

Soil Gas Sampling Enhanced Existing Plays and Indicate Multiple New Oil and Gas Trends in Fortesa's Onshore Coastal Position (Senegal)*

Rogers Beall¹

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¹Fortesa International Senegal, Houston, Texas (rogers@fortesa.com)

Abstract

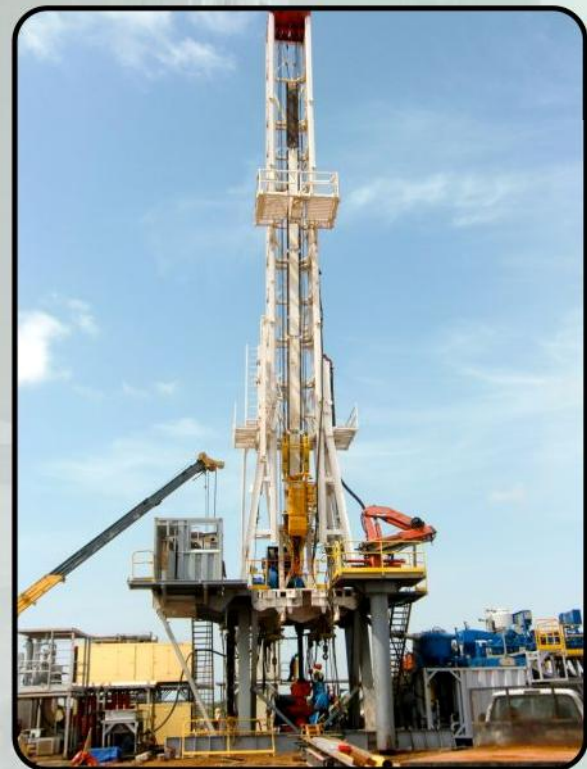
Fortesa has produced gas and condensates in our Onshore Permits in northern Senegal since 2002 in reservoirs that are primarily Lower Senonian slope sands, with closure set-up by faulting related to the Kayar Fault Zone. Seismic quality is sufficient to reliably map the architecture of the various play concepts revealed clearly by Fortesa's very large, dense Geochemical seepage sampling, but it remains insufficient to define individual sands due to the various resolution attenuation factors normally endemic in Delta Front Sandstones, e.g. rapid sedimentation, faulting, channeling and rock velocity variations arising these factors and from mudstones and silting within the sandstones. As a result, reliable seismic depth conversion has been historically problematic leading to difficulties in well prognosis plans and lack of confidence in tying well control to good seismic controls.

To reduce exploration and development risk, in 2002 at the start of our new exploration program Fortesa contracted Exploration Technologies, Inc. to collect surface soil gas samples from both our coastal producing trend and later expanded into our undrilled shelf trend further east from the coast. In total, 4100 samples were obtained using a 1 X 1 km grid on our whole permit, with double sampling in core coastal production areas. Using methane/ethane (dry), and ethane propane (wet) ratios, coupled with methane and ethane anomaly magnitudes resulted in recognition of a series of hydrocarbon play trends and areas that correlate incredibly well with Fortesa's extensive regional seismic, gravity, magnetics, surface geology and our well control from actual drilling results.

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Hedberg Conference | 18-20 June 2019 – Houston, Texas
Rogers Beall, President Fortesa International Senegal

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THE COASTAL HYDROCARBON RESOURCES FOR **SÉNÉGAL**

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50 Years With No Successful Commercial Discovery

From the Advent of Modern Drilling in the 1950s
until 2014, the Offshore MSGBC went with Basically
NO Significant Commercial Discoveries

(Mauritania's *Chinguetti Field* Produced, but was not commercially successful from Discovery to P & A)

Why was this?

Excellent Companies had explored in the MSGBC
e.g. Shell, Exxon, Unocal, Pecten, Woodside, Premier, Total, ELF, Mobil,
Marathon, Amoco, Tullow, etc.

Diender Permit Location – Dakar, Senegal (NW Africa)

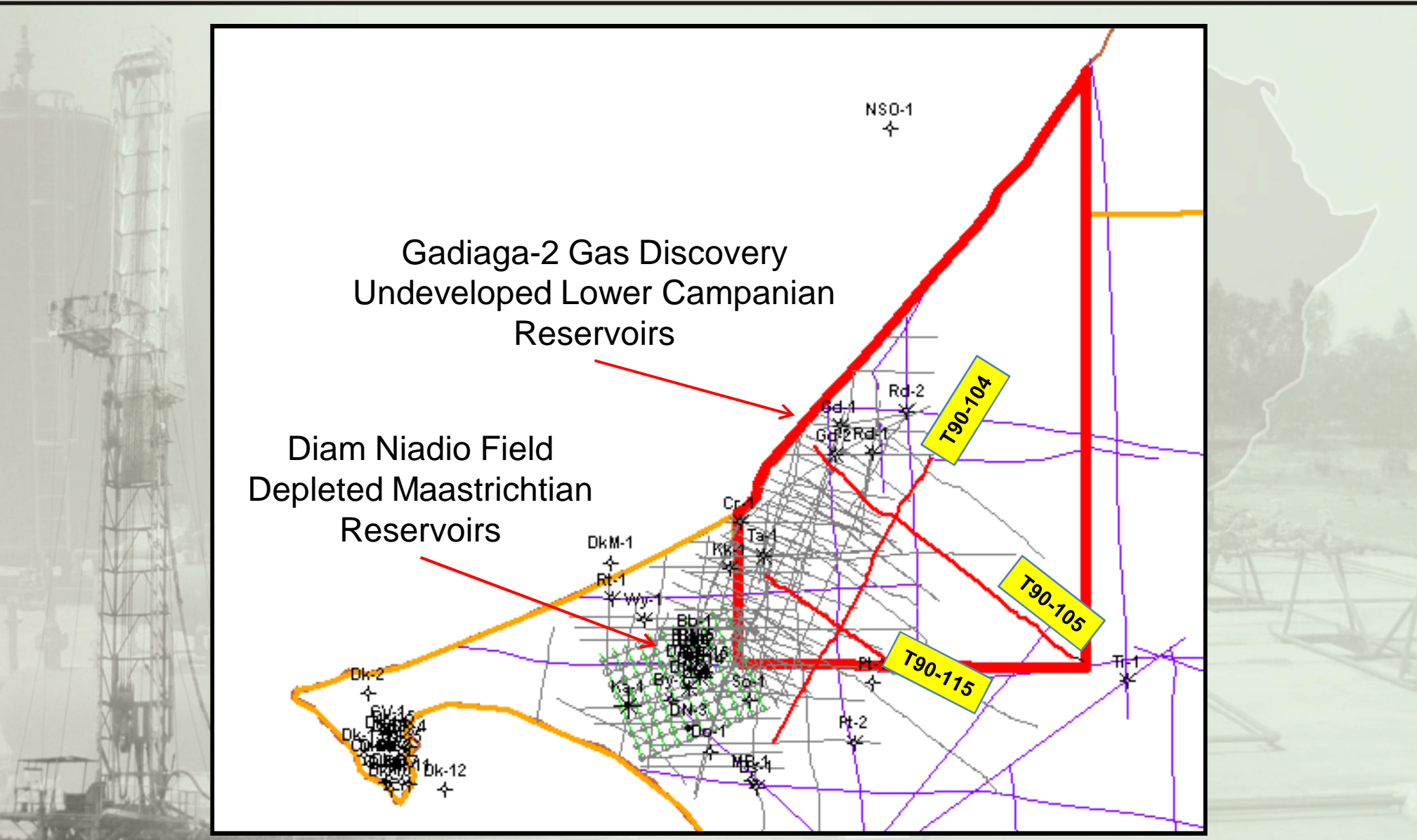


Senegal

Overview

- An example is Senegal's Onshore: with much seismic and exploration effort with >80 wells drilled (>\$350 million value), only two significant wells (>10 BCF = \$80 million gross Revenue) were drilled, none by IOC's.
- Most of these 80 wells were drilled on single plunging anticlines that were poorly controlled on the plunge directions with 2D seismic data. Gadiaga and Diam Niadio are the only exceptions and they produced mainly gas.
- The single-plunging anticlines formed as divergent wrenching structures.
- Clearly this Exploration was not cost-effective, returning only 20-cents on the dollar and giving NO commercial Play Fairways to pursue thru 1997.
- However, low relief closures drilled in shelf locations on passive continental margins often produce highly commercial oil and gas fields.
- Few wells, if any, wells have been drilled to-date on low-relief closures on the passive margin shelf north & east of the Dakar High.
- Current geochem mapping supports that significant Gallic Cretaceous Play Fairways exist on the shelf along the eastern margin of our Diender permit.

Seismic and Well Control (80+ Wells Onshore) ca. 1997



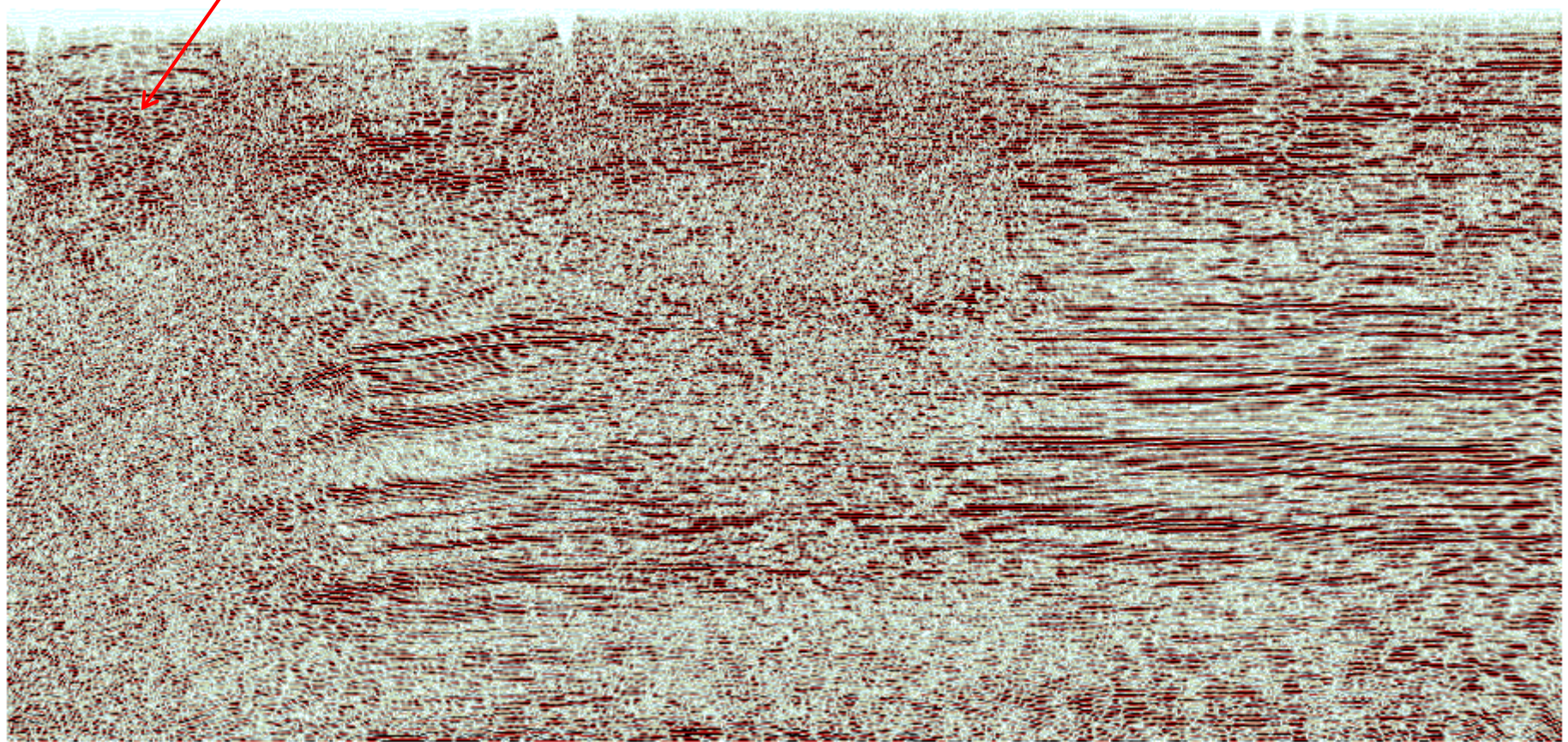
T90-105 Dip Line – Un-interpreted

NW

Gadiaga

Where are the Structures, Play Fairways?

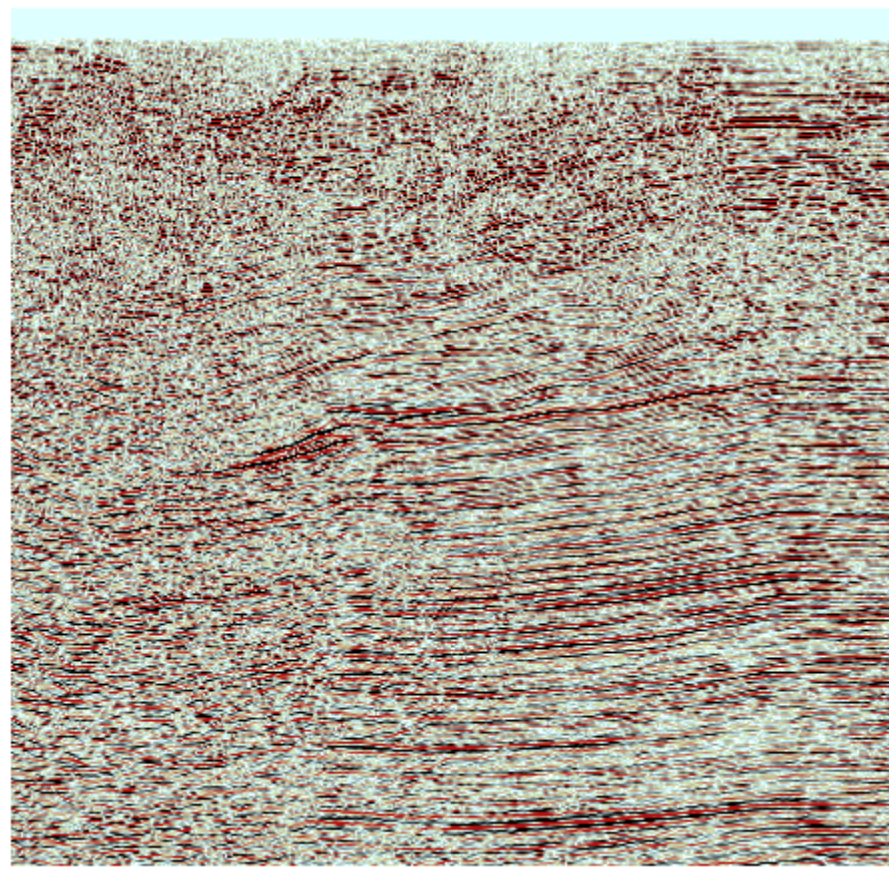
SE



T90-115 Dip Line – Un-interpreted

NW

SE



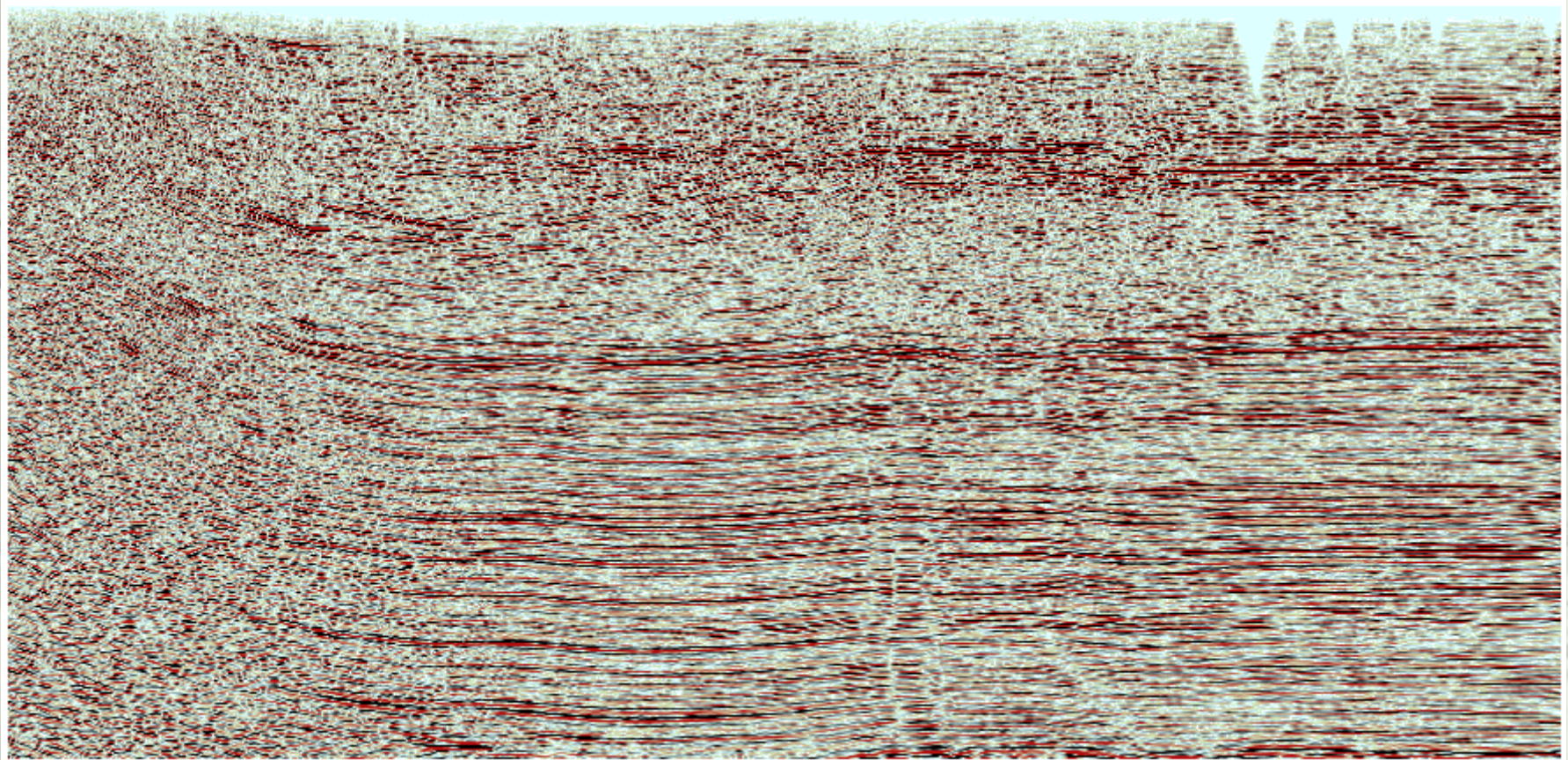
Where are the Structures, Play Fairways?

T90-104 Strike Line – Un-interpreted

SSW

Where are the Structures, Play Fairways?

NNE



S é n é g a l

Overview

- FORTESA has developed & produced gas, condensates in our Onshore Permit in northern Senegal since 2002 from reservoirs that are middle to outer shelf sands.
- To reduce E & P risk and as a tool to help lay-out our new 3D seismic program in 2002, Fortesa contracted *Exploration Technologies, Inc.* to design surface soils gas sampling grids in our coastal producing trend area, thinking our Gas was coming from cretaceous source rocks under the Atlantic.
- After SNE was discovered in 2014, we expanded our sampling to 4100 samples to cover our whole Exploration permit to the EAST of the Neocomian, Jurassic Carbonate Shelf Edge.
- Using methane/ethane (dry), and ethane propane (wet) ratios showing anomaly magnitudes, we are finally able to recognize a series of new hydrocarbon PLAY FAIRWAYS that integrate well with Fortesa's extensive regional seismic, gravity, magnetics, surface geology and well control from actual drilling results.

MSGBC Success finally came from 2012 through Integrating the *Petroleum Systems*

- Fortesa's initial efforts in 1997 were to bring Stranded Gas to Market via Developing the Gd-2 discovery well into the Gadiaga Gas field.
- Discouraged that Gadiaga Field did NOT have a big GeoChem Signature
- Focused instead on 3D interpretation, development drilling, selling Gas
- Re Exploration, we sought Extensive Regional Geologic Understanding
 - Source rocks, identification of sub-basins, Play Fairway Trends
 - Reservoir & Trapping mechanisms, verses desired large Structures
- Full Integration of All GeoSciences
 - seismic, gravity & magnetics, 4100 Soils Gas Geochemistry samples, surface geology, well control, 2D & 3D Seismic, biostratigraphy
- Results were a keen understanding of all of Regional MSGBC Data Points Governing the Multiple *Petroleum Systems* in-place!

S é n é g a

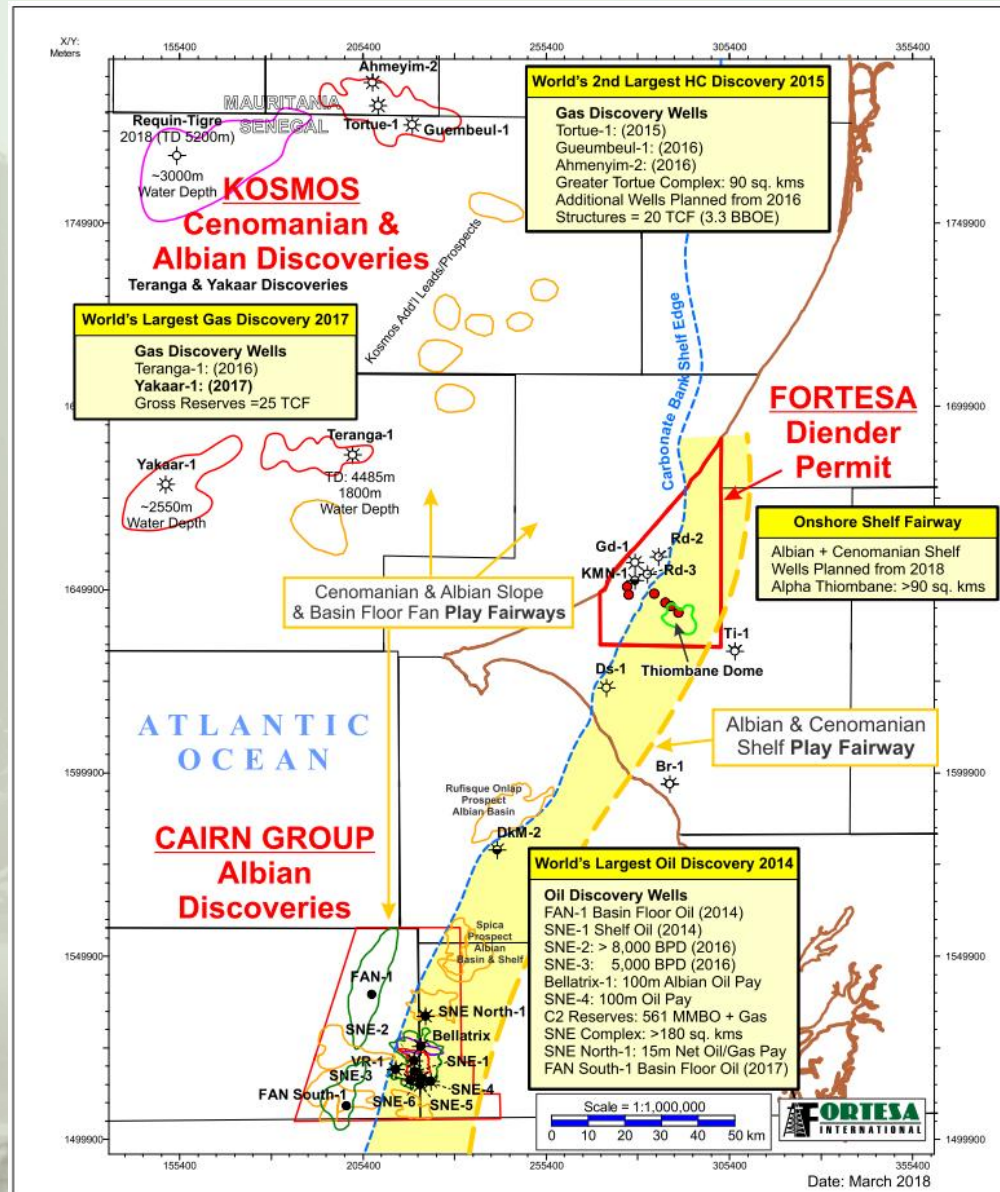
Overview

- Readily apparent are the outlines of Gadiaga, Kabor and Diam Niadio fields, and also what we can now interpret to be delta lobes, fault trends and canyon or channel head pinch-outs, one of which opens out down-dip from Gadiaga to host Kosmos' large DW Teranga Gas Discovery.
- Two Fortesa Gadiaga Gas Field wells where our Soils-Gas anomalies indicated oil then 'recovered oil' in 2012 & 2014, unique to our producing Gadiaga Gas field.
- Typing of that recovered oil revealed a previously unknown, but regionally predicted Early Jurassic Marine / Lacustrine source rock(s).
- In 2014, this Fortesa Early Jurassic Oil, along with DW SNE Field Discovery situated shoreward from the Carbonate Shelf Edge was a real wake-up call for Fortesa & GeoChem
- *Carbonate Shelf Edge runs N-S our entire onshore permit!*

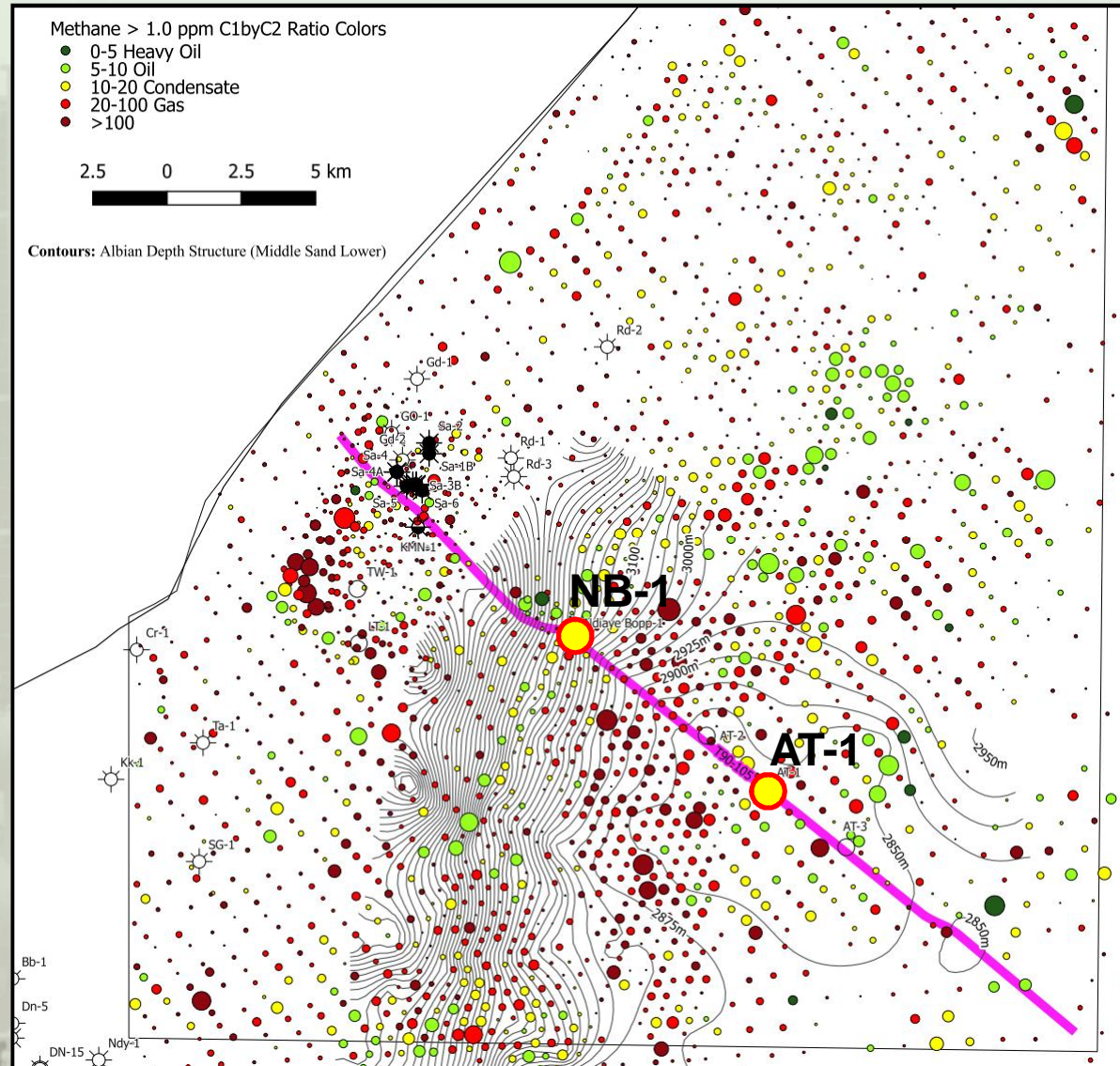
KMN-1 Oil



Correlation with Recent Offshore Discoveries from 2014



Thiombane DOME from 2017: Methane Surface Geochemical Anomalies C1/C2 Ratio Colors

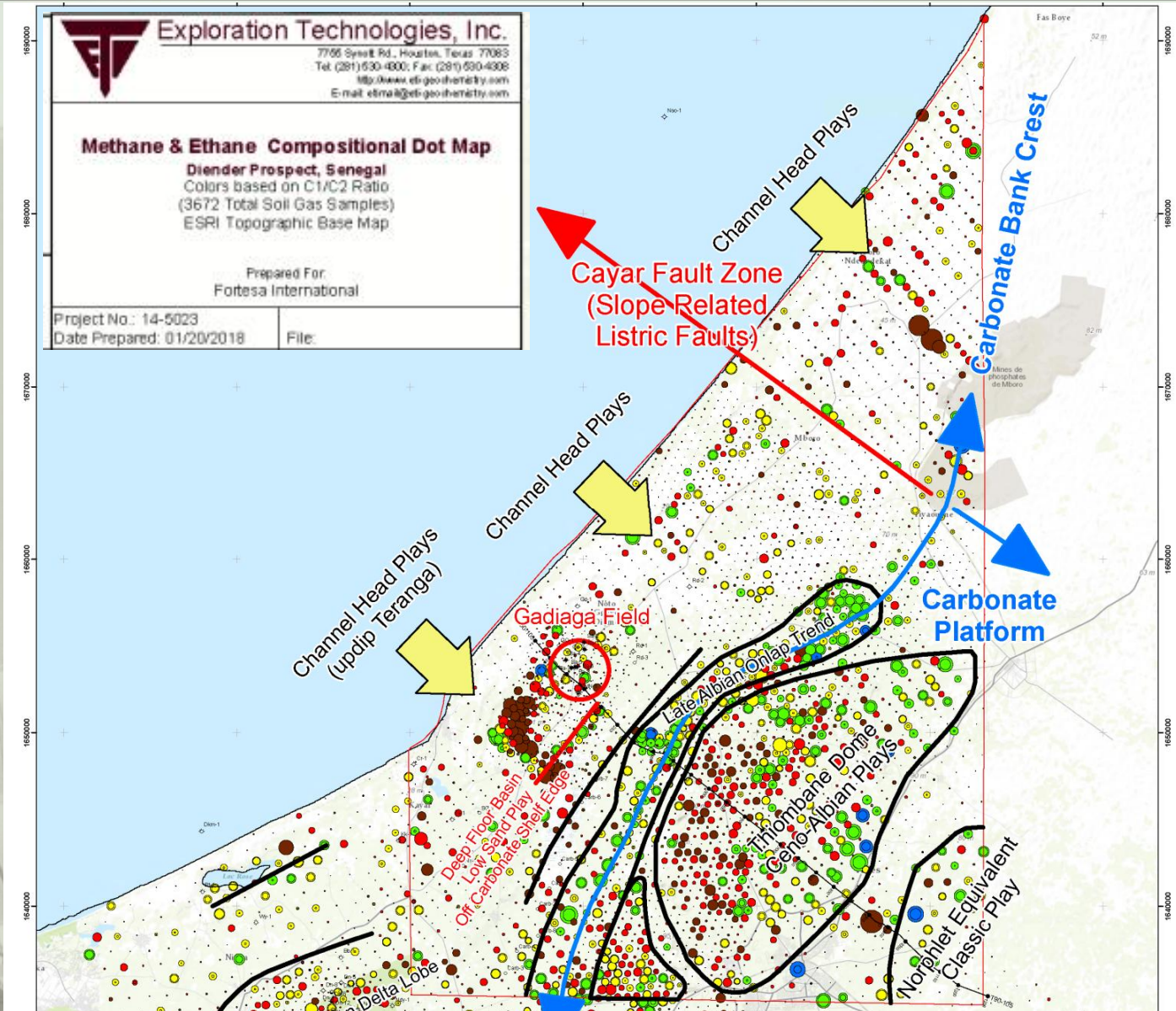


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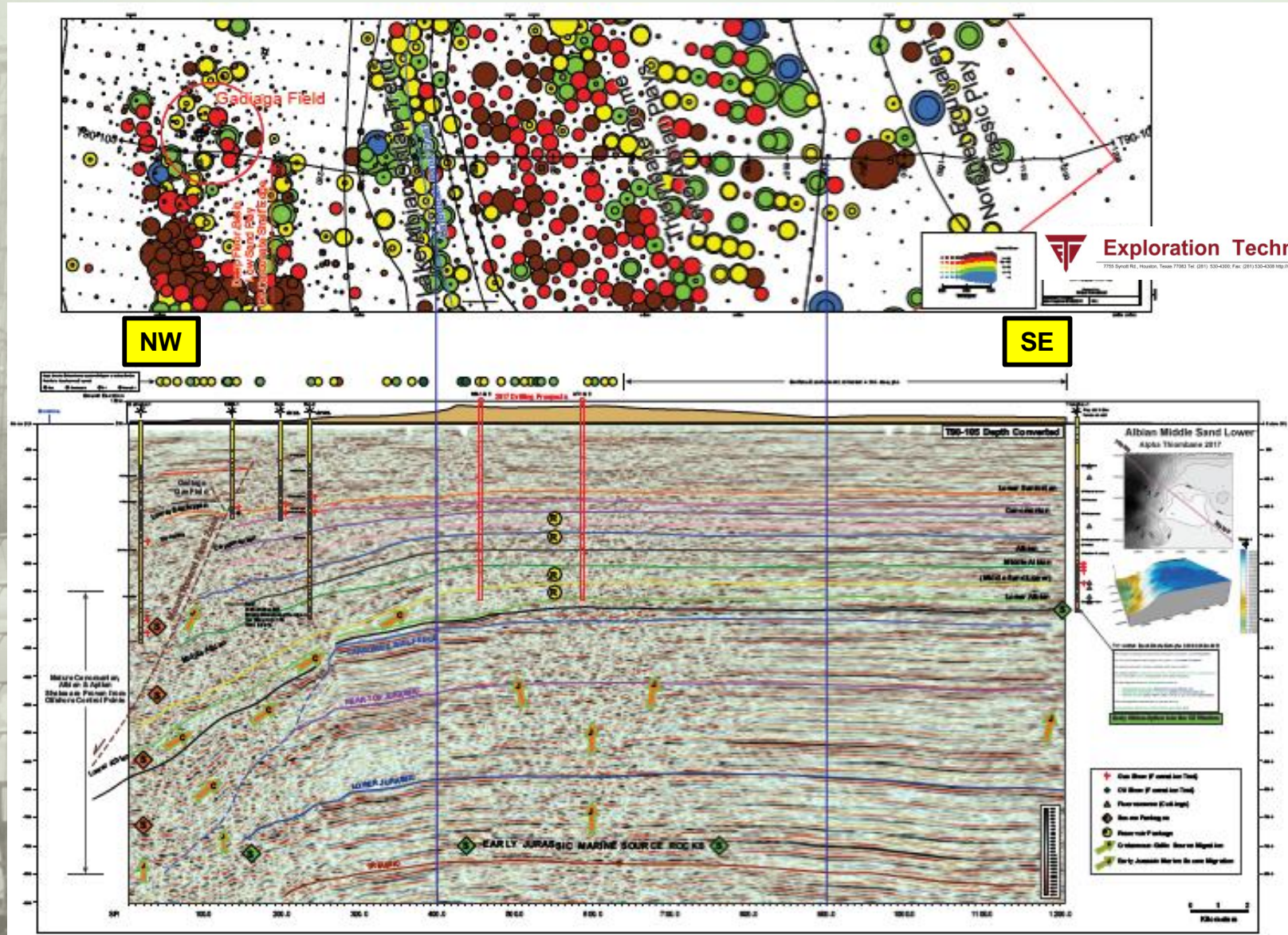
New Plays Revealed from 2017

- To the East where our Diender Permit remains undrilled, at least two new seismically predicted deep plays were nicely confirmed by strong GeoChem anomalies.
- The larger of these is the Thiombane Dome for which our eastern closure was previously uncertain due to seismic depth conversion uncertainties.
- Another is a consistent 40-kilometre long wedge-out trend on-lapping the shelf along the carbonate platform shelf edge to the west of the Dome that is associated with persistent high ethane to propane ratio anomaly ratios.

Methane & Ethane Compositional Dot Map Revealing New Plays Fairways seen from 2017



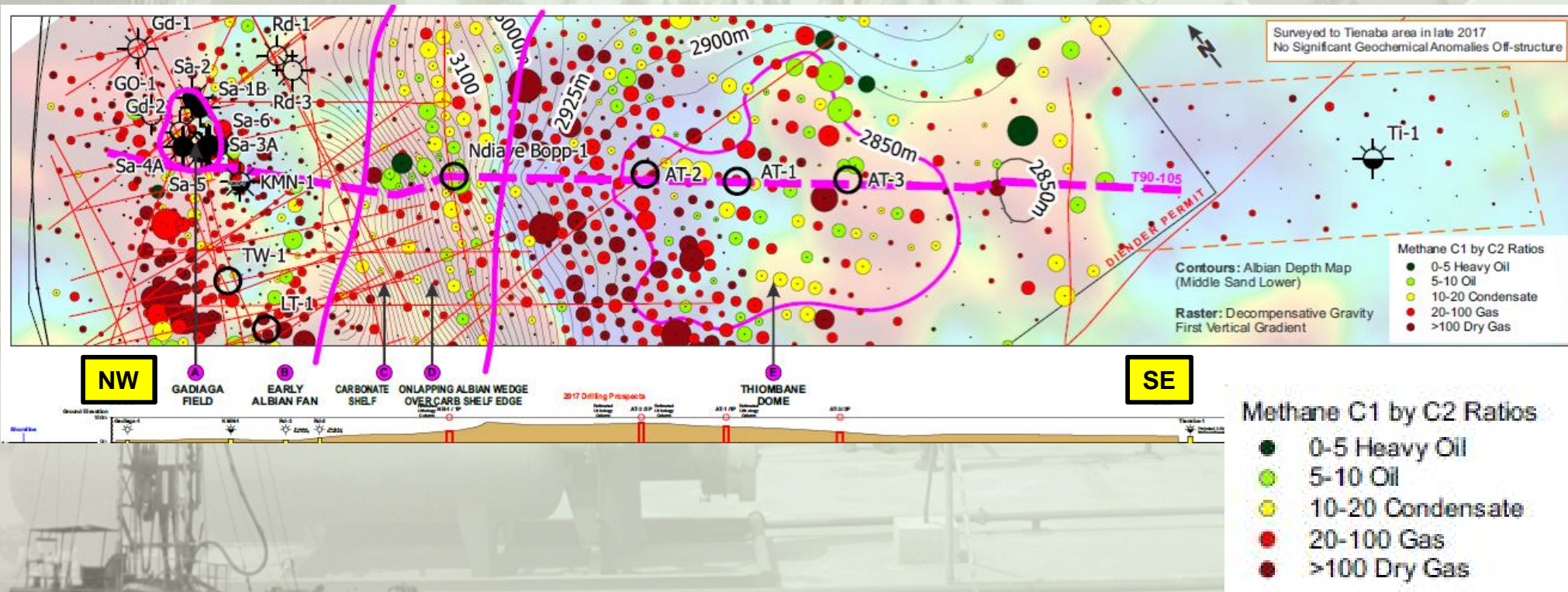
Methane & Ethane C1/C2 Dot Profile along Regional 2D Seismic Dip Line



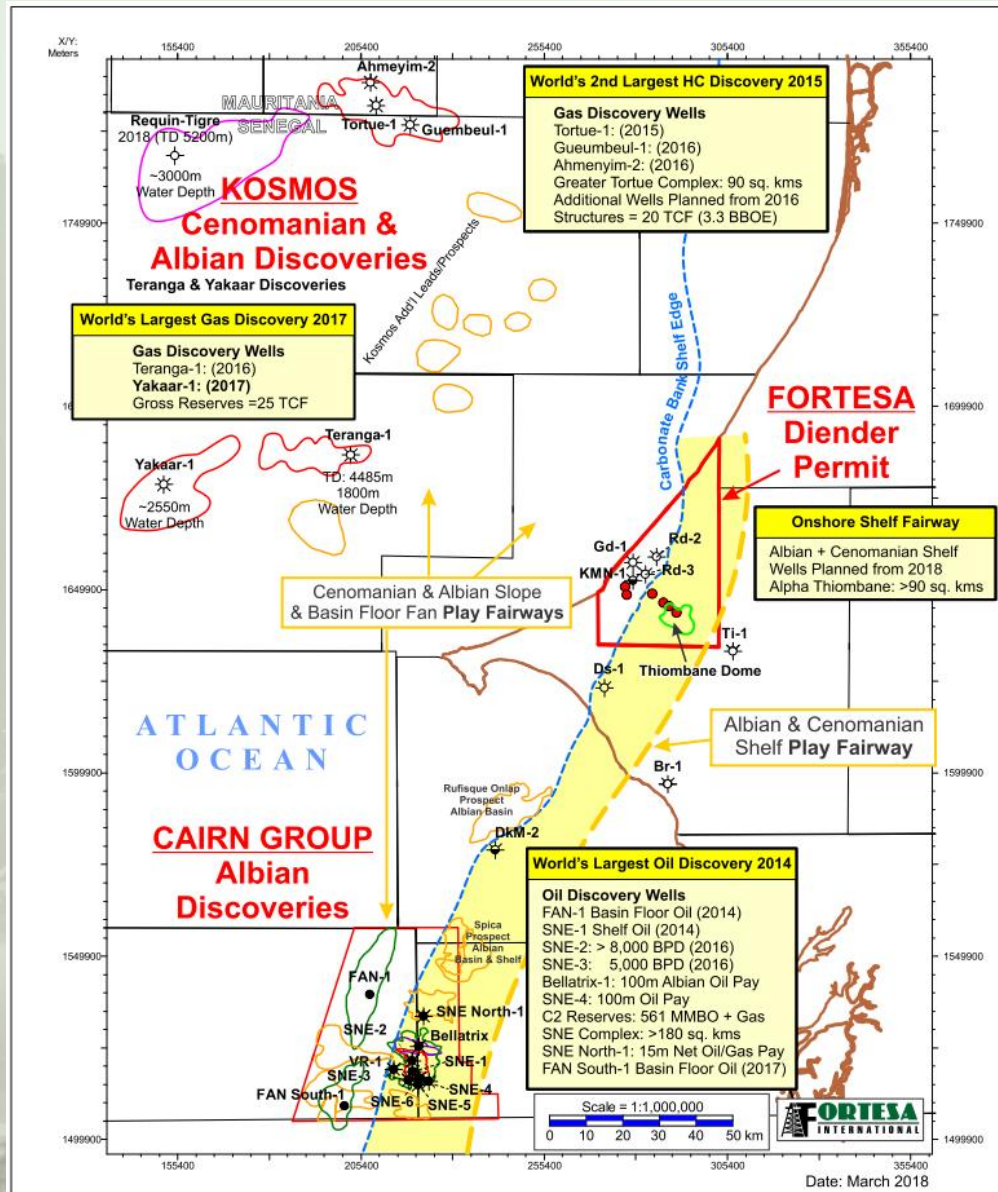
Play Fairways from Gadiaga Field to Thiombane Dome Area

Methane Anomalies C1/C2 Ratios over Decompensative Gravity

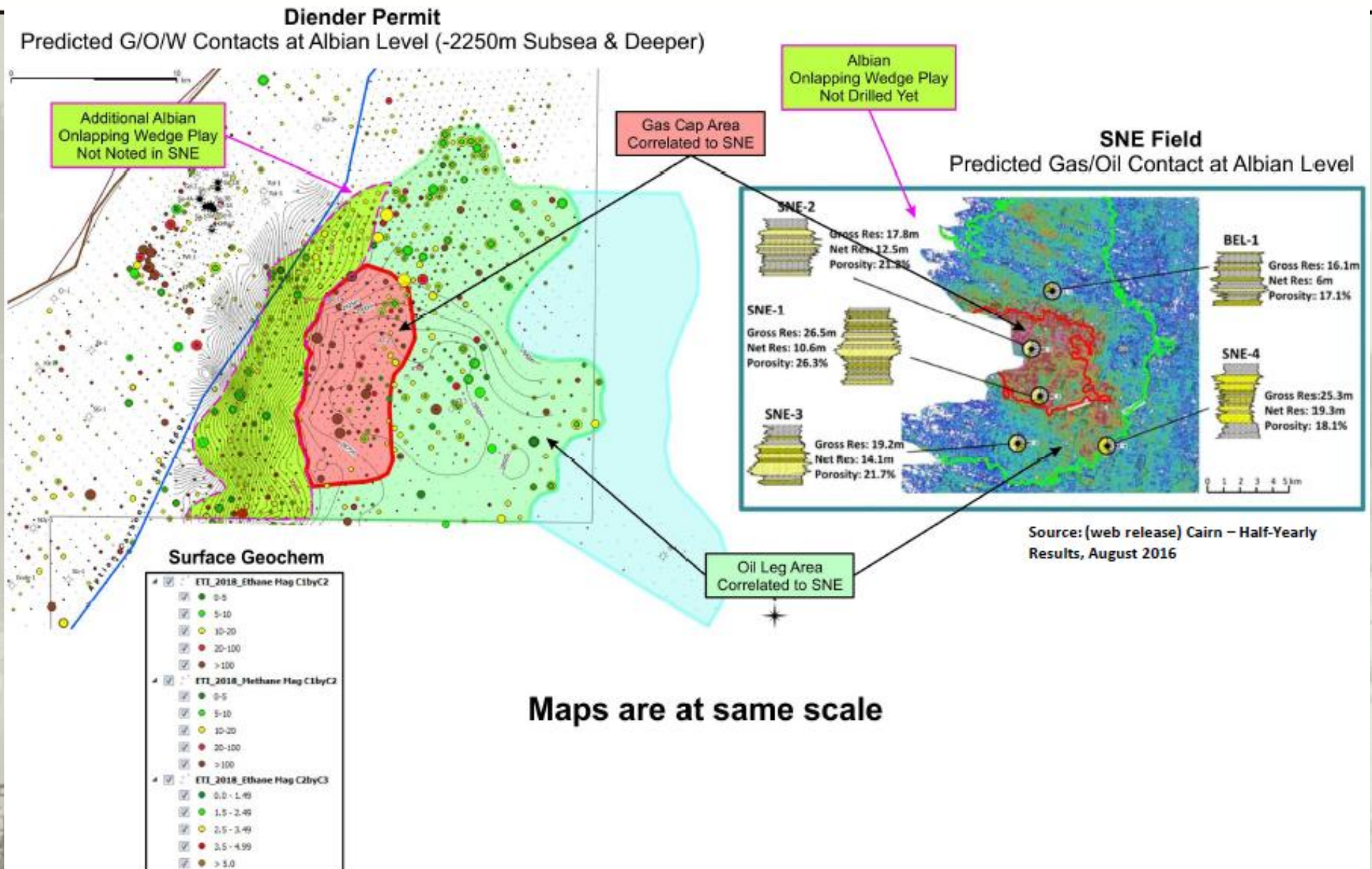
- Signature Oil & Condensate Accumulations along Onlapping Wedge Trend
- Substantial Gas Accumulation over Thiombane Dome
- No Significant GeoChem Anomalies Off-Structure at Ti-1 Well (1955 Test)



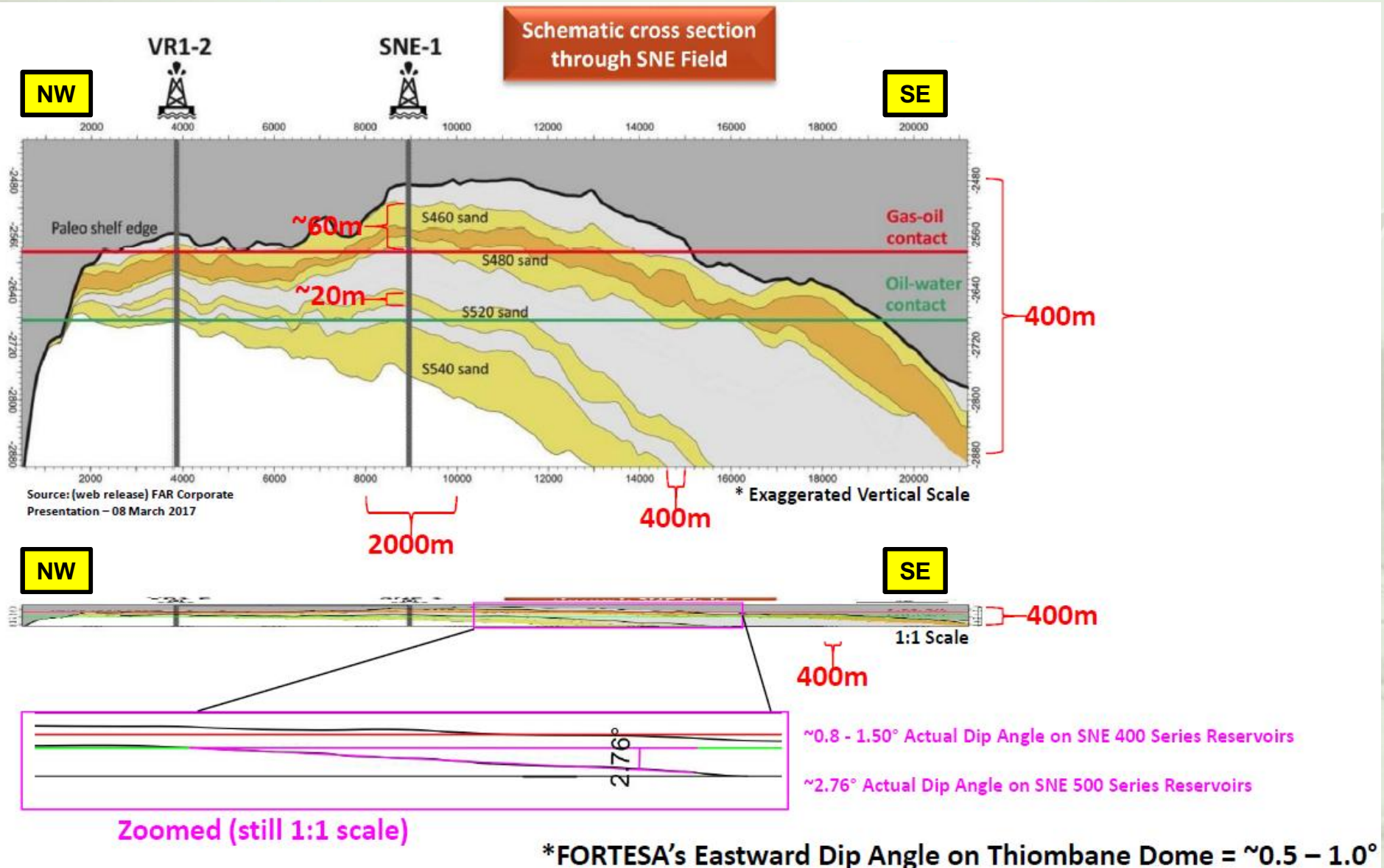
Correlation with Recent Offshore Discoveries



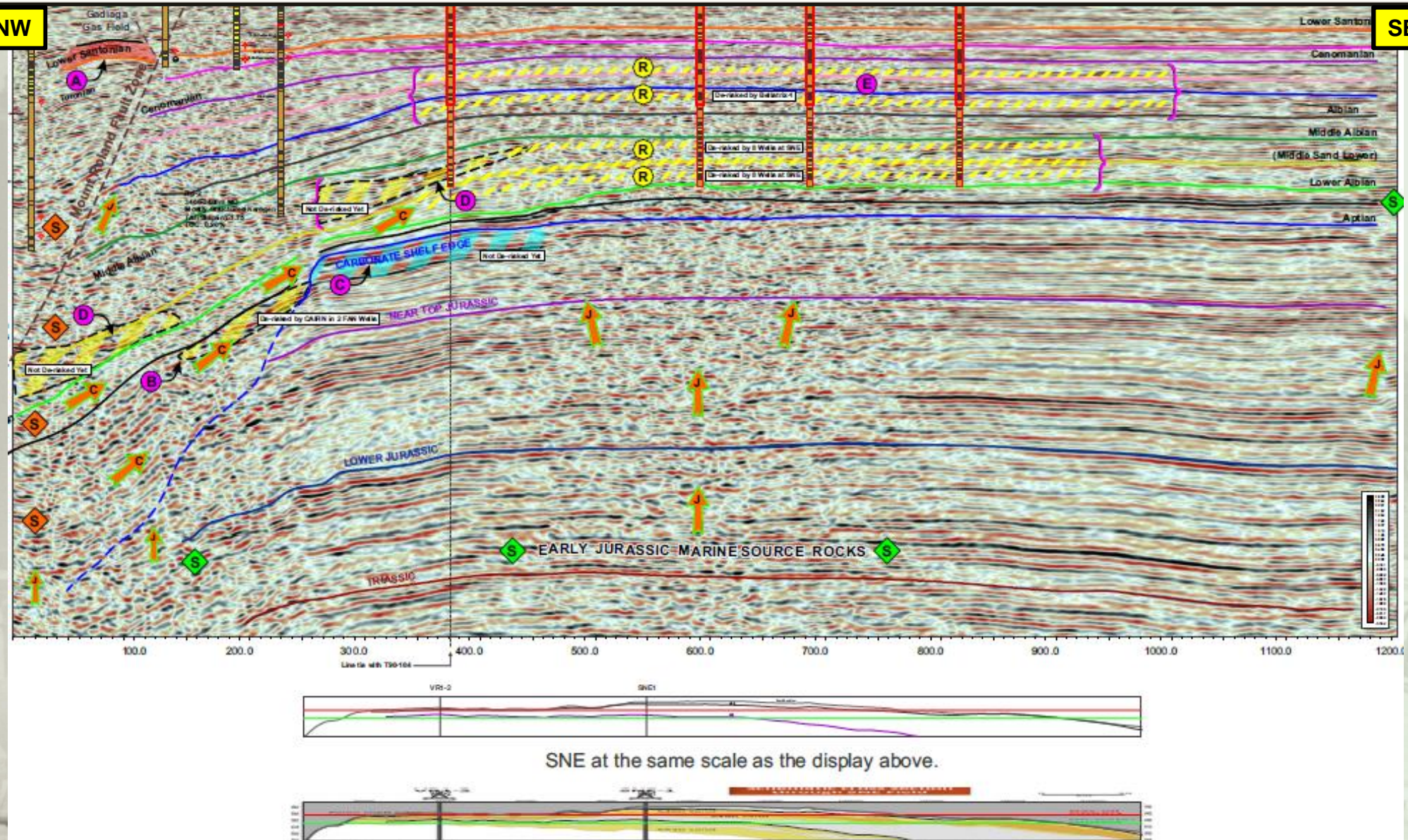
Direct Comparisons in Senegal's Buried Hill PLAY FAIRWAY



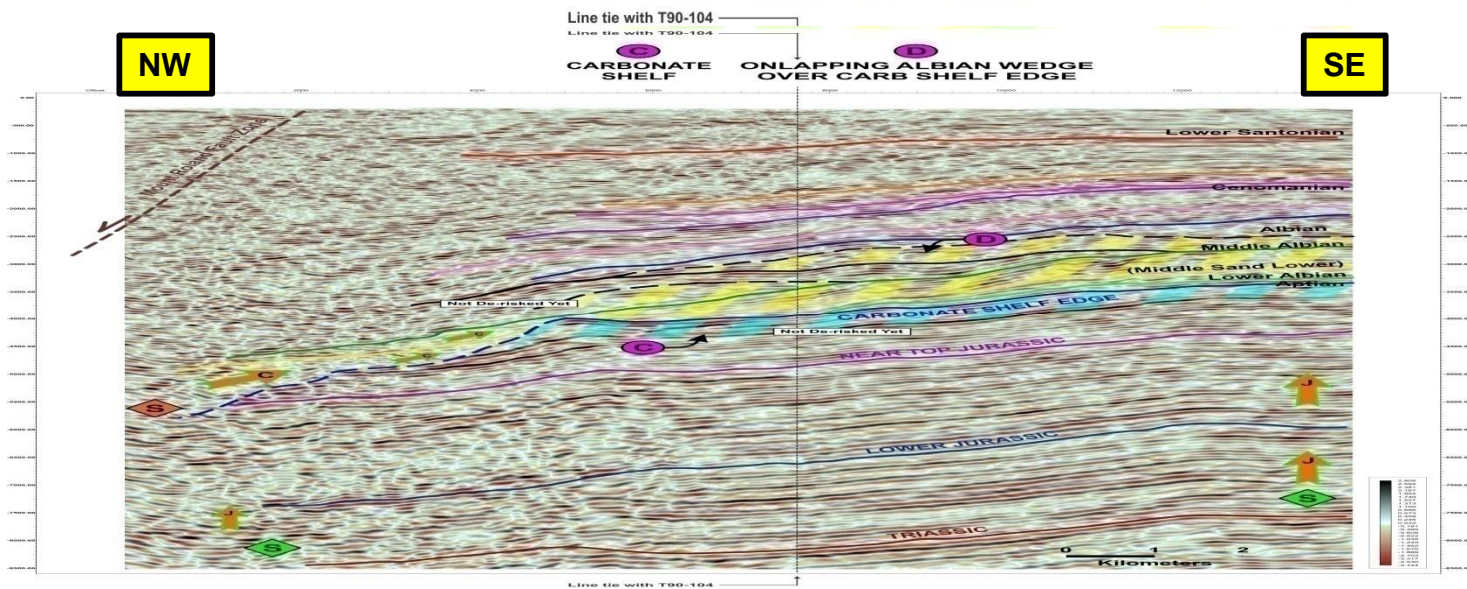
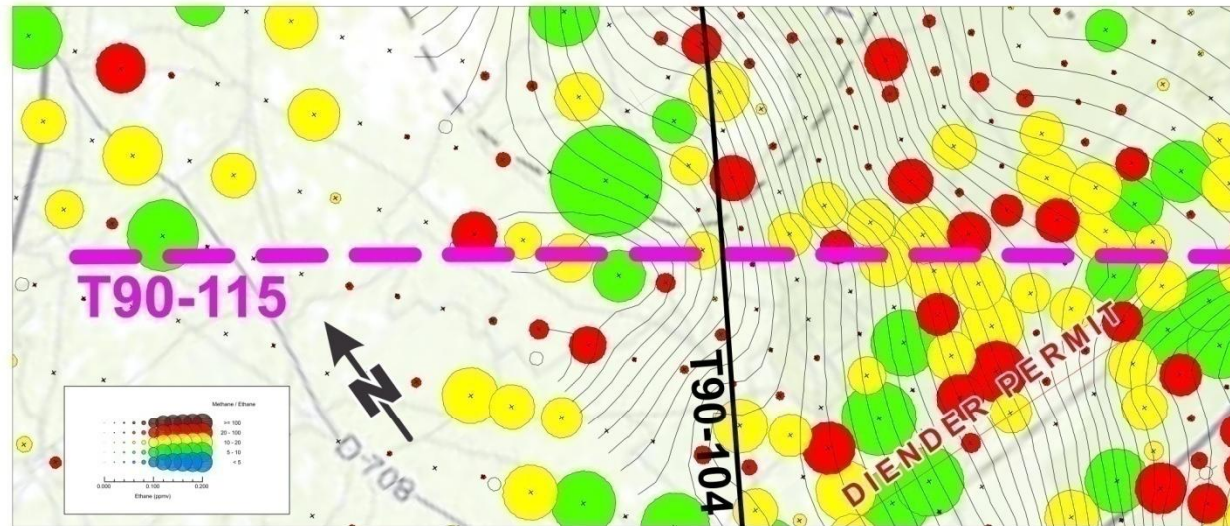
Exaggerated Scale vs. 1:1 Scaling of SNE Discovery Area

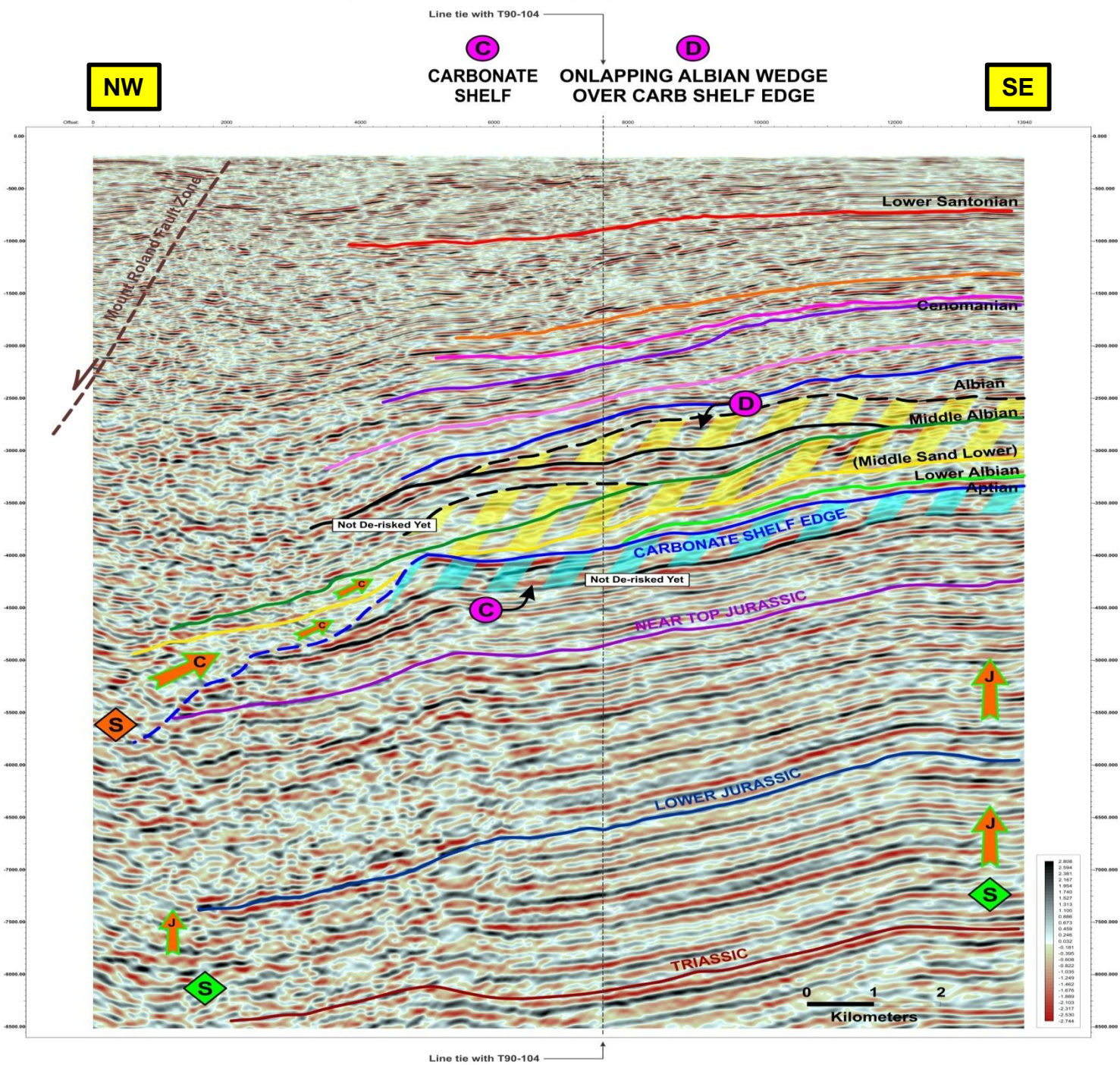


Eastern Closure Thiombane Dome vs. SNE Discovery Displayed with Identical Horizontal and Vertical Scales

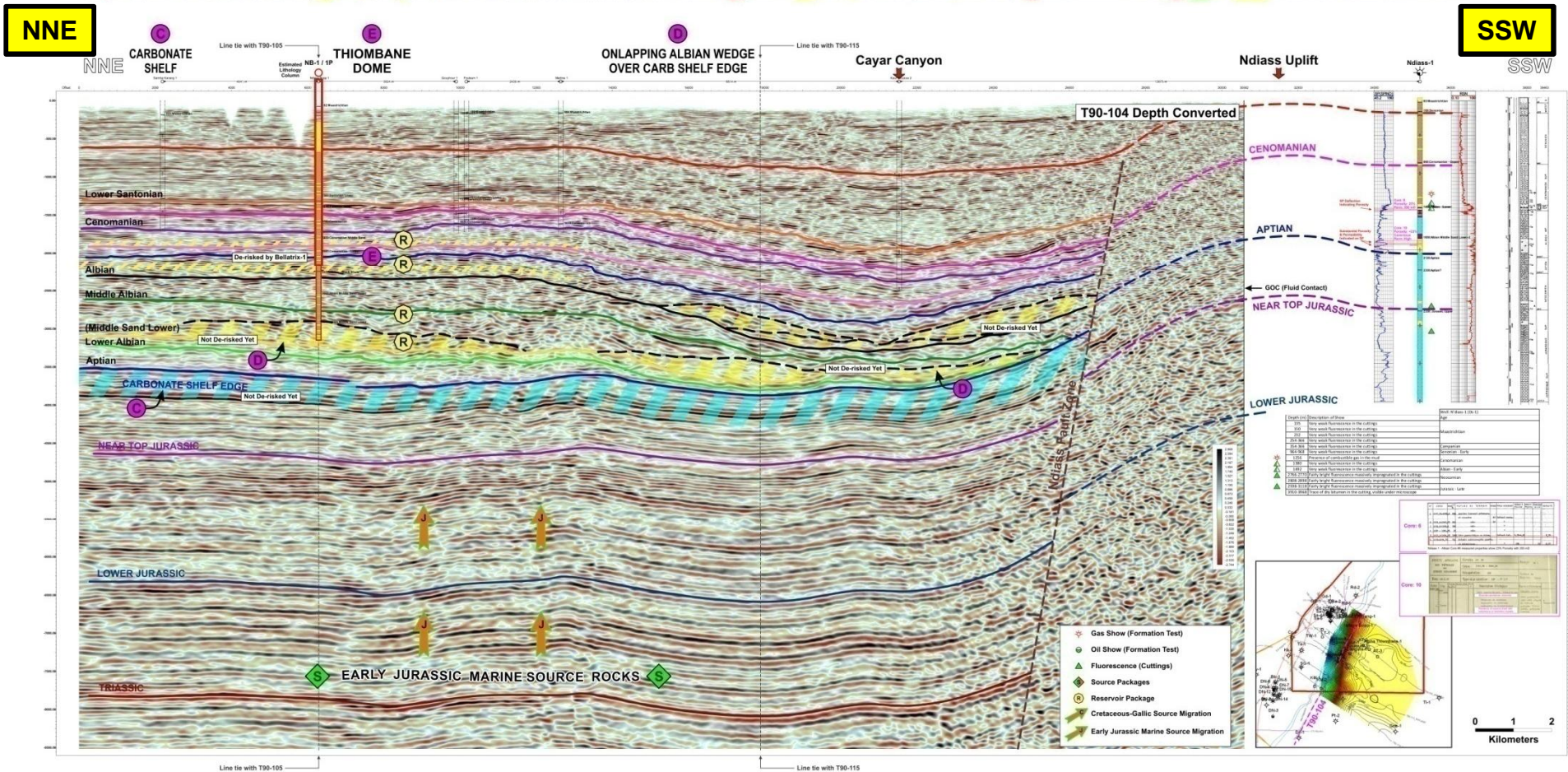
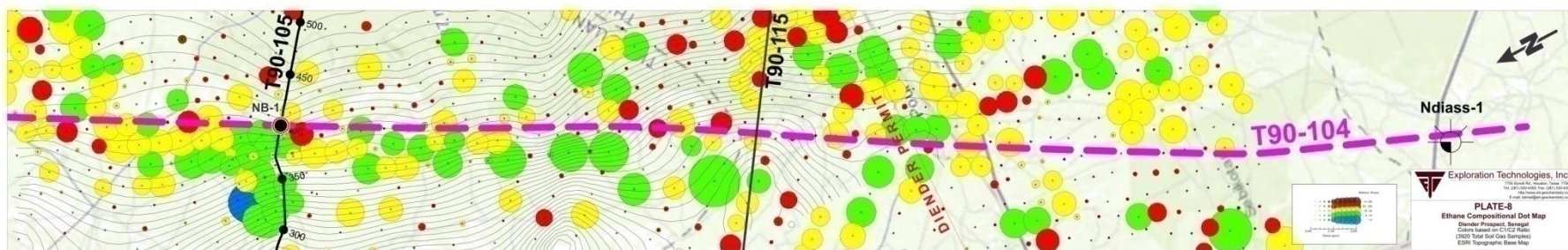


Ethane Anomalies Over Onlapping Wedge Events on 2D Dip Line (Zoomed Seismic Section on Following Slide)





Ethane Anomalies Over Onlapping Wedge Events on 2D Strike Line



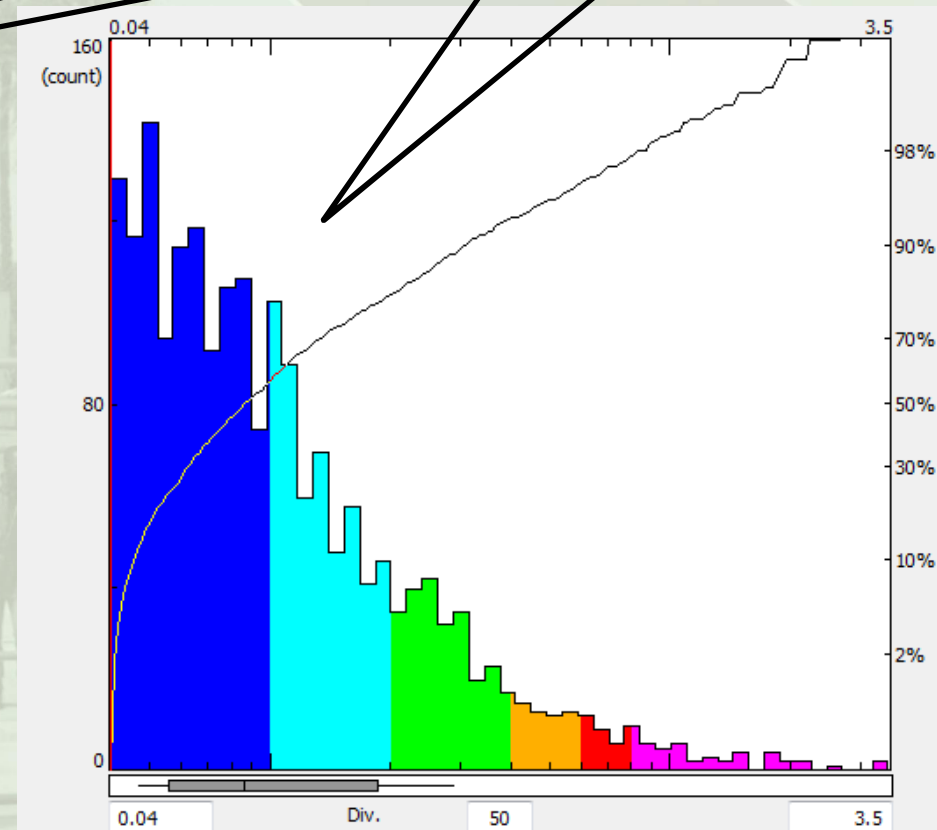
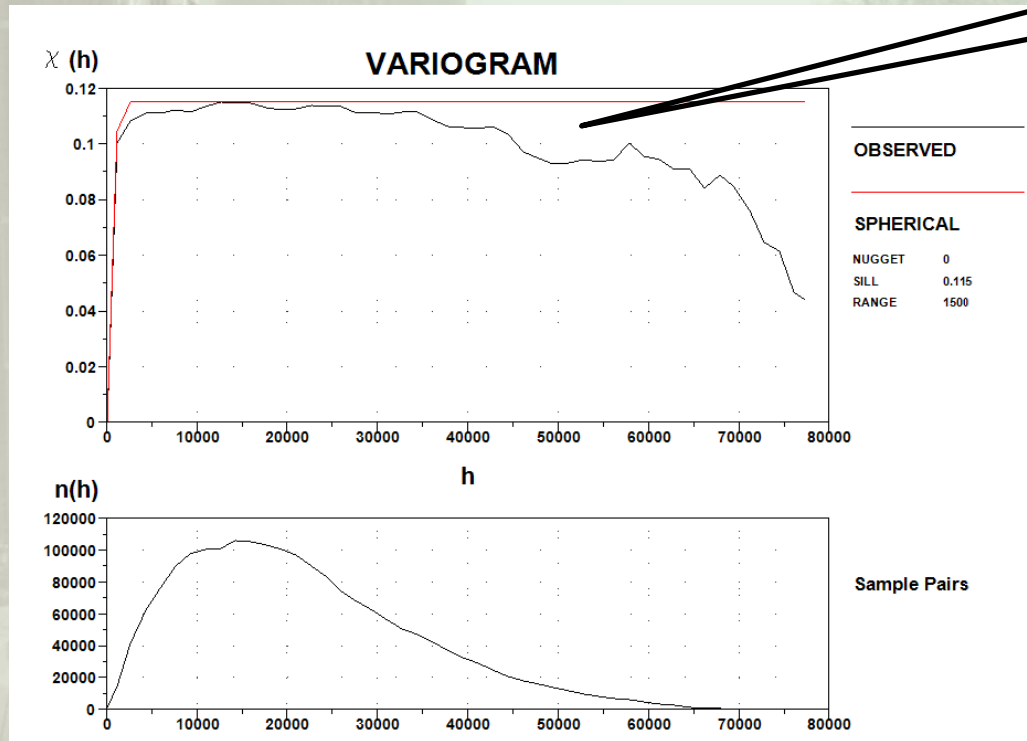


Integration of Gravity/Magnetics and Soils Gas Anomalies

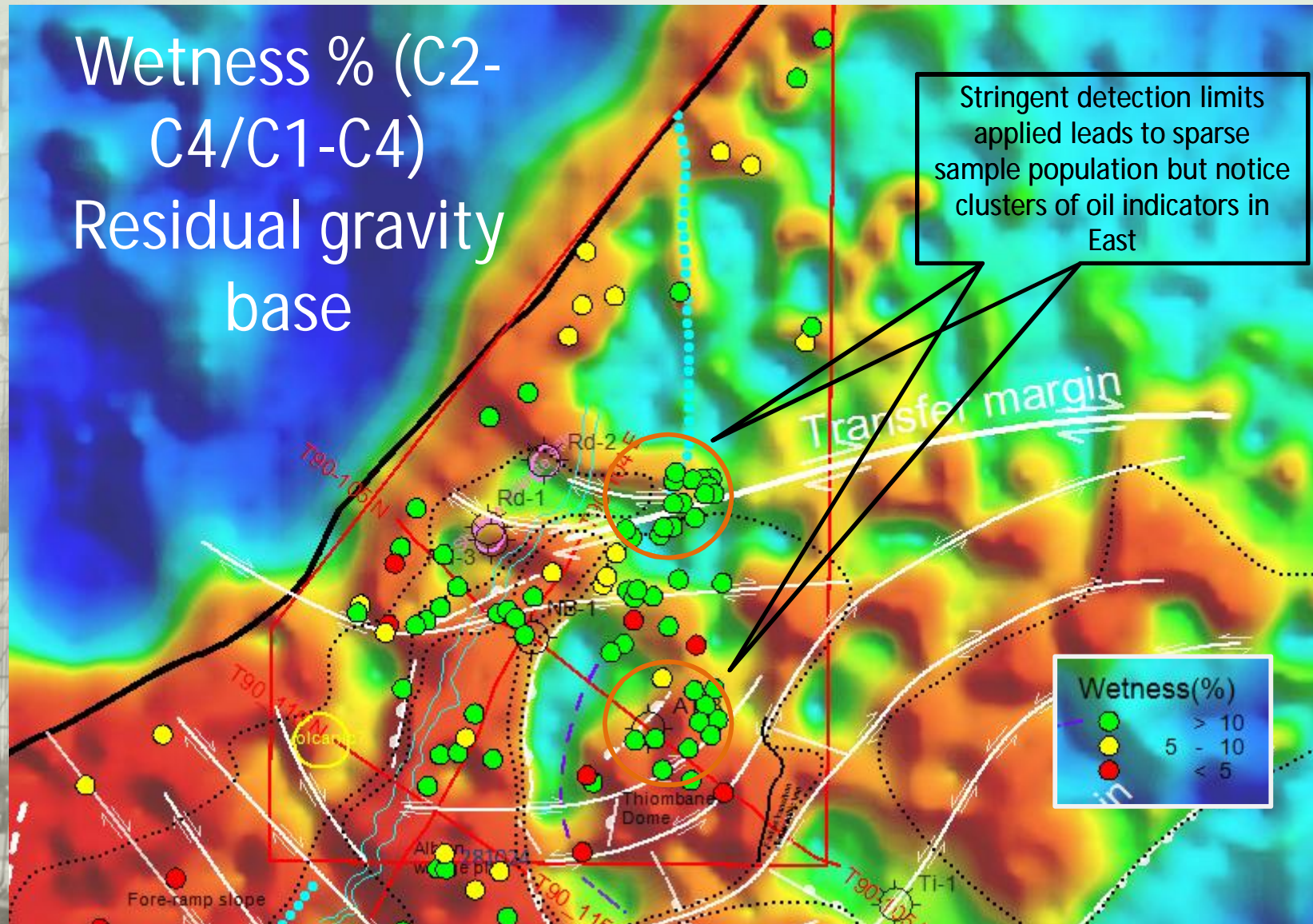
Stringent Detection Limits

- As per ETI guidance:
 - Methane > 3ppm (~500 samples of 3920 measurements)
 - Ethane > 0.04ppm (~2000 samples of 3920 measurements)
 - Propane > 0.025ppm (~1650 samples of 3920 measurements)
 - (Normal butane, no guidance) > 0.025ppm (~500 samples of 3920 measurements)

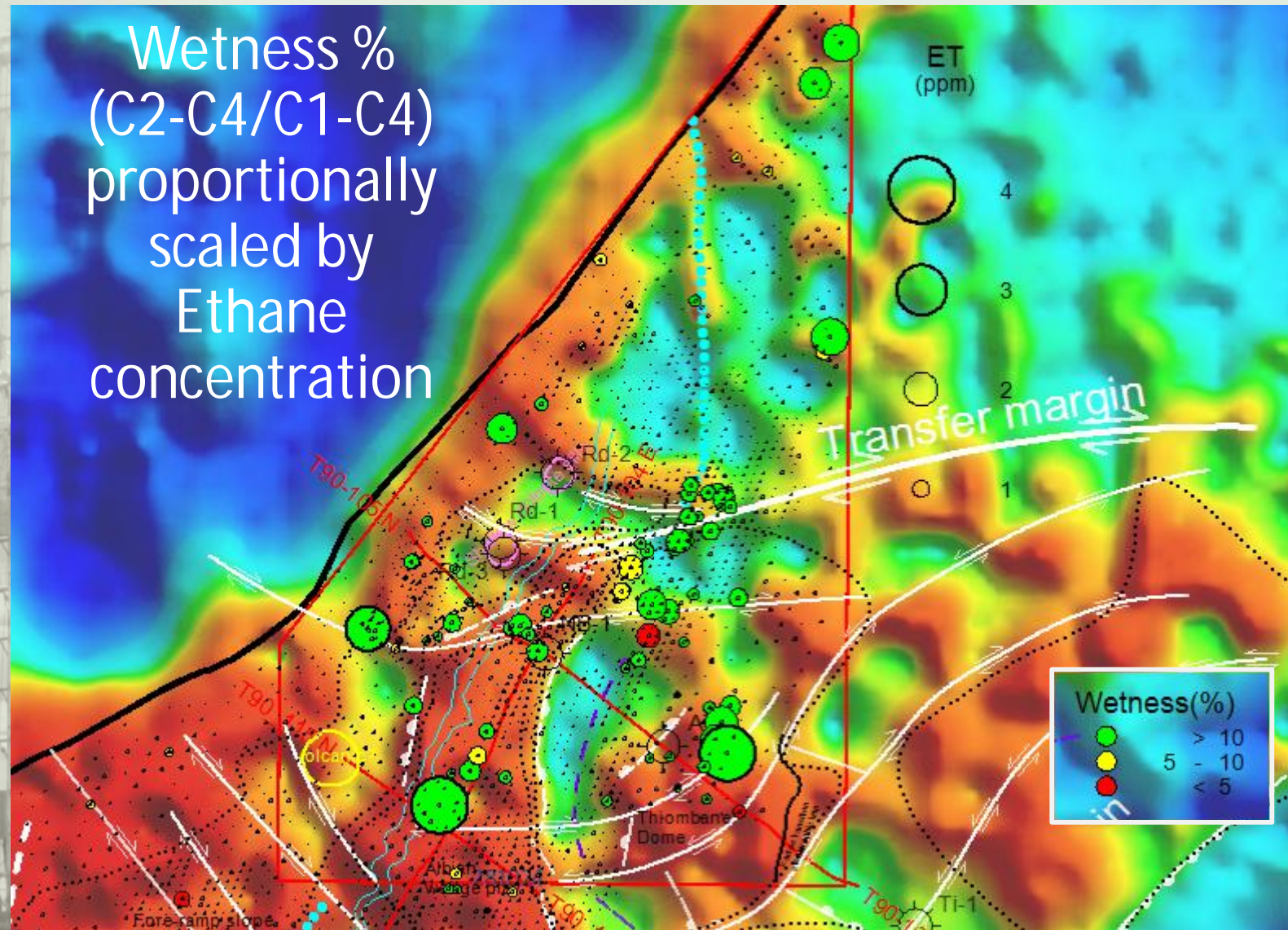
Distribution of Ethane Content



Residual Gravity Showing Deep Structures That Control the Soils Gas Anomalies



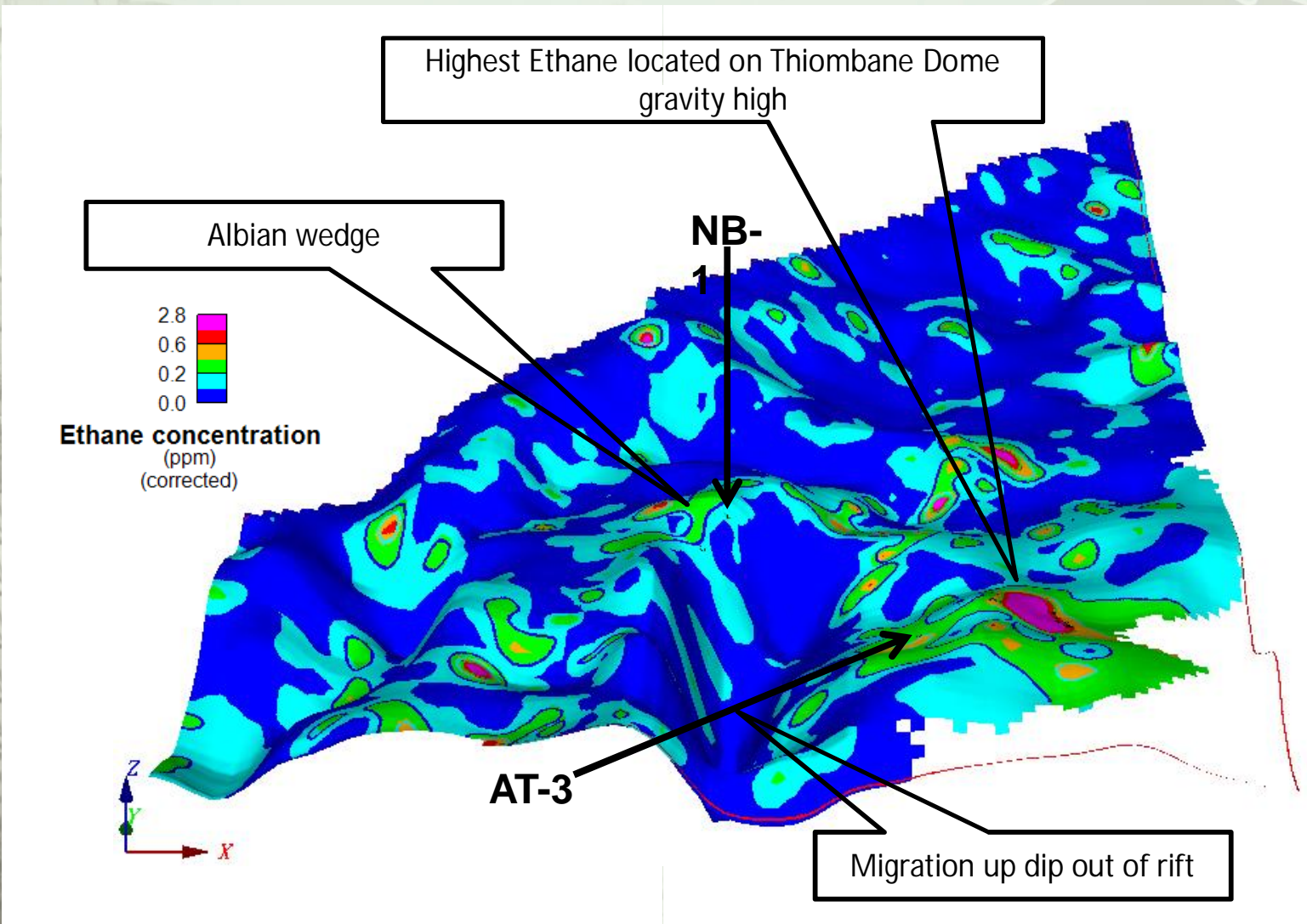
Residual Gravity Showing Deep Structures That Control the Soils Gas Anomalies



Ethane Concentration Draped Over Residual Gravity

(3d view to North, *no vertical exaggeration*)

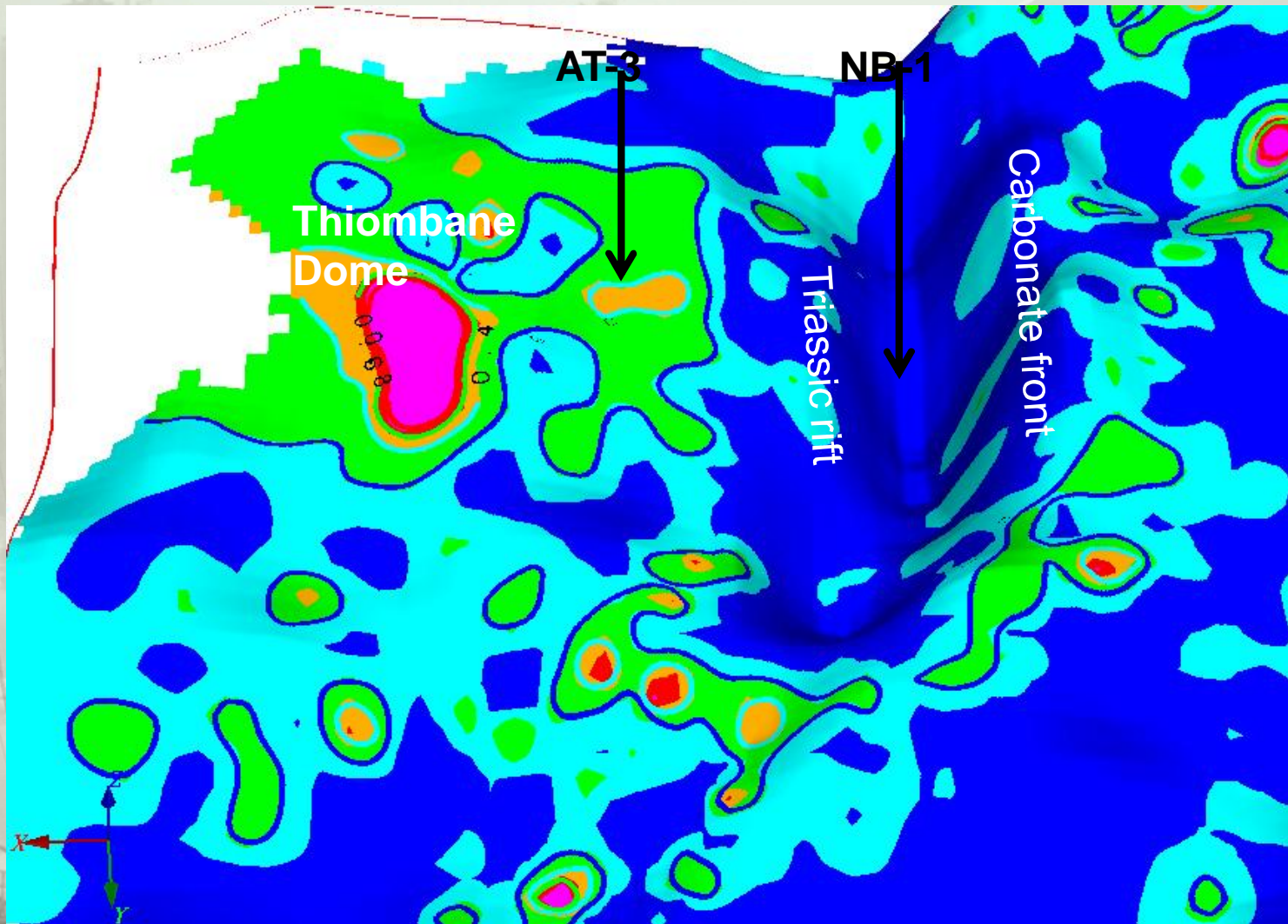
How the Charge Works – Underlying Source Graben Morphology



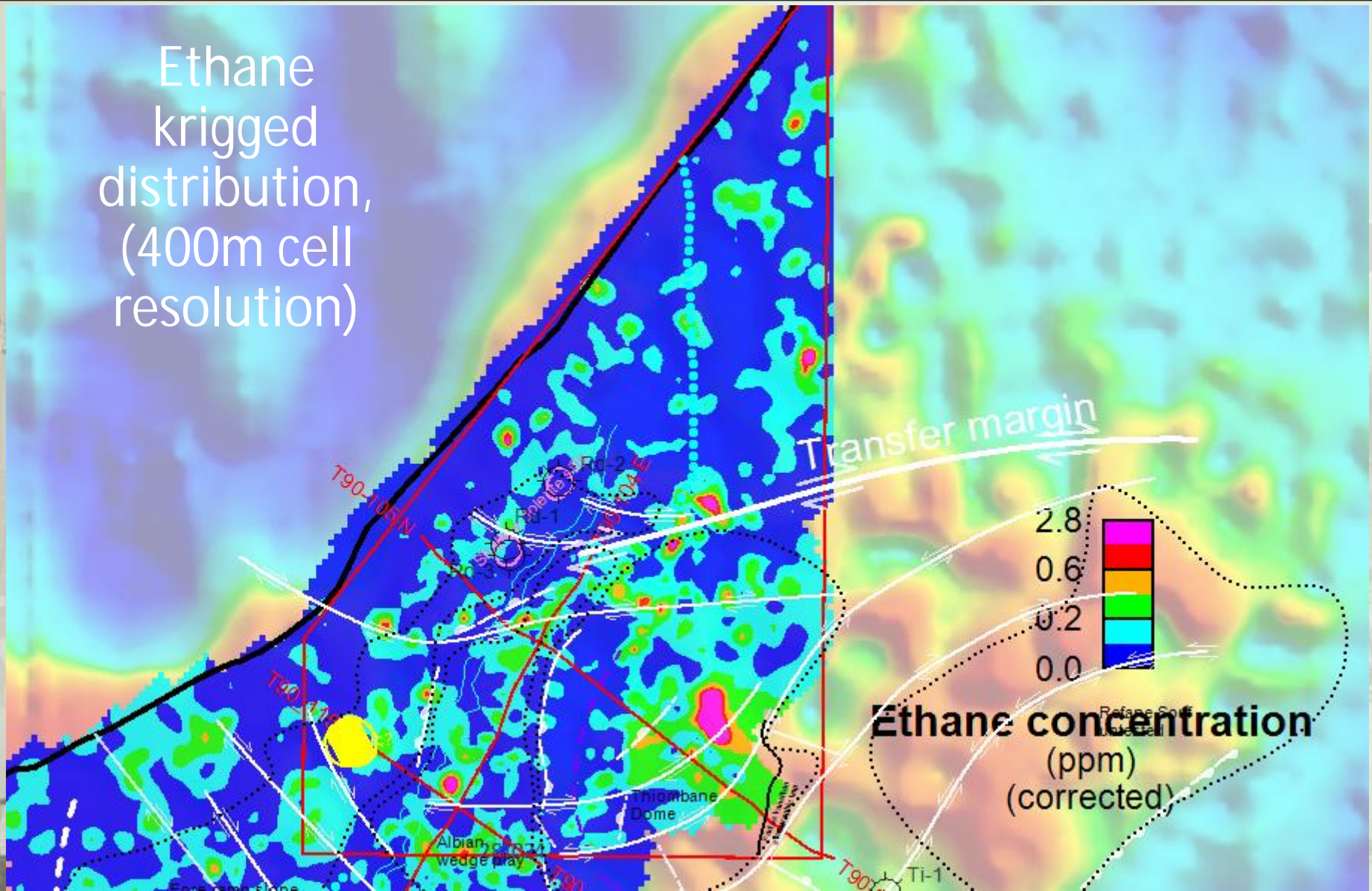
Ethane Concentration Draped Over Residual Gravity

(3d view to South, *no vertical exaggeration*)

How the Charge Works – Domed Albian Surface Following Uplift

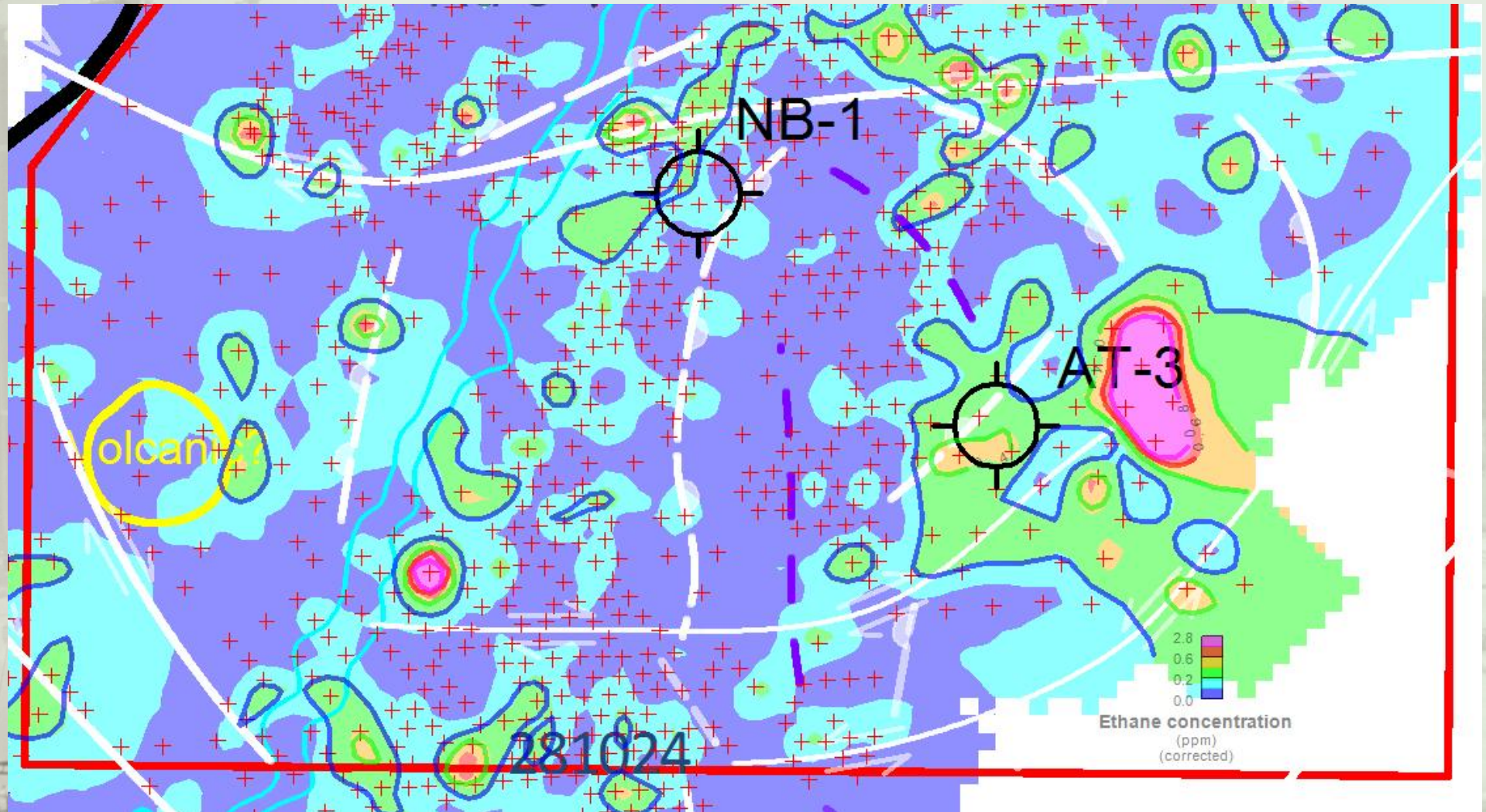


Ethane
krigged
distribution,
(400m cell
resolution)



Ethane Krigged Distribution, (400m cell resolution)

Good samples above strict detection limit (red pluses)



S é n é g a l

Conclusion

- Our close sampling dataset of Soil Micro- Gas seepage GeoChem Sampling result in Anomalies whose size and presence upon integration consistently correlates with all other geological and geophysical data confirming our indicated oil exploration Play Fairways and 95 wells drilling results!
- Integrating the GeoChem Values with all other G&G data gives an extra measure of confidence to us for our Exploration drilling prospects.
- What started as apparent doubts re Structural Closures, NO correlated Play Fairways, unclear apparent Trapping mechanisms has resulted into
 1. Correlated Play Fairways with Giant Commercial Discoveries
 2. GeoChem Anomaly correlation to and compatibility with 95 onshore well control points
 3. Oil Discovered on the flank of our double faulted anticlinal closure Producing Gas Field
 4. Proving a whole new the Early Jurassic Lacustrine Source Rock in the MSGBC Littoral
- 'Super Basin' now in-addition to a Super Giant Petroleum System??
- Full integration of Soil Gas GeoChem anomalies has provided a truly significant revelation and proven risk reduction factor in our Exploration and Development program going forward in 2019 in Senegalese Exploration
- *We should have realized much earlier what our GeoChem was showing to us!*

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Thank You

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