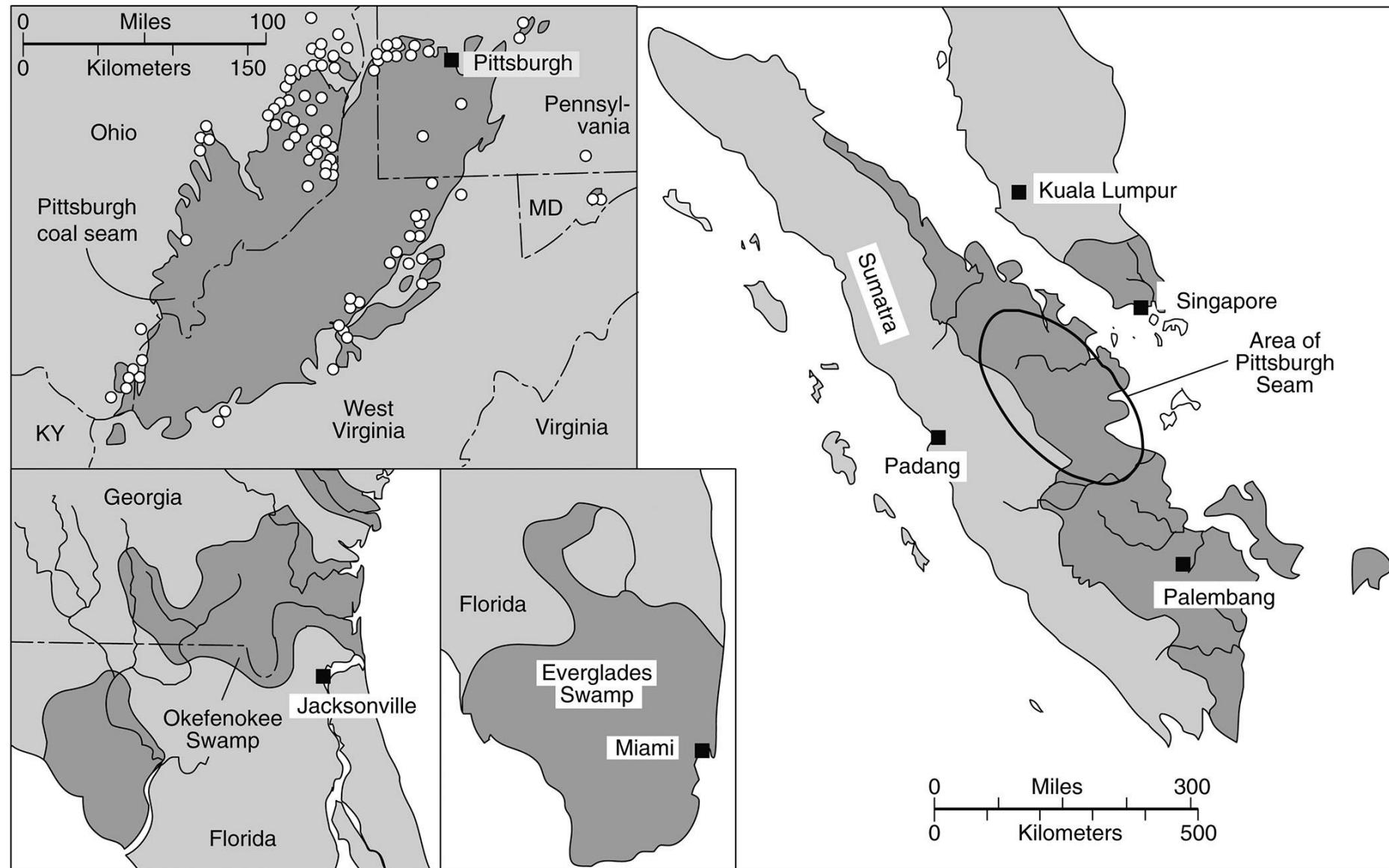


Types of Coal

Rank of coal	C	H	Volatile	Fixed carbon	Calorific value	
	(Weight percent)				(Btu/lb)	(MJ/kg)
Lignite	73.0–78.0	5.2–5.6	45–50	50–55	<8,300	<19.31
Subbituminous	78.0–82.5	5.2–5.6	40–45	55–60	8,300–11,500	19.31–26.75
Bituminous						
High-volatile	82.5–87.0	5.0–5.6	31–40	60–70	11,500–14,000	26.75–32.56
Medium-volatile	87.0–92.0	4.6–5.2	22–31	70–80	>14,000	>32.56
Low-volatile	91.0–92.0	4.2–4.6	14–22	80–85	>14,000	>32.56
Anthracite	92.0–98.0	2.9–3.8	2–14	85–98	>14,000	>32.56

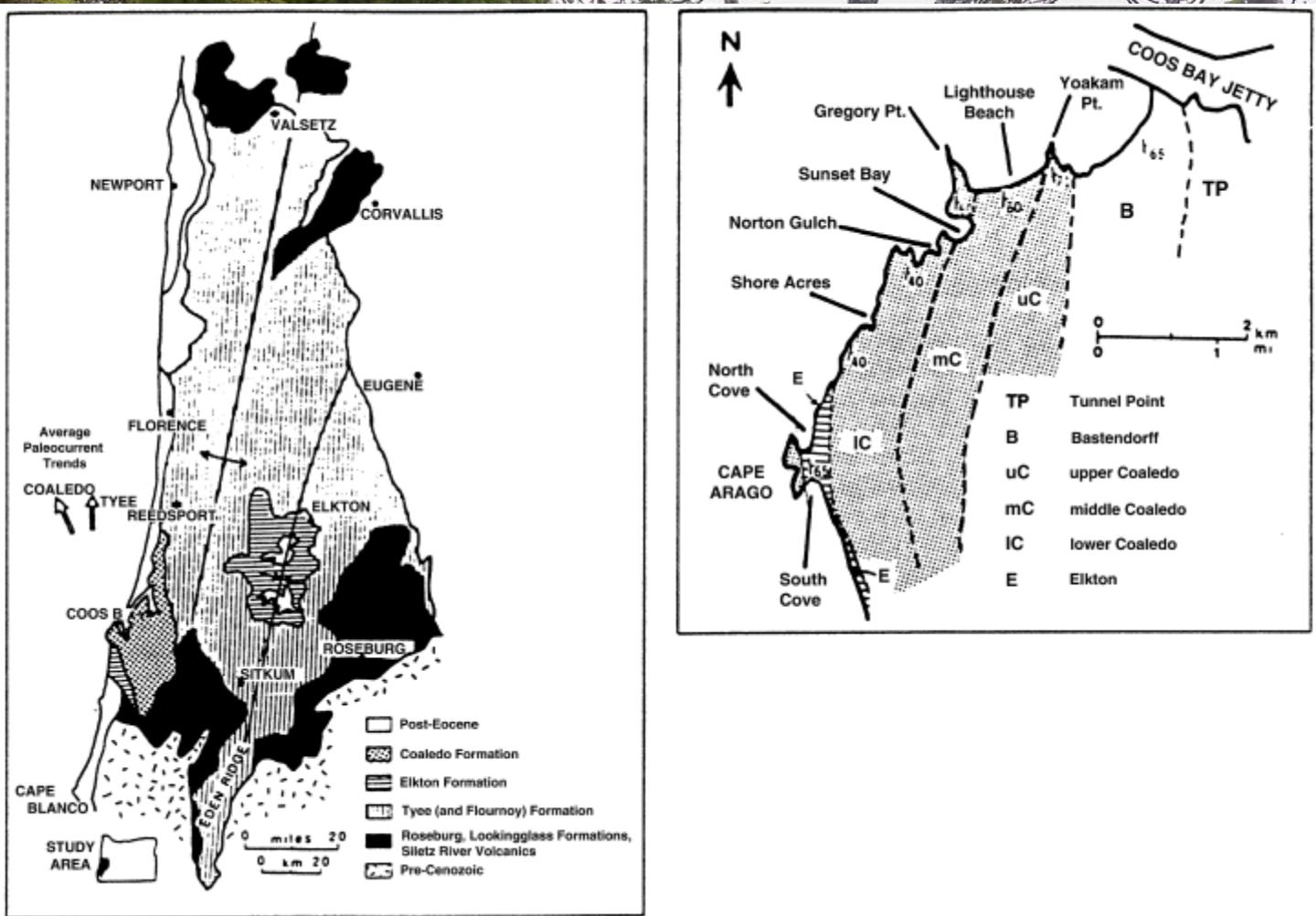


Coal basins



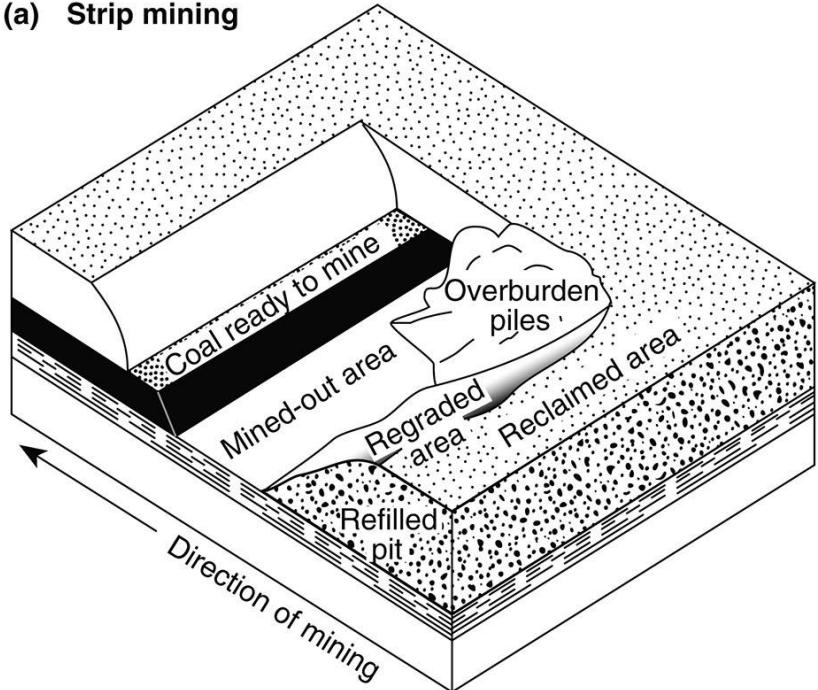




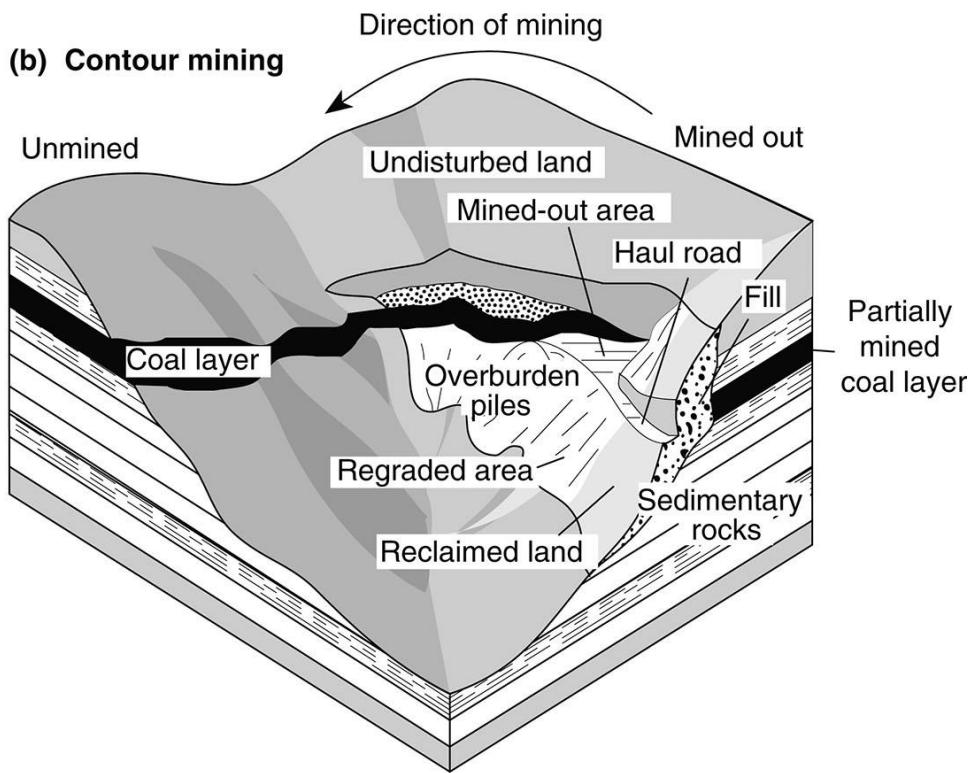




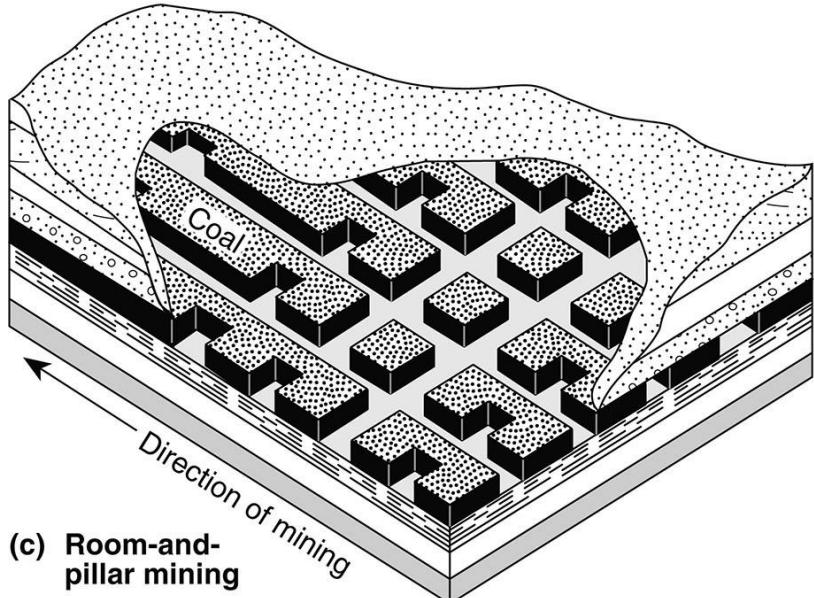
(a) Strip mining



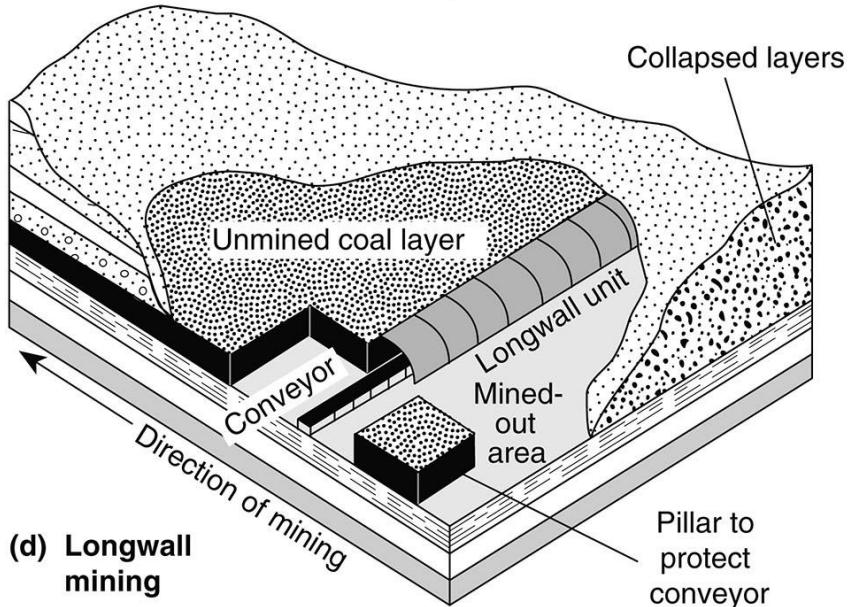
(b) Contour mining



(c) Room-and-pillar mining



(d) Longwall mining







Während des Betriebs
or der Aufschütt-
im Untergrund-
Verboten!

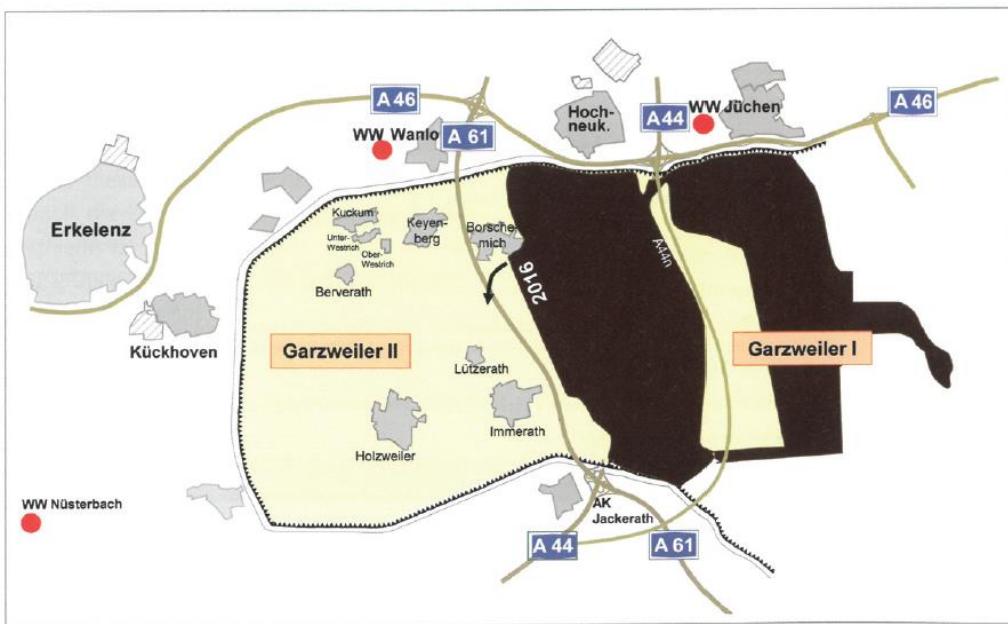




Lignite Mining in Germany (Garzweiler)

- Formed during the Miocene (5-25 Ma) when coastal swamps inundated the region
- Lignite is deposited in three beds with average thickness of 40 meters, occurring 40-210 meters below the surface
- Lower thermal grade b/c of water content (55-60%) compared to coal / anthracite
- Interbedded with sand, gravel, and clay
- Pumps must remove groundwater for mining
- IMPACTS: groundwater contamination, human resettlement (>40,000 people in the Rhineland), greenhouse gas emissions

51.070449, 6.496475



The village of Immerath is going to get totally destroyed. Once more than 1.200 people were living there.

- IMPACTS: groundwater contamination, human resettlement (>40,000 people in the Rhineland), greenhouse gas emissions



(a)



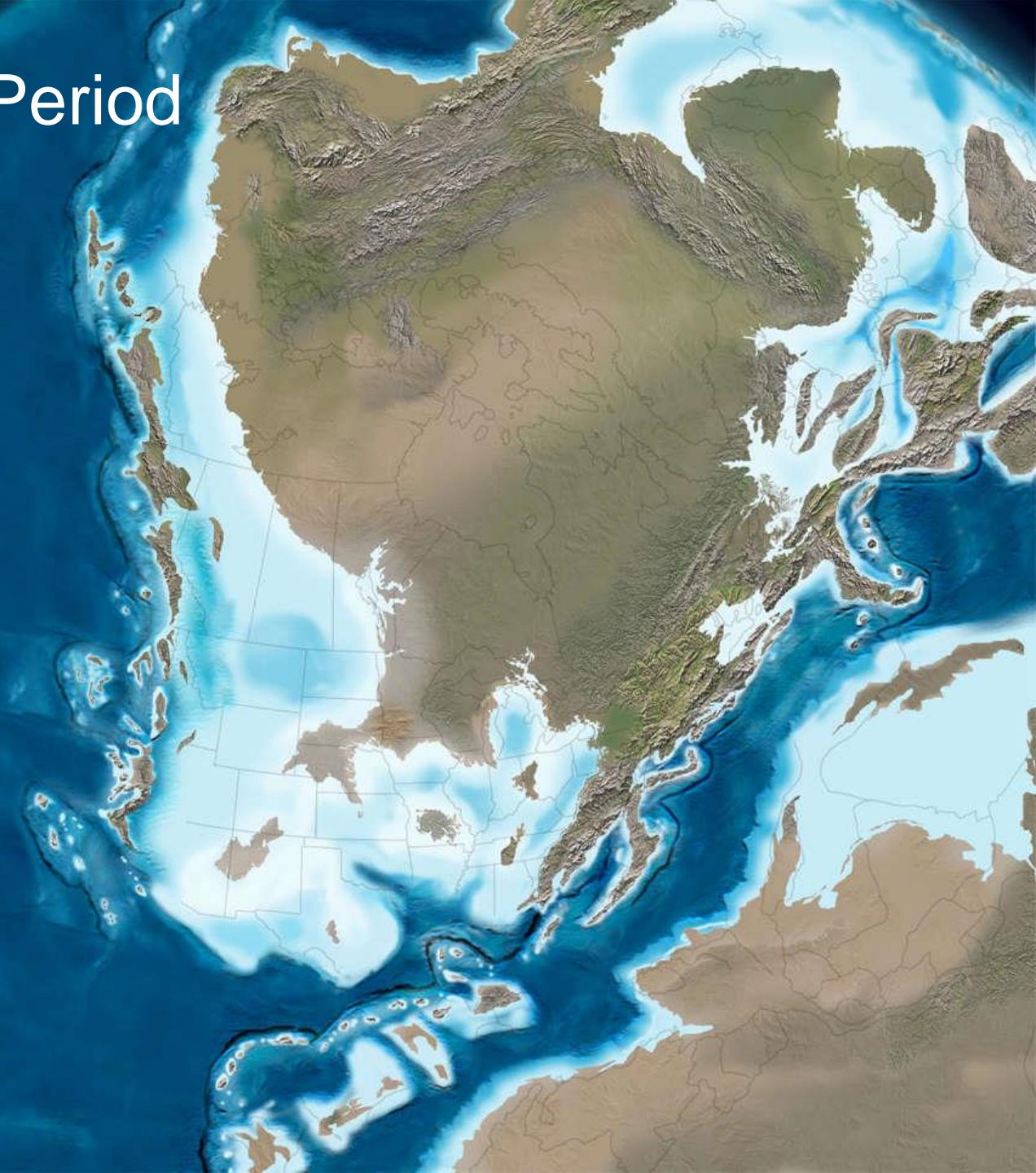
Surface coal mining at the Freedom lignite mine in North Dakota, supplies about 16 million tons of coal each year to the basin Electric Power Cooperative.



After mining, the dragline replaces the waste rock and the area is graded to near-original contours (including wetlands), covered with topsoil and revegetated (Dakota Coal Company)

Carboniferous Period

~300-350 Ma

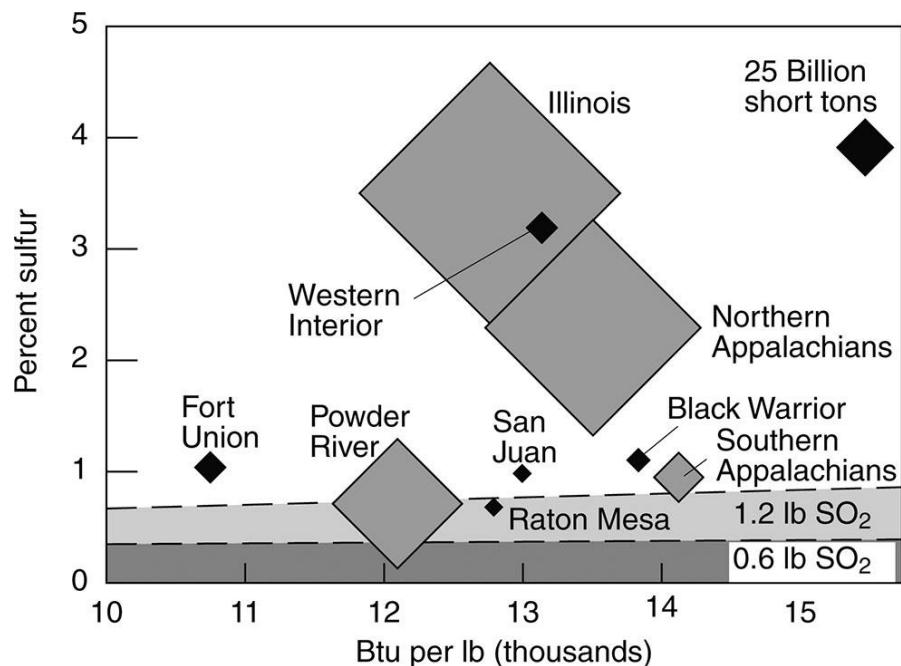


What happens to coal?

- USA: 93% for electricity, 7% for steel production (coke)
- China: 85% electricity, 15% for steel
- France: Only 5% is for electricity

Main by-products

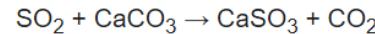
- Ash (30%) - gangue minerals like clays and quartz (SiO_2)
- Sulfur (pyrite FeS_2 , gypsum CaSO_4)
Seawater or fresh water?
- Sulfur and nitrogen combine vapor to create acid rain
- Trace metals vaporize ($\sim 1,500^\circ\text{C}$)
50% Hg, 22% Cr, 28% Ni, 62% As



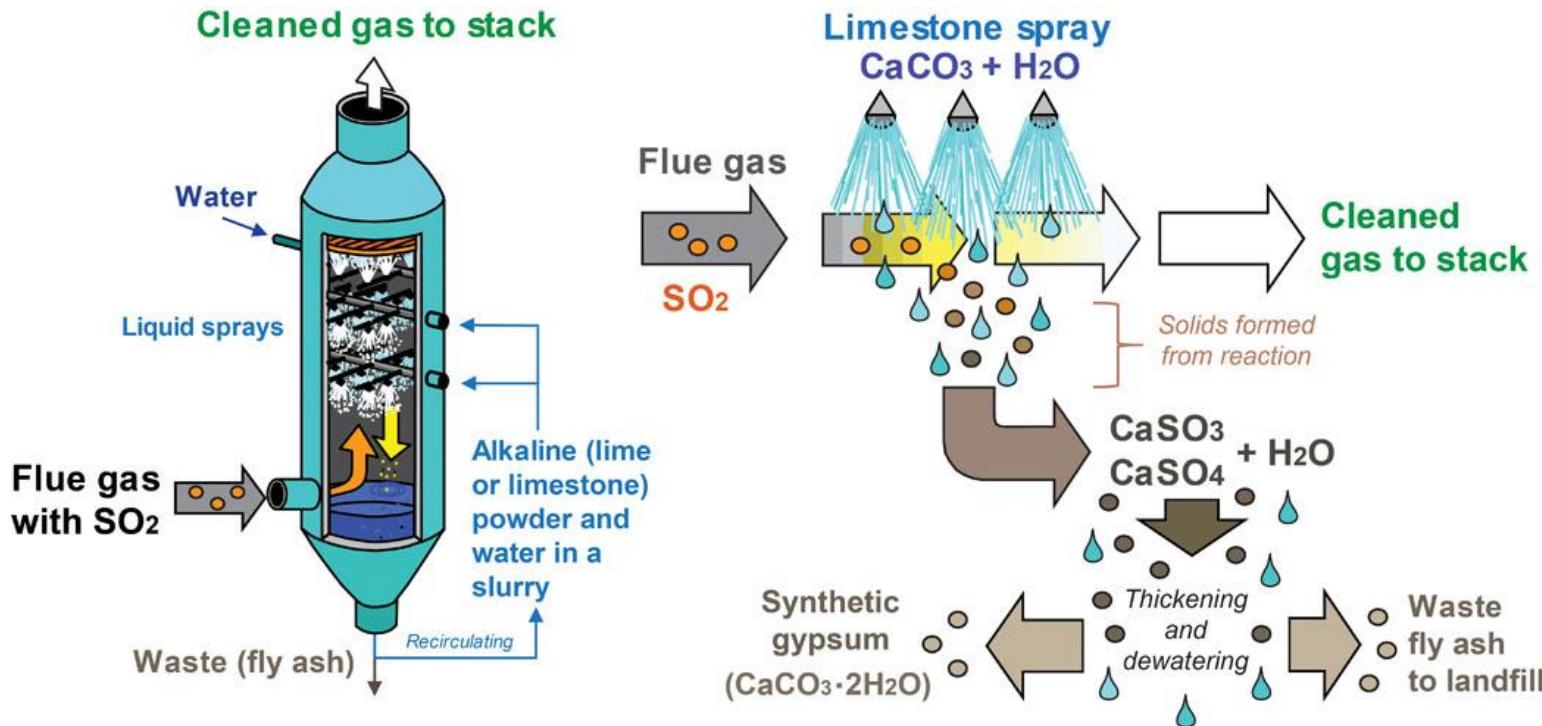
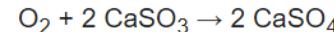
“Clean Coal”

- Removes sulfur before (washing) and after combustion (scrubbers)
- Increases plant construction costs by ~50%
- Takes up 50% of land area
- Removes 80-90% of SO_2

Scrubbing with limestone follows the following idealized reaction:



The resulting calcium sulfite oxidizes in air to give gypsum:



CO₂ Emissions from Coal

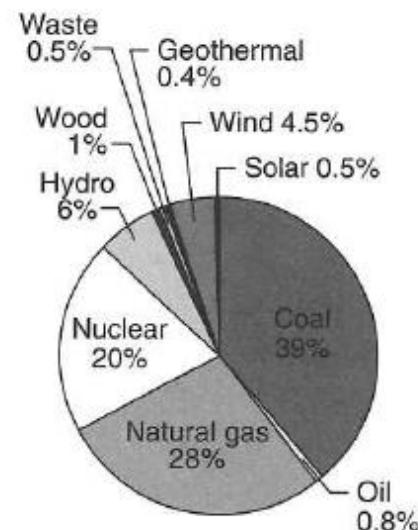
- Monitoring required as of 1995 and emissions are limited by the EPA
- Must capture / store 20-40% of CO₂ emissions
- Integrated Gasification Combined Cycle (IGCC) technology
Captures 65% of CO₂ and most Hg
Converts coal to gas (which is cleaner to burn)



Fossil Fuel Atmospheric Pollution

Fuel type	Carbon dioxide	Sulfur dioxide	Nitrogen oxides
Coal	972.73	5.91	2.72
Oil	793.18	5.45	1.82
Natural gas	554.55	0.045	0.77

Relative contributions to atmospheric pollution in 2014 by fossil fuels for electric power generation in the USA.
Data from US Energy Information Administration and the US EPA

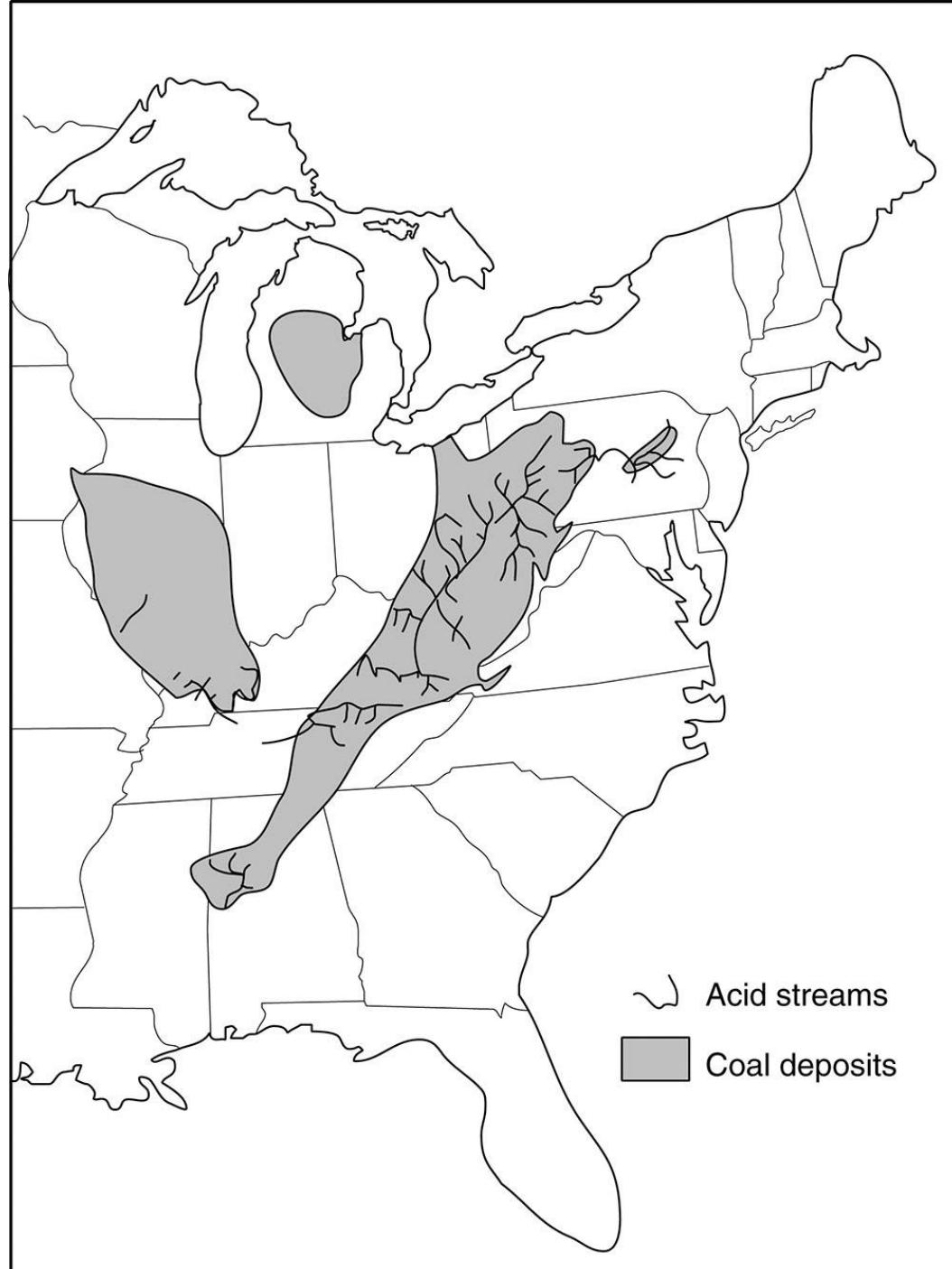


Fuel type	Carbon dioxide	Sulfur dioxide	Nitrogen oxides
Coal	972.73	5.91	2.72
Oil	793.18	5.45	1.82
Natural gas	554.55	0.045	0.77

Coal Taxes:

- 1977: Black Lung Disability Trust Fund (BLDTF)
- US Coal producers pay \$1.10 / ton underground, \$0.55 / ton surface mined coal
- 1977: Abandoned Mine Land Reclamation Fund (AMLRF)
- US Coal producers pay \$0.35 / ton surface coal, \$0.15 / ton underground coal. As of 2012, \$10.1 billion was in the fund

Distribution of streams in the USA made acidic by coal mining prior to present mining regulations



Fuel type	Carbon dioxide	Sulfur dioxide	Nitrogen oxides
Coal	972.73	5.91	2.72
Oil	793.18	5.45	1.82
Natural gas			

Coal

- 1900: Fuel for 1/3 of US tonnage
- US coal miners strike
- 1902: Repealed
- US coal miners strike under \$1000

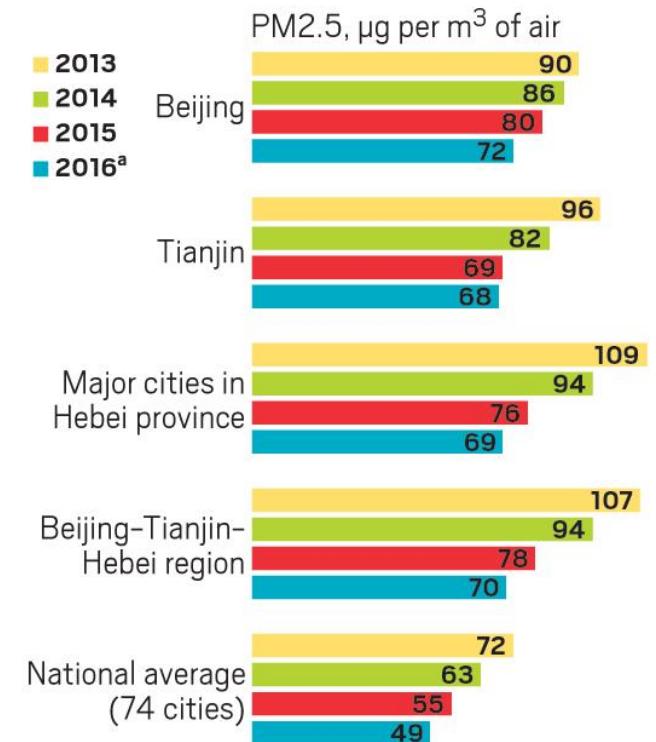


INJURED BEING TREATED IN MINE HOSPITAL.

USA made acidic by coal mining prior to present mining regulations



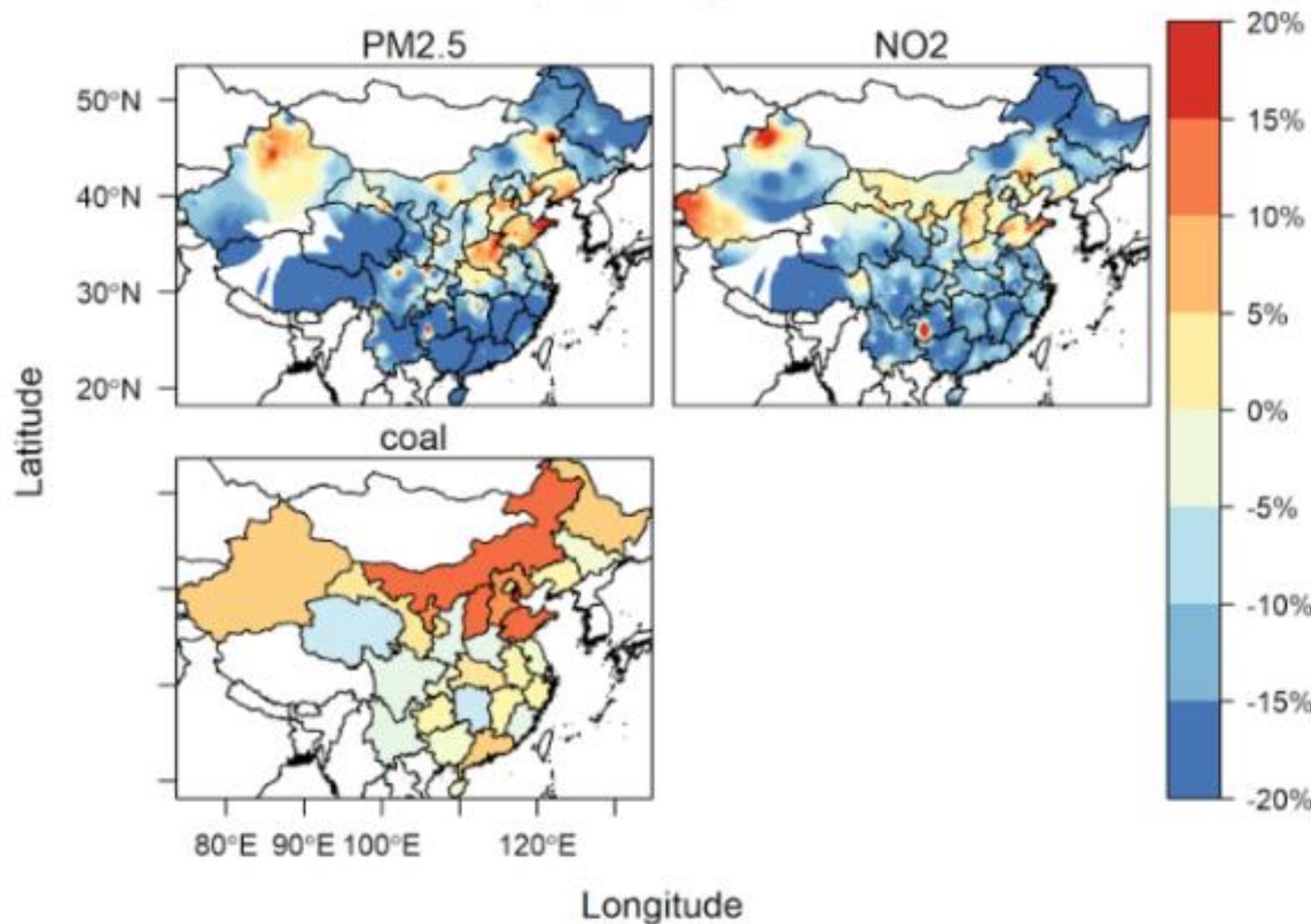
Coal Producing Areas and Air Quality





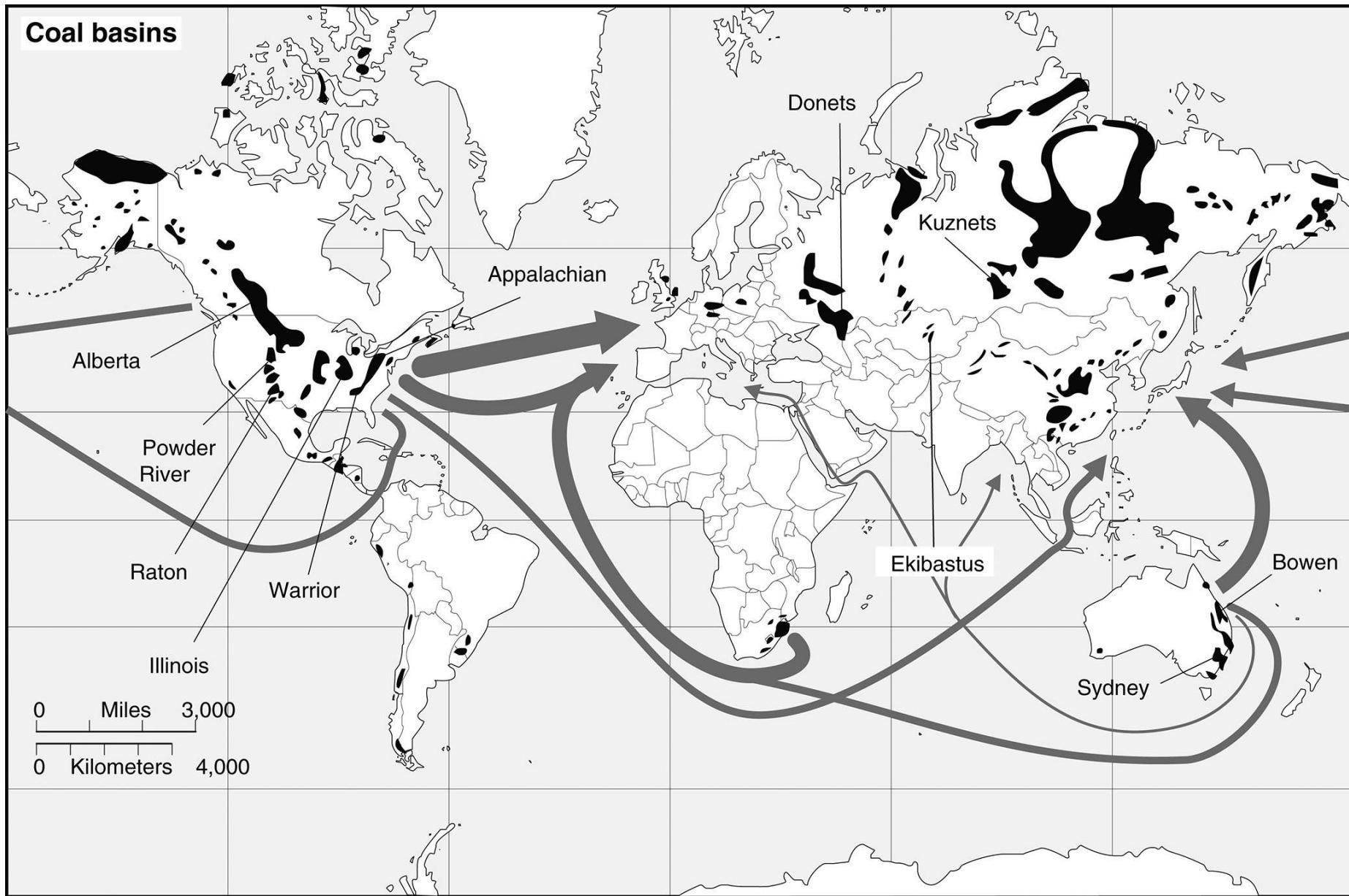
Analysis from the Ministry of Environmental Protection in China, indicated that of the PM 2.5 pollution generated from within the city of Beijing itself, 31% came from motor vehicles, 22% from coal burning, 18% from industrial production, and 14% from dust given off by construction and other sources.

Coal consumption and air quality, winter 2018-19 year-on-year



Sources: MEE; Shanxi Fenwei Energy Information Services

Coal basins



Coal Mining and Productivity

- Mechanization increased productivity significantly in the late 20th century from ~2 to 7 tons/miner/hour
- Wyoming (open pit): 30 tons/miner/hour
- West Virginia (underground): 2 tons/miner/hour
- India gets 60% of its electricity from coal and produces at only 0.4 tonnes/miner/hour
- Accounted for 56.8% of China's domestic energy generation in 2020, down from 72.4% in 2005
- China produces up to 0.15 tonnes/miner/hour
- ~6 million workers in underground mines, 1,000 die annually in mining accidents

