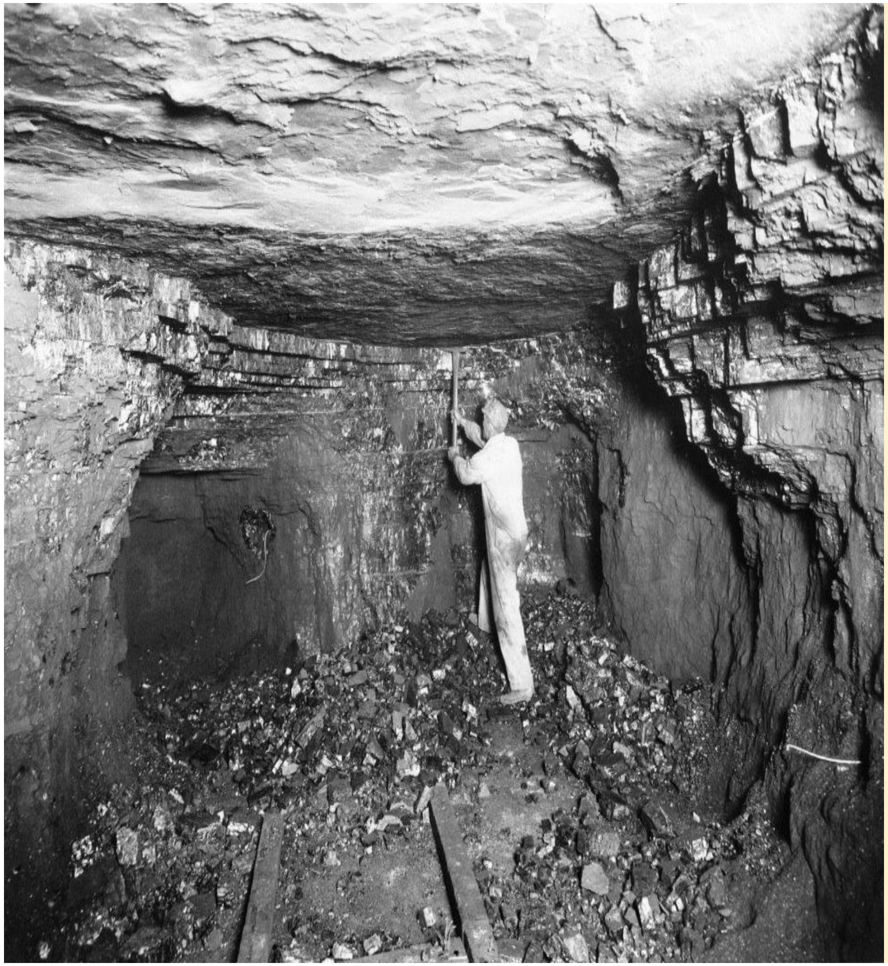
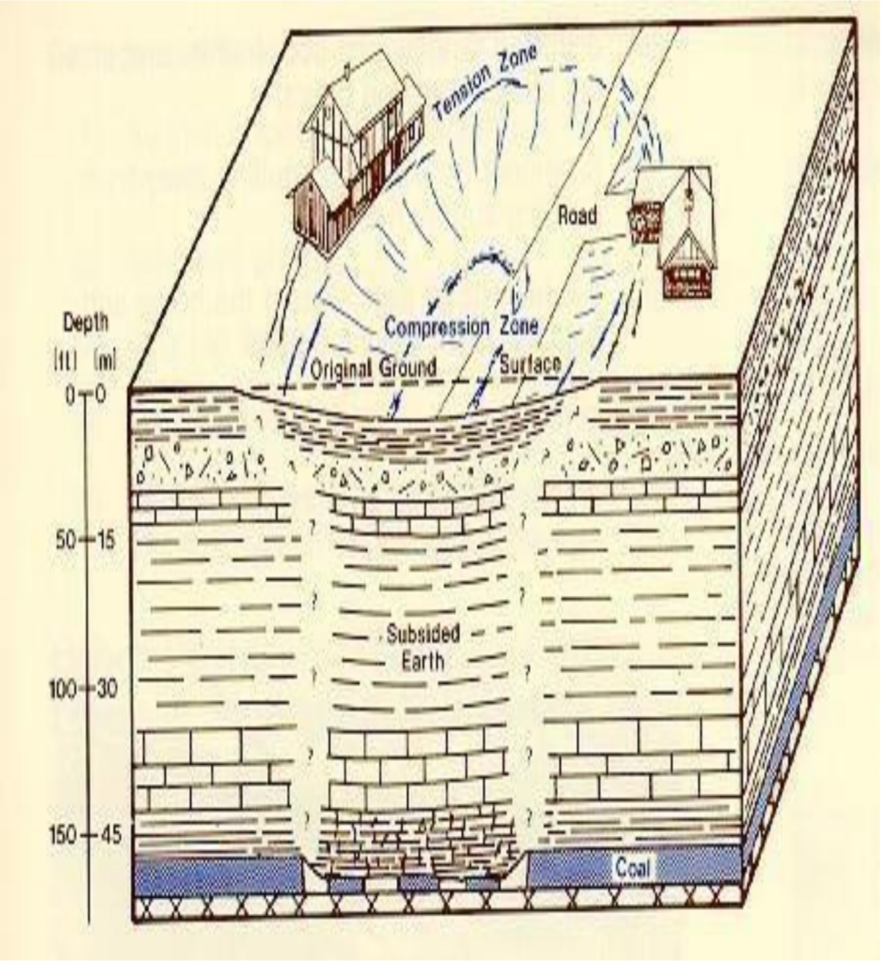
MINE SUBSIDENCE





What happens when we pull pillars or extract a longwall panel? The ground moves in to fill the opening created by the full extraction. The overburden loses the sub-adjacent support and falls into the void created by removing the coal or seam material. This is known as **Subsidence.** **Overburden Zones -** The ground movement occurs in 3 or 4 zones which can be differentiated from each other by severity of strata disturbance.

- **Overburden Zones** (h = seam thickness)
- **Caving** Zone
  - ✓**Complete Caving** Zone (<6h, 4 avg.)
  - ✓**Partial Caving** Zone (<12h, 8 avg.)
- **Fracture** Zone (24-60h)
- **Bending** Zone (>60h)
- **Surface Subsidence** Zone
- **Caving Height (h_{im}):** The height of the complete caving zone.

him = (h – d) / (K – 1)

him = Caving Height, h = Mining Height

d = Roof Sag, K = Bulking Factor

Bulking Factor (K): Ratio of the **Broken** Rock Volume to the **Unbroken** Rock Volume.

	Bulking Factor	
Rock Type	Original, Ko	Residual, Kr
Sand	1.06 – 1.15	1.01 – 1.03
Clay	< 1.20	1.03 – 1.07
Broken Coal	< 1.30	1.05
Clay Shale	1.40	1.10
Sandy Shale	1.60 – 1.80	1.25 – 1.35
Sandstone	1.50 – 1.80	1.30 – 1.35

Sag Factor (c): The proportion of mining height (h) that the roof sags.

d = c h, c = Sag Factor

h = Mining Height, d = Roof Sag.

Rock Type	Sag Factor
Strong Sandstone	0.10 – 0.15
Medium Sandstone	0.15 – 0.25
Sandy Shale	0.35 – 0.40
Shale	0.40 – 0.50

Caving Height (h_{im}): The height of the complete caving zone.

him = [h (1– c)] / (K – 1)

him = Caving Height

c = Sag Factor

h = Mining Height

K = Bulking Factor

- **Surface Subsidence Zone.**

• Ground surface drops, typically, the maximum subsidence is around **60- 70%** of the seam thickness.

• In flat-lying areas, this can cause "**ponding**".

• The surface is also **stretched, compressed and tilted** (depending on the part of the subsidence trough).

• The surface effects are **directly** proportional to coal **thickness** and **inversely proportional** to **depth.**

- **Surface Extension Zone.**

• In the surface soil layer at the edges of the panel.

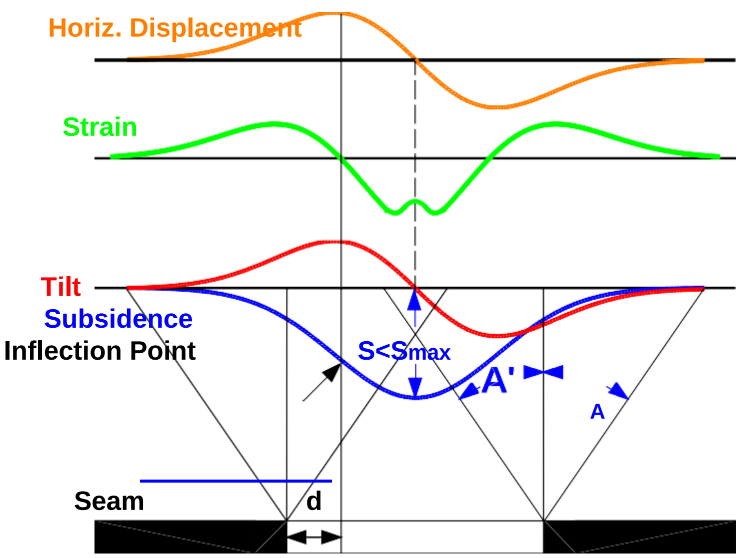
• Surface is stretched, cracks can form, up to **50 feet** deep

• **Permeability increases** often with major effects on aquifers and water tables

The **Angle-of-Draw or Limit Angle (A)** is the outward angle between the normal to the seam at the panel edge and a line connecting the panel edge and the point on the surface where the observed subsidence is zero. All of the surface subsidence occurs within the angle-or-draw.

The **Internal Angle-of-Draw (A')** is the internal angle between the normal to the seam at the panel edge and a line connecting the panel edge and the point on the surface interior to the panel where the observed subsidence is no longer affected by the panel edge. For a wide panel, the Internal Angle-of-Draw delineates the area of maximum possible subsidence. Often the Internal Angle-of-Draw is considered to be equal to the "external" Angle-of-Draw, although there is no reason these angles have to be exactly equal.

SubCritical Panel:



The **Maximum Possible Subsidence (Smax)** is the maximum vertical surface displacement for a panel that is wide enough that the edges do not limit the subsidence in the center of the panel (a critical or supercritical panel).

The **Maximum Subsidence (S)** is the maximum vertical surface displacement for a narrow (subcritical panel, S < Smax) or a wide panel (critical or supercritical, S = Smax).

The **Subsidence Factor (a)** is the percentage of the seam thickness (h) that shows up as the maximum possible vertical displacement (Smax) on the surface. **Smax = a * h**

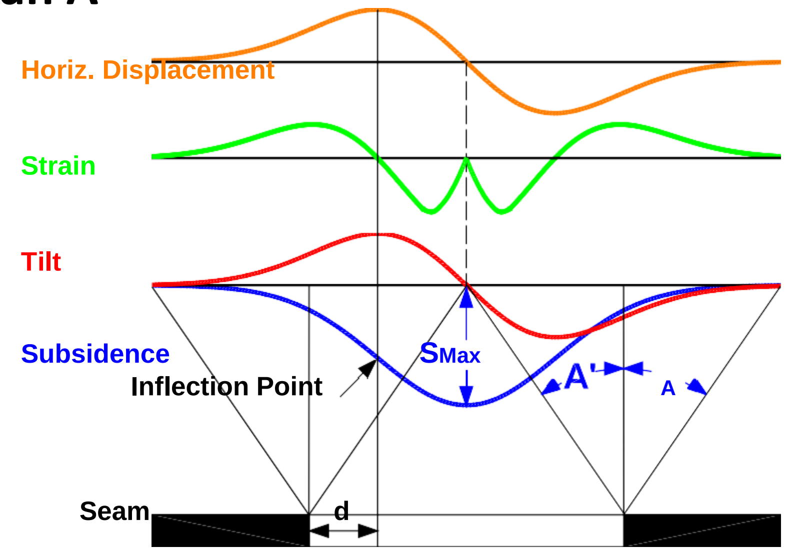
The **Inflection Point** on the subsidence curve is the point were the downward curve at the edge of the panel changes to the upward curve going to the middle of the panel. The Inflection Point is where the surface slope is maximum and the strain changes from tension to compression. The Inflection Point is generally considered to be the point of half subsidence (S/2) and to occur slightly in from the panel edge.

The term **SubCritical** refers to a panel where the width (W) is so narrow in relation to the depth that the lines denoting the internal angle-of-draw cross before they reach the surface. The maximum possible subsidence is never obtained.

W/H < 2 tan A'

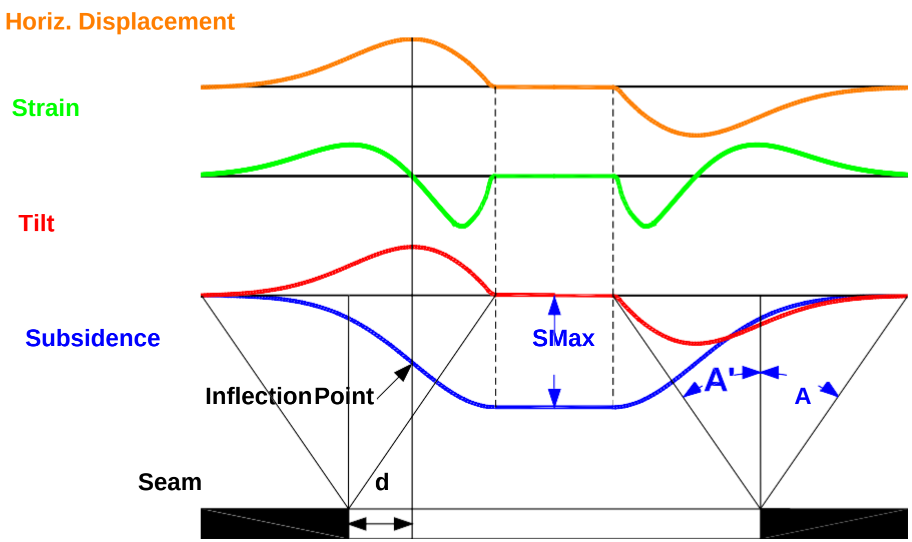
Critical Panel: A **Critical** panel has exactly the required ratio of width (W) to depth (H) that the lines denoting the internal angle-of-draw just meet at the surface. The maximum possible subsidence is obtained at exactly one point in the middle of the panel.

W/ H = 2 tan A'



SuperCritical Panel: A SuperCritical panel is so wide in relation to the depth (H) that the lines denoting the internal angle-of-draw do not cross or meet before they reach the surface. The maximum possible subsidence is obtained at all points between the surface intersections of the internal angle-of-draw lines.

W/H > 2 tan A‘



Damage Criteria:
The Geological Engineering Handbook contains tables for determining damage levels from the expected subsidence, slope and strains.
There are Damage Criteria Tables for:

(A)Buildings – brick/masonry, steel and concrete, timber frame
(B)Highway bridges
(C)Roads
(D)Railroads
(E)Pipelines
(F)Prime farmland
(G)Forest and Grazing Lands
(H)Surface water
(I)Aquifers

In some tables, the damage is classified as:

- Architectural
- Functional
- Structural

To use these tables:
•**Calculate** the subsidence, slope and horizontal strains using graphs, profile functions or computer programs.
•**Compare** the **calculated** subsidence values to **suggested** values in the tables.
•**Determine** the expected **Damage Levels.**
(Damage handbook table available in hardcopy)

Mine subsidence is the settlement of a part of the Earth's crust due to removal of subsurface solids or underground excavation. Settlements may vary in magnitude from complete collapse or substantial lowering to small distrotions of the ground surface.

Mine subsidence control is the use of techniques to prevent or reduce subsidence movements to avoid or minimize damage to surface structures, to limit fracturing of strata above the mine, or to control subsurface stresses to assist mining operations while maximizing extraction. These techniques are also referred to as ground control , surface stabilization, or subsurface stabilization. Subsidence control techniques for active mining have been developed most extensively in European coal fields by empirical and theoretical studies.