

SPE165433

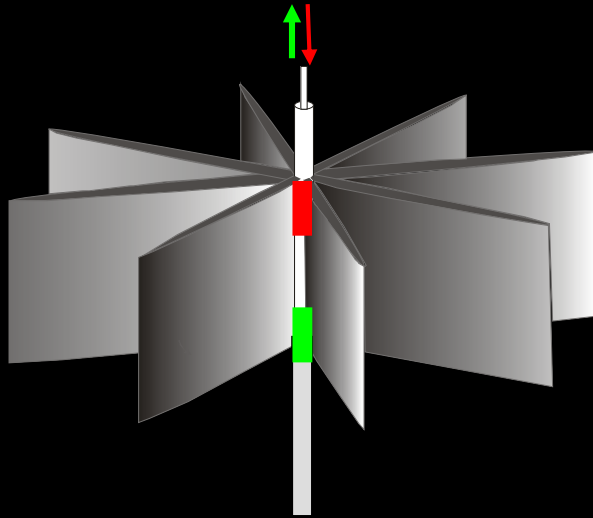
Vertical Single-Well SAGD with Multiple Producers

Grant Hocking¹ and Dale Walters²

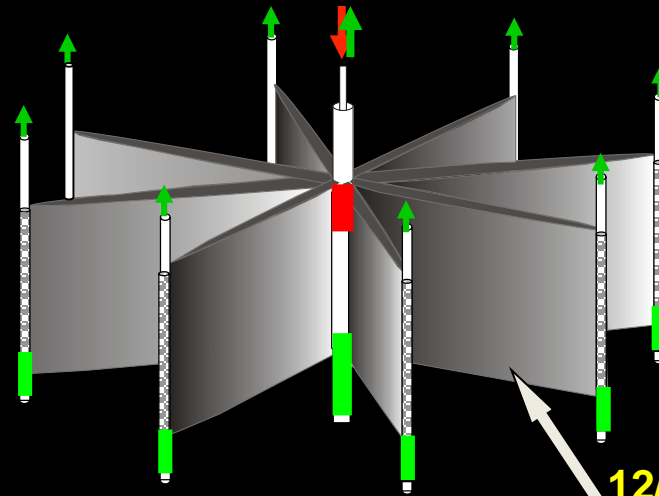
¹GeoSierra, ²Taurus Reservoir Solutions

Frac Enhanced SAGD

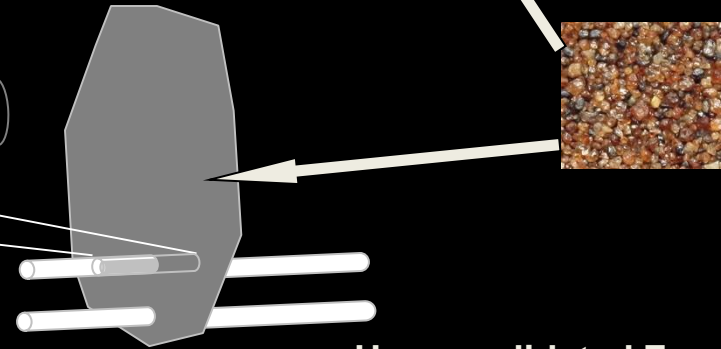
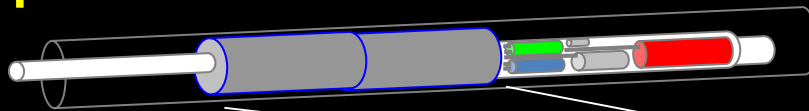
Single-Well SAGD



Single-Well SAGD with Multiple Producers



Hz open-hole stimulation



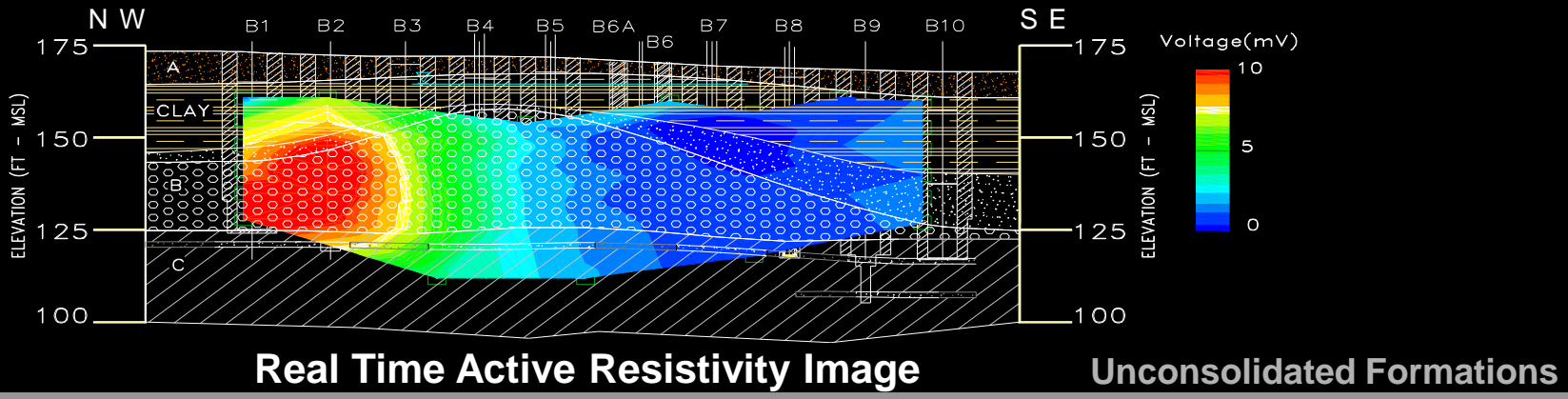
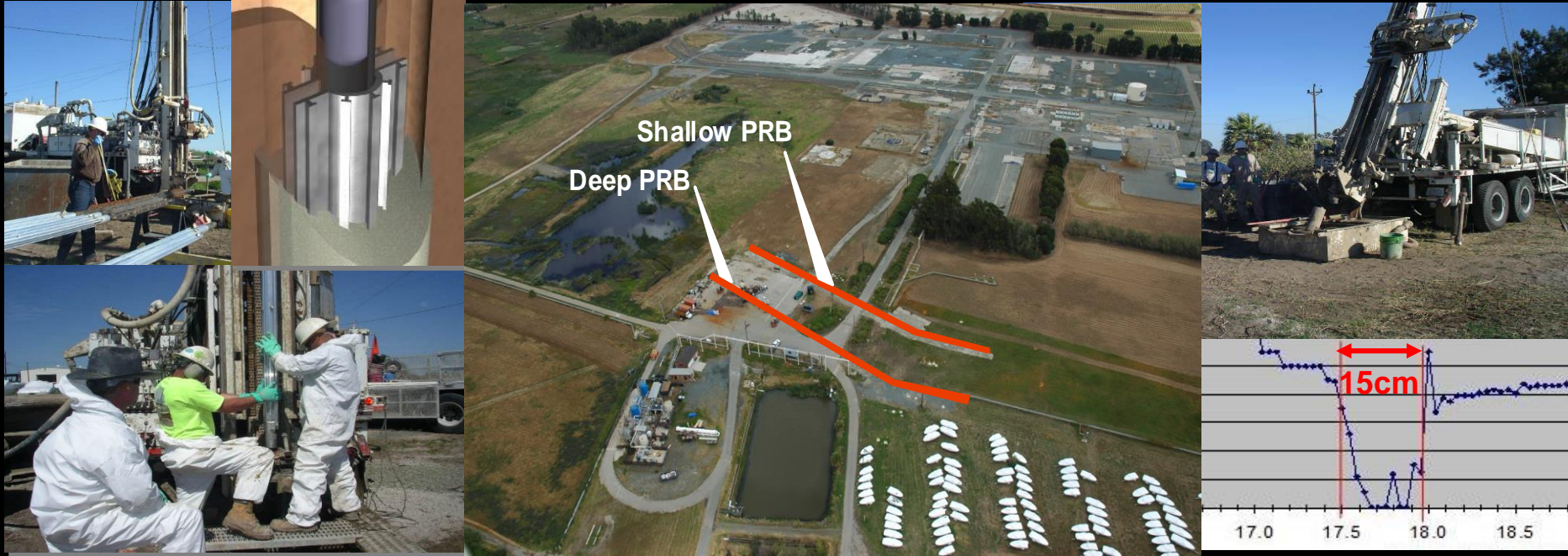
12/20 Garnet

Unconsolidated Formations

Azimuth Controlled Fracturing



Azimuth Controlled Fracturing

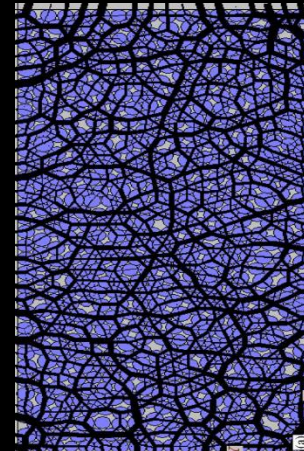


Non-Brittle Weak Formations

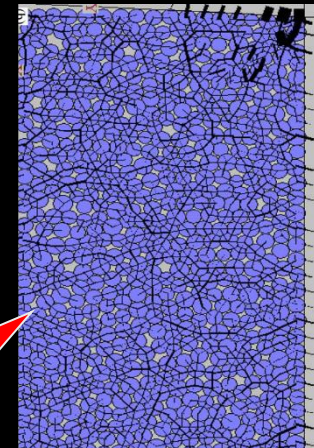
Weakly Cemented Formations

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

Isotropic Compression
Force Chains Shown



Force Chains
Destroyed

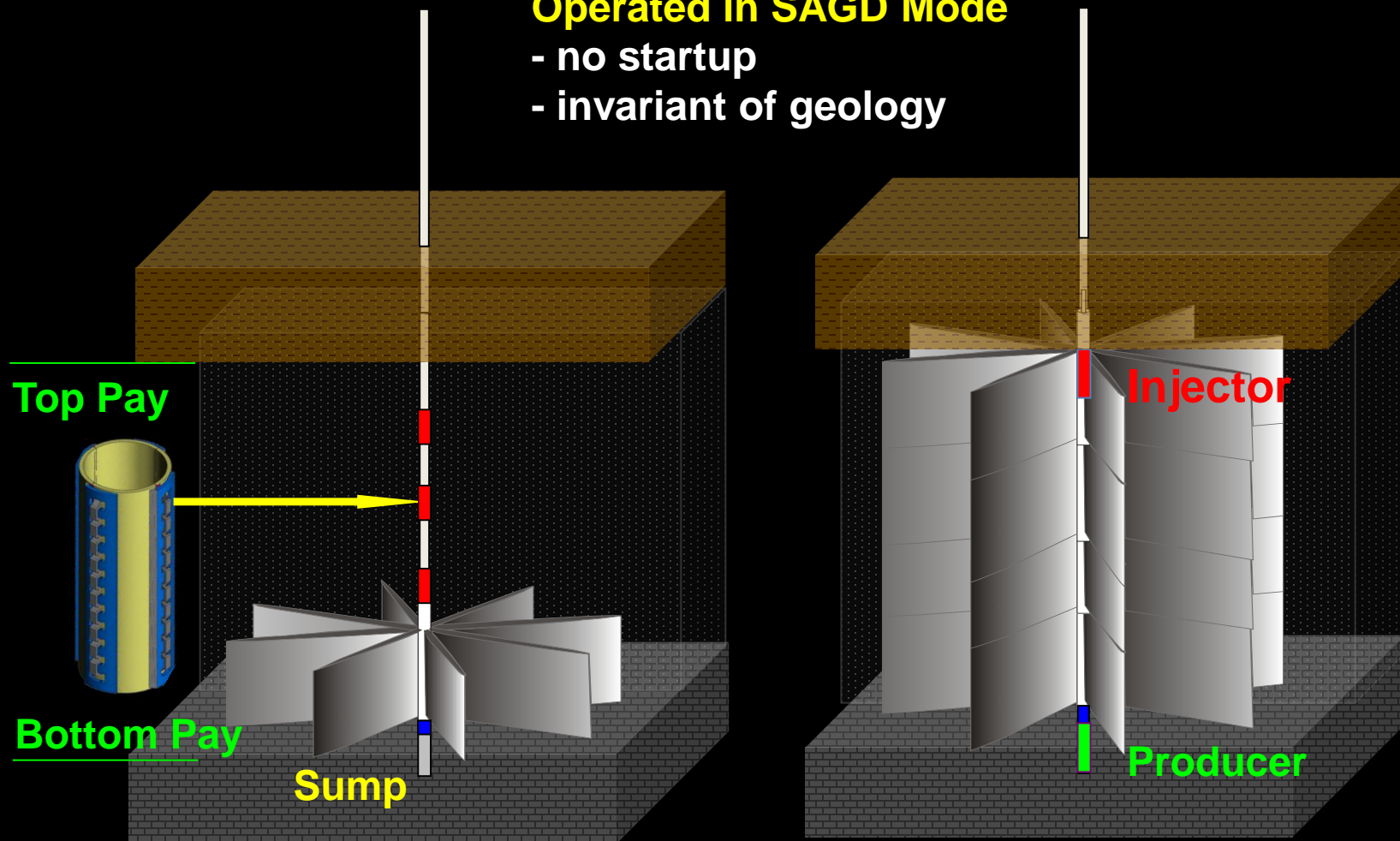


Minor Shear Strain
Destroys Force Chains

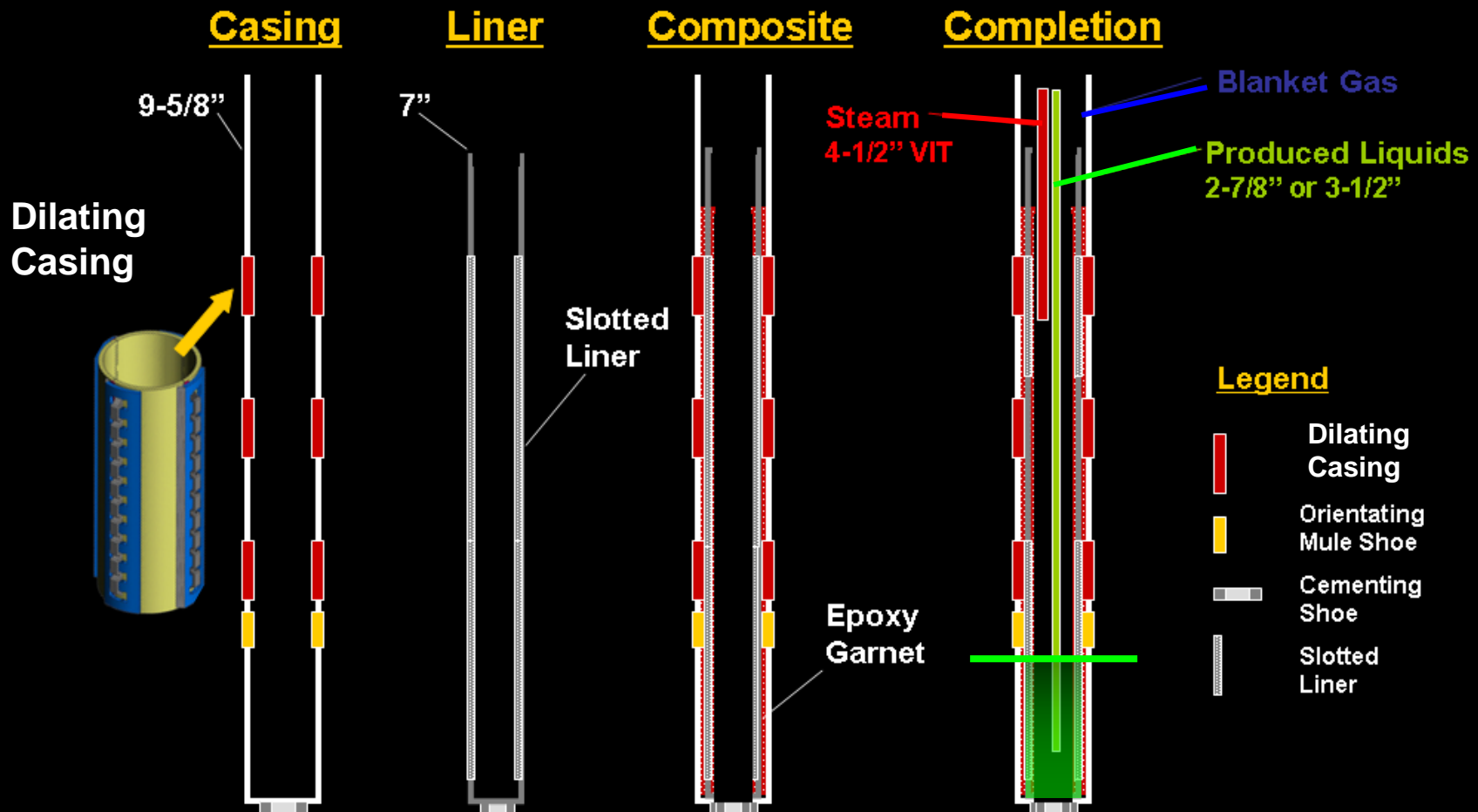
Well Construction Sequence

Operated in SAGD Mode

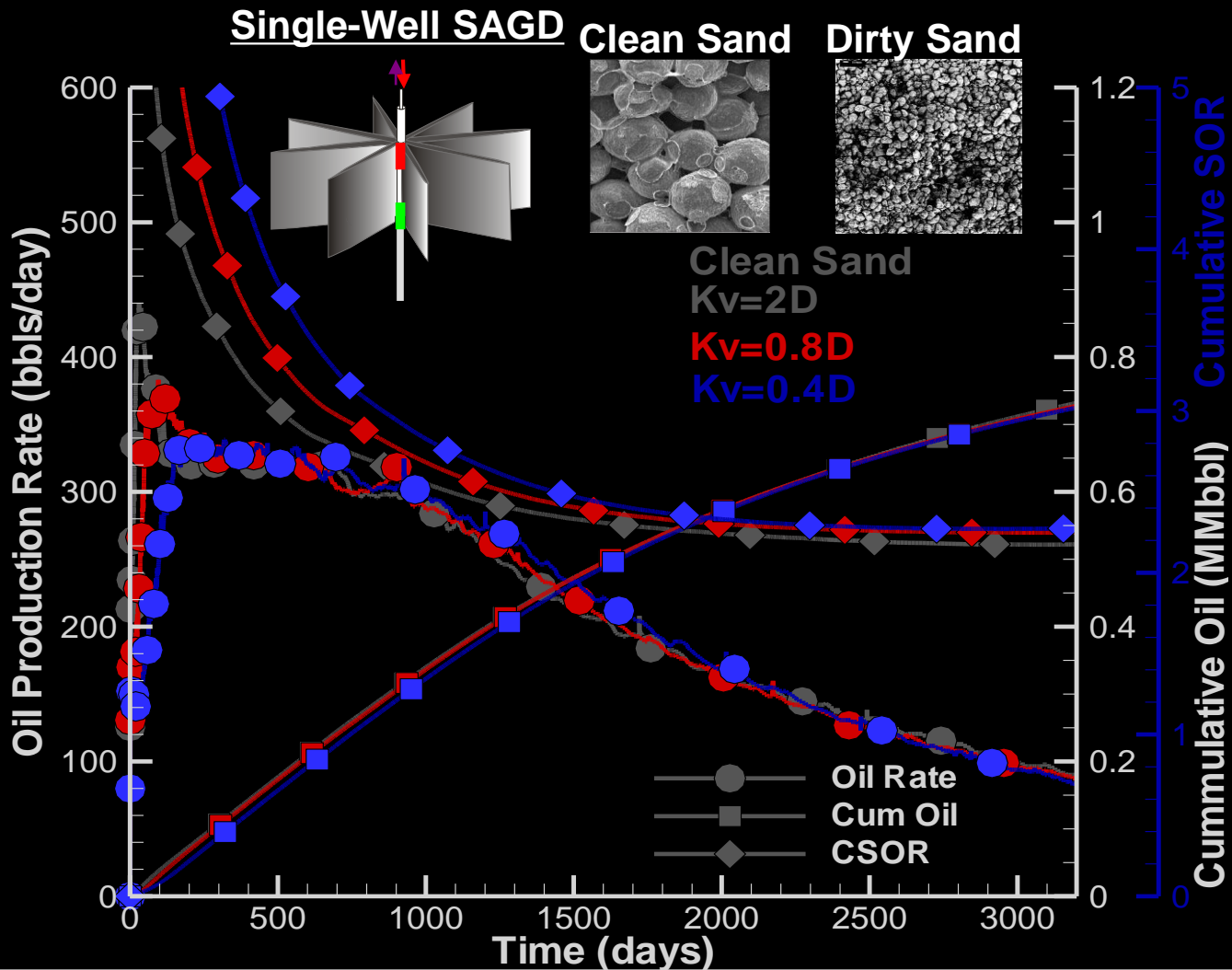
- no startup
- invariant of geology



Single-Well SAGD Completion



Single-Well SAGD vs Vert Perm



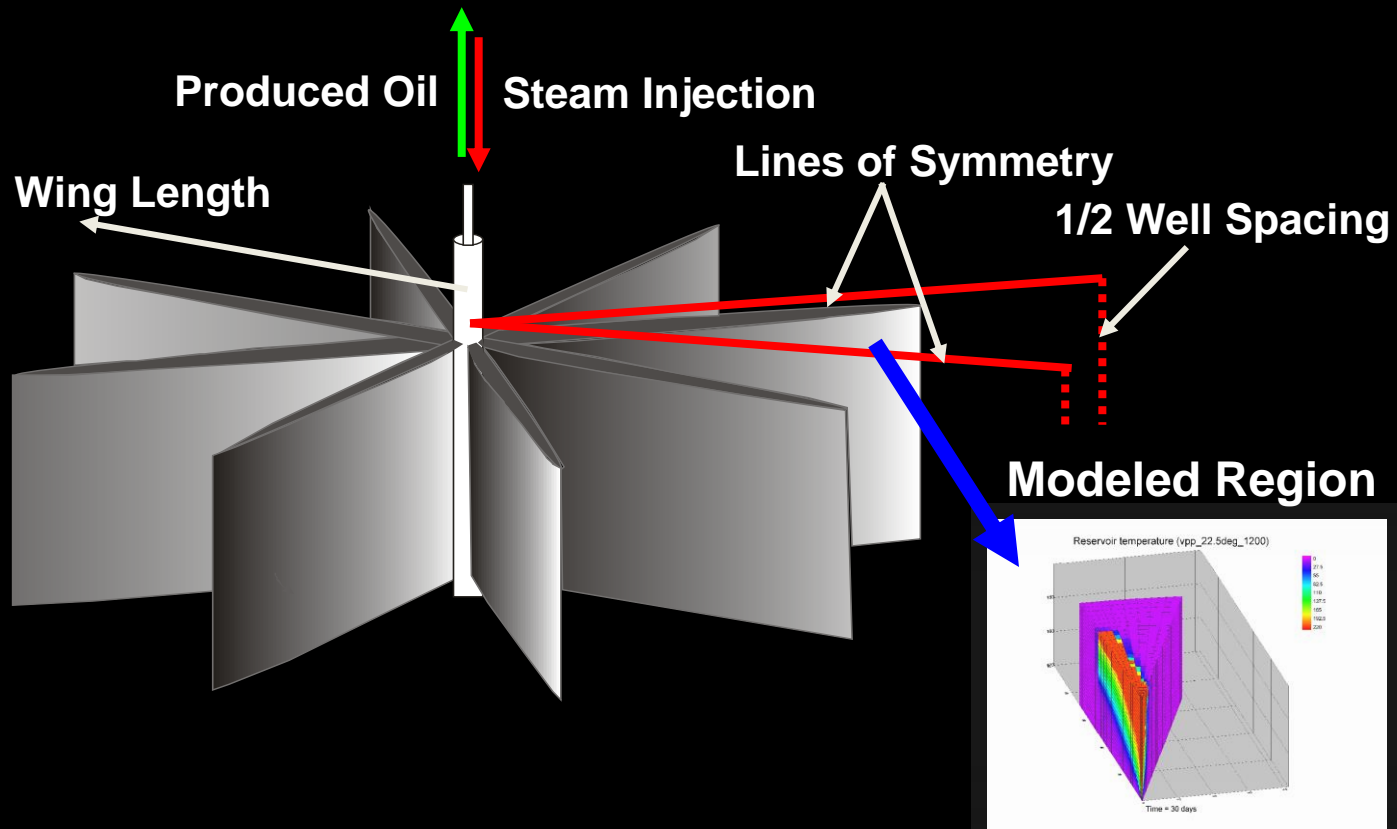
SAGD

$$q \propto \sqrt{k_v}$$

$$t \propto \frac{1}{\sqrt{k_v}}$$

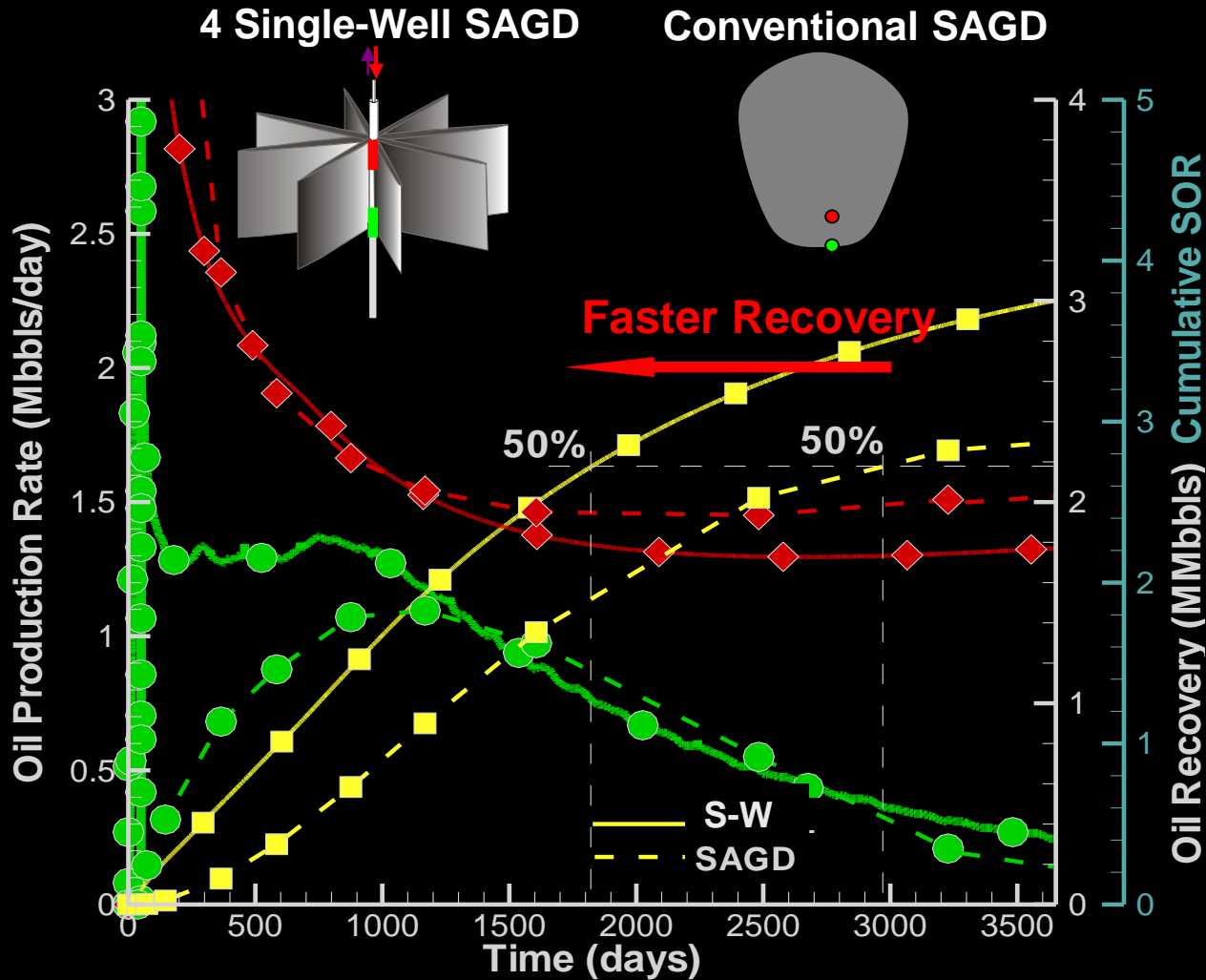
Athabasca Bitumen
Sp=1,750kPa

Reservoir Idealization



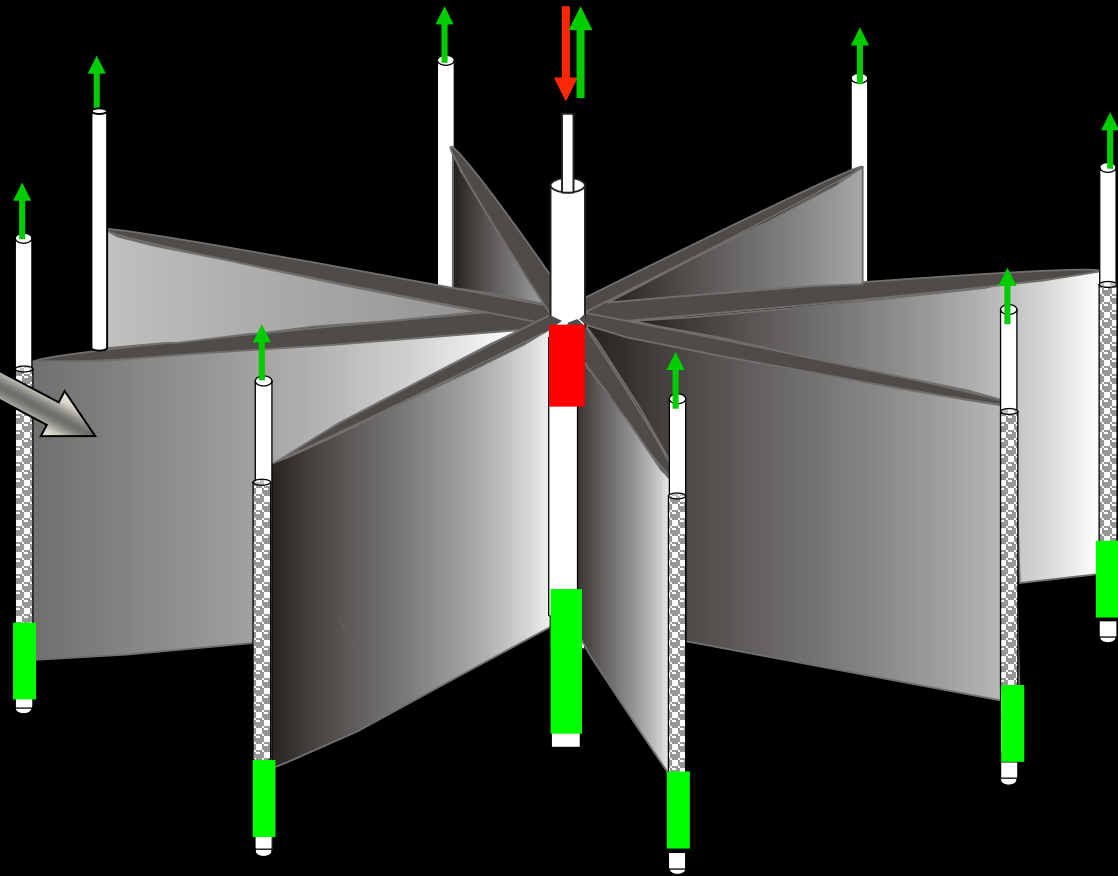
High confidence in reservoir simulations due to minimal dependence on vertical perm

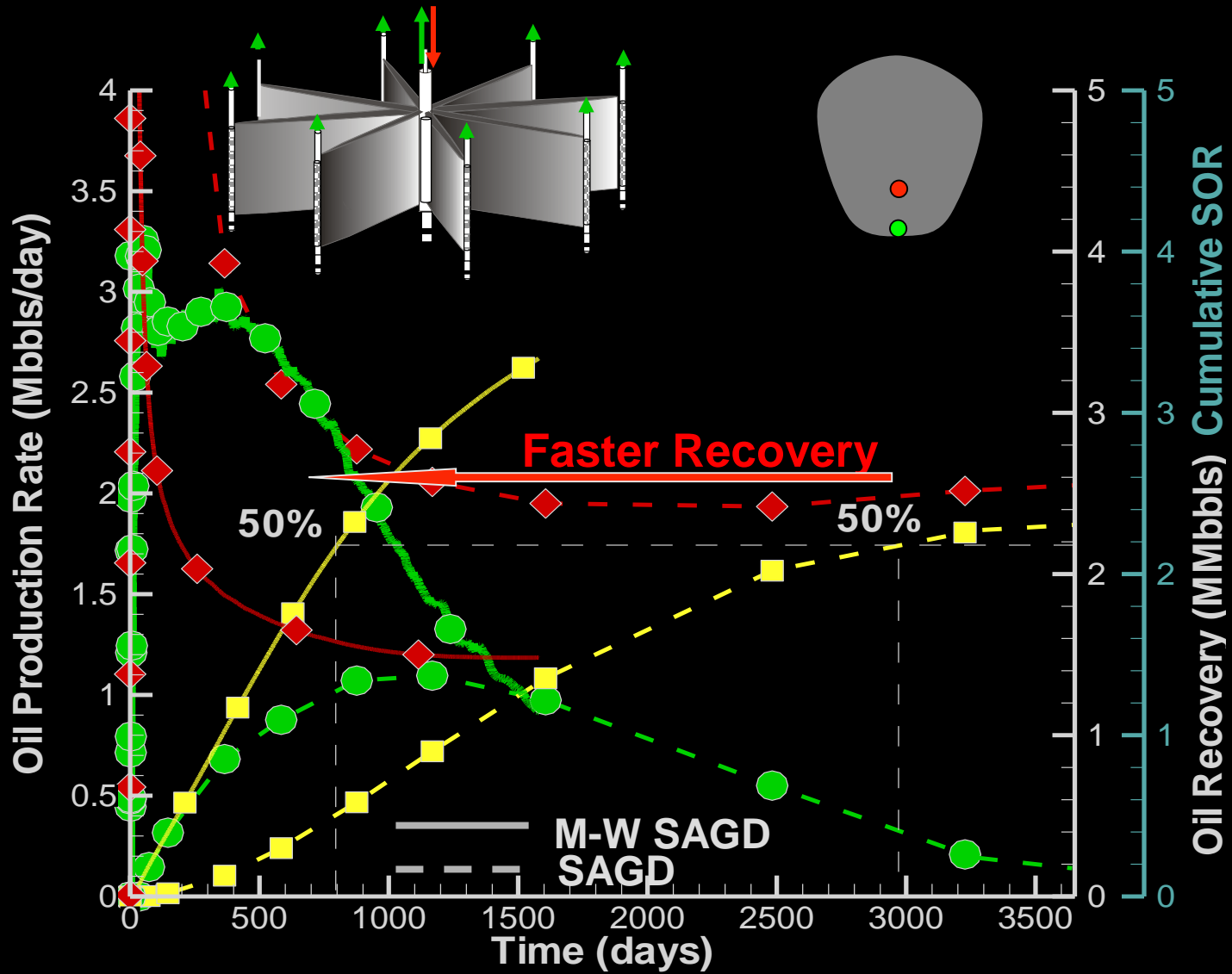
Single-Well SAGD vs Conv SAGD



Vertical Single-Well SAGD with Multiple Producers

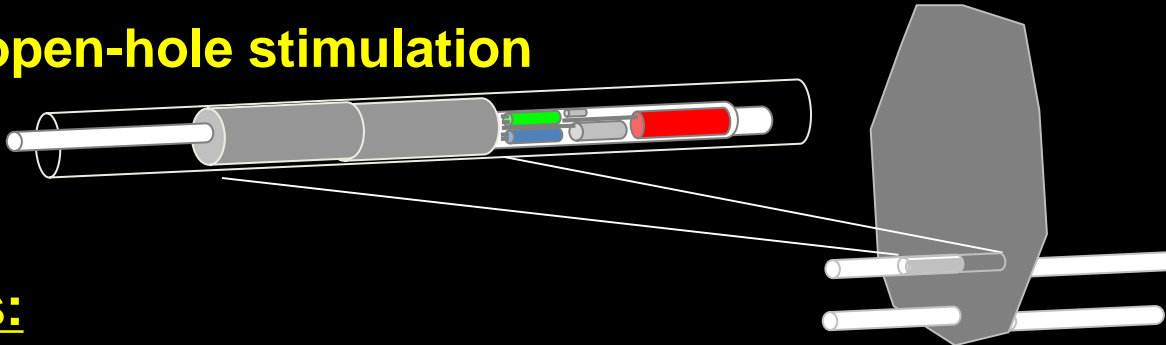
12/20 Garnet





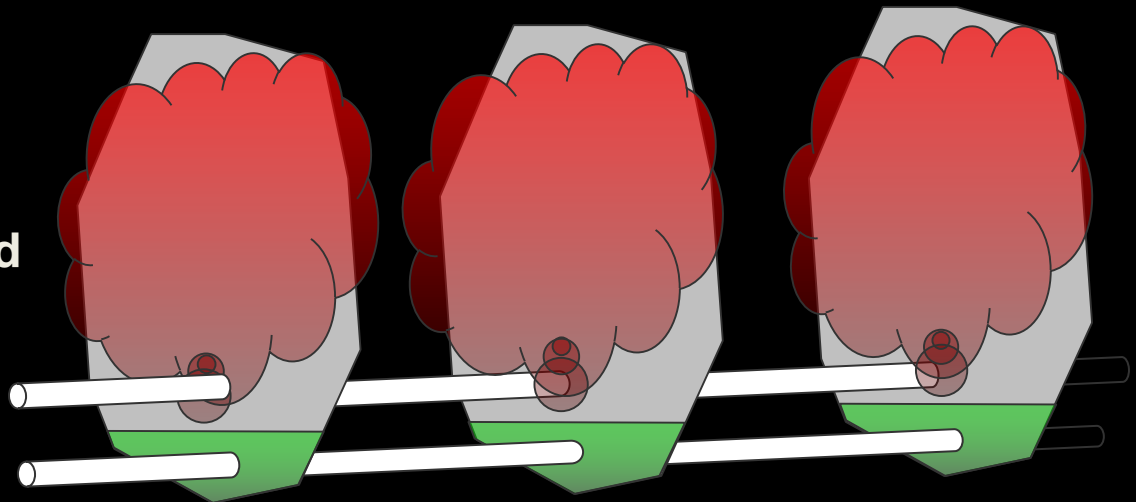
Frac Enhanced Conventional SAGD

Hz open-hole stimulation

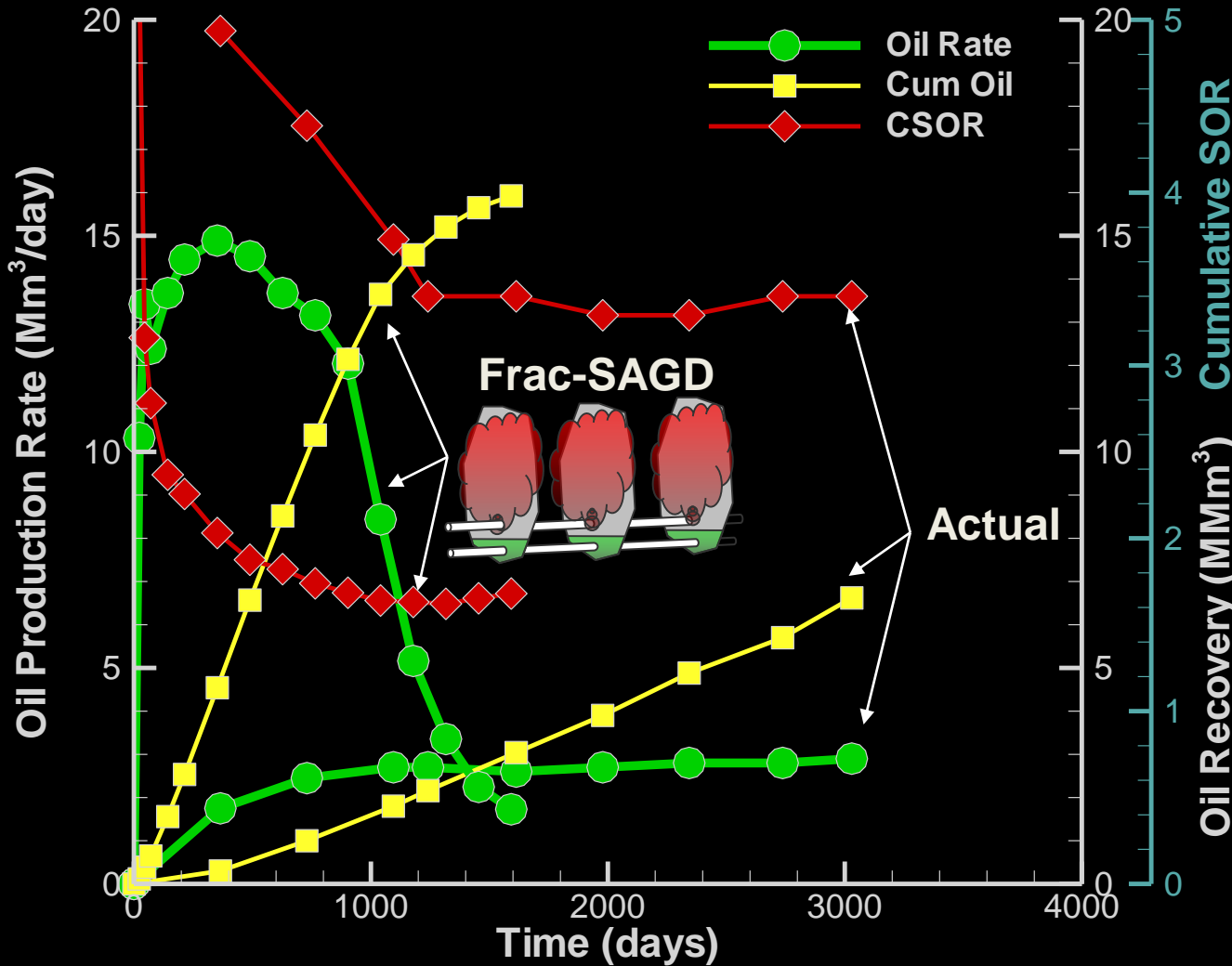


Benefits:

- Simpler & more reliable to operate
- SAGD mode at startup
- Engineer around geology
- Quick re-startup
- Operate at low pressure
- Flow conformance assured



Frac Enhanced SAGD @ Firebag



Oil Recovery (MMm³) Cumulative SOR

- Benefits:**
- Lower CSOR
 - Faster Recovery
 - 6x NPV₁₀
- Quantified:**
- Cost: \$16 vs \$32 /bbl
 - Capacity: 380k vs 180k bpd
 - Carbon Footprint: <50% carbon/bbl
 - Net Income up by 4x Δ \$3.4B/yr*

*Bitumen \$50/bbl
52m pay, 1,850kPa, $\phi=0.3$, $S_o=0.79$

Conclusions

- **Stimulation completion dictates the outcome**
 - Mini-Frac thru' perms or open-hole suspect in non-brittle weak formations
 - Essential to initiate frac in non-brittle formations
 - Need to re-assess earlier stimulation data & experience
- **Process not depth limited, strength limited**
- **Frac SAGD performance ~invariant of geology**
- **Frac enhance best geology first, not poorest**
 - Highest ROI, best sustainable and environmental practice
- **As built issues**
 - Permeability of planes needs to be high
 - Demonstrate azimuth control of planes from Hz wells
 - Steaming trials required to quantify performance