

the Energy to Lead

Fracture Design & Simplistic 3-D Parametric Modeling New Albany Shale Project

June 4, 2009

Doug Walser

Steve Wolhart

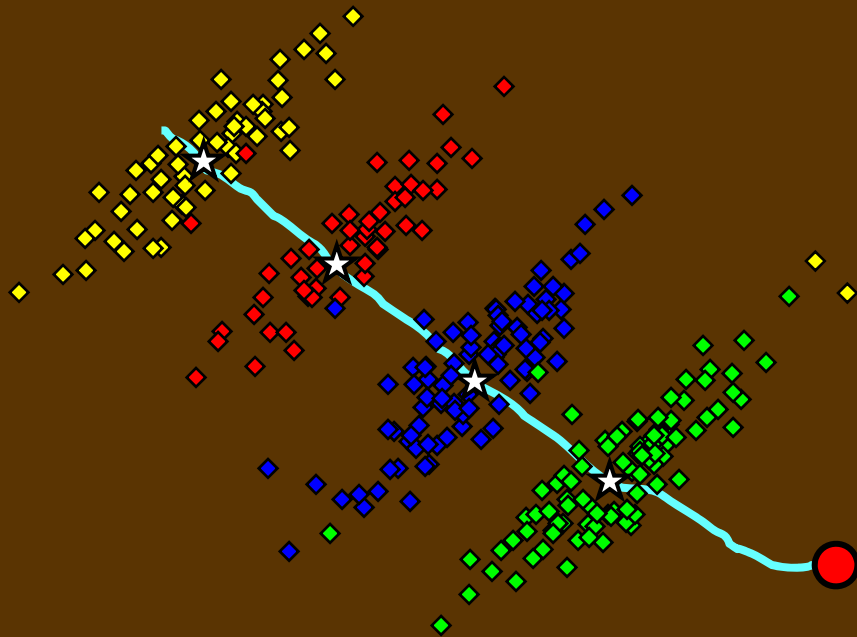
 Pinnacle

What we'll Cover

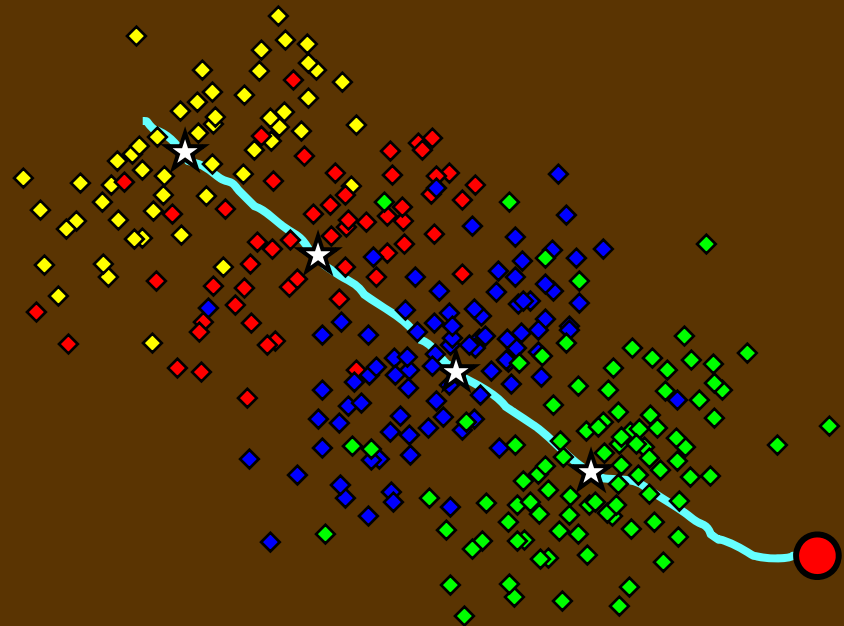
- > **Applicability of 3-D parametric modeling to NAS**
- > **Comparison of modeling runs**
- > **Clarity and agreement in stimulation process?**

Issue 1: can a 3-D parametric model adequately simulate a NAS stimulation?

Yes.

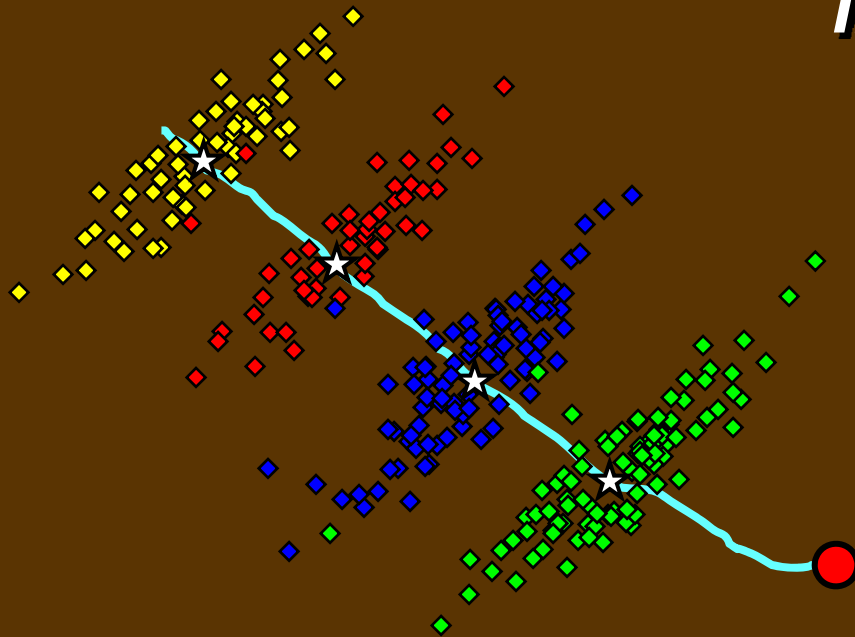


And No.



Issue 1: can a 3-D parametric model adequately simulate a NAS stimulation?

Yes.

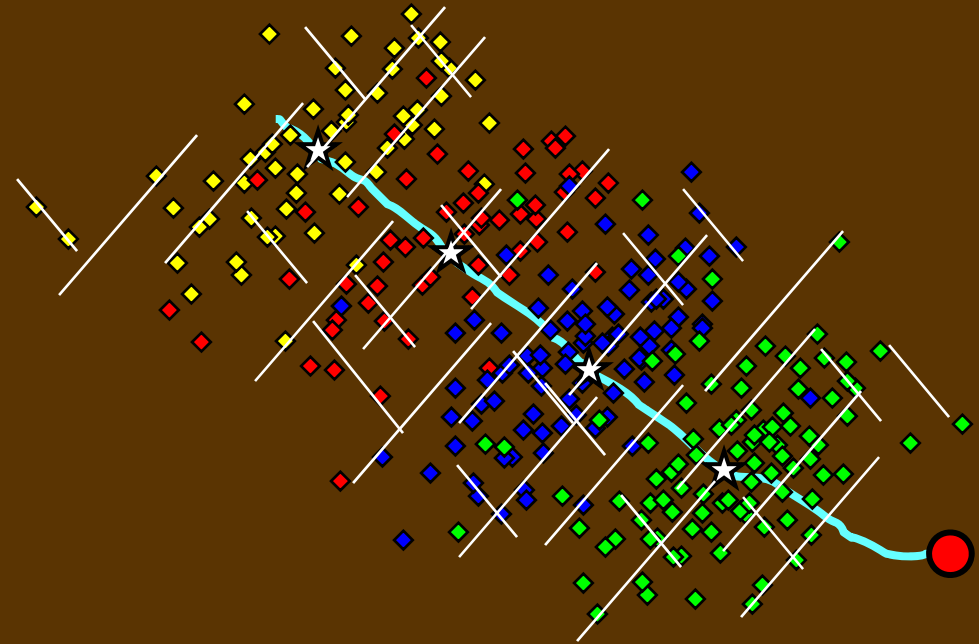
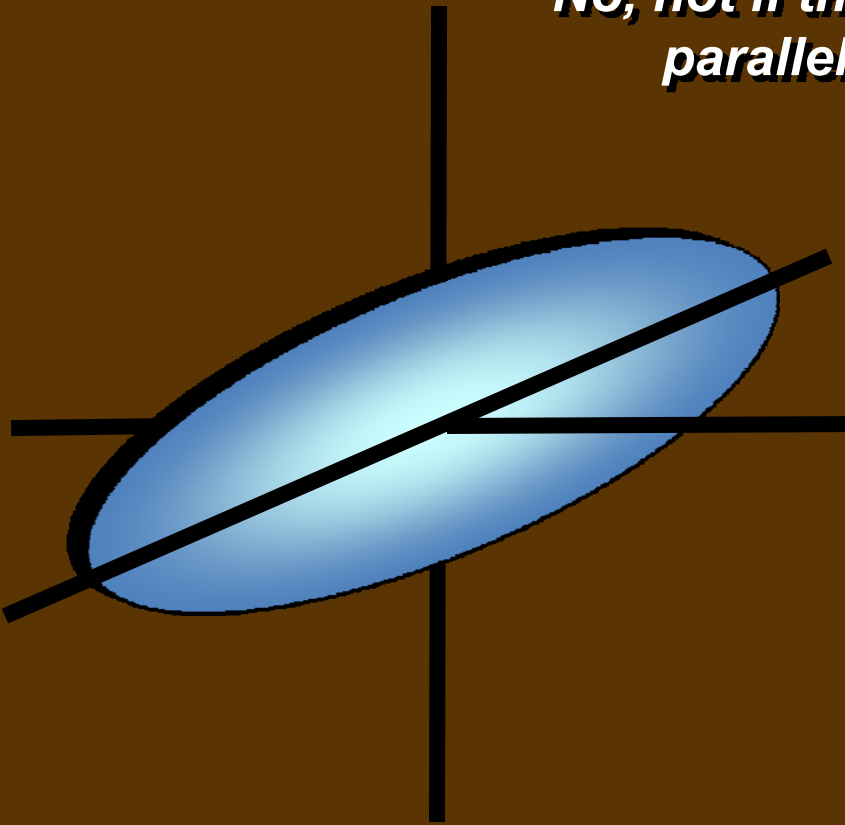


However, simple bi-wing induced fractures may be an indication of lack of natural fracturing

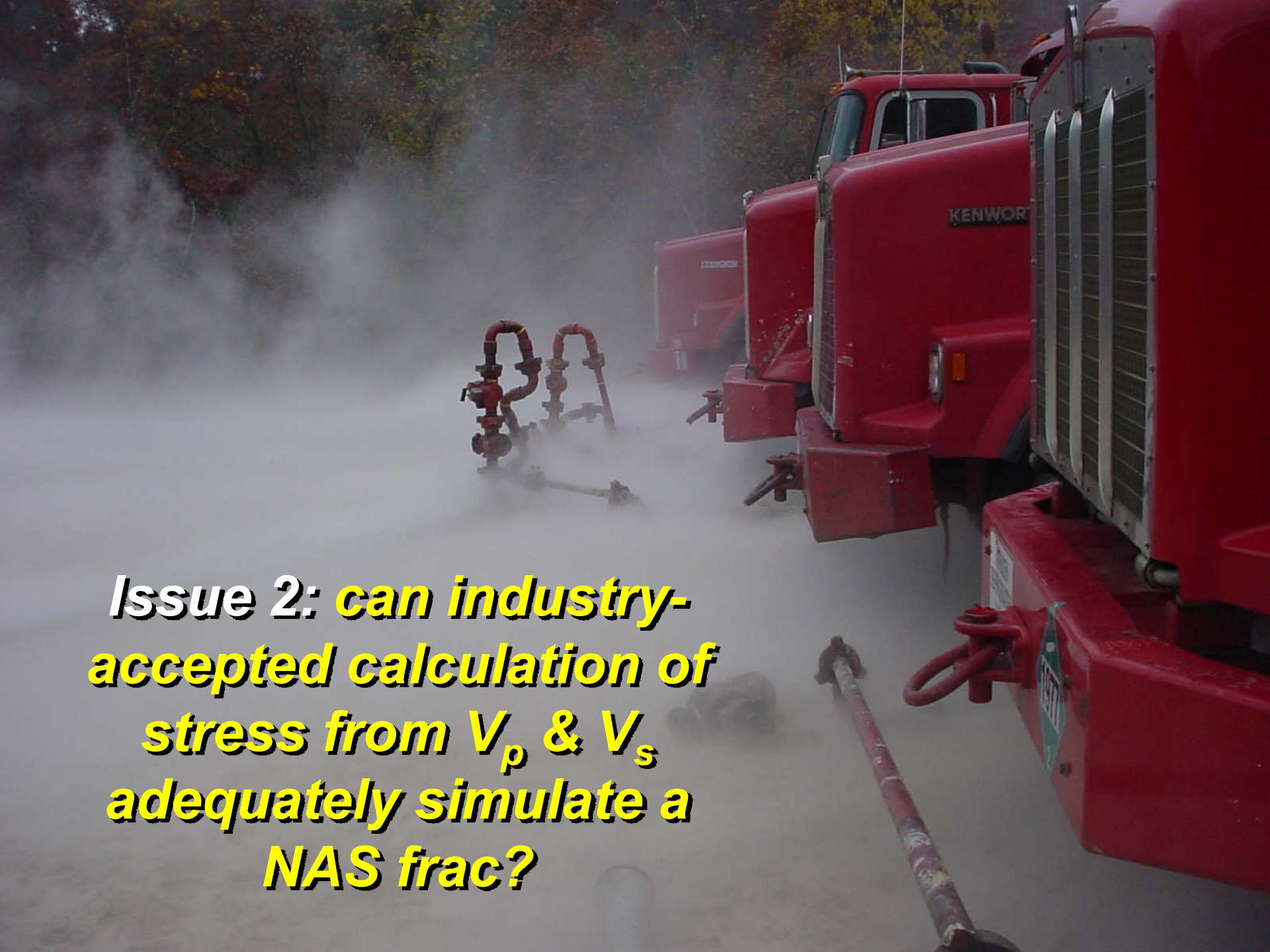
This can be a real problem in a marginal play (substantially reduced surface area exposed to reservoir)

Issue 1: can a 3-D parametric model adequately simulate a NAS stimulation?

No, not if the fracture network consists of multiple parallel and orthogonal induced fractures



(Reference ongoing Texas A&M work on network fracture modeling)

A line of red Kenworth trucks is parked on a road, with a thick mist or fog obscuring the background. In the foreground, there is a piece of hydraulic equipment, possibly a pump or a valve, connected to the trucks. The trucks are Kenworth models, as indicated by the "KENWORTH" logo on the side of the nearest truck. The scene is set outdoors, with trees visible in the background through the mist.

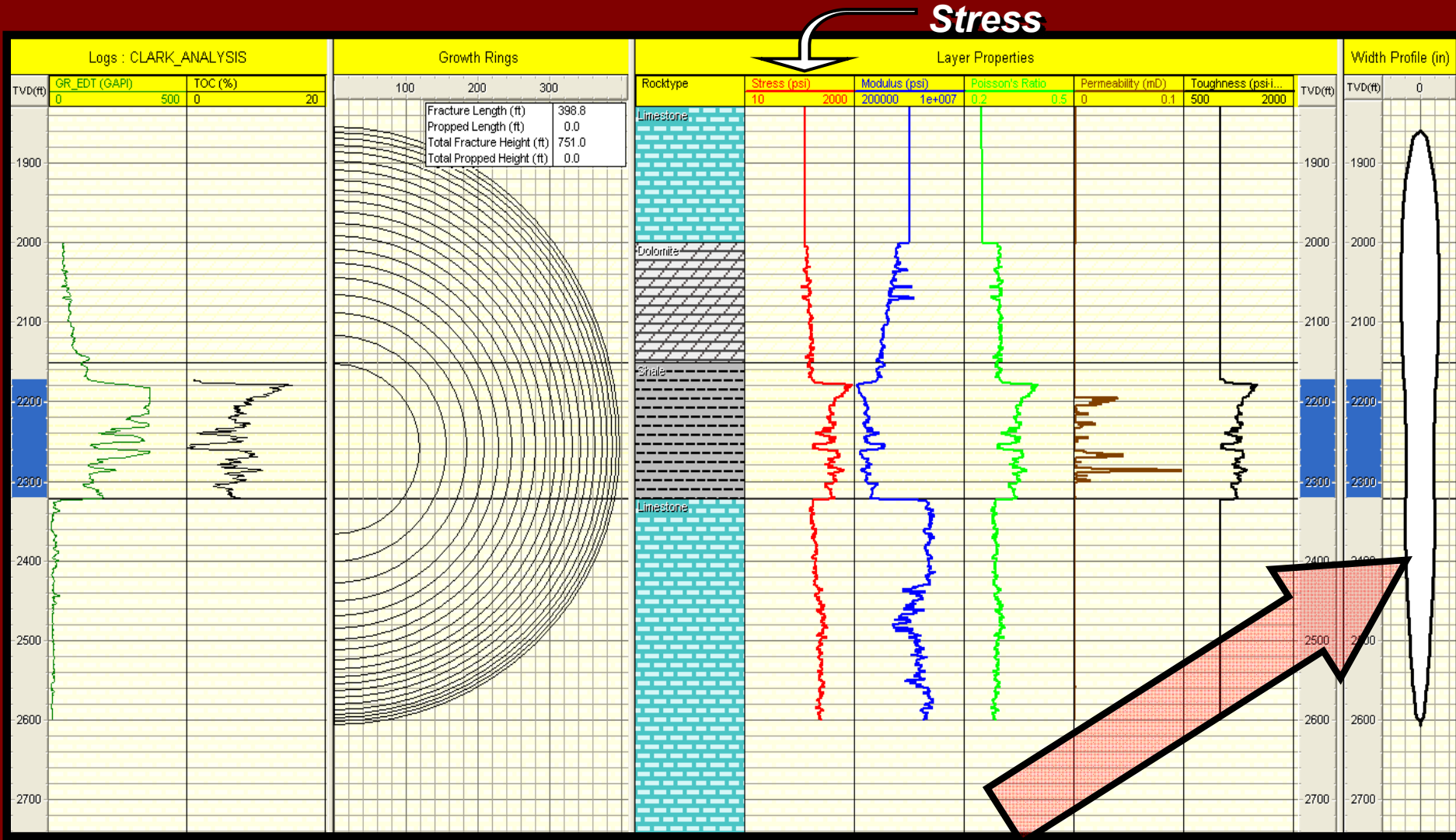
Issue 2: can industry-accepted calculation of stress from V_p & V_s adequately simulate a NAS frac?

Limited applicability & validity of industry-accepted calculation of stress from V_p & V_s

$$\nu = \frac{0.5 \left(\frac{\Delta T_{\text{comp}}}{\Delta T_{\text{shear}}} \right)^2 - 1}{\left(\frac{\Delta T_{\text{comp}}}{\Delta T_{\text{shear}}} \right)^2 - 1}$$

$$E = \rho v^2 \left(\frac{3v_c^2 - 4v_s^2}{v_c^2 - v_s^2} \right)$$

$$\sigma = \frac{\nu}{1 - \nu} \sigma_{\text{vertical}} + \alpha \frac{1 - 2\nu}{1 - \nu} p_{\text{pore}} + E_\varepsilon$$



Industry-accepted calculation of stress from V_p & V_s on a semi-soft shale results in parametric model instability

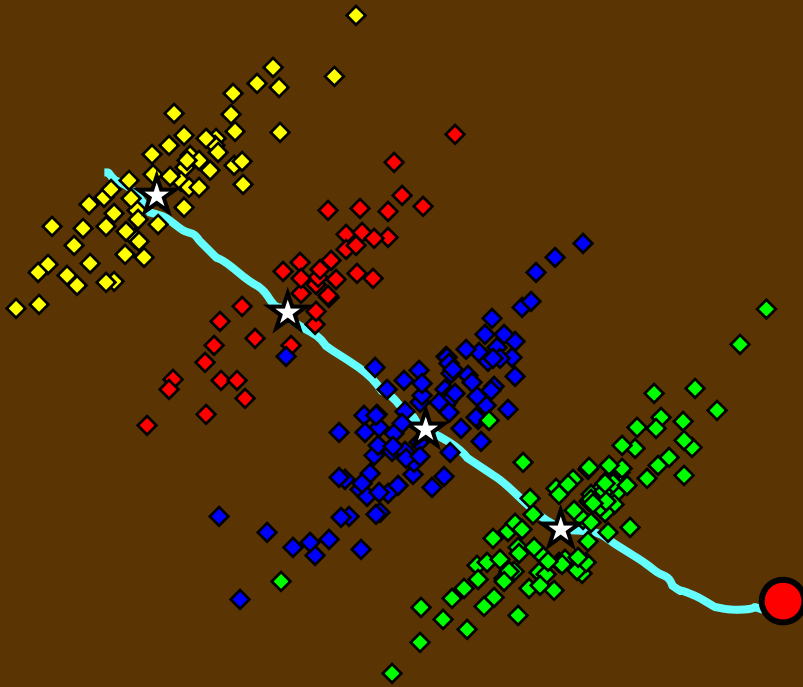
J. Ray Clark No. 1, Christian County. Thanks to Jim Lorenzen, ResTech Inc. for channel calculations



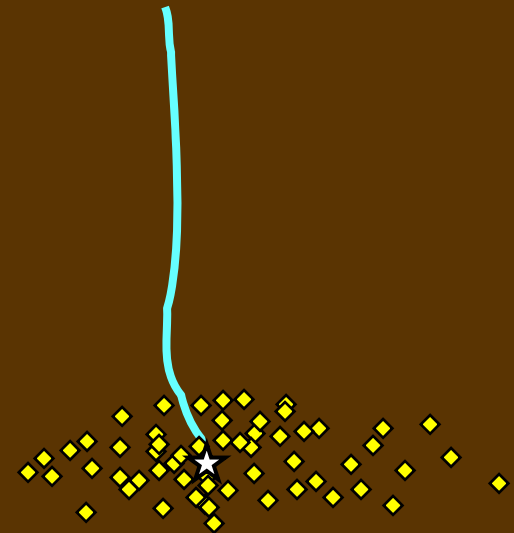
Issue 3: So, if layer and model construction from V_p & V_s is out --- is there another alternative with 3-D Parametric modeling?

Issue 3: *Alternative to layer and model construction from V_p & V_s*

Consider a side view of 1 of these stages --- then utilize a conventional GR/PE/ ϕ_e and known stresses (or net pressures) to build a calibrated model

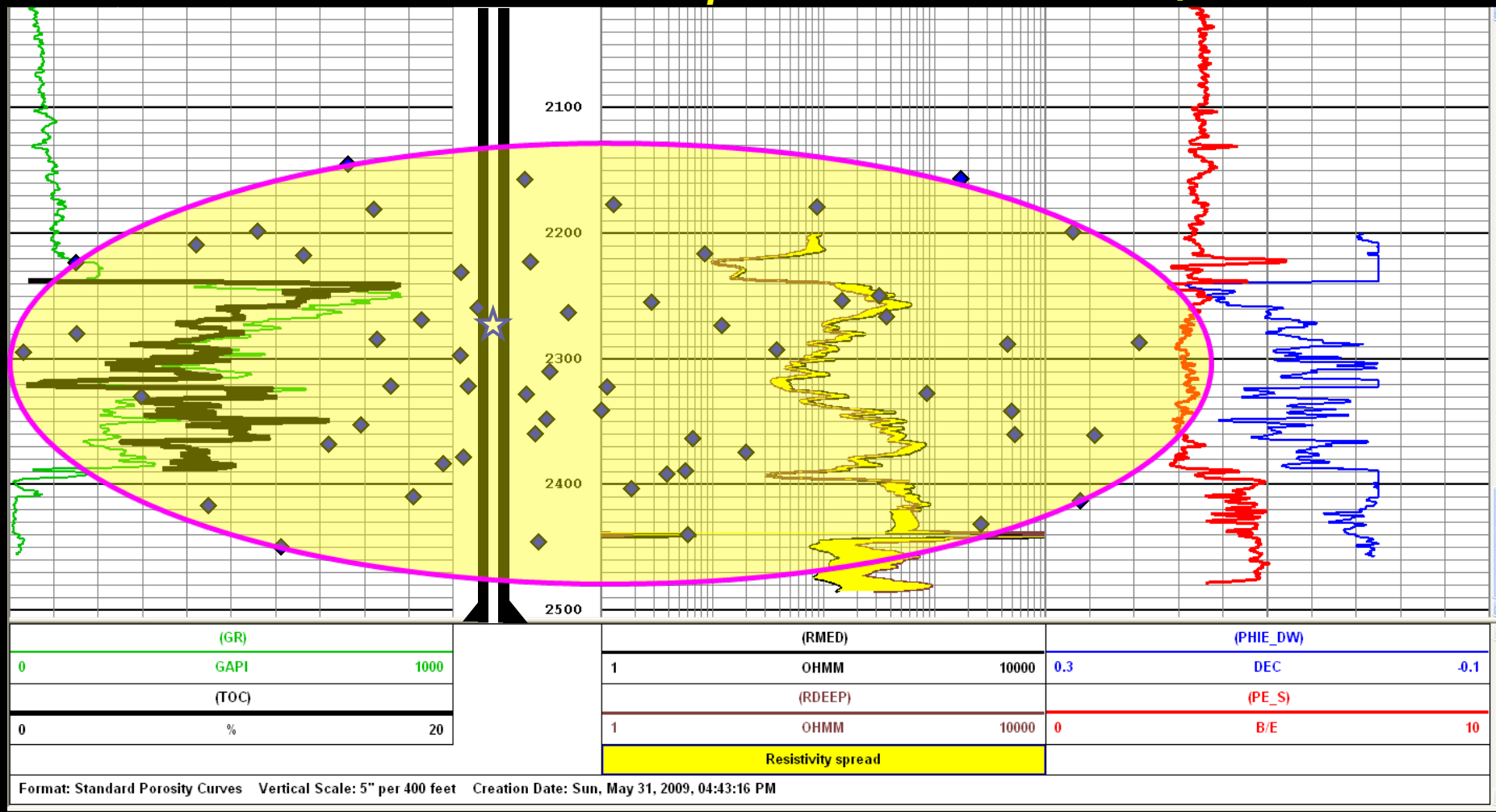


Map view (looking from above)



Side view (looking down lateral)

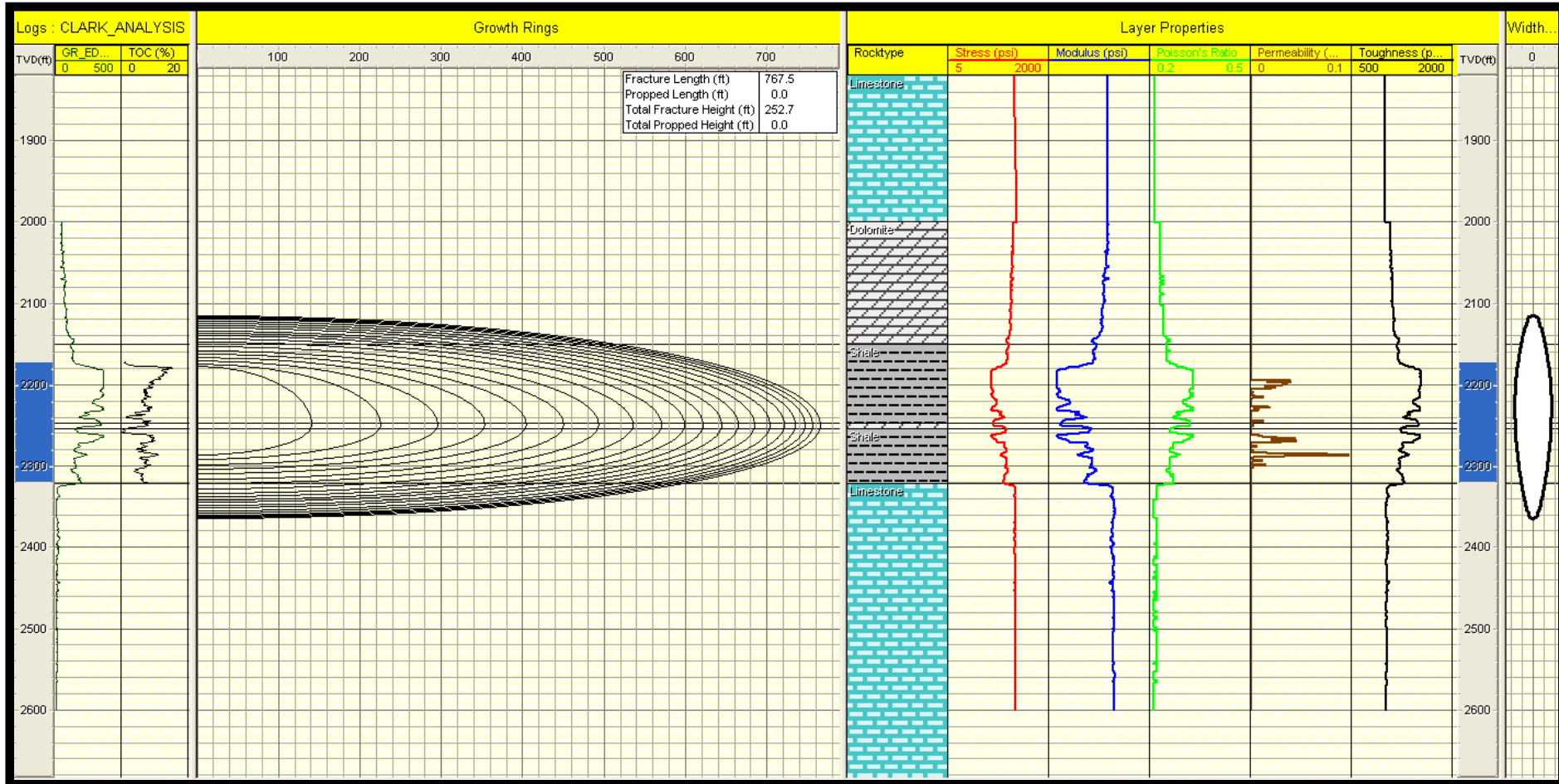
Issue 3: Alternative to layer and model construction from V_p & V_s --- GR/PE/ ϕ_e



DPI-2444-21, Haley's Mill Field, Christian County

Alternative to layer and model construction from V_p & V_s

--- Stress from GR/PE/ ϕ_e & local calibration



J. Ray Clark No. 1, Christian County.

Summary, 3-D Parametric Modeling

- > Useful when network complexity is limited
- > Stress from GR/PE/ ϕ_e & local fracture gradients may be more practical than use of industry-accepted calculations involving V_p & V_s
- > Calibrating models from microseismic monitoring results most useful and informative.

So, what's working, and what's not?

- Large waterfracs in shallow, normally pressured shale may not be viable
- Substantial experimentation with 70 – 85Q foam
 - Large foam fracs may be acceptable in terms of preventing water blockage, but generally have unacceptable μ
 - 80 – 100 times the vis of water
 - 4,000 – 5,000 times the vis of N₂
 - Low μ promotes network complexity
 - High μ promotes fracture simplicity
- Straight N₂ utilized in shallower NAS almost exclusively
- Some limited MistFracSM, Vapor Frac, and other +95Q systems experimentation
- Major paradigm shift may be necessary, as N₂ completions alone may not meet minimum production expectations to stimulate extraordinary Wall Street interest



NITROGEN
REFRIGERANT
LIQUID

KENWORTH

gti.

RPSEA
• Research
• Partnership to
• Secure Energy
• for America

 Pinnacle