

AV Detailed Structural Interpretation Using 3D Seismic Curvature Analysis, Neuquen and San Jorge Basins, Argentina*

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3D Seismic Goals - YPF

Increase production

- Infill drilling
- Waterflood / enhanced recovery
- Step-out potential
- Deeper potential

Reserve enhancement / quantification

Improve prediction of reservoir properties

Delineate subtle structural features

- Faults with small displacements – low frequency
- Fractures

Study Locations

San Jorge Basin

- El Guadal Norte Field

Neuquen Basin

- Bajo Del Piche Field
- Senal Cerro Bayo Field

Conclusions

Improved seismic interpretations

- Characterize existing fields
- Identify new reserves

3D seismic curvature analysis

- Presence and extent of small-displacement faults
- Location of natural fracture systems

Integration with engineering and geology

Selected References

Fronza, S. and C. Cocchia, 1998, Un Caso de Aplicacion de la Sismica 3D en la Prospeccion de Reservorios Multicapa en la Cuenca del Golfo San Jorge: Simposio de Sistemas Petroleros de las Cuenca Argentinas.

Homovic et al., 1994, Faja Plegada en el subsuelo de la Cuenca del Golfo San Jorge: Boletin de Informaciones Petroleras, No. 37.



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OUTLINE

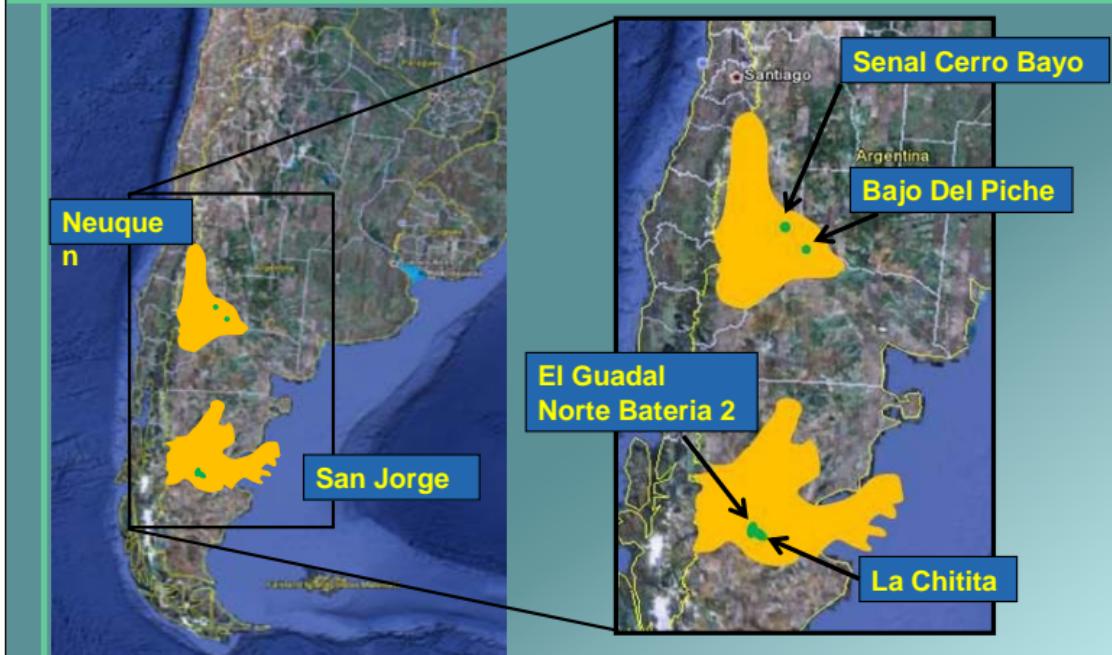
- Location
- Structural Challenge
- 3D Seismic Curvature Analysis
- Conclusions

- Increase Production
 - Infill Drilling
 - Waterflood / Enhanced Recovery
 - Step-Out Potential
 - Deeper Potential
- Reserve Enhancement / Quantification

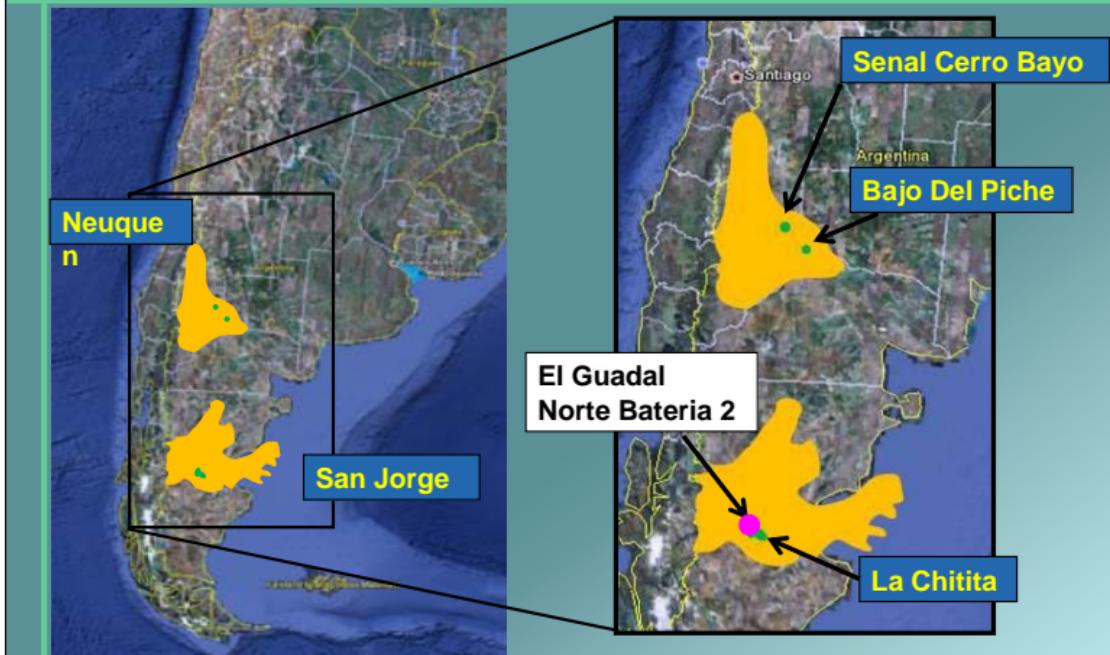
- Improve Prediction of Reservoir Properties
- Delineate Subtle Structural Features
 - Faults with Small Displacements – Low Frequency
 - Fractures
 - Secondary Features



STUDY LOCATIONS



STUDY LOCATIONS



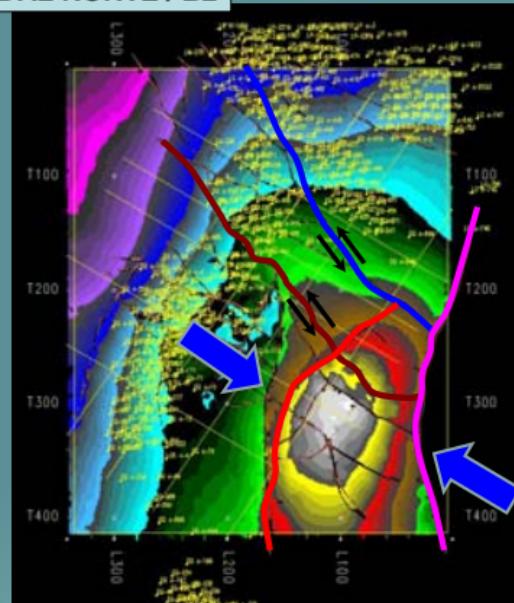
COMPLEX STRUCTURE

EL GUADAL NORTE / B2

- Extension in Mesozoic
- NW-SE Trending Normal Faults
- Andean (Tertiary) Compression
- NE-SW Elongate Structures and Reverse Faults
- Compression Parallel to Normal Faults - Reactivation of Pre-Existing Faults
- Strike-Slip, Reduced Throw

Homovic et al. (1994)

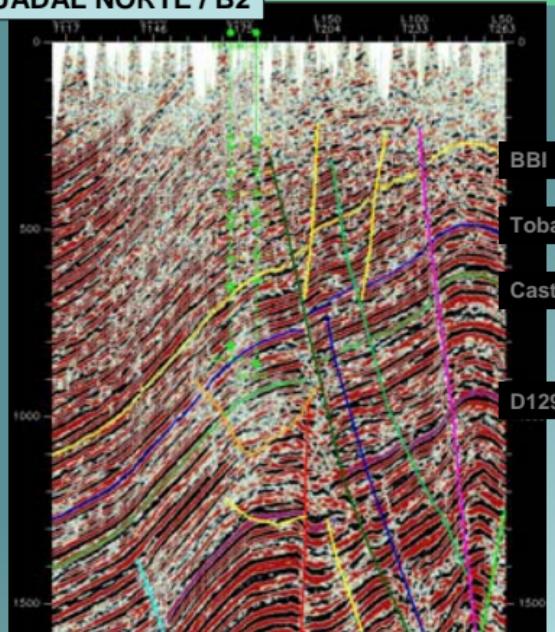
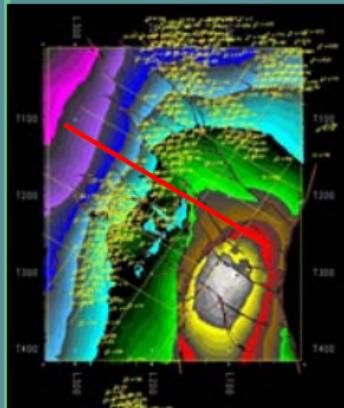
Fronza and Coccia (1998)



COMPLEX STRUCTURE

EL GUADAL NORTE / B2

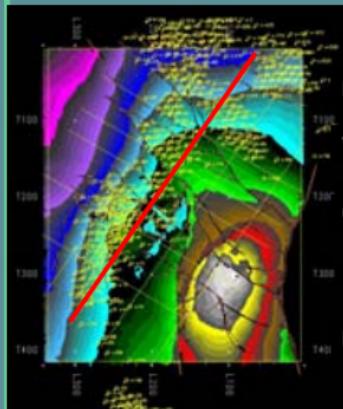
- Structure Increases in Magnitude, Fault Complexity
- Secondary Faults Clear, Form in Response to Structural Growth
- Opportunity for Additional Drilling – Structurally Higher



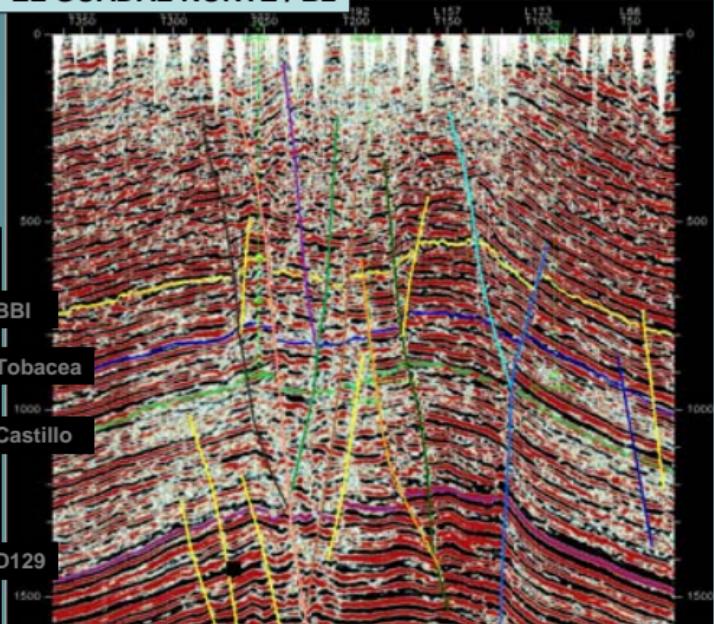
COMPLEX STRUCTURE



- Complex System of Faults
- Complexity Increases At Structural High
- Requires Care and Reviewing Time Slices, Curvature Information

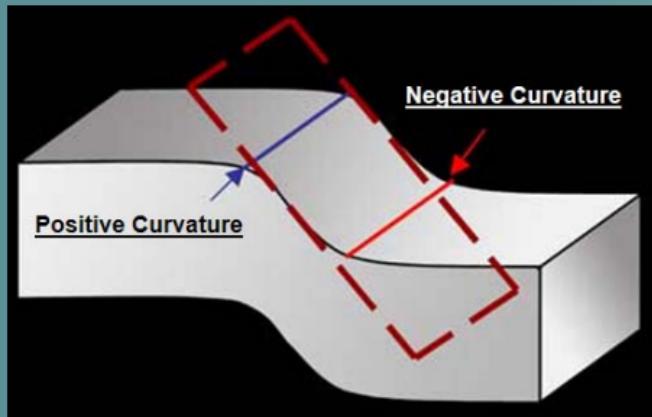


EL GUADAL NORTE / B2



3D SEISMIC CURVATURE

- Curvature Inherent in 3D Seismic Volume
- Each Sample Correlated to its Nearest Neighbors
- Creates Essentially a 3D Dipmeter Volume
- Positive Curvature - Anticlinal
- Negative Curvature - Synclinal
- Parallel Lines of Positive and Negative Indicate Faults
- Most Positive Curvature, Most Negative Curvature Indicate Possible Fractures

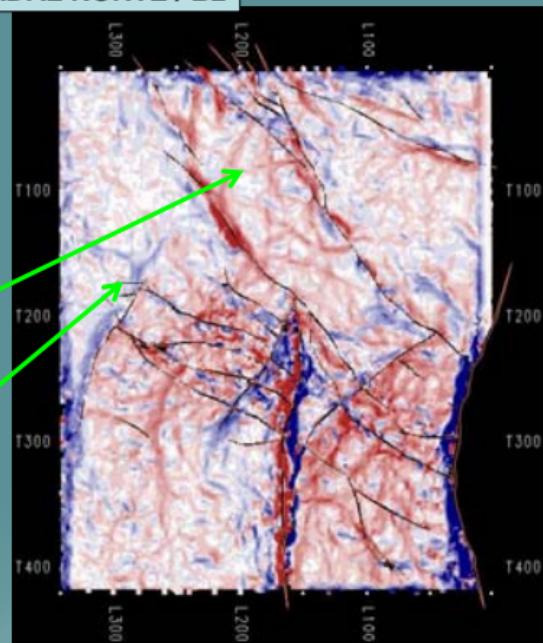


3D SEISMIC CURVATURE

EL GUADAL NORTE / B2

Maximum Curvature

- Abrupt Change in Positive Curvature (Anticlinal) to Negative Curvature (Synclinal)
- Many of the Larger Faults Interpreted from 3D Volume
- Visualize Small Faults and Fractures (Flexure)
- Maximum Curvature Extracted Along Horizon Indicates Longer Extent
- Definition of Fault System

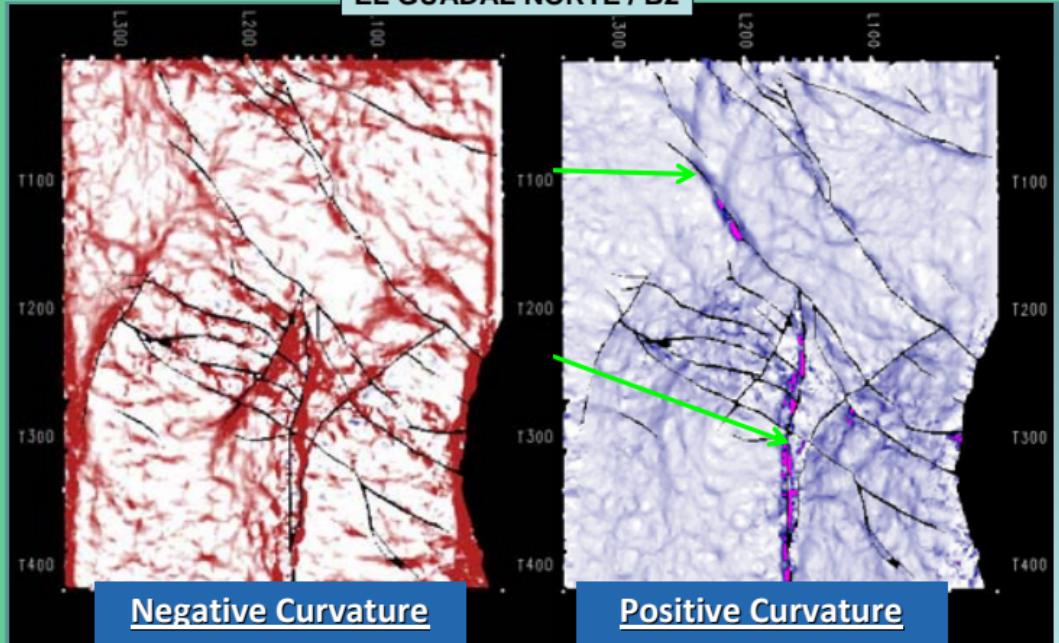




3D SEISMIC CURVATURE



EL GUADAL NORTE / B2

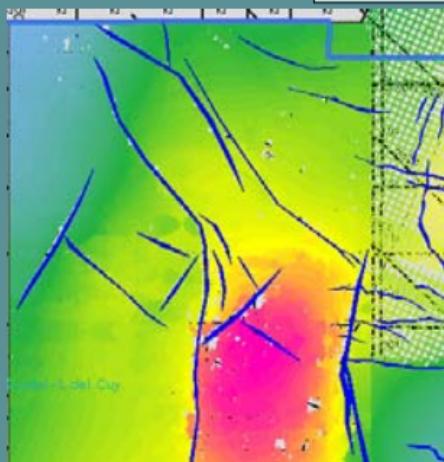




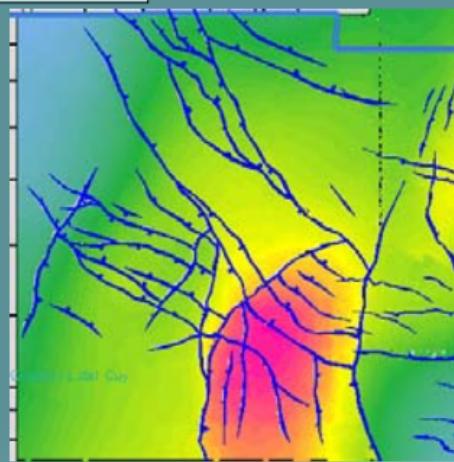
3D SEISMIC CURVATURE



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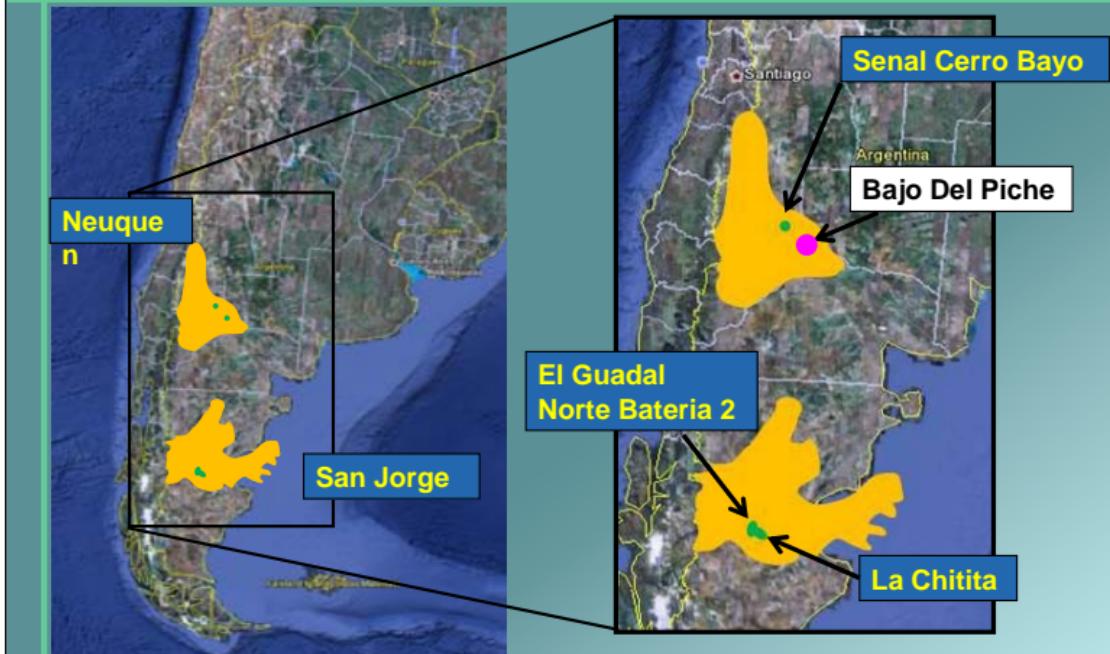


Two-Way Time
Conventional Seismic Data



Two-Way Time
3D Curvature Data

STUDY LOCATIONS

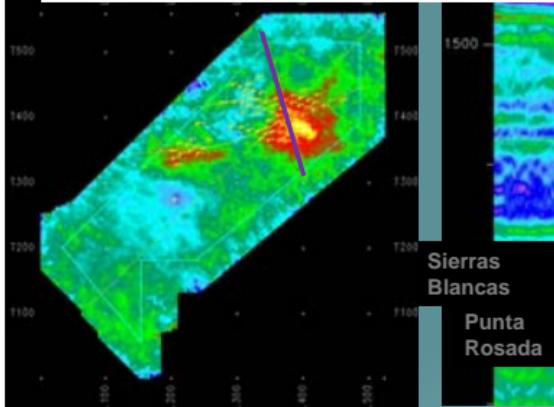


ACOUSTIC INVERSION

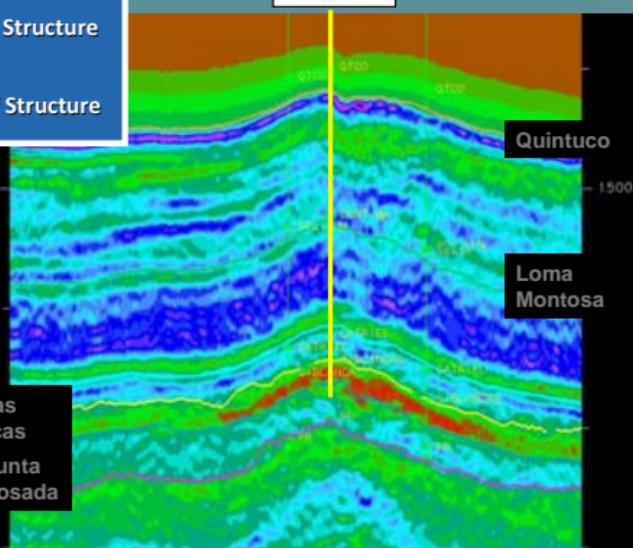


BAJO DEL PICHE

- BDP-24 Well Excellent Producer
- Low Impedance in Sierras Blancas On Structure
- Additional Area to the SE
- Low Impedance in Loma Montosa Off Structure



BP-24

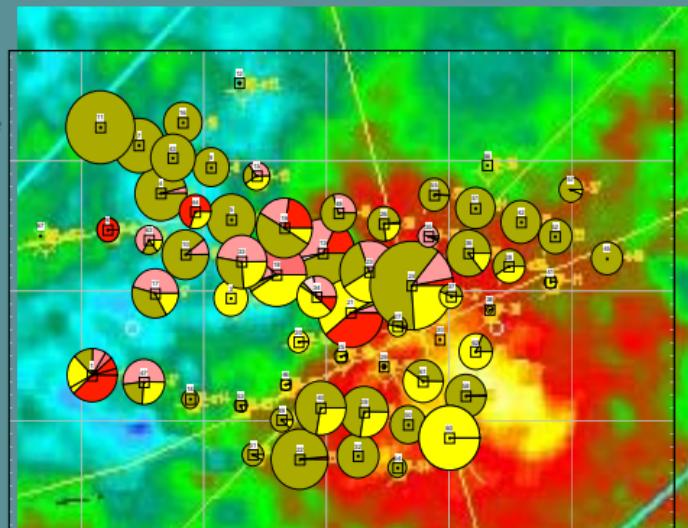


ACOUSTIC INVERSION



BAJO DEL PICHE

- Best Producing Wells Not on Lowest Impedance Areas
- Composite Effect of Structure and Stratigraphy
 - Structural Position
 - Low Impedance



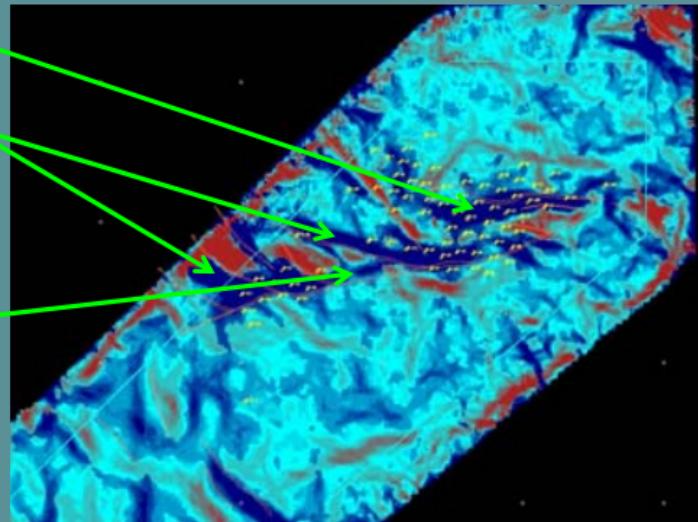
RMS Acoustic Impedance – Sierras Blancas

3D SEISMIC CURVATURE

BAJO DEL PICHE

Maximum Curvature

- Majority of Wells on Positive Curvature
- Undrilled Positive Curvature Areas Remain
- Test Against Structure Map, Stratigraphy, Engineering Data
- Identification of South Fault



3D SEISMIC CURVATURE

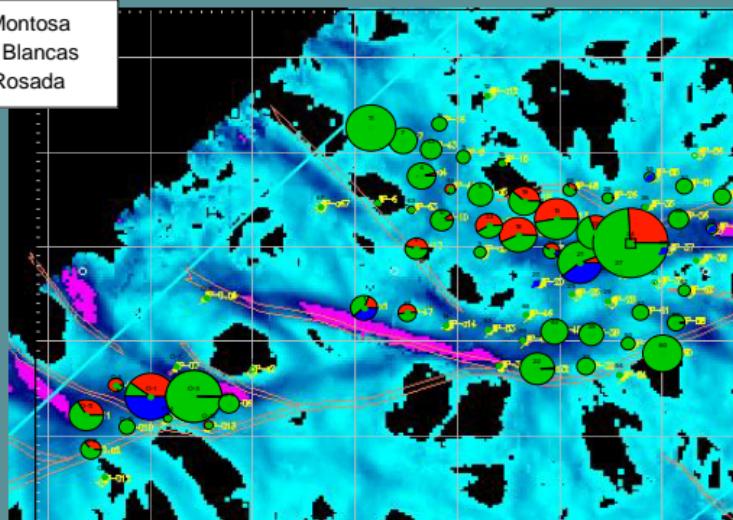


BAJO DEL PICHE

- Loma Montosa
- Sierras Blancas
- Punta Rosada

Positive Curvature

- Best Wells on Positive Curvature Highs
- Poor Wells in Area of Low Curvature
- Fracturing



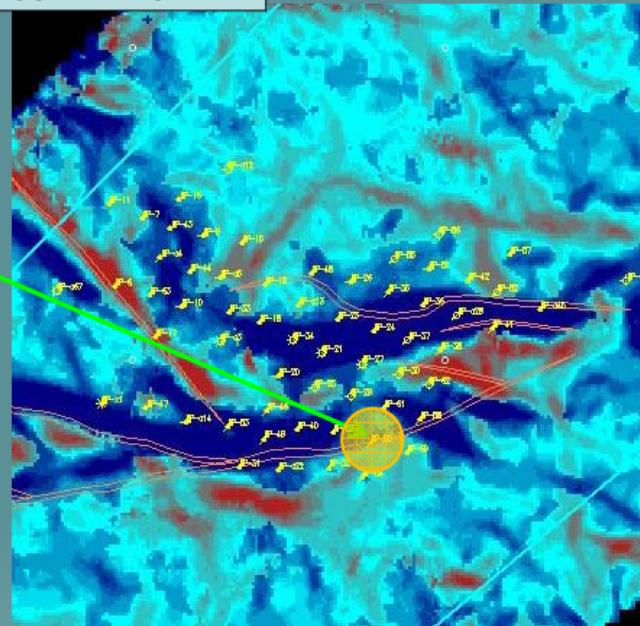
3D SEISMIC CURVATURE



BAJO DEL PICHE

Sierras Blancas Structure

- South Fault Displays Reverse Dip-Slip Displacement - Transpression
- South Fault Extent Identified Mainly by Curvature Volume
- Integrate with Well Control, QC



Note of Presenter:

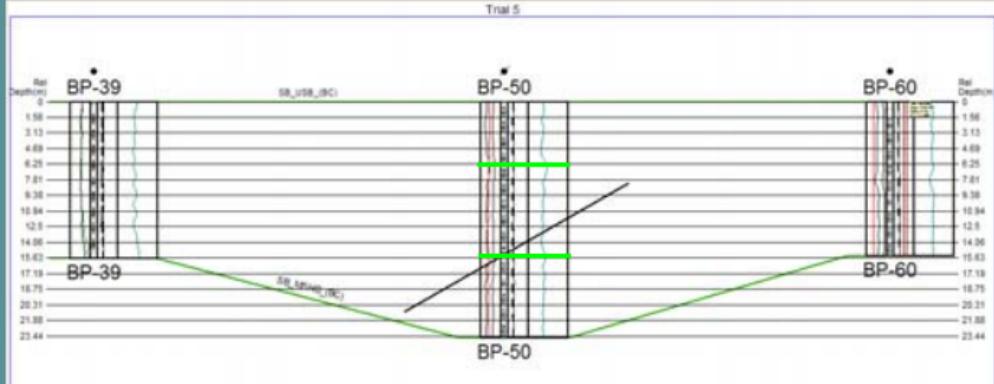
- Curvature maps. 2) Attribute work. 3) Northeast feature probably extends off concession. 4) Fault traps to SW are being evaluated. 5) Charco Bayo lineament related structural deformation may extend to the east.

3D SEISMIC CURVATURE



BAJO DEL PICHE

Trial 5

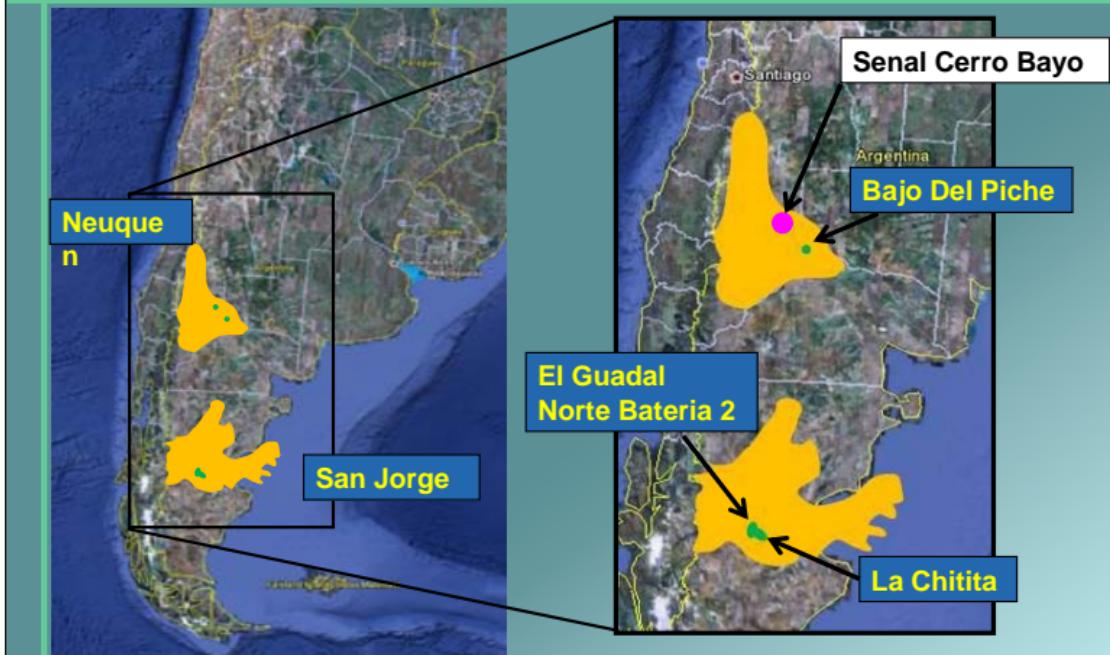


- BP-50 Well Cut by Fault Within Sierras Blancas
- Repeated Section

Note of Presenter:

- 1)Curvature maps.
- 2) Attribute work.
- 3) Northeast feature probably extends off concession.
- 4) Fault traps to SW are being evaluated.
- 5) Charco Bayo lineament related structural deformation may extend to the east.

STUDY LOCATIONS

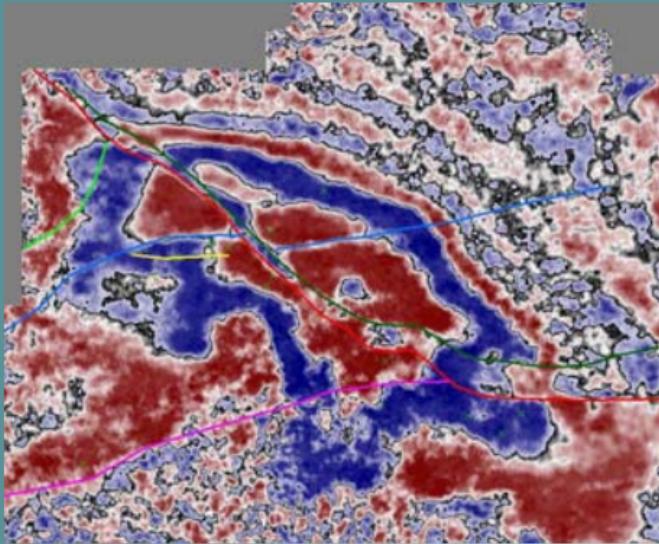


COMPLEX STRUCTURE

SEÑAL CERRO BAYO

- Definition of Major Faults
- Different Fault Orientations
- Subtle Faults?

Time Slice 1440 msec



COMPLEX STRUCTURE



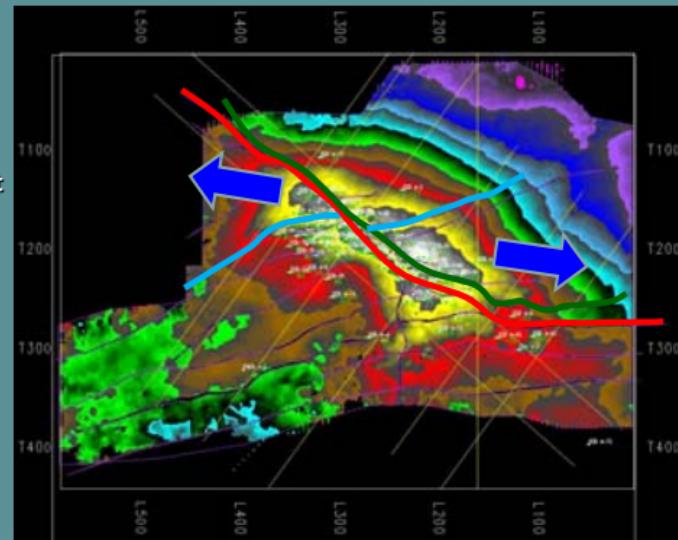
SENAL CERRO BAYO

- Extension WSW-ENE Trending Normal Faults
- Main Fault (Red) and Antithetic (Green) Cut Pre-Existing
- Shows Right-Lateral Offset on Structural Crests and Transverse Faults
- Trans-Tension – Releasing Bend in Fault
- Inversion

Mendiberri and Carbone (2002)

Cabaleiro (2002)

Borgnia (2007)



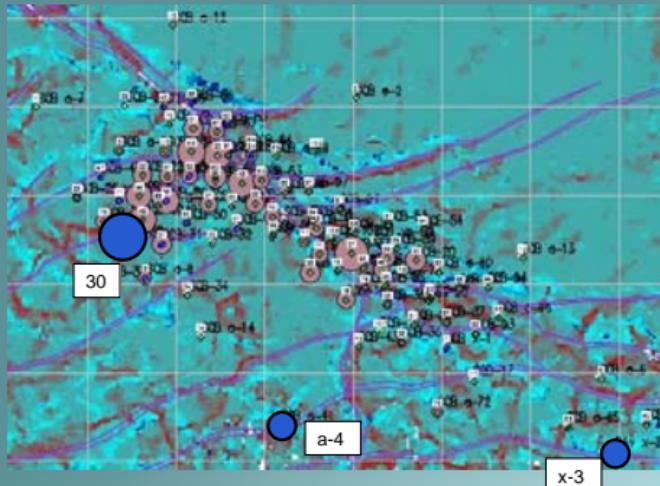
3D SEISMIC CURVATURE



SENAL CERRO BAYO

Cum Water Production Overlay

- Well 30 – Very High Water Cut
 - Shallow
 - Odd Interpretation of Aquifer
 - Cut by E-W Fault
 - Explains Production Behavior
- Other Wells with High Water Cut are Located on E-W Faults, Fractures
- E-W Faults Appear Open
- N-S Faults Appear Closed
- Implications for Rock Mechanics / Stress Field
- Directional Drilling

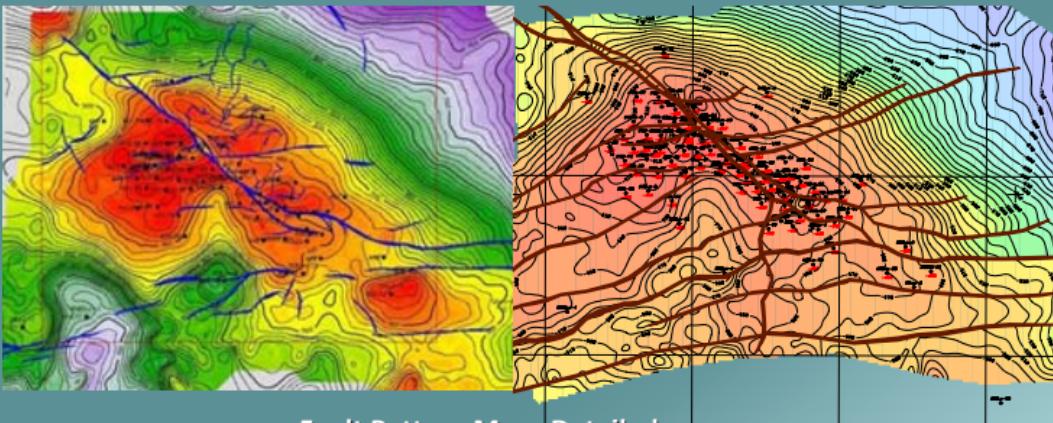


COMPLEX STRUCTURE



BEFORE

AFTER



- Fault Pattern More Detailed
- Faults More Continuous
- Explains Structural Style
 - SW-NE Trend on West Side
- Explains Production Anomalies

CONCLUSIONS

- **Improved Seismic Interpretations**
 - Characterize existing fields
 - Identify new reserves
- **3D Seismic Curvature Analysis**
 - Presence and Extent of Small-Displacement Faults
 - Location of Natural Fracture Systems
- **Integration with Engineering and Geology**