Single-Well SAGD: Overcoming Permeable Lean Zones and Barriers

Grant Hocking[1], Travis Cavender[2] & John Person[2]

[1]GeoSierra [2]Halliburton

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Thermal Enhanced Bitumen Recovery

Conventional SAGD

- Reduced Steam Pressure
  - Shallow depth, Caprock integrity, Outcrop proximity
- Geological Issues
  - Vertical Perm, Shale barriers, Lean zones

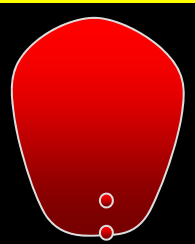
Conventional CSS

- Geological Issues
  - Bottom water, Caprock integrity, Top gas

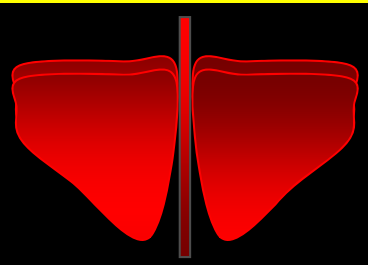
Single-Well SAGD

- Engineer around Geology
  - High permeable propped vertical planes
  - Operate in SAGD mode

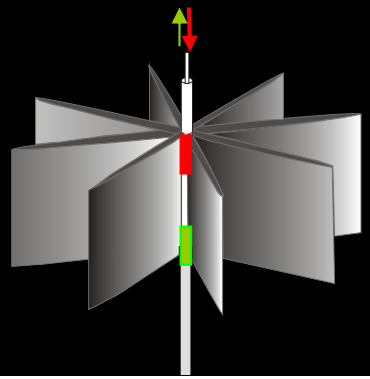
Conventional SAGD



Conventional CSS



Single-Well SAGD



Weakly Cemented Formations

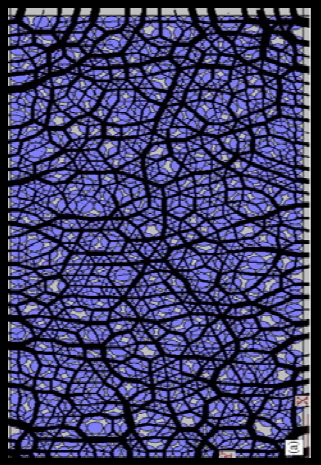
Hydraulic Fracturing

- Conventional
  - Strong, Hard Rocks – Brittle Fracture
- Frac & Pack
  - Weak, Soft Sediments – Ductile Process

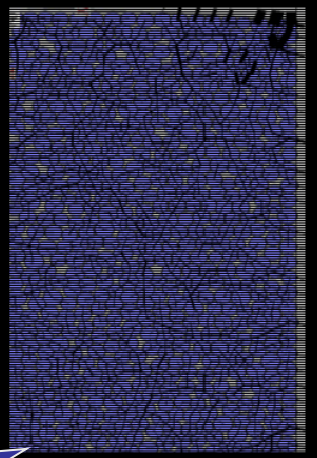
Weakly Cemented Formations

- Minimal Cementation, Soft & Weak
- Stress State
  - Force Chains Fragile
    - Easily Destroyed
    - Minor Vibration or Shearing
    - Grain Contact Dissolution
    - Over-Pressurization
  - Minimal Formation Stress Contrast
    - Stress Contrast can not be maintained over geological time
- Constitutive Behavior
  - Ductile Frictional Behavior
  - Anelastic

Isotropic Compression
Force Chains Shown



Force Chains Destroyed



Minor Shear Strain Destroys Force Chains

Early Field Trials of Azimuth Control

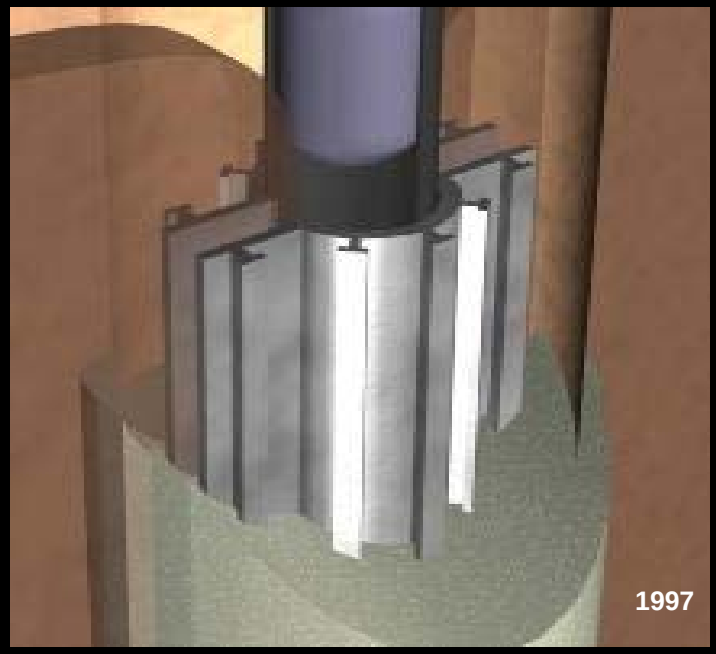
Azimuth Control Initiation Devices

Single Azimuth Tools

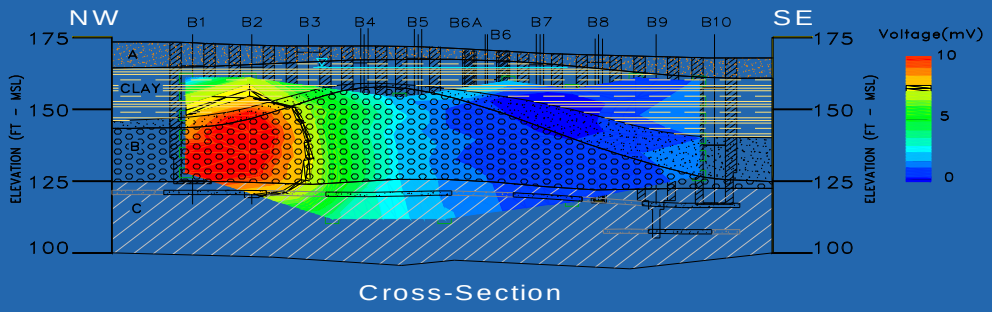
Prototype

1st Generation

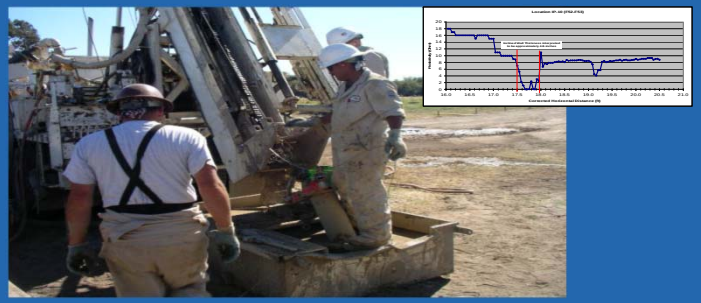
2nd Generation



Azimuth Control Iron Propped Planes

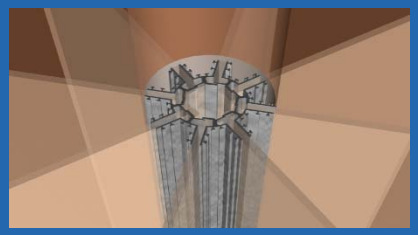


Cross-Section



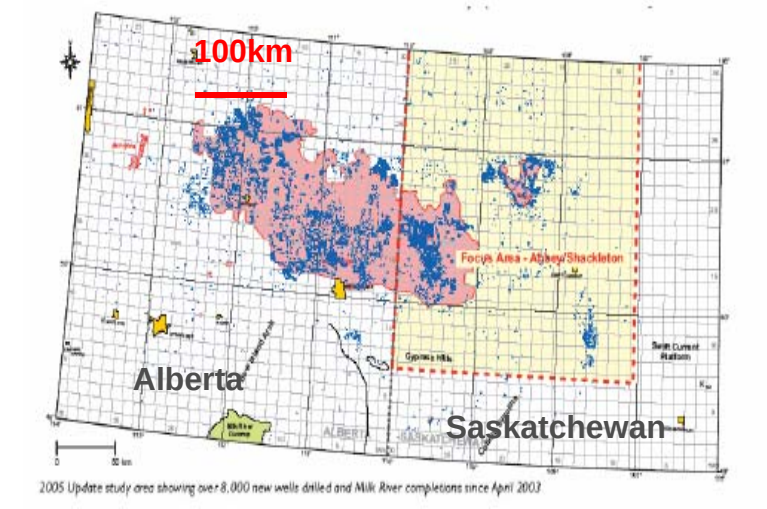
Multi-Azimuth Vertical Planes

Each individual Plane Initiated & Propagated by Dedicated Tubing

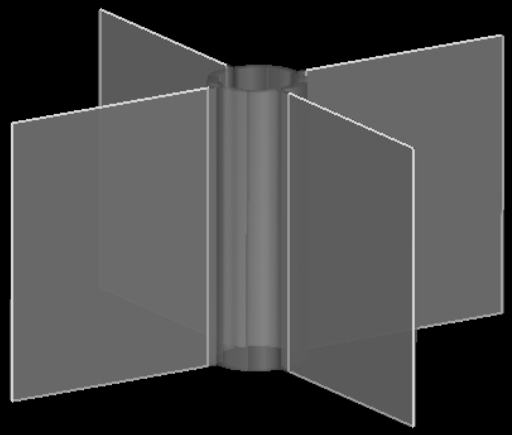


Diametrically Opposite Cavities are Dilated to Initiate Azimuth Controlled Vertical Planes

Milk River Tight Gas Field Trials

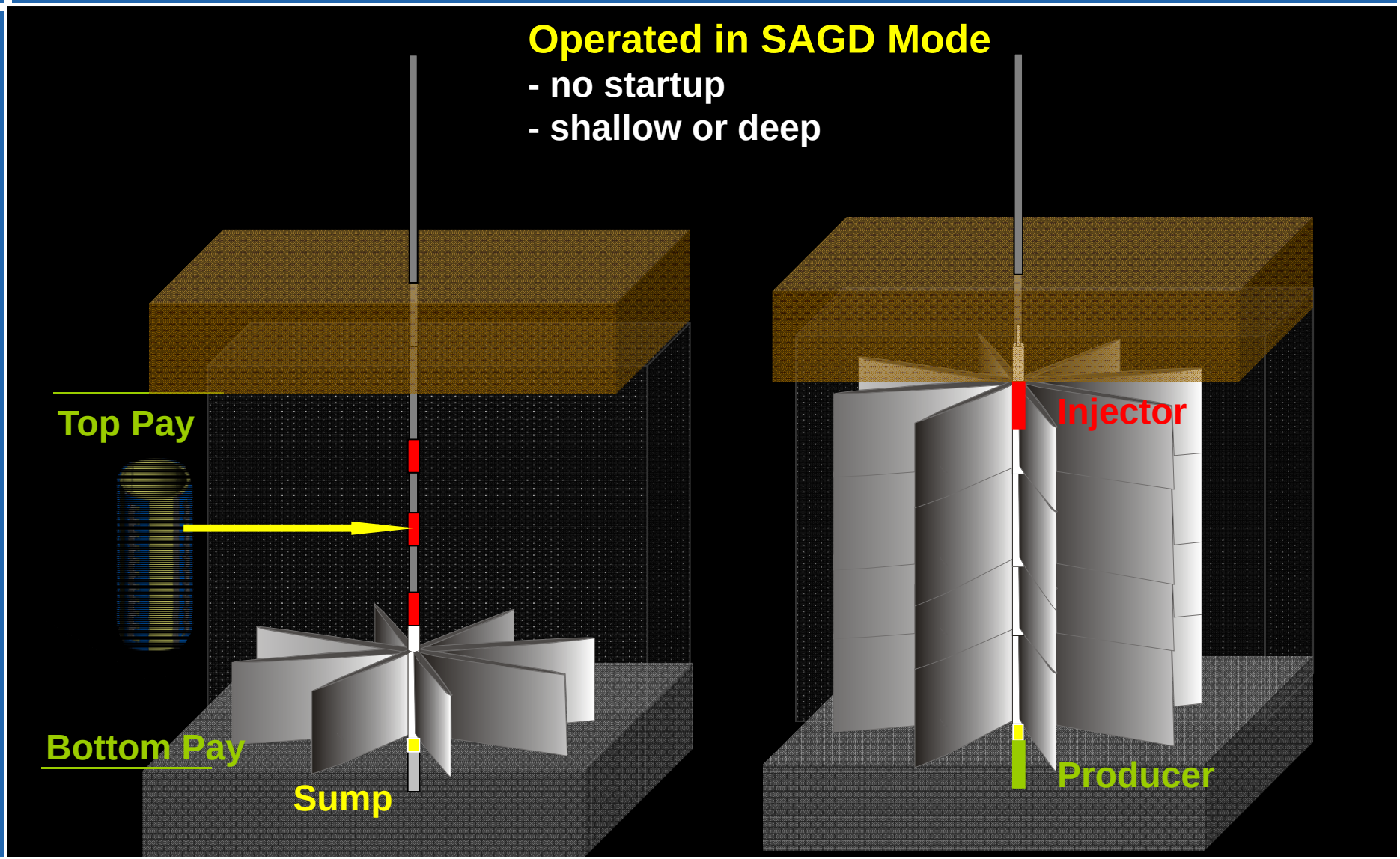


Four (4) propped wings

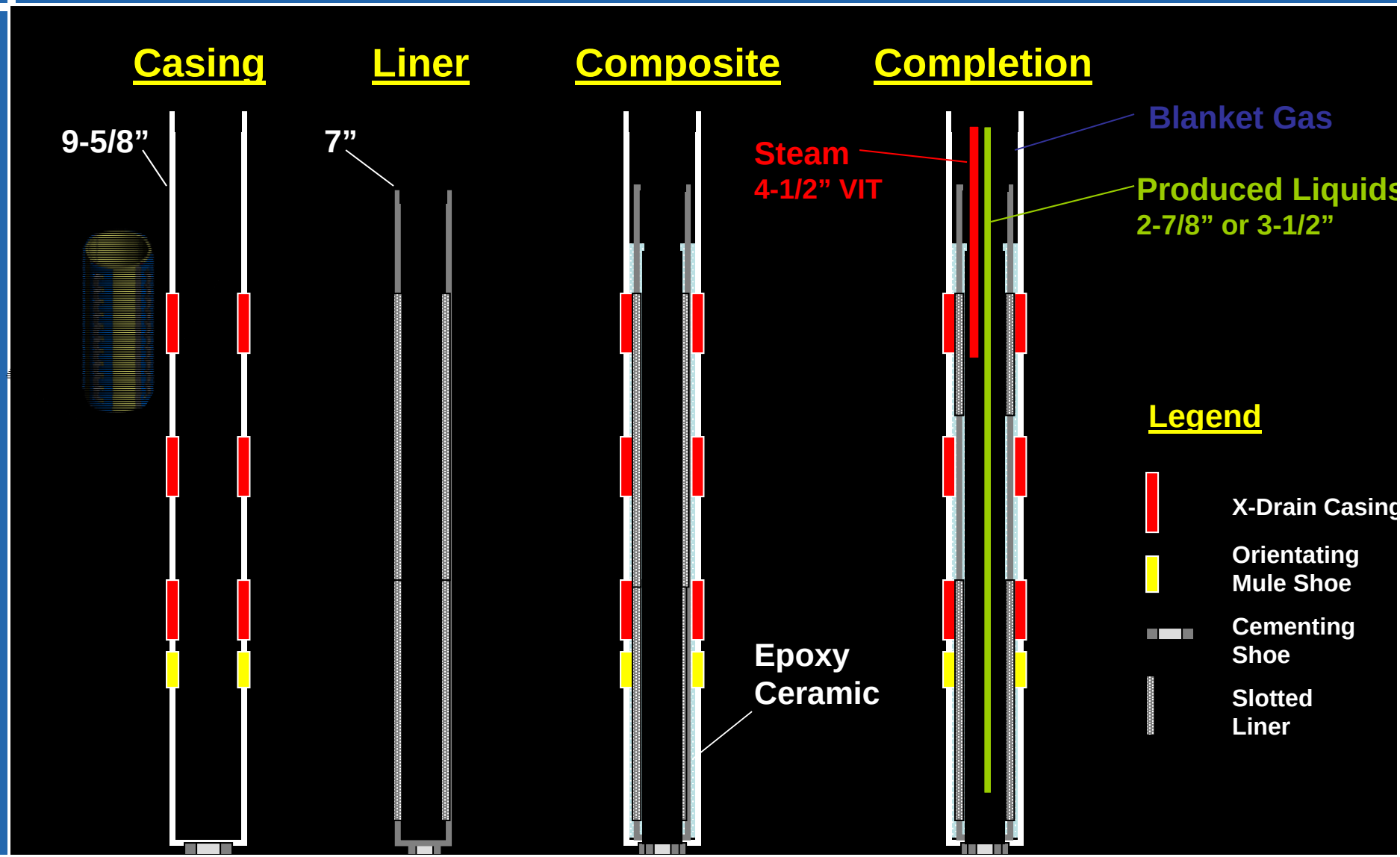


4-1/2” J55 Casing

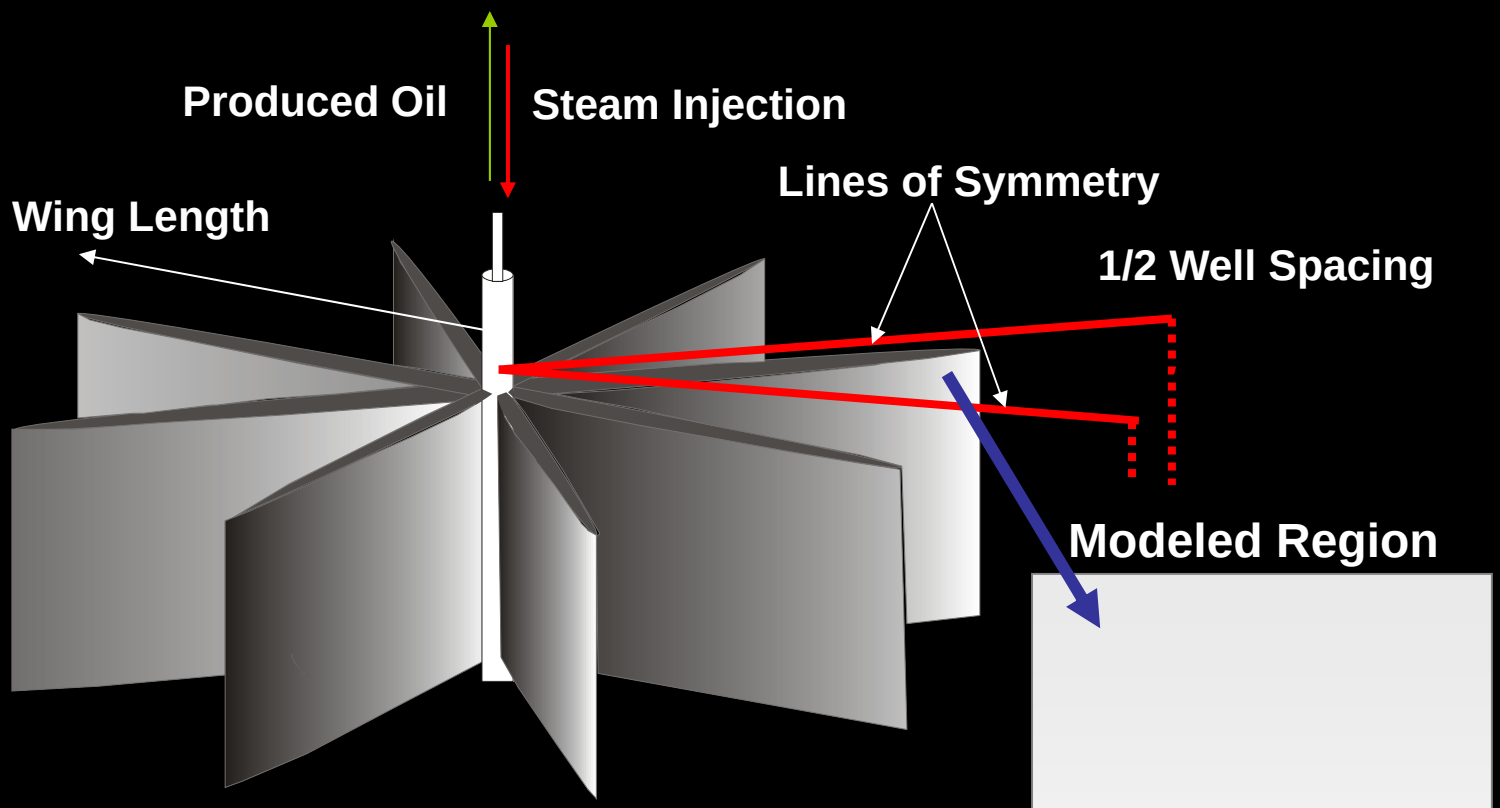
Single-Well SAGD System



Single-Well SAGD Completion

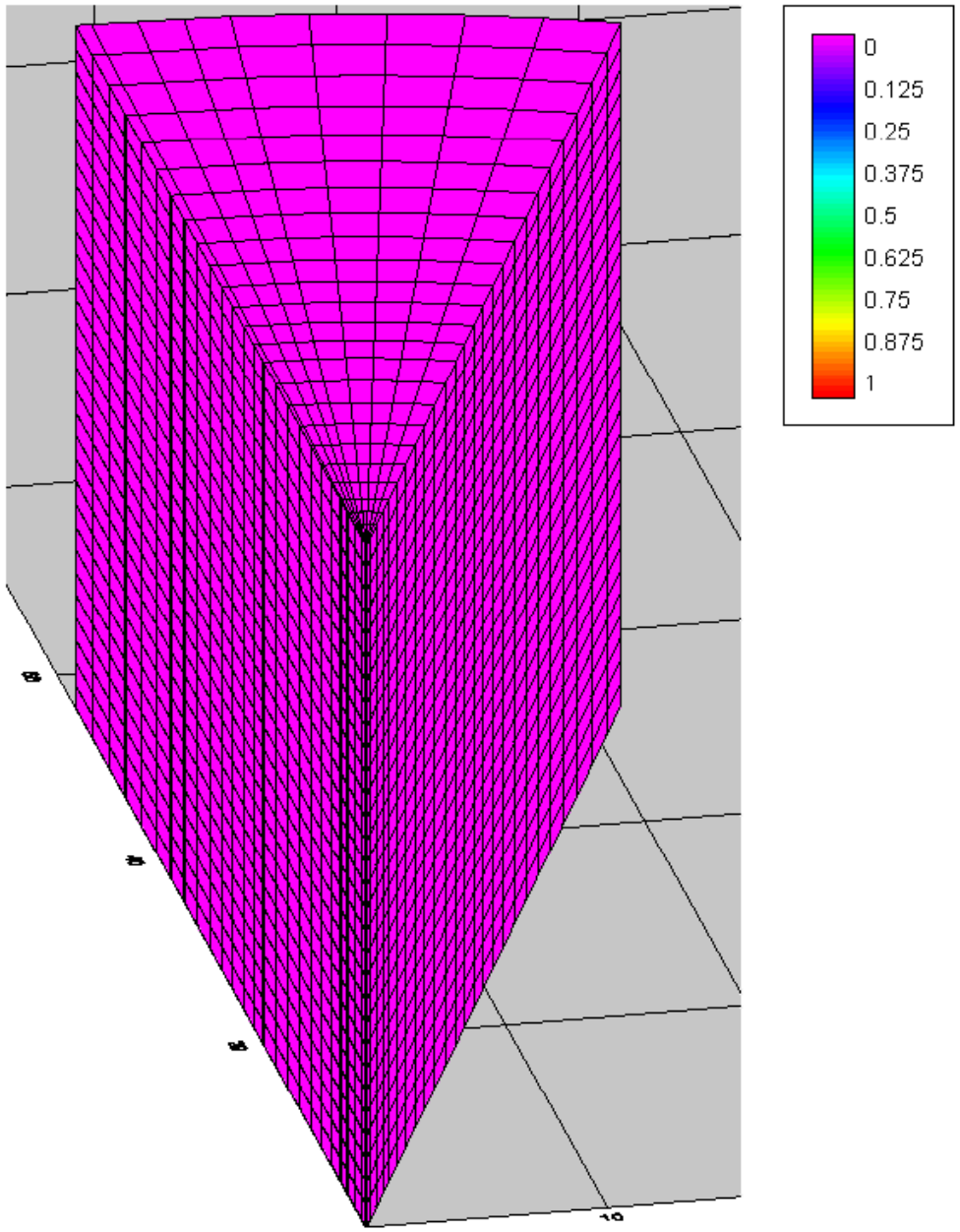


Thermal Simulation Model Idealization



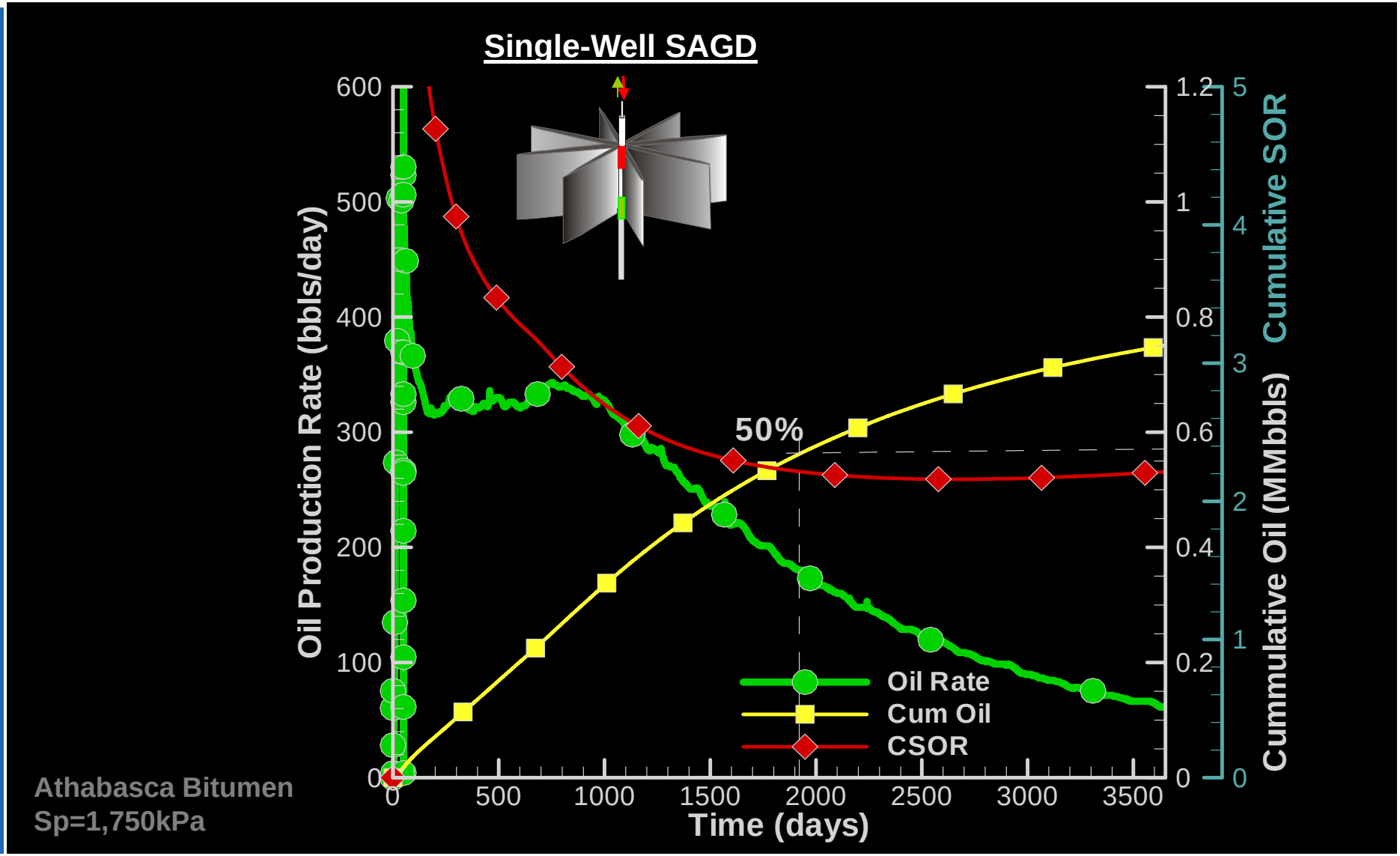
TRS-Thermal Simulator
Athabasca Bitumen
Sp=1,750kPa and 1,200kPa

Gas saturation (vpp_22.5deg_1200_50_56)

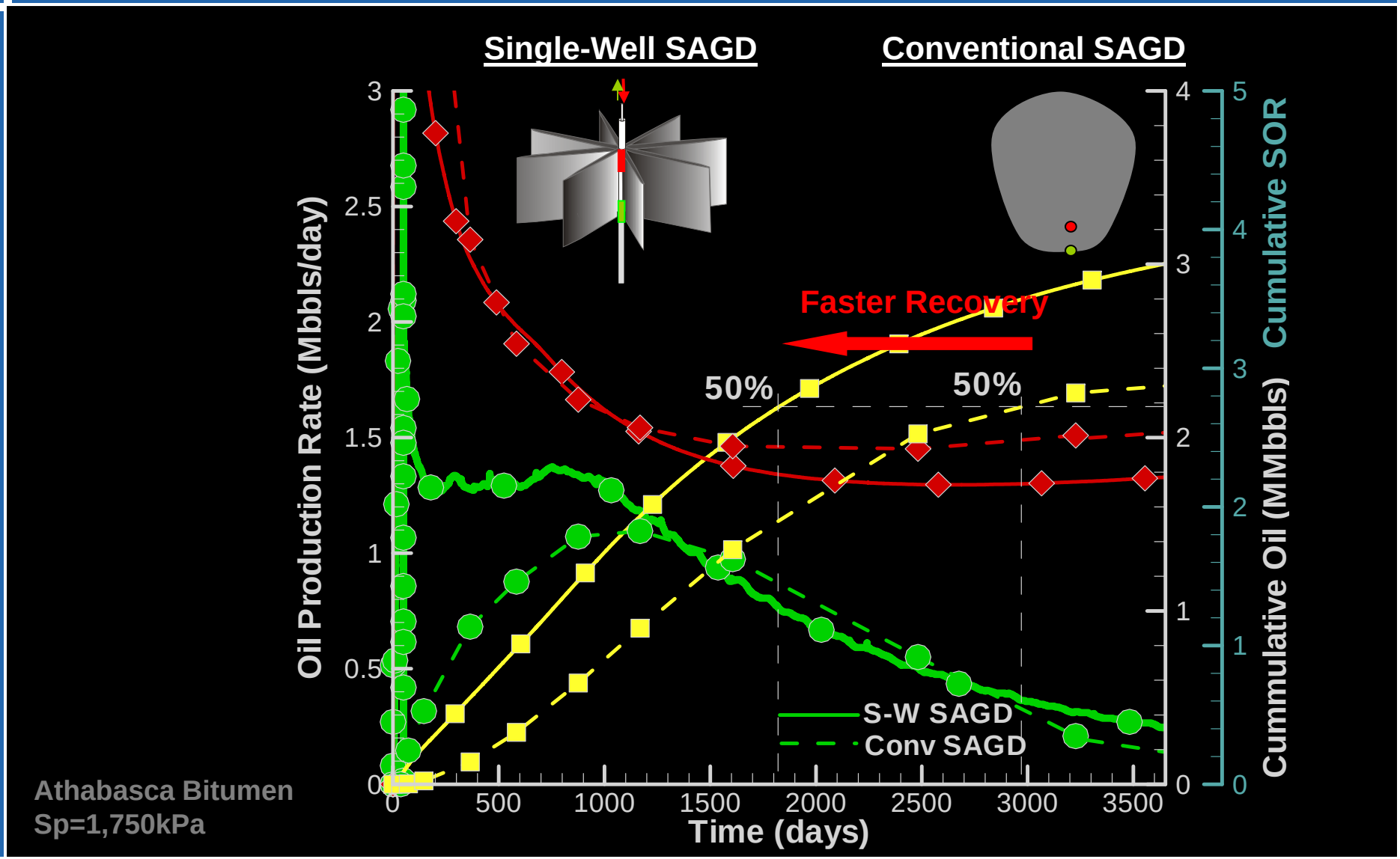


Athabasca Bitumen
Sp=1,750kPa

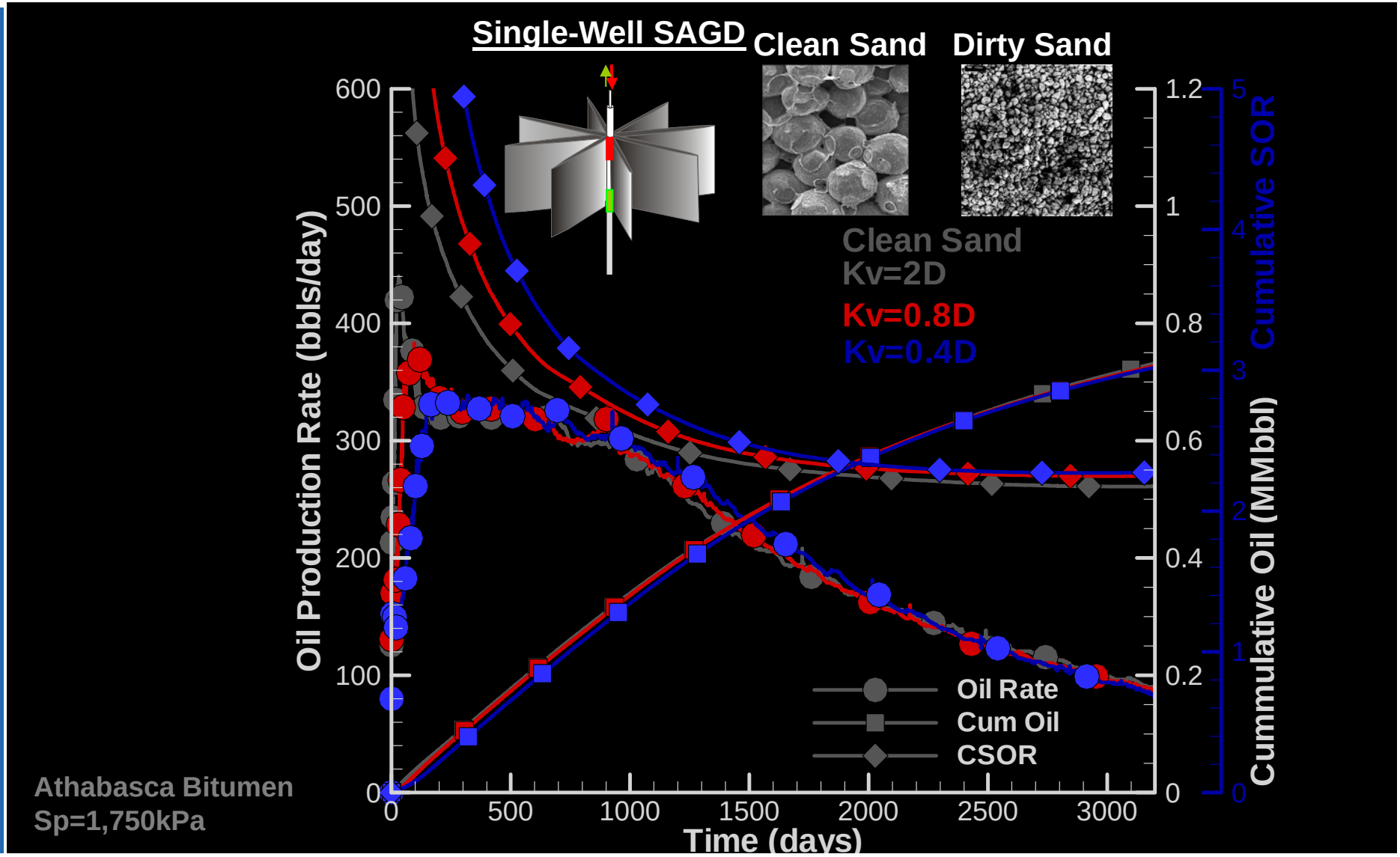
Single-Well SAGD in Channel Sand



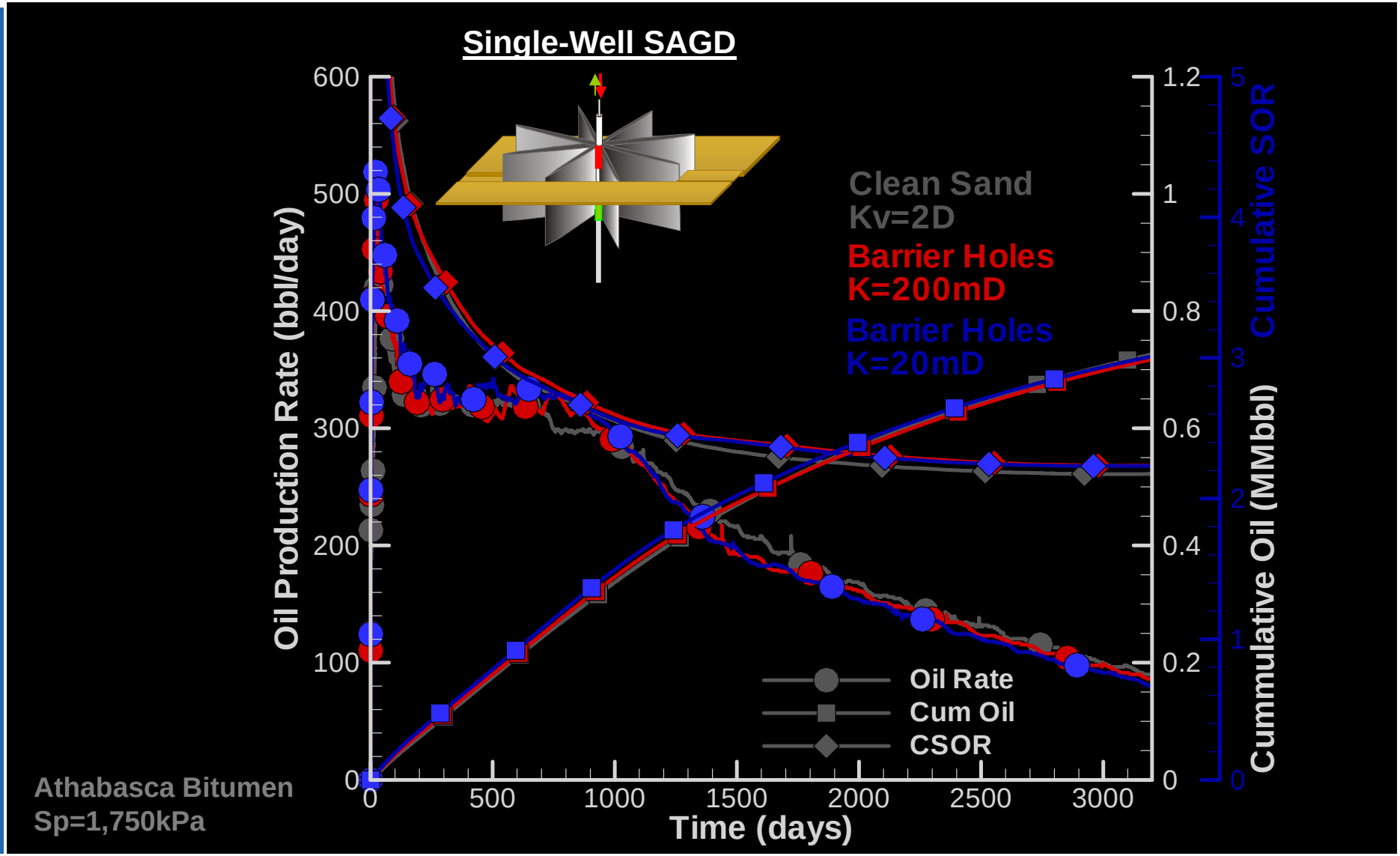
4x Single-Well vs Conventional SAGD



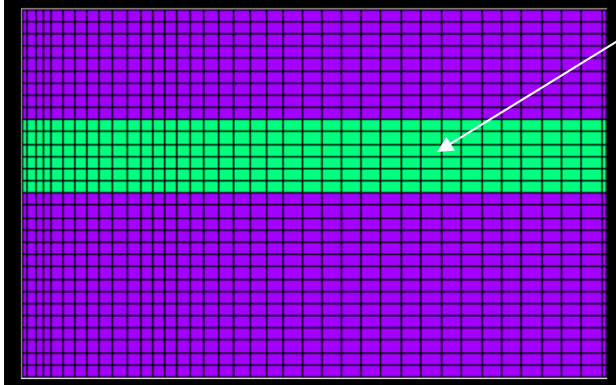
Single-Well SAGD Clean-Dirty Sands



Single-Well SAGD Shale Barrier

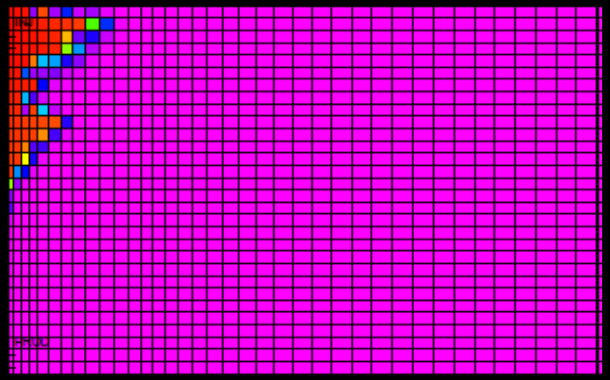


Permeable Lean Zone

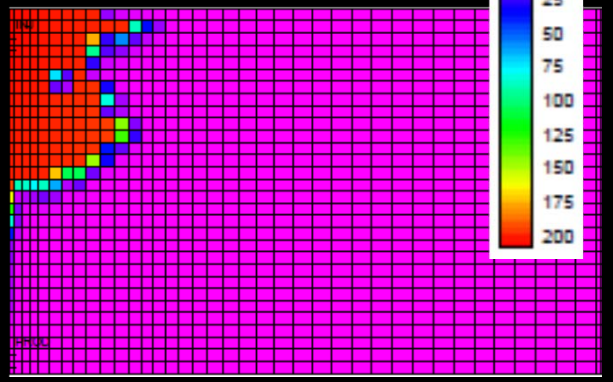


Permeable lean zone

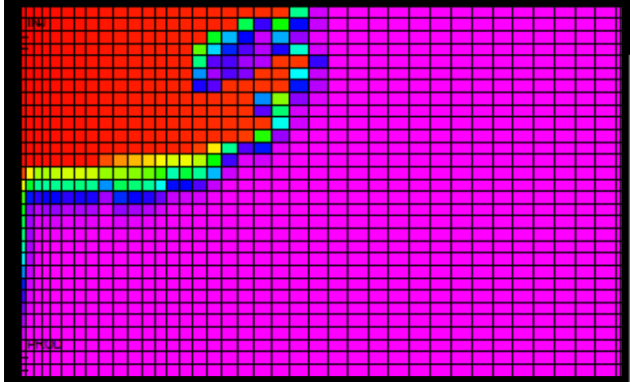
Water Saturation



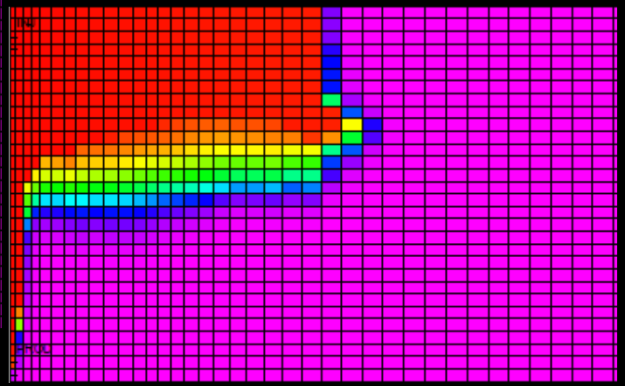
Temperature 0.1day



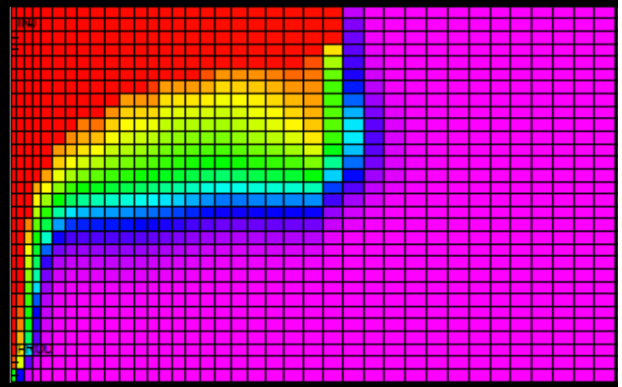
Temperature 1day



Temperature 6days

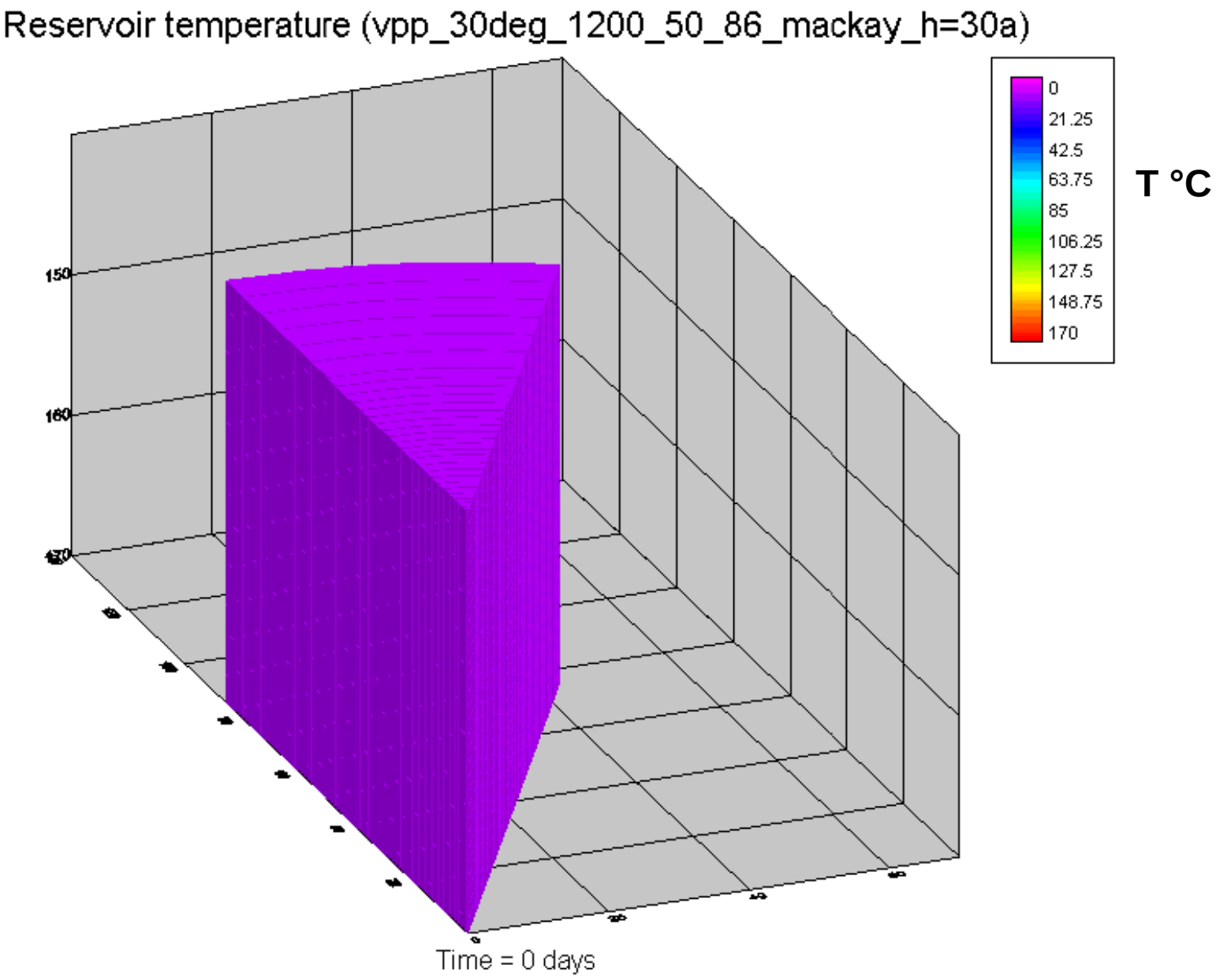


Temperature 30days



Temperature 90days

Athabasca Bitumen
Sp=1,200kPa



Athabasca Bitumen
Sp=1,200kPa

Conclusions

- **Process not depth limited**
- **Reservoir simulations indicate performance almost invariant of geology**
- **As built issues**
  - Skin between coalesced vertical planes
  - Permeability of planes needs to be high
    - In placed permeability
    - Maintain permeability over time
  - Steaming trials required to quantify issues

Acknowledgements
Dale Walters, Taurus Reservoir Solutions for reservoir simulations
Suncor, for access & field support of Milk River trials