Kansas Geophysics in the 21st Century

Kansas Geological Survey

Berexco, Inc.

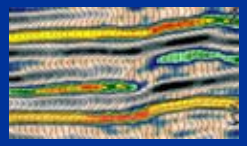
US DOE

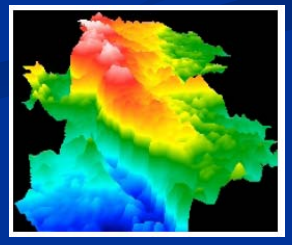
Contract FE-002056

Wellington – Anson Bates Fields

3D Seismic P-Wave Analysis

October 29, 2010





Hedke-Saenger Geoscience LTD

Project Participants

KU KANSAS GEOLOGICAL SURVEY
The University of Kansas

U.S. DEPARTMENT OF ENERGY

DEPARTMENT OF GEOLOGY
KANSAS STATE UNIVERSITY

KU THE UNIVERSITY OF KANSAS
Department of Geology

BEREXCO

PARAGON
GEOPHYSICAL SERVICES, INC

fairfieldnodal

noble energy

LOCKHART GEOPHYSICAL

ECHO GEOPHYSICAL CORPORATION
INTEGRITY-STABILITY-INNOVATION

HALLIBURTON

HEDKE-SAENGER GEOSCIENCE, LTD

Bittersweet Energy Inc.

Petrotek

Charter Consulting
Integrated Geology & Geophysics

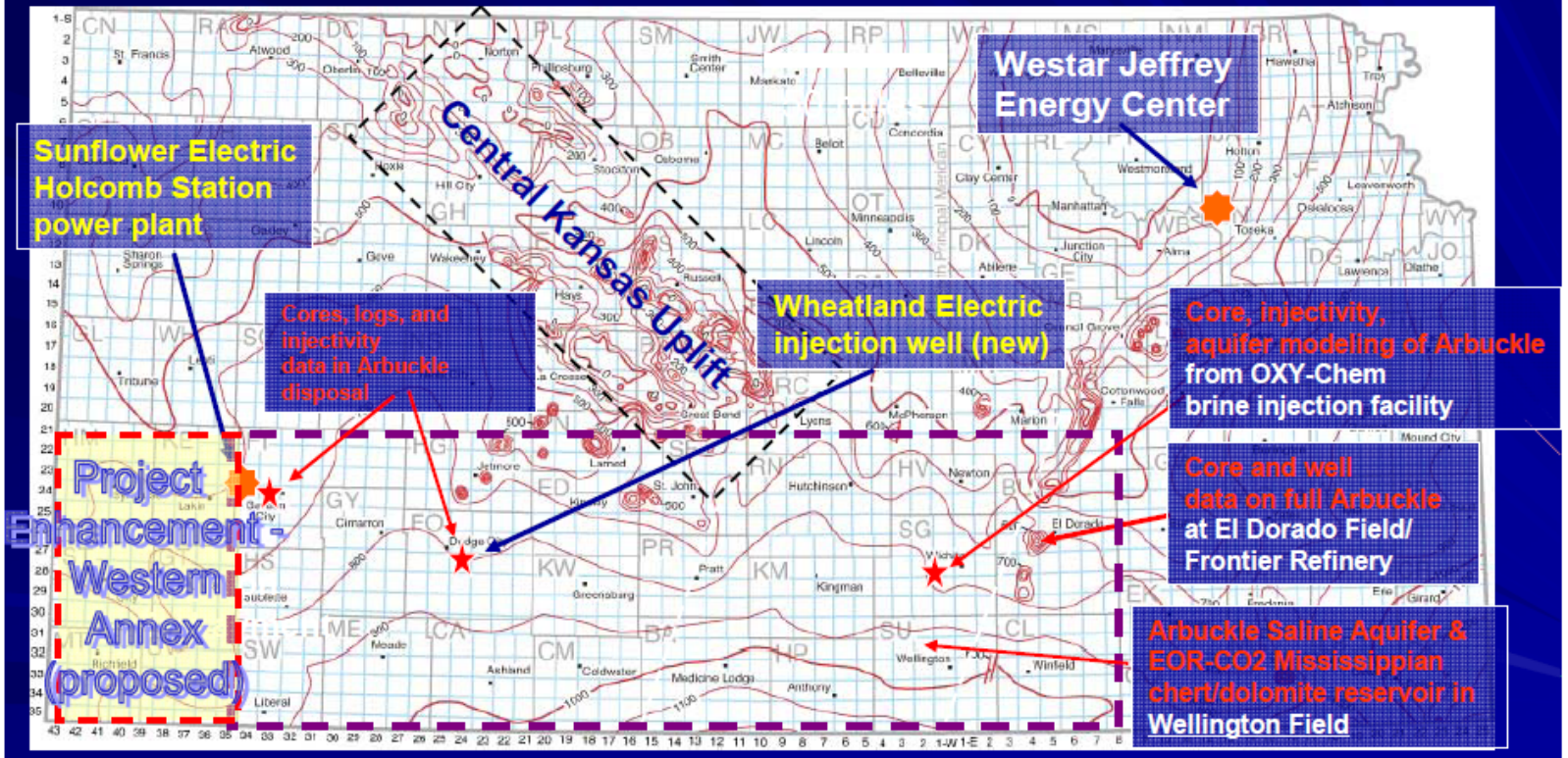
KOGER
REMOTE SENSING

LOGDIGI
A LEADING CONSULTING COMPANY

Regional Scope

DOE-CO2 Project Study Area

Wellington Field (Sumner County) + 17+ Counties



Contours = thickness of Arbuckle Group (100 ft C.I.)

Regional study → ~20,000 sq. miles

50 miles

Wellington Field – Analytical Elements

- Multi-Component 3D Seismic Acquisition (Paragon Geophysical)

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- Gravity Data Acquisition & Processing (Lockhart Geophysical / Allen Cogbill)

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- Magnetic Data Acquisition & Processing (Lockhart Geophysical)
- P-Wave Seismic Processing (Echo Geophysical, FairfieldNodal)
- Converted Wave Seismic Processing (FairfieldNodal)

Wellington Field – Analytical Elements

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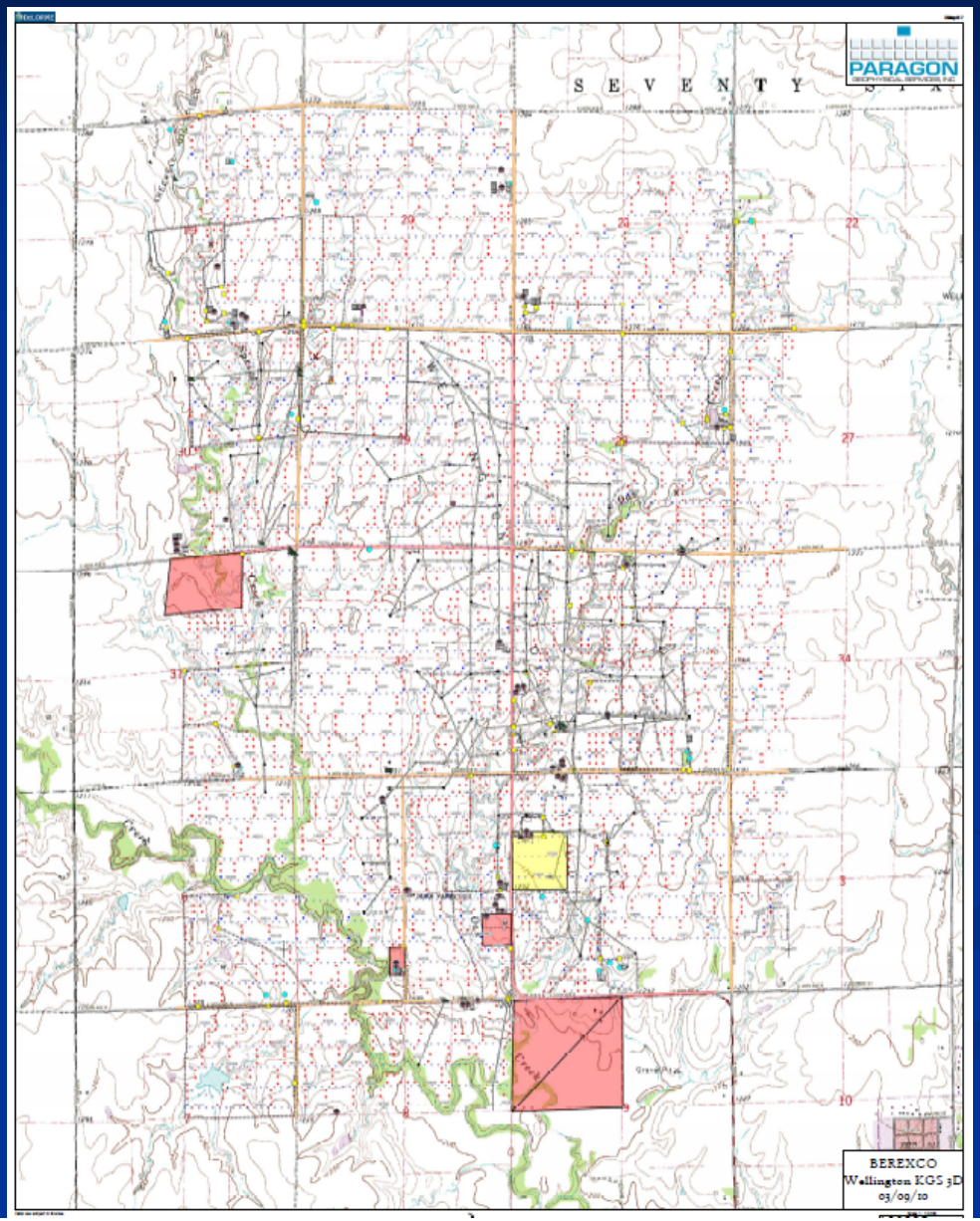
- Gravity Data Acquisition & Processing (Lockhart Geophysical)
- Magnetic Data Acquisition & Processing (Lockhart Geophysical)
- P-Wave Seismic Processing (Echo Geophysical, FairfieldNodal)
- Converted Wave Seismic Processing (FairfieldNodal)
- 2D Shear Wave Acquisition / Processing (Paragon Geophysical) / (FairfieldNodal)

3D Multi-Component Acquisition Design

- Active channels per VP: 1152
- Active Receiver Lines: 18, 9 on either side of VP
- Channels per line: 64, Single 3C digital phones
- Receiver Interval: 165 ft
- Receiver Line Interval: 495 ft
- Energy Source: 2-60,000# Vibrators
- Source Interval: 165 ft
- Source Line Interval: 660 ft
- Total receivers: 3831
- Total Sources: 2811
- Subsurface Image/VP: 3.11 sq mi (10,331 ft x 8,415 ft)
- Maximum offset: 13,324 ft
- Production Sweep: 6-150 Hz, 3dB, 2x40 sec, 3 sec listen
- Total Acquisition Time: 38 days (~73 VP's/day)

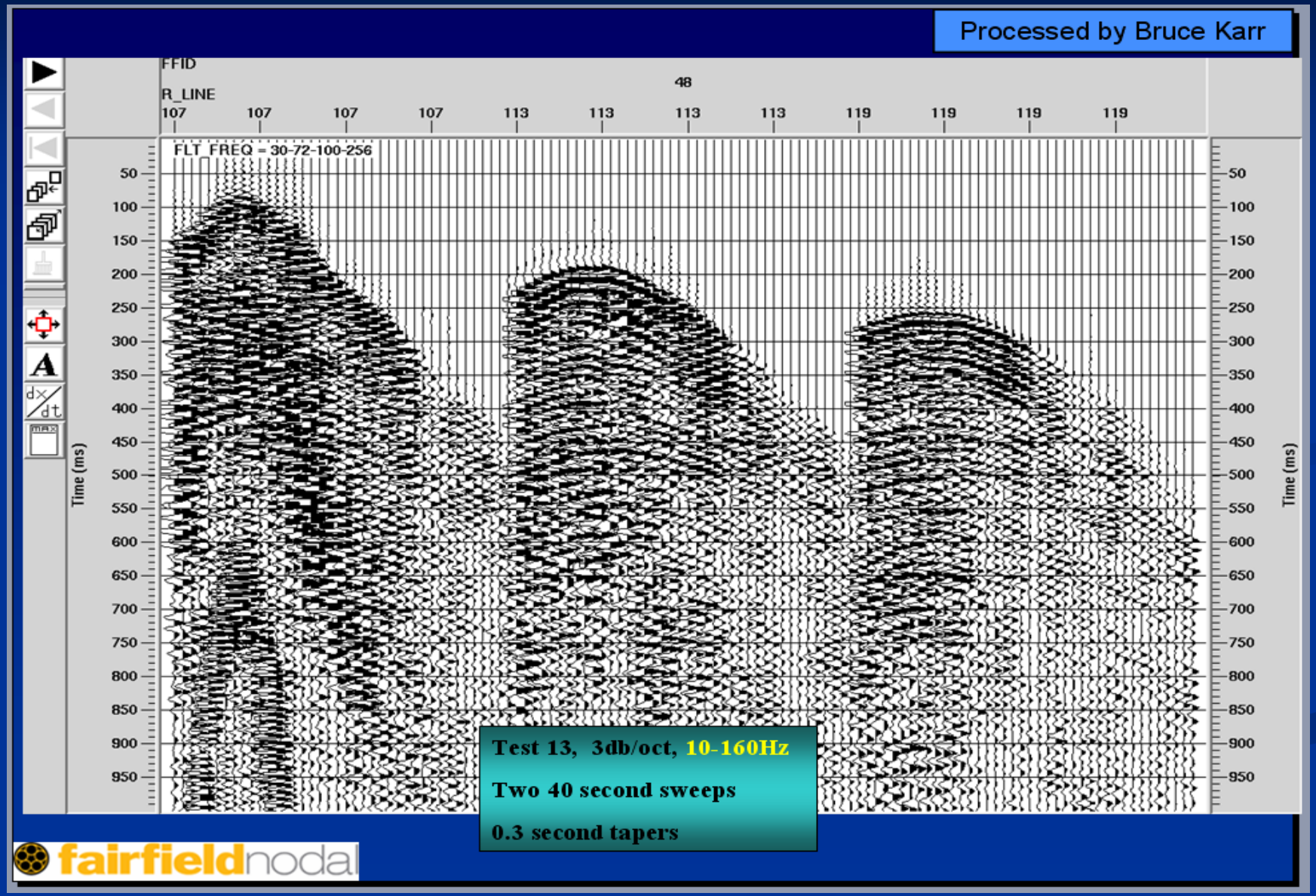
3D Multi-Component Acquisition Field Layout



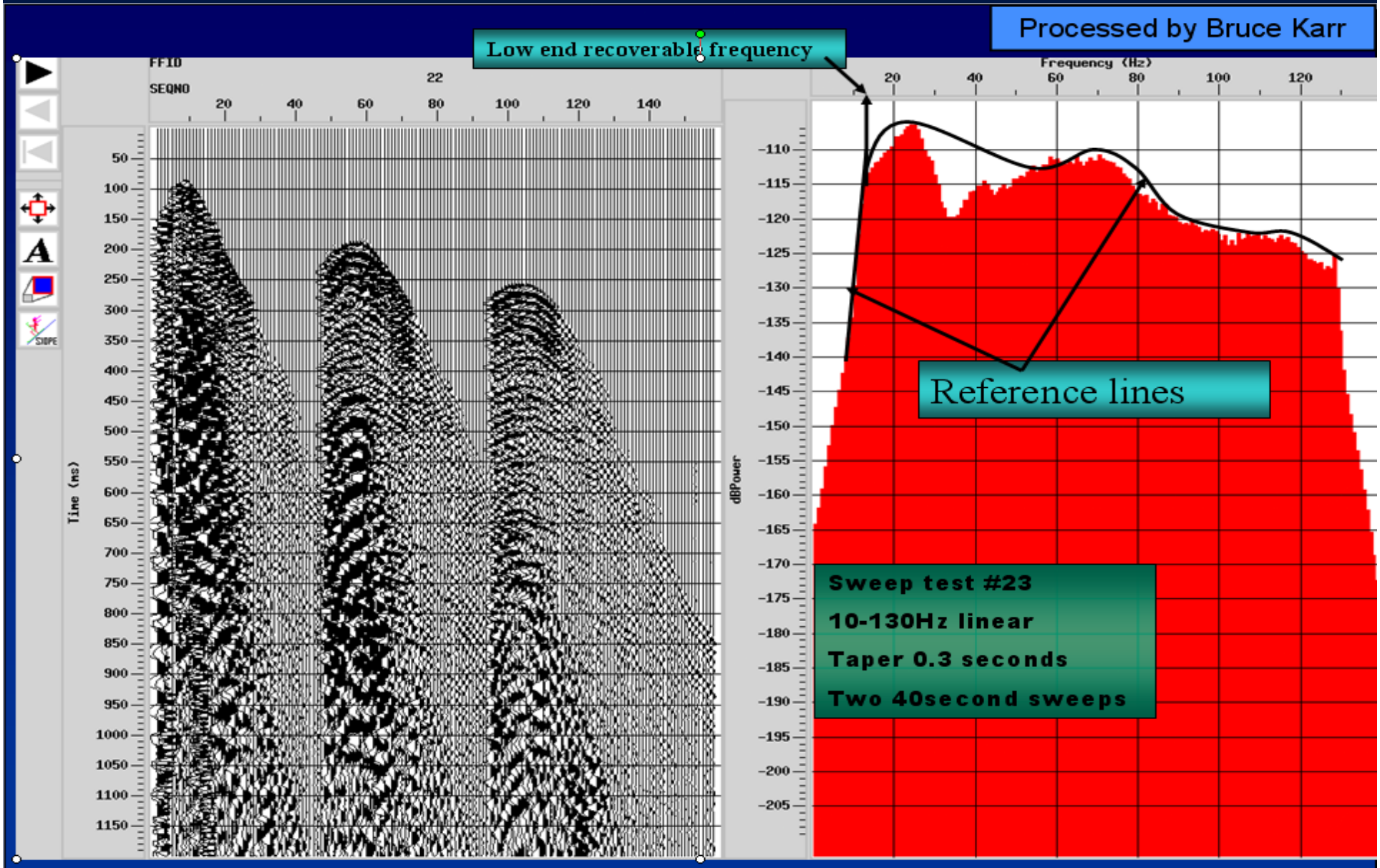
Field Test Schedule

Sweep Tests			Wellington 3D					
			February 18, 2010					
Number of Vibs Vary			Revision 1					
Listen time 3 sec								
Start Taper = varies			3D3C P-Wave					
End Taper .300 sec								
Number of Vibs	File #	Test #		Sweep Frequencies	Sweep Length	# of Sweeps	Low end Taper Length	High end Taper Length
Low end Frequency tests & sweep length								
2 vib	?	1	(+3db/oct)	Sweep 10-130	10 Seconds	8	0.3 Seconds	0.3 Seconds
2 vib	?	2	(+3db/oct)	Sweep 10-130	20 Seconds	4	0.3 Seconds	0.3 Seconds
2 vib	?	3	(+3db/oct)	Sweep 10-130	20 Seconds	4	0.6 Seconds	0.3 Seconds
2 vib	?	4	(+3db/oct)	Sweep 10-130	20 Seconds	4	1.2 Seconds	0.3 Seconds
2 vib	?	5	(+3db/oct)	Sweep 10-130	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	6	(+3db/oct)	Sweep 10-130	40 Seconds	2	0.6 Seconds	0.3 Seconds
2 vib	?	7	(+3db/oct)	Sweep 10-130	40 Seconds	2	1.2 Seconds	0.3 Seconds
2 vib	?	8	(+3db/oct)	Sweep 10-130	40 Seconds	2	2.4 Seconds	0.3 Seconds
High Frequency tests								
2 vib	?	9	(+3db/oct)	Sweep 10-110	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	10	(+3db/oct)	Sweep 10-120	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	11	(+3db/oct)	Sweep 10-140	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	12	(+3db/oct)	Sweep 10-150	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	13	(+3db/oct)	Sweep 10-160	40 Seconds	2	0.3 Seconds	0.3 Seconds
Test number of vibs								
1 vib	?	14	(+3db/oct)	Sweep 10-130	40 Seconds	2	0.3 Seconds	0.3 Seconds
3 vib	?	15	(+3db/oct)	Sweep 10-130	40 Seconds	2	0.3 Seconds	0.3 Seconds
4 vib	?	16	(+3db/oct)	Sweep 10-130	40 Seconds	2	0.3 Seconds	0.3 Seconds
Test db/octs								
2 vib	?	17	(+1db/oct)	Sweep 10-120	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	18	(+1db/oct)	Sweep 10-130	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	19	(+1db/oct)	Sweep 10-140	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	20	(+5db/oct)	Sweep 10-120	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	21	(+5db/oct)	Sweep 10-130	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	22	(+5db/oct)	Sweep 10-140	40 Seconds	2	0.3 Seconds	0.3 Seconds
Additional Low Frequency Test								
2 vib	?	23	Linear	Sweep 10-130	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	24	(+3db/oct)	Sweep 6-130	40 Seconds	2	0.3 Seconds	0.3 Seconds
2 vib	?	25	Linear	Sweep 6-130	40 Seconds	2	0.3 Seconds	0.3 Seconds

Representative Field Record



Field Record – Frequency Analysis



Gravity Data to Estimate Near Surface Density / Velocity

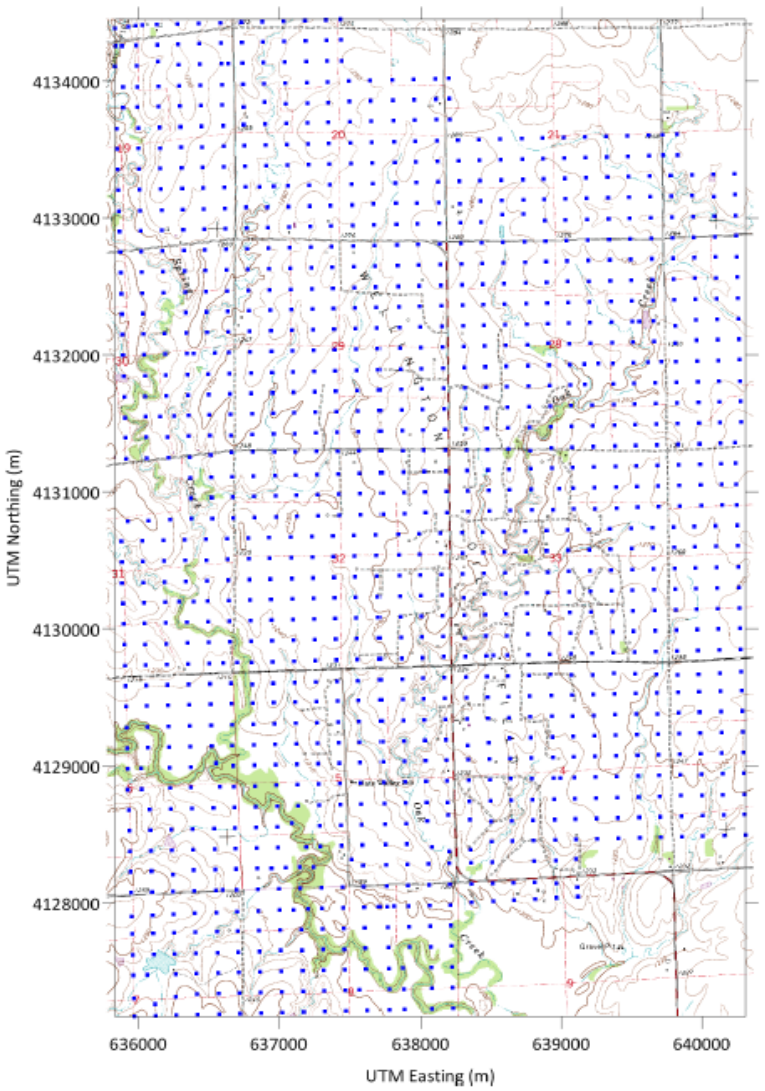


Figure 2: Map showing the locations of the 1290 gravity stations acquired during the Wellington survey.

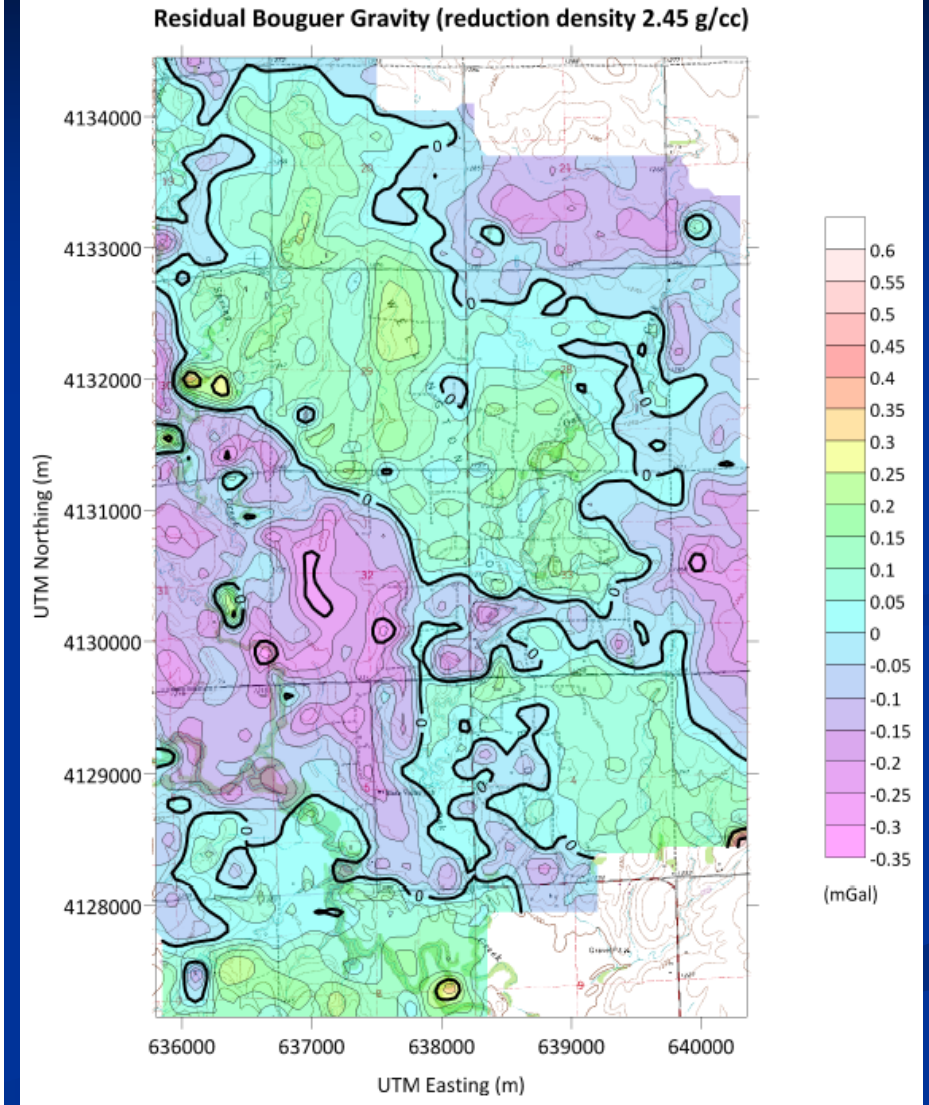


Figure 4: Contour map of the residual Bouguer gravity anomaly (contour interval 0.05 mGal), calculated by subtracting a least-squares plane from the observed Bouguer gravity anomaly.

Courtesy Lockhart Geophysical / Allen Cogbill – Geophysical Software

Estimated Near Surface Densities / Velocities

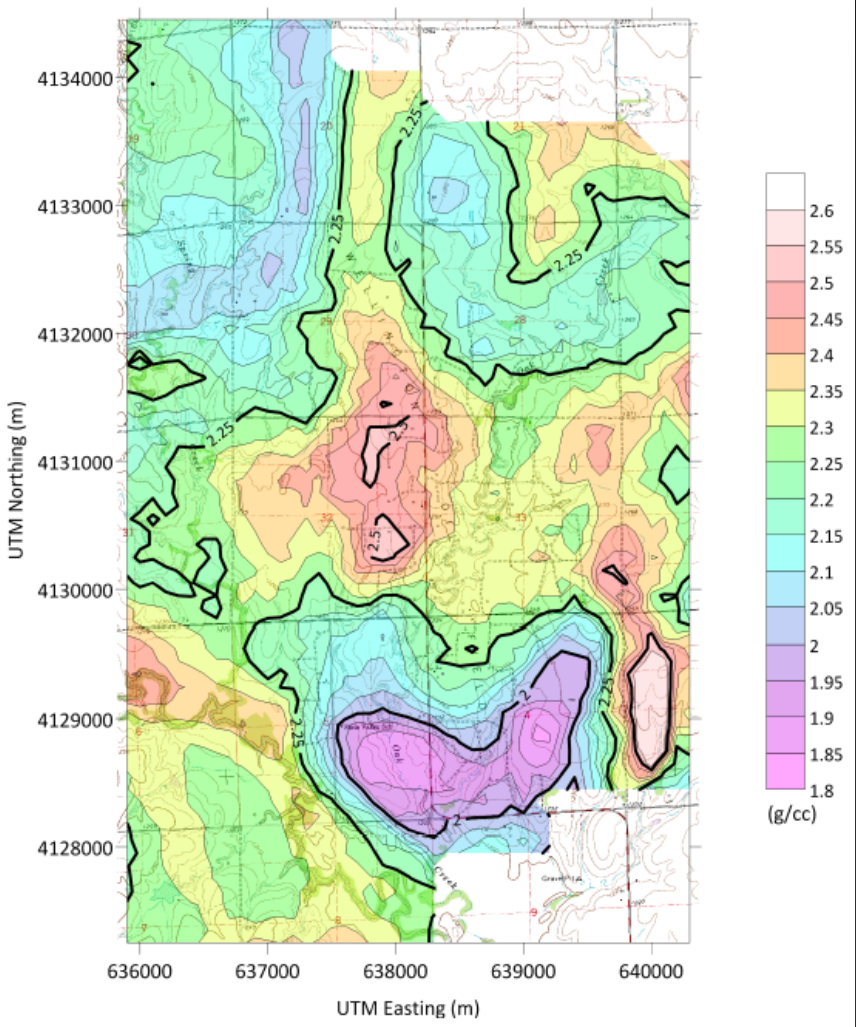


Figure 5: Color contour map of the estimated near-surface densities for the Wellington survey. Contour interval 0.05 g/cc.

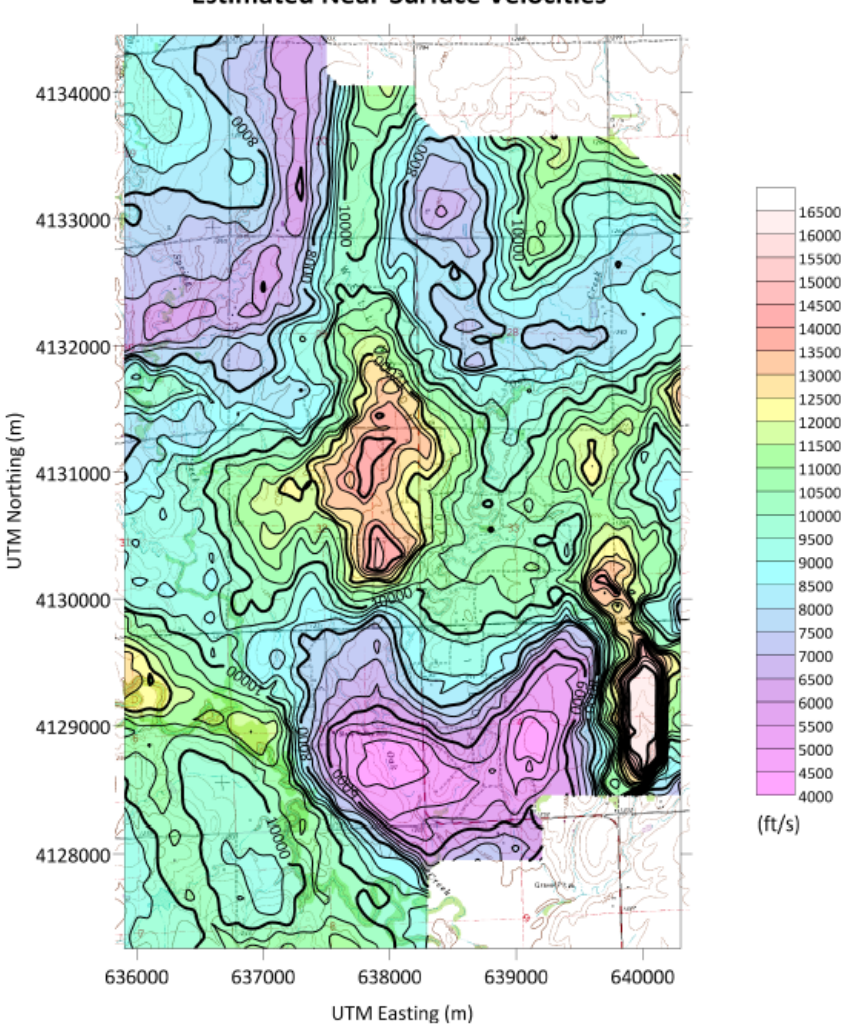
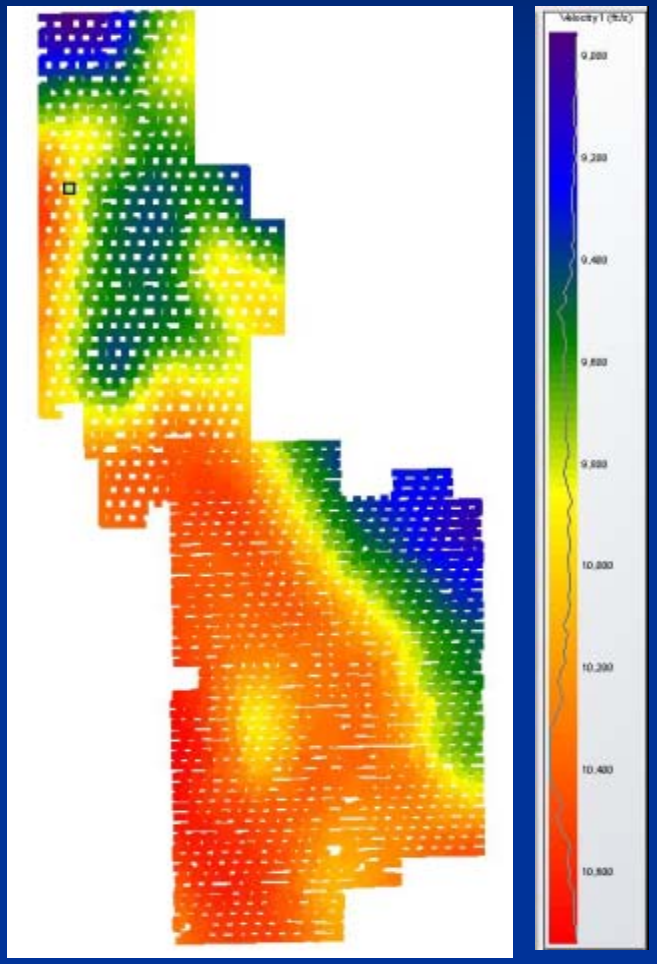


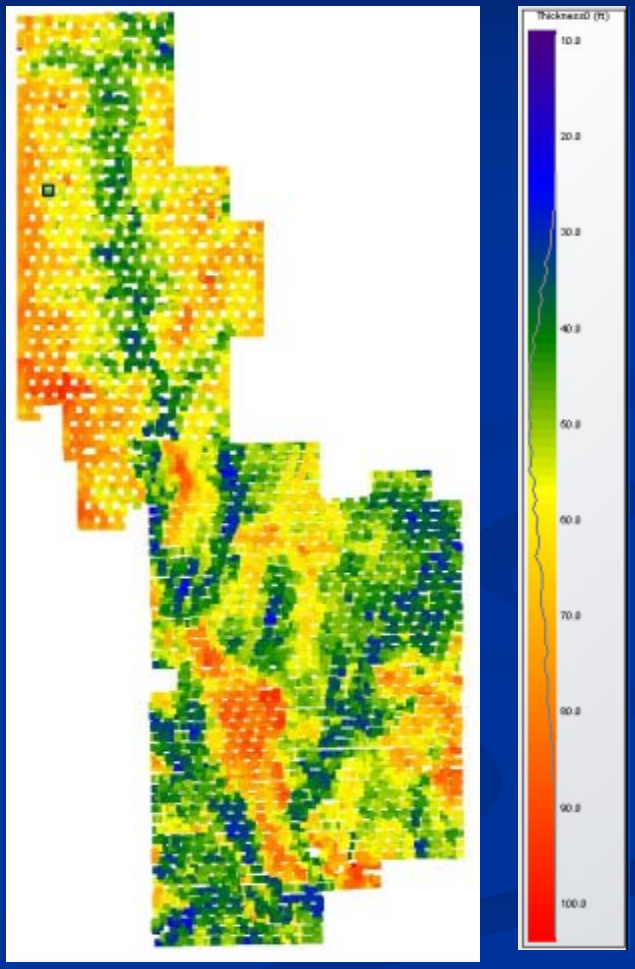
Figure 6: Color contour map of the estimated near-surface velocities for the Wellington survey. Contour interval 500 ft/s.

Noble Energy Merge-Refraction Statics

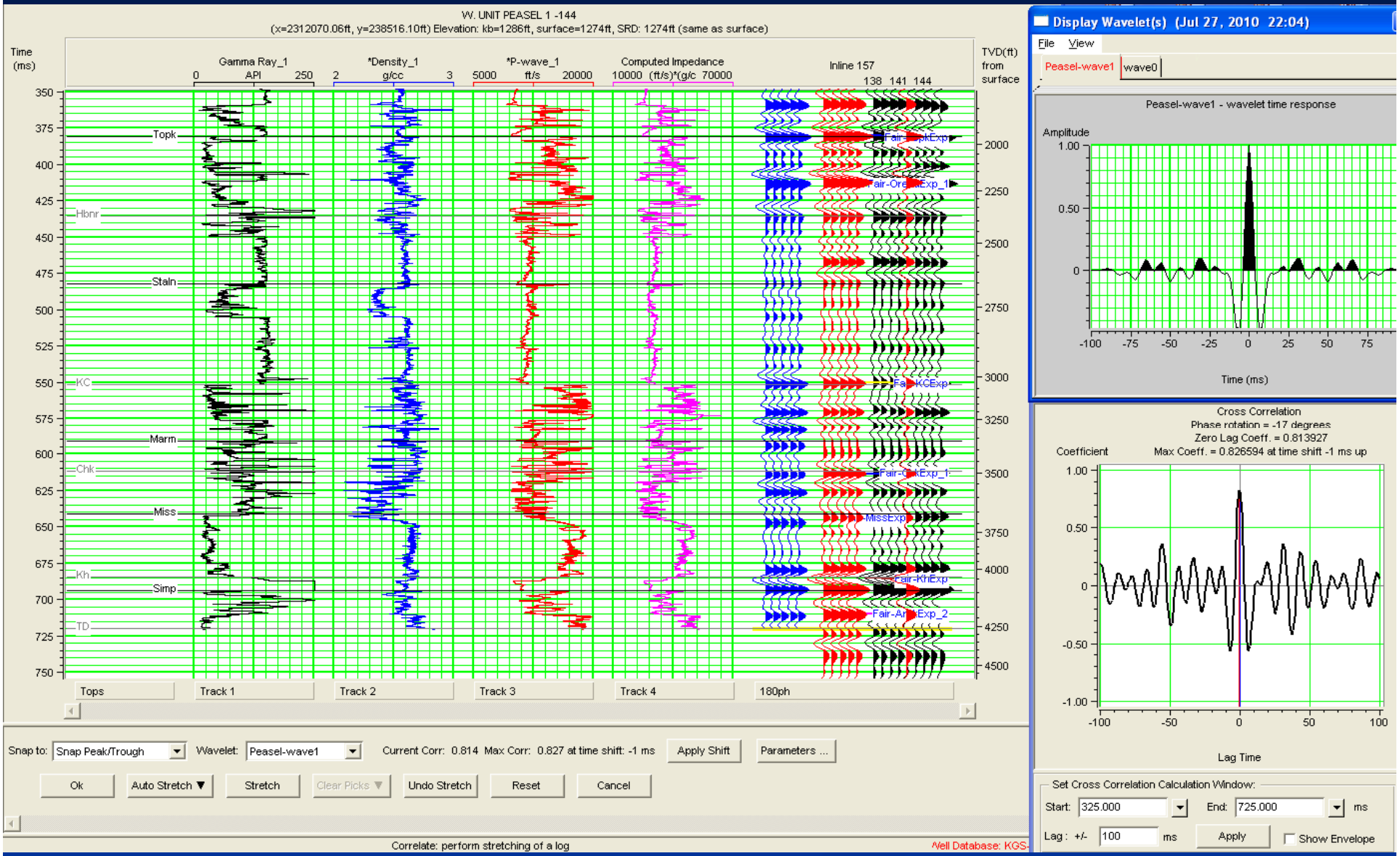
Refractor Velocity



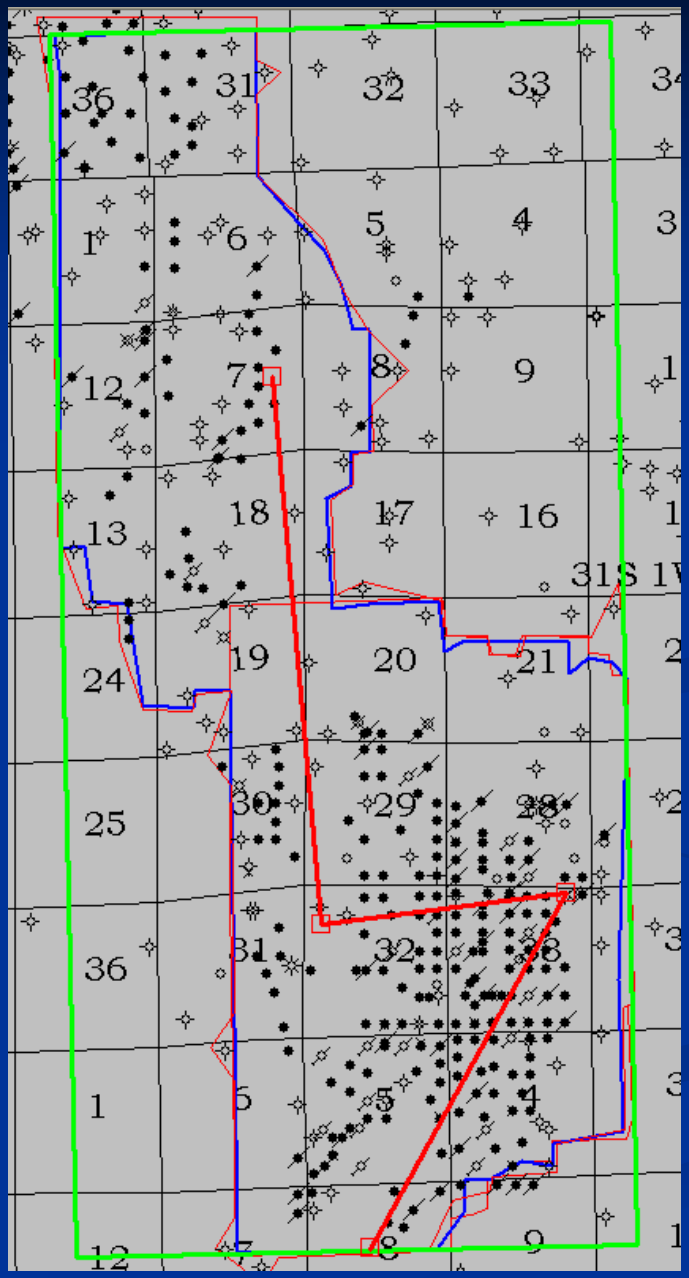
Weathering Thickness



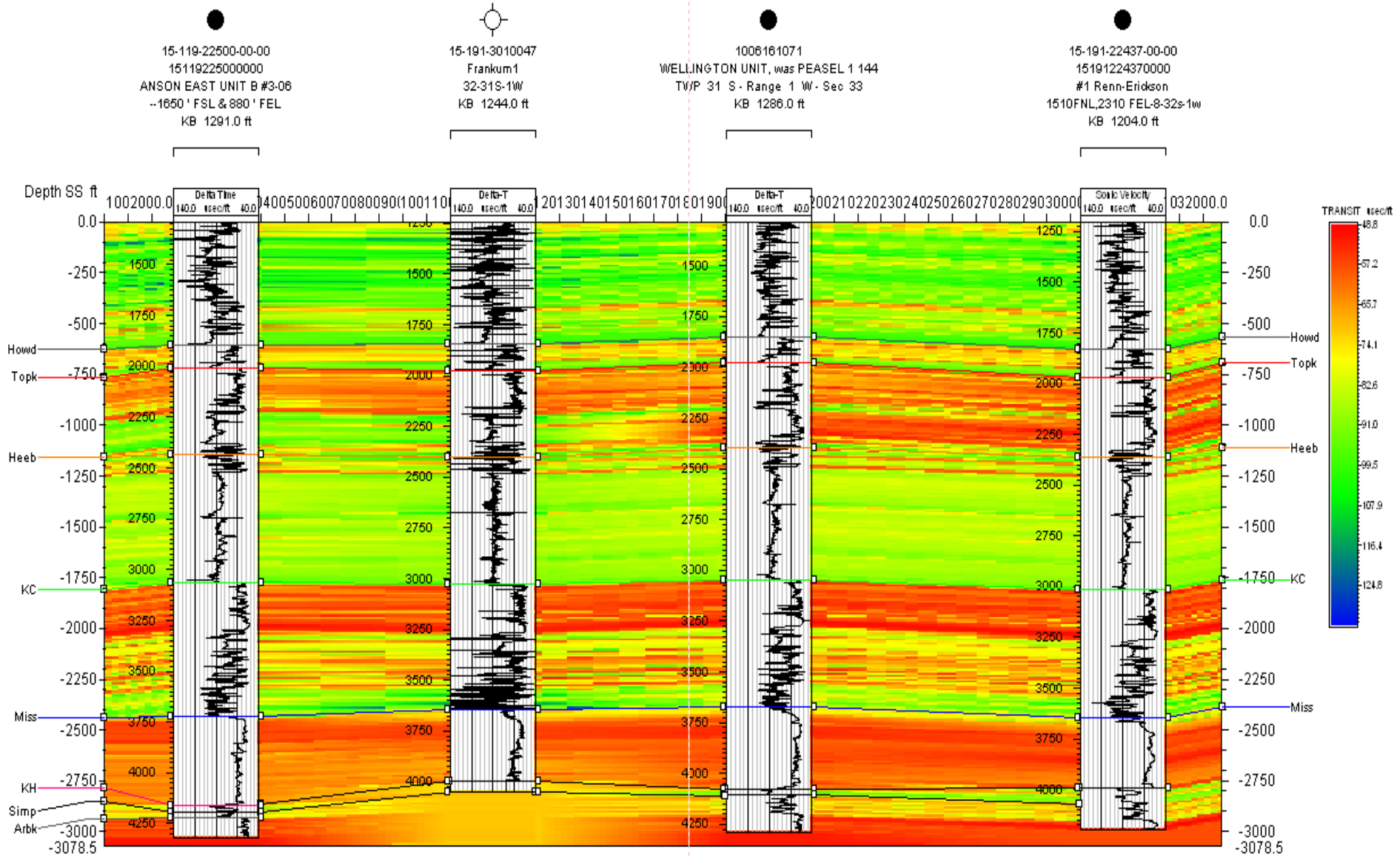
Forward Modeling



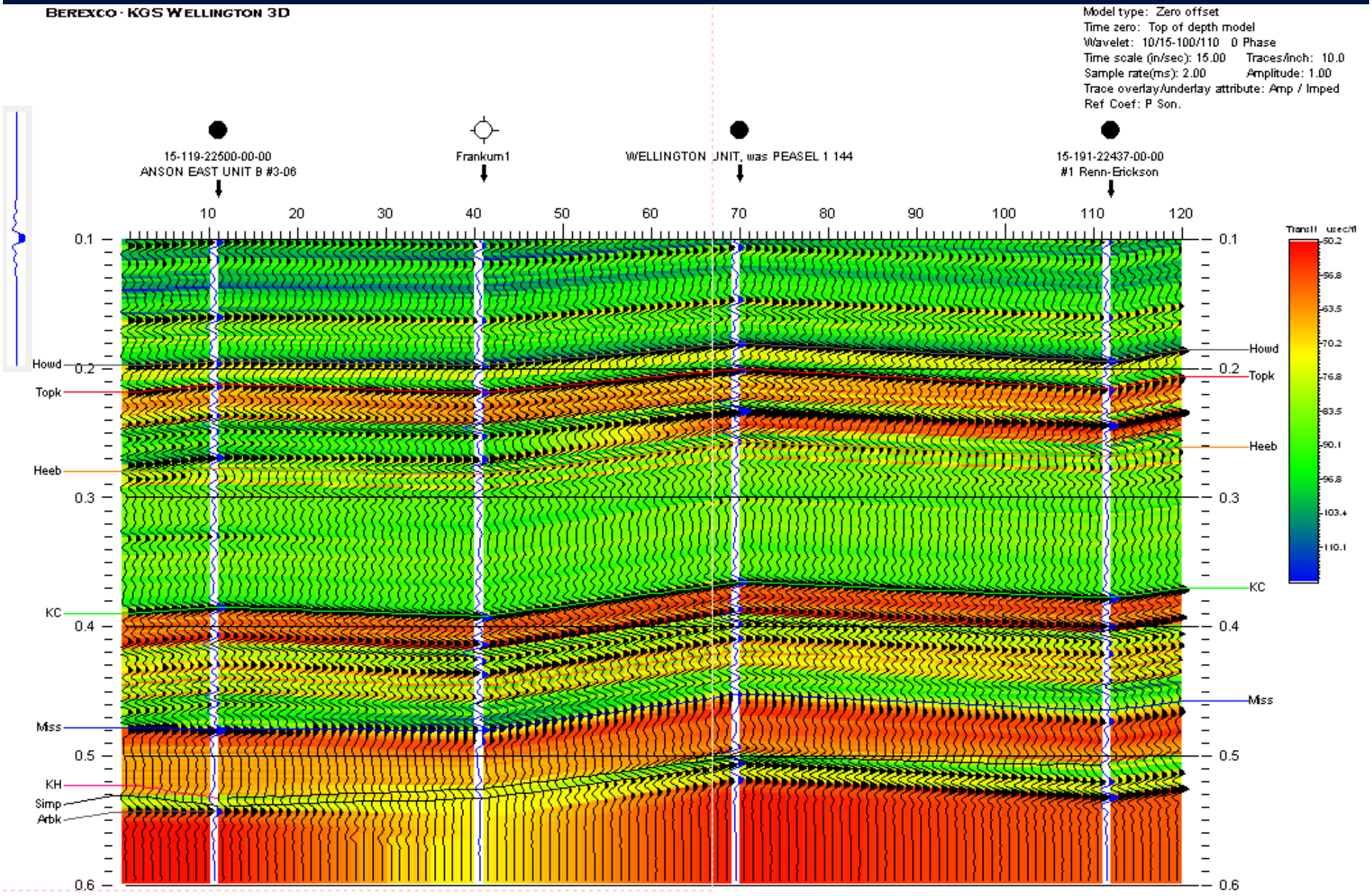
Model Profile Index



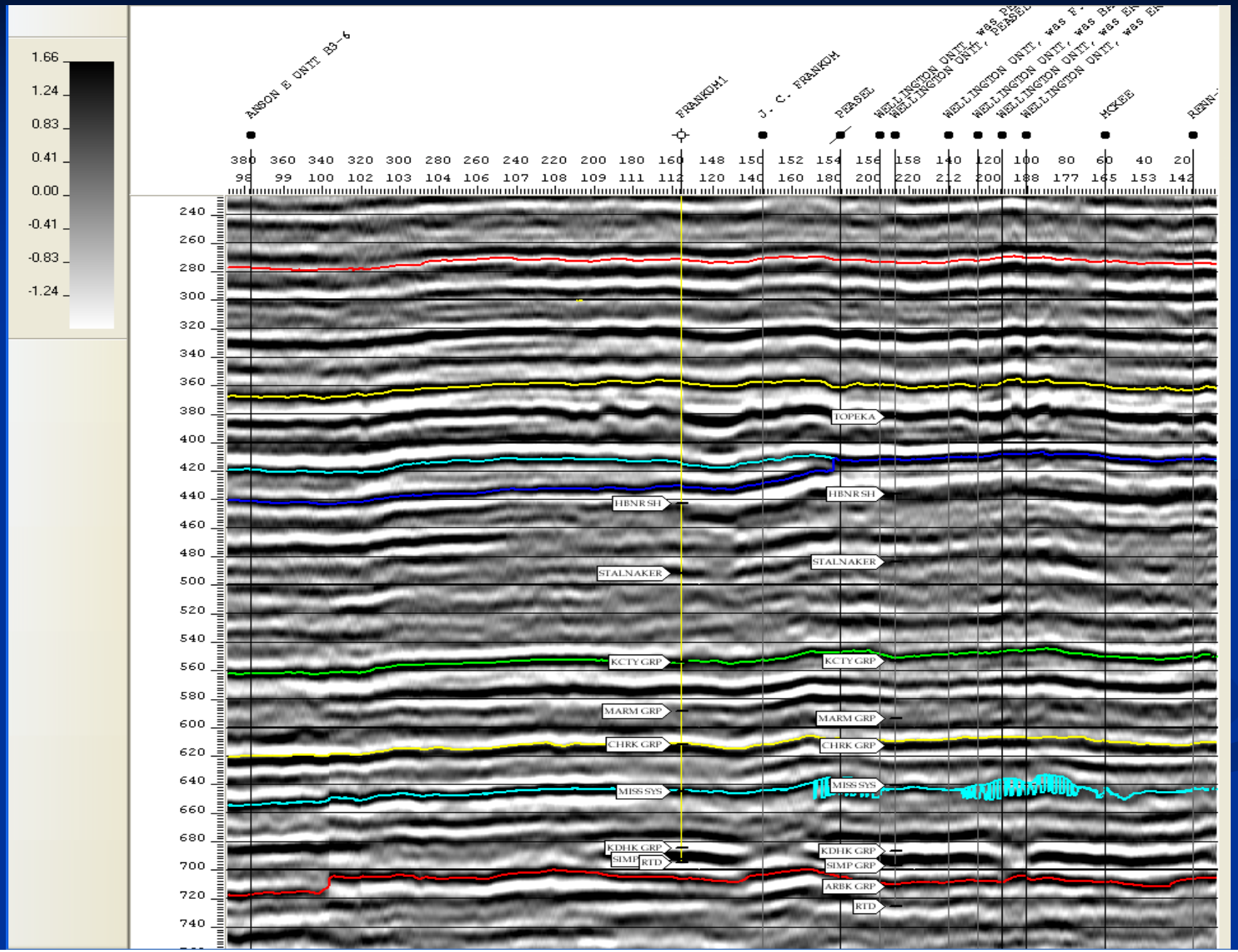
Forward Modeling - Velocity



Forward Modeling – Amplitude / Velocity

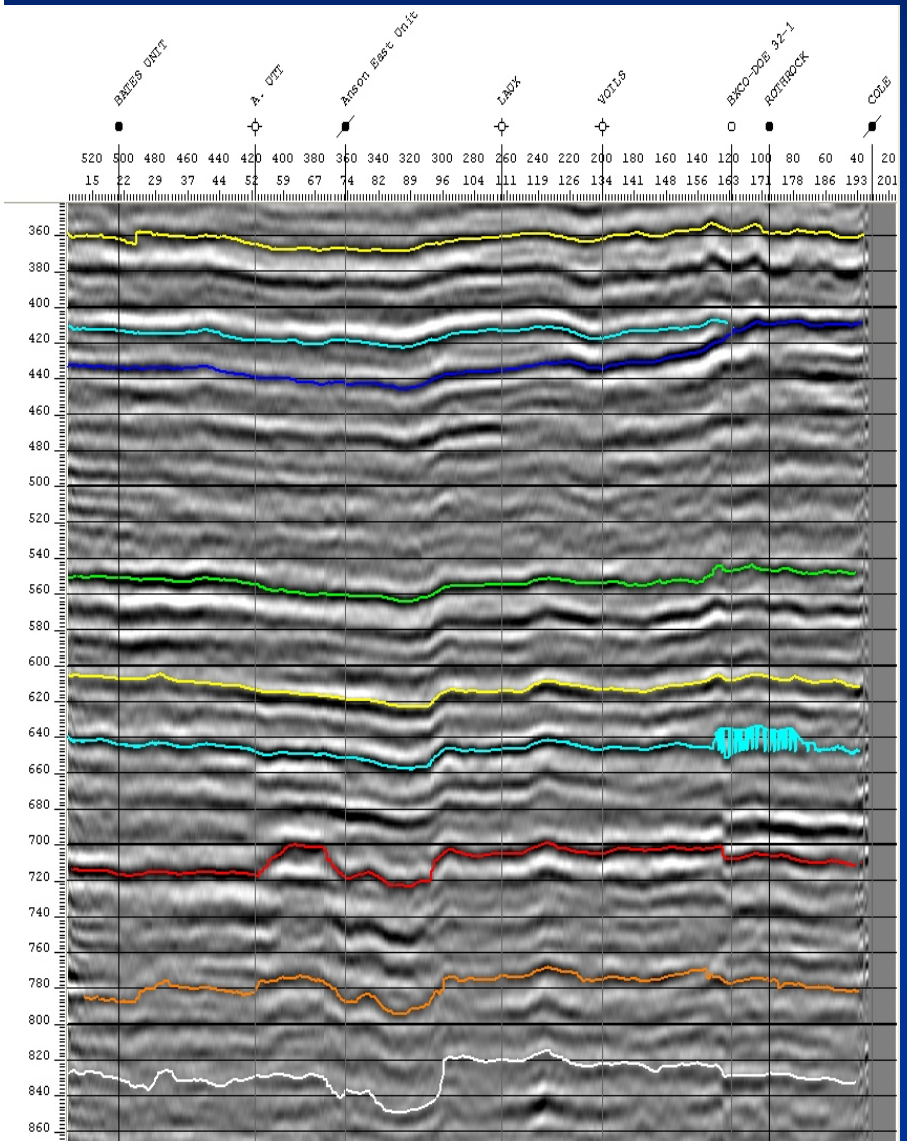


Arbitrary Profile – Real Data

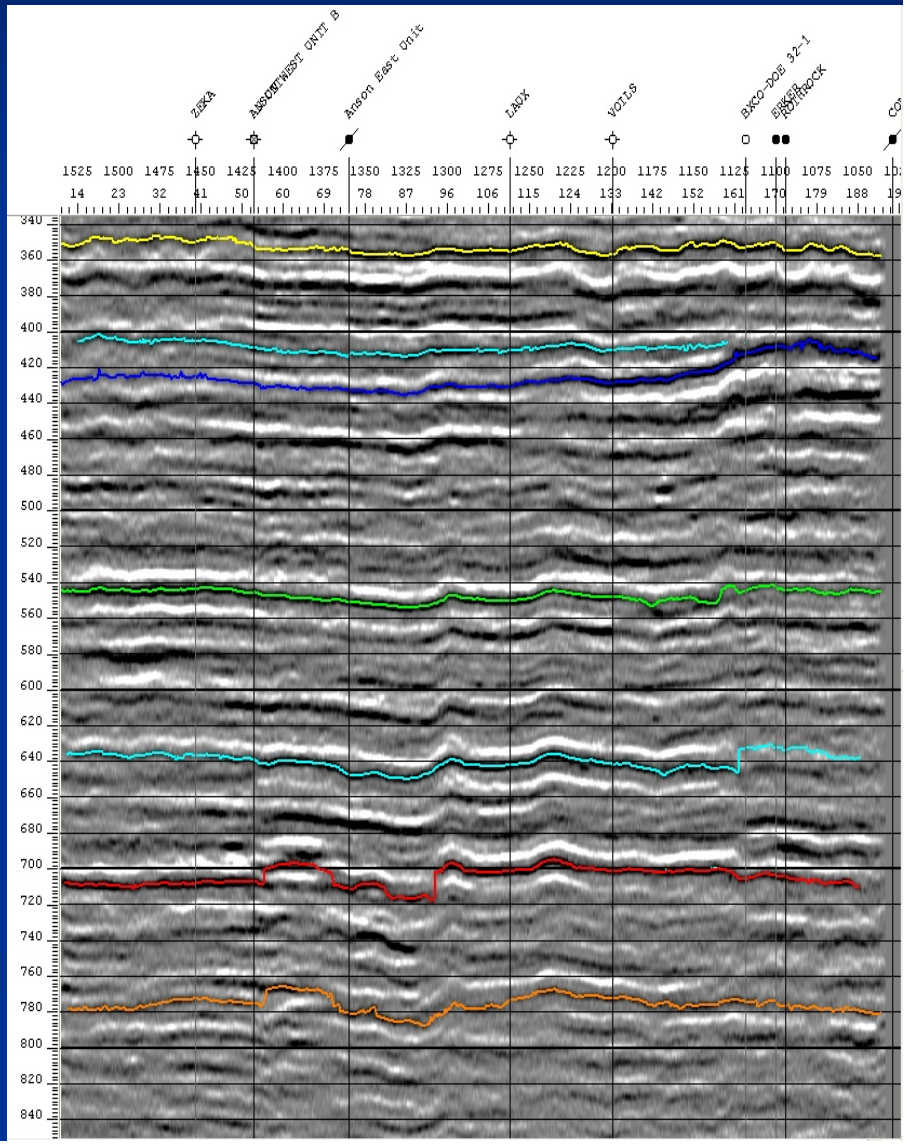


Dual Processing Comparisons

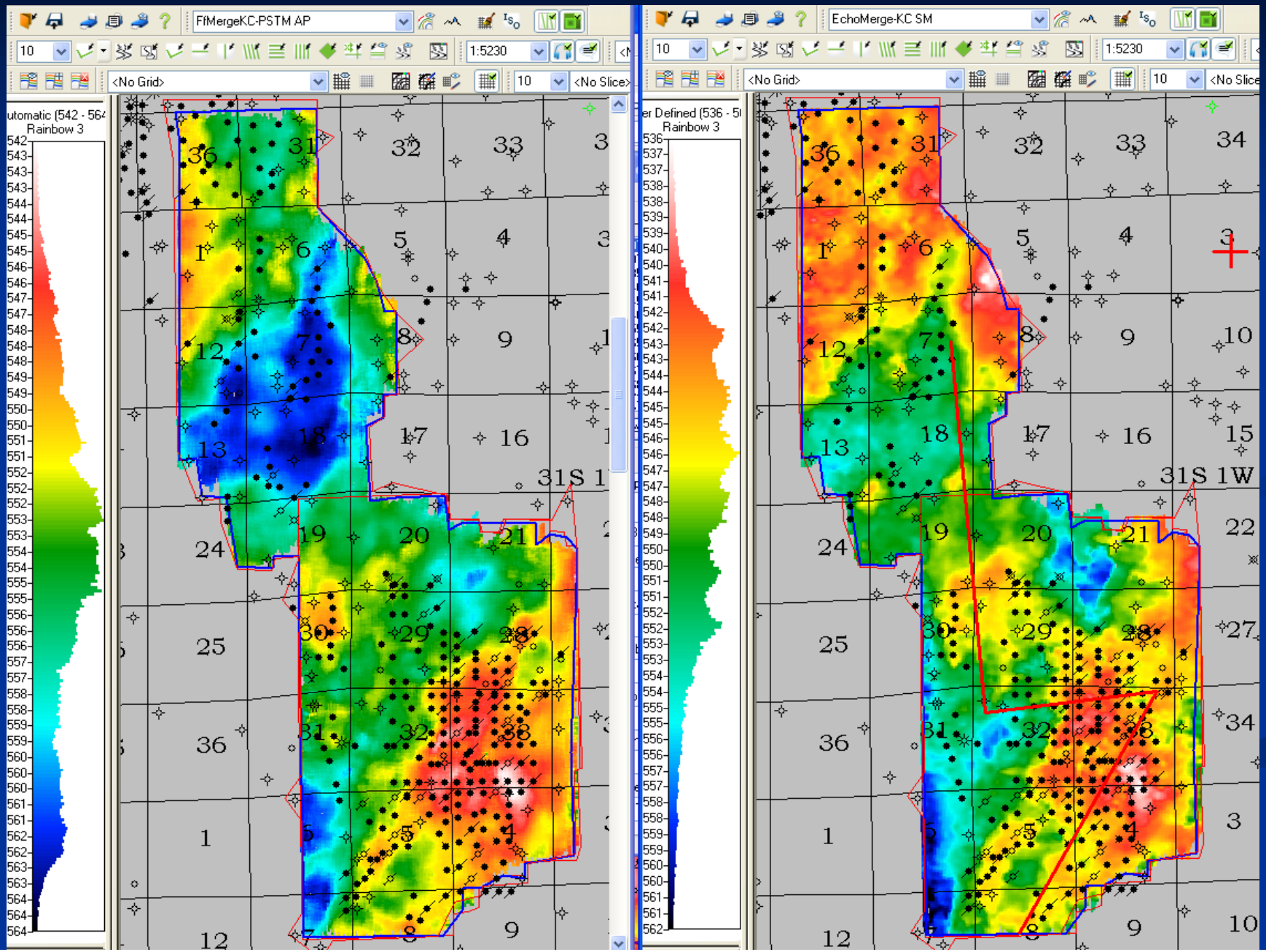
- FairfieldNodal



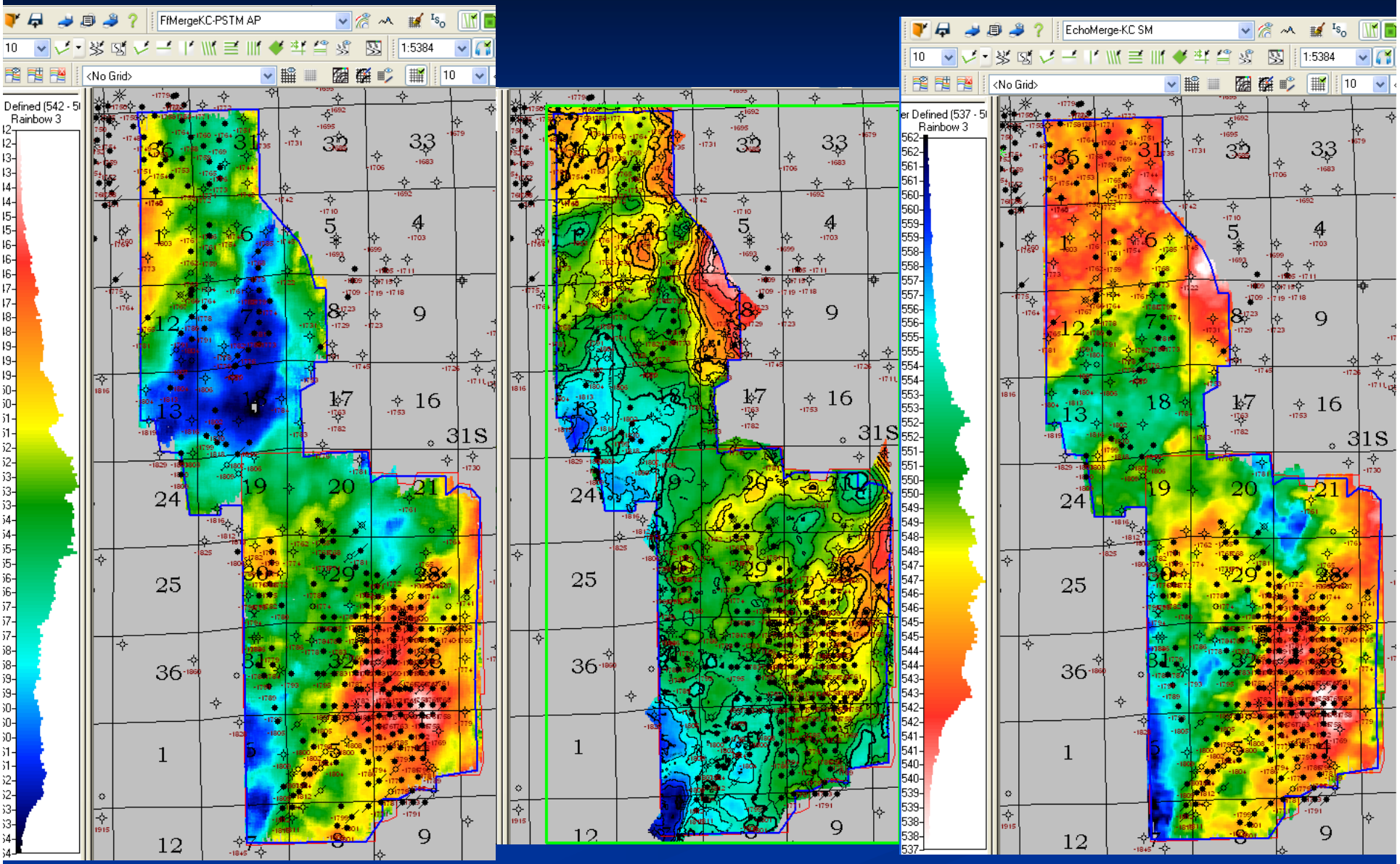
- Echo Geophysical



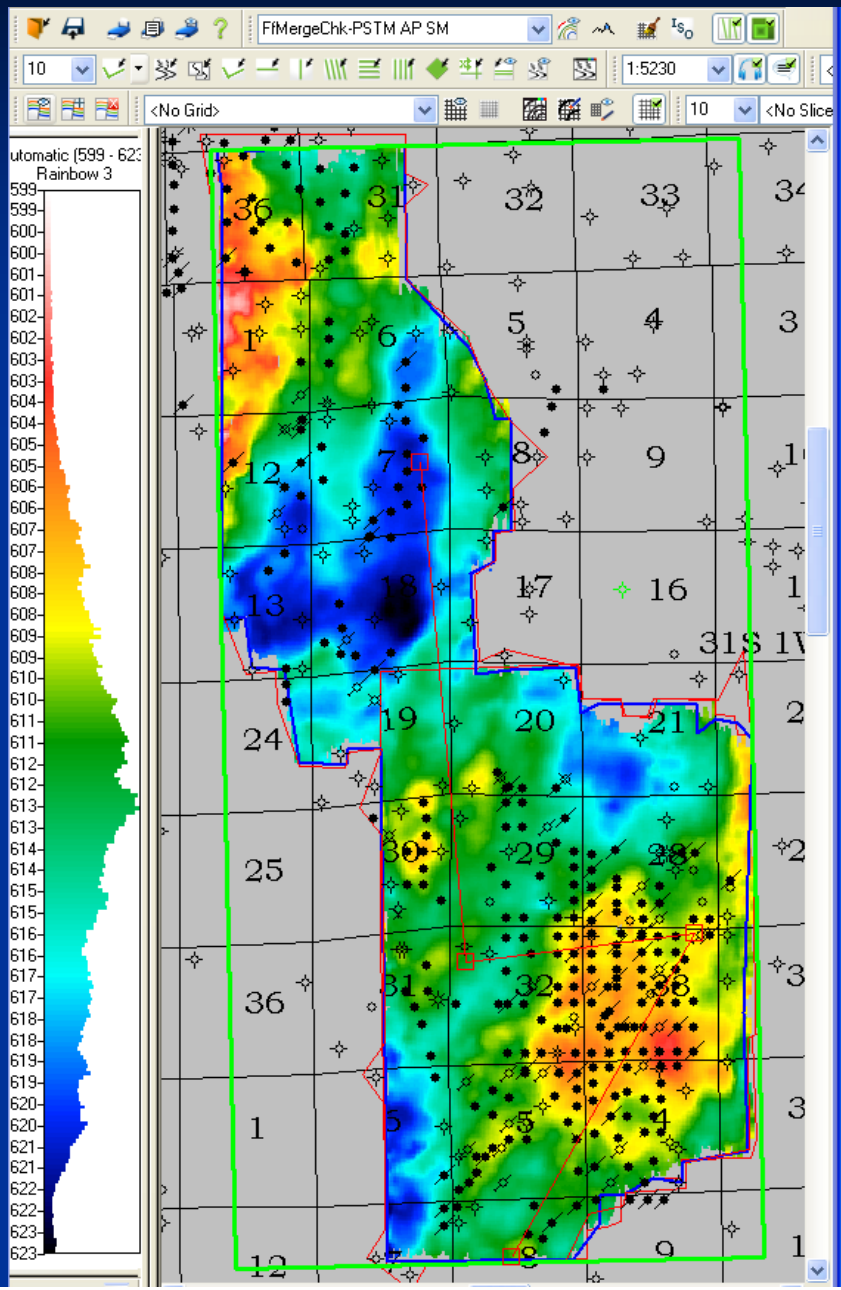
- Fairfield – KC Time
- Echo – KC Time

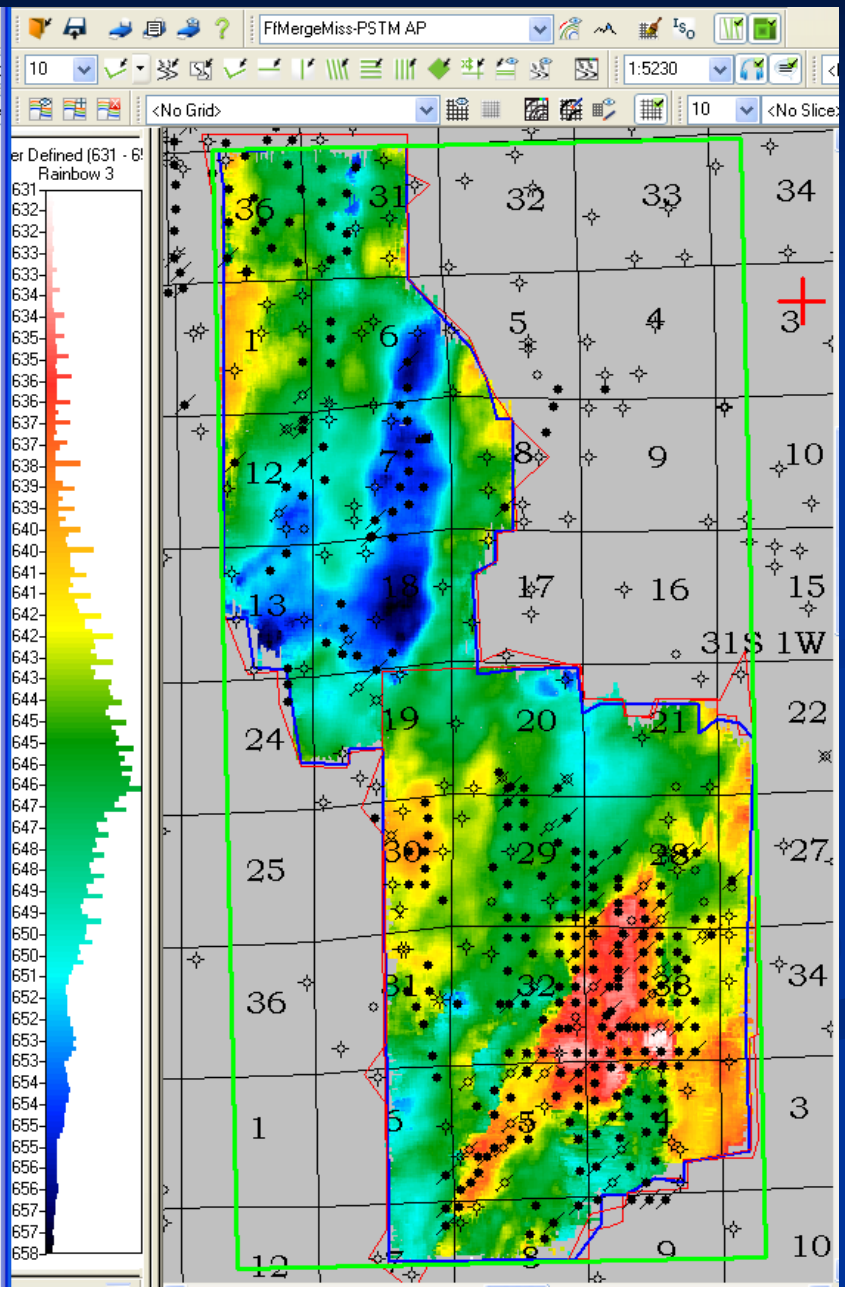


Ff KC Time – KC Depth – Echo KC Time

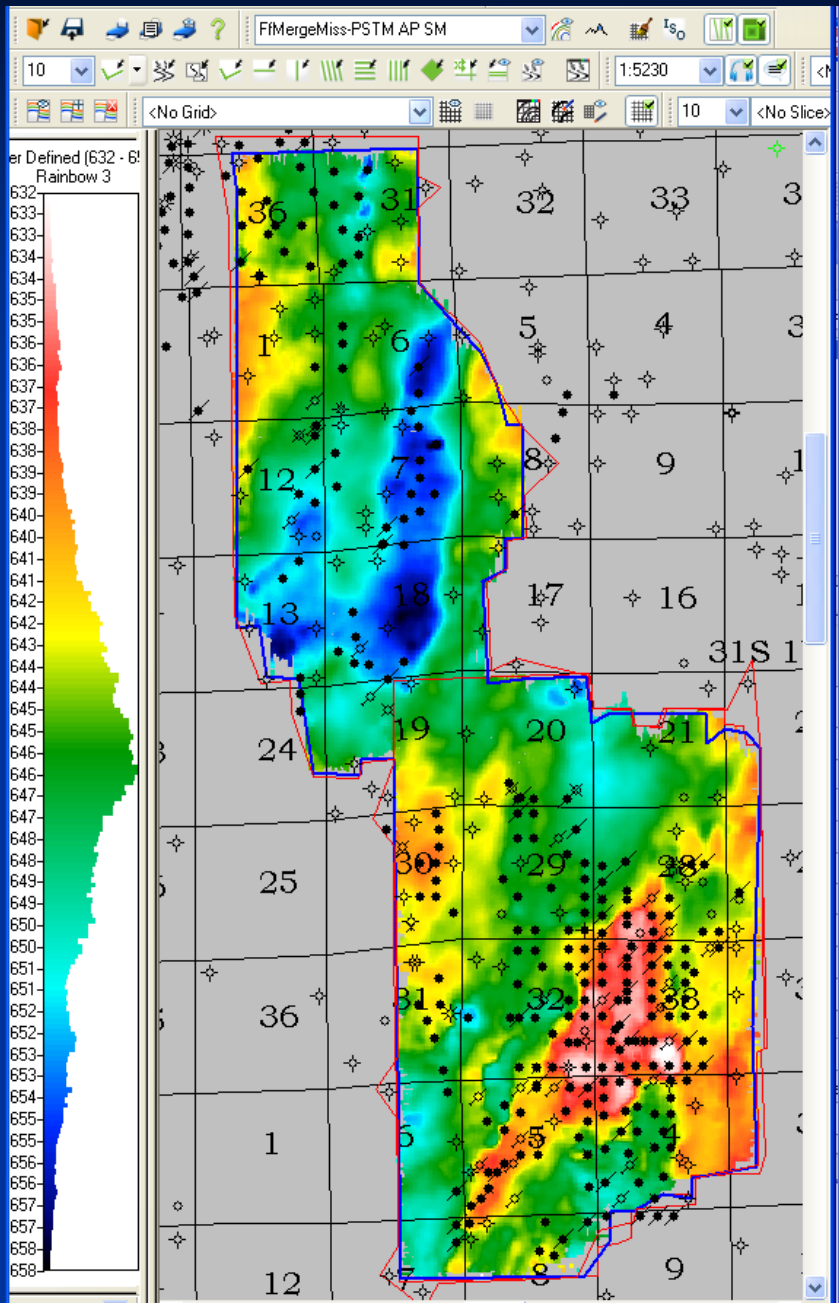


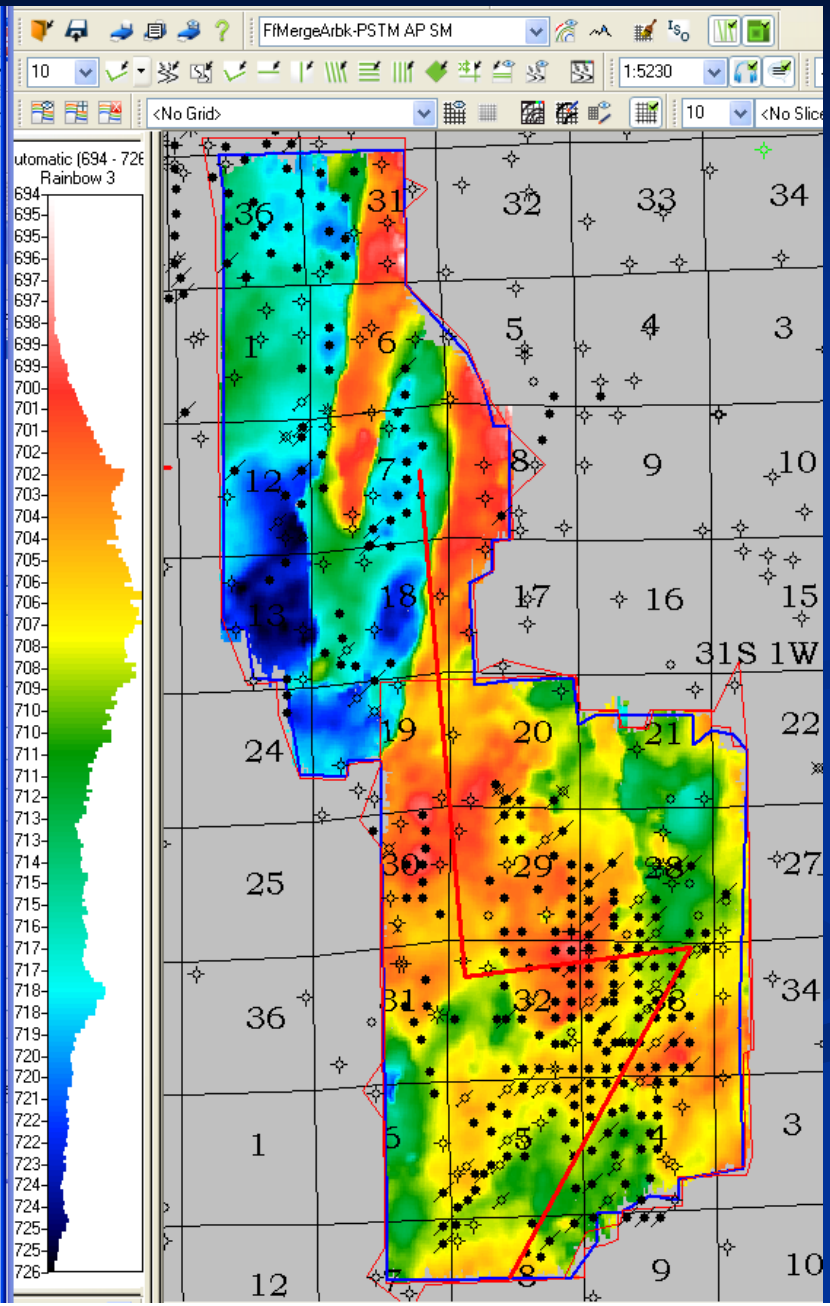
- Cherokee Time
- Miss Unconformity Time





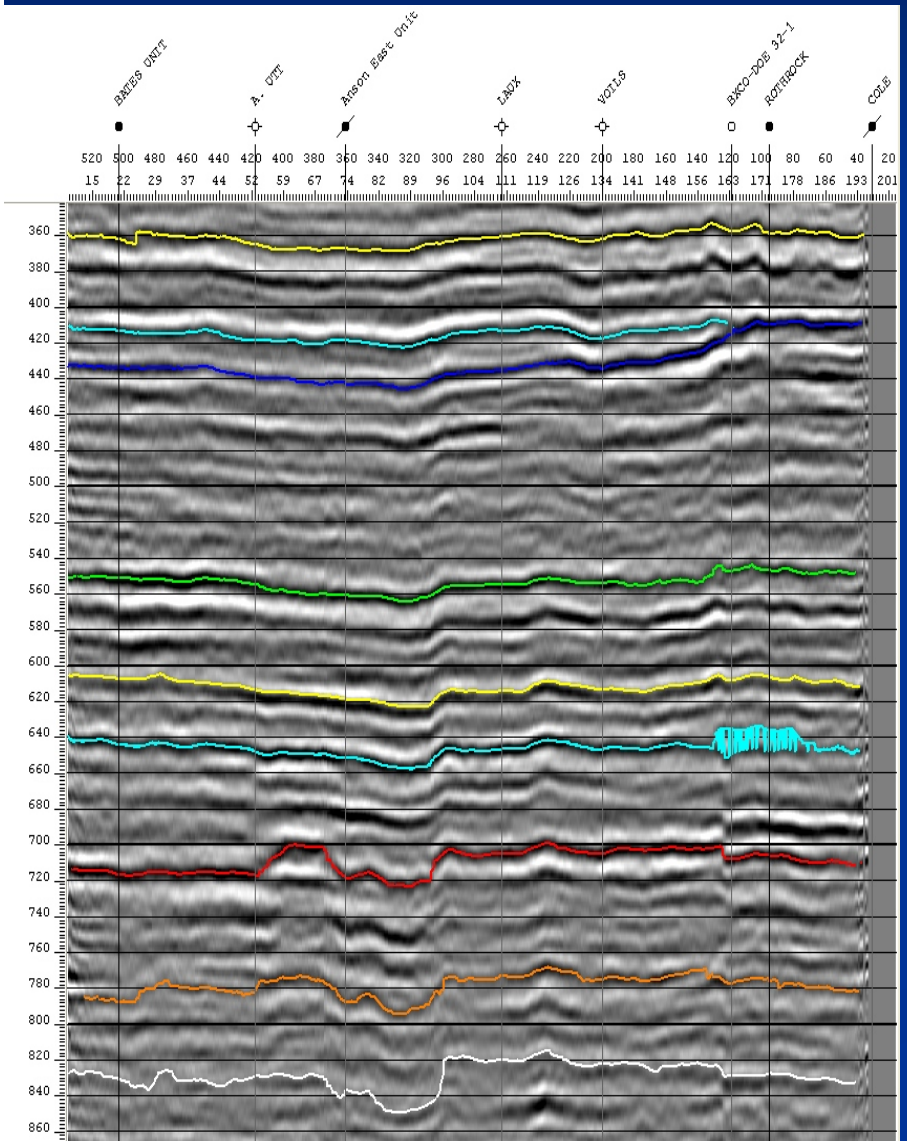
- Miss Uncf Time
- Arbuckle Time



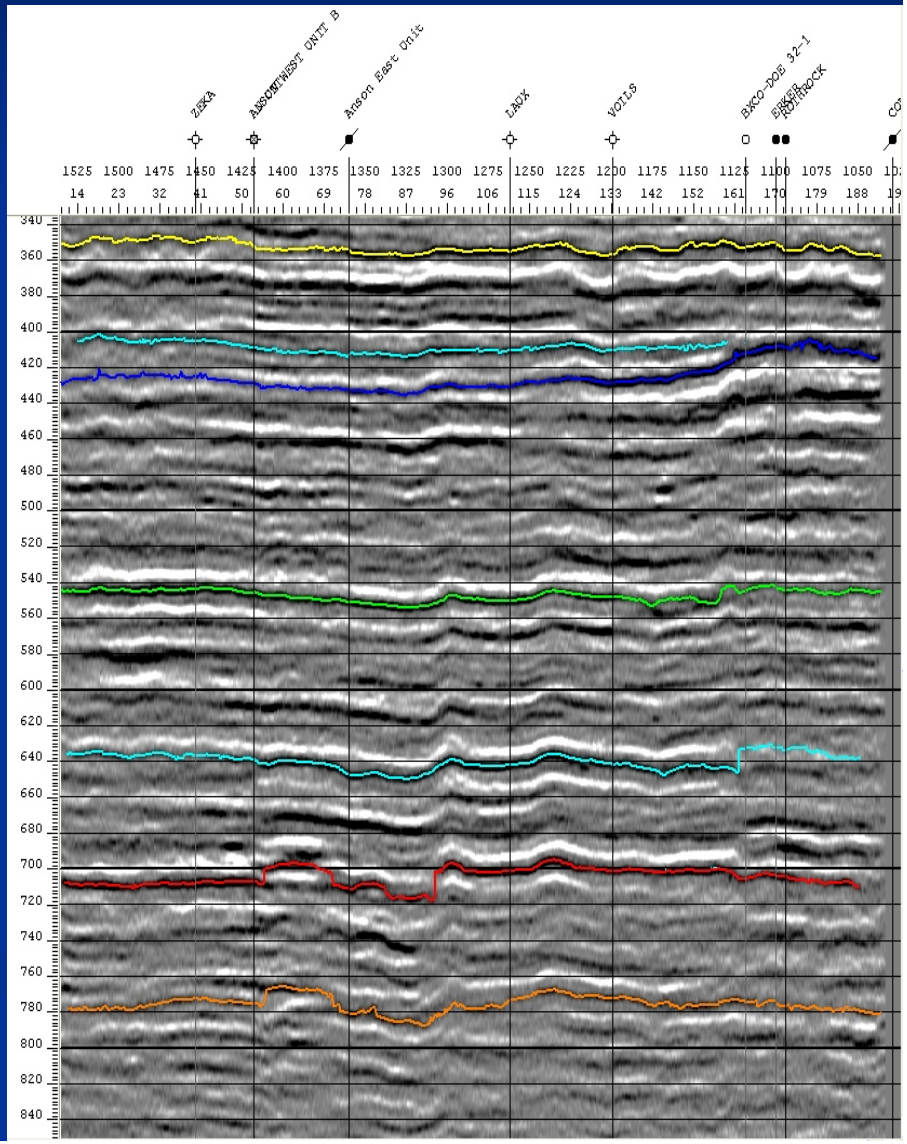


Shallow – Deep Structural /Stratigraphic Linkages

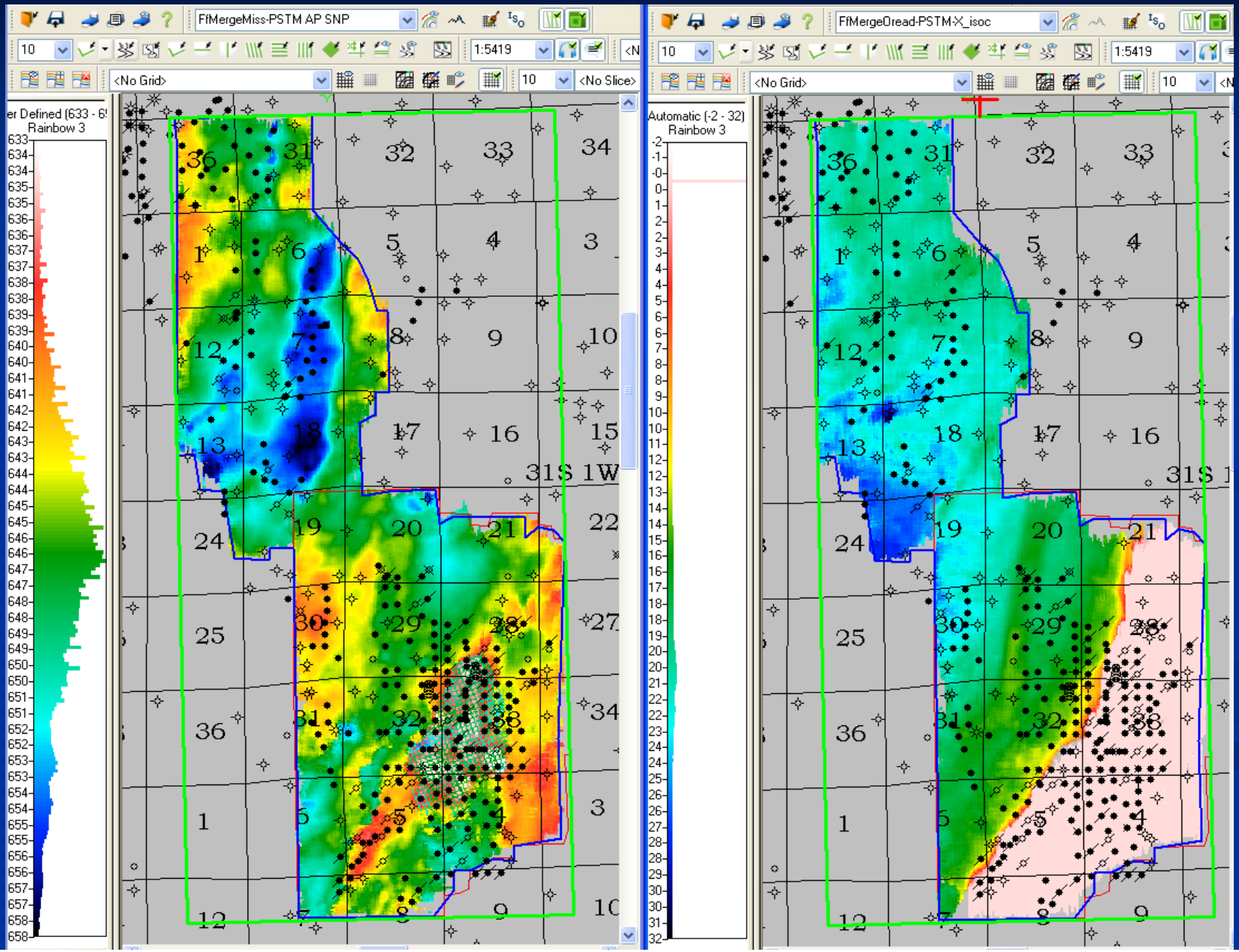
- FairfieldNodal



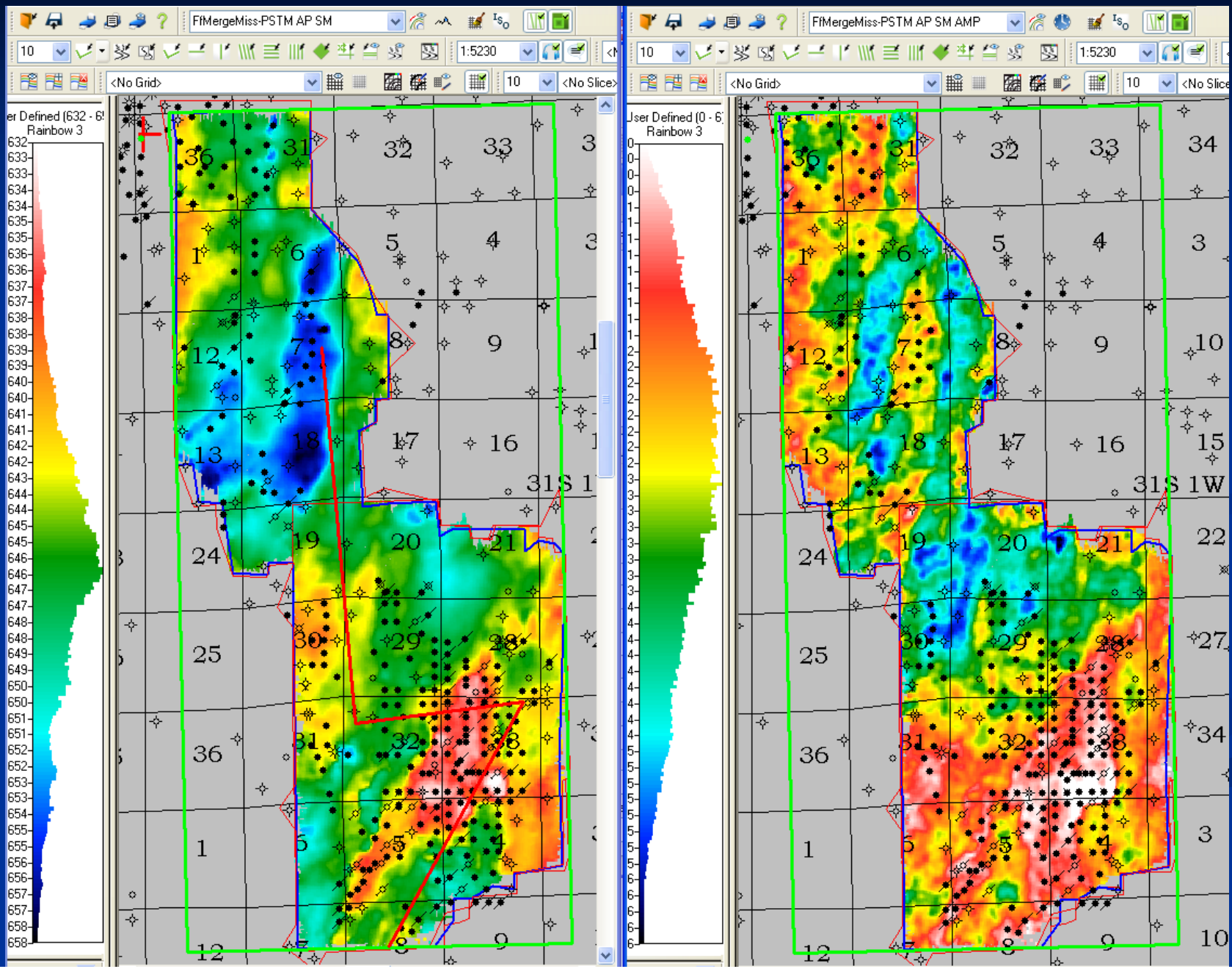
- Echo Geophysical



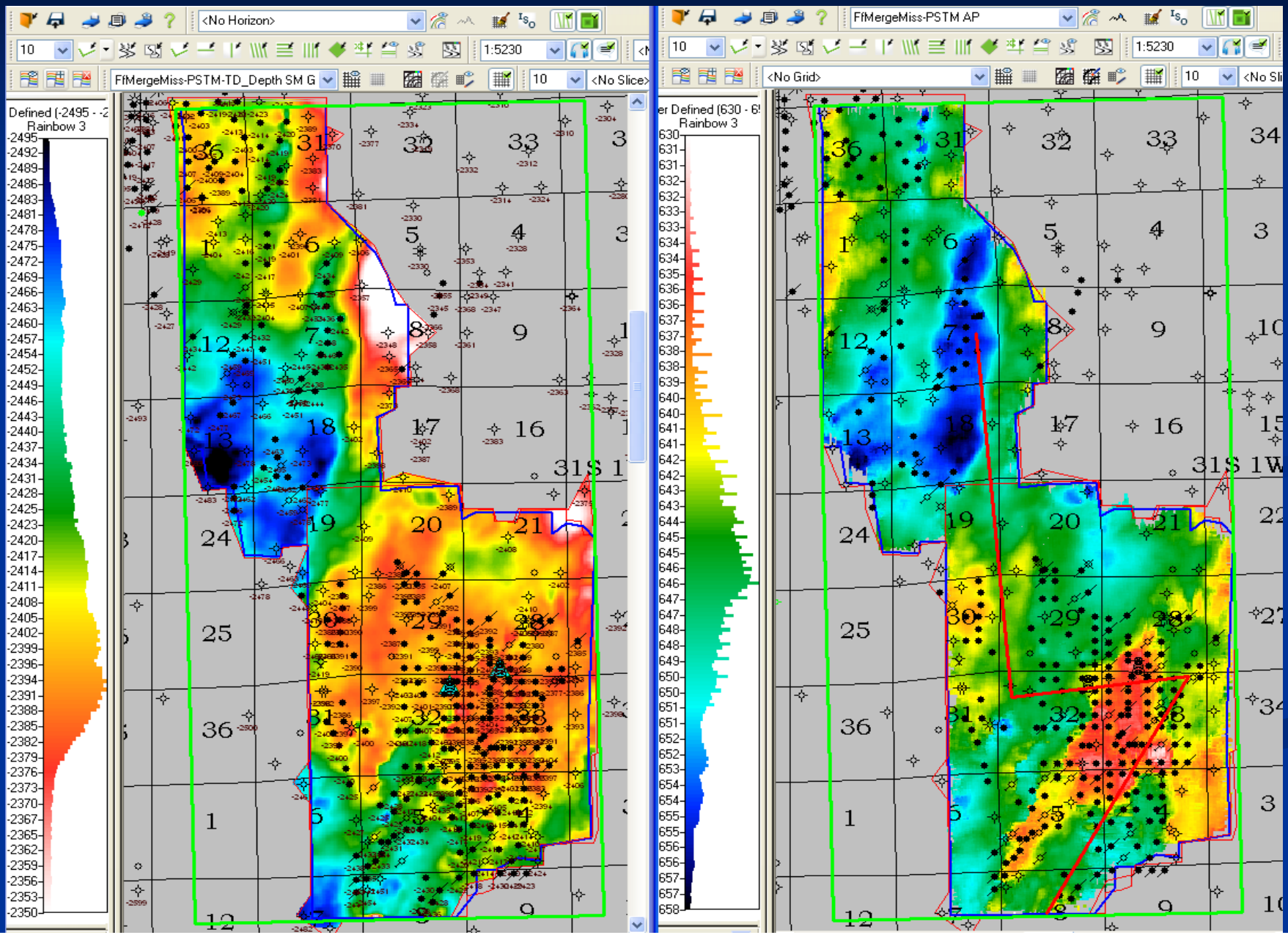
Shallow – Deep Stratigraphic Linkage



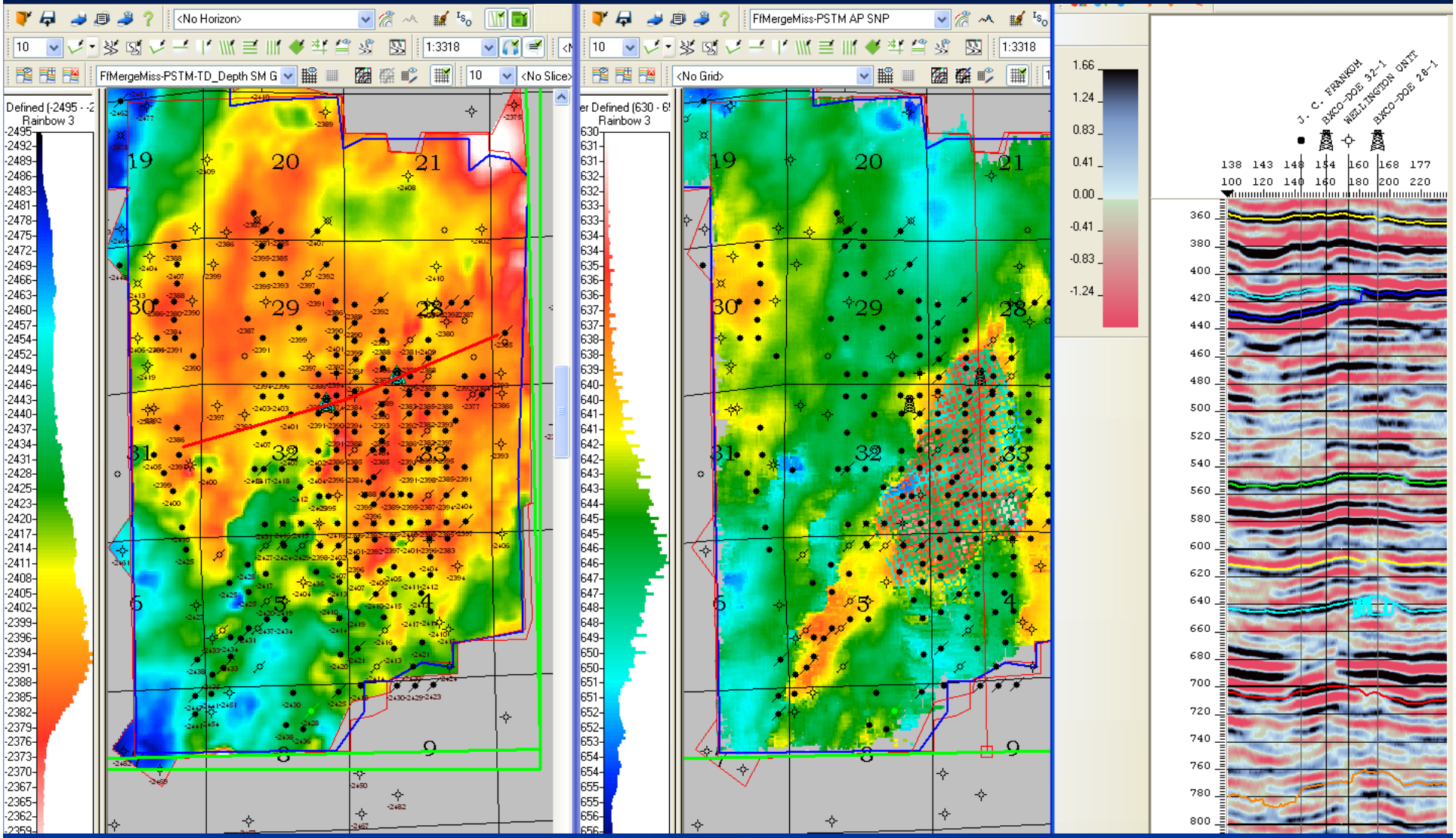
Miss Uncf – Time vs Amplitude



Miss Uncf Depth Converted Structure vs Time



Miss TDepth – Time - Profile

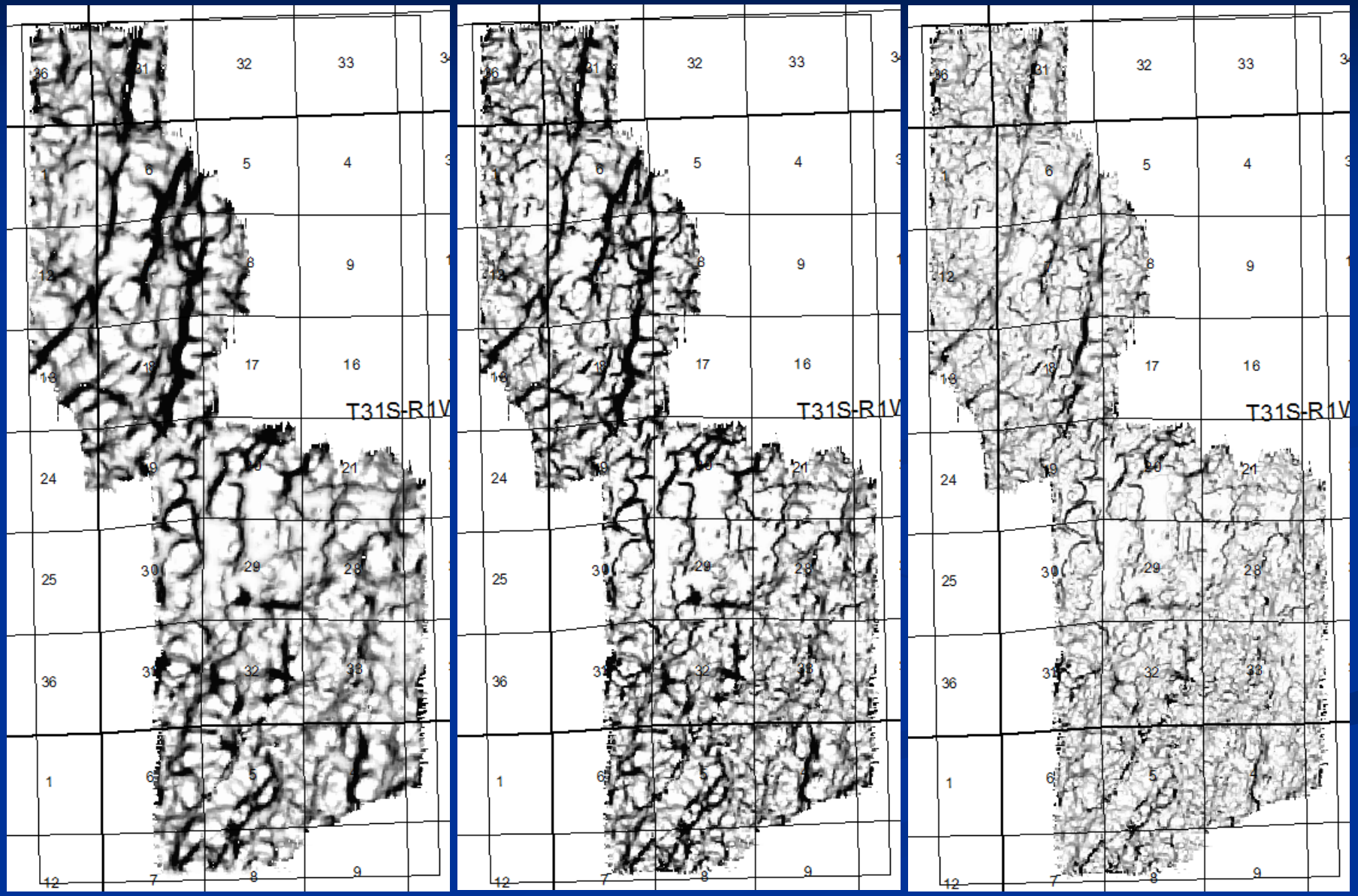


Volumetric Curvature Analysis

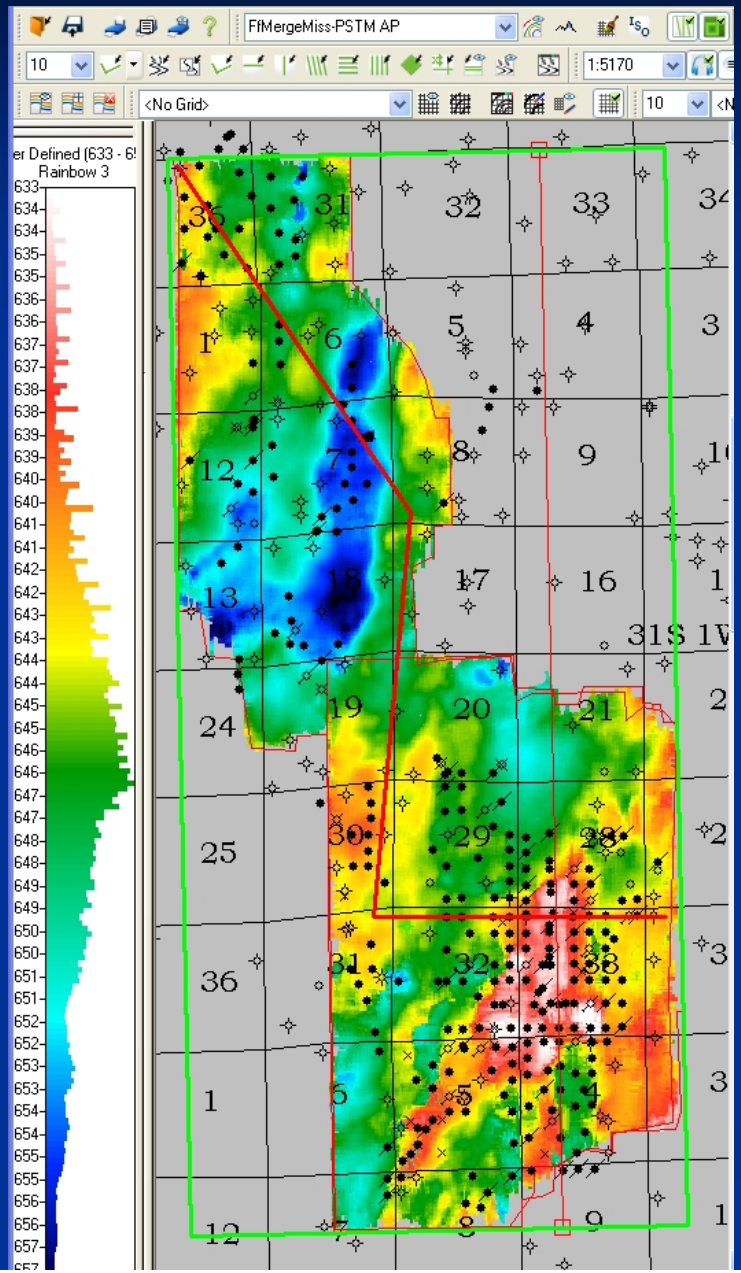
- Susan Nissen, Chuck Blumentritt / Geotexture
- Independent of Horizon Picking
- ‘a’ Parameter Controls Detail
  (Higher ‘a’ = Finer Detail)

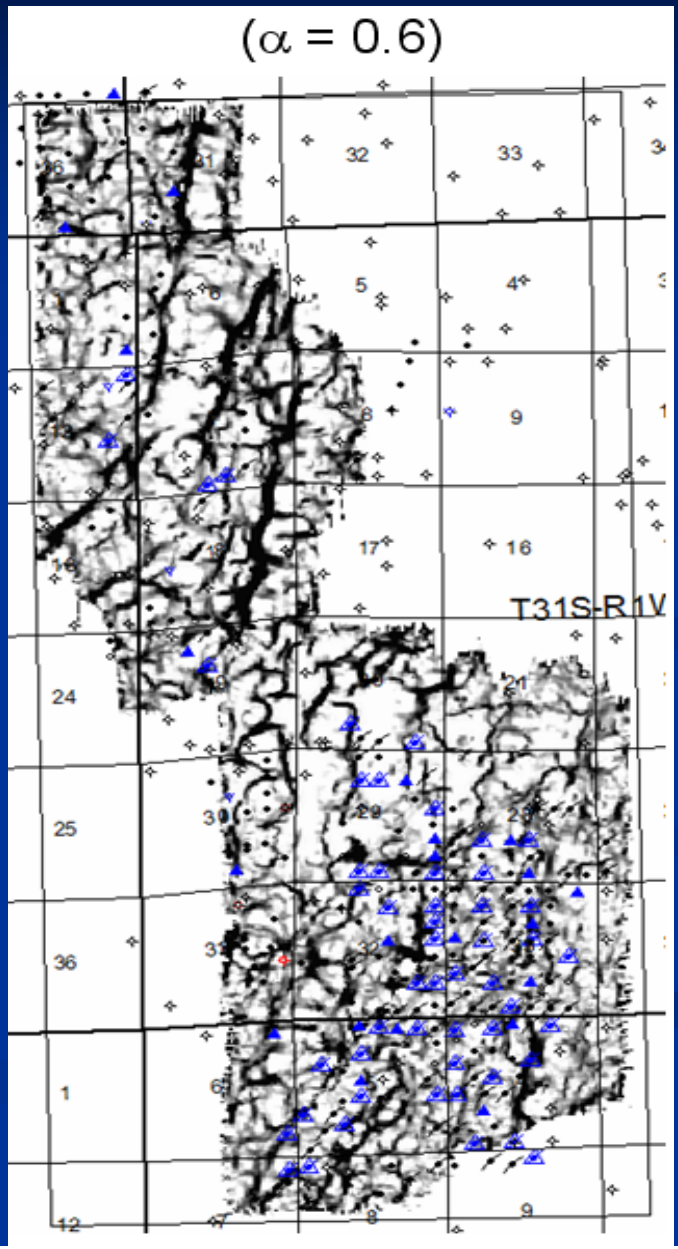
Most Negative Curvature Extracted Along Mississippian Unconformity

(α = 0.4) (α = 0.6) (α = 0.8)



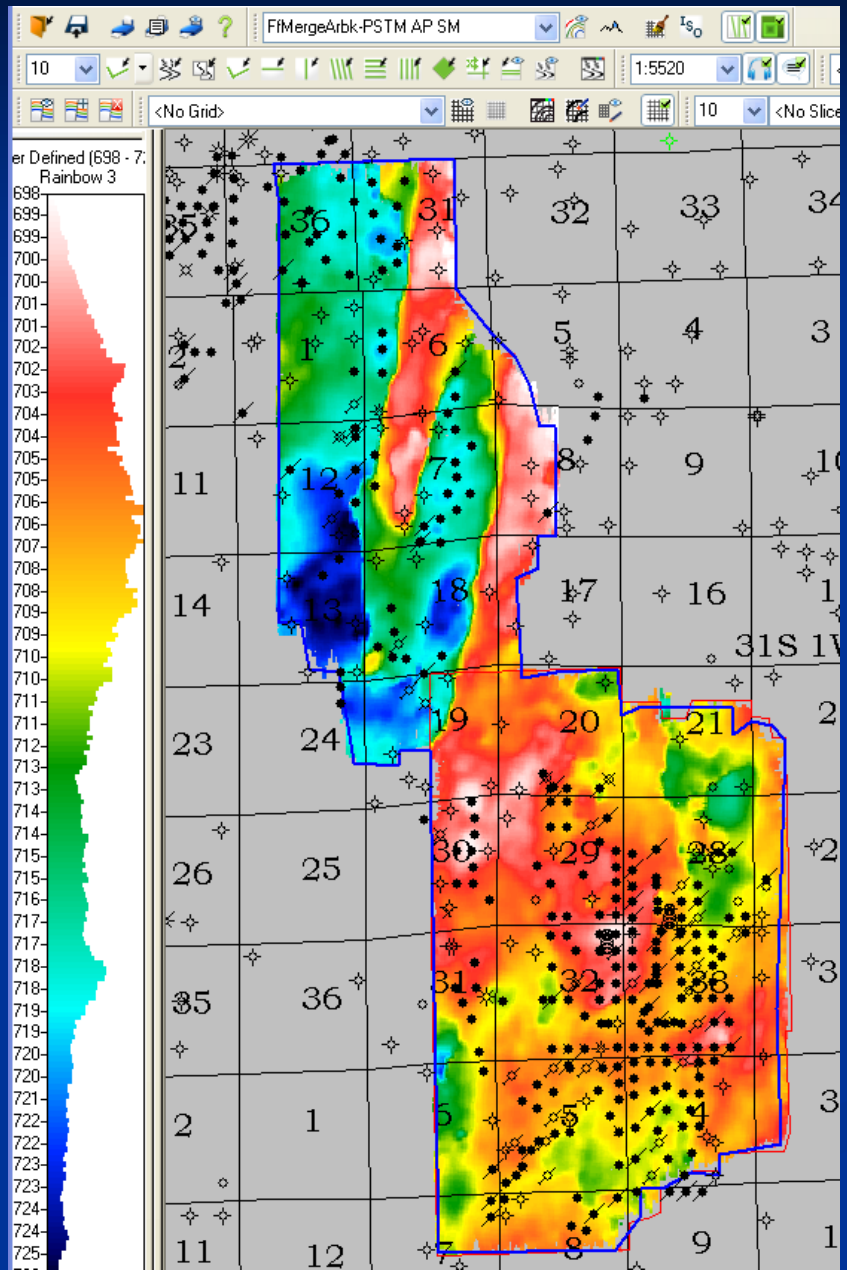
Mississippian Time & Most Negative Curvature

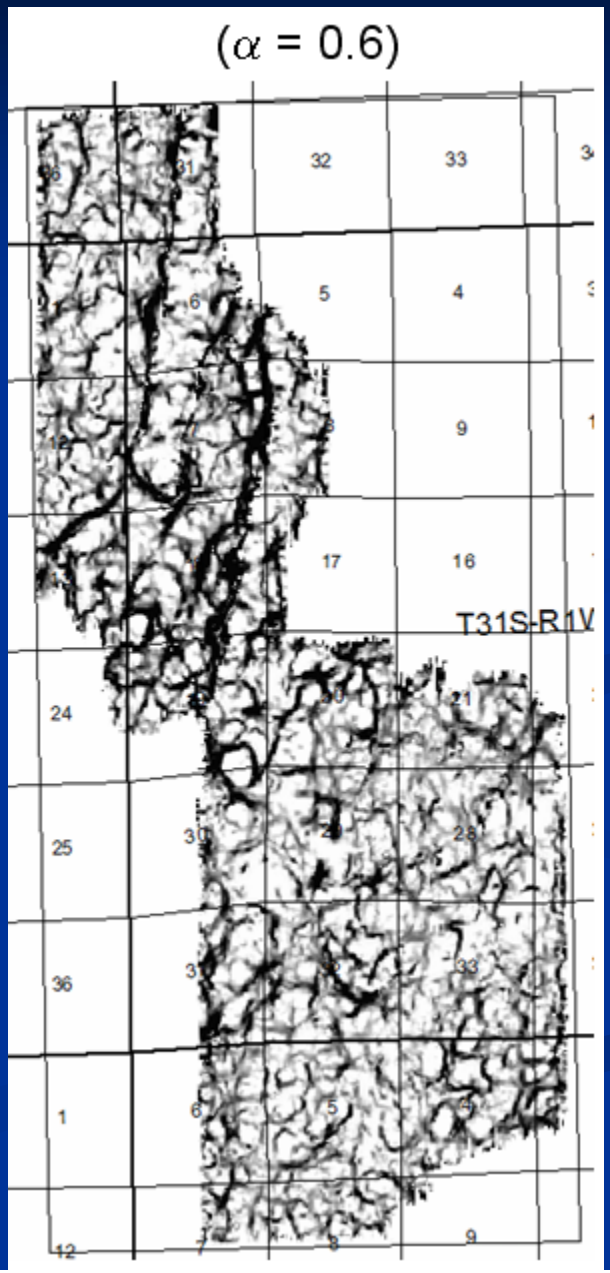




Courtesy of
Susan Nissen
Geotexture

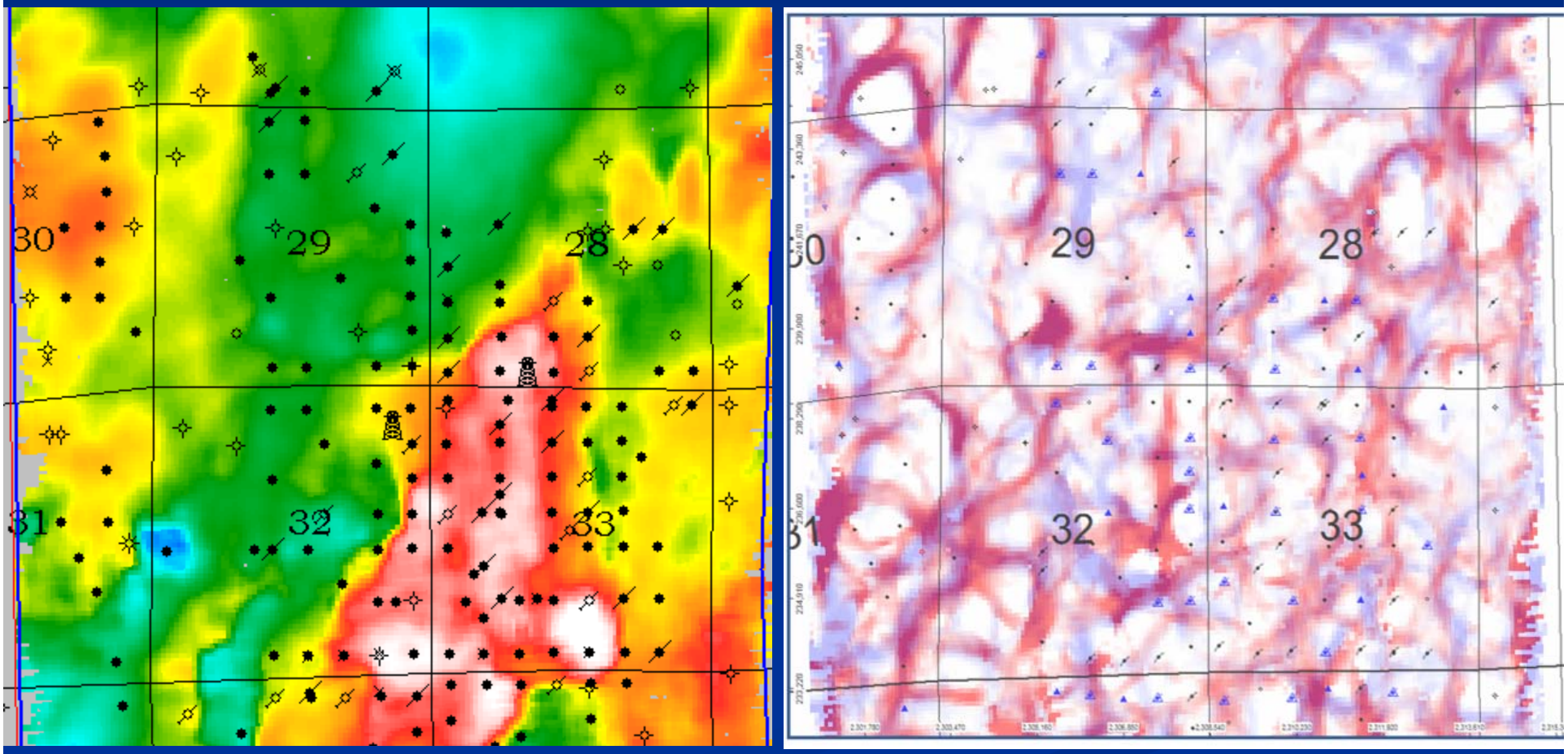
Most Negative Curvature – Arbuckle Time





Courtesy of
Susan Nissen
Geotexture

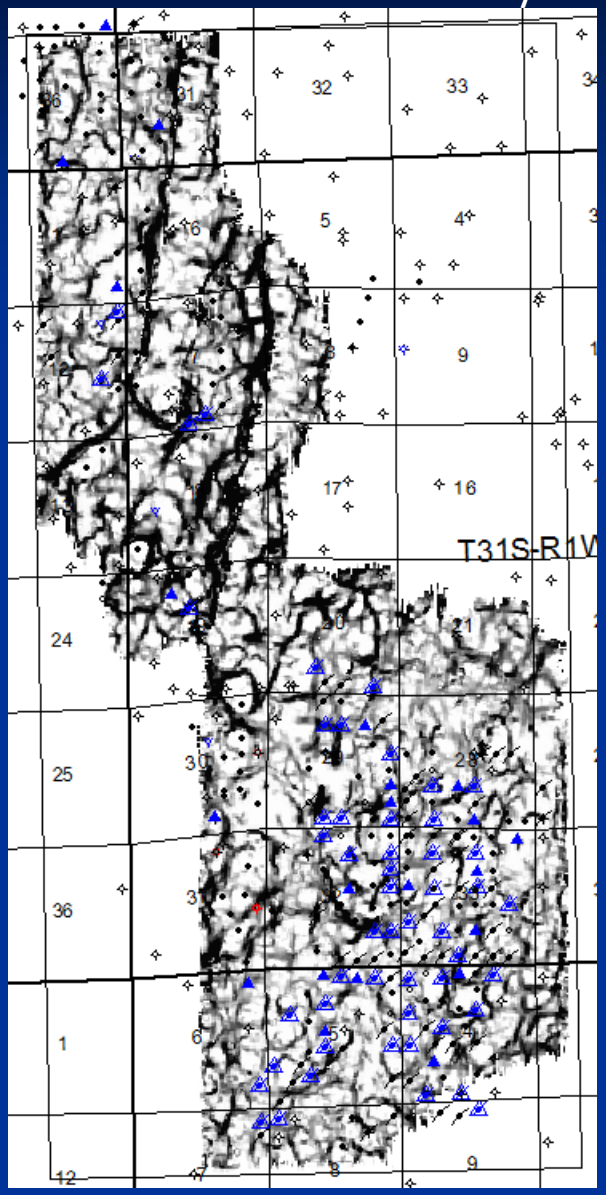
Miss Time vs Miss-Arbk Curvature Overlay



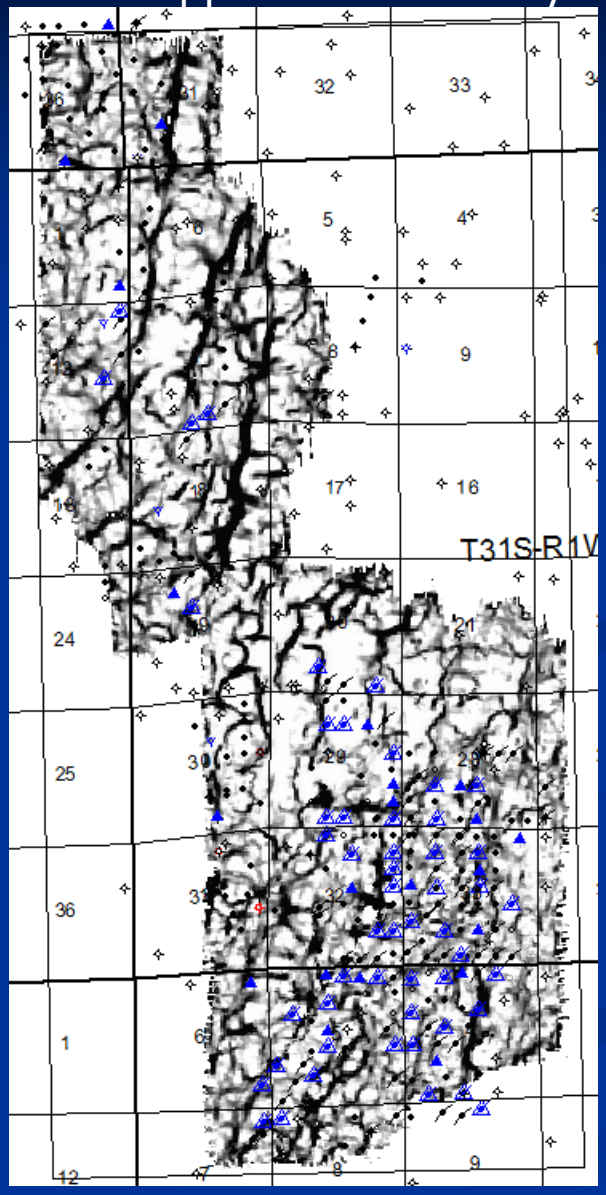
Courtesy of Susan Nissen / Geotexture

Most Negative Curvature (α = 0.6)

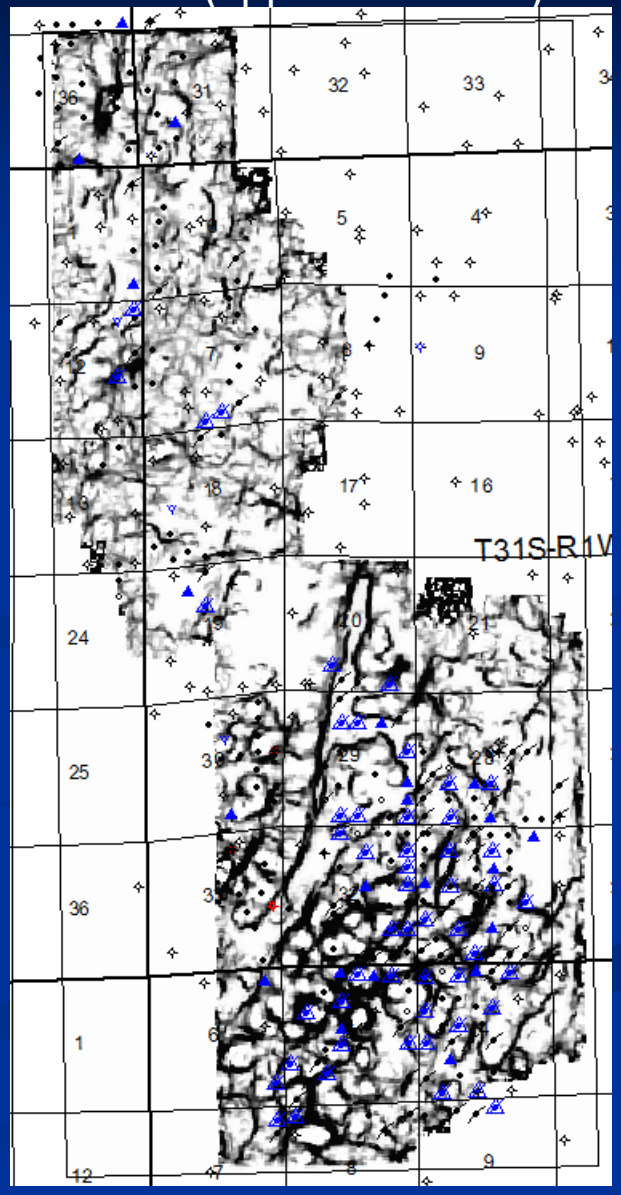
Arbuckle unconformity



Mississippian unconformity



360 ms (approx. Howard)



Courtesy of Susan Nissen / Geotexture

Geomodeling

- Jason Rush, Kansas Geological Survey

KU KANSAS GEOLOGICAL SURVEY
The University of Kansas

Geomodeling

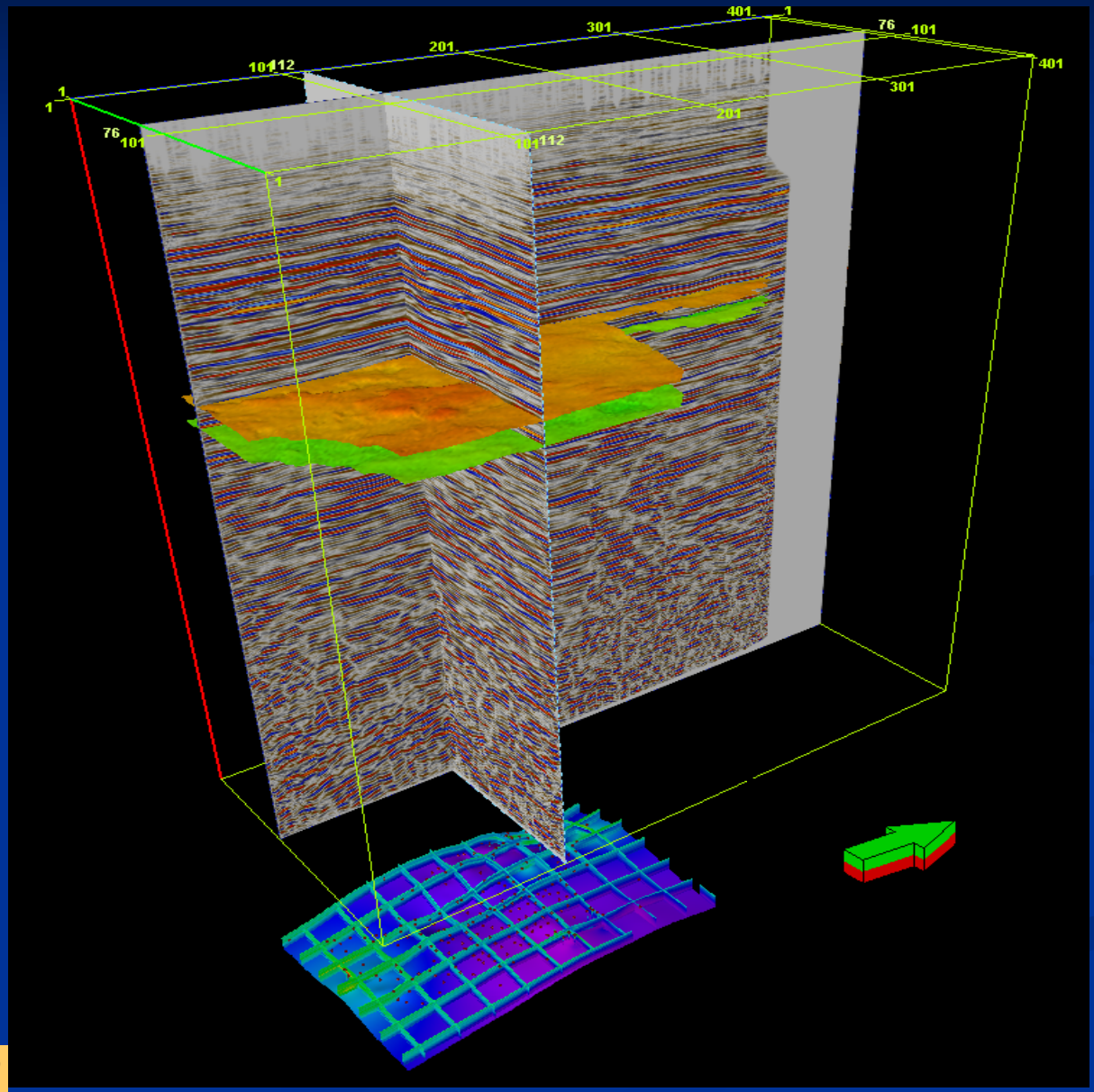
- Jason Rush, Kansas Geological Survey
- Seeking Highly Accurate Porosity Volume

KU KANSAS GEOLOGICAL SURVEY
The University of Kansas

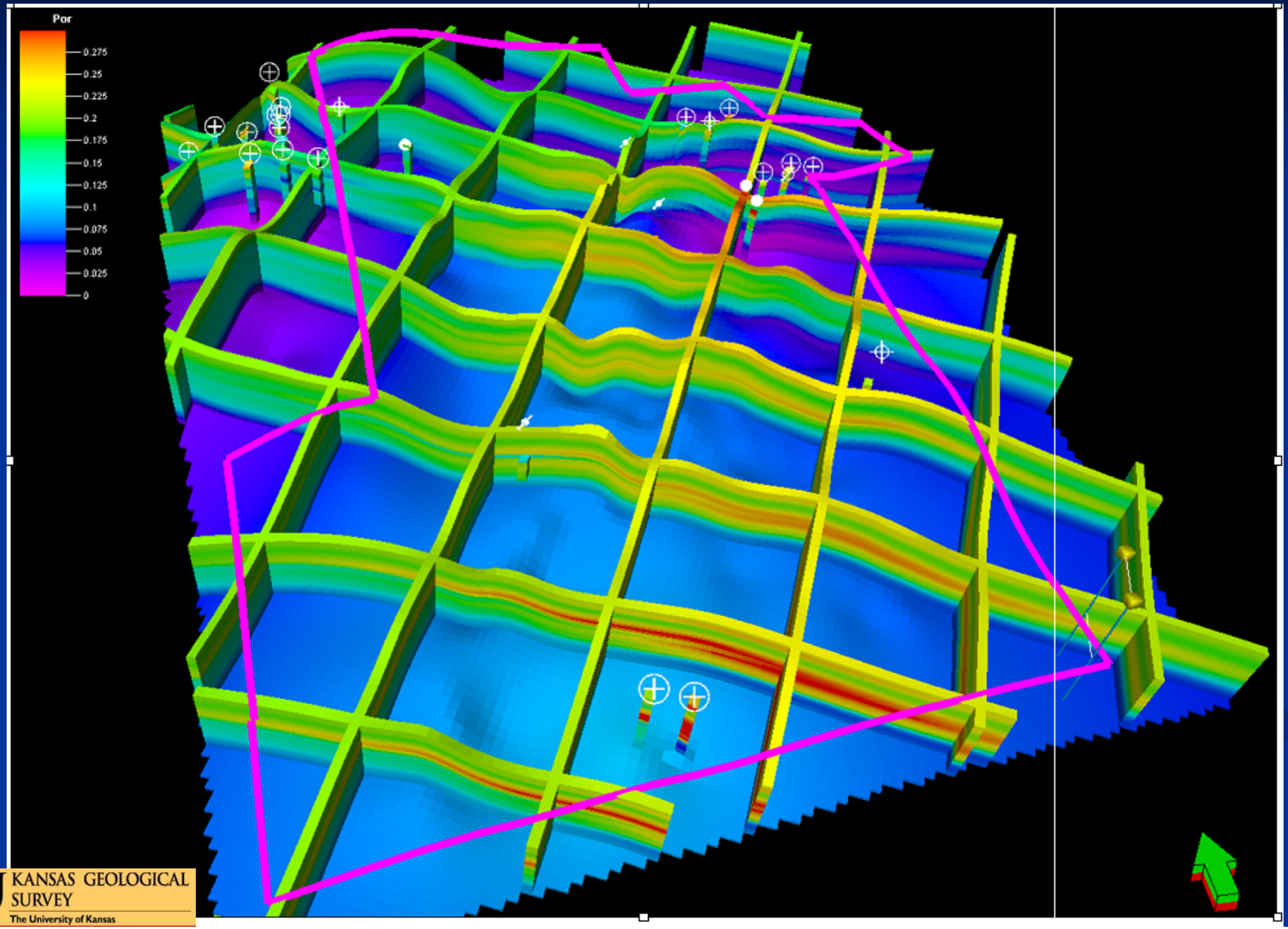
Geomodeling

- Jason Rush, Kansas Geological Survey
- Seeking Highly Accurate Porosity Volume
- Will Integrate Well Control, Seismic

Seismic vs Geomodel



Porosity Model Building



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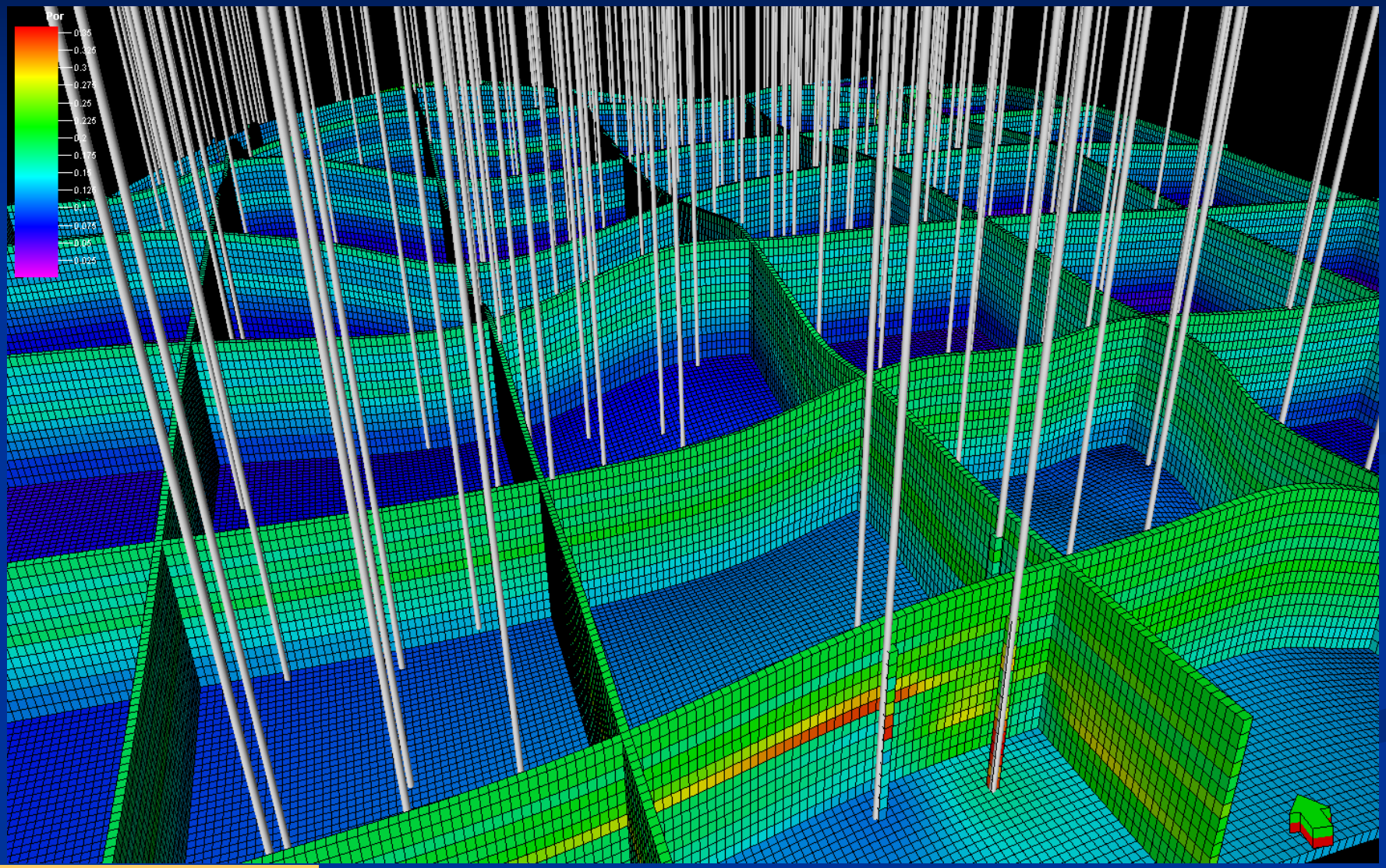
Geomodel Basis



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Future Processing & Analysis

- 2D Shear Wave Acquisition to Assist / Verify Converted Wave Processing

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- Impedance Inversion to assist and feed Geomodel

Thank You