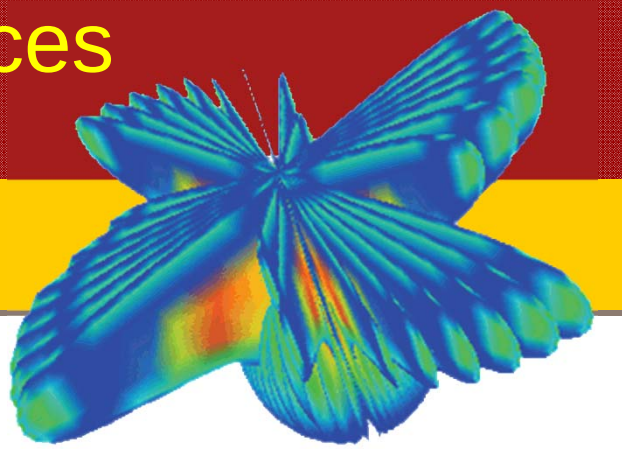
Sustainable Fracturing Rationale to Reach Well Objectives – The Impact of Uncertainties and complexities on Compliance Assurances

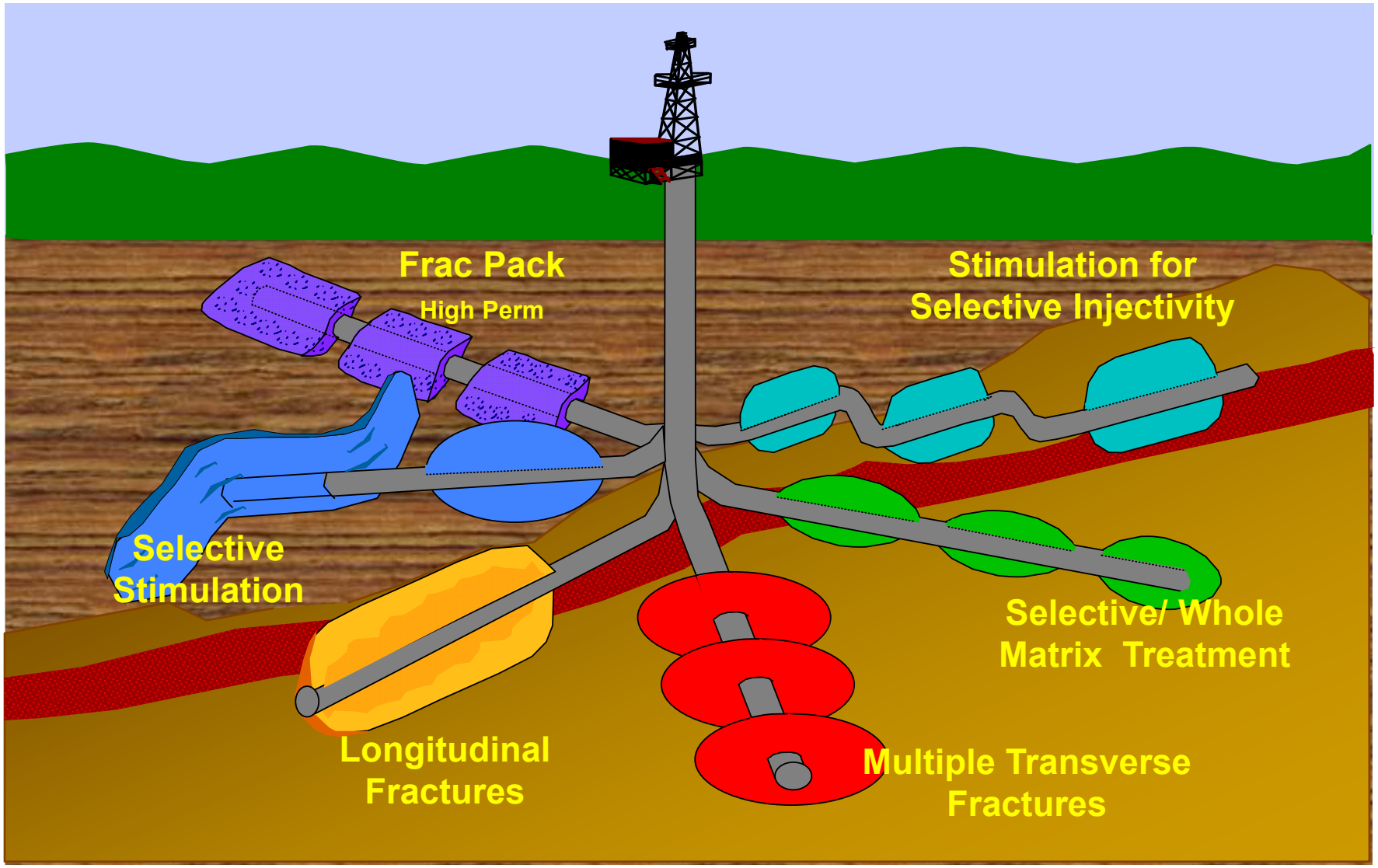


OVERVIEW

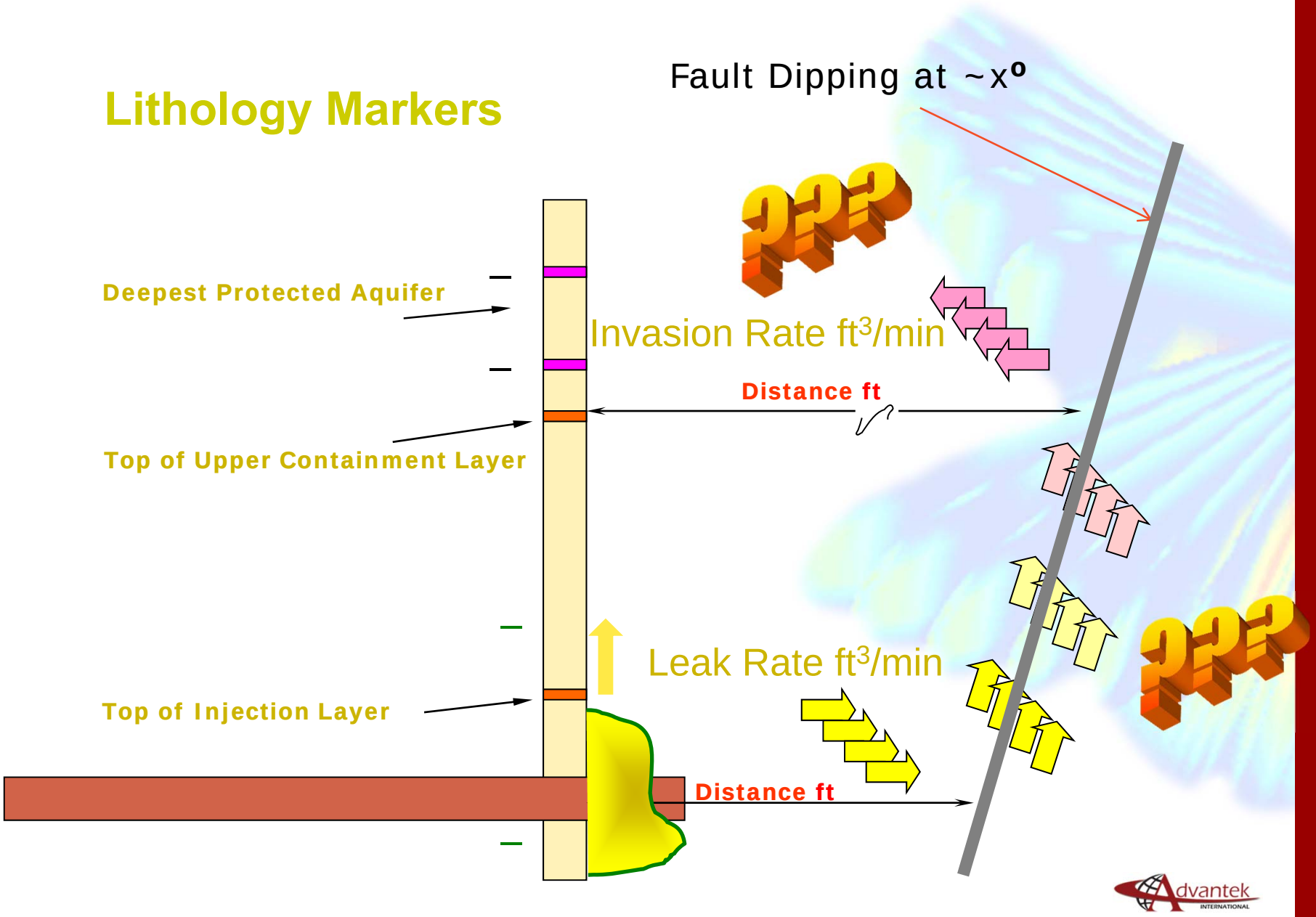
Ahmed Abou-Sayed

Advantek International

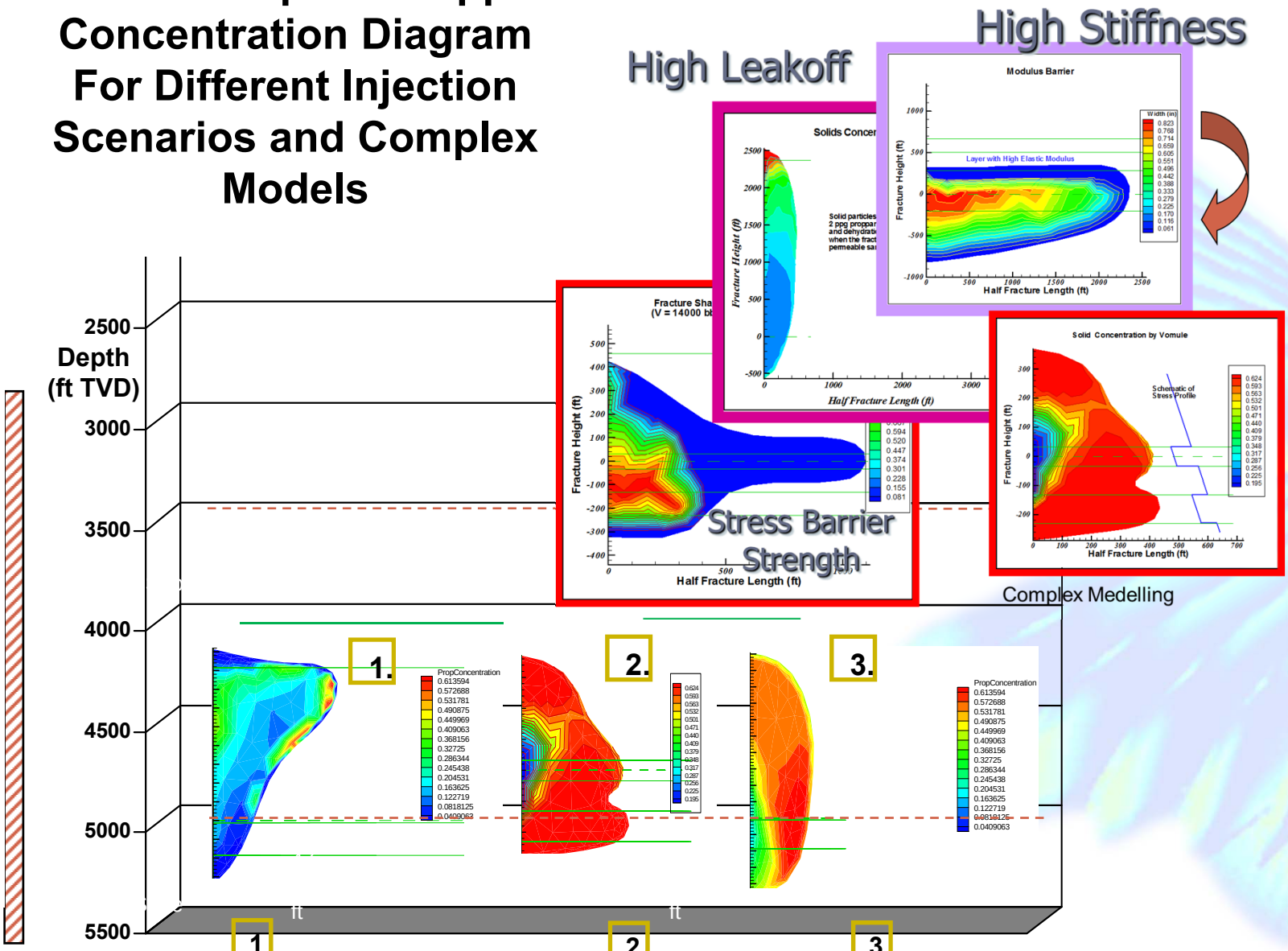
Variety of Fracturing Configurations



MIGRATION, BREACHING & FAULT/SEAL INTEGRITY



Fracture Shape & Proppant Concentration Diagram For Different Injection Scenarios and Complex Models

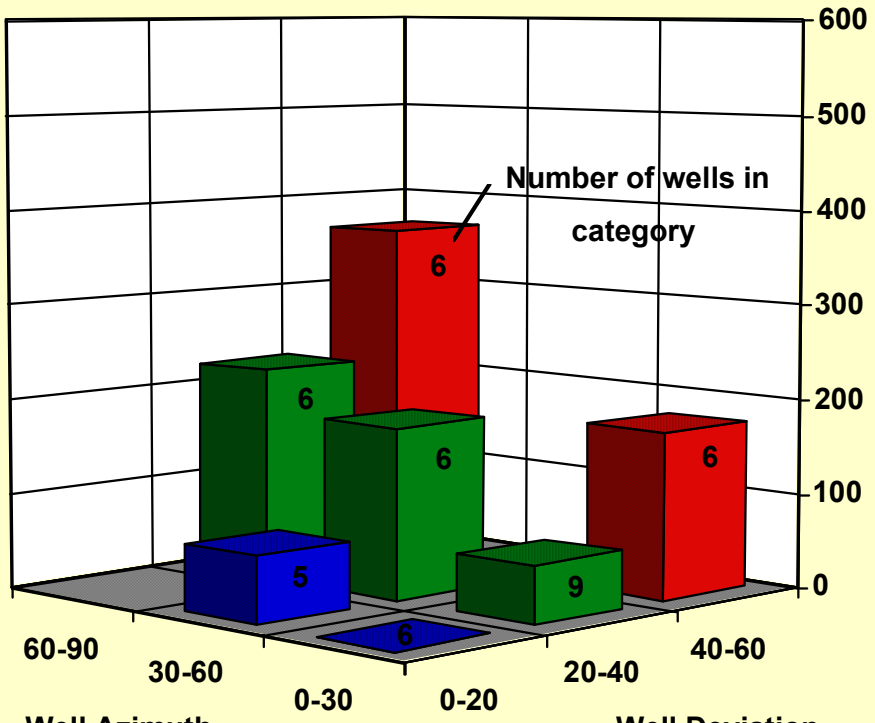


1	2.	3.
4752 ft Injection Point Mid Sand Layers Modeled 5390 bbls Injected 0.81 psi/ft Shale Stress Gradient	3280 ft Injection Point Mid Sand Layers Modeled 14000 bbls Injected 0.85 psi/ft Stress Gradient	4752 ft Injection Point Mid Sand Layers Not Modeled 13400 bbls Injected 0.81 psi/ft Stress Gradient

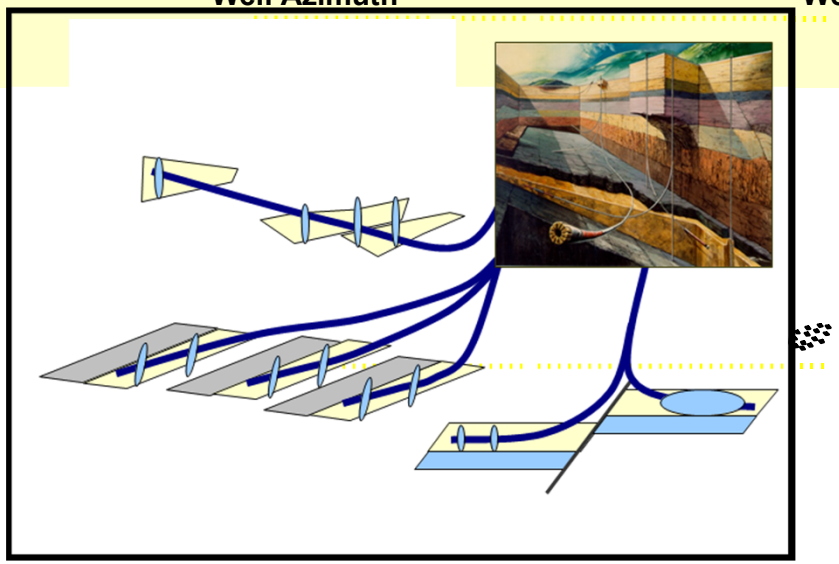
EPA FRACTURING DESIGN and ASSURANCE

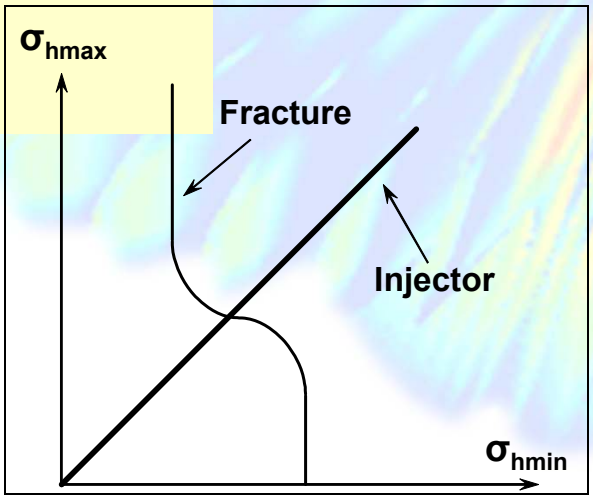
Advantek INTERNATIONAL

Stress Anisotropy Effect

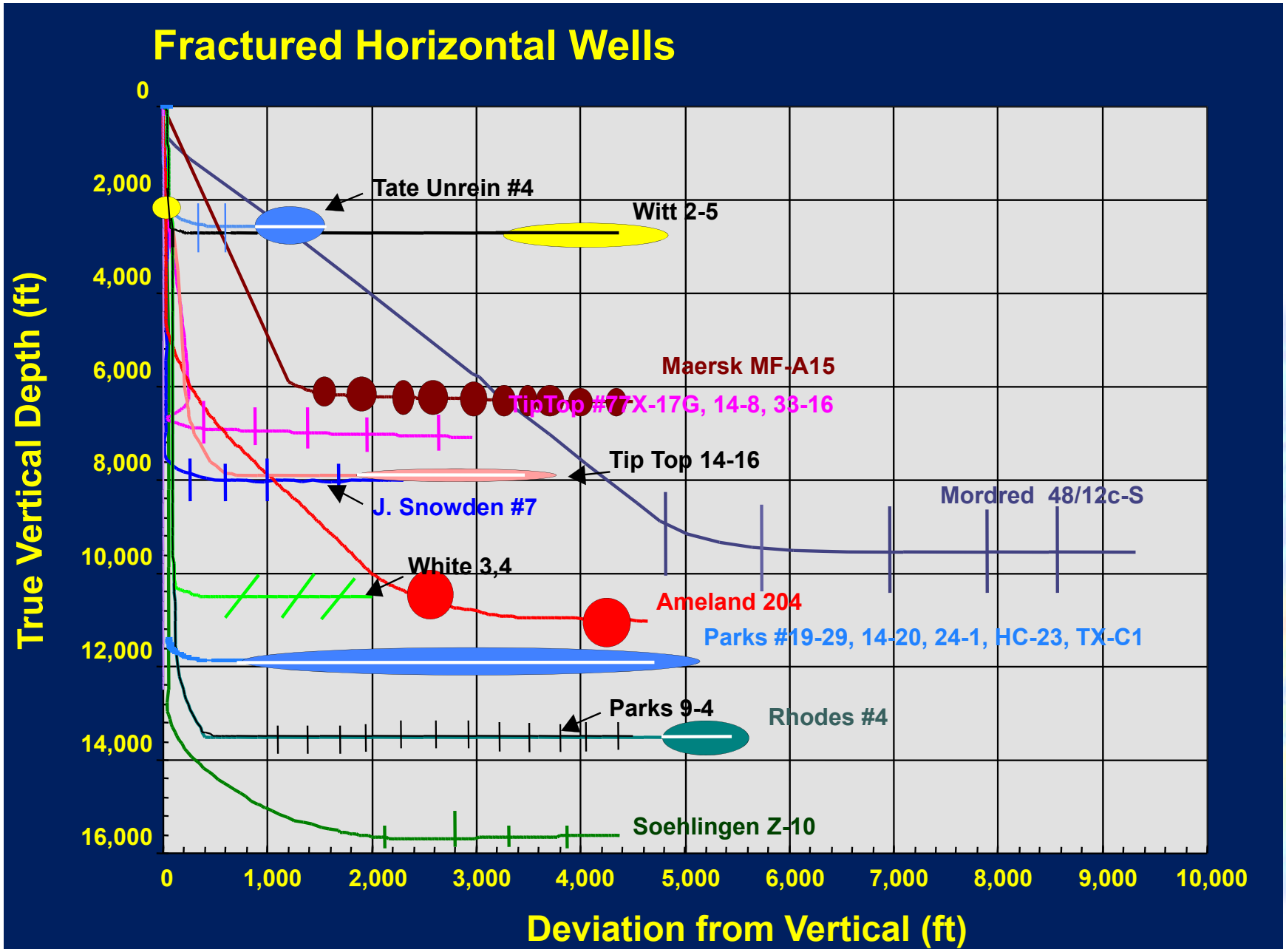


Increased Intercept Pressure (psi)

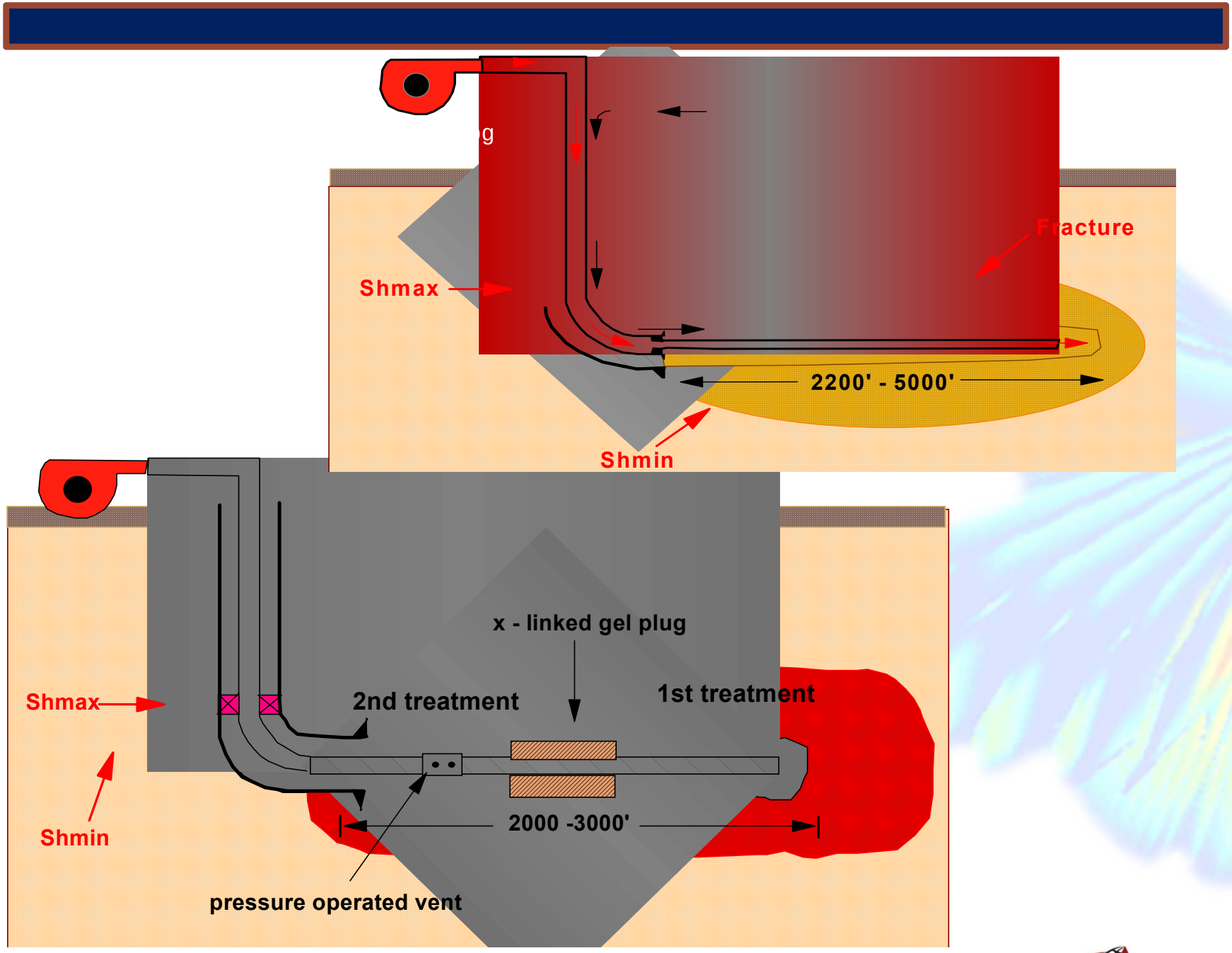




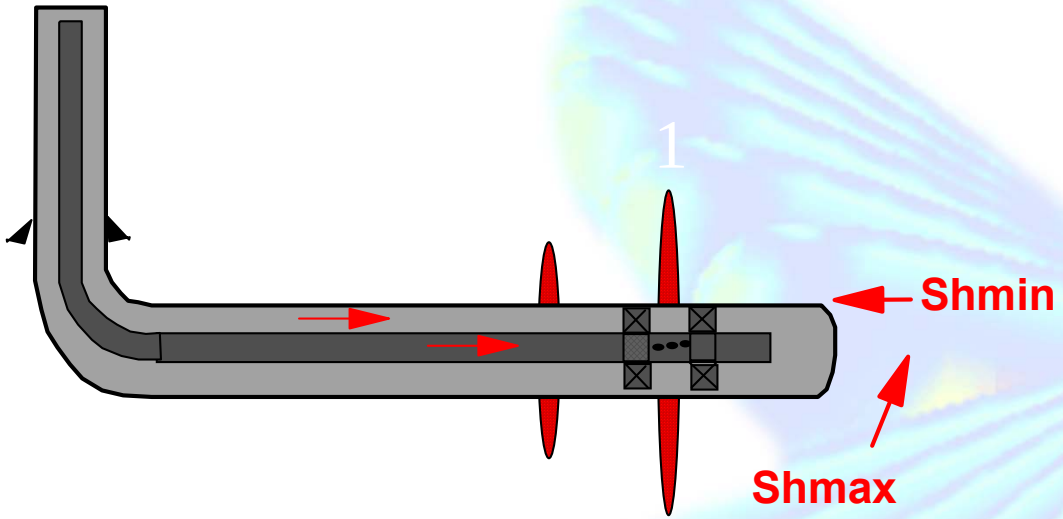
EPA FRACTURING DESIGN and ASSURANCE

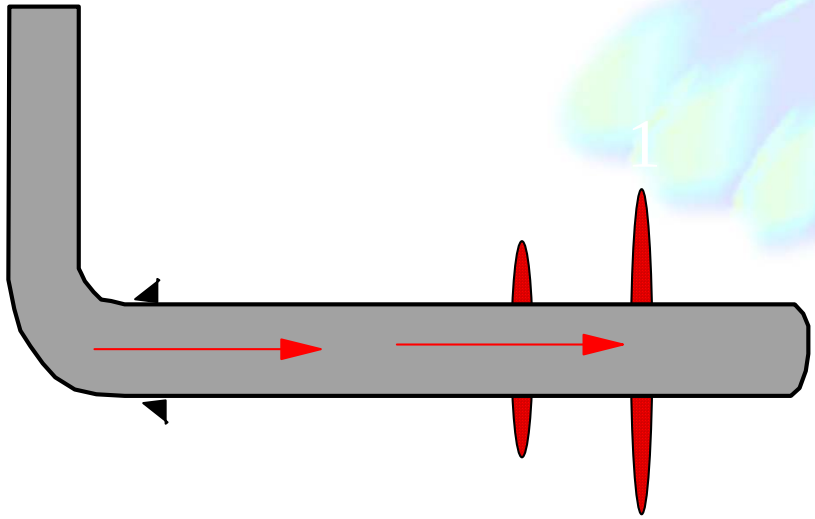


Advantek INTERNATIONAL


Fracture
Shmax
2200' - 5000'
Shmin
x - linked gel plug
Shmax
2nd treatment
1st treatment
Shmin
2000 -3000'
pressure operated vent

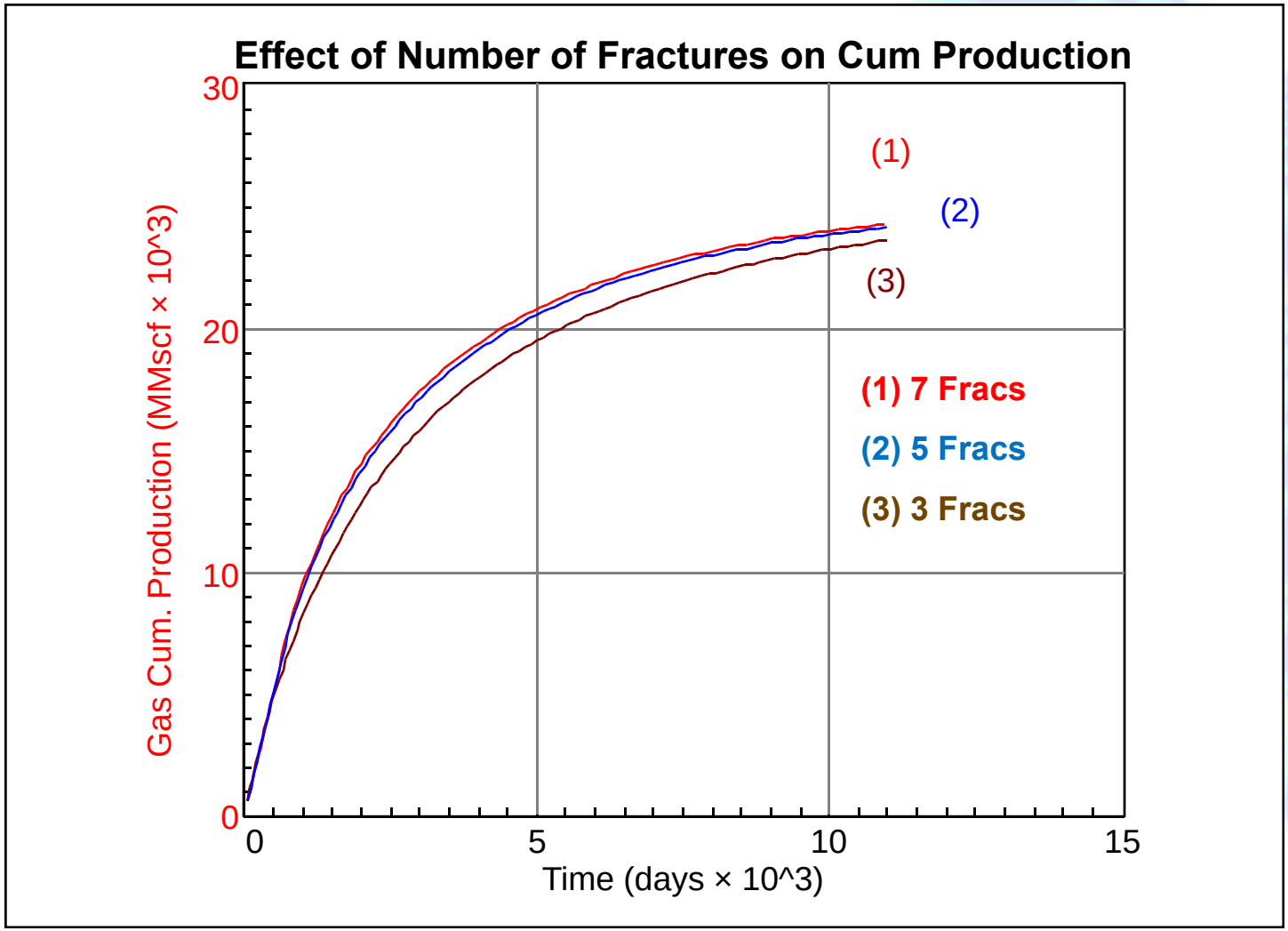
Horizontal Well Technology (Completions/Stimulation)





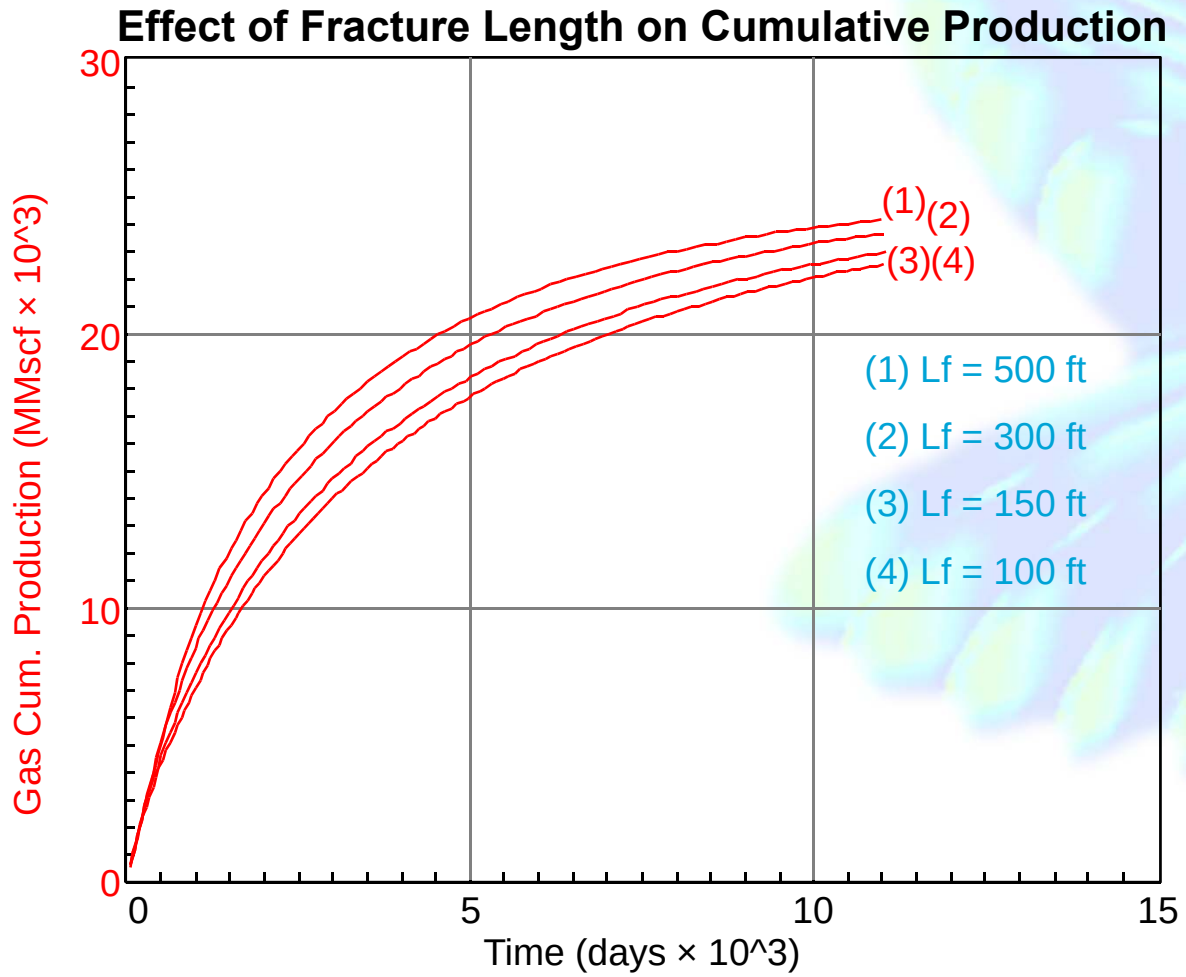
EPA FRACTURING DESIGN and ASSURANCE

Gas Potential



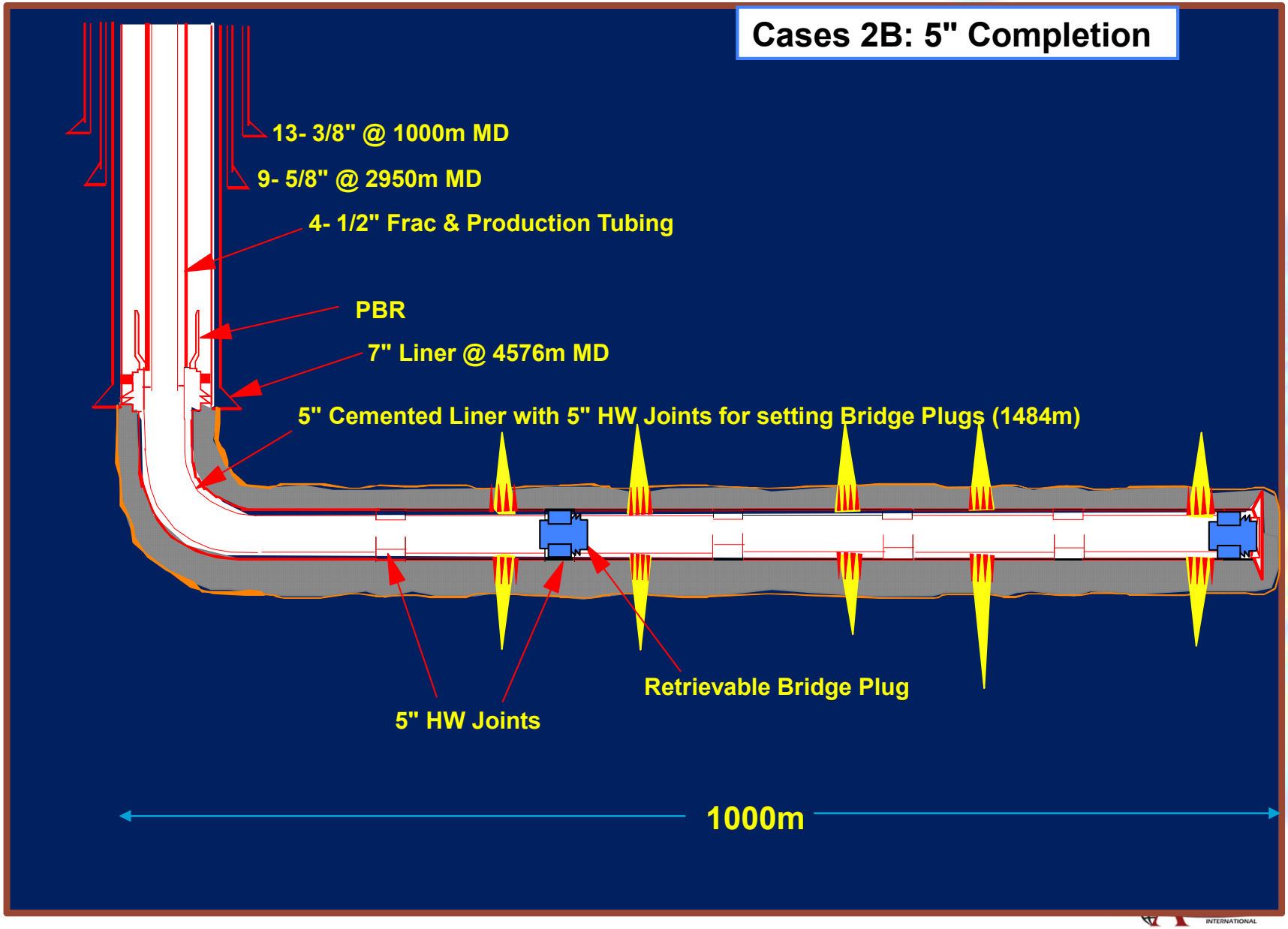
EPA FRACTURING DESIGN and ASSURANCE

Gas Potential



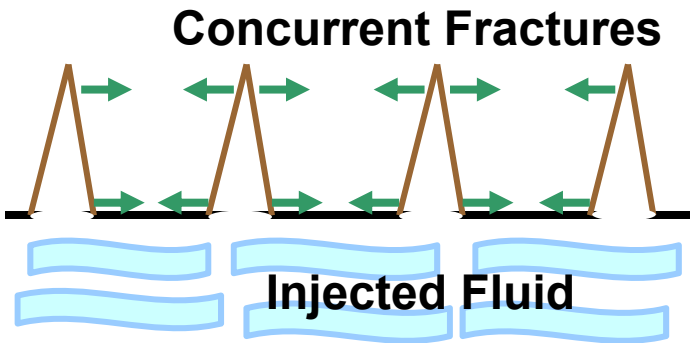
EPA FRACTURING DESIGN and ASSURANCE

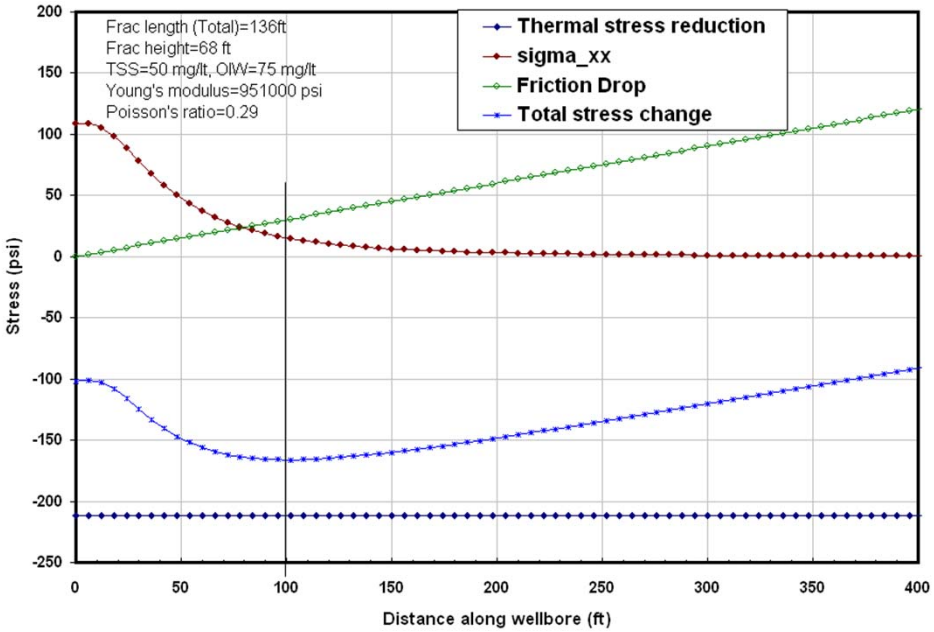
Multi-Frac Horizontal Well

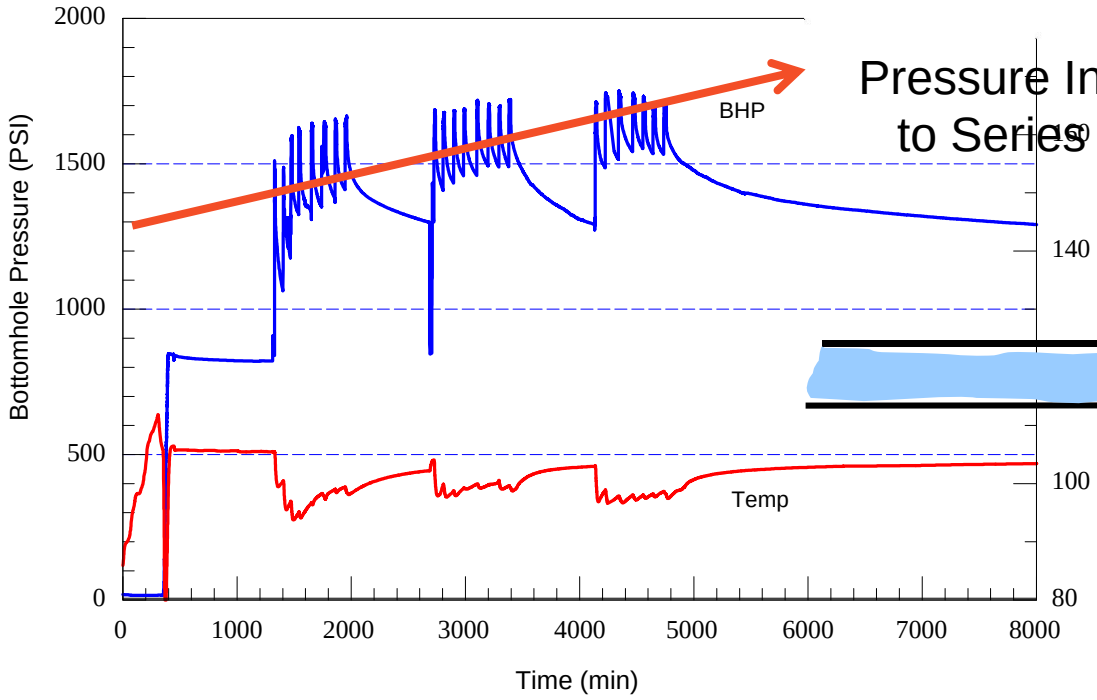


PRESSURE DURING SEQUENTIAL PUMPING

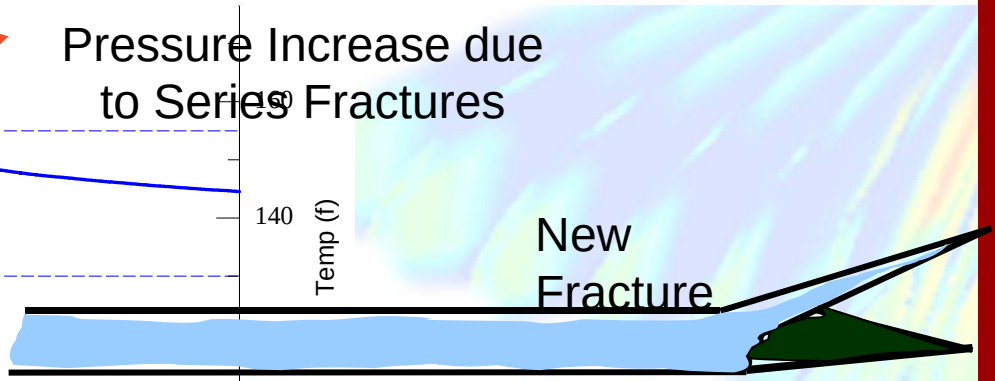
Stress along Well due to Concurrent Parallel Fractures







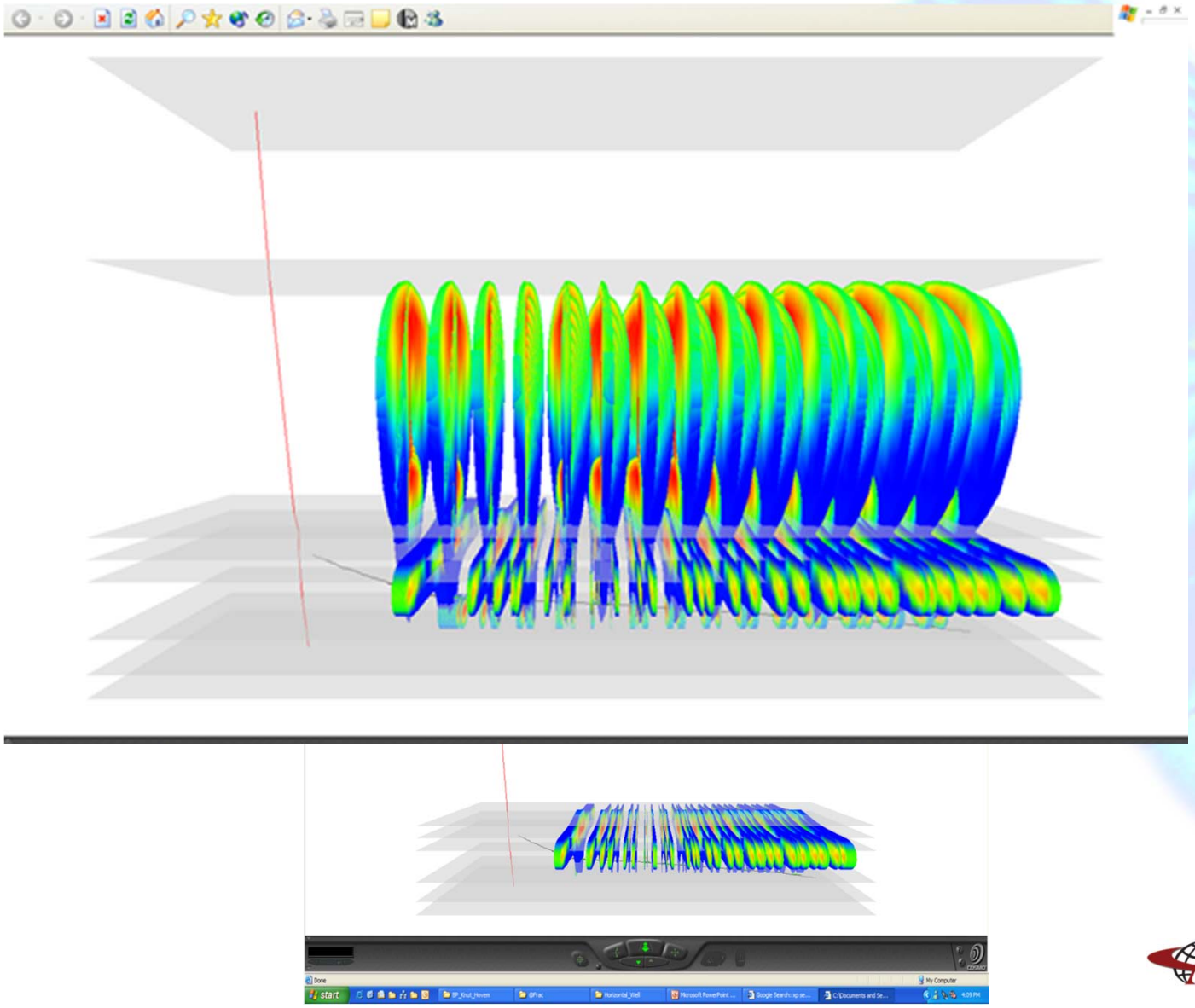
Pressure Increase due to Series Fractures



EPA FRACTURING DESIGN and ASSURANCE

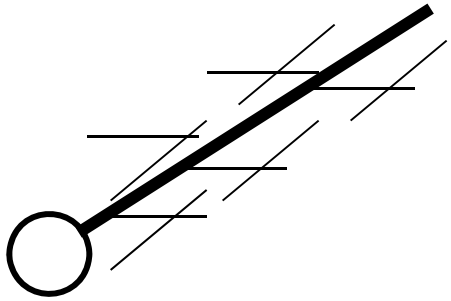
MULTIPLE FRACTURING OF LONG HORIZONTAL WELLS – ANISOTROPIC STRESS

- Strongly anisotropic, layered stress field

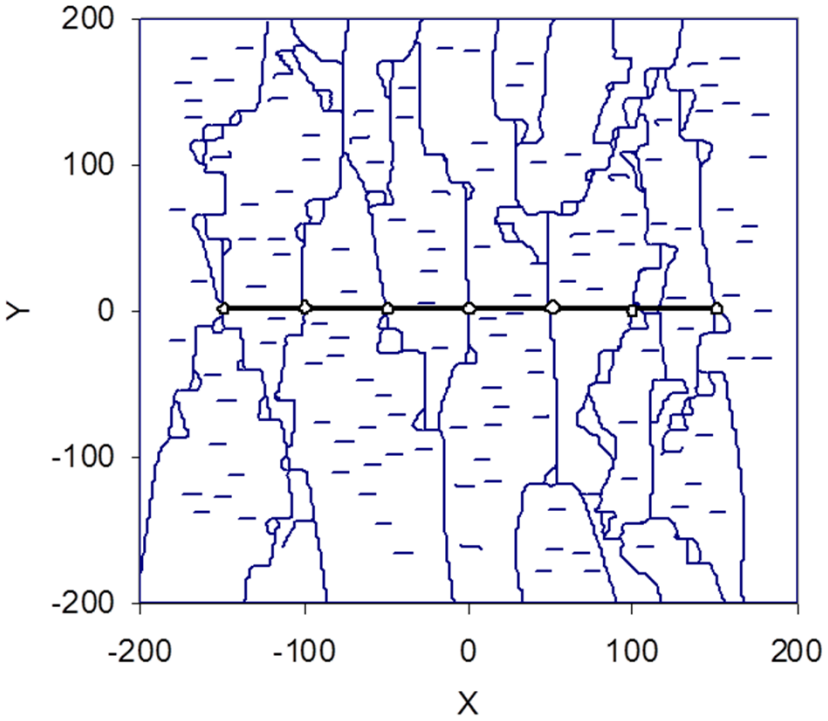


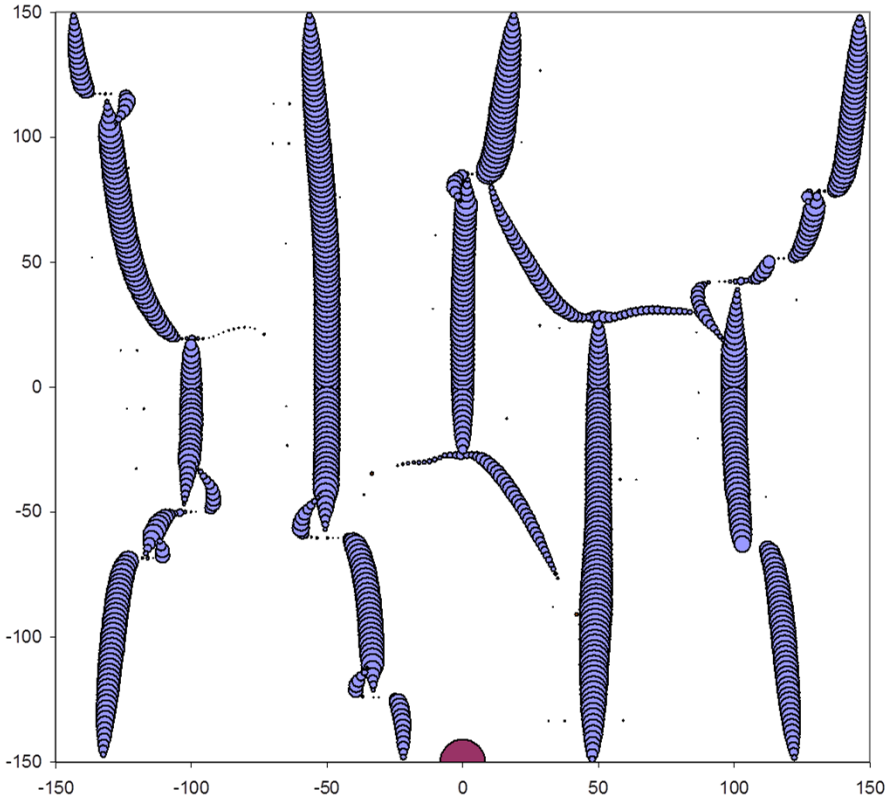
EPA FRACTURING DESIGN and ASSURANCE

Fracture Network in a Weakly Anisotropic Stress Field



Conjugate Fractures





After Olson, ARMA 2008

EPA FRACTURING DESIGN and ASSURANCE

CONCLUDING REMARKS

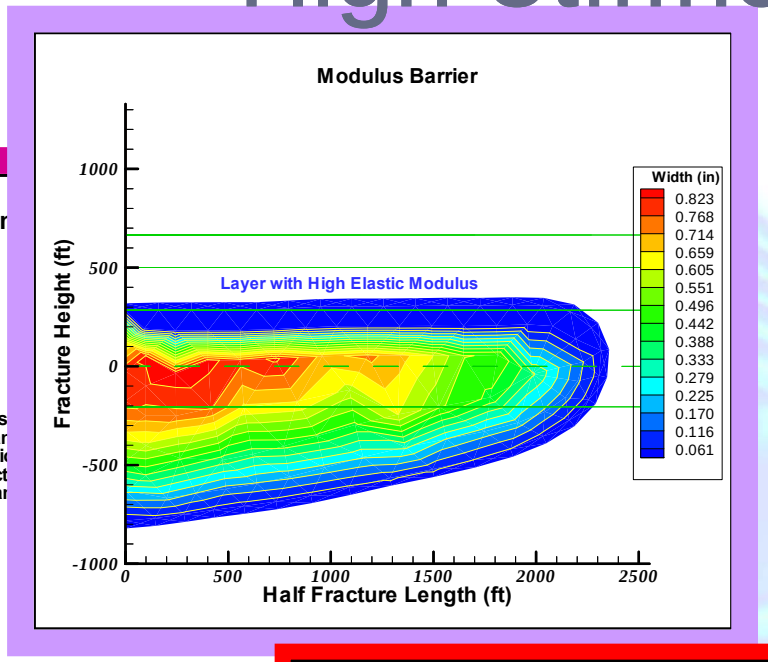
CONCLUDING REMARKS

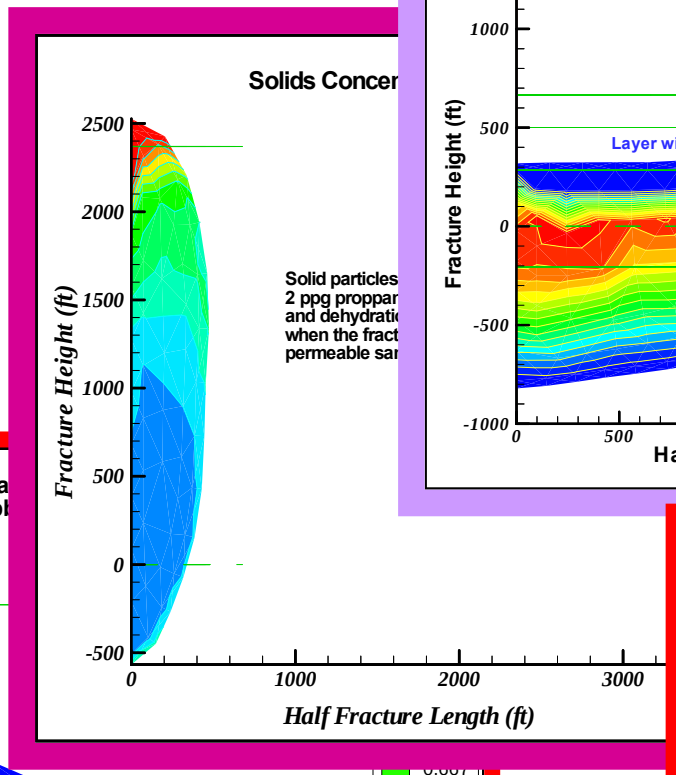
- Hydraulic fracturing has been a reliable contributor to US O&G supply for half a century. They must be thoroughly designed
- Fracture design requires site/well specific input, routine recipe solutions are not appropriate for assurance.
- Well trajectories vis a vis stress field azimuth play a major role in establishing treatment pressures and well connectivity.
- Breaching, loss of containment and frac fluid migration need always be significant factors in job design and implementation.
- Assurance must be a primary factor in stimulation via complete data collection, sophisticated modeling and live monitoring.
- Pressure transient tests have advanced and are currently sufficient and necessary for better identification of fractures.
- Multiple fractures in single wells must be designed with sufficient certainty and complexities and need close monitoring

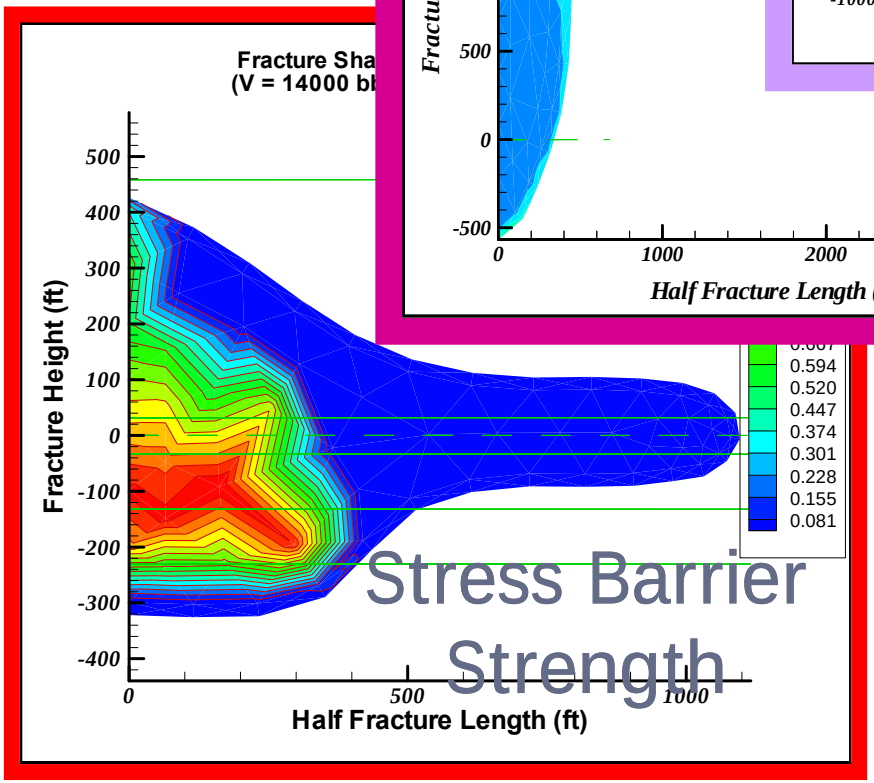
EPA FRACTURING DESIGN and ASSURANCE

High Leakoff

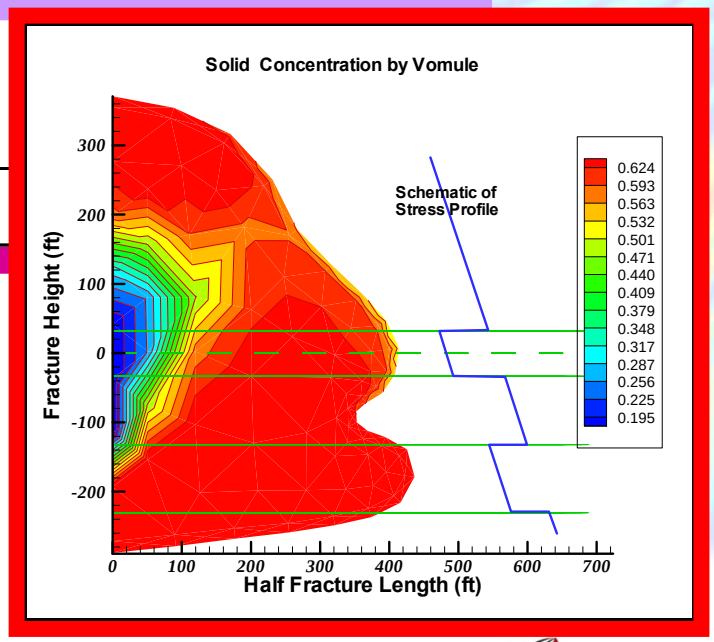
High Stiffness







Stress Barrier Strength



Complex Medelling

Advantek INTERNATIONAL

EPA FRACTURING DESIGN and ASSURANCE

Sustainable Fracturing Rationale to Reach Well Objectives – The Impact of Uncertainties and Complexities on Compliance Assurances

Ahmed Abou-Sayed
Advantek International

The statements made during the workshop do not represent the views or opinions of EPA. The claims made by participants have not been verified or endorsed by EPA.

The presentation will discuss lessons learned; extract best practices and guidelines applied to injection of fluids and slurries during fracturing and exploration and production (E&P) associated streams disposal (wastes, produced water, drill cuttings, and solids/proppant flow-back). Fracture generation, propagation and multiplication during multiple injections in same well, batch injections and re-fracturing is covered. Design requirements, monitoring and assurance of containment for environmentally safe injections are covered. Results from major worldwide injection projects are viewed from operator's and regulator’s perspectives.