INTRODUCTION TO COAL MINING

WEIR INTERNATIONAL, INC.

HISTORY OF COAL IN THE UNITED STATES

- Coal was one of man's earliest sources of heat and light
- Coal was first discovered in the United States along the Illinois River in the 1670s
- First commercial mining occurred near Richmond, Virginia in 1750
- Between 1850 to 1950, coal was the most important energy fuel in the country
- Today, coal accounts for more than half of the electric power generation
- Coal is also critical for supplying coke for the nation's steel industry

ORIGIN OF COAL

- Most of the coal was formed about 300 million years ago
- Remains of vegetation sank to the bottom of swamps, forming a soggy, dense material called peat
- Deposits of sand, clay and other mineral matter buried the peat
- Increasing pressure from deeper burial and heat gradually transformed the peat into coal
- The formation of one foot of coal requires an estimated three to seven feet of compacted plant matter

TYPES OF COAL

- Coal is classified in four general categories or “ranks”:
  - Anthracite
  - Bituminous
  - Sub-bituminous
  - Lignite

Increasing rank

Increasing carbon content

Increasing heating value

- The ranking of coal is based primarily on its carbon content and calorific value
- The amount of energy in coal is measured in British Thermal Unit (Btu) per pound
- Approximately 90% of the coal in the US is in the bituminous or sub-bituminous category

MINING METHODS

Surface Mining

- Surface mining is:
  - Generally the least expensive and most productive mining method to extract coal
  - Typically used when the coal seam is relatively close to the surface
- Surface mining can recover nearly 90% of the coal from a reserve deposit
- Total annual US production from surface mining is 60%

Underground Mining

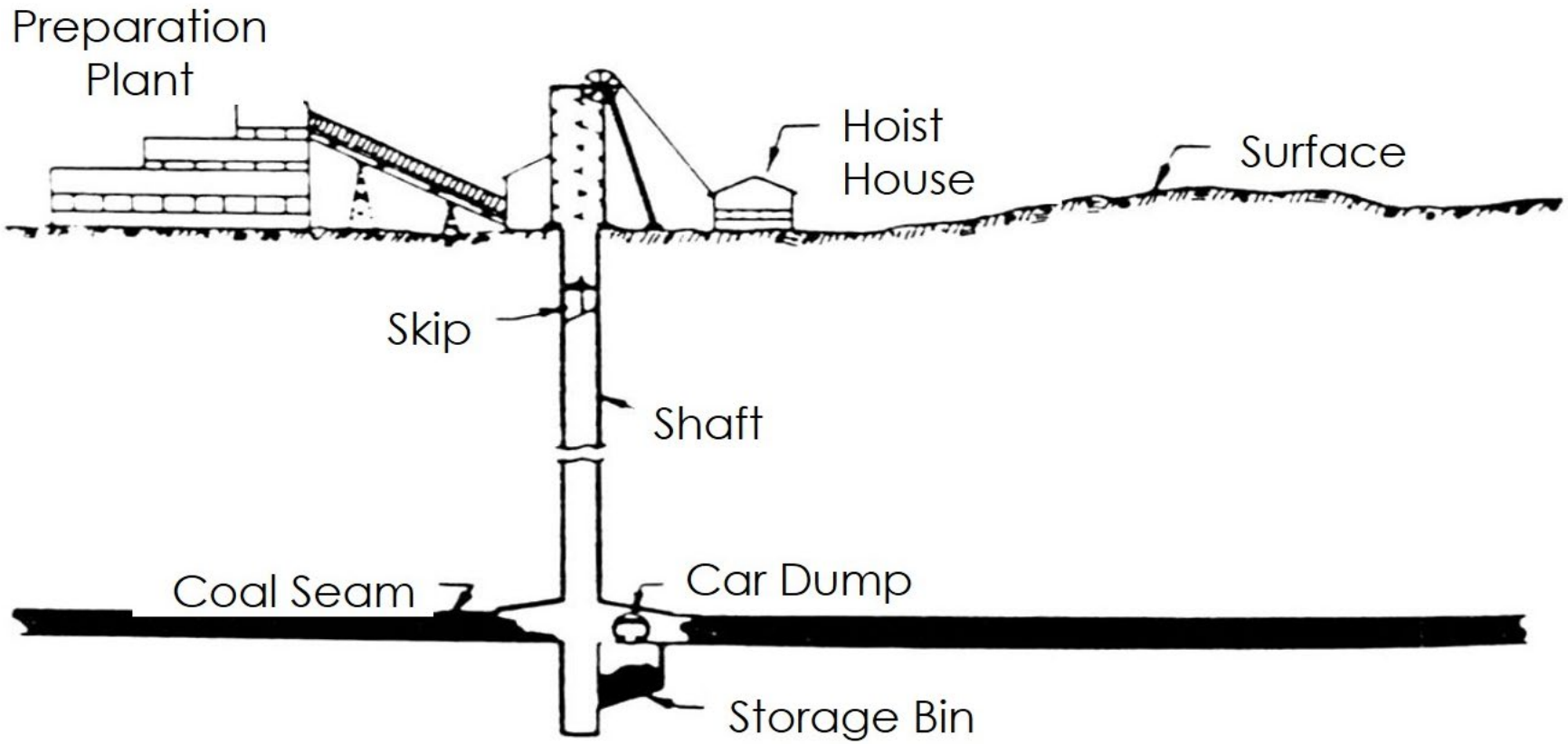
- Underground mining is typically employed where surface mining is not economical
- Major underground coal mining methods include:
  - Room-and-Pillar
  - Longwall
- Depending on the mining method, underground mining recovers 45 - 60% of a reserve deposit by continuous miner methods and approximately 70% by longwall mining methods
- Total annual US production from underground mining is 40%

TYPES OF UNDERGROUND MINE ACCESS

- The decision on type of access depends upon the coal seam's location relative to the surface
- Access to underground coal seams:
  - Shaft Mine
  - Slope Mine
  - Drift Mine

SHAFT MINE

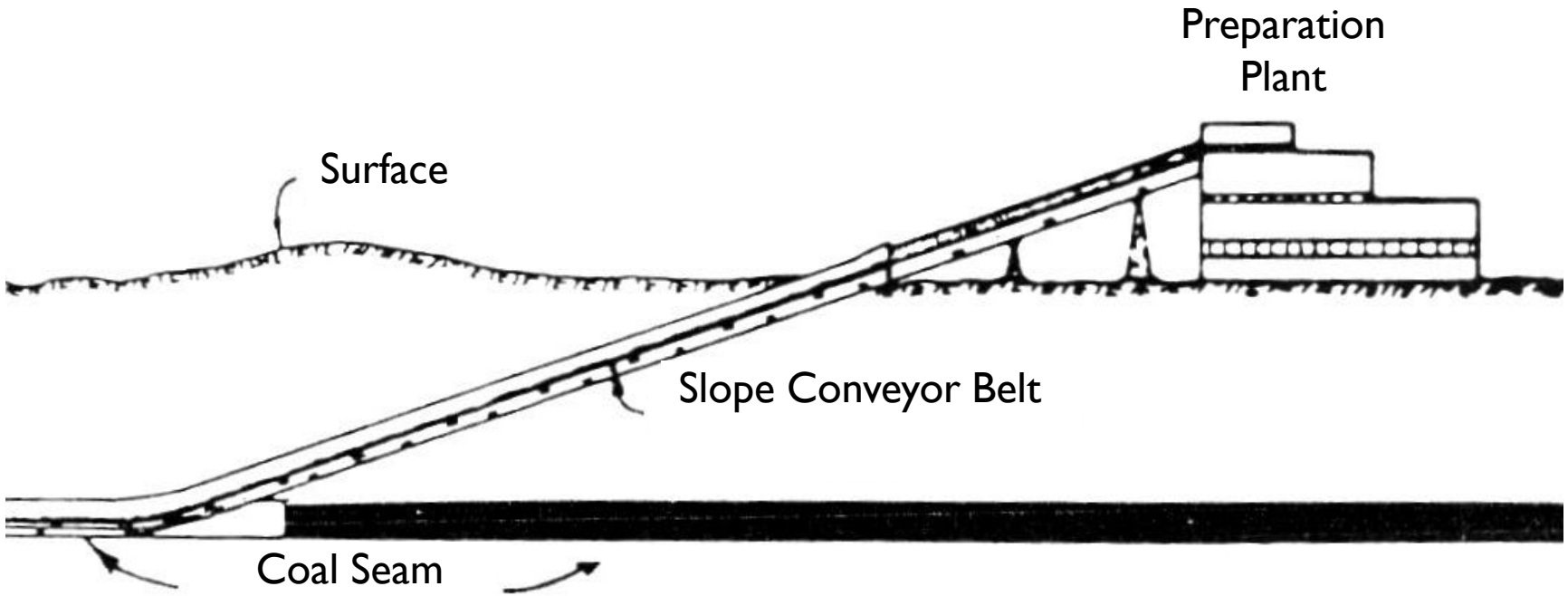
- Frequent choice for deep deposits
- Vertical access openings are developed from the surface to the coal
- The shaft provides access for personnel, coal removal and ventilation


Preparation
Plant
Hoist
House
Surface
Skip
Shaft
Coal Seam
Car Dump
Storage Bin

SHAFT MINE

SLOPE MINE

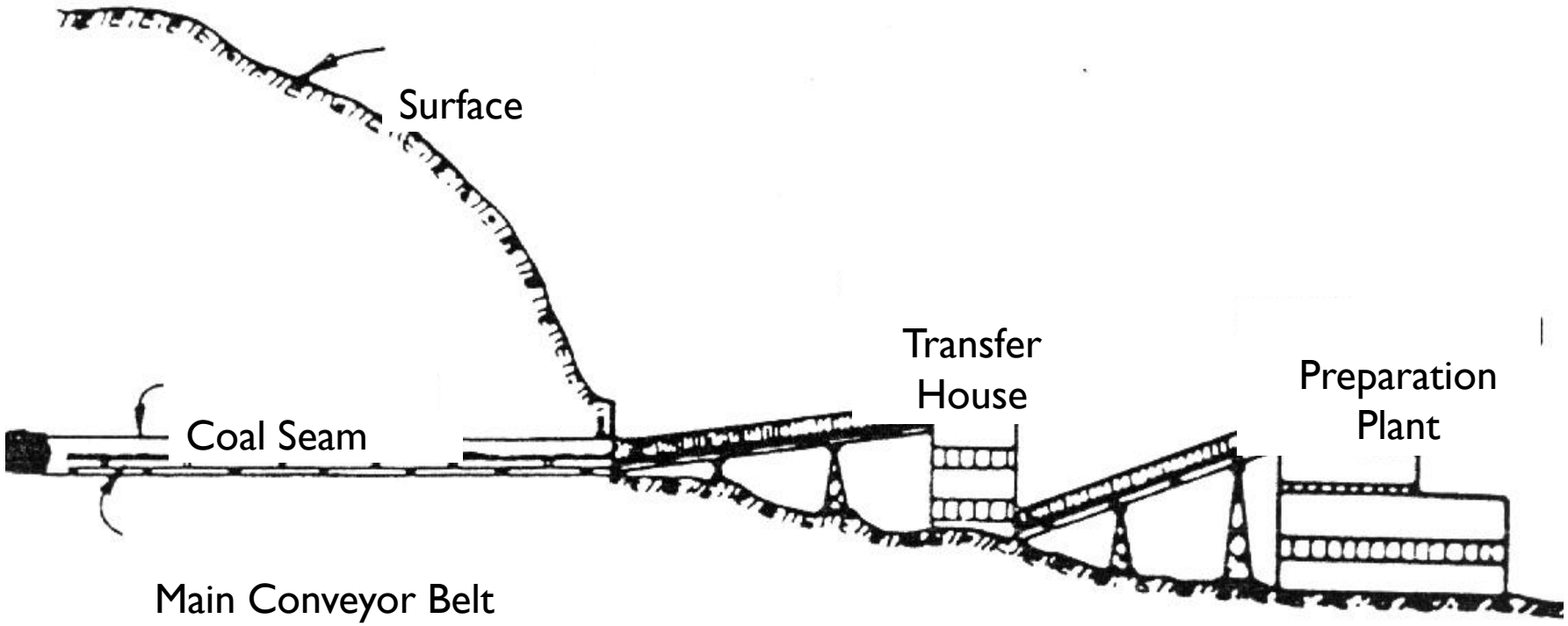
- Frequent choice for deep deposits
- Frequent choice for shallow deposits
- Access by driving an incline opening from the surface
- The slope provides access for personnel, coal removal and ventilation
- Conveyor belts are used to transfer coal from underground to the surface
- Slope mines still require shaft openings for ventilation and at times personnel access



SLOPE MINE

DRIFT MINE

- Frequent choice for deep deposits
- Frequent choice when the coal seam outcrops on the slope of a hill side
- Entrance or entrances can be developed horizontally to access the coal seam
- Provides least expensive access to the coal seam



DRIFT MINE

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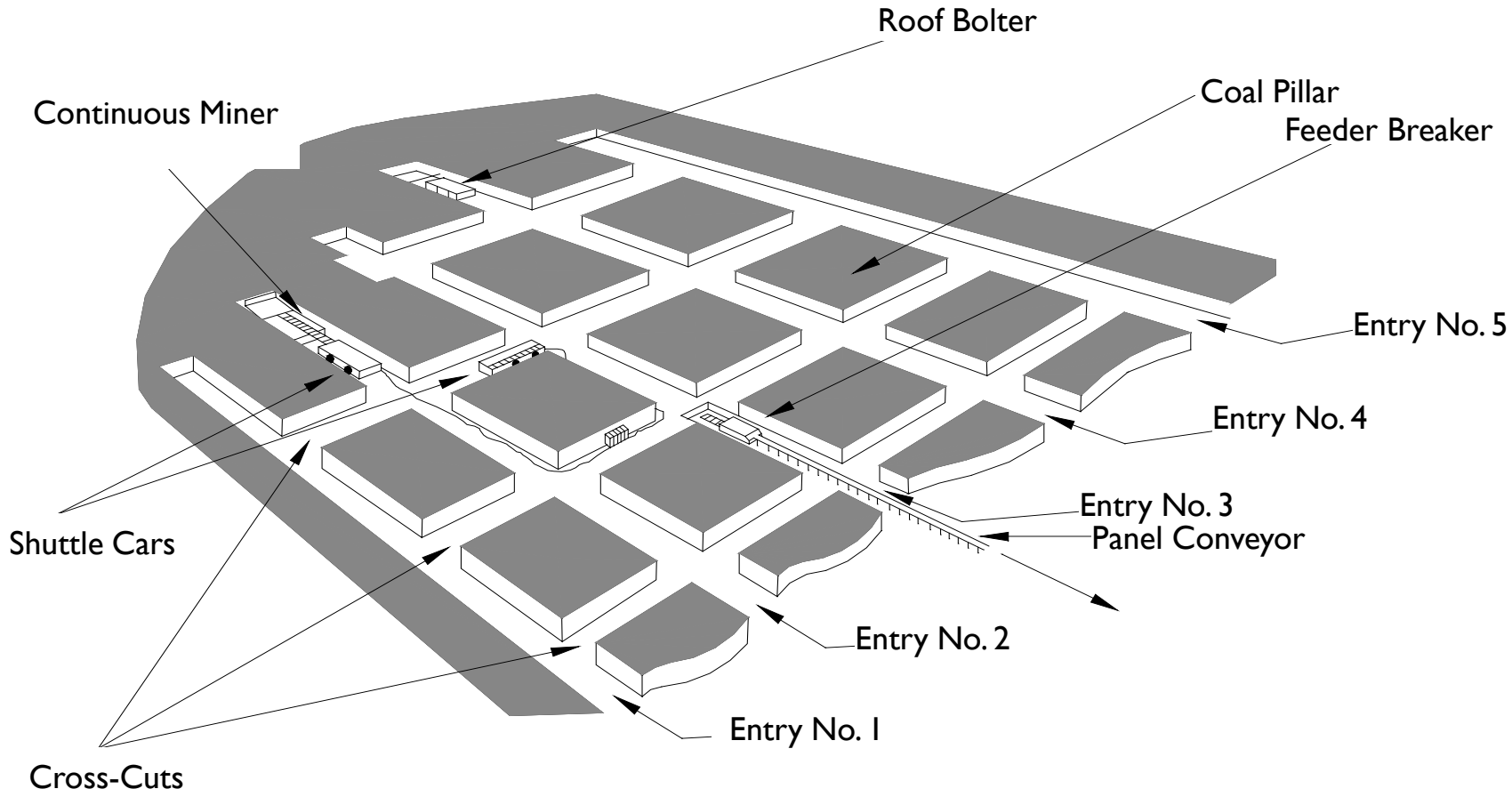
ROOM-AND-PILLAR MINING

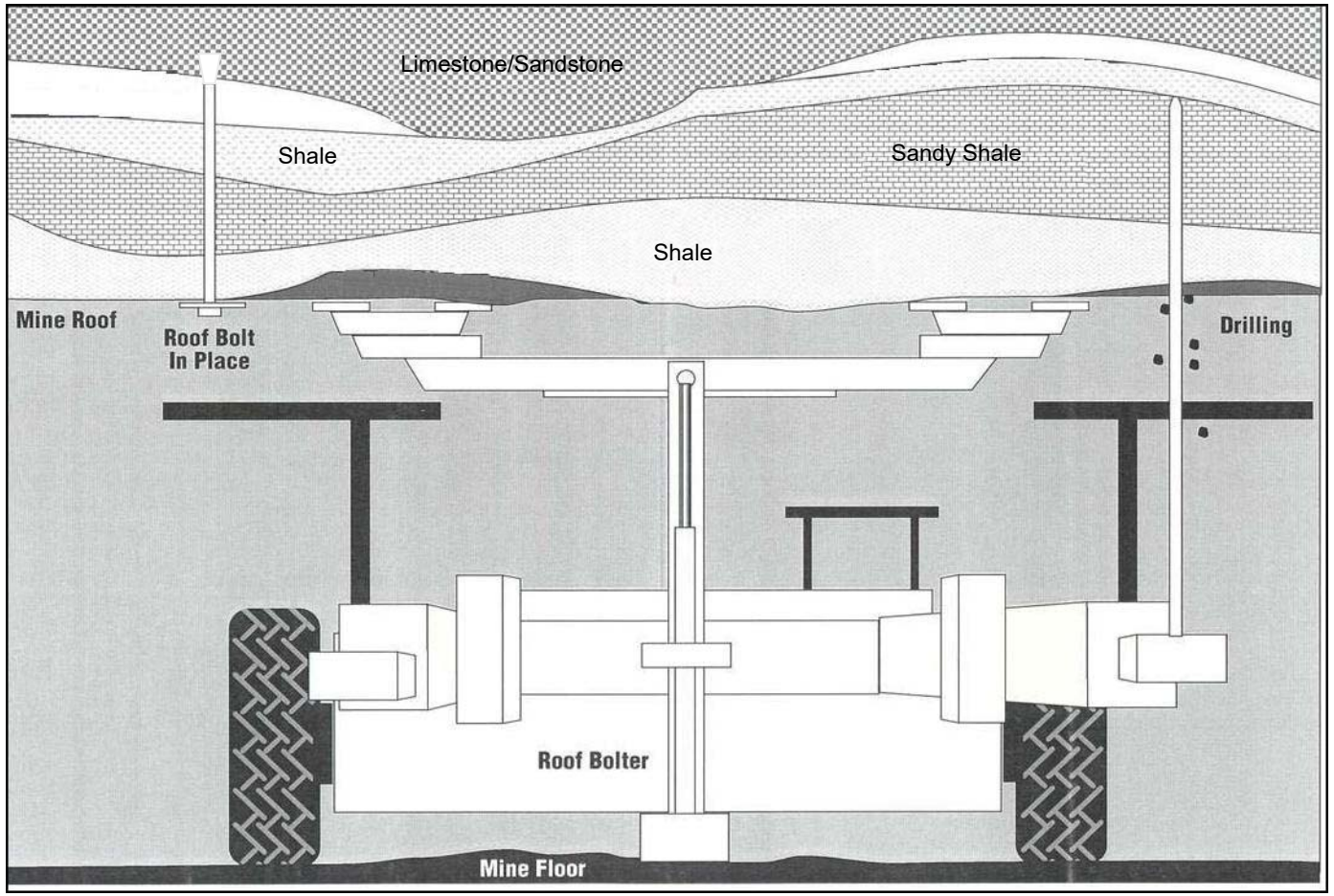
- Most underground mines in the US use room-and-pillar mining methods
- This method of mining is as follows:
  - Excavate a series of tunnels or “rooms” in the coal seam using continuous miners, along with shuttle car/ram car haulage
  - Leave columns or “pillars” of coal to help support the mine roof
  - Install roof bolts using a roof bolting machine to provide additional support and protection for underground personnel

ROOM-AND-PILLAR MINING EQUIPMENT

- Major types of mining equipment in room-and-pillar mining include:
  - Continuous Miner
  - Shuttle Car/Ram Car/Continuous Haulage
  - Scoop
  - Roof Bolter
  - Feeder Breaker



ROOM-AND-PILLAR MINING



ROOF BOLTING IN UNDERGROUND MINES

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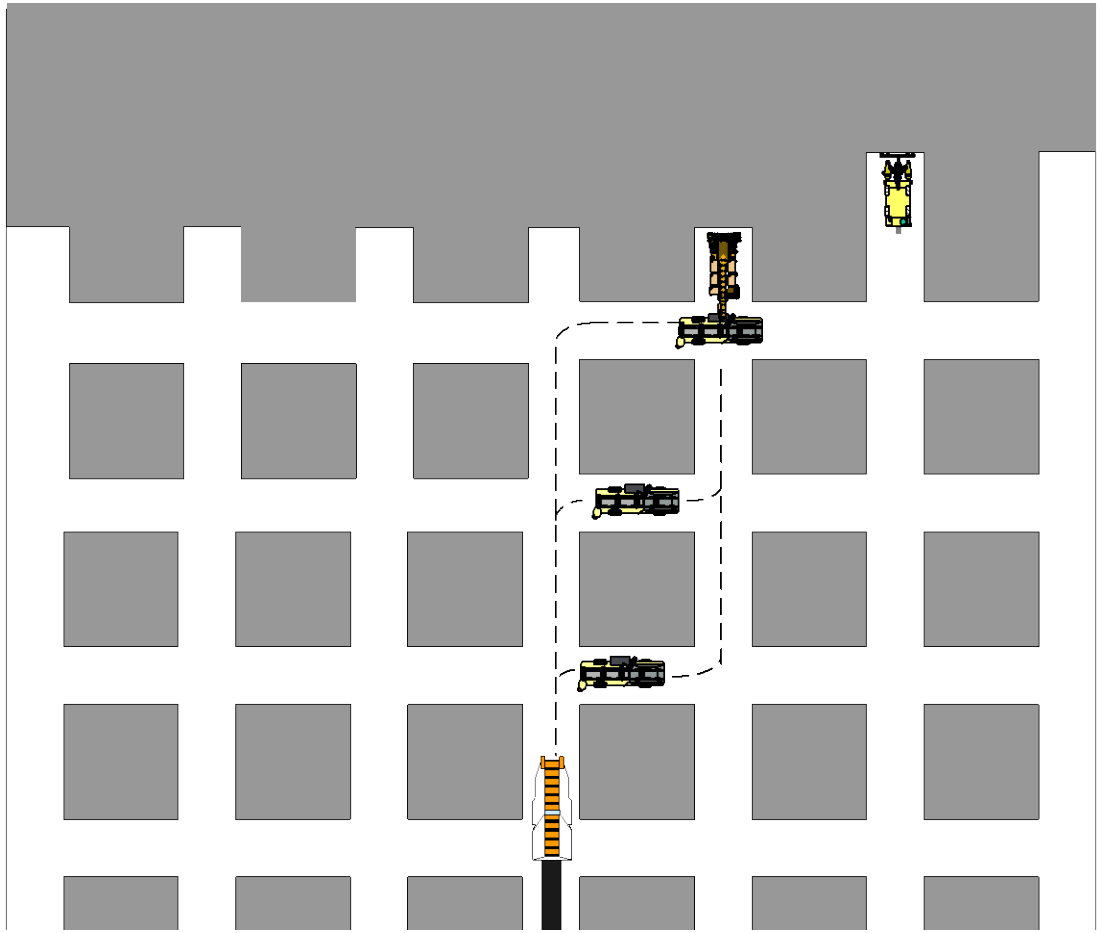

Legend:
CM = Continuous Miner
RB = Roof Bolter
SC = Shuttle Car
F = Feeder Breaker
B = Belt Conveyor
---- = Haulage Routes

ROOM-AND-PILLAR MINING SEQUENCE

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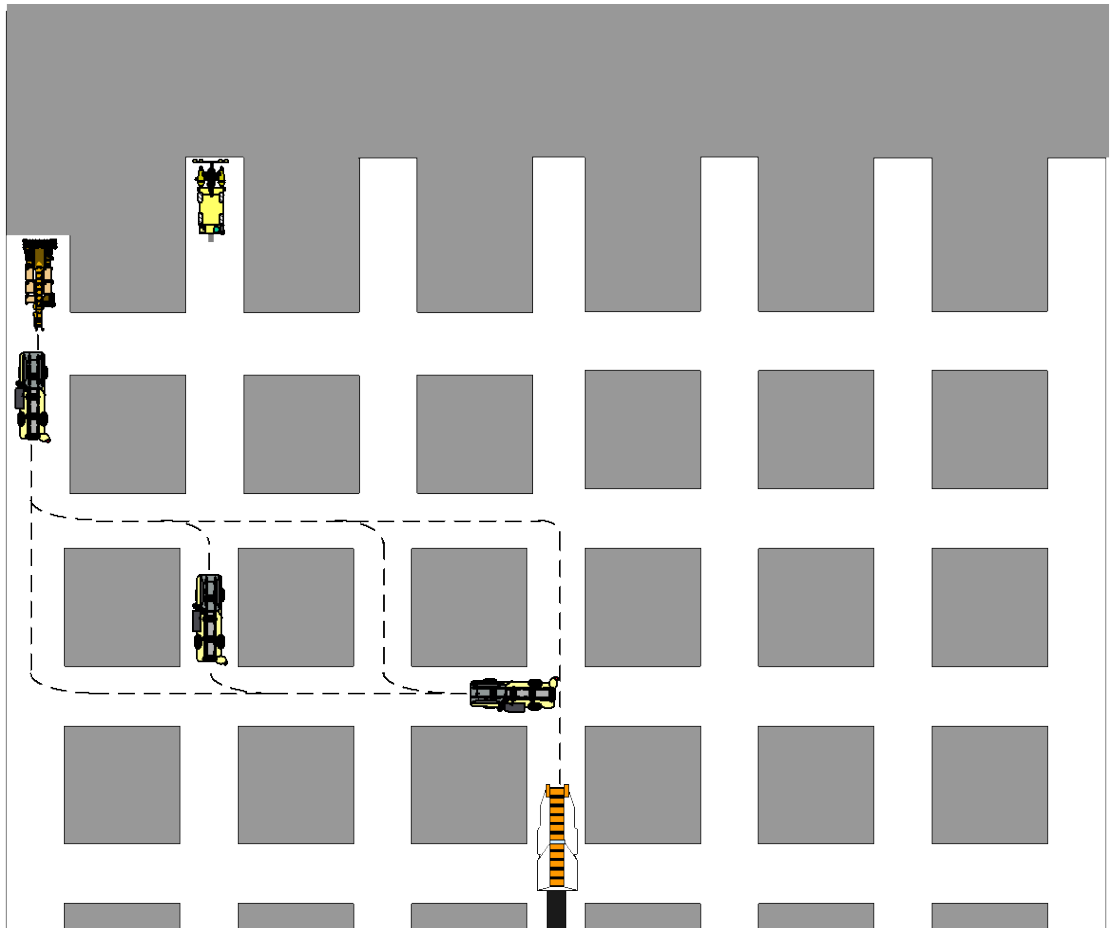

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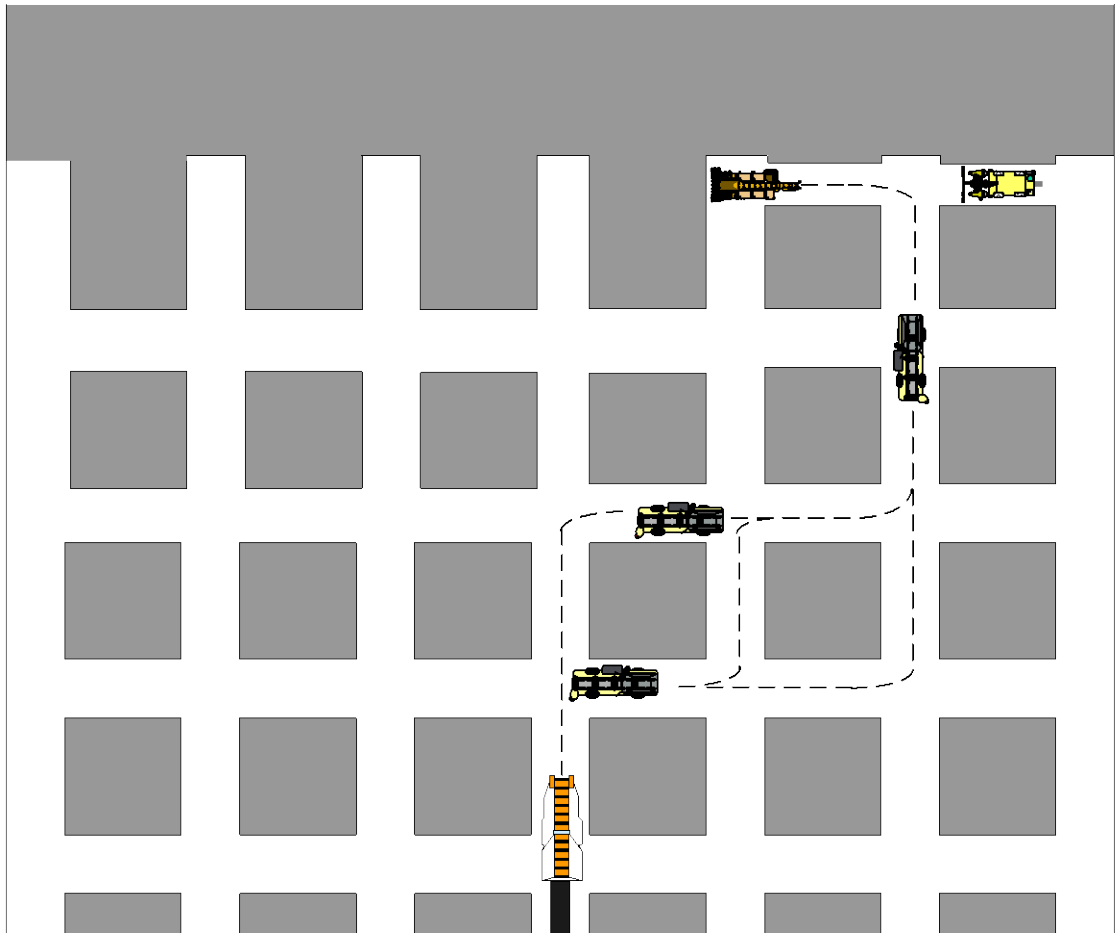

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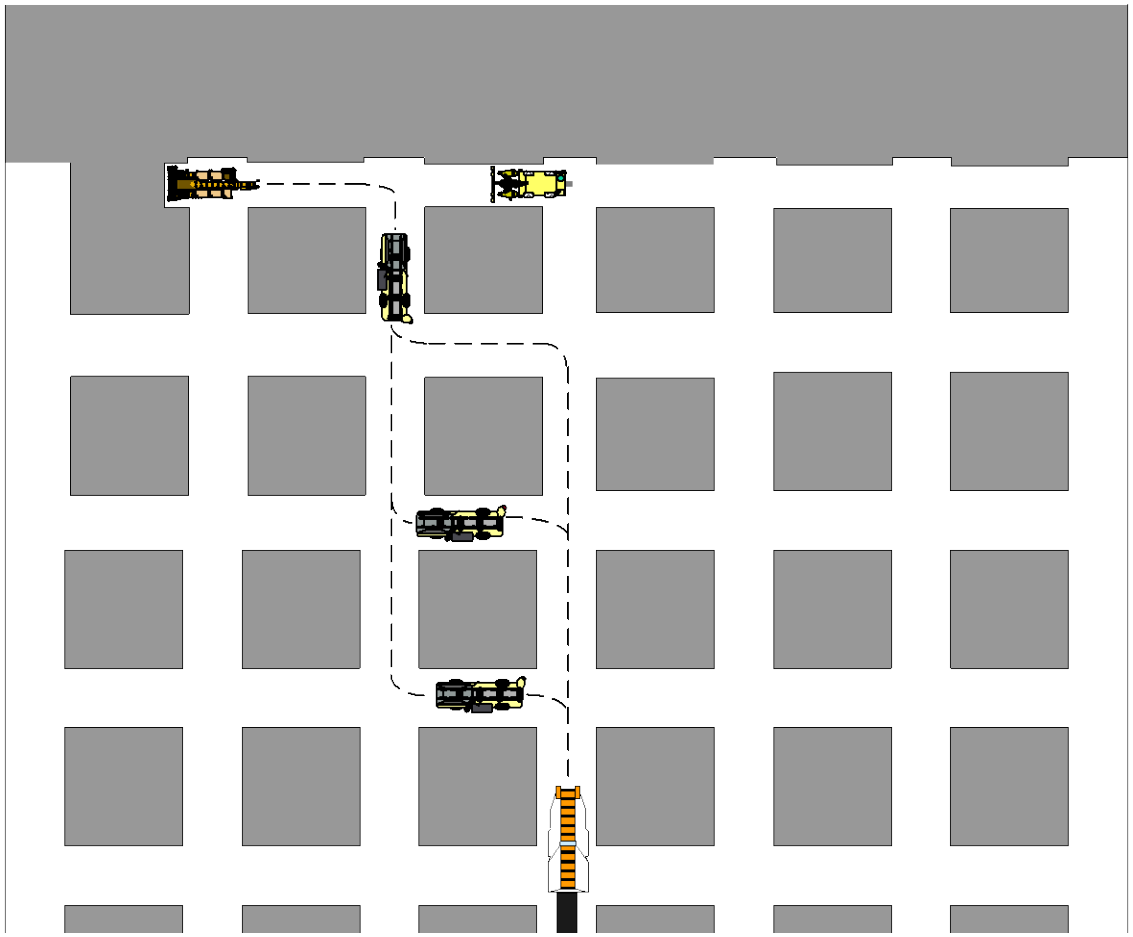

ROOM-AND-PILLAR MINING SEQUENCE

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CONTINUOUS MINER

JOY 12CM12

SHUTTLE CAR

JOY 10SC32

SCOOP

COAL HAULER

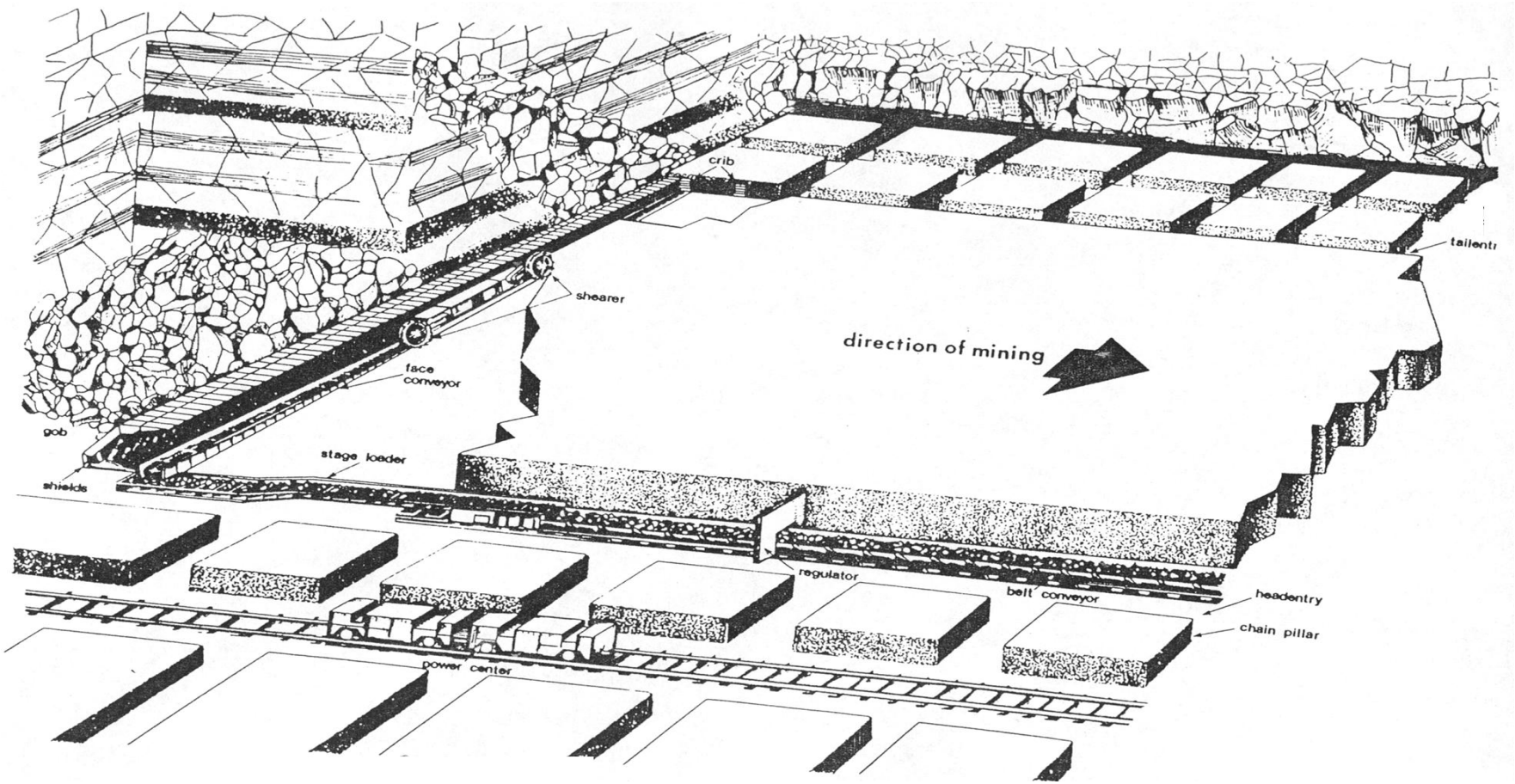
RAM CAR

ROOF BOLTER

FEEDER BREAKER

LONGWALL MINING

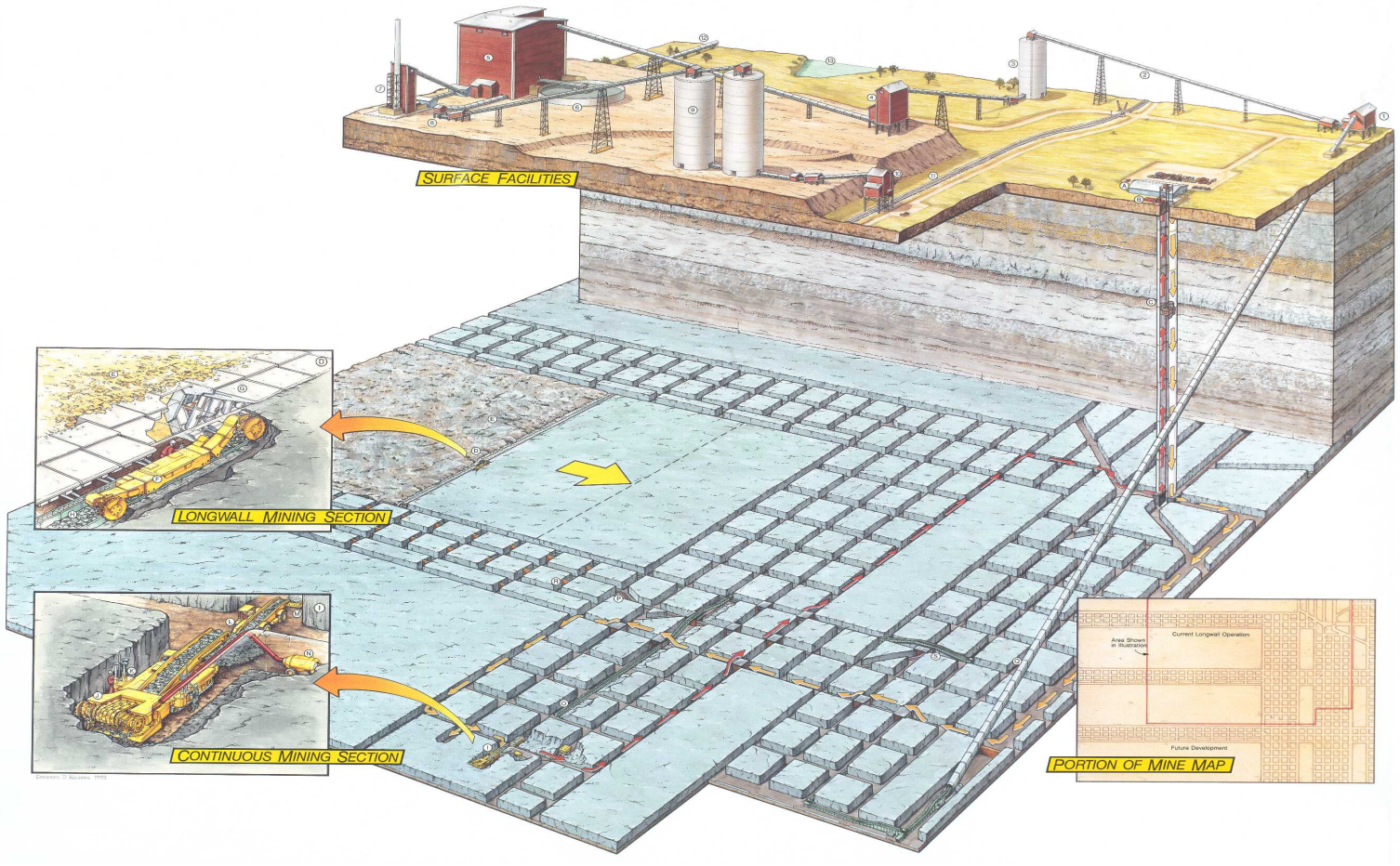
- Two parallel sets of entries are excavated in the coal seam
- These entries are connected at their far ends by another set of entries to form a block of coal, referred to as the "longwall"
- Typically, the block of coal is 1,000 feet wide and over one mile long
- A rotating shearer or plow traverses across the block cutting the coal
- Hydraulic roof supports advance with the shearer or plow while the roof behind the supports is allowed to fall



LONGWALL MINING LAYOUT

SHORTWALL AND CONVENTIONAL MINING

- A shortwall uses a continuous mining machine in conjunction with hydraulic, self-advancing roof supports to cut coal panels
  - Typical panels are 150 to 200 feet wide and over a half mile long
- Conventional mining is performed by:
  - Cutting a slot under the coal seam
  - Drilling holes in the seam
  - Loading holes with explosives
  - Blasting the coal
- These mining methods are rarely used in the US today



UNDERGROUND MINE LAYOUT

SURFACE MINING

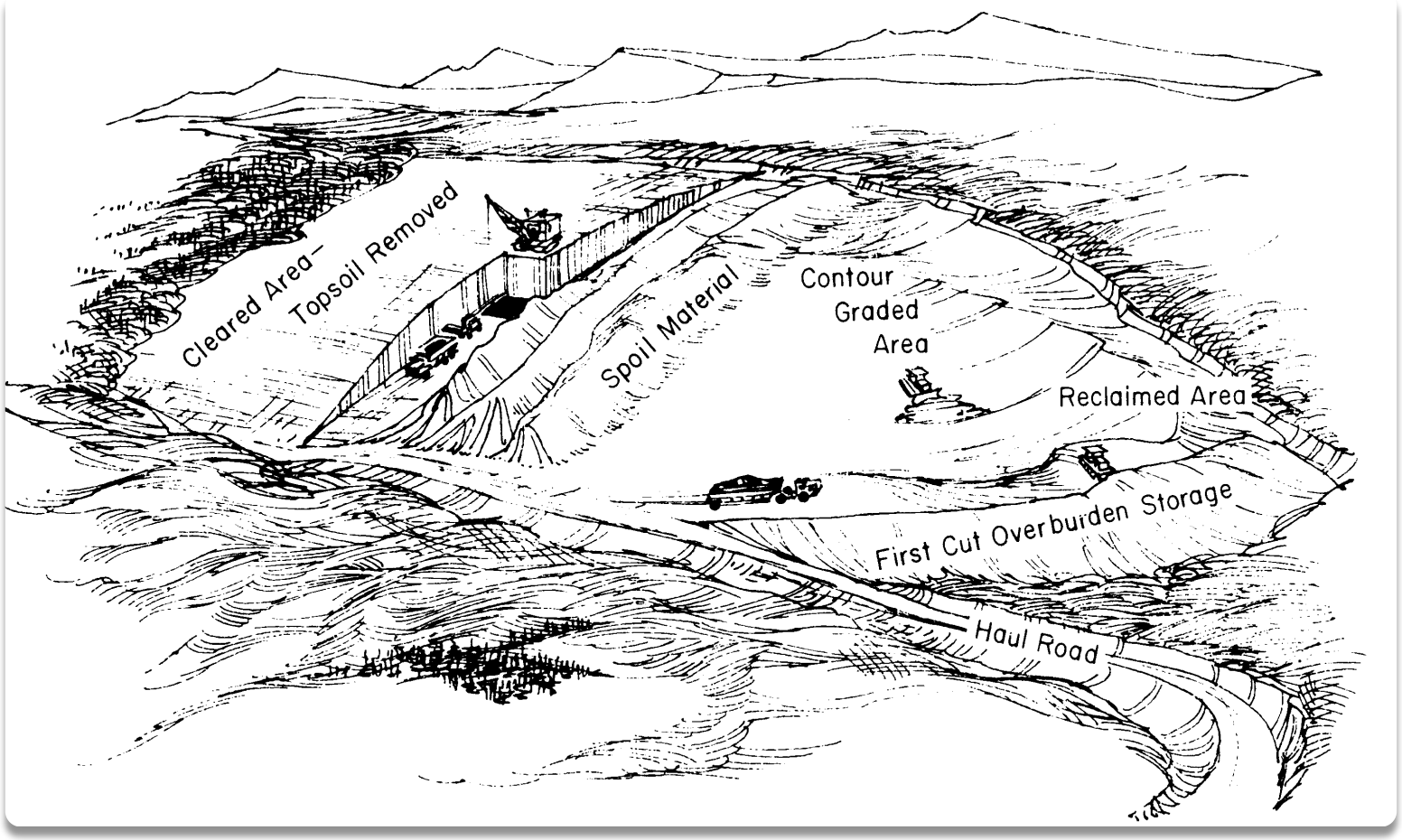
- Surface mining methods are generally more productive than underground mining methods
- 90% of the coal mined west of the Mississippi River is produced by surface mines
- 40% of the coal mined east of the Mississippi River is produced by surface mines
- Productivity from western surface mines in 2005 was 21.30 tons per total employee-hour, compared to 3.27 tons per total employee-hour from eastern surface mines

TYPES OF SURFACE MINING METHODS

- Major surface mining methods include:
  - Area Mining
  - Contour Mining
  - Mountaintop Removal
  - Highwall Mining
  - Auger Mining

AREA MINING

- Surface mining where the surface is flat or gently rolling
- Draglines and/or shovels are used to remove the strata overlying the coal
- Draglines typically can move up to 120 cubic yards per bucket load
- Shovels typically can move up to 70 cubic yards per bucket load
- The overlying strata may have to be drilled and blasted with explosives prior to being moved with draglines or shovels
- The overburden material is replaced after the coal has been removed



AREA MINING

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DRAGLINE MINE

SHOVEL AND TRUCK

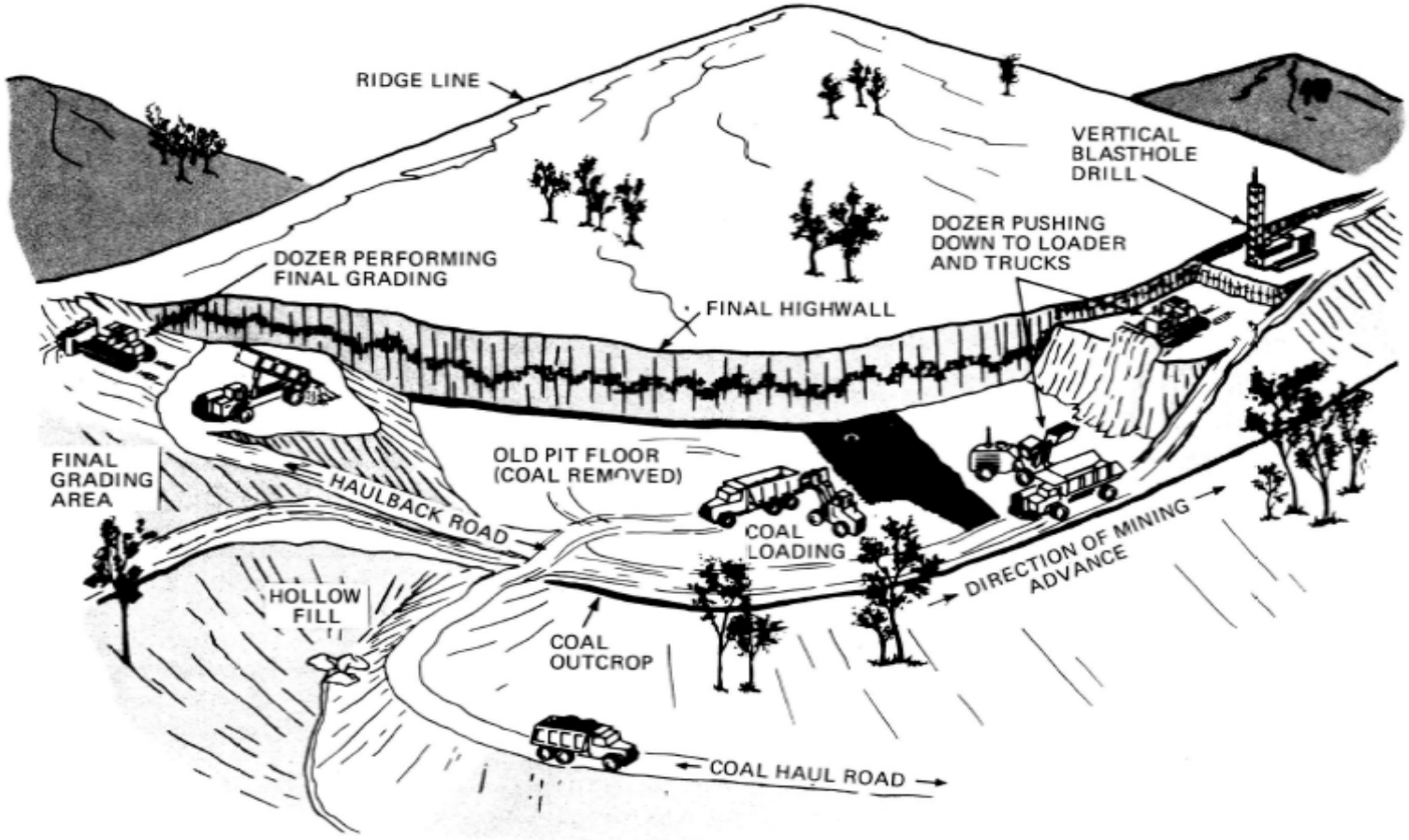
COAL LOADER

DRILL

DOZER

CONTOUR MINING

- Usually associated with a coal seam that outcrops at a certain elevation above drainage in a mountainous mining region
- Mining follows the seam outcrop around the hill or mountain
- Overburden material is either hauled or pushed
- Mined-out contour benches are reclaimed and re-seeded



CONTOUR MINING

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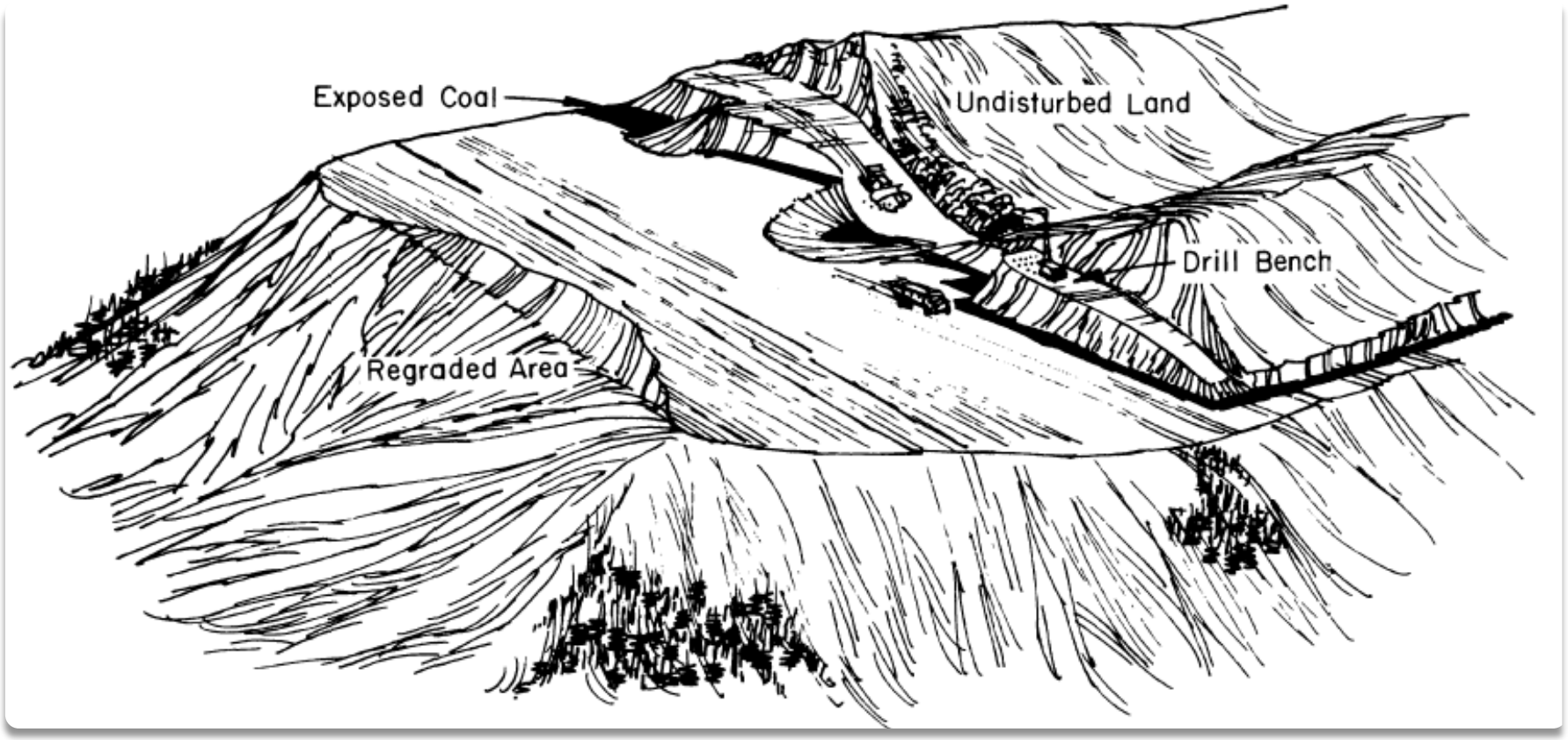
MOUNTAINTOP MINING

- Used to recover coal seams which are close to the top of hills or mountains
- All the strata above the coal seam(s) is removed
- Overburdened material is backstacked or placed in valley fills
- Mined areas are reclaimed, which provides a suitable site for various development opportunities



MOUNTAINTOP MINING

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HIGHWALL AND AUGER MINING

- Highwall mining and auger mining are generally used to recover coal after contour mining has been completed
- Highwall mining uses a continuous miner cutter head to advance into the coal seam from the highwall
- Highwall mining can extend up to 1,000 feet into the coal seam
- Auger mining uses a drilling tool with screw-like extensions to penetrate and extract the coal
- Auger mining can extend up to 250 feet into the coal seam

HIGHWALL MINER

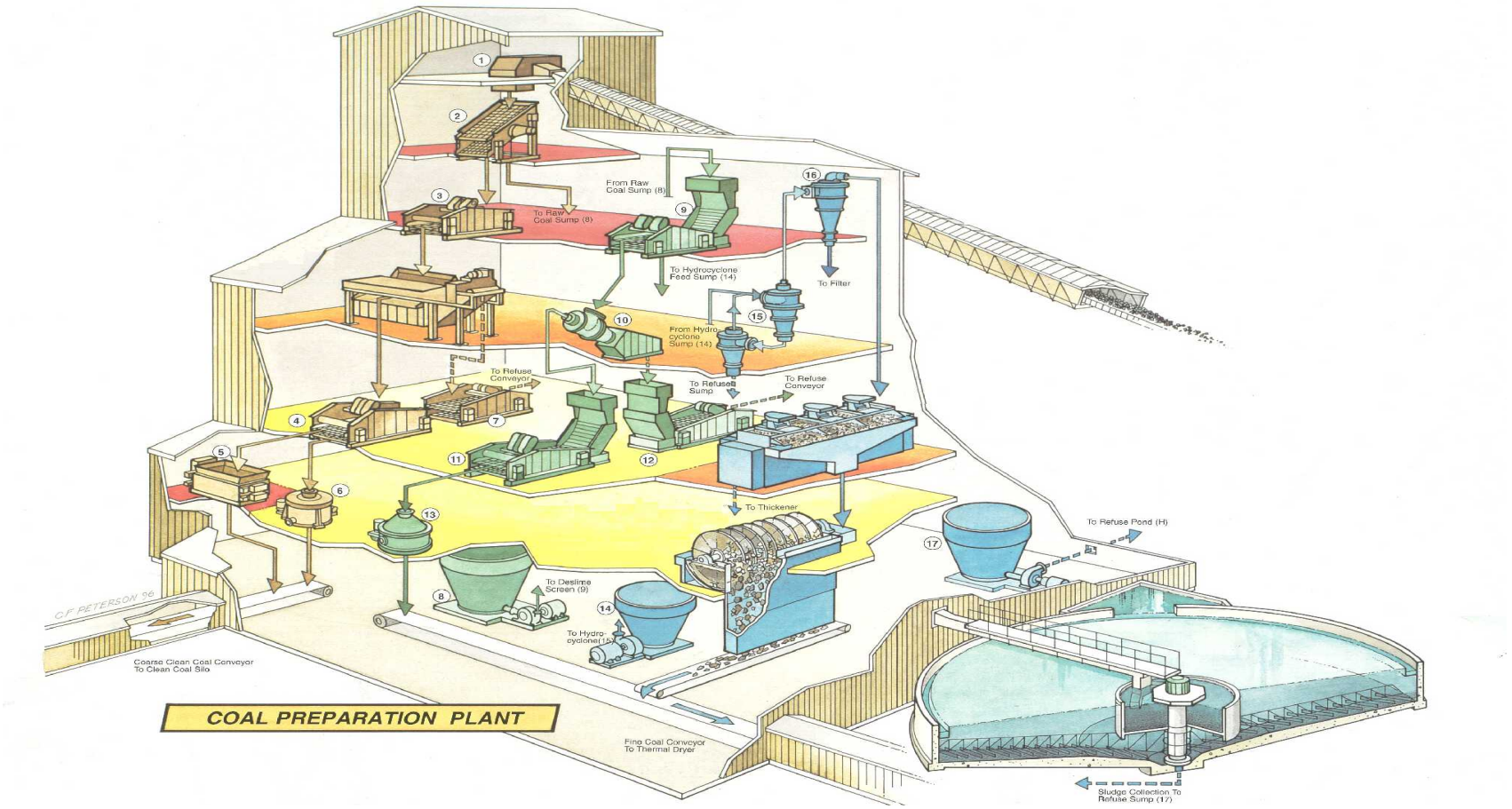
AUGER MINE

COAL PREPARATION

- Underground mined coal is typically transported by belt conveyors to a preparation plant located on the surface
- Surface mined coal is typically hauled by trucks to the preparation plant
- Purpose of coal preparation is to improve the quality of the run-of-mine coal to make it suitable for marketing
- Type of coal preparation primarily depends on:
  - The inherent quality of the coal
  - Customer specifications

COAL PREPARATION

- Surface mined coal is typically hauled by trucks to the preparation plant
- Improve coal quality and marketability by:
  - Cleaning to remove inorganic impurities
  - Sizing, crushing and/or screening
- Primary coal preparation methods include:
  - Jig
  - Dense medium separators
  - Floatation
  - Spirals



COAL PREPARATION PLANT

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COAL MINING REGULATIONS

- Coal mining is one of the most regulated industries in the US
- Companies must comply with literally hundreds of operating and environmental requirements and regulations
- Considerable planning by mining engineers and operating personnel, relative to all aspects of the operation, is required before permission from local, state and federal government agencies is granted to develop a coal mine
- As long as ten years can elapse between starting to plan for a mine and mining the first ton of coal
- Safety in coal mining is highly regulated, requiring great diligence and close cooperation by management, the workforce and the government agencies
- The Coal Mine Health and Safety Act of 1969 is the major safety directive for federal regulations governing safety in the industry
- Regulations governing the mining industry are enforced by the Mine Safety and Health Administration (MSHA), in compliance with Part 30 of Code of Federal Regulations for Mineral Resources
- Compliance to the regulations is mandatory for each surface and underground mining operation in the US
- Due to the more complex nature of underground mining, there are more regulations governing the underground coal mines than surface mines

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