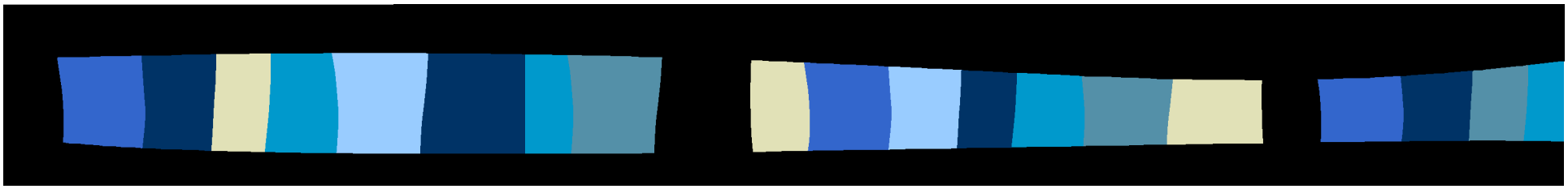
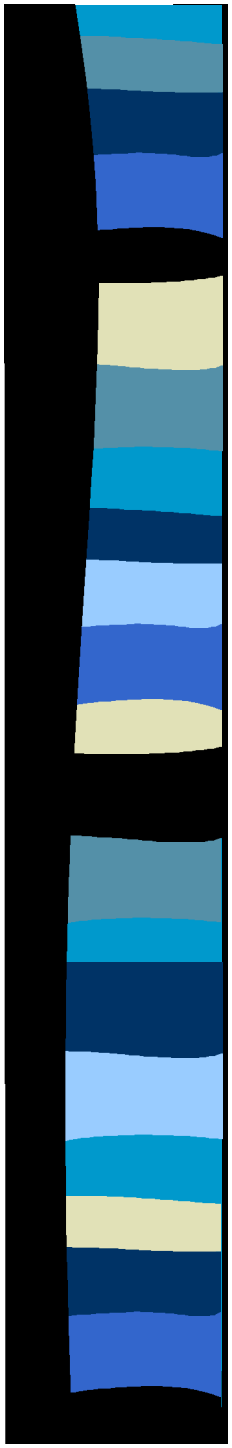
Underground Mining Methods



Stanley C. Suboleski

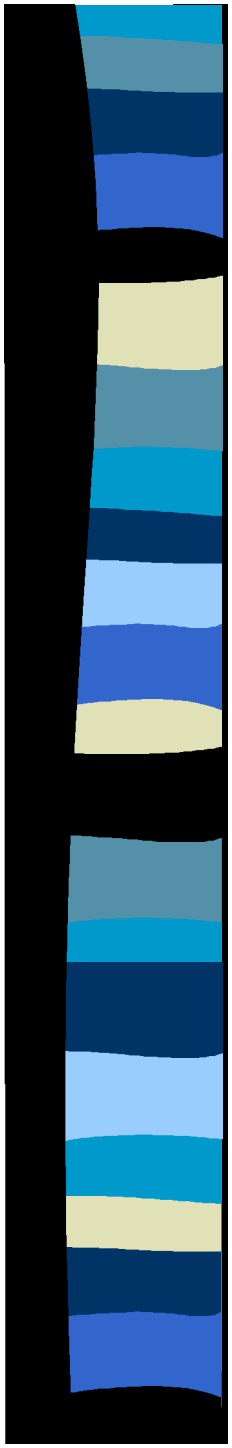
Virginia Tech

June 23, 1999



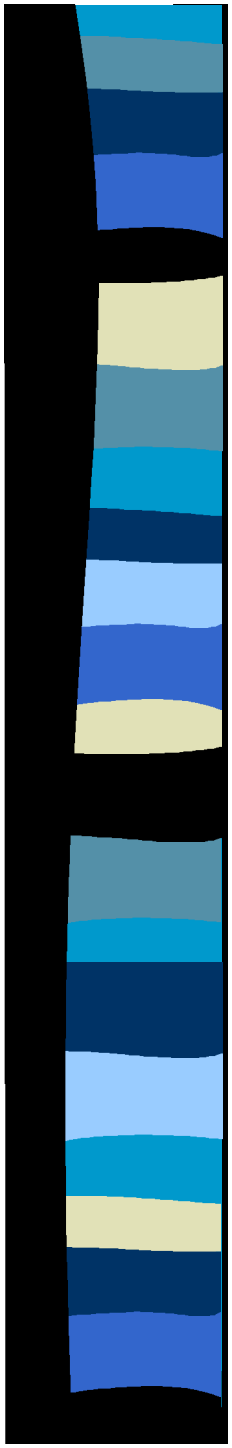
Two Main Methods

- Room & Pillar
  - Mostly with continuous miners
- Longwall
  - Develop longwall panels with room & pillar using continuous miners
- About 10% of underground production still comes from drilling & blasting
- Total underground output = 421mt (1997 data)



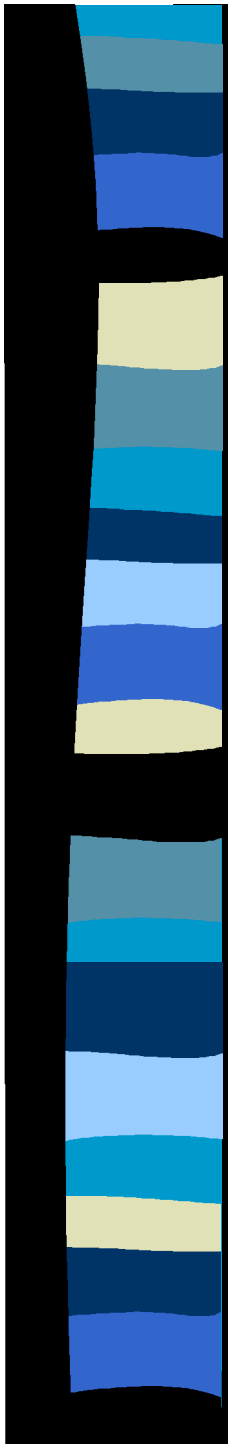
FIRST, MUST ACCESS THE MINE

- Drift (Adit)
  - Seam outcrops, access from ground level
- Slope
  - Drive incline in rock at up to 16 degrees
  - Allows belt haulage
- Shaft
  - Use: elevators/skips, for: people/coal
  - Use shaft if >1500 feet, economics dictate



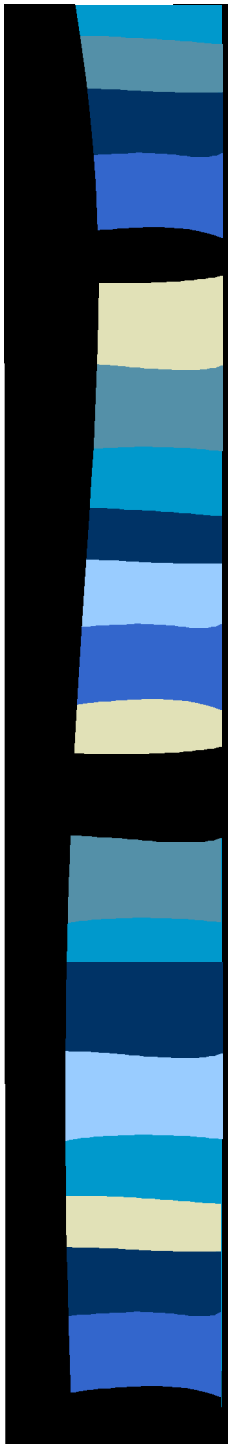
LIKE A CITY, OR LARGE BUILDING, SERVICES MUST BE PROVIDED

- Transport people (rail, rubber tired)
- Transport supplies (materials / maintenance)
- Transport product (coal)
- Support roof
- Provide electrical power
- Provide fresh air (& suppress dust)
- Provide fresh water
- Get rid of waste water
- Dispose of trash



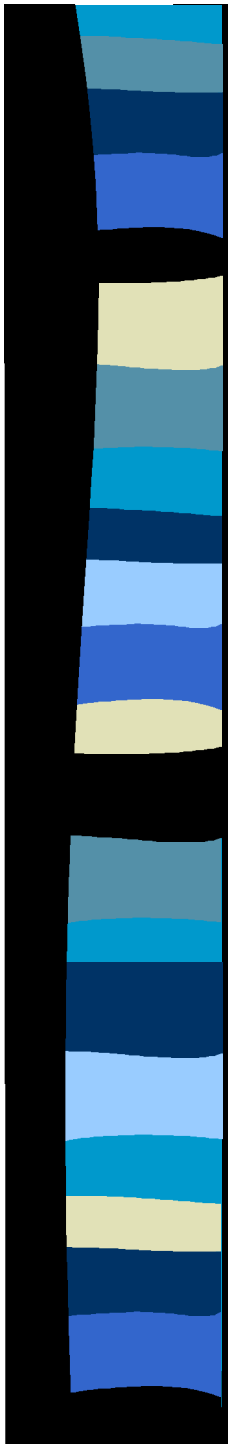
ROOM & PILLAR

- Mine “streets & avenues” (entries and crosscuts)
- Leave pillars to support roof (may mine later)
  - Designed by formula
- Plan view-looks like city with “greenbelts”
  - “Greenbelts” are large barrier pillars left to separate work areas
- Use continuous miner



MINE PLAN

- Main entries (7-9 openings)
- Submains (5-7 openings)
- Panels (panel entries, butt entries)
- Rooms (at times)
- Openings limited to 20-ft width
  - **Openings serve as air ducts and travelways**
  - **Return air is isolated from fresh air, two escapeways must be provided from face**
- Longwall panels are solid coal blocks, usually 1000 ft by 10,000 ft, accessed by “gate” roads

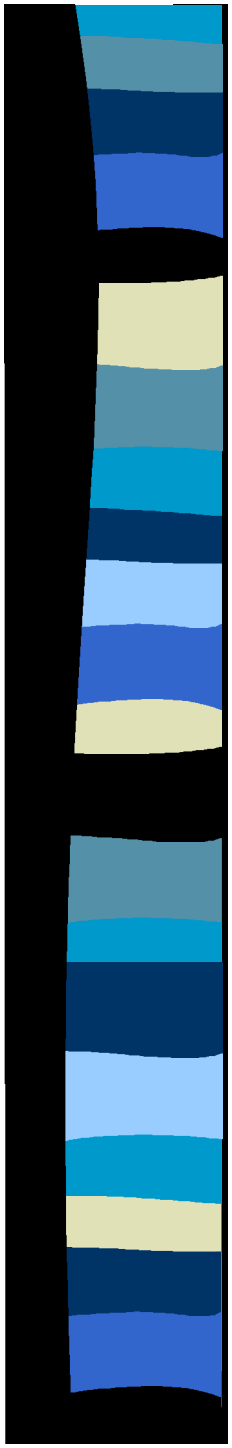


ALL SERVICES EXIST TO SUPPORT MINING AT FACE

- Continuous miner - rips coal, using tungsten carbide bits - miner mines at 4-25 t/m and conveys coal into shuttle cars
- Shuttle cars are electric (cable) “trucks” which haul for up to 600 feet or so (usual = 300-400 feet)
  - Haul to feeder-breaker which acts as surge bin/crusher and feed coal onto belt
  - Hold 3-25 tons/load, depending on seam thicknesss and amount of rock mined

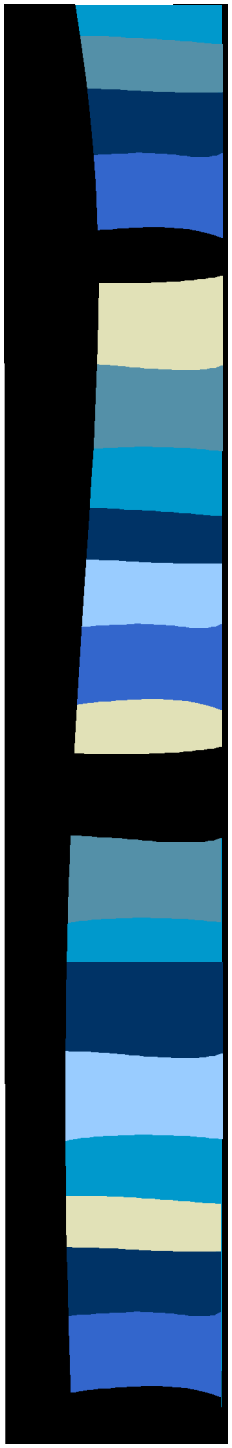
FEEDER-BREAKER FEEDS COAL ONTO BELT CONVEYORS

- Conveyors transport coal to surface or into skips for shaft access
  - Usual sizes - 42” to 72”
  - Speeds - 500 - 800 fpm
- Longwall requires largest conveyors
  - 54”-60” usual from face



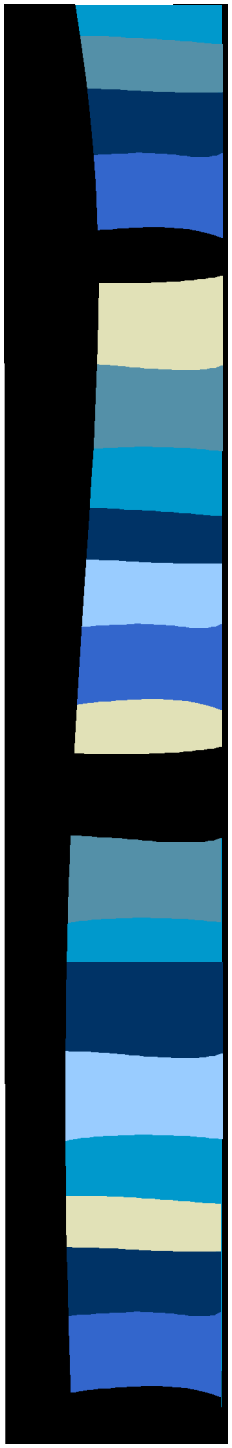
ROOF BOLTS INSTALLED BY ROOF BOLTING MACHINE

- Roof supported by inserting reinforcing rods
- No one may work under unsupported roof
  - **Cut depths limited to position of shuttle car operator (35’ to 40’ with remote control miner)**
- When miner place changes, bolter moves in
  - **Bolt 3-6 min/row or 0.75-1.50 min/ft**
  - **Use two bolter operators, twin-boom bolter**
- A few operations attach bolters to miners, bolt as they advance



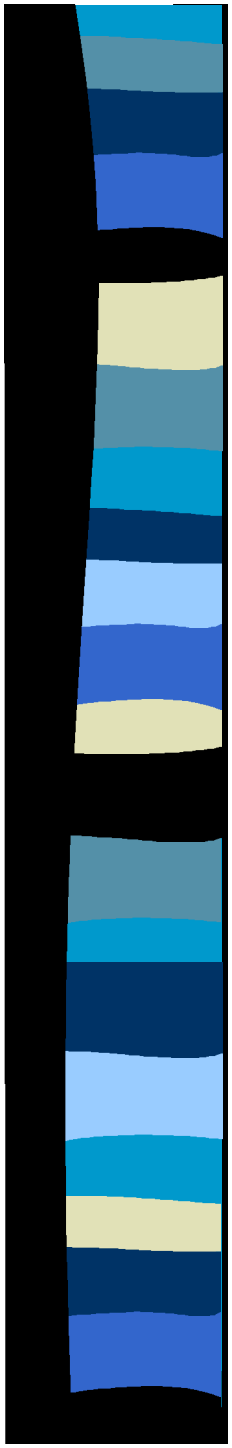
ROOF SUPPORT

- Insert bolts into the roof on regular pattern (3’-8’ length, usually)
  - 4’ x 4’ or 5’ x 5’ most common
- Either “glue” (resin) a re-bar bolt in, or
- Use expansion bolt anchors or
- Glue in the anchor only
  - Anchors allow pre-tensioning of bolts



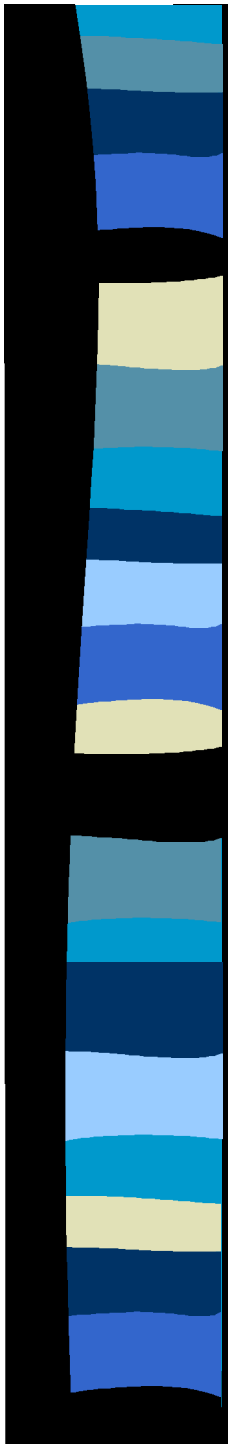
ROOF BOLTS GENERALLY WORK WELL

- Form “reinforced” rock, strong beam
- Or, may “hang” weak rock from stronger overlying rock layer
- Roof fall fatalities are now at 8 -12 per year
  - Half are in violation of the law, under non-bolted roof
  - Roof fall fatalities exceeded 100 per year around 1970



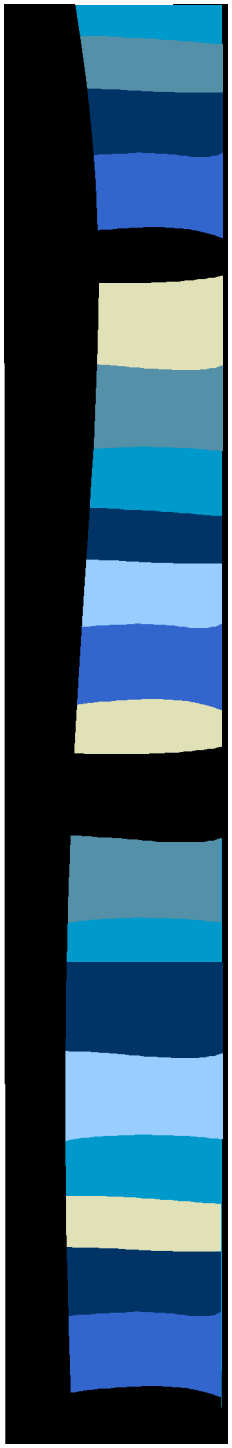
VENTILATION

- Provides oxygen, dilutes methane & dust
  - Methane explosive when at 5-15% concentration
- Most coninuous miners have dust scrubber
  - Draw air into ducts at front of miner
  - Efficiency up to 96-97%
- Air directed to working face with brattice cloth (plastic curtains)
- Alternatively, hang tubing & use fan to draw air to face



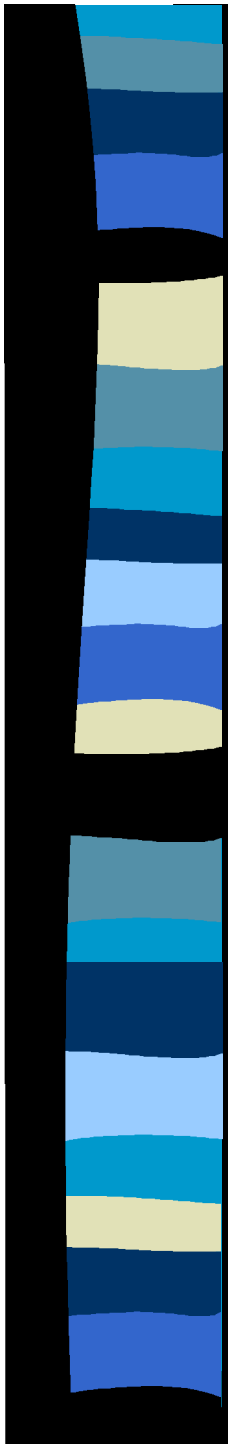
VENTILATION

- Fresh air ventilates one face only, then it is “return” air
  - Separate air streams with concrete block walls or “stoppings”
- Maximum allowable methane content is 1%
- Control major flow with adjustable doors in airways (“regulators”)



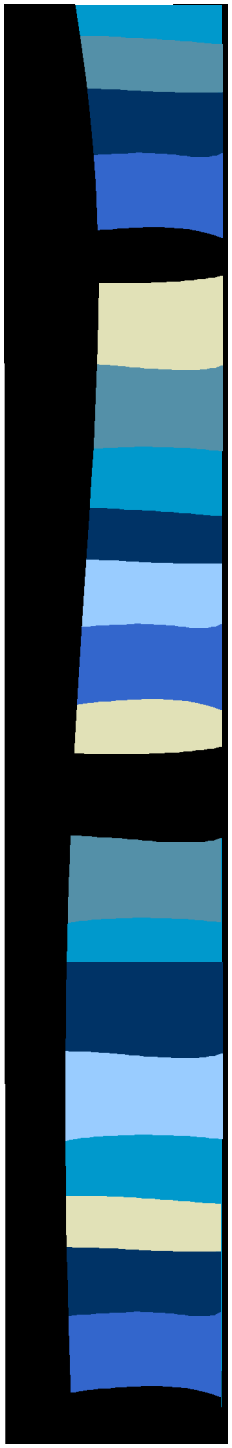
PRODUCTION RATES

- 150 - 400 ft/shift usual, tonnage depends on seam thickness
  - 500 - 2000 tons/shift (usual)
- New miners load at 10 - 25 tpm
- Most continuous miners load only 60-120 min/shift
  - **Load only 12**
  - **10-25% of shift time**



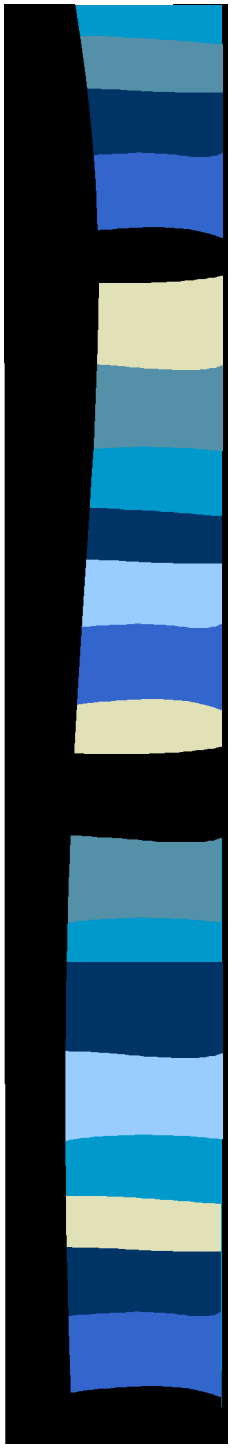
LONGWALL

- More nearly continuous method
- Analogous to “deli meat slicer” (shearer)
- Shearer mounted on chain conveyor
  - Coal cut falls onto conveyor
- Width of face usually 850 - 1100 ft
  - Depth of slice is 30 - 42 inches
- Behind face supported for 20’ or so by steel supports - each 1.50 or 1.75 m wide
  - Each support holds up to 600-1200 tons
- Supports connected to conveyor
  - By pushing, lowering & pulling - can walk conveyor and selves forward



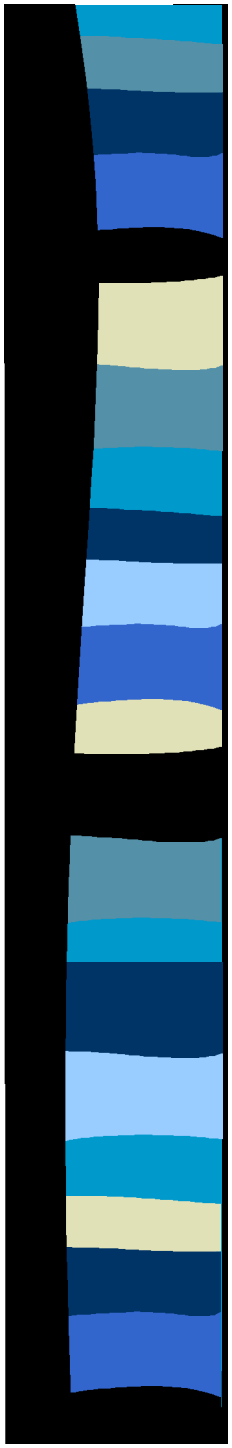
LONGWALL

- Panels (solid block of coal)
  - Usually 850’ - 1100’ wide & 7500’ - 15,000’ long
  - Contain 1.5 - 4 mm tons per panel
- Shearers cut at 35 - 65 t/min (2000-4000 tph)
- Output per year = 2 - 6 mm tons
- 6,000 - 20,000 t/day (max = 40,000)
- Cut 200-500 min/day
  - 20% - 45% of time (???)



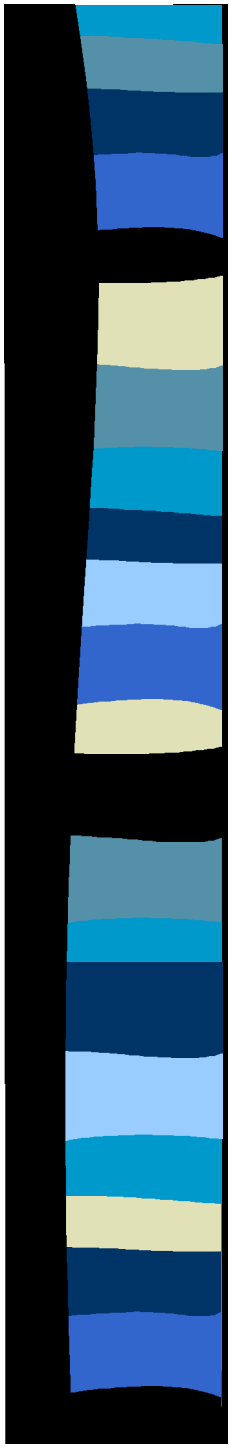
LONGWALL

- Capital intensive
  - $30M for face equipment only
  - $50-80M additional for mine / processing
- Require large, regularly shaped reserve
  - 50M ton minimum
  - Prefer 100-200M tons
- Mine-specific design / limited ability to move to other reserves



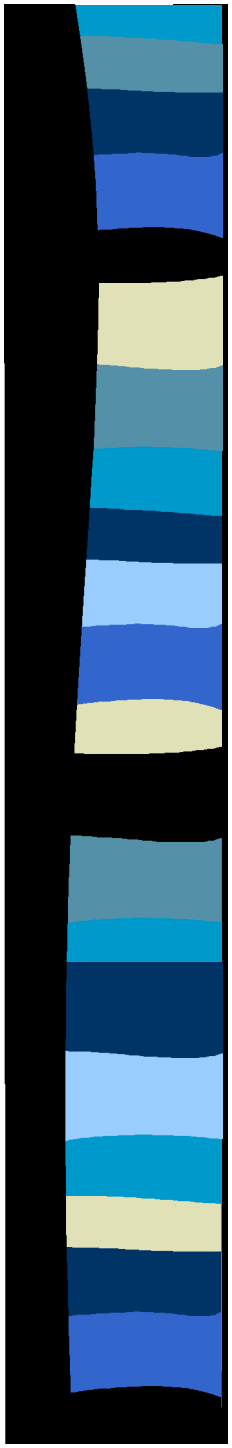
CONTINUOUS MINER SUMMARY

- Capital for section is $3-5 million
- Flexible, can move readily to other reserves
- One longwall usually requires three continuous miners for development
- Annual output for miner section is 0.3 - 0.8 million tpy



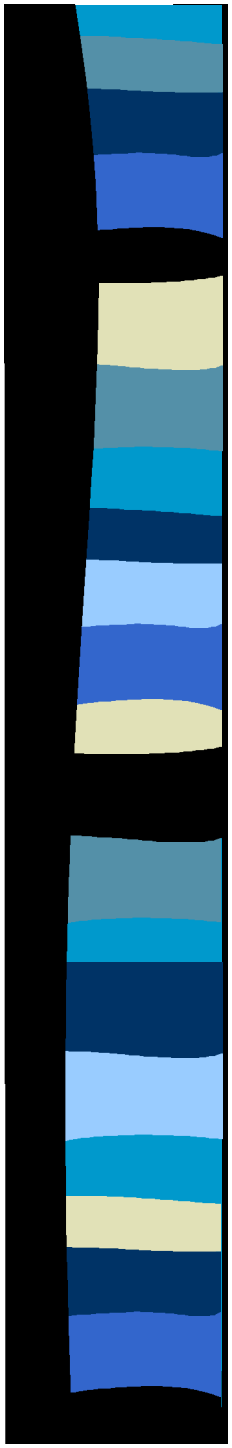
ENVIRONMENTAL

- Longwall strata caves behind supports
  - Surface subsides to maximum of 50-70% of seam thickness
  - “Tilt” area may damage structures, so must provide special support methods at the structures to minimize damage
  - Subsidence trails face position by a few days to a week or two, about 95% occurs in a few weeks



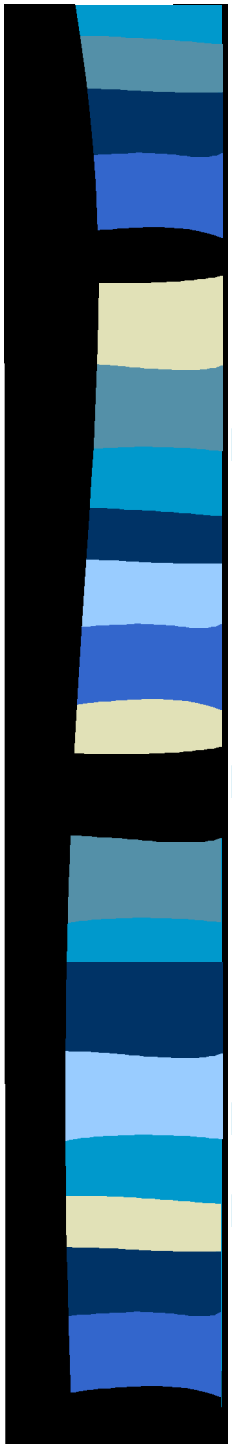
LONGWALL SUBSIDENCE

- Ground water flow is altered
- Some wells lose flow, temporarily or permanently; a few gain
- May need to drill wells deeper
- Connection from near surface to mine is possible if depth to aquifer is less than 40 x seam thickness (240 ft for 6-ft seam)



SUMMARY

- Longwall (45% of UG output from only 60 faces -- average of 3 million tpy each)
  - **High output, high capital**
  - **Low operating cost, 70-80% (?) reserve recovery**
  - **Low flexibility**
- Continuous Miners
  - **Medium output, low-medium capital**
  - **Moderate operating cost, 40-60% reserve recovery**
  - **High flexibility**



SUMMARY

- **Can use underground methods in +100 ft of overburden (actual minimum depth depends on whether strip ratio favors surface mining)**
  - **Roof subject to surface cracks when shallower**
- **Use longwall in large, thick (mine 6-ft min.), regularly-shaped reserves**
  - **Only economic method if seam is >1500 ft deep**
- **Else, use continuous miner and room & pillar**
- **While best walls far exceed cm productivity, on average, tons per manhour are close**

ARCH COAL INC.

Longwall mining machines have revolutionized underground coal mining, enhancing safety and productivity.


Continuous Miners
A full line for all
seam heights