Shell's In situ Conversion Process – Factors Affecting the Properties of Produced Shale Oil

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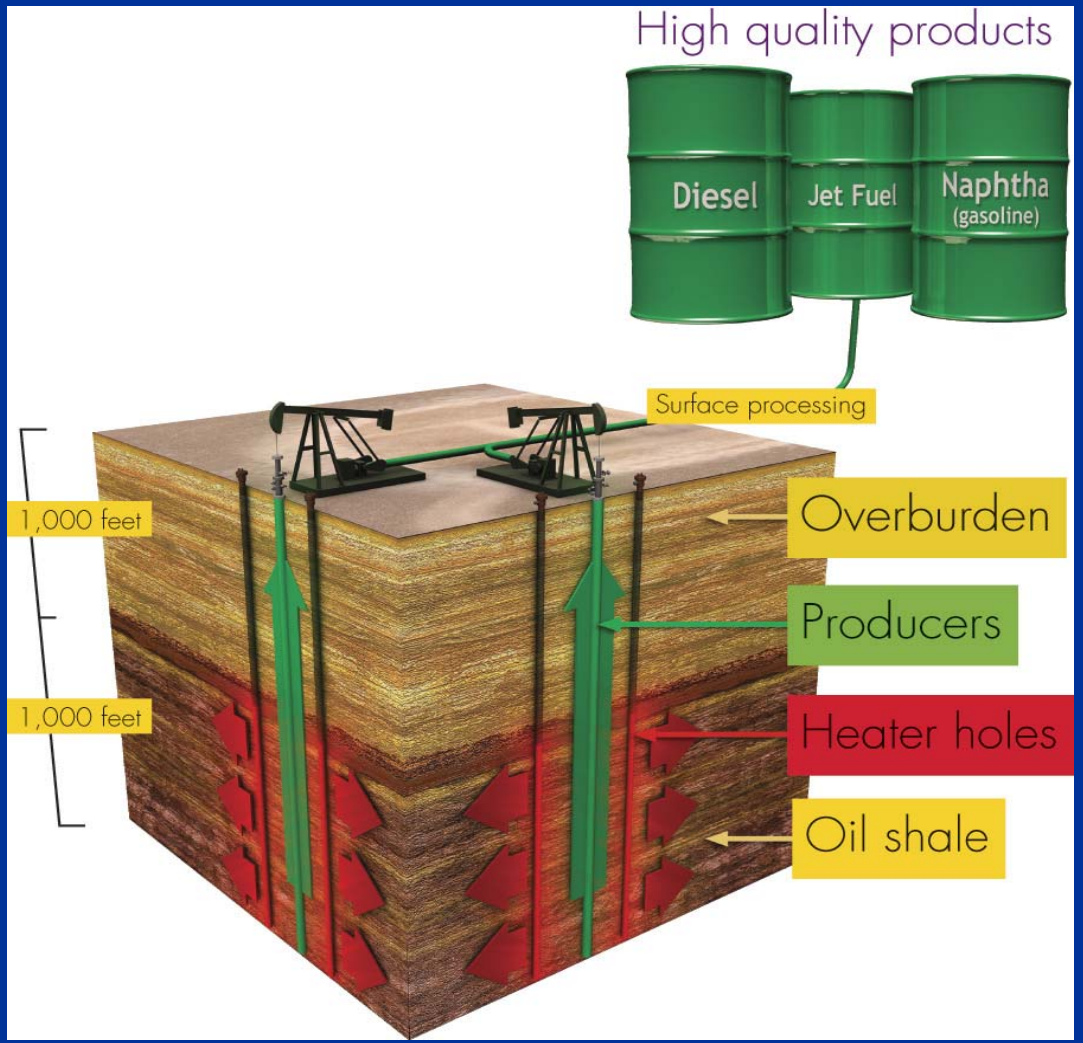
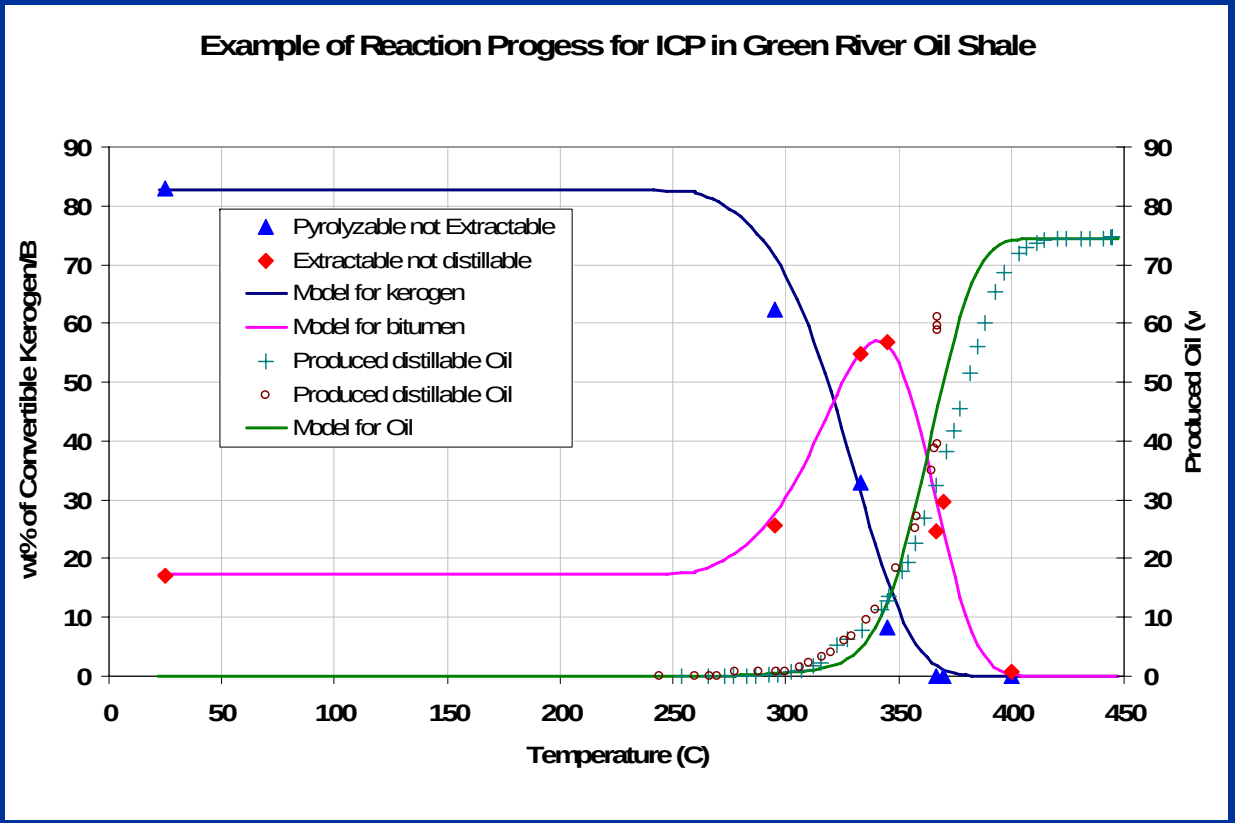
In situ Conversion Process

- Electric or other heaters inserted into holes gradually heat shale subsurface
- Applicable to oil shale and heavy oil
- Technology converts kerogen by gradual heating in oil shale
- Results in a high recovery of light hydrocarbon products yielding high quality transportation fuels



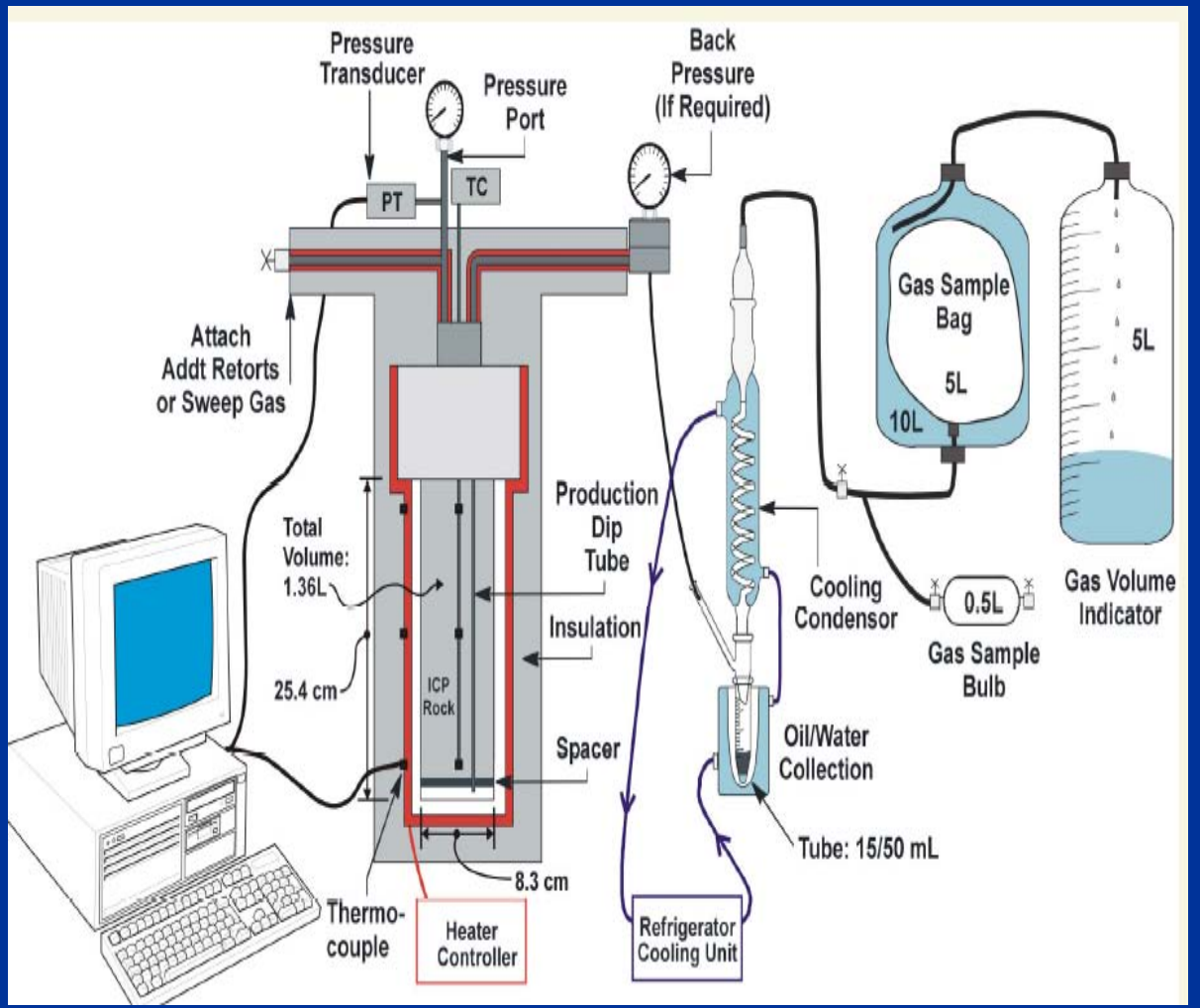
What is going on during ICP?

- Cracking and recombination reactions
- Distillation
- Heating rate and pressure interact to affect product quality
- Different reaction pathways are favored depending on residence time and phase



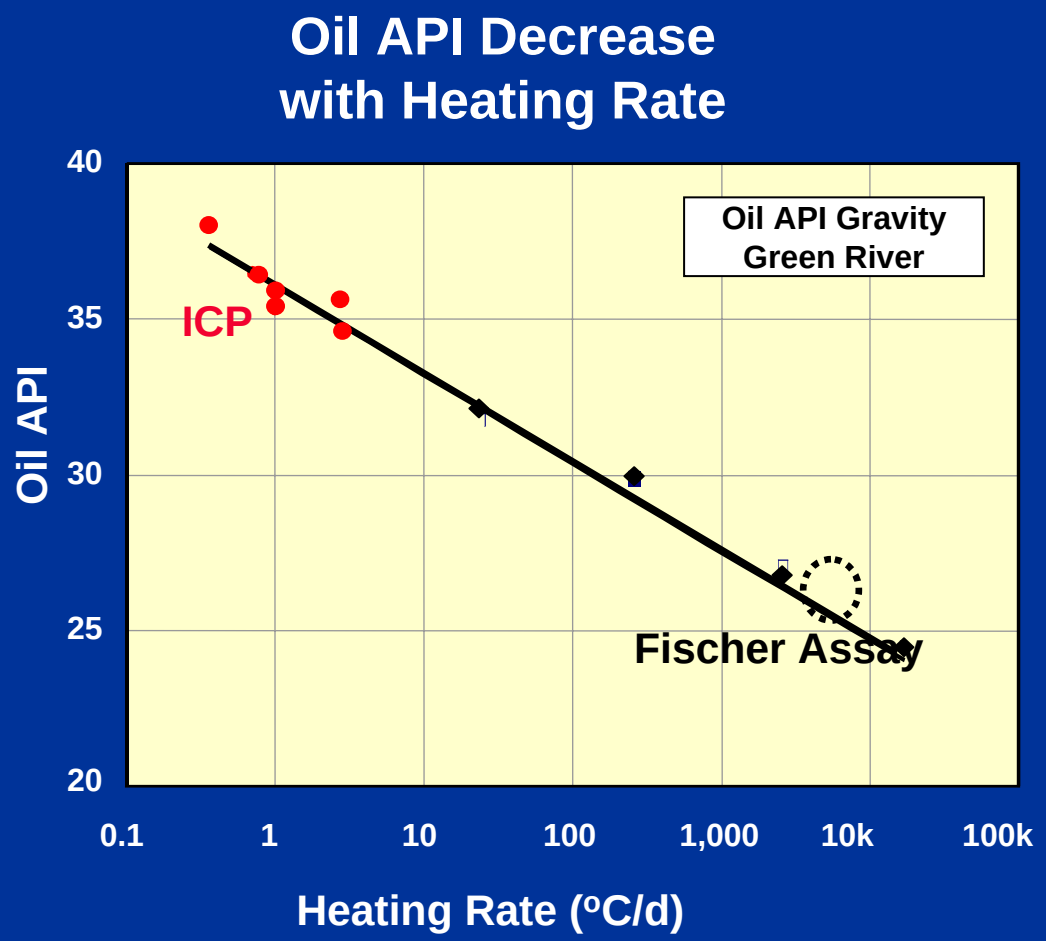
oil shale kerogen is converted to (ICP) oil, gas, and carbon residue (coke) with bitumen produced as an intermediate

Laboratory Pyrolysis Experimental Setup



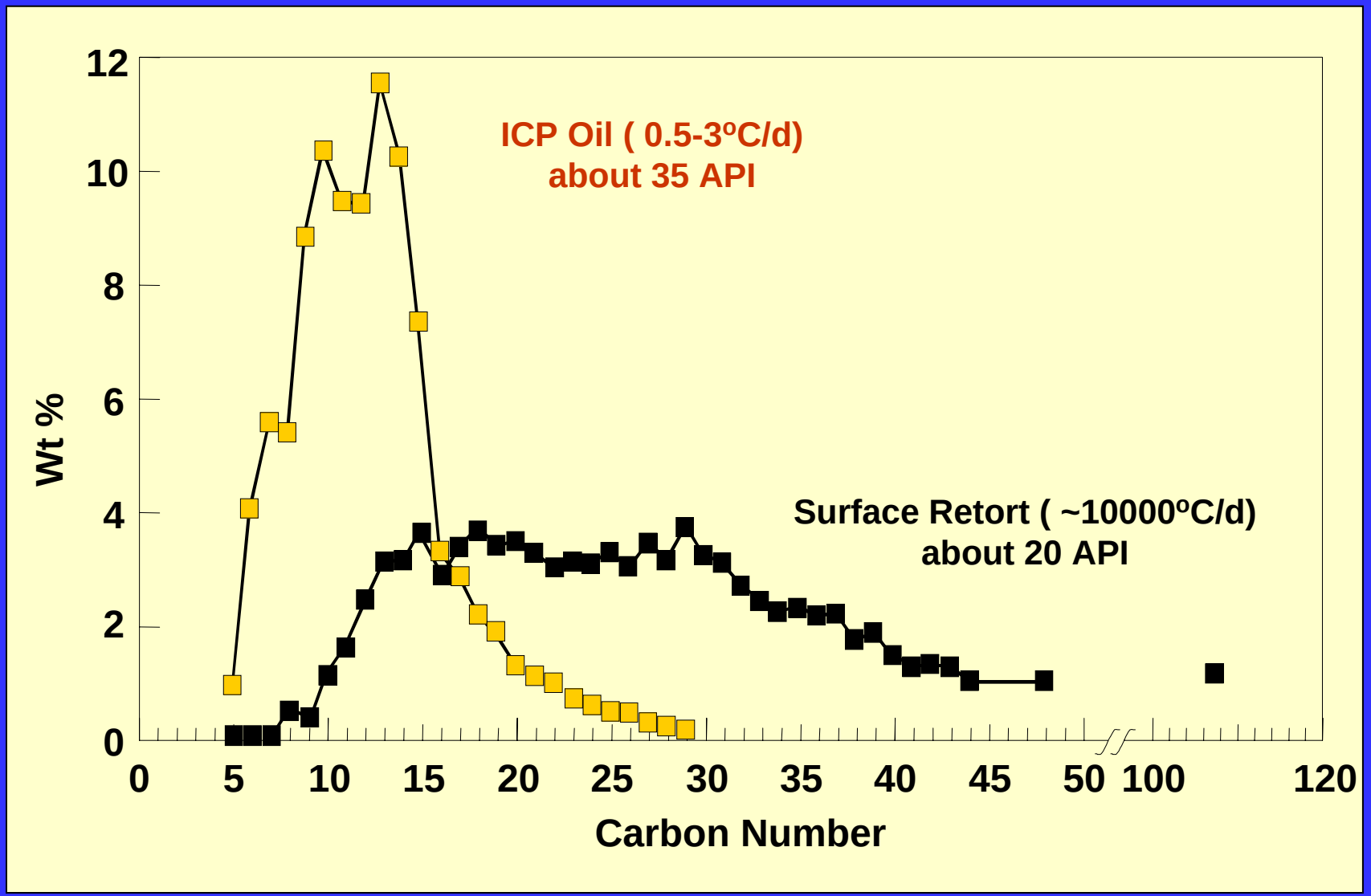
- Homogenized sample
- Uniform temperature
- Pressure controlled
- “Leaky” system similar to process

Heating Rate

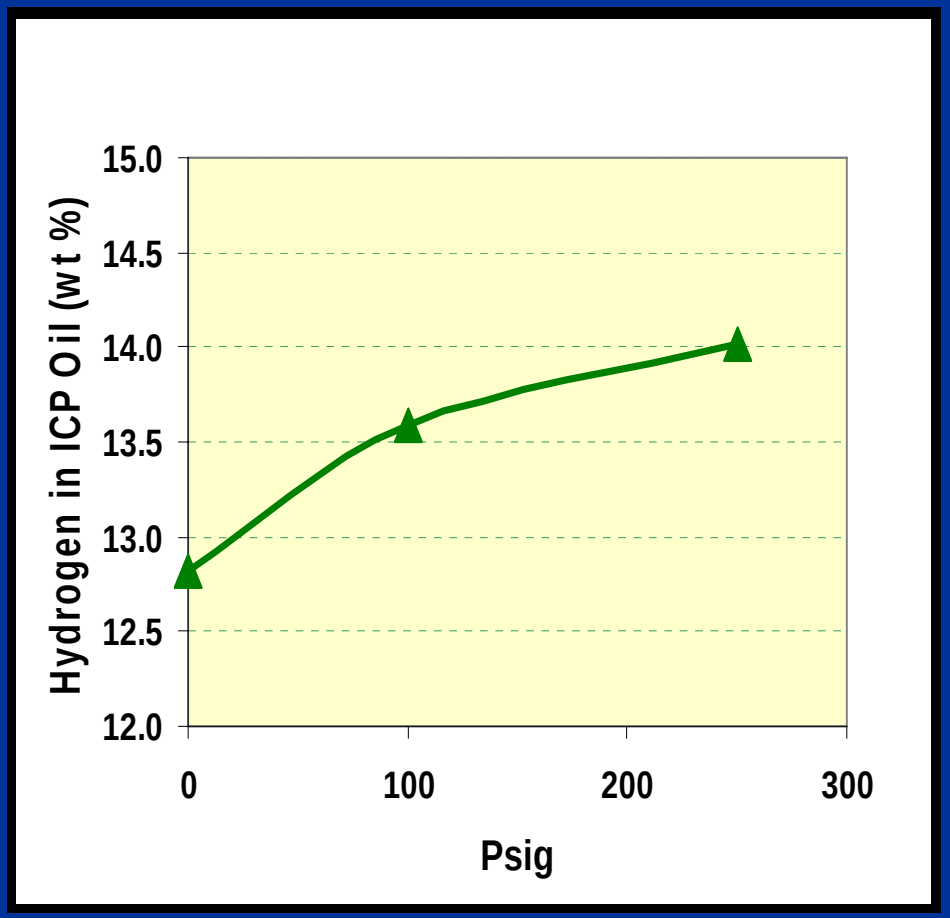


- Slow heating
  - Changes relative reaction rates
  - Affects volatilization of fragments
- Wide range of rates
  - From ICP
  - To Surface retorting (reflected in Fischer Assay)

Slower Heating Rate Increases Oil Quality



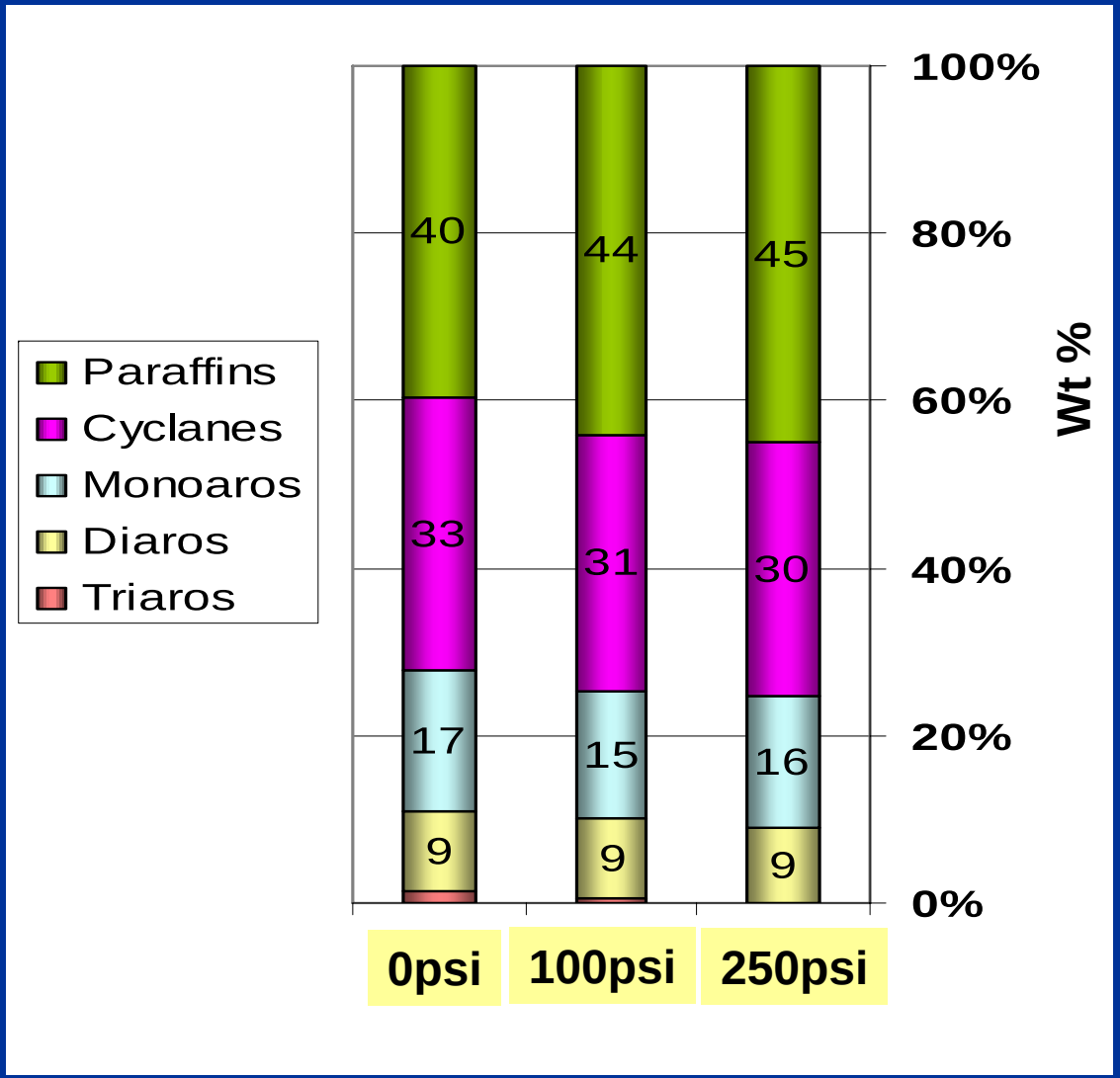
Pressure Increases Hydrogen Content of Oil



- Higher pressure produces products containing more hydrogen
- Could be due to smaller molecules or due to shift in chemical composition

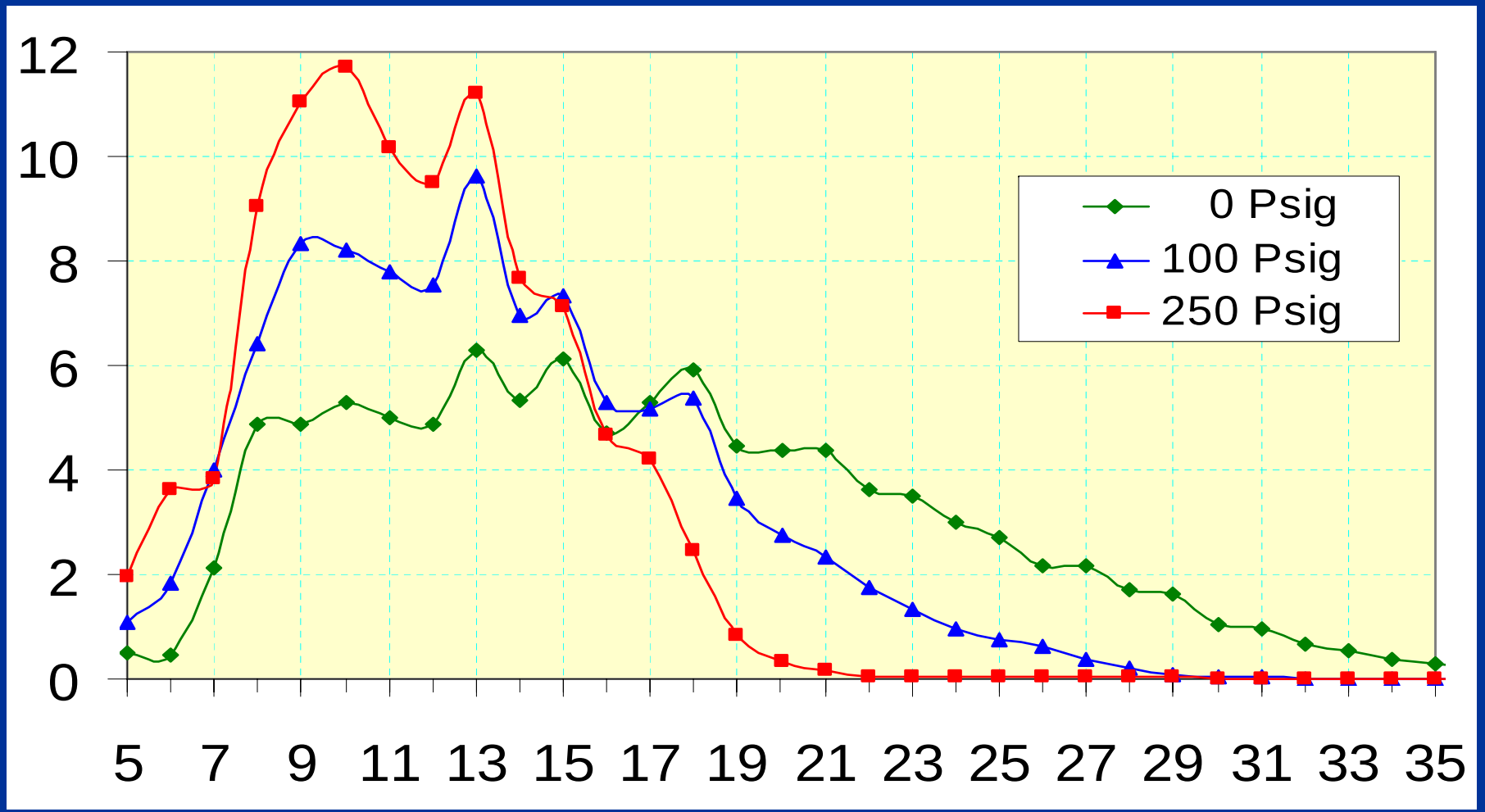
ICP Oil API Increases with Pressure

API ⟶ 35° 44° 50°



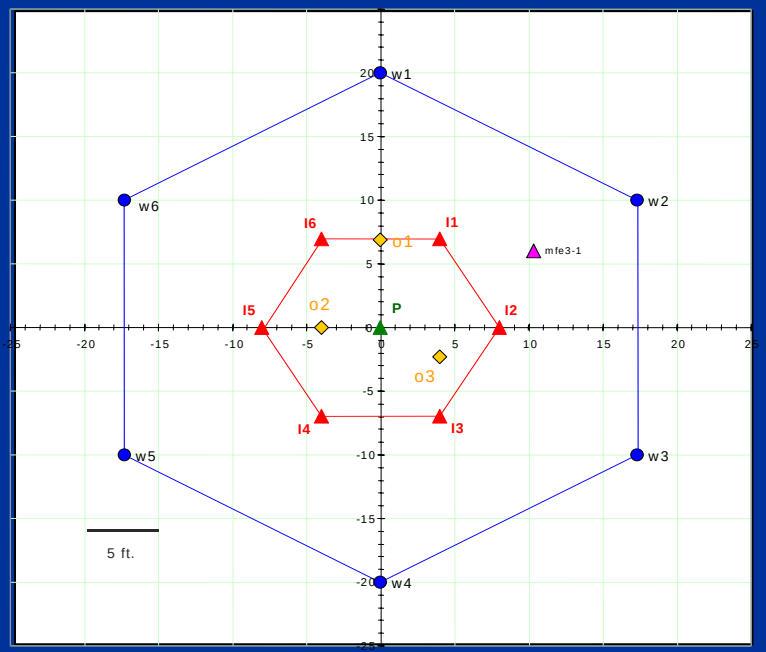
- API gravity increases with pressure
- No significant changes in chemical composition
- Triaromatics disappear

Product Quality Shift with Pressure Due to Reduction in Molecular Size



ICP Pilots

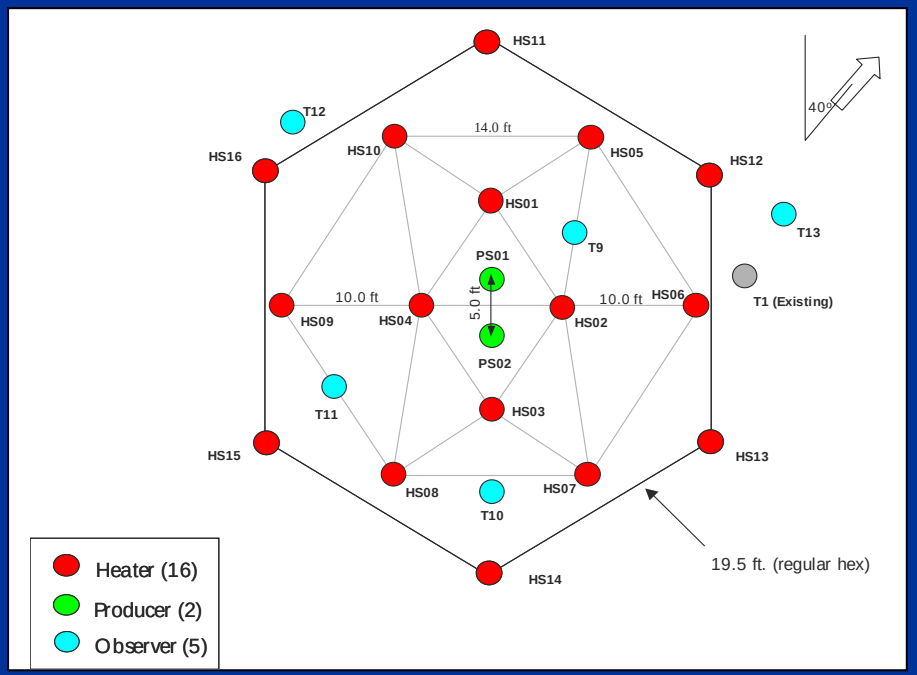
Colorado Oil Shale ('97/98) (MFE)



- ✓70' - 127' depth
- ✓Low pressure production

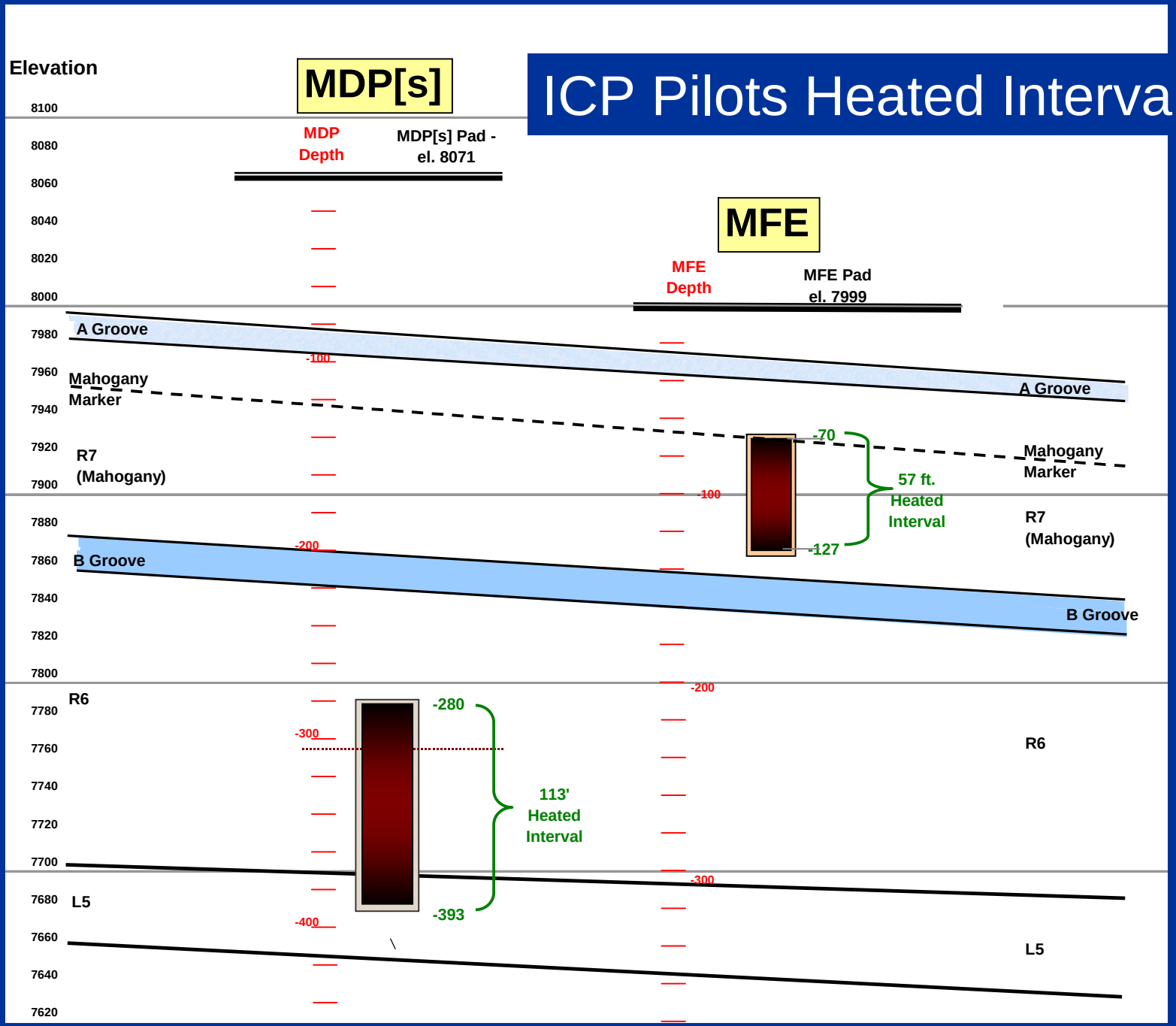
ICP Pilots

Colorado Oil Shale ('04/05) (MDP(s))

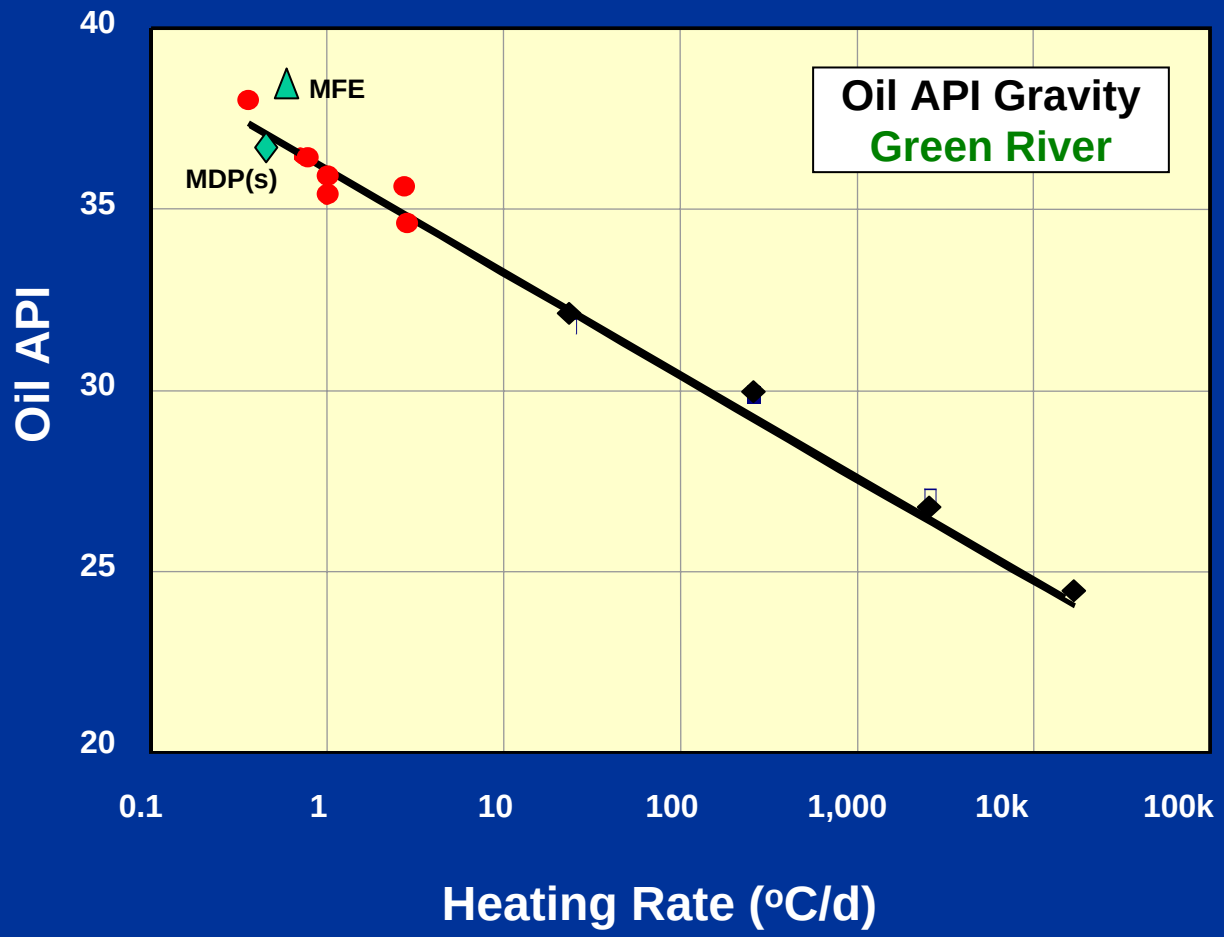


- ✓ 280' - 393' depth
- ✓ More heaters
- ✓ Wider spacing
- ✓ Low pressure production

ICP Pilots Heated Intervals

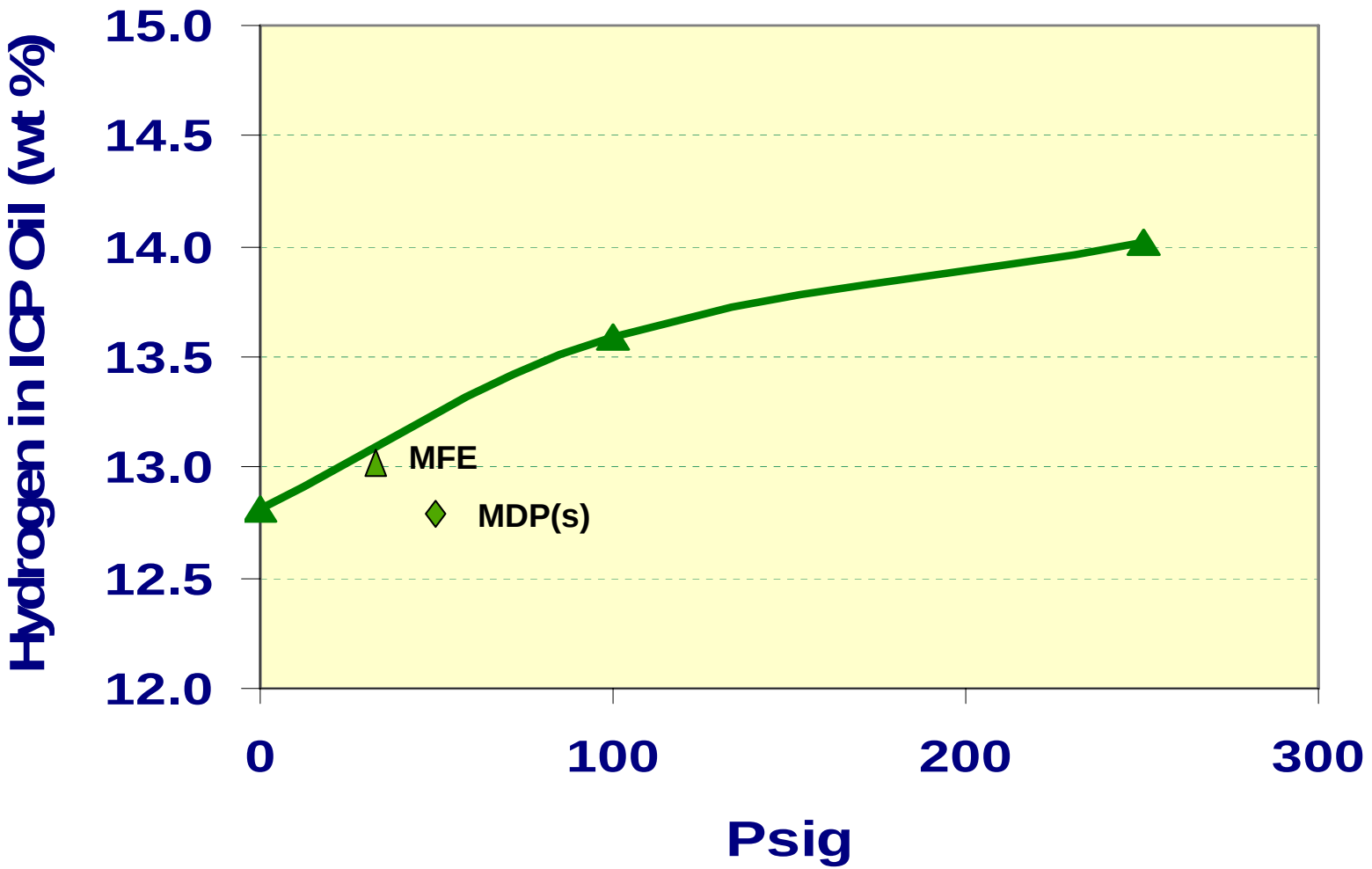


Heating Rate in Lab and Pilots



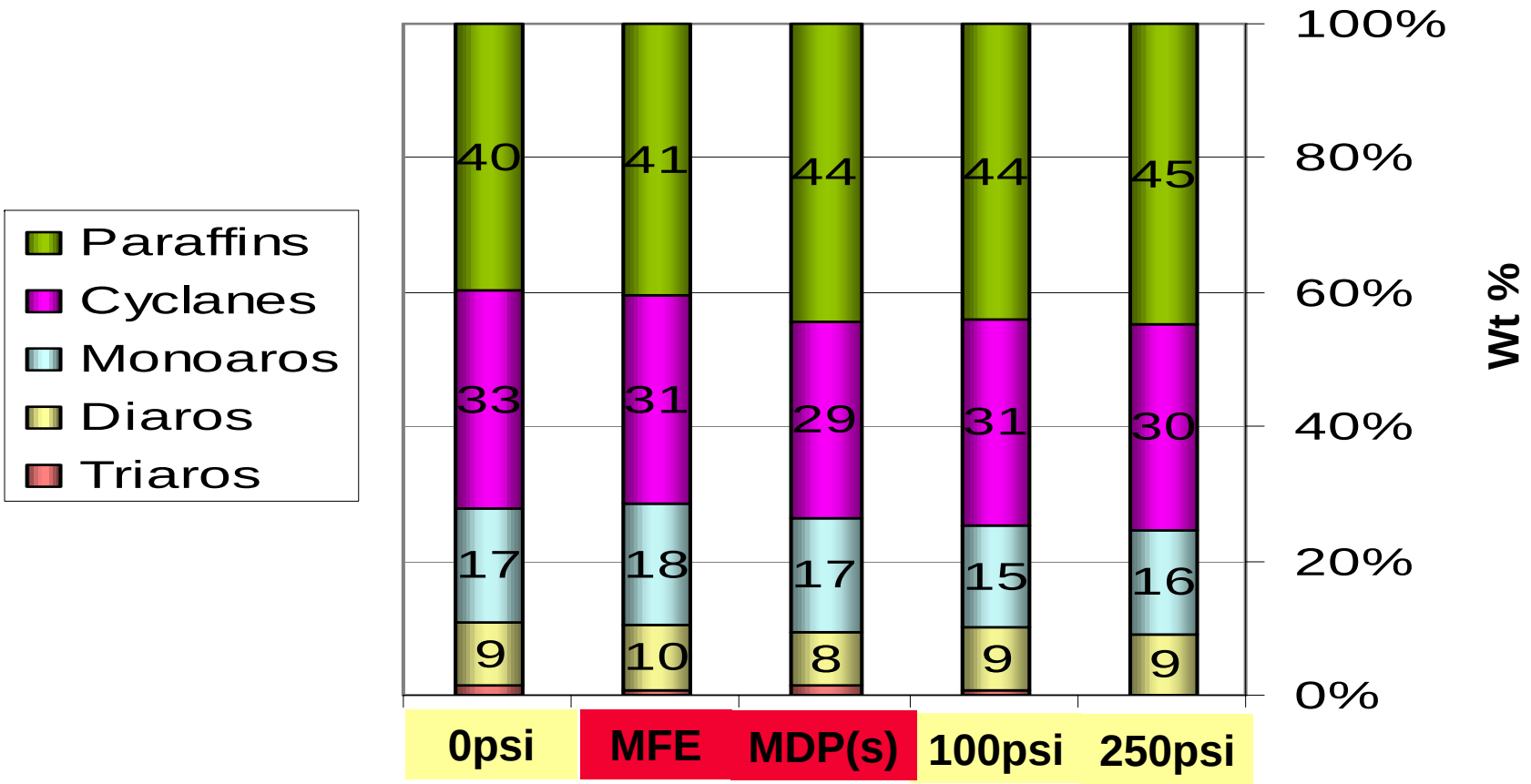
- Lab data predicts pilot results for API gravity

ICP Pilot Oil Hydrogen Content Close to Lab Data

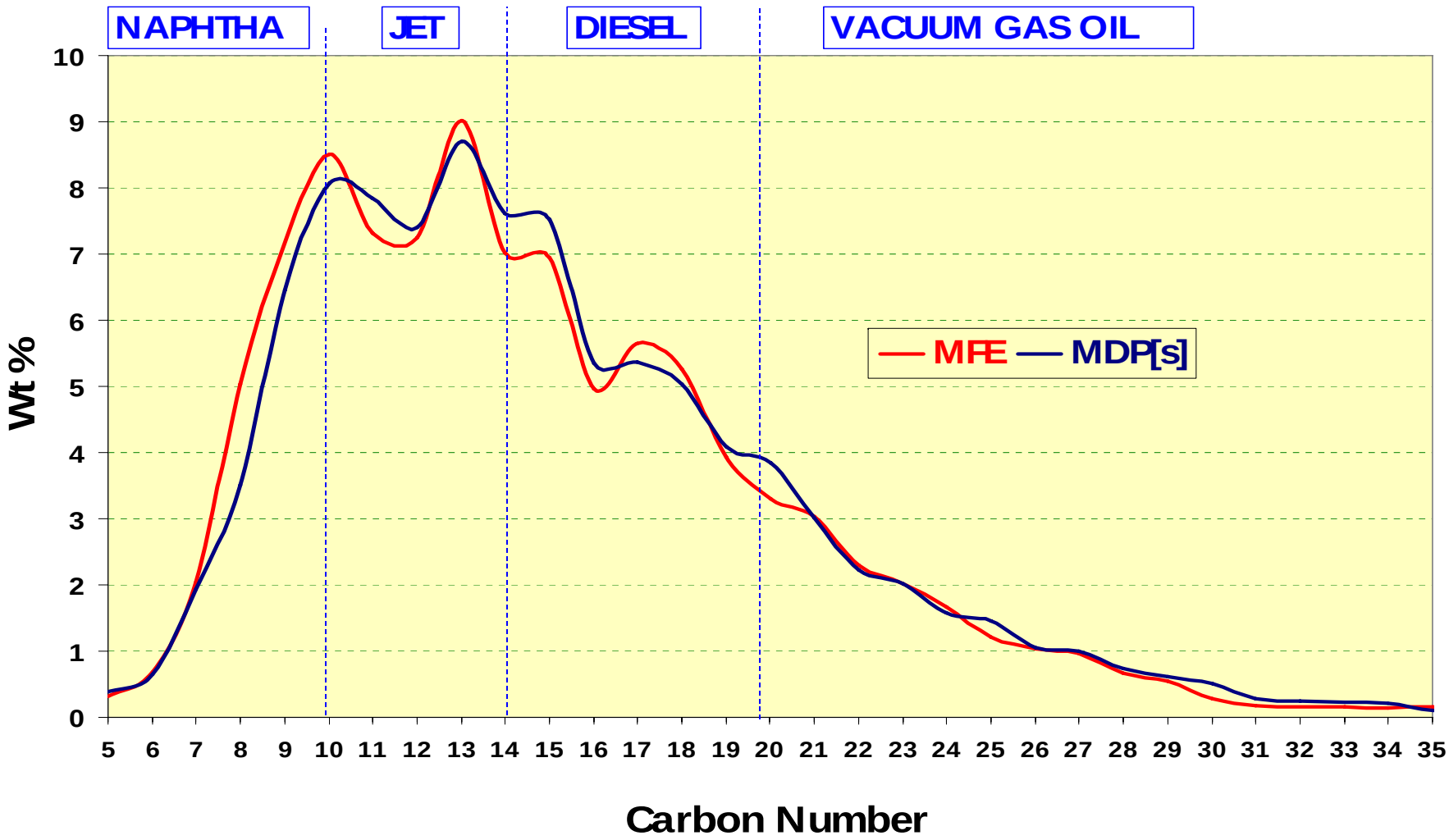


Pilot Oil Composition Consistent with Lab Data

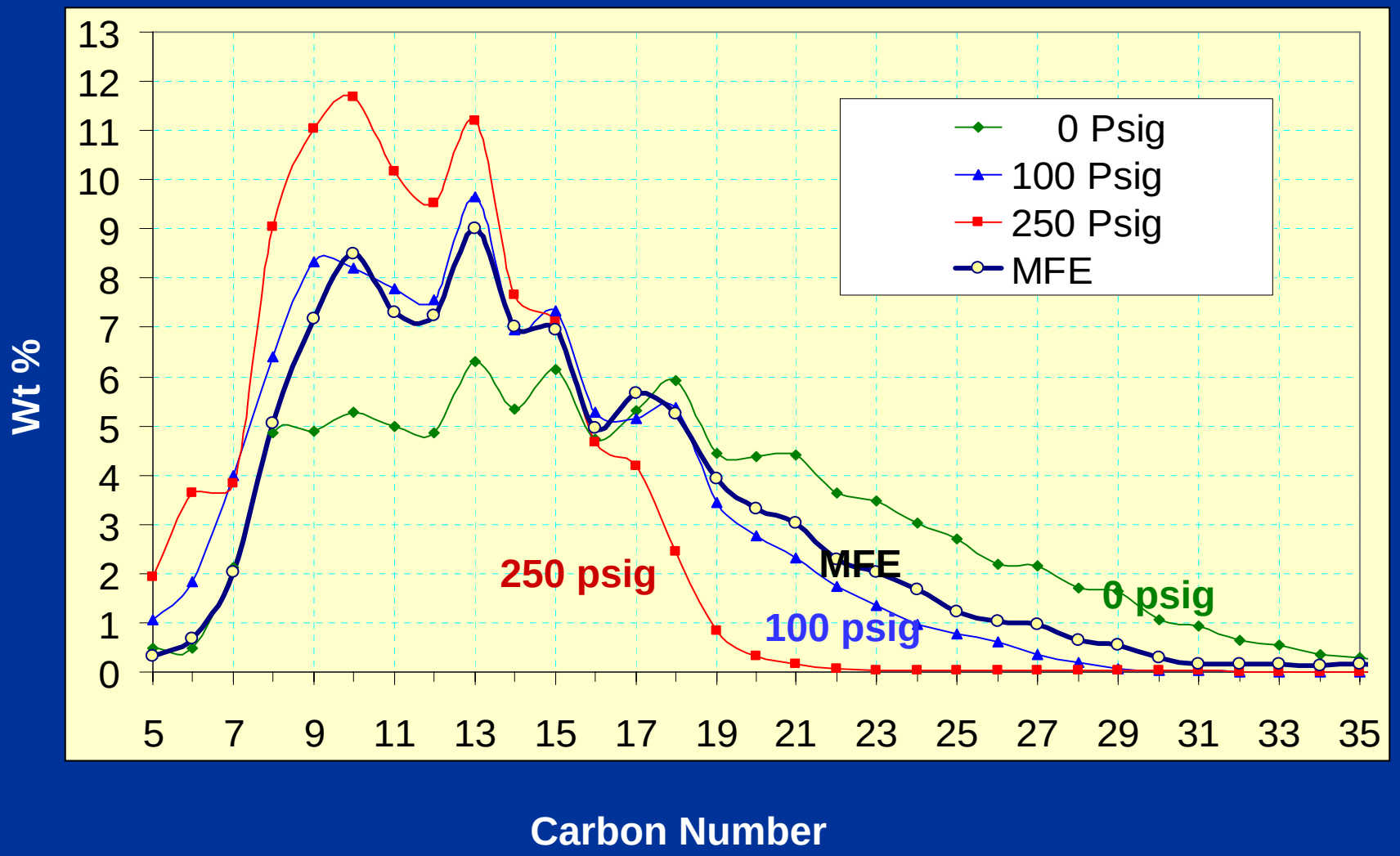
API ⟶ 35° 36° 38° 44° 50°



MFE and MDP(s) ICP Oils Have Very Similar Boiling Point Distributions



Pilot ICP Oil TBP Data Consistent with Lab Results



Conclusions

- Pore pressure and temperature in the pyrolysis zone control the ICP oil quality
- ICP pilots produce oil with properties consistent with lab data
- No effect of depth observed in range of 70’ to 393’
- No effect observed due to lithostatic stress