# *4th Annual Ryder Scott Reserves Conference*
## *May 9, 2008*

# *"Adapting The PRMS to Unconventional Resources"*

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***Chairman Emeritus at Ryder Scott Company***

# *Disclaimer and Attributions*

- The opinions and conclusions included in this presentation are those of the presenter and are not attributable to any company or organization.
- Appreciation is extended to Kerogen Resources Inc and Rimrock Energy LLC for selected information contained herein.

# *SPE's Role In Reserves Definitions Began 46 Years Ago*


- SPE Board appointed 12-man committee in 1962 – "Special Committee On Definitions Of Proved Reserves For Property Evaluation"

- Comprised of 2 oil companies, 1 gas pipe line, 1 college professor, 2 banks, 2 insurance cos. and 4 consultants

# *Committee Members were…*

- J.J. Arps – consultant & chair
- Wm. F. Burke – Lone Star Gas
- Prof. J.M. Campbell – Oklahoma University
- D.V. Carter – Mobil
- C.R. Dodson – United California Bank
- W.S. Eggleston - Consultant
- K.M. Fagin - SW Life Insurance Co.
- C.H. Keplinger - Consultant
- J.F. King – Mutual Life Insurance Co.
- Morris Muscat – Gulf Oil
- E.G. Trostel – D&M
- W.W. Wilson – Continental Illinois Bank

# *SPE's Role Began 46 Years Ago – cont.*

- In June 1965, definitions approved by SPE Board (with API concurrence; AGA objected)
- Board Vote:  7 yes, 3 no, 2 abstained

# Key sentence in 1965 definitions

- PROVED RESERVES – The quantities of crude oil, natural gas and natural gas liquids which geological and engineering data demonstrate with reasonable certainty to be recoverable in the future from known oil and gas reservoirs under existing economic and operating conditions. ***They represent strictly technical judgments, and are not knowingly influenced by attitudes of conservatism or optimism.***

# WHAT'S NEW IN THE 2007 PRMS DEFINITIONS?

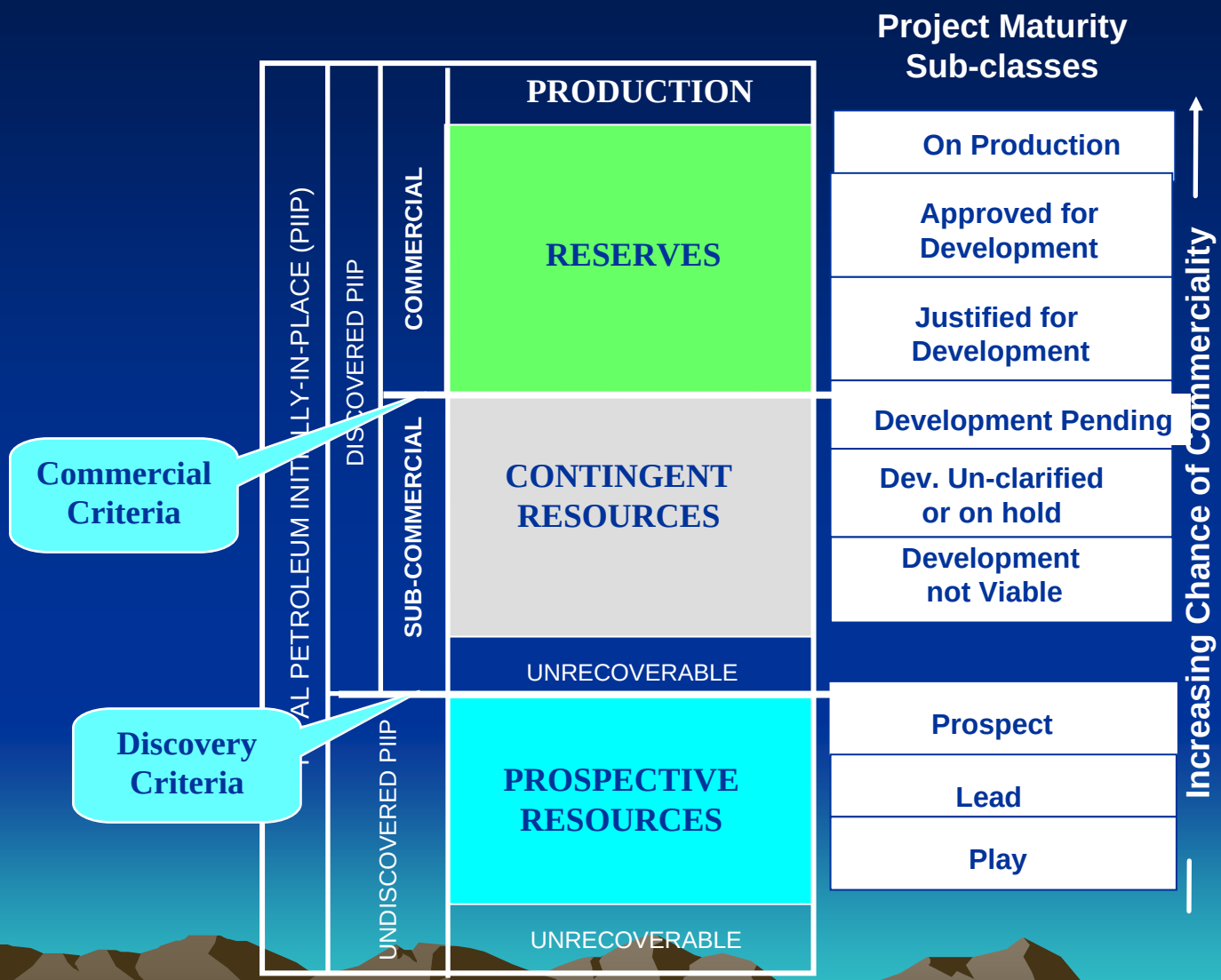
- **SYSTEM IS "PROJECT BASED"**
- ***RESOURCES "CLASSIFICATION" IS BASED ON COMMERCIALITY***
- ***RESERVES "CATEGORIZATION" IS BASED ON UNCERTAINTY OF RECOVERY***
- **PRICES AND COSTS BASED ON FORECAST CONDITIONS**
- ***RECOGNITION OF UNCONVENTIONAL RESOURCES AND RESERVES***
- ***EXPANDED SECTION ON "ANALOGS"***
- **GUIDANCE ON "BOOKING (REFERENCE) POINT"**

# ALL HYDROCARBON RESOURCES …..

Follow the same general estimation template:

- Rock volume
- Hydrocarbons in place
- Development plan and execution
- Capital funding for extraction methodology
- Operating costs (including taxes)
- Commercial recovery efficiency
- Predicted production profile
- Cash flow projections

# Sub-classify by Project Maturity



# *"JUSTIFIED FOR DEVELOPMENT"*

- "Implementation of the development project is justified on the basis of reasonable forecast commercial conditions at the time of reporting and that there are reasonable expectations that all necessary approvals/contracts will be obtained. A project maturity sub-class that reflects the actions required to move a project forward toward commercial production. "

  ( PRMS Glossary – Appendix A)

# PRMS Definition of UNCONVENTIONAL RESOURCES

Unconventional resources exist in petroleum accumulations that are pervasive throughout a large area and that are not significantly affected by hydrodynamic influences (also called “continuous-type deposits”). Examples include coal bed methane (CBM), basin-centered gas, shale gas, gas hydrates, natural bitumen, and oil shale deposits. Typically, such accumulations require specialized extraction technology (e.g., dewatering of CBM, massive fracturing programs for shale gas, steam and/or solvents to mobilize bitumen for in-situ recovery, and in some cases, mining activities). Moreover, the extracted petroleum may require significant processing prior to sale (e.g., bitumen upgraders).

# PRMS Unconventional Resources "words of guidance" – 1/3

For these petroleum accumulations that are not significantly affected by hydrodynamic influences, reliance on continuous water contacts and pressure gradient analysis to interpret the extent of recoverable petroleum may not be possible. Thus, there typically is a need for *increased sampling density* to define uncertainty of in-place volumes, variations in quality of reservoir and hydrocarbons, and their detailed spatial distribution to support detailed design of specialized mining or in-situ extraction programs.

# PRMS Unconventional Resources "words of guidance" – 2/3

It is intended that the resources definitions, together with the classification system, will be appropriate for all types of petroleum accumulations regardless of their in-place characteristics, extraction method applied, or degree of processing required

# PRMS Unconventional Resources "words of guidance" – 3/3

Similar to improved recovery projects applied to conventional reservoirs, successful pilots or operating projects in the subject reservoir or successful projects in *analogous reservoirs may be required to establish a distribution of recovery efficiencies for non-conventional accumulations*. Such pilot projects may evaluate both extraction efficiency and the efficiency of unconventional processing facilities to derive sales products prior to custody transfer.

# ANALOGS

- 4.1.1 Analogs

- Analogs are widely used in resources estimation, particularly in the exploration and early development stages, where direct measurement is limited. The methodology is based on the assumption that the analogous reservoir is *comparable* to the subject reservoir regarding *reservoir* and fluid properties that control ultimate recovery of petroleum. By selecting *appropriate* analogs, where performance data based upon comparable development plans (including well type, well spacing and stimulation) are available, a similar production profile may be forecast.

# ANALOGS – cont'd.

- Analogs are defined by features and characteristics including, but not limited to, approximate depth, pressure, temperature, reservoir drive mechanism, original fluid content, reservoir fluid gravity, reservoir size, gross thickness, pay thickness, net-to-gross ratio, *lithology, heterogeneity,* porosity, permeability and development plan. Analogous reservoirs are formed by the same, or very similar, processes with regard to sedimentation, diagenesis, pressure, temperature, *chemical and mechanical* history and structural deformation.
- Cont'd

# ANALOGS – cont'd

- Comparison to several analogs may improve the range of uncertainty in estimated recoverable quantities from the subject reservoir. While reservoirs in the same geographical area and of the same age typically provide better analogs, such proximity alone may not be the primary consideration. In ALL CASES, evaluators should *document* the similarities and differences between the analog and the subject reservoir/project. Review of analog performance is useful in quality assurance of resource assessments at all stages of development.

# What's Missing in "SPE Analogs" for Unconventional Reservoirs?

Maybe terms like:

- Organic richness
- Thermal maturity
- Depth & geological age
- TOC
- Vitrinite reflectance
- Poisson's ratio
- Stress profiles
- Brittleness
- Roughness
- Sorption Isotherms
- Seals
- Completion efficiency

Terms not applicable:

- Contacts
- Lowest Known Hydrocarbons
- Drive mechanisms
- Saturations(?)
- Net pay(?)
- Structural position

# *UNCONVENTIONAL PUDs*

- US SEC – “one offset” rule, firm operator commitment
- SPE PRMS – “justified” in the opinion of the evaluator supported by adequate evidence (Think P-90)
- PUD locations should be defensible using adequate data, including rock info, analogs plus high confidence in drilling *and* completion efficiency. 3-D Seismic and micro seismic may be desirable.
- PUD locations should not be contingent upon success of any other PUD location
- Reservoir simulation is excellent reservoir analysis methodology but may not be the best reserves tool
- *PUDs may be best handled through multi-well projects particularly in gas shales because of frac efficiency.*

# *A BRIEF LOOK AT GAS SHALES*

- *…..Particularly some Barnett Shale examples to generate your interest and thoughts……*

# Considerations in Gas Shale Candidate Selection – *Creating a "reservoir" out of a virtually impervious container*

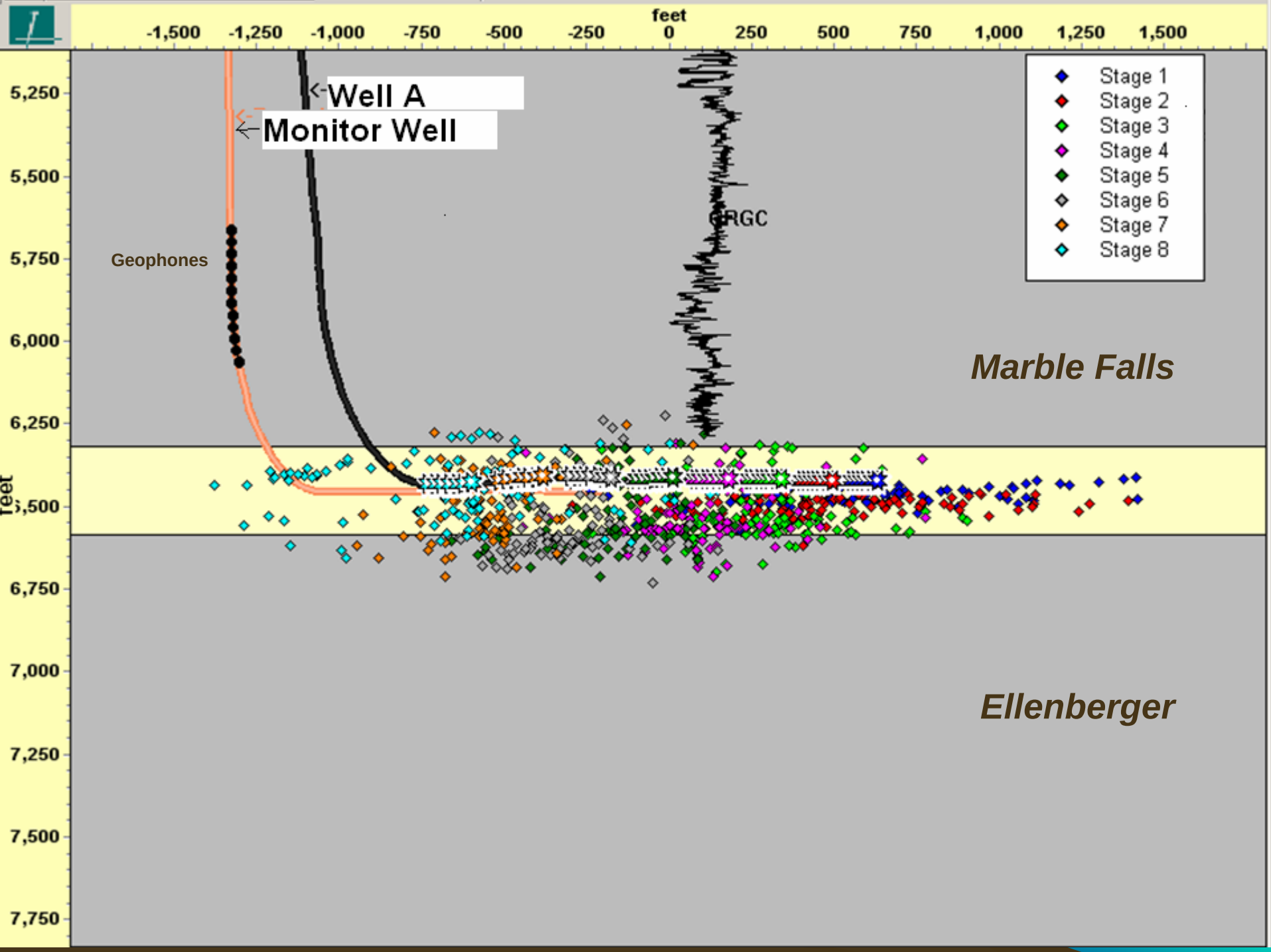
- Effect of matrix modulus and Poisson's ratio.
- Stress effects on fractures remaining open.
- Effect of associated and unassociated oils.
- Effects that create a *Rubblized* drainage volume.
- Location of faults, bedding planes, stresses, frac breakdown pressures, maturity variations, pore pressure, structures, frac barriers, kerogen types/development and water sources.

# *What does micro-seismic really tell you?*

- Location trends of sounds (micro-bursts/mini-earthquakes) in the rock that are above a certain energy (the gate level).
- There are high and low energy events and high and low confidence events.
- A decent view of fracture extension, fracture direction, fracture isolation, upper and lower frac penetration, and fracture “flow path” development.
- In some cases, it can tell you the effect of near-field and far-field stresses, bedding planes and faults.
- M-S can confirm complex rock fracturing.
- There are also sounds totally unconnected with a frac.
- Can we use this to estimate rock volume for reserves estimation?

# *TWO BARNETT SHALE FRAC EXAMPLES - April 2008*

- Names are redacted
- Simplified display format
- Presented only for limited discussion purposes
- Your “general” questions are encouraged


feet
-1,500
-1,250
-1,000
-750
-500
-250
0
250
500
750
1,000
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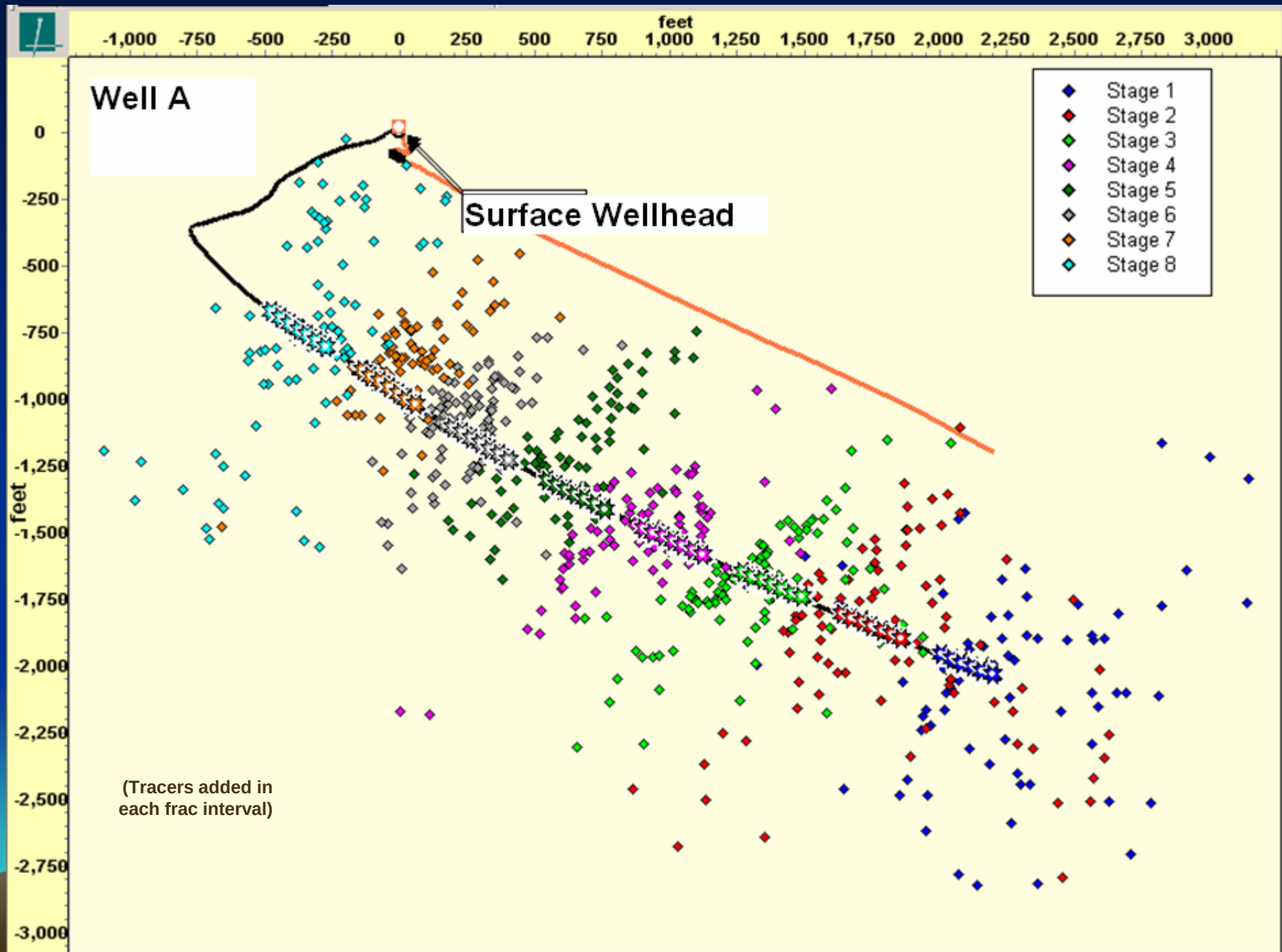
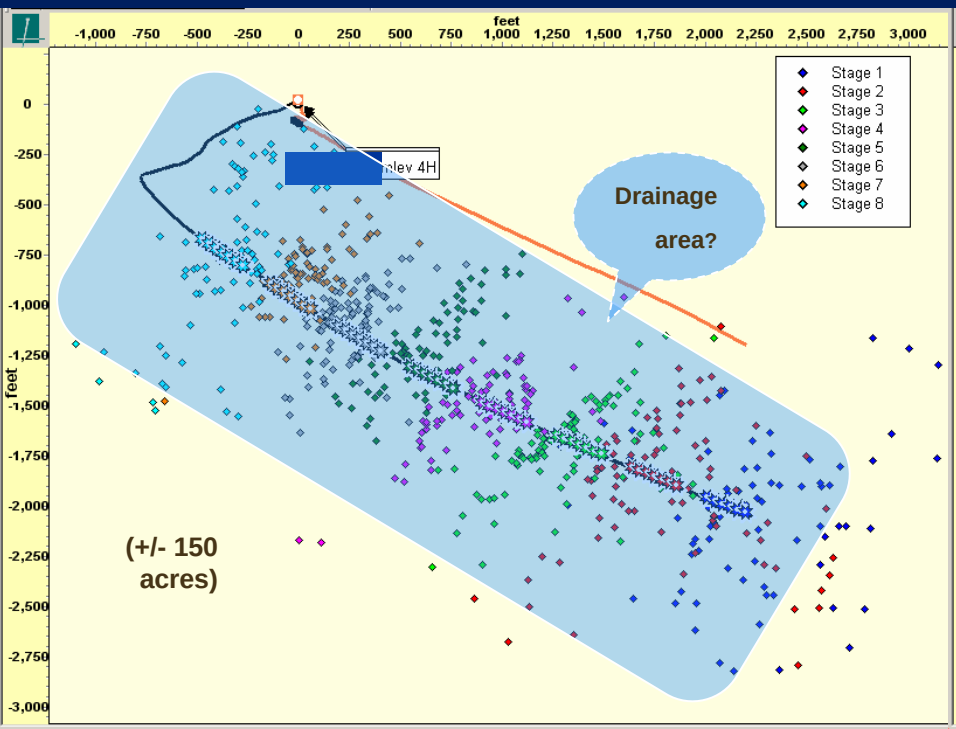
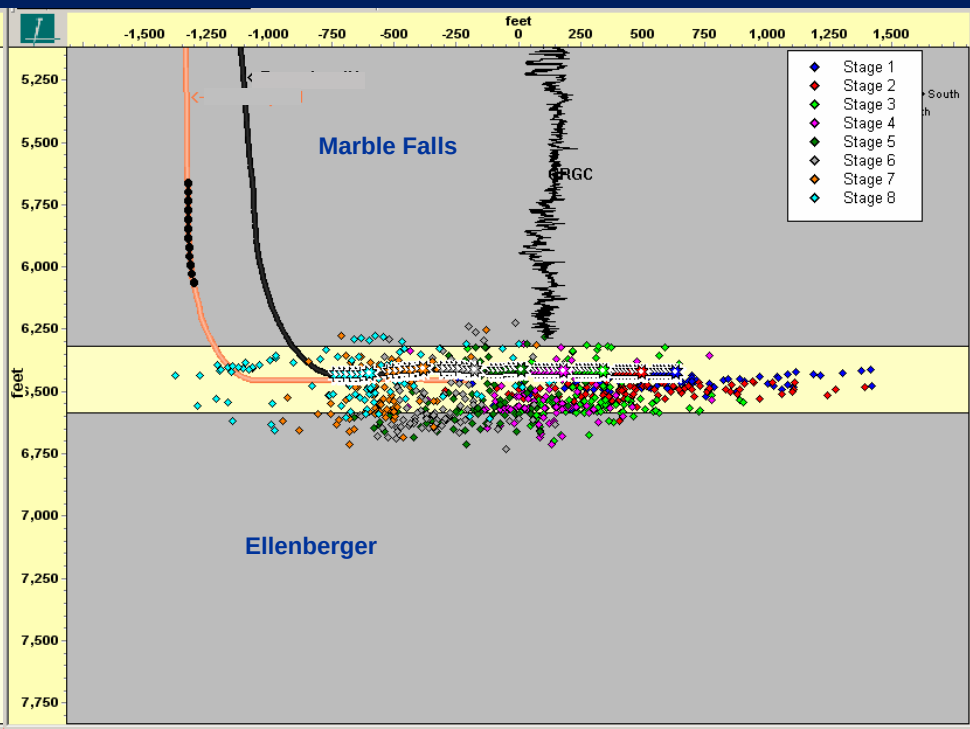
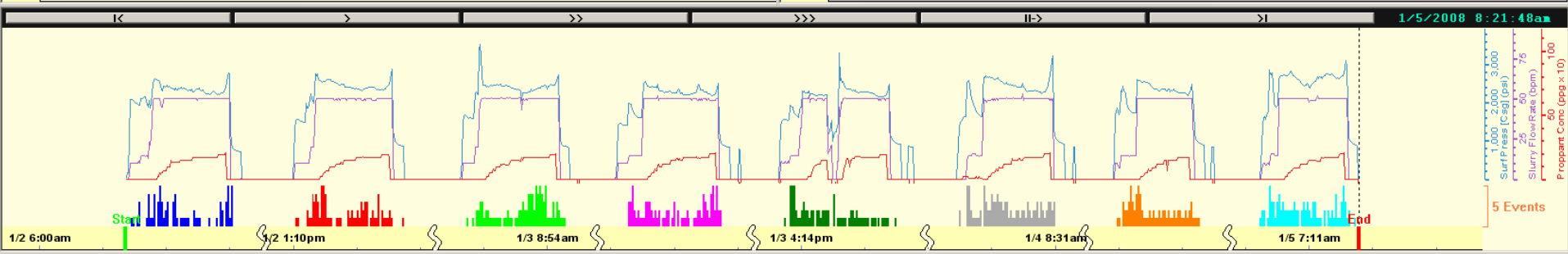
1,500
5,250
5,500
5,750
6,000
6,250
6,500
6,750
7,000
7,250
7,500
7,750
Well A
Monitor Well
GRGC
Geophones
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Stage 6
Stage 7
Stage 8
Marble Falls
Ellenberger


feet
-1,000 -750 -500 -250 0 250 500 750 1,000 1,250 1,500 1,750 2,000 2,250 2,500 2,750 3,000
Well A
Surface Wellhead
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Stage 6
Stage 7
Stage 8
feet
0 -250 -500 -750 -1,000 -1,250 -1,500 -1,750 -2,000 -2,250 -2,500 -2,750 -3,000
(Tracers added in each frac interval)

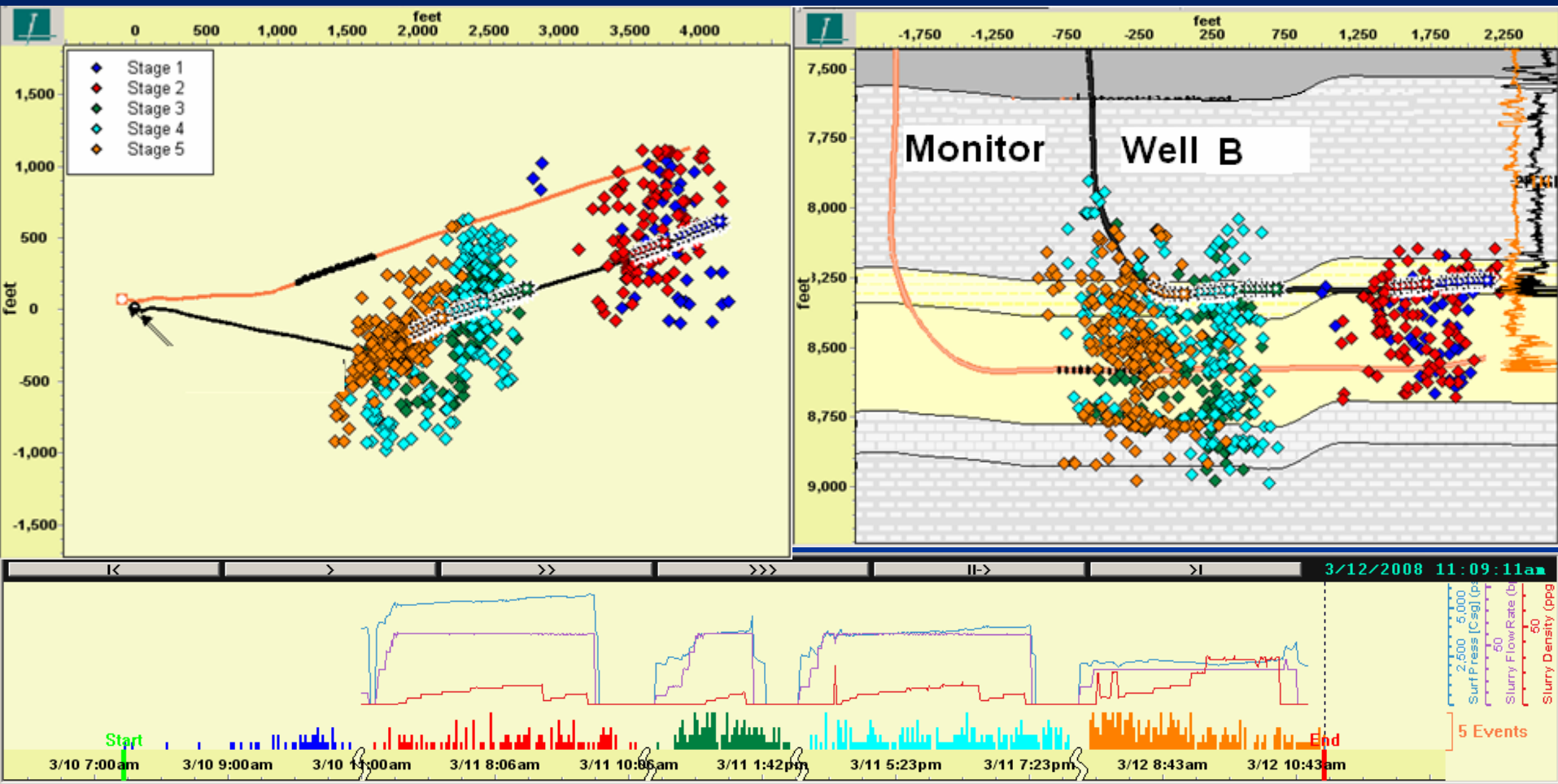
# Micro-Seismic Views - Static



# Another Well……
# And the drainage area is…..?



# THANKS FOR LISTENING

- Questions?
- Comments?
- Arguments?