# Modeling Analysis and Process Optimization for Different Oil Shale Deposits

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28th Oil Shale Symposium
Golden Colorado
13-19 October 2008

# Outline – Why, What, When, Who

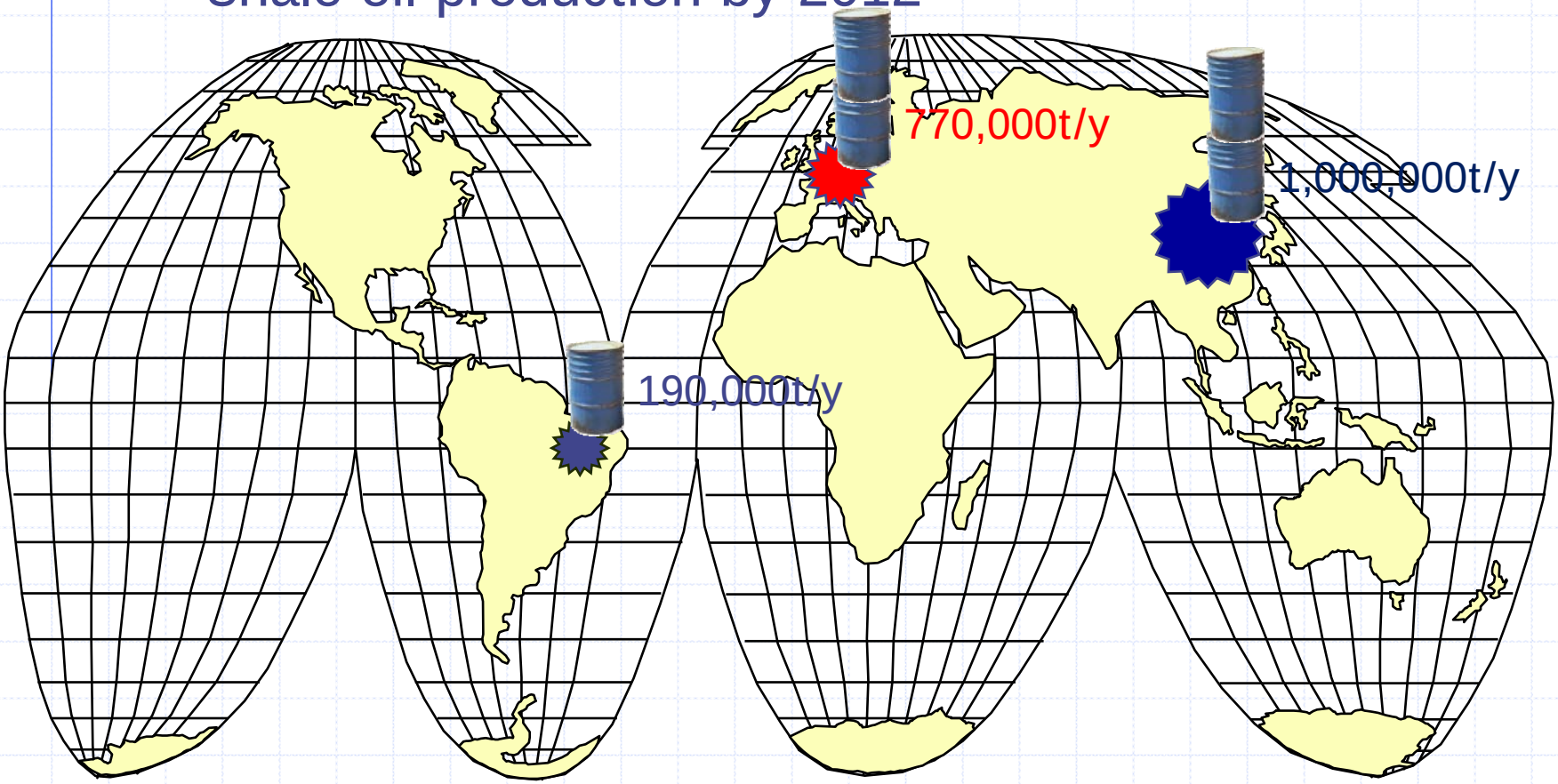
- Why do we do modeling analysis for oil shale processes?
- What kind of models are available ?
  - Refer to Rick's presentation
- What is required to undertake model analysis?
- When do we need oil shale modeling?
- What has PROCOM done in oil shale model development?
  - Some examples of oil shale process models

# Why? background of modeling analysis for oil shale process

- Oil price is likely to stay high;
- Profitable margin for oil shale process is expected at about $30~50/bbl;
- Huge driving force for oil shale development;
- Processes are at varying stages of development but have to be compared;
- How can development be made cost & time effective
  - – lots of modeling
  - + appropriate test work in lab and plant.

# Shale oil production increasing

- Shale oil production by 2012



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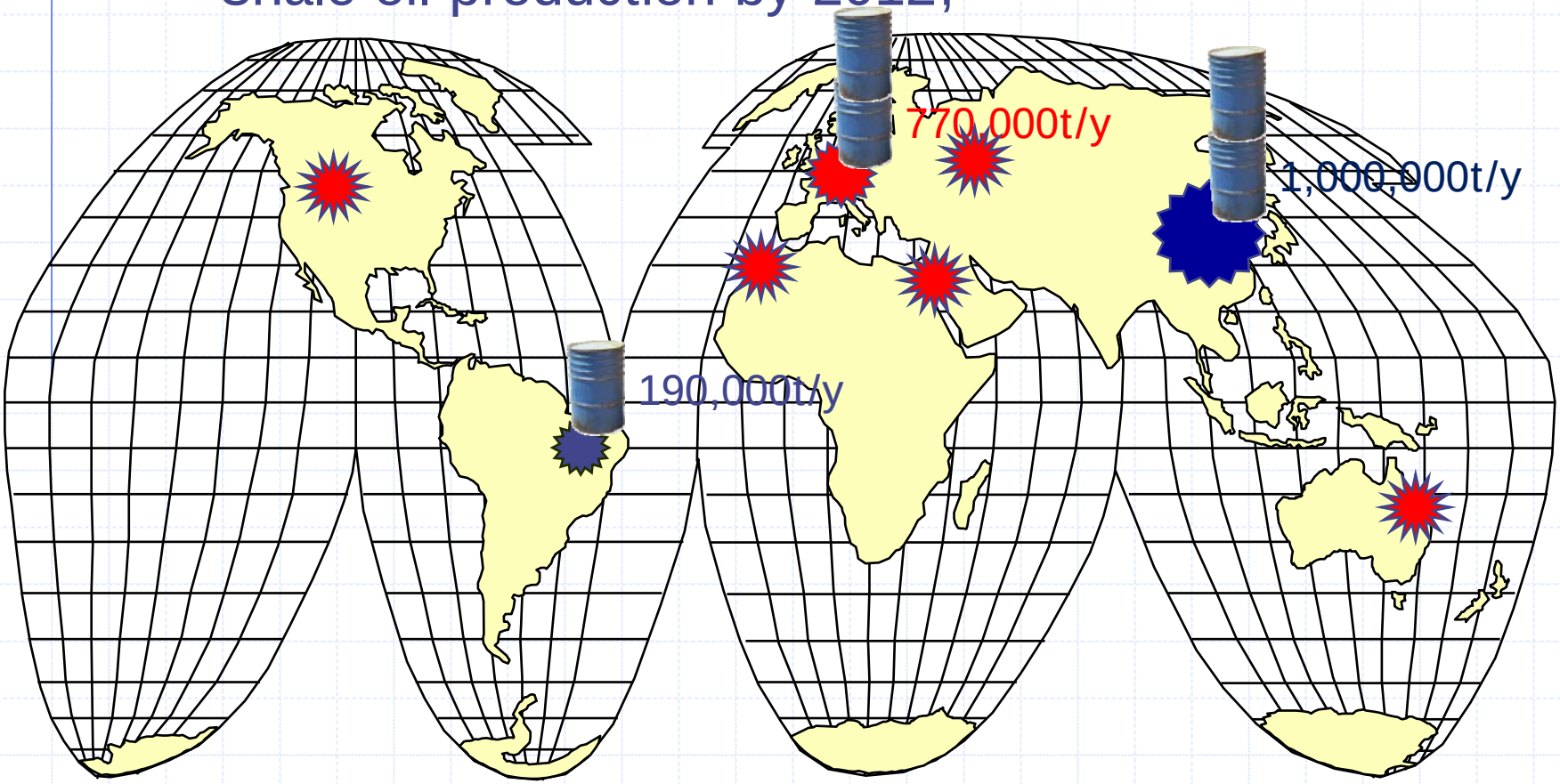
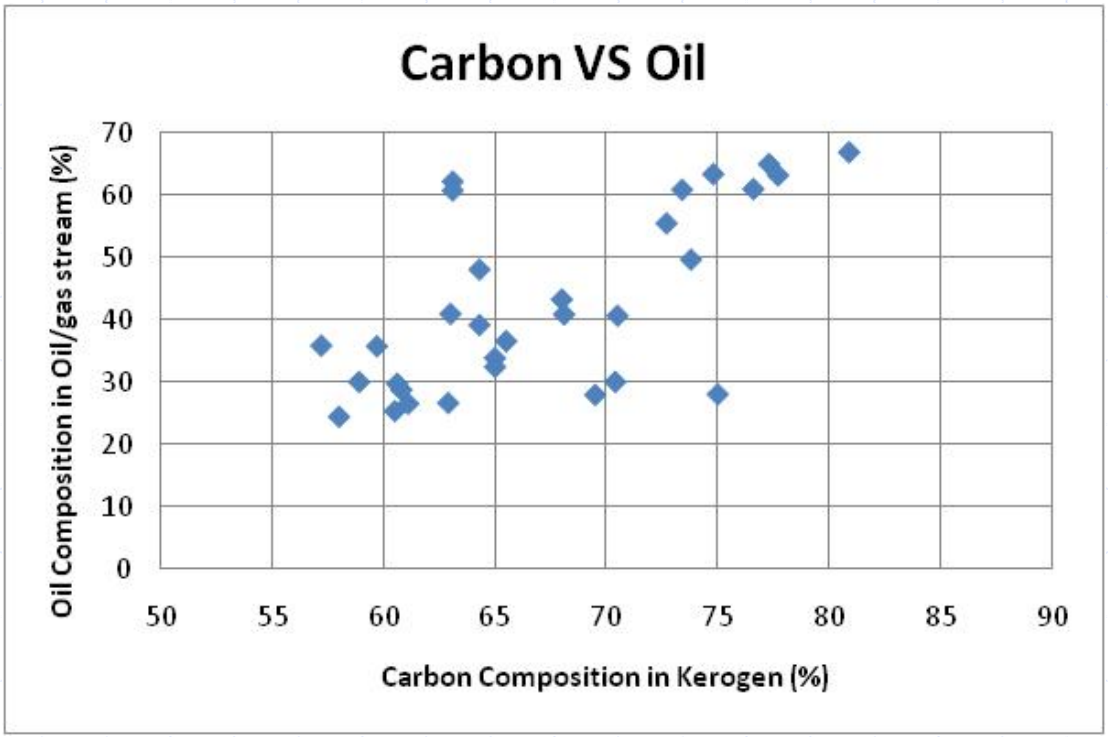


# Complexity of oil shale pyrolysis reaction

- Oil shale chemical and physical properties are different for different oil shale deposits (E. Volkov 1999);



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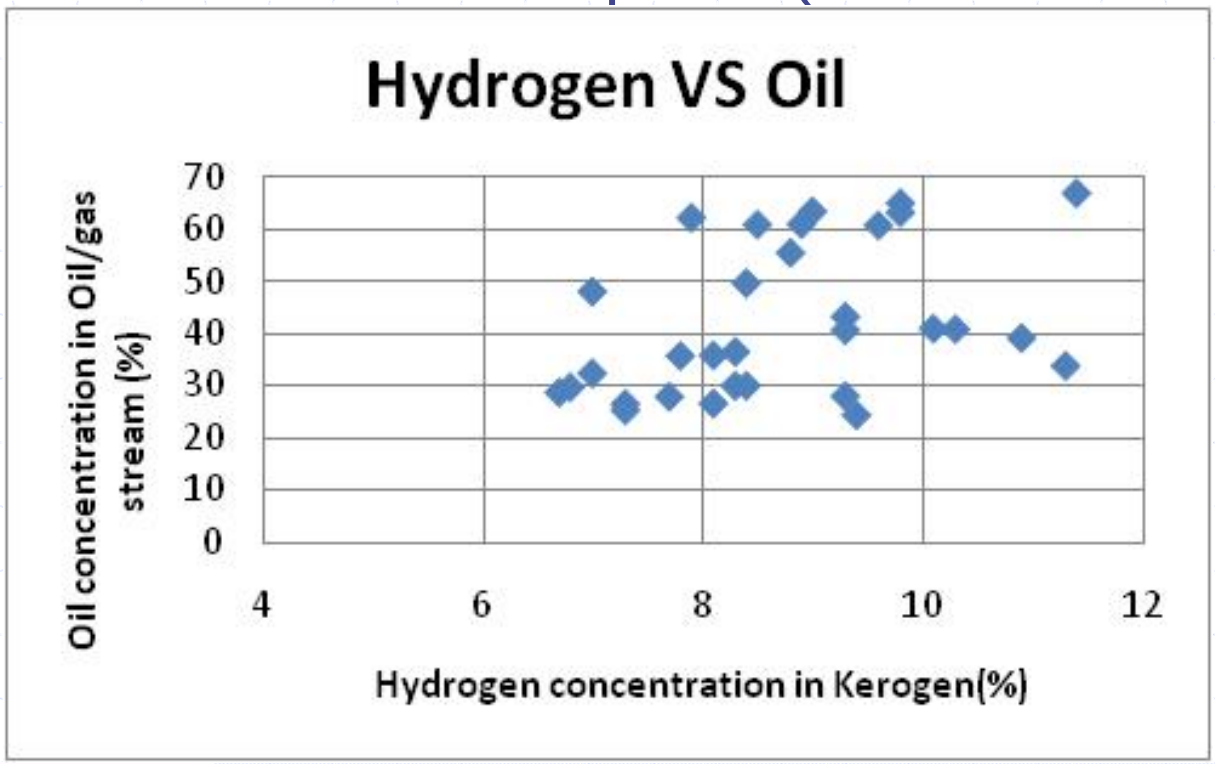


# Modeling analysis in oil shale process selection

- There is no oil shale technology which is capable of handling all oil shale deposit
- Each deposit should be studied individually to develop a suitable process
- Each shale needs a special process
  - Vertical retort (lump shale-gas heat carrier)
  - Rotary kiln retort (fine shale-solid heat carrier)
  - Fluidized bed retort (very fine shale)
  - In-situ conversion process
- Modelling analysis is a powerful tool to help understand your shale and the limit of your technology

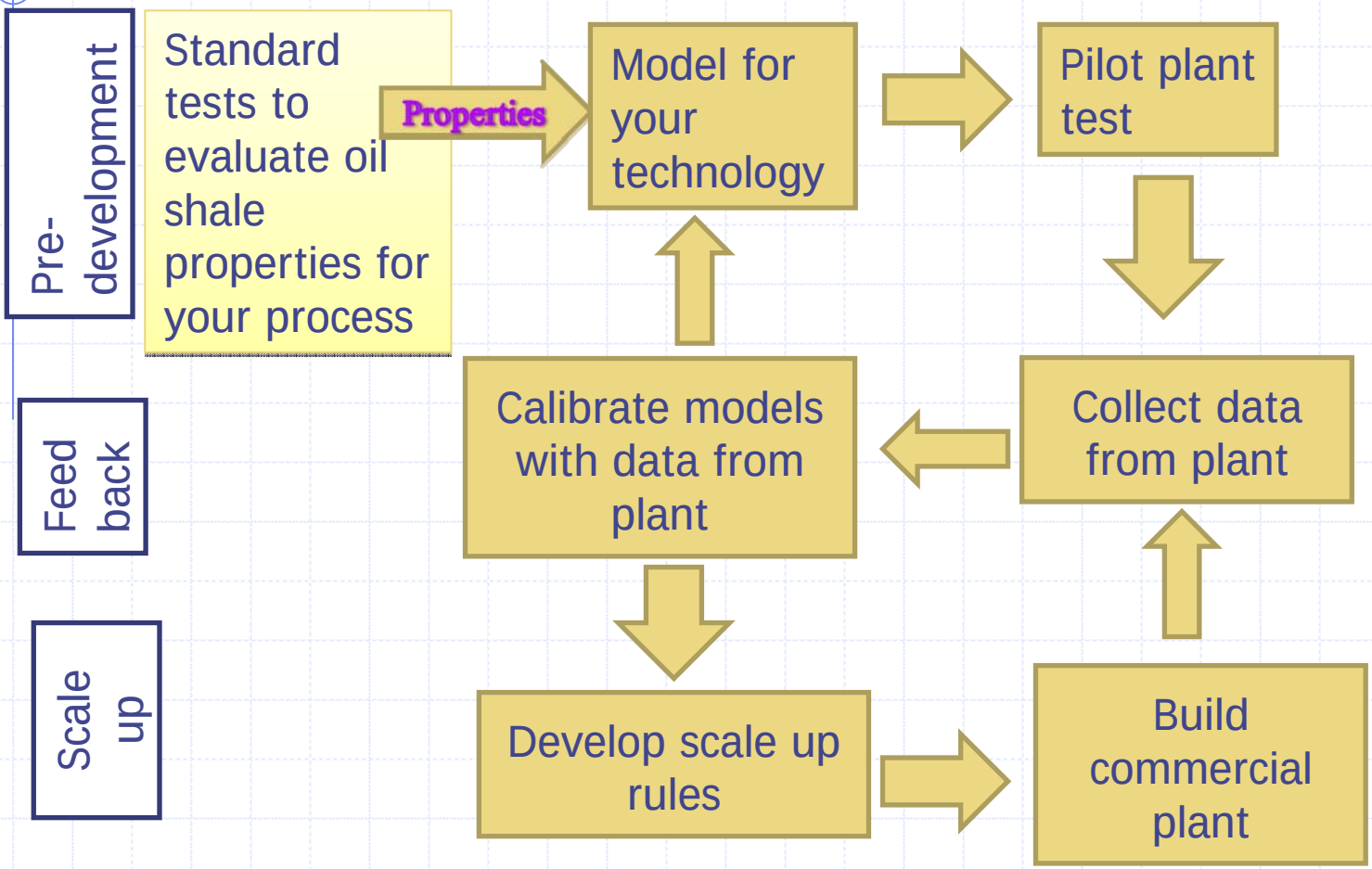
# Who needs oil shale model analysis?

- Oil shale researcher – properties, process selection
- Oil shale developer – technology limit
- Oil shale investor – cost and profit margin
- Oil shale designer – heat & mass balance, equipment sizing
- Oil shale operator – training in process control, trouble-shooting, operation optimization
- PROCOM is capable of developing a model for your shale with knowledge in different process technologies and understanding of various oil shale properties and limits of most technologies

# When do we need oil shale modeling?

- Feasibility study stage
  - What do we need to know about the shale resource?
  - What kind of tests should be done?
- Design stage
  - Thermal and mass balance analysis
  - Equipment sizing
  - Process optimization
- Operation stage
  - Operator training
  - Process trouble shooting
  - Process performance analysis

# When do we need oil shale models?



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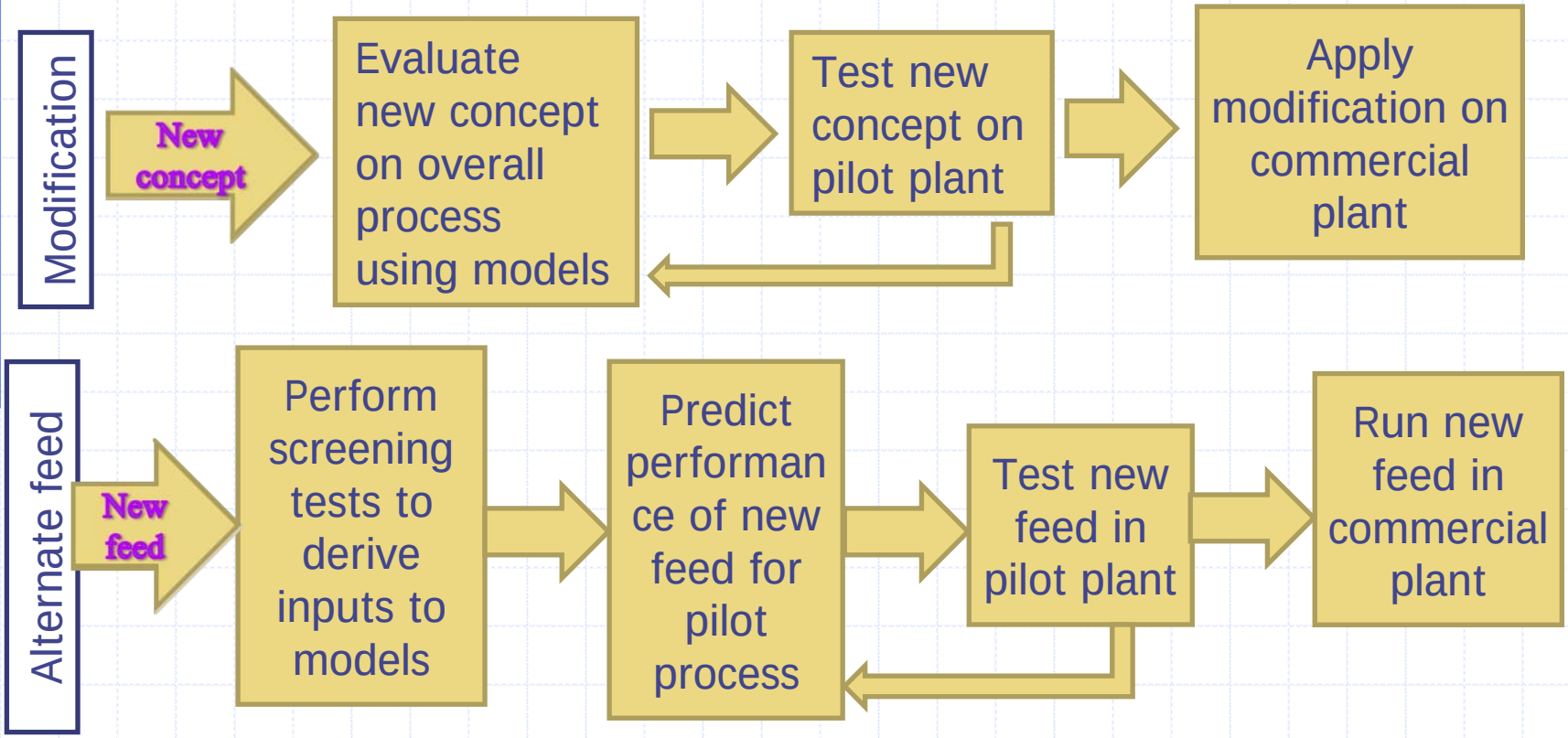
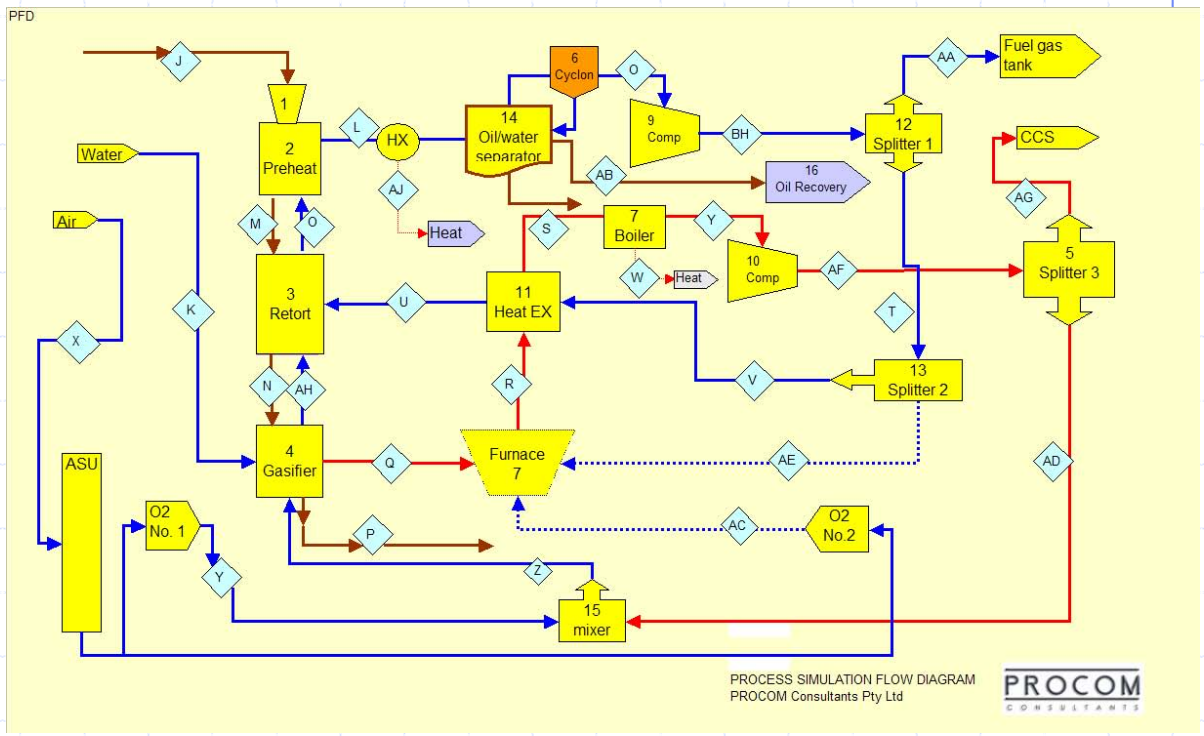


# What we have done in oil shale model development?

- Developed a flexible Excel Spreadsheet model for different technologies:
  - Ability to simulate rotary and vertical retort process
  - Thermal property package for some oil shale resources
- Established model for three different oil shale deposits using rotary and vertical retort model;
- Integrated oil shale property package with other commercial programs such as ASPEN Plus.

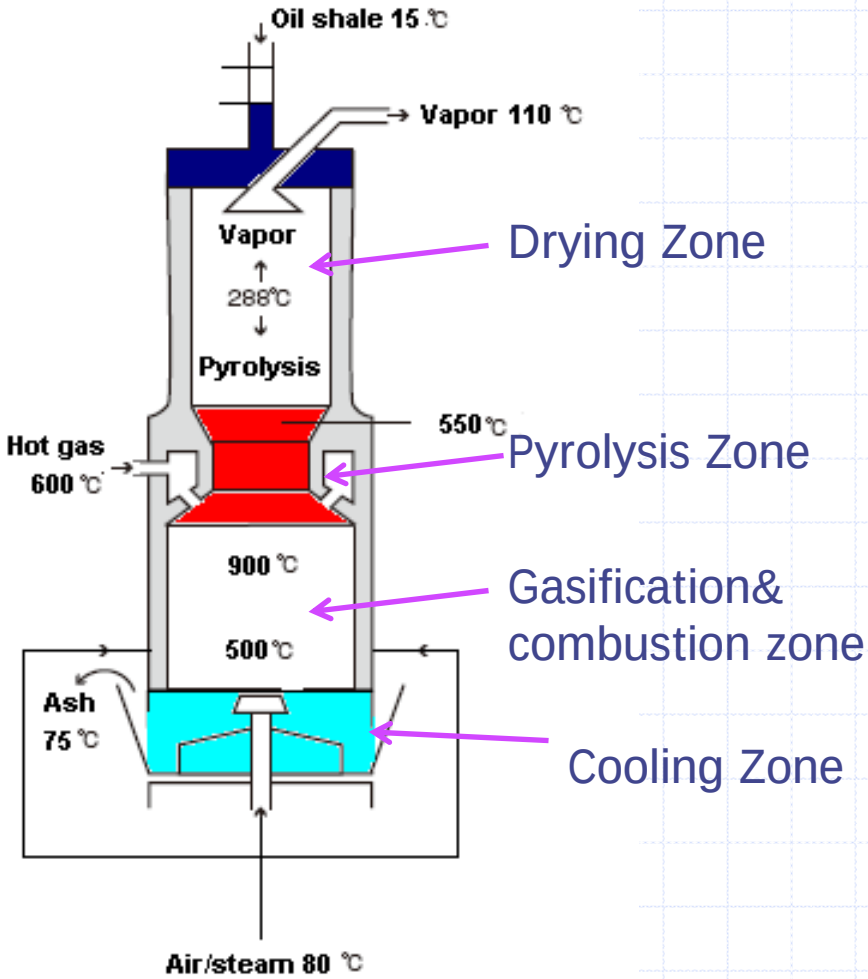
# What's done - Oxygen combustion retort & $CO_2$ capture

- Developed oil shale process simulator for current conventional vertical lump retort;
- Shale from two deposits analyzed on economic performance
- (J.Jia 2007 OSS)

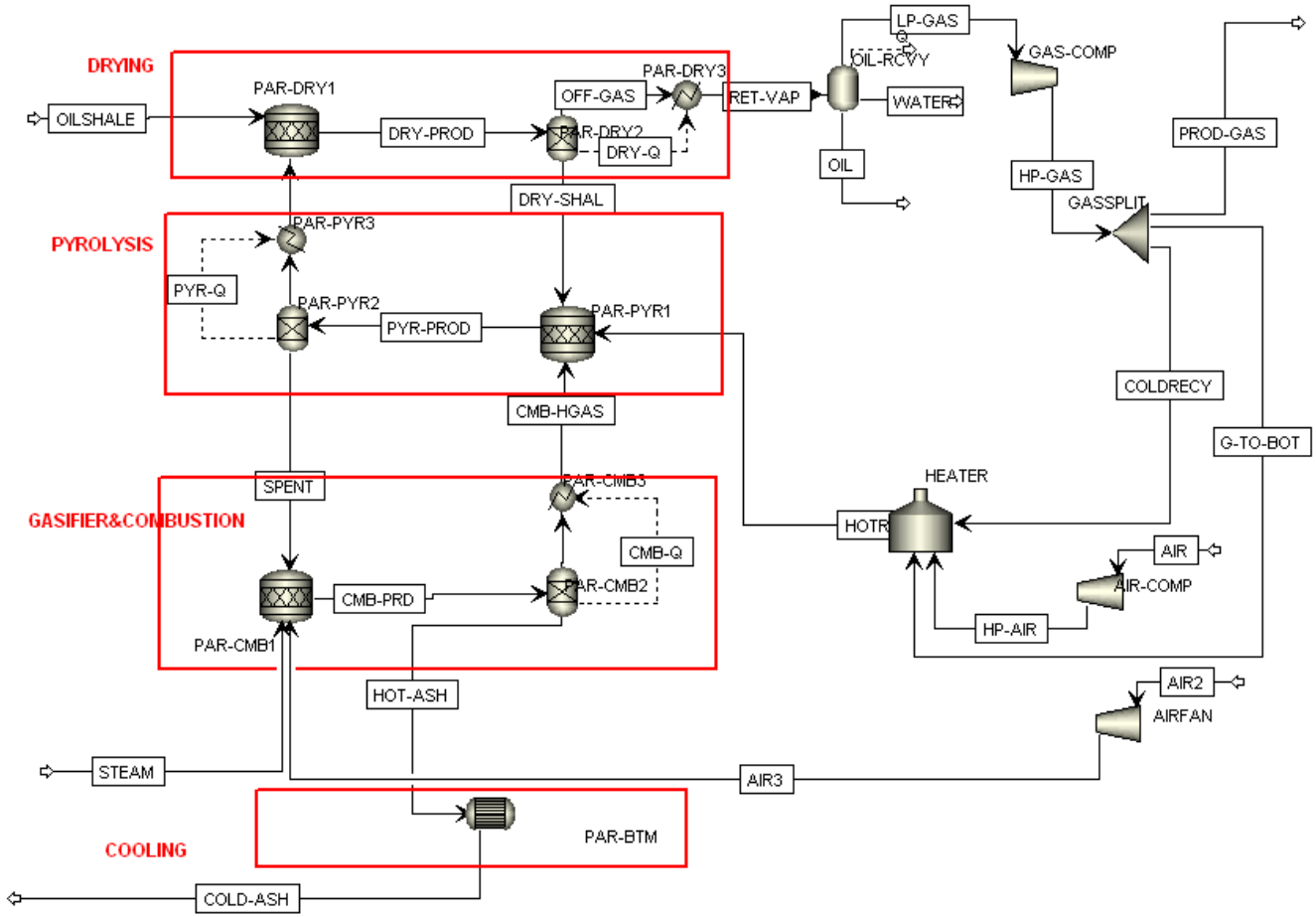


# Shaft kiln gasification/combustion retort model and pilot test

- Design of the pilot gasification/combustion retort (FMG China)
- Simple and reliable operation performance
- Capacity of handling 1 t/hour
- Commercial plant produced 370,000 tons of shale oil last year



# ASPEN model for gasification & combustion retort pilot



# Modeling initial result versus pilot test

**Fuel Gas Comparison**

| Component | ASPEN Model (%mol dry) | Plant data (%mol dry) |
|---|---|---|
| H2 (v%) | 12.20 | 11.3~16.5 |
| CO | 7.25 | 2.2~4.0 |
| Hydrocarbon | 8.20 | 2.0~4.2 |
| CO2 | 8.36 | 17.6~20.2 |
| O2 | 0.23 | 0.2~1.0 |
| N2 | 63.77 | 58.5~64.9 |
| H2S(ppm) | 0.00 | 5200~7800 |
| **Total** | 100.00 | |

# Modelling initial result Versus Pilot test

**Product Comparison**

| Item | ASPEN Model (kg/h) | Plant data (kg/h) |
|---|---|---|
| Oil | 23.70 | 21.17~28.12 |
| Gas (NCM/H) | 96.46 | 10~46 |
| Retort water | 31.48 | 46.31~119.09 |
| Ash | 509.98 | 463.13~529.3 |

# Commercial plant of gasification/combustion retort

- Commercial plant capable of producing 370,000 t/year shale oil
- 20 retorts are grouped together with common feed and oil/gas recovery system
- Each retort can be isolated in case of operation upset

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# Conclusions

- Modeling analysis is important throughout the feasibility study, process design, pilot test, commercial plant scale up, and plant performance improvement .....
- The current model can be adapted for different types of oil shale if oil shale property data is available;
- The model is a helpful tool in operator training and process control training;
- Modeling analysis experience for different technologies will minimize project risk and bring huge cost and time saving in project development.