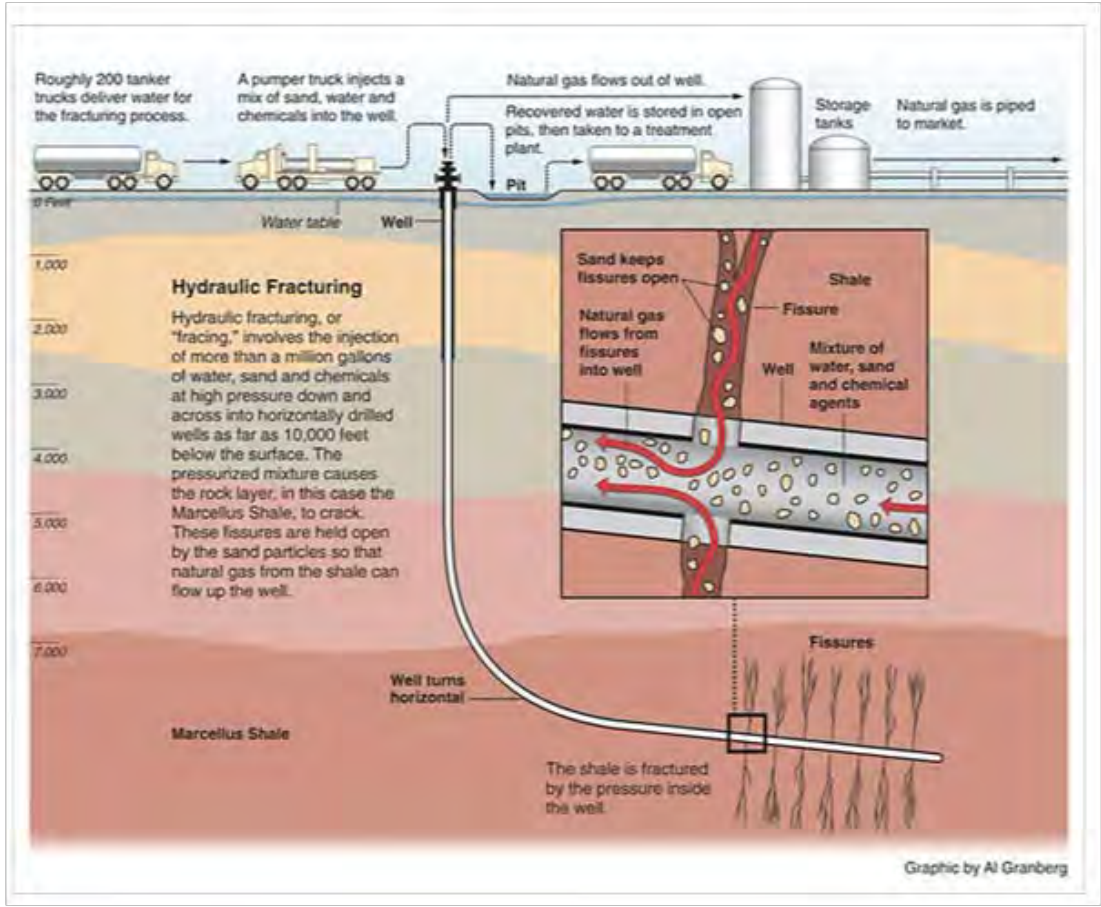


FIGURE 4.2 Crude oil distillation.

Fraction	Boiling Point Range	Comments
Gases Methane (65–90%), ethane, propane, butane	Below 20°C	Similar to natural gas. Useful for fuel and chemicals. Also obtained from catalytic cracking and catalytic reforming. Some of it is flared because of cost of recovery. <i>n</i> -Butane, however, is practically always recovered.
Naphtha Light naphtha (C ₅ ,C ₆ hydrocarbons)	70–140°C	Naphtha is predominantly C ₅ –C ₉ aliphatic and cycloaliphatic compounds. May contain some aromatics. Base for gasoline. Useful for both fuel and chemicals. Light naphtha is now considered undesirable for gasoline because catalytic reforming yields benzene, which is toxic and has a relatively low octane number.
Heavy naphtha (C ₇ –C ₉ hydrocarbons)	140–200°C	
Atmospheric gas oil Kerosene	175–275°C	Contains C ₉ –C ₁₆ compounds useful for jet, tractor, and heating fuel.
Diesel fuel	200–370°C	Contains C ₁₅ –C ₂₅ compounds, mostly linear. Useful for diesel and heating fuels. Gas oil is catalytically cracked to naphtha and may be steam cracked to olefins.
Heavy fractions Lubricating oil	Above 370°C	Used for lubrication
Residual or heavy fuel oil	Above 370°C	Used for boiler fuel. Vacuum distillation gives vacuum gas oil for catalytic cracking.
Asphalt or “resid”		Used for paving, coating, and structural applications.



North American shale plays (as of May 2011)



Current shale plays

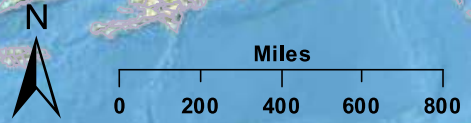
Stacked plays

- Shallowest / youngest
- Intermediate depth / age
- Deepest / oldest

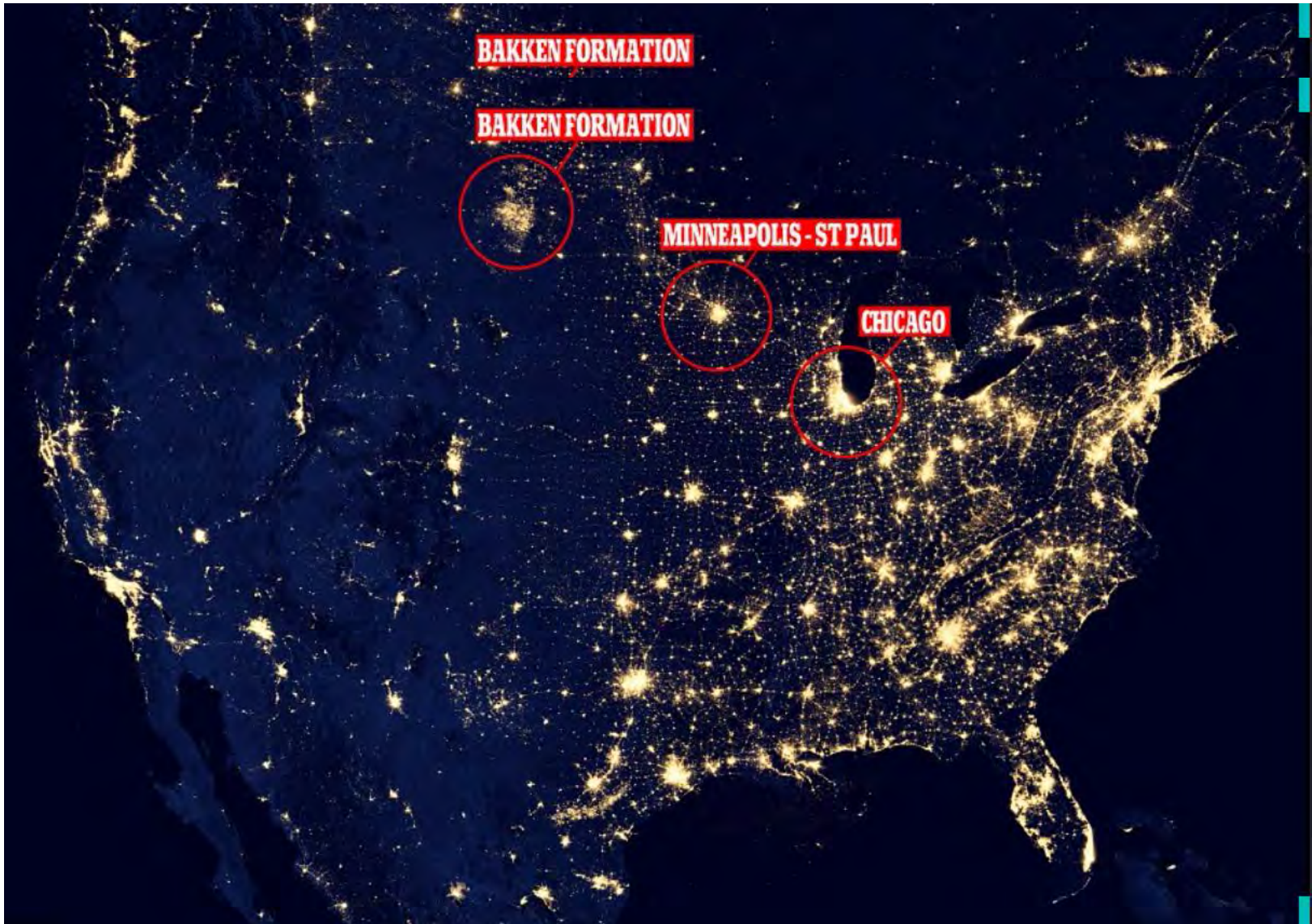
* Mixed shale & chalk play
 ** Mixed shale & limestone play
 *** Mixed shale & tight dolostone-siltstone-sandstone play

Prospective shale plays

Basins



Methane Flaming

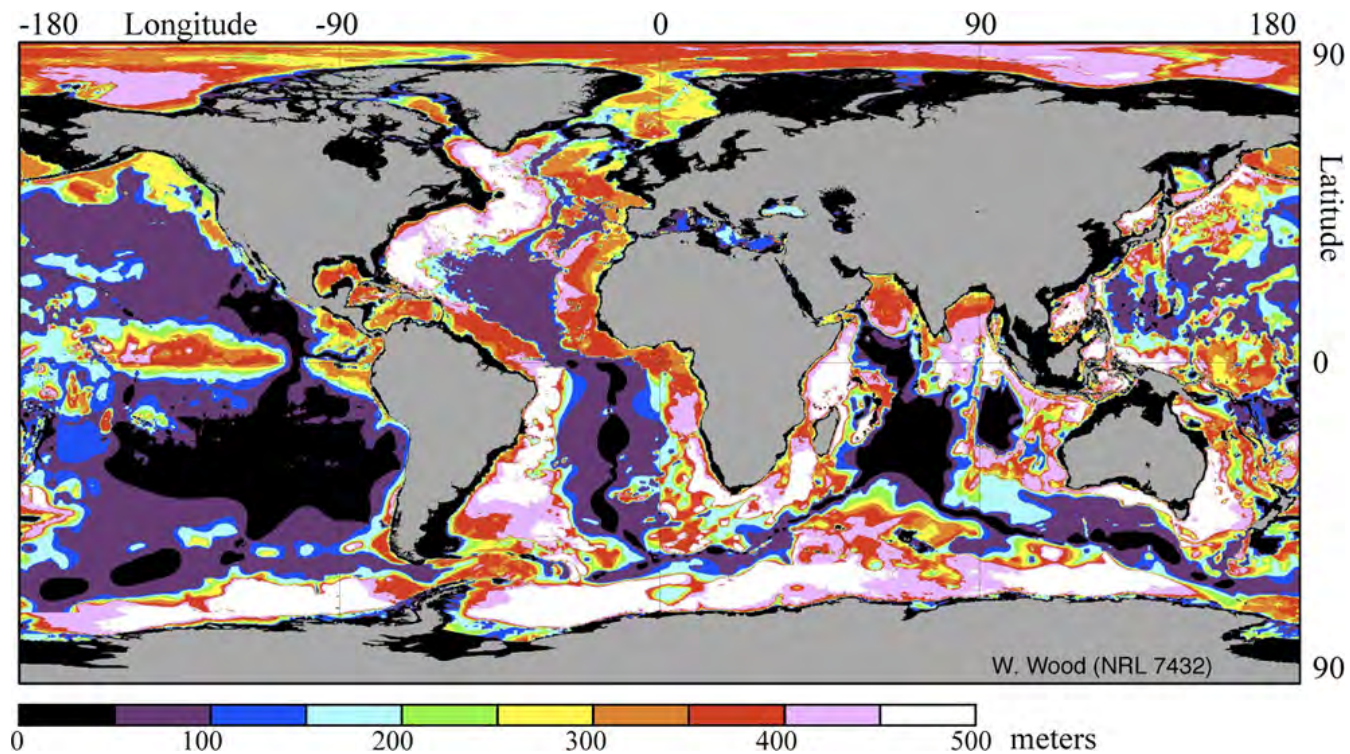




Methane Hydrate –structure.
methane: gray-carbon, green hydrogens
water: red-oxygen, white-hydrogen,



Burning Ice - methane hydrate



Synthesis of Biobased Terephthalic Acid from Methane

Thermogenic/Biogenic Methane

- In 2018, the U.S. produced $0.76 \times 10^{12} \text{ m}^3$ of methane.
- In 2017, the U.S. consumed $0.77 \times 10^{12} \text{ m}^3$ of methane.
- In 2016, the U.S. had $70 \times 10^{12} \text{ m}^3$ of estimated methane reserves.
- The U.S. has $1,500 \times 10^{12} \text{ m}^3$ of estimated methane hydrate reserves.
- In 2013, first marine extraction of methane hydrate (Nankai Trough).

Renewable Biogas

- In 2013, U.S. biogas production was $12 \times 10^9 \text{ m}^3$ annually.
- Near-term, U.S. biogas production could reach $60 \times 10^9 \text{ m}^3$ annually.
- U.S. chemical industry consumes $46 \times 10^9 \text{ m}^3$ of methane.
- Methane (wt/wt) has a 25-fold greater impact relative to CO_2 on climate change over a 100-year period.