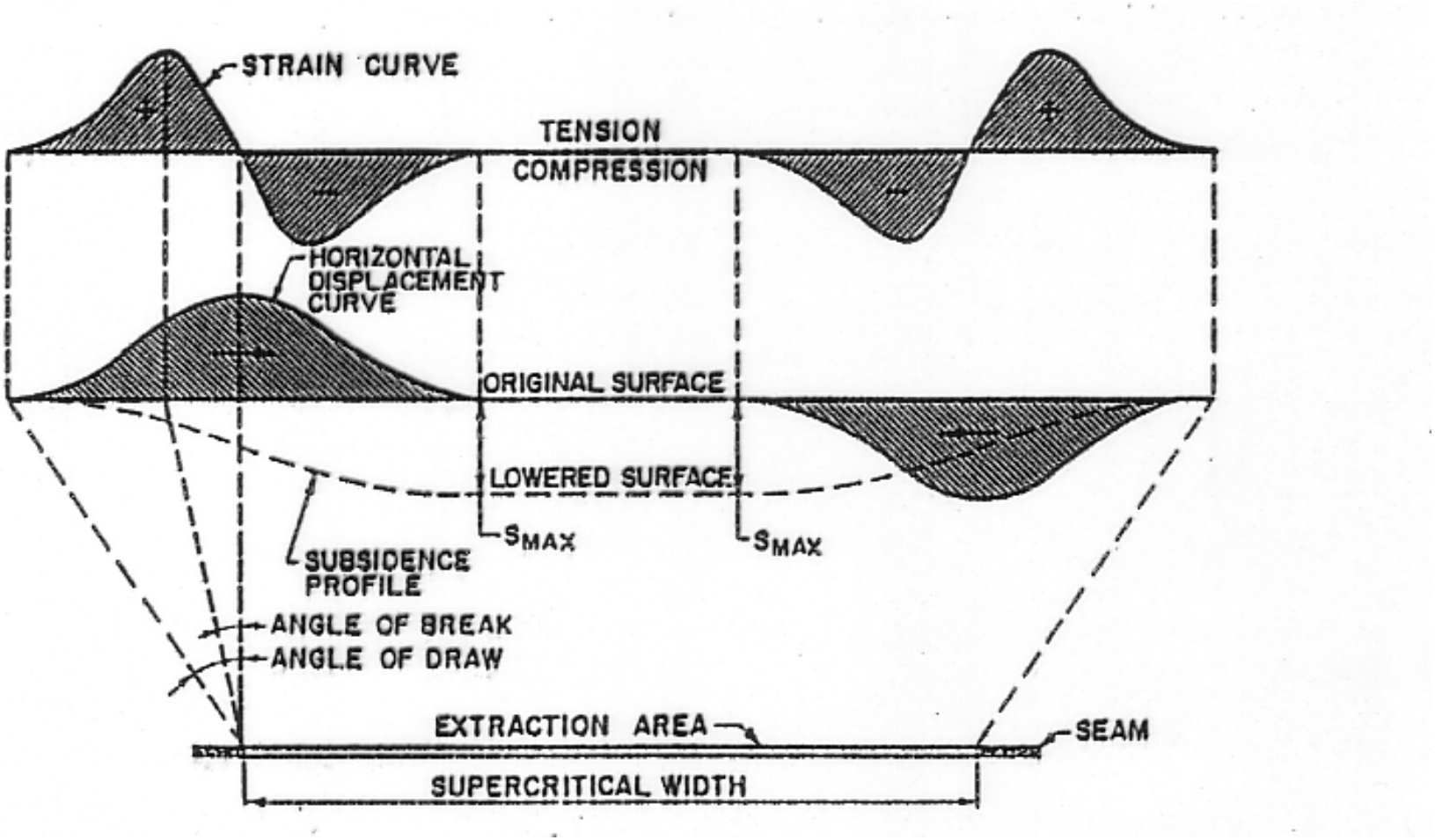
Sub-Critical Extraction



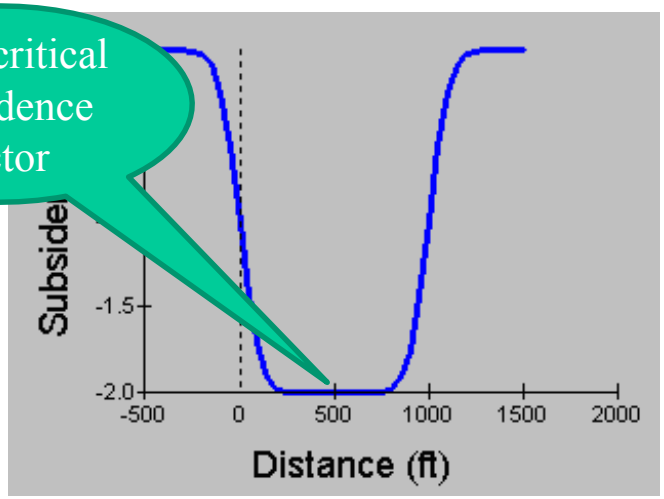
Critical Extraction



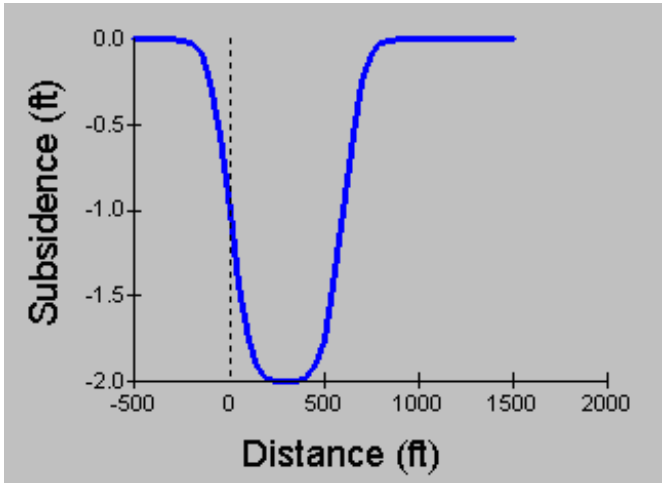
Supercritical Extraction



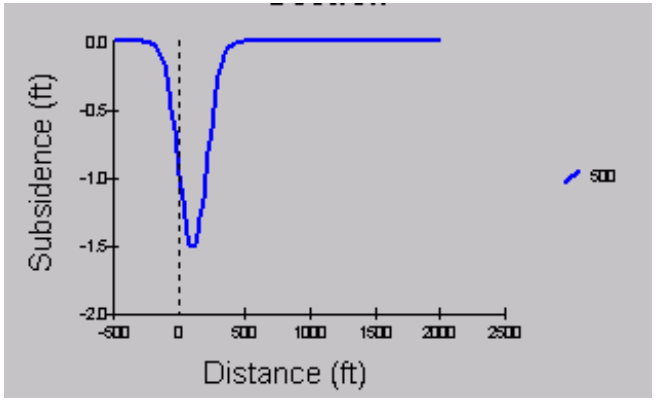
Critical and Subcritical Profiles



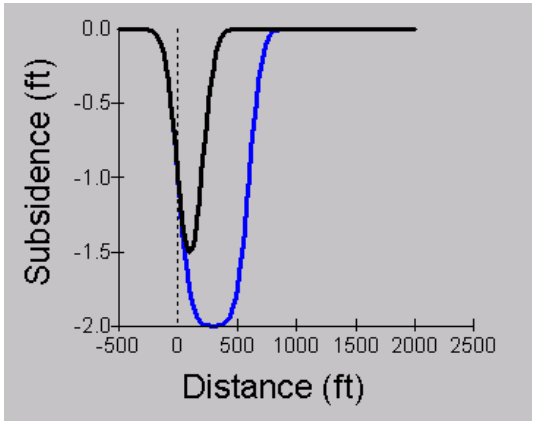
Supercritical



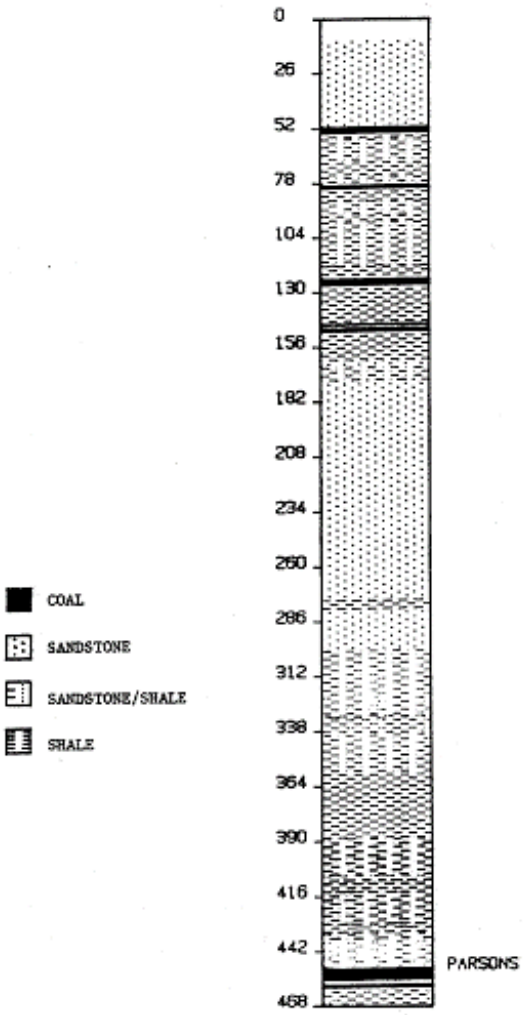
Critical



Subcritical



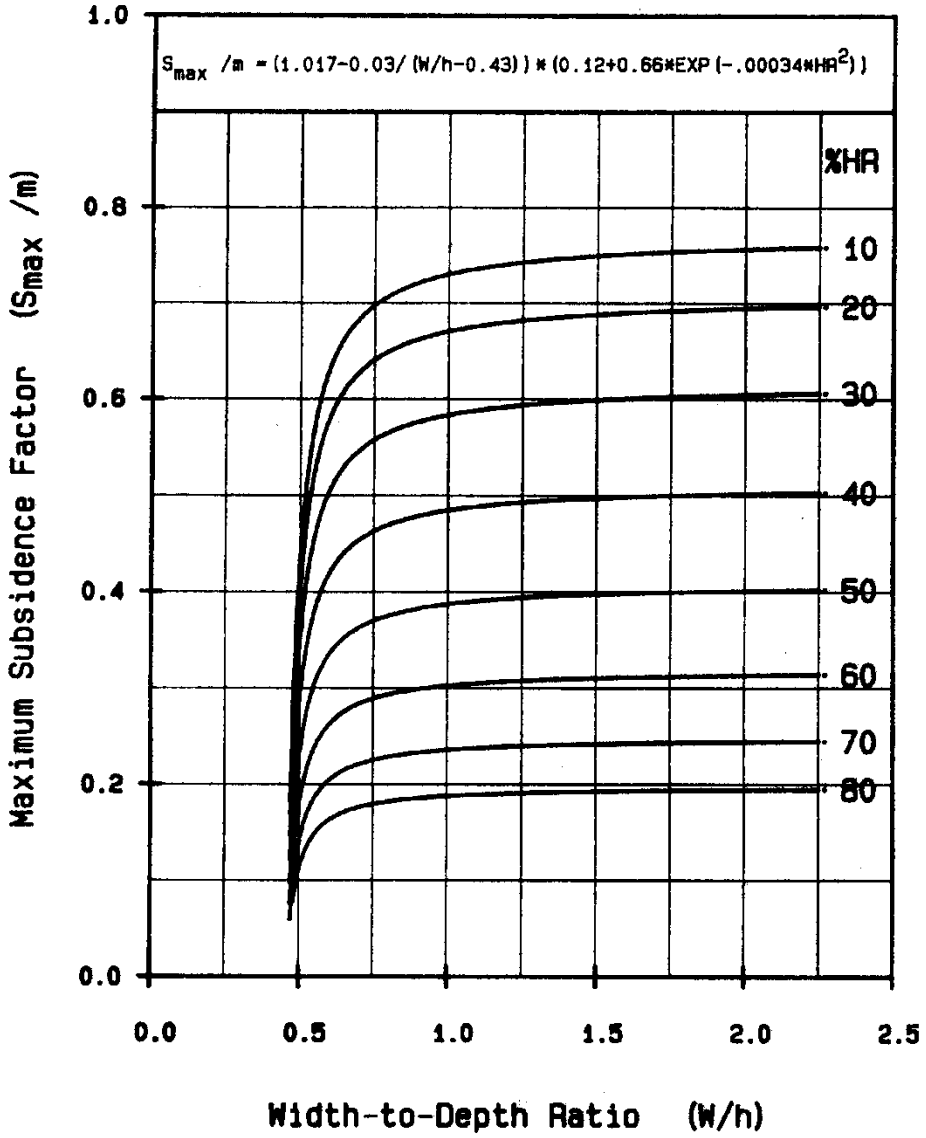
Subcritical & Critical



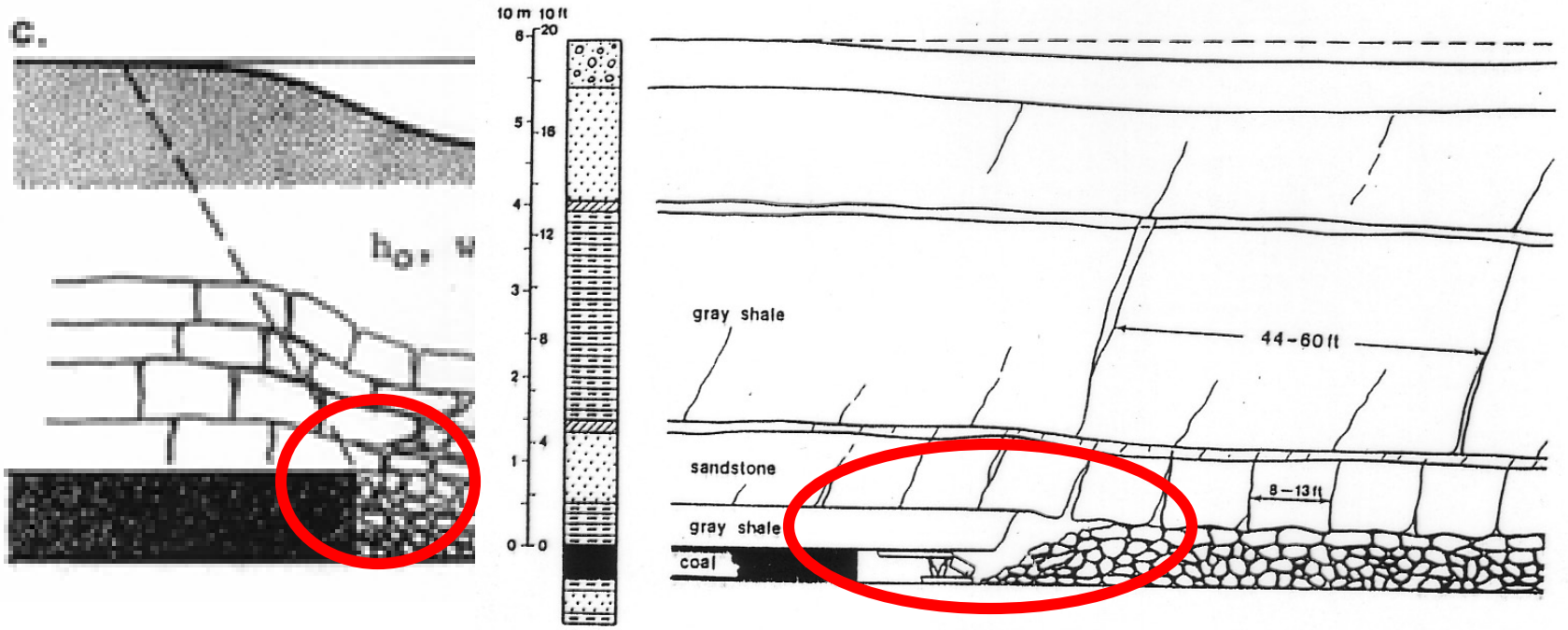
% Hardrock is Determined from Lithology

Defined, in subsidence investigations, as the sum of the strong rocks (e.g., sandstone, limestone), having a minimum thickness of 5 feet, expressed as a percentage of the total overburden thickness.

Correlation of the Smax factor with %HR for all W/h



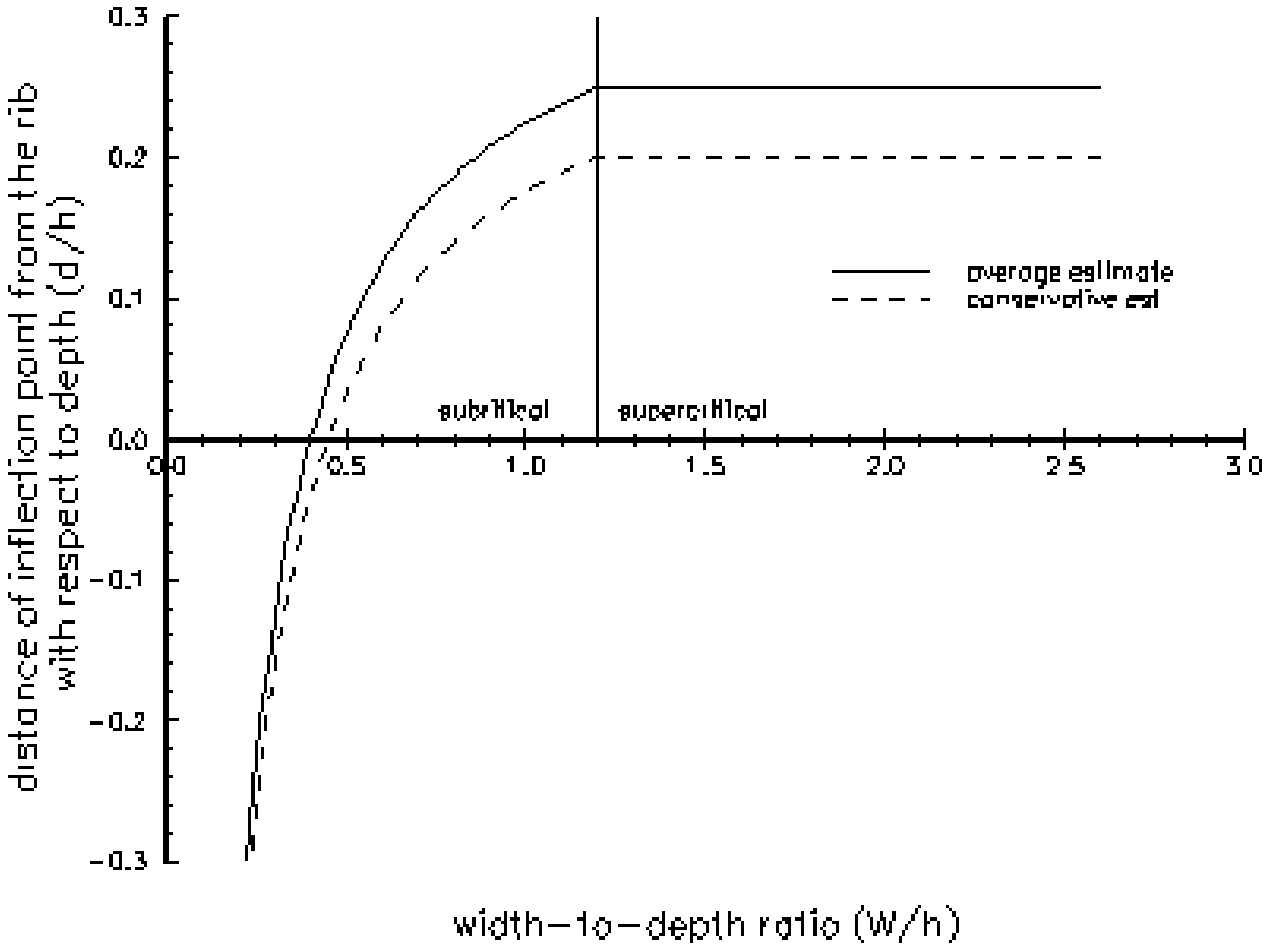
Edge Effect



Immediate and main roof behavior in the Lower Kittanning seam.

The definition of edge effect is very important in predictions

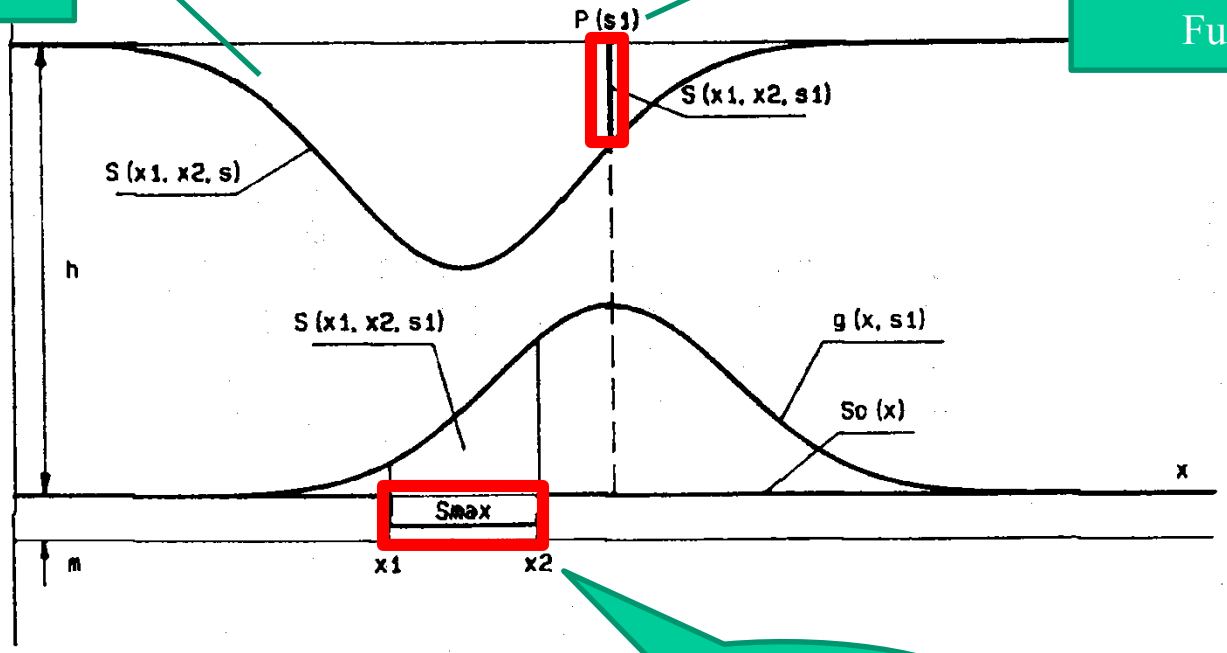
Correlation of edge effect to W/h



Concept of Influence Functions

Subsidence Trough

Subsidence at Point P is calculated based on a Bell Shaped Function

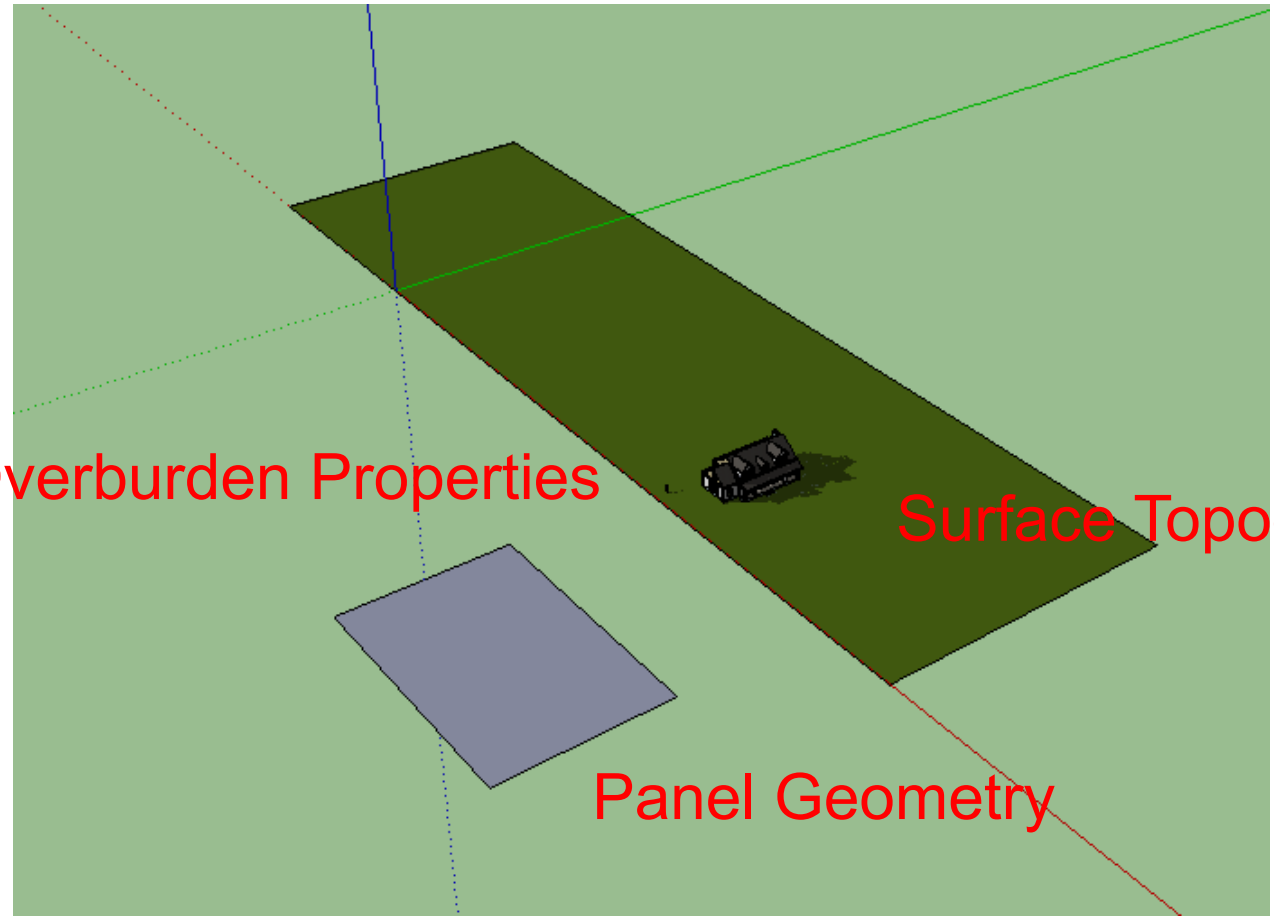


Extracted Area

Influence Function Method: Typical Input

- Any mine opening (and multiple seam)
- Any surface topography (points)
- Subsidence factor, edge effect per panel
- Regional Parameters

Typical Parameters Needed for Subsidence Prediction



Typical Mine Layout

Polygonal Mine Plan and Scattered Points

Mine Plan and Surface Points in AutoCAD

Typical Input

Mine Layout converted to input for ground deformation calculations

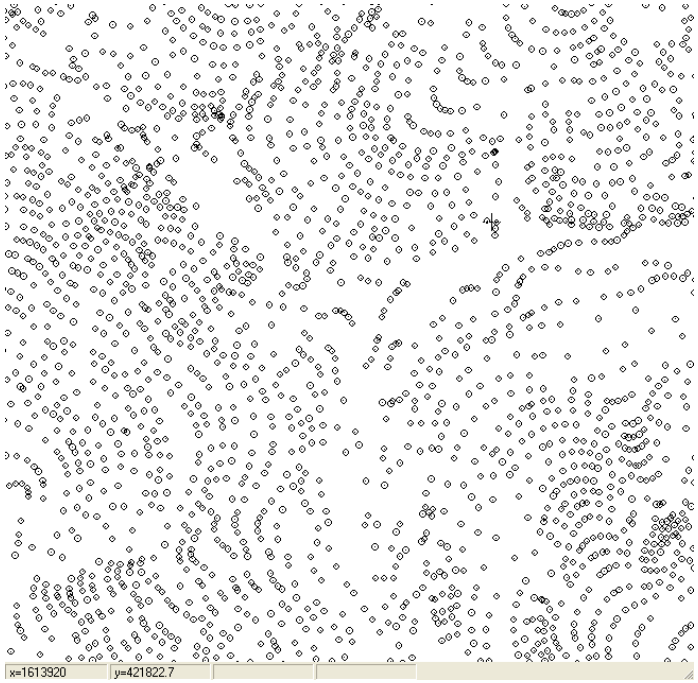
Typical Output

- Vertical displacement or subsidence (length)
- Horizontal displacement or lateral movement (length)
- Slope or tilt (unit less, %)
- Horizontal strain (unit less, 1/1000)
- Vertical curvature (or flexure) (1/length)

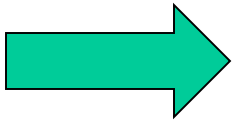
Points on the Surface

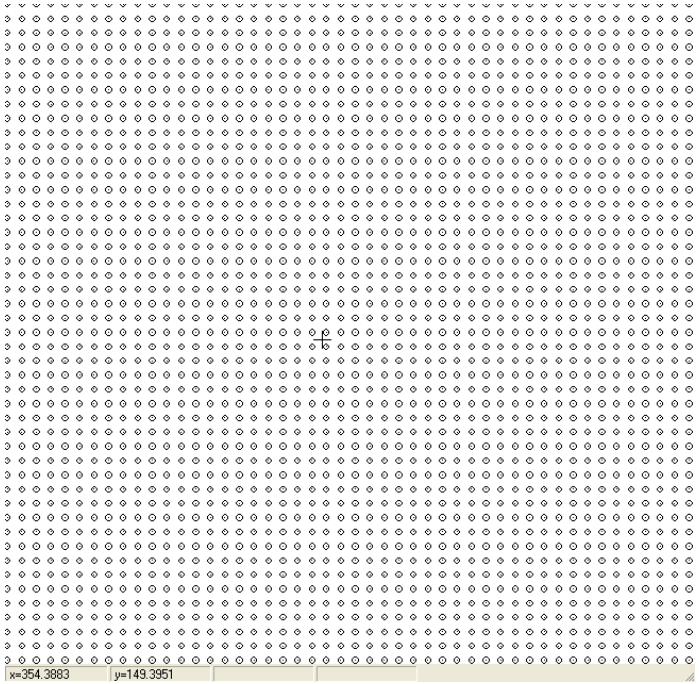
- XYZ points (scattered surface points)
  - Profile lines,
  - Individual locations
- Points on a Grid files are needed
  - Generate contours of deformation indices
  - Large areal coverage

Convert XYZ points to Grid Points



gridding



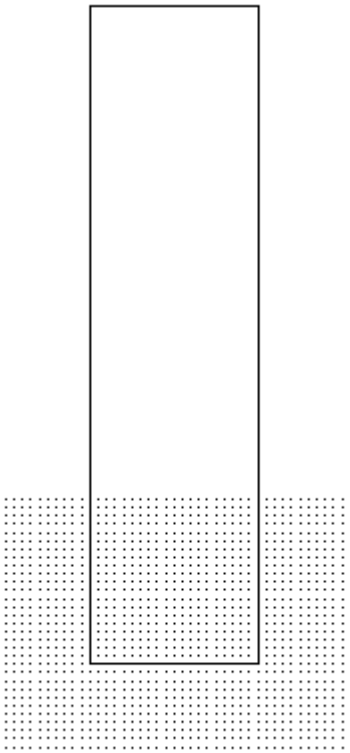


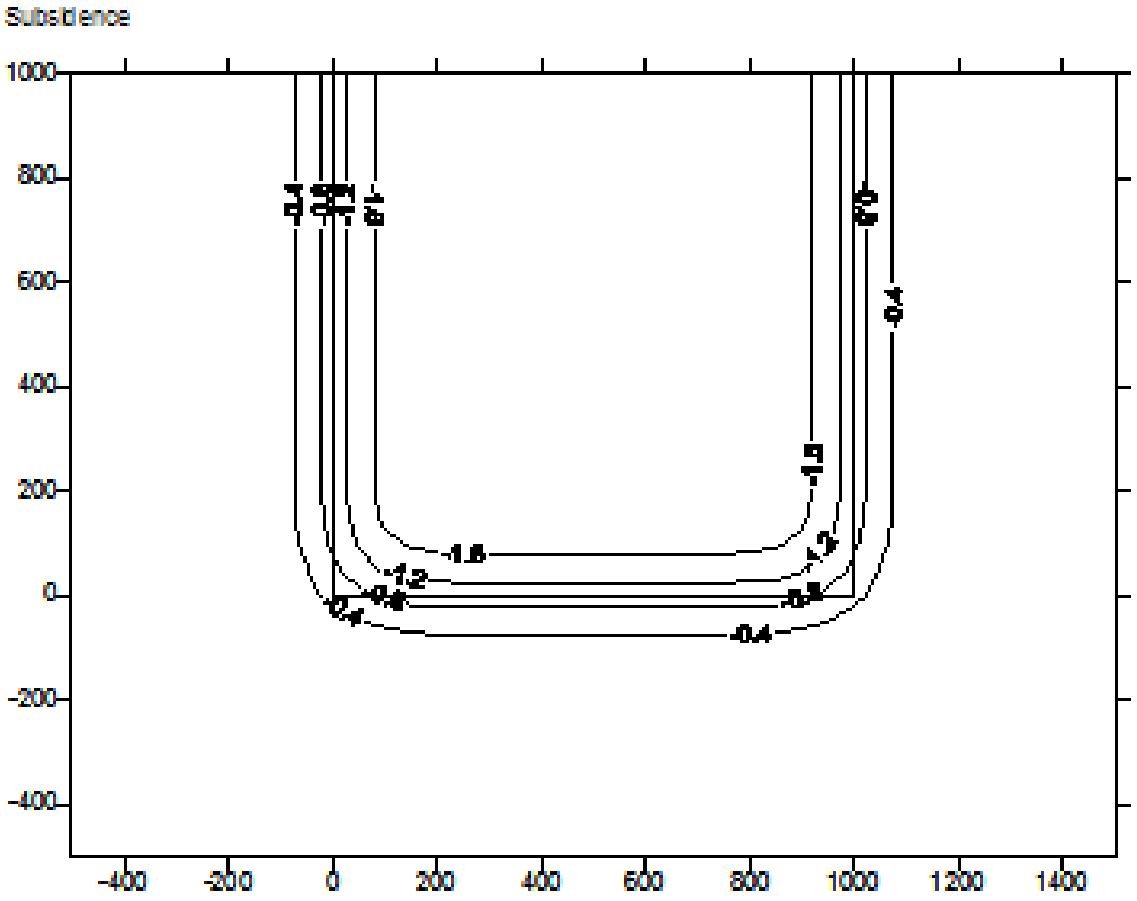
- Use any gridding software such as Surfer, Carlson Software,
- Can use any gridding method (1/x, Kriging, etc.)

Output Plots and Charts

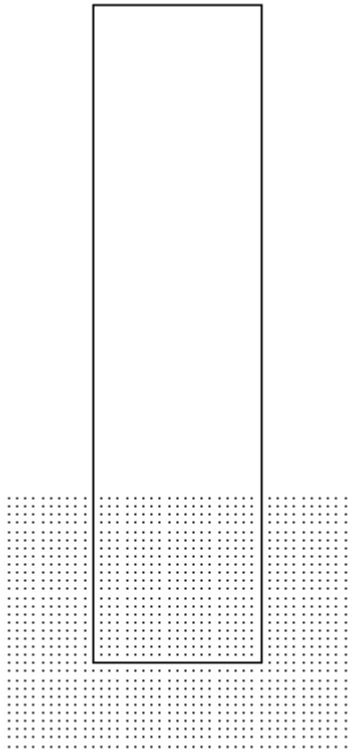
- Sections
- Vector Plots
- 2D Contours and 3D Projections

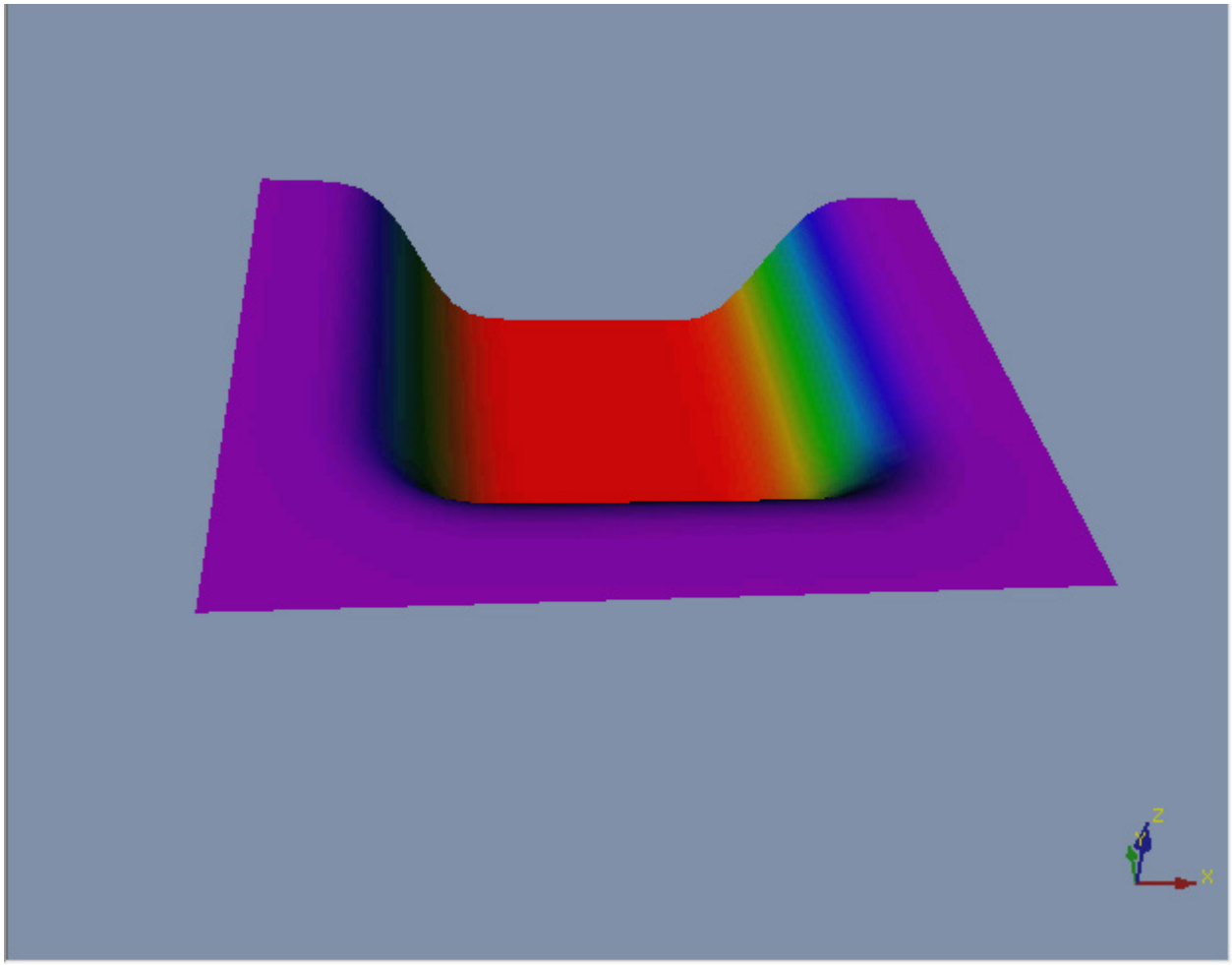
Subsidence Contours over of a Longwall Panel for Flat Topography



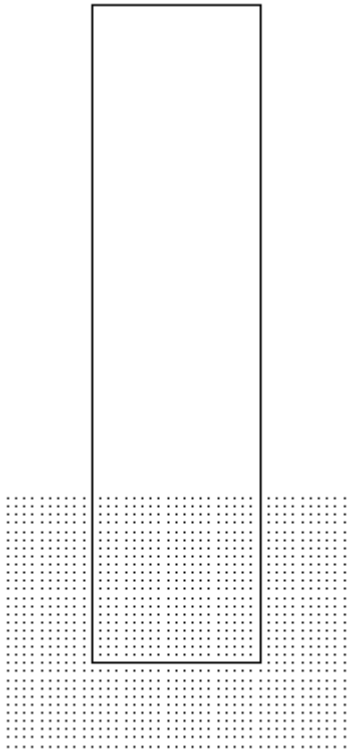


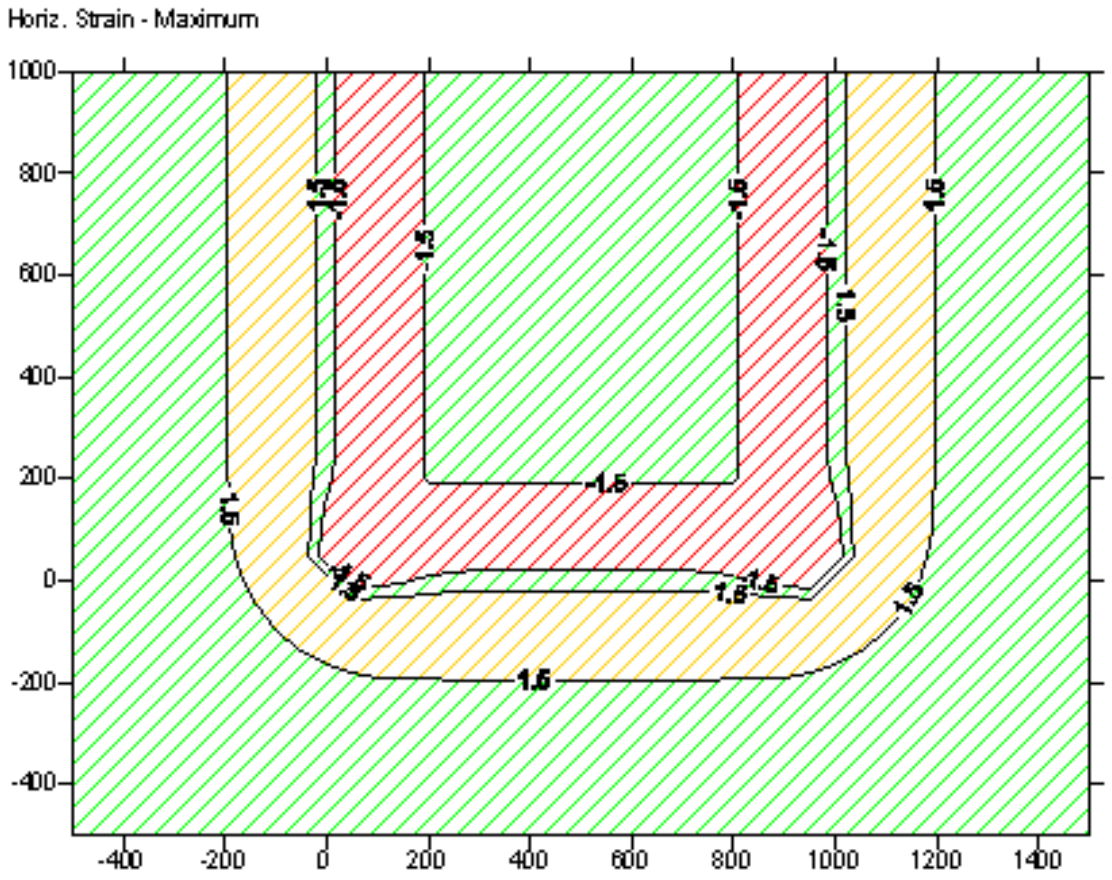
Subsidence over a longwall on Flat Terrain



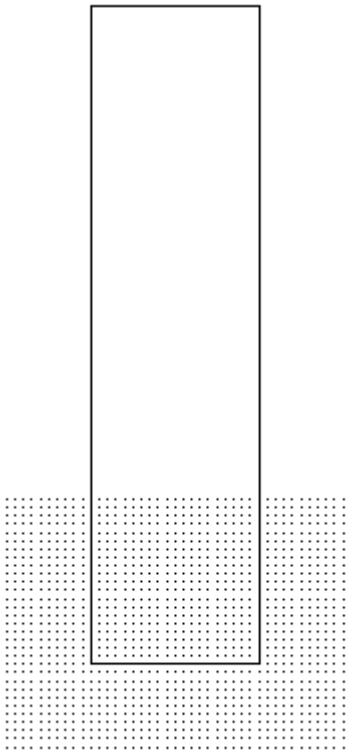


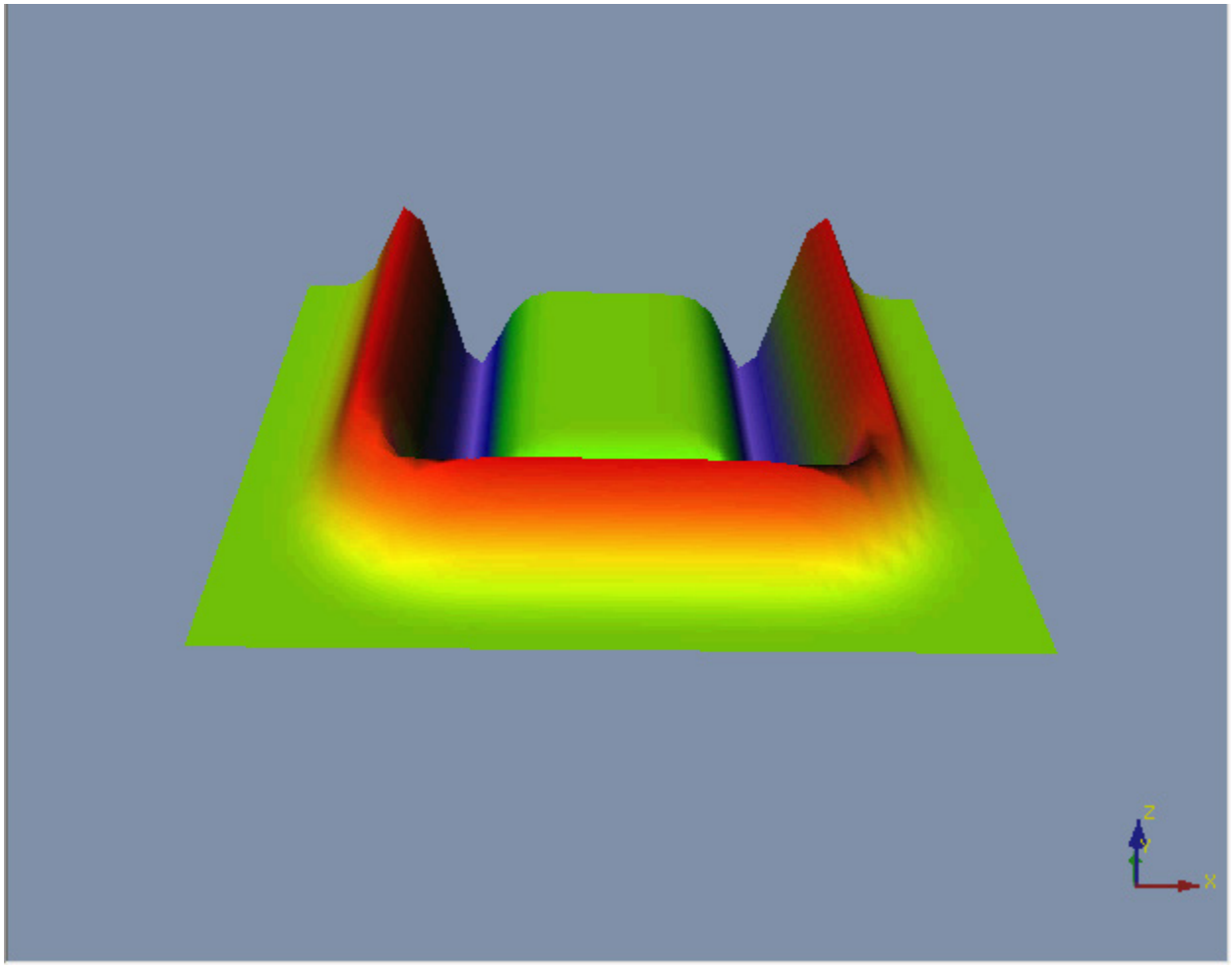
Horizontal Strain Contours over a Longwall Panel for Flat Topography



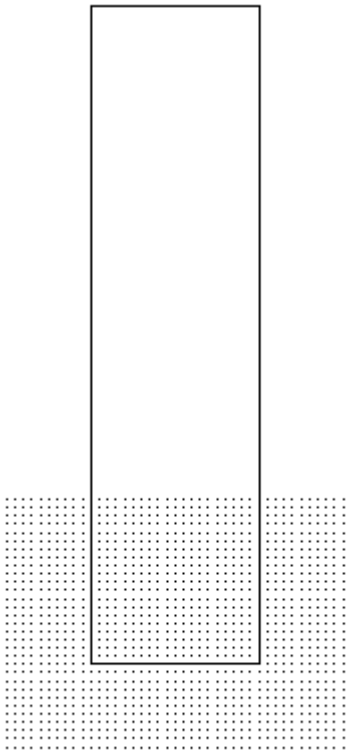


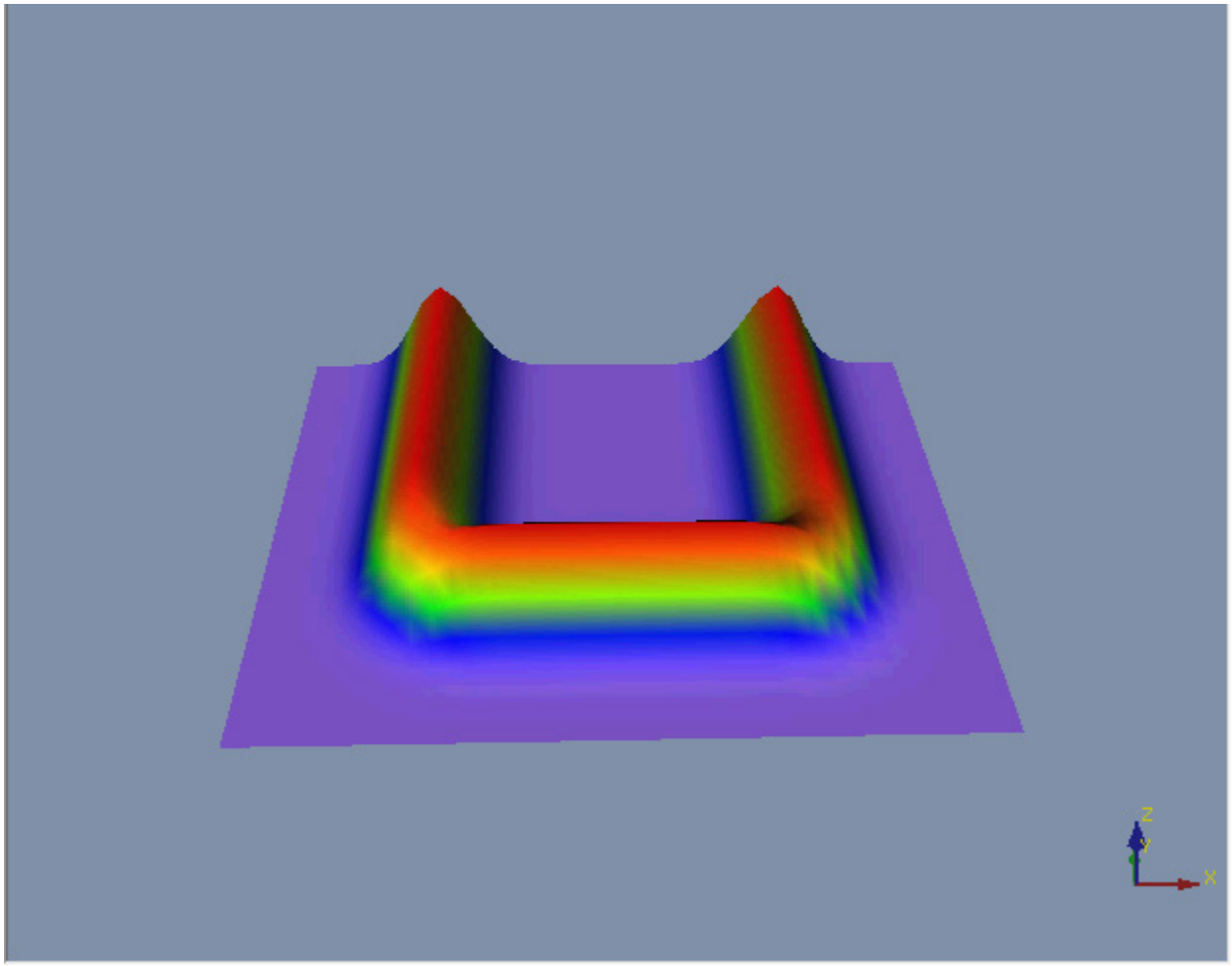
Maximum Strain over a Longwall Panel on Flat Surface



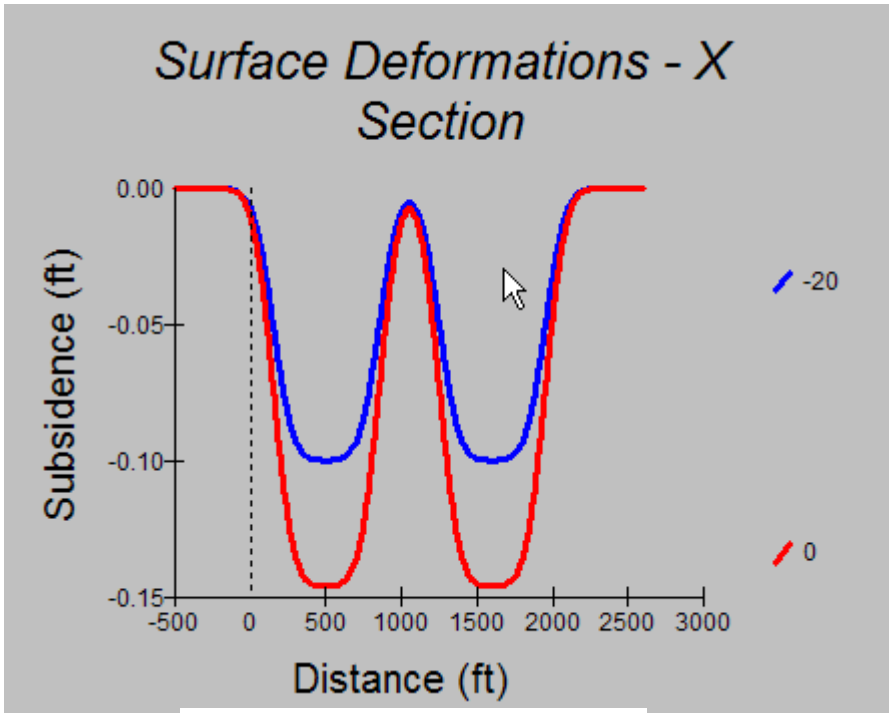


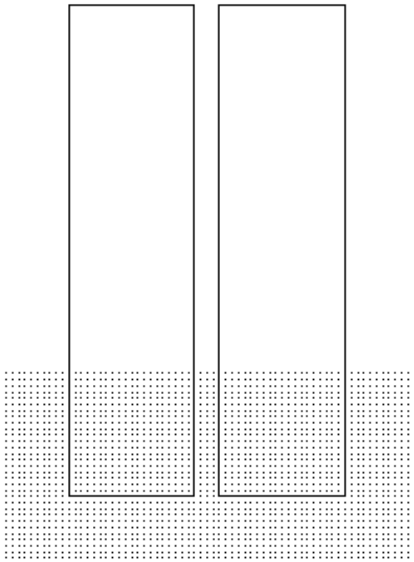
Maximum Tilt (slope) over a Longwall Panel on Flat Surface

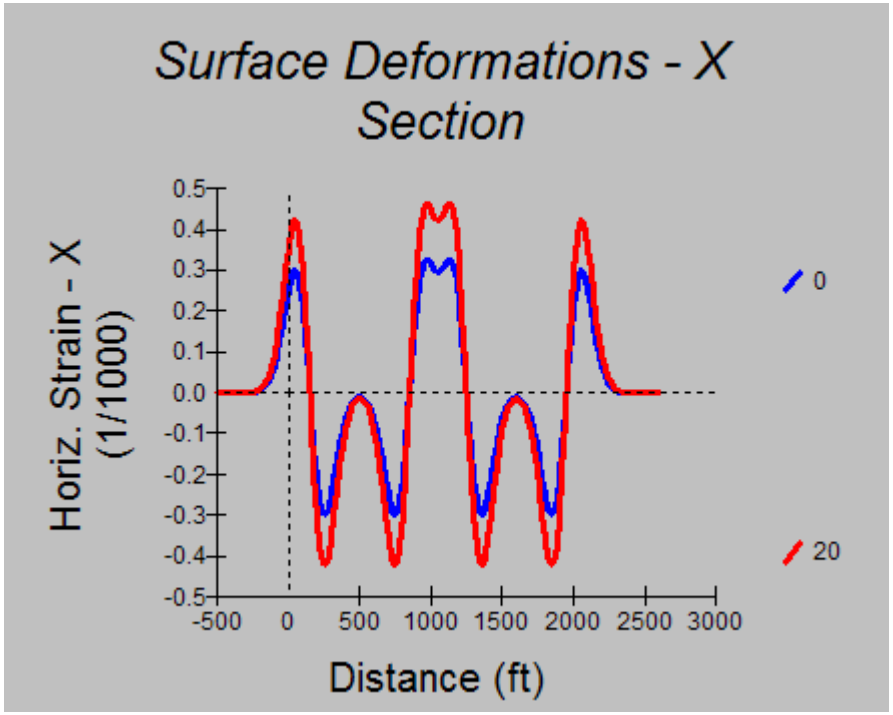




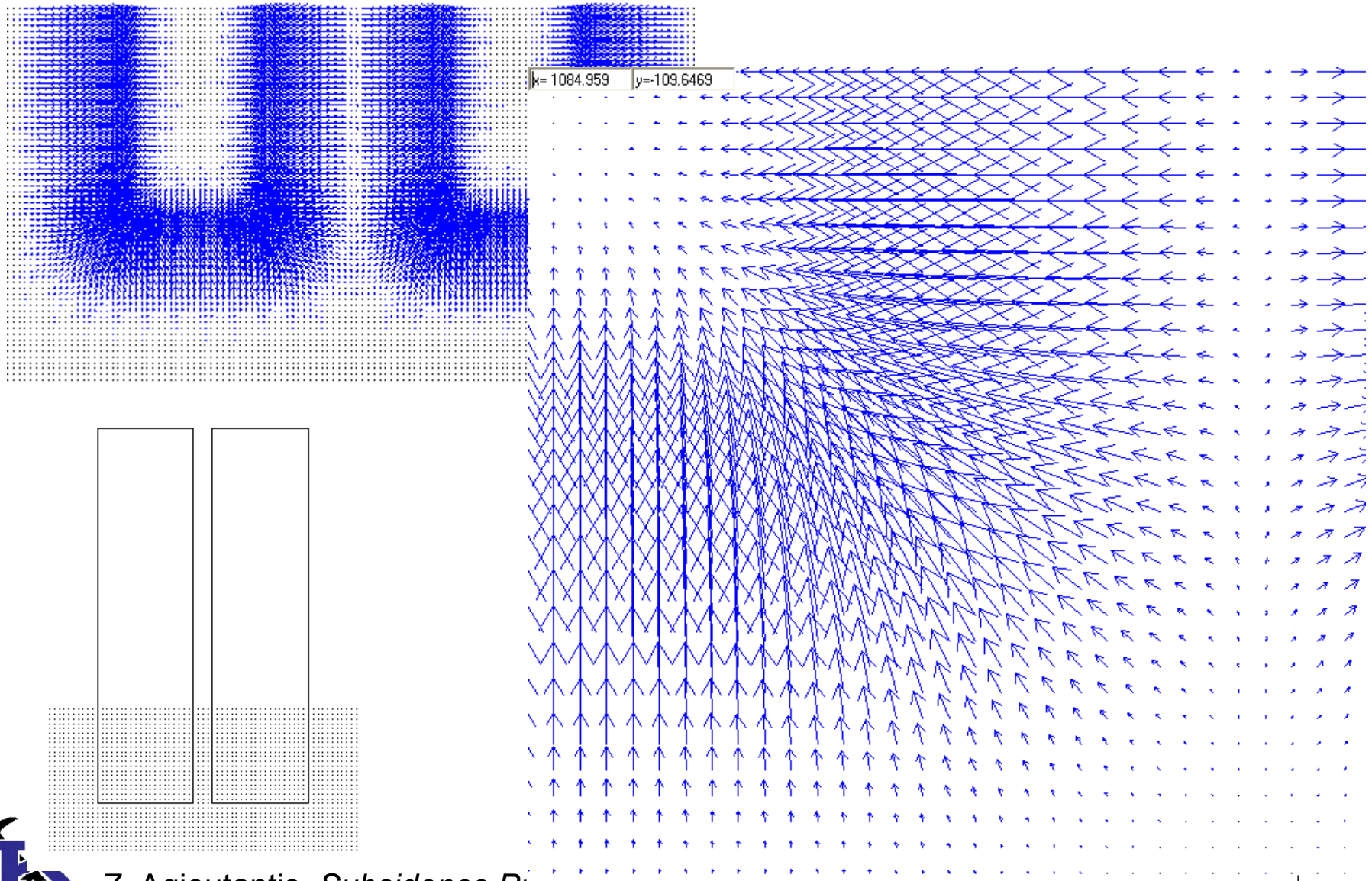
Transverse Profiles over Longwalls





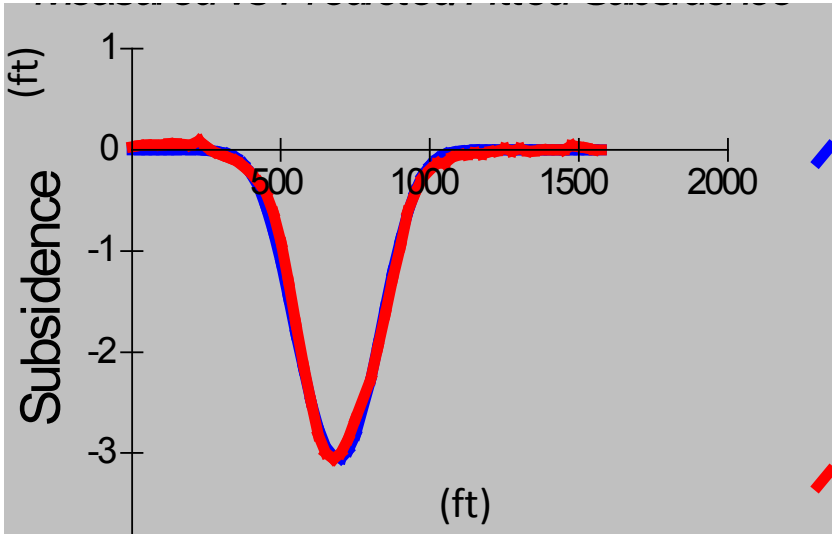


Vector Plots (Horizontal Displacement)

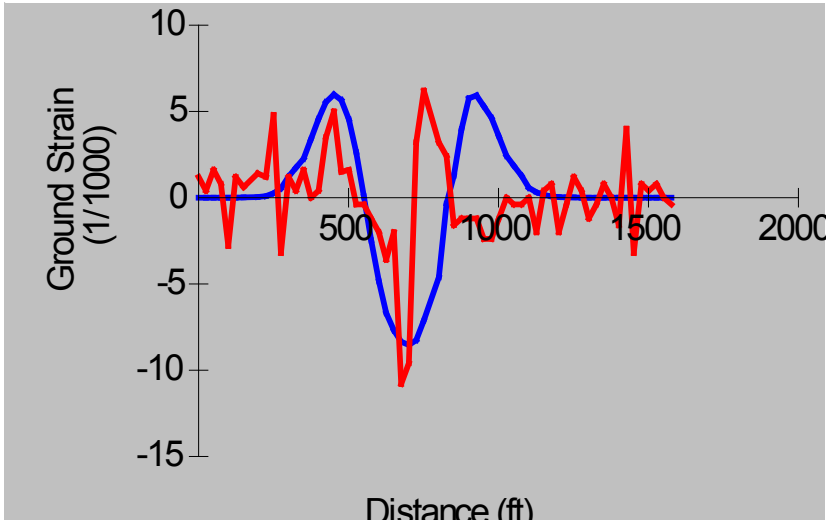


Calibration (1/2)

Subsidence Calibration



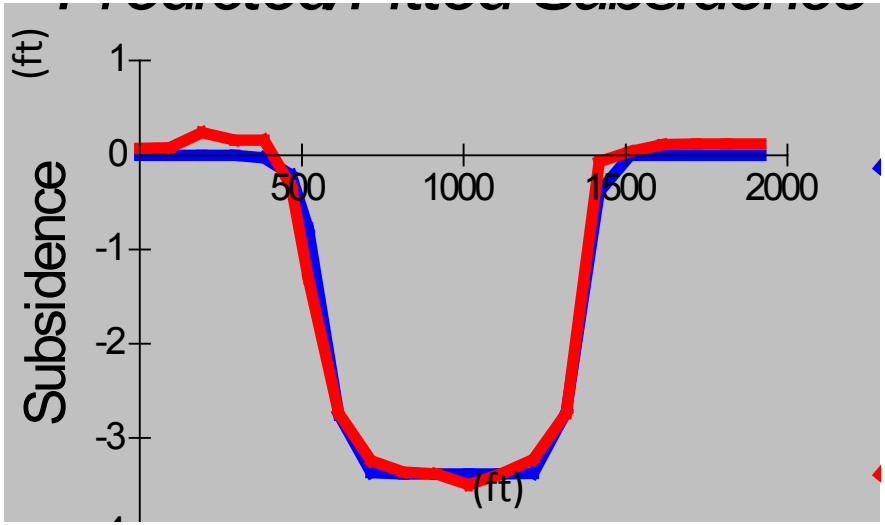
Strain Calibration



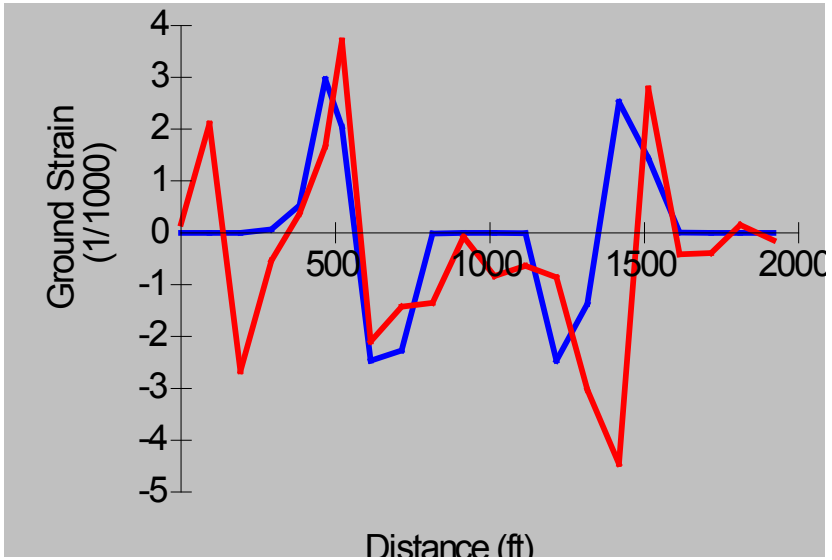
Parameter	Subsidence Calibration	Strain Calibration
Tanb	3.00	3.00
Smax/m	53.0	45.0
EdgeAdjust	167.00	153.50
Perc_Error	13.21	33.58

Calibration (2/2)

Subsidence Calibration



Strain Calibration



Parameter	Subsidence Calibration	Strain Calibration
Tanb	2.50	3.00
Smax/m	52	45
EdgeAdjust	150	150
Perc_Error	7.90	38.95

Dynamic Analysis

- Subsidence movements that occur as panels are extracted beneath the surface.

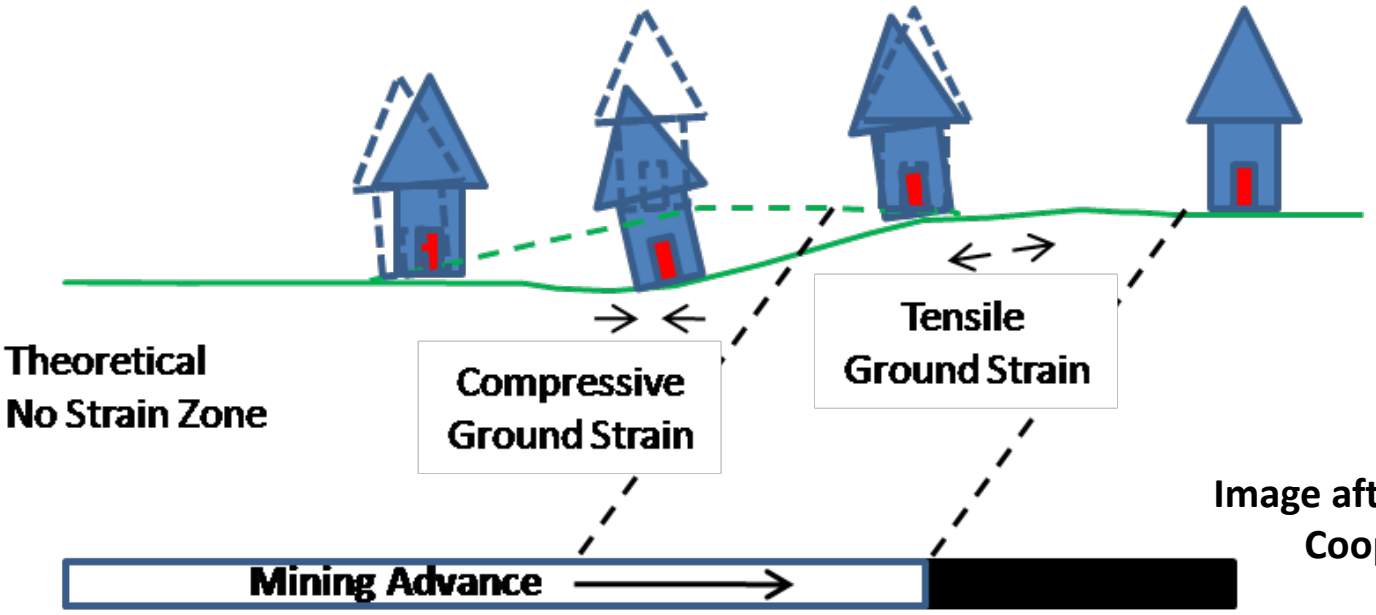
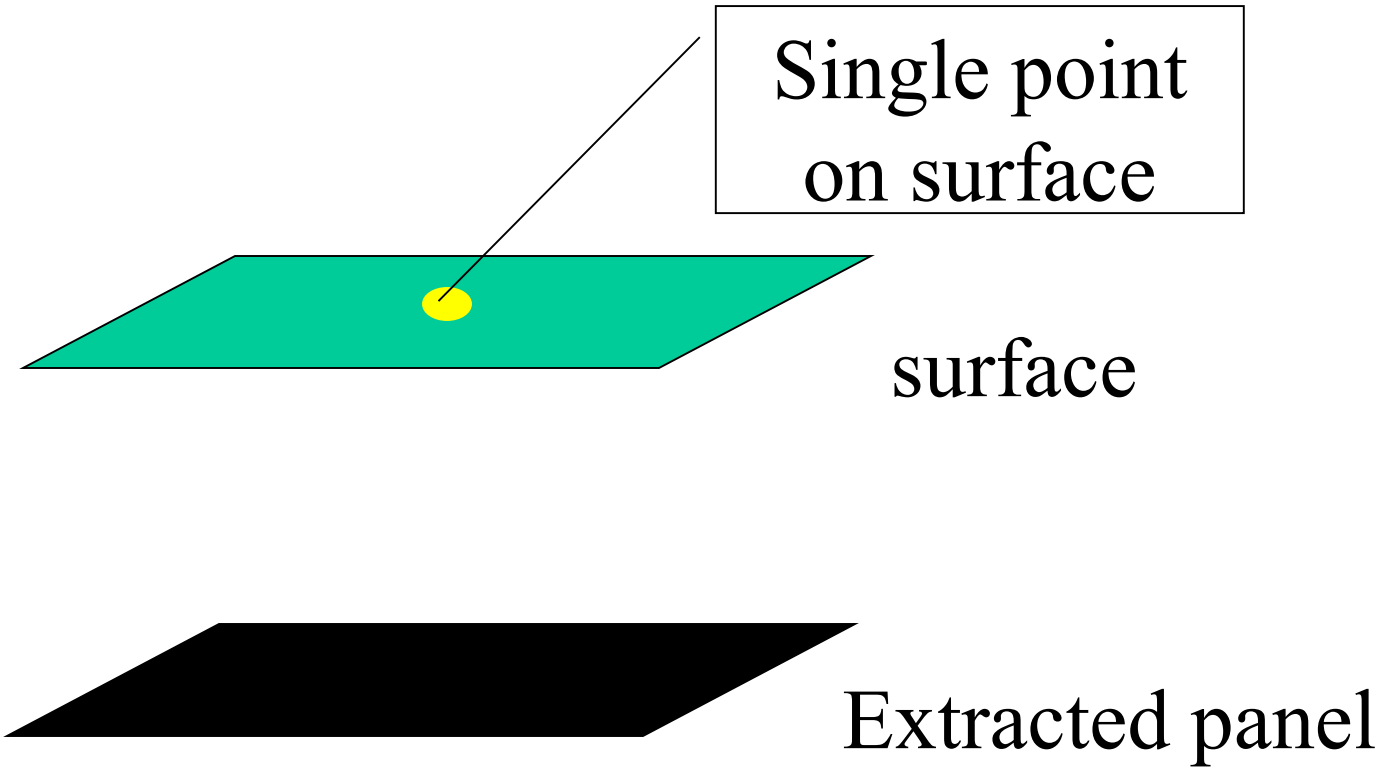


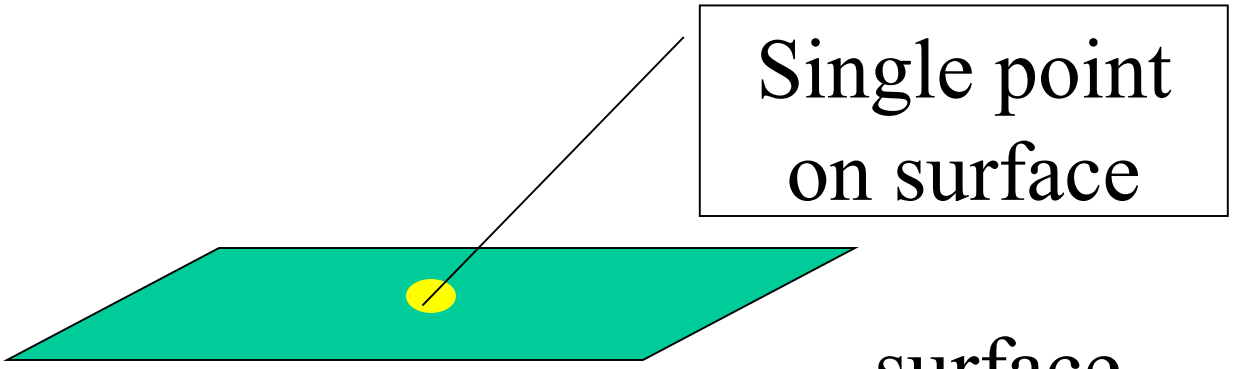
Image after Geddes and Cooper (1962)

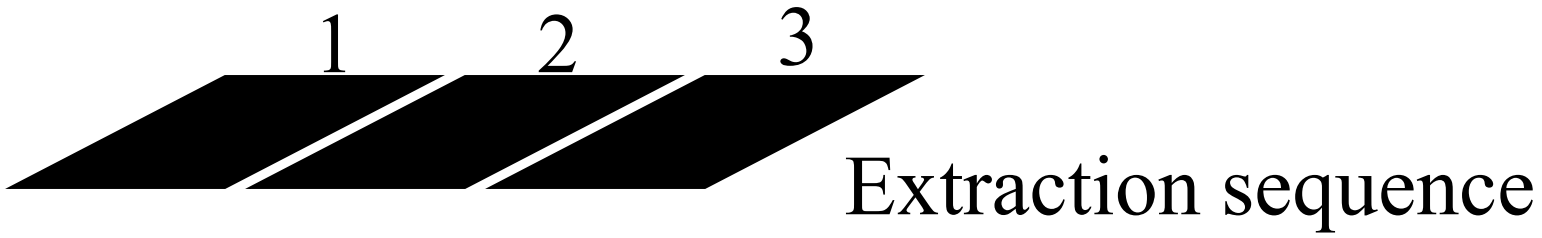
- Surface structures affected by dynamic subsidence experience both tensile and compressive strains.

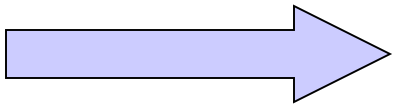
Conceptual Panel Geometry



Assume Extraction Sequence of Panel

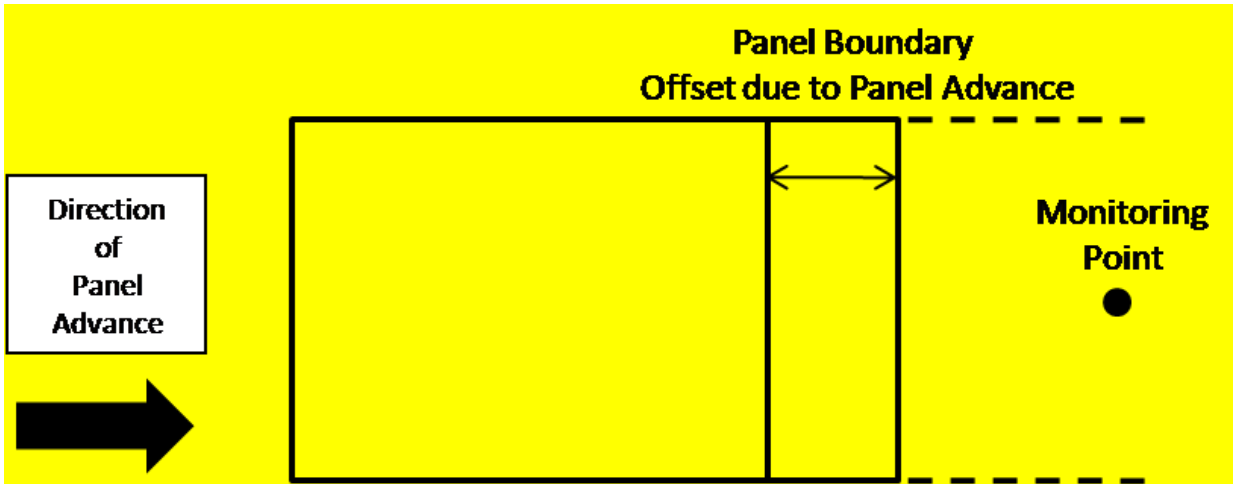




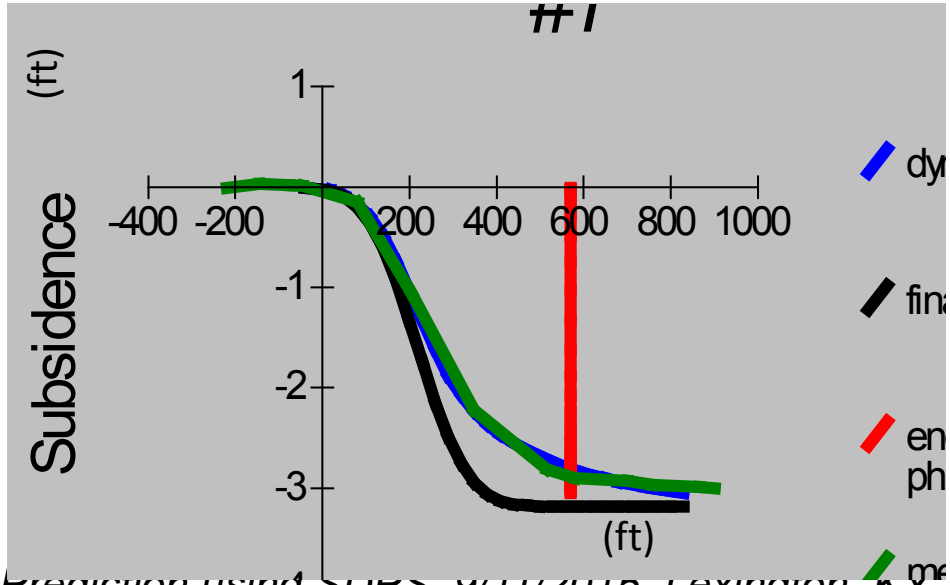


Dynamic Subsidence Development Example

Dynamic subsidence prediction panel and point layout

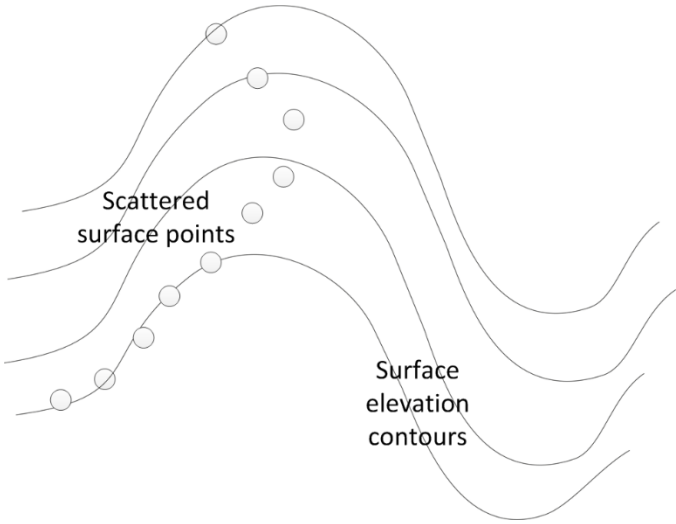


Dynamic subsidence prediction curves

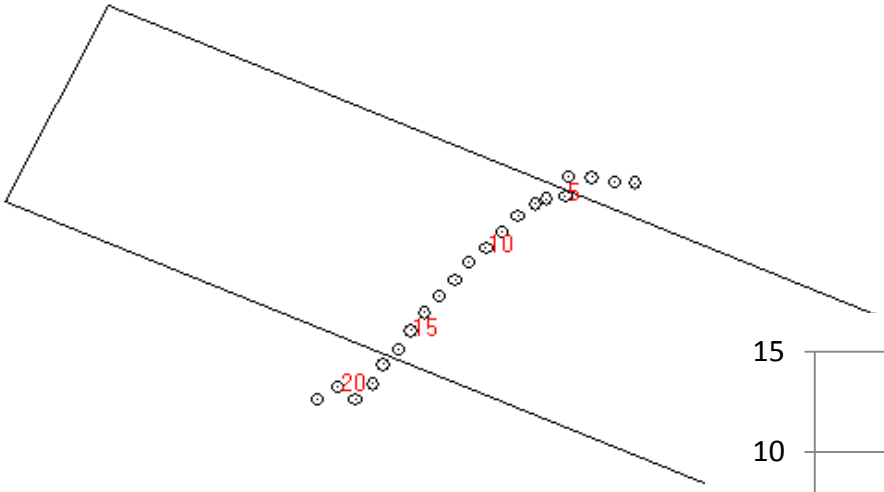


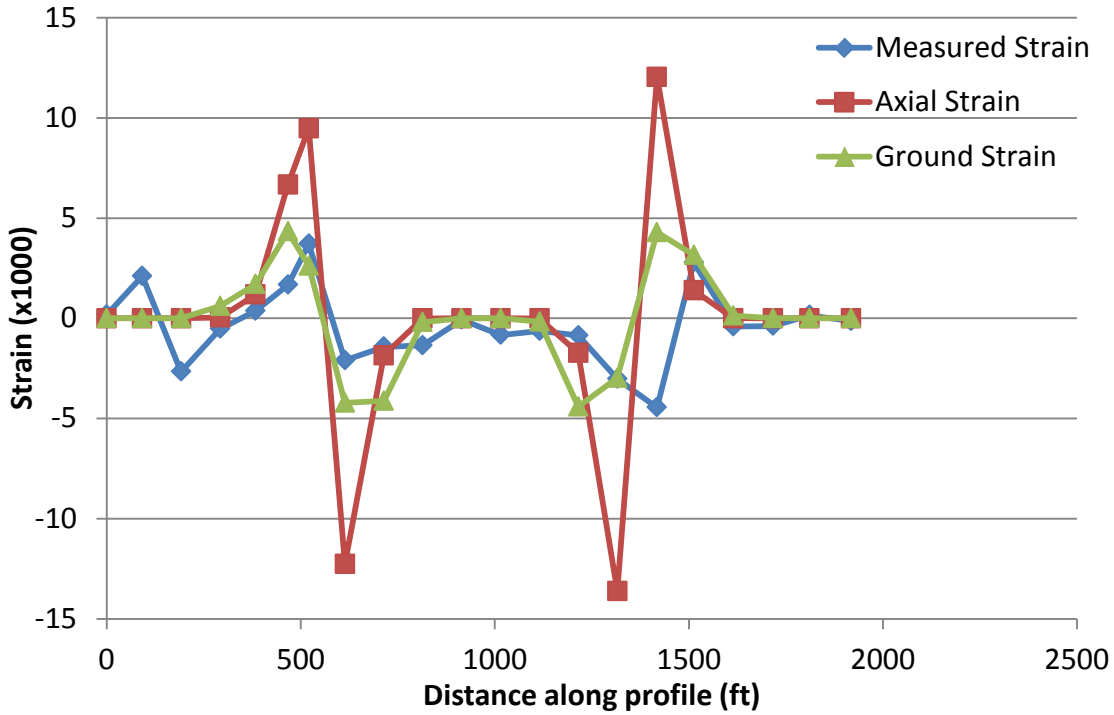
Ground Deformation Prediction on Undermined Streams

- Application of the concept of influence function
- Critical points
  - Determination of Ground and Horizontal Strain
  - Techniques to overcome the 1D nature of stream geometry
  - Punching Pillars



Case Study – LW in SW Pa





Thank you