[AV]First Gas after 40 Years – The Geophysical Challenges of the Saturn Gas Complex*

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Abstract

ConocoPhillips has held Block 48/10b in the UK southern North Sea for some 40 years. The first gas production from the Saturn field in this block was achieved in September 2005. The main geophysical challenge of this block is to understand the sub-salt wall structure of the Rotliegendes reservoir. A variety of geophysical techniques have been applied, some of the earlier methods are briefly reviewed. The main emphasis of this presentation is the interpretation of the pre-stack depth migrated data and its subsequent depth conversion, including a subjective method of removing the artifact created under the salt water overhangs. The result of the recent horizontal wells, together with the pre and post drilling interpretations are used to show the limitations of the seismic reflection data to predict the details of the reservoir structure beneath this salt wall. Finally, a brief review will be made of the two previously stranded gas fields that will be developed using these new Saturn facilities

First Gas after 40 Years – The Geophysical Challenges of the Saturn Gas Complex

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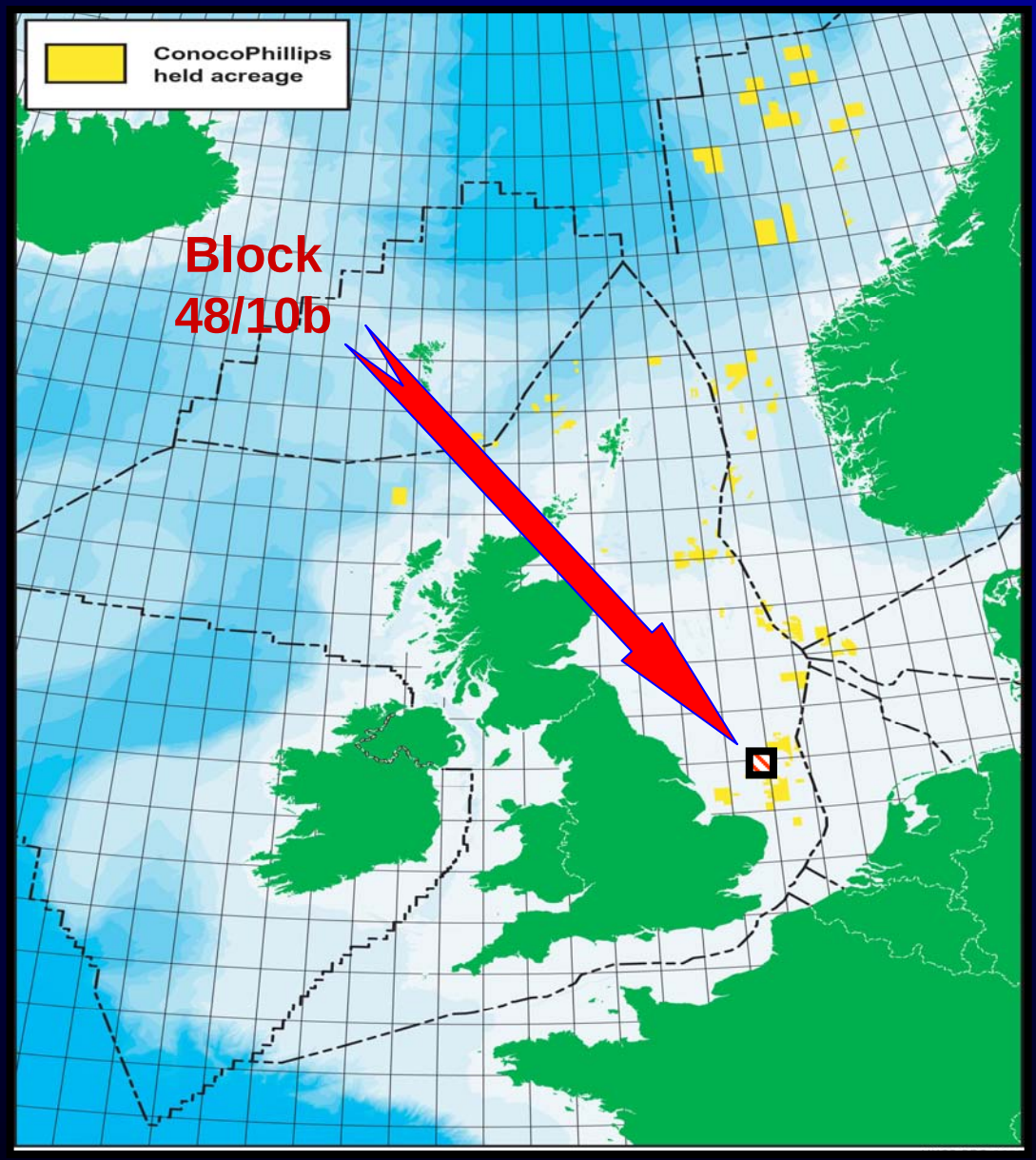
Geographical setting



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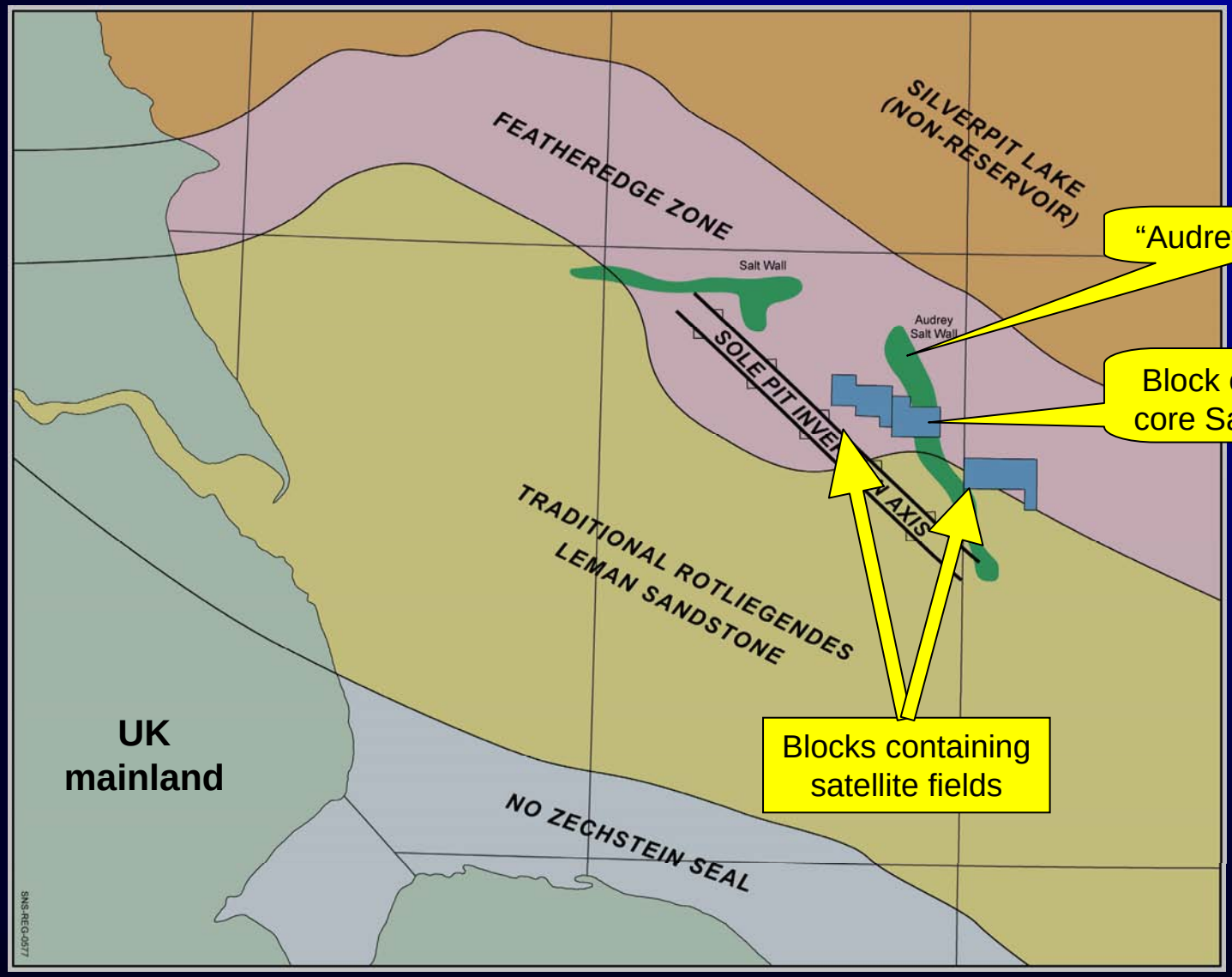
Lower Permian Rotliegend reservoir facies



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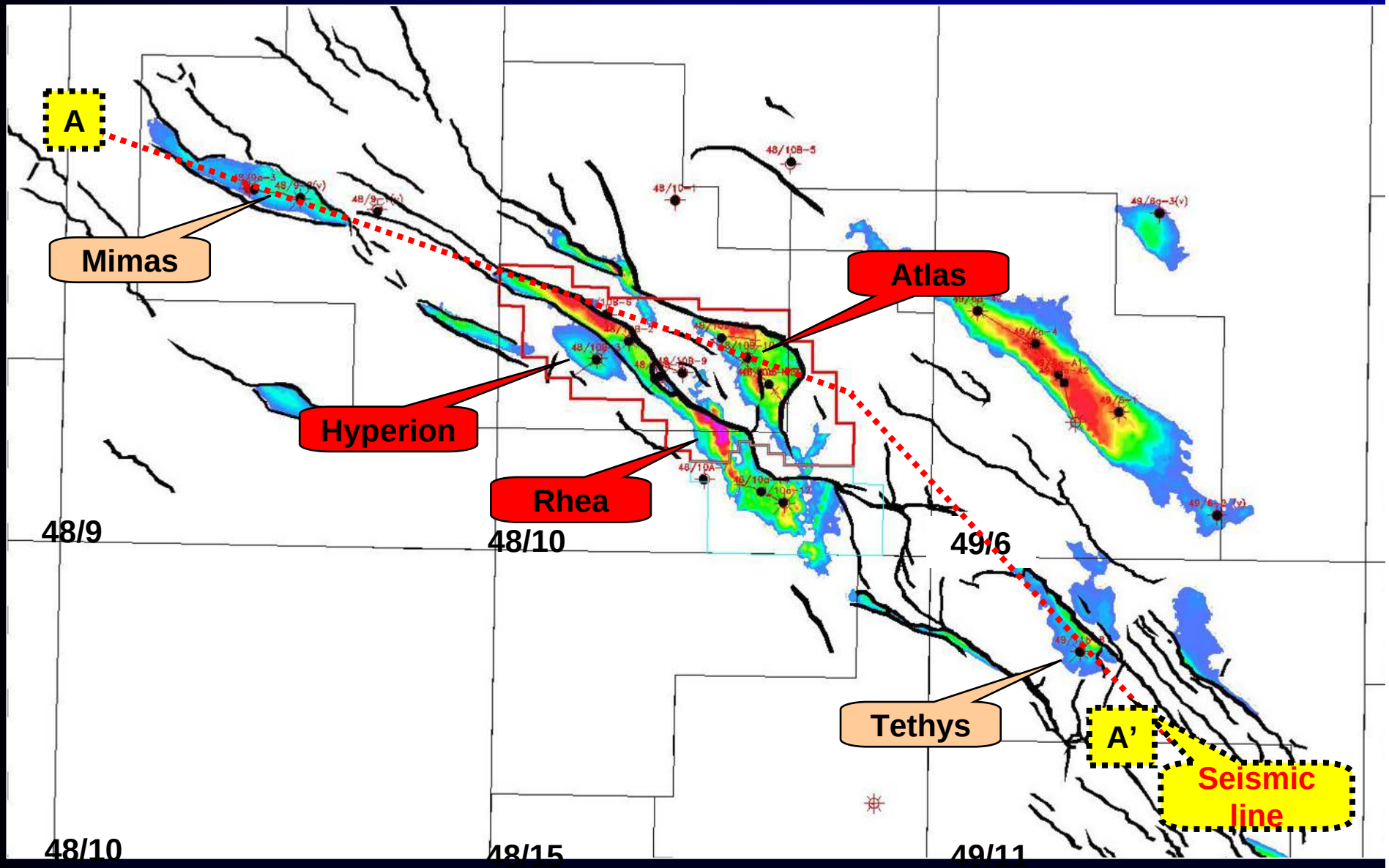
Top Rotliegend Depth Closure Map



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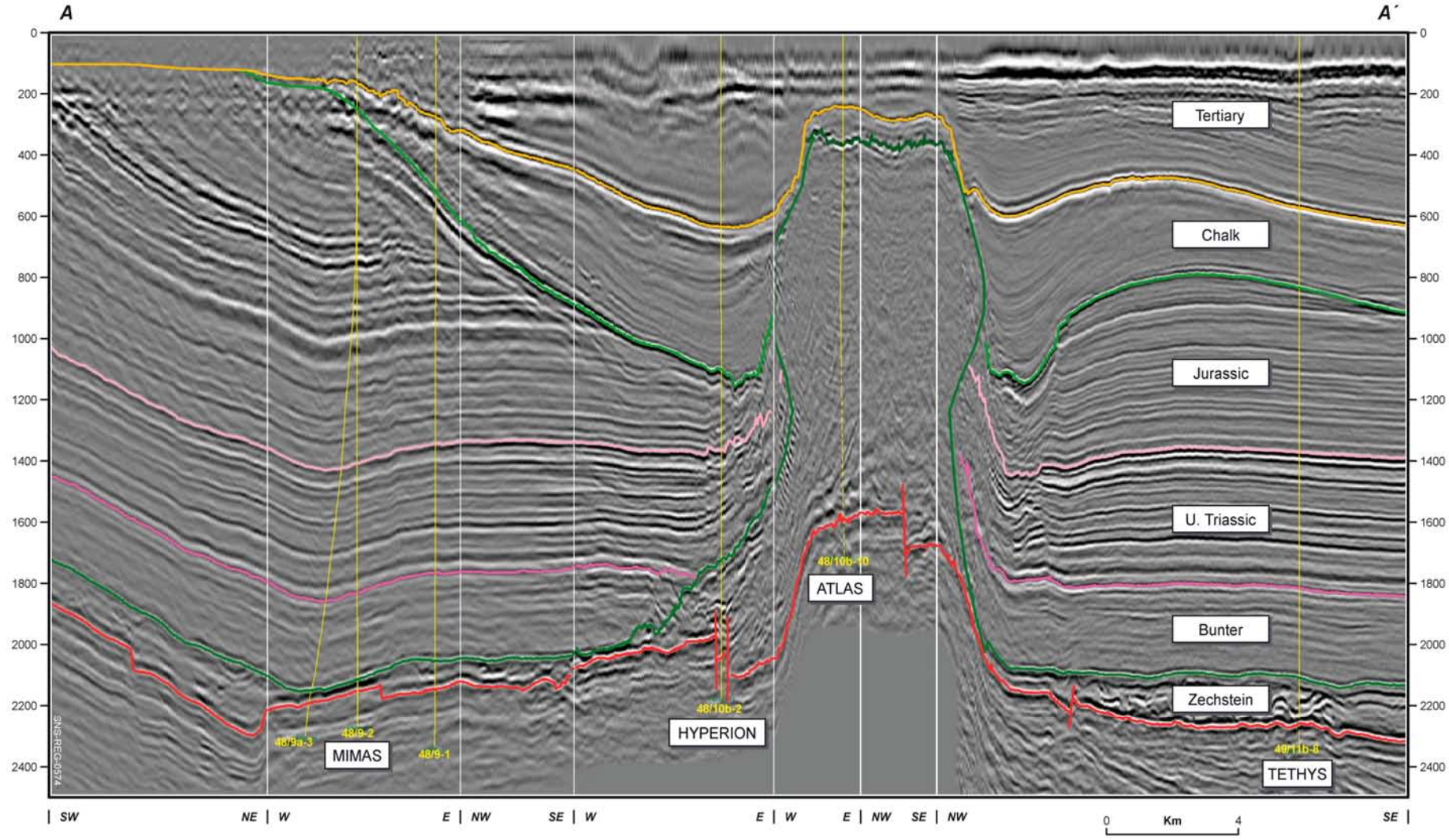
Seismic Line (Time) Across Saturn Satellites



Seismic line shows Sole Pit inversion on left, across Audrey salt wall in centre to a more benign area on the right. Note the poor data quality around and under the salt wall flanks.

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Saturn Project Timetable

48/10 Block award to Heritage Phillips	1965
48/10b re-issued to Heritage Conoco	1986
First gas discovery (48/10b-2)	Dec 1986
Final appraisal well td (48/10b-13)	Jan 2004
ConocoPhillips project sanction	May 2004
First Gas (40 years after initial license)	Sept 2005
1st & 2nd satellite fields drilled	Summer 2006

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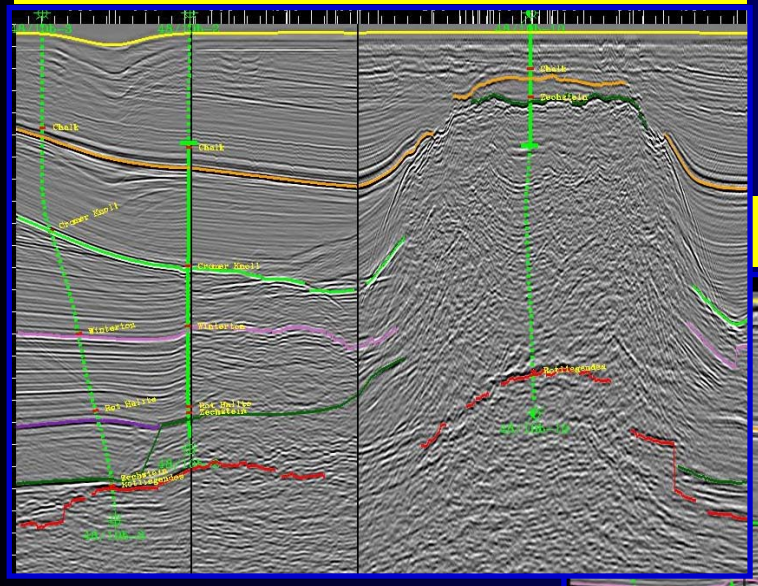
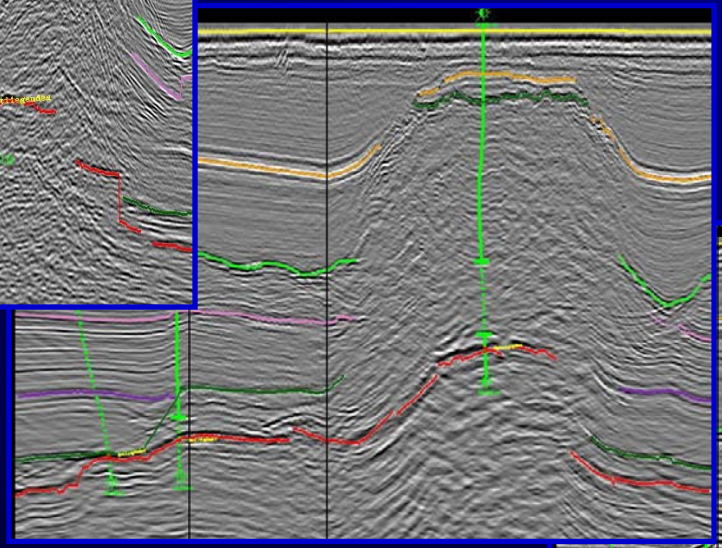
2D – 3D – PSDM across Hyperion & Atlas

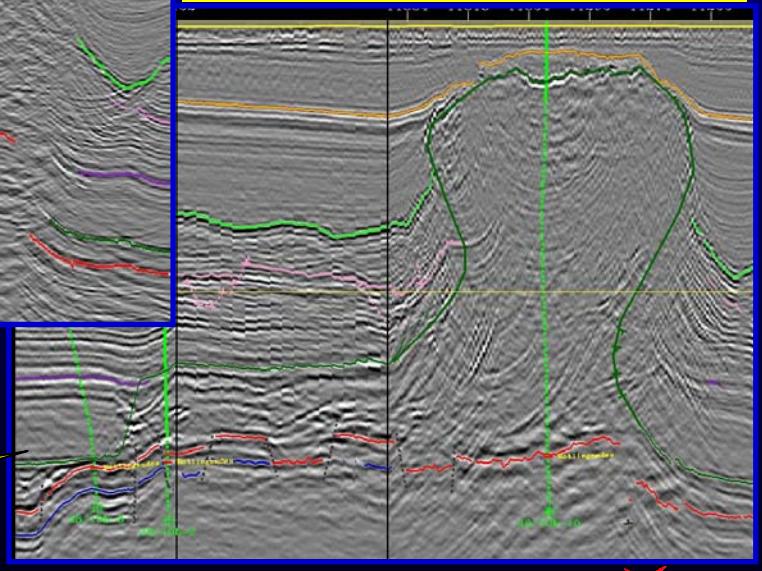
2D Time migrated - 1989



3D Time migrated -1993



3D Depth migrated -2001



"Seismic" depth

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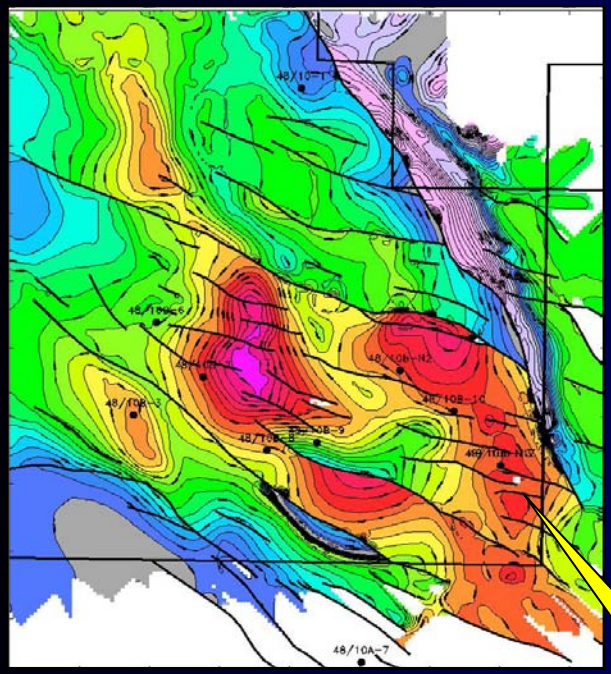
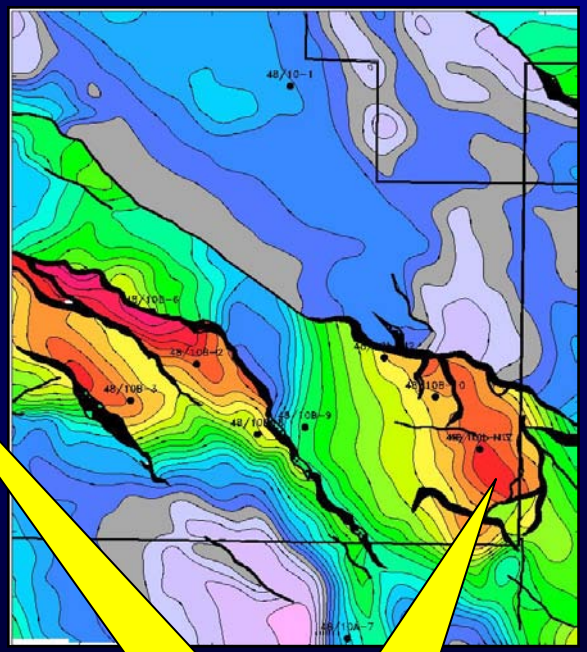
Rotliegend Interpretations in depth

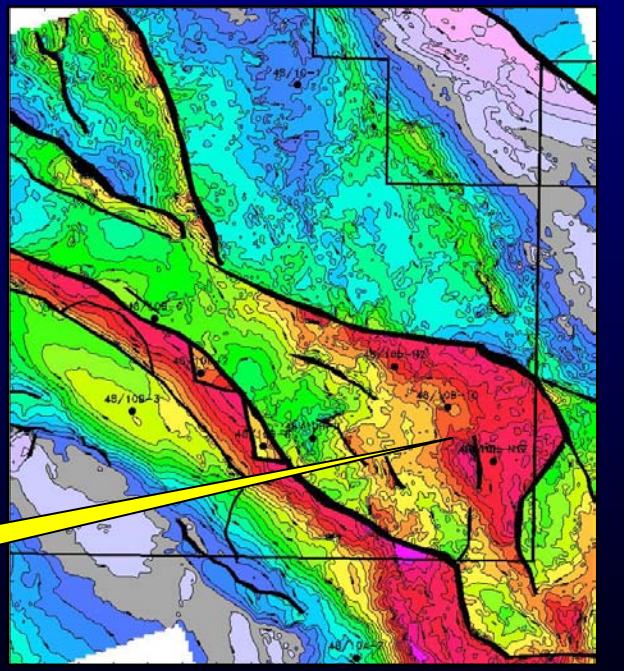
2D data -1989



3D data - 1993



PSDM data - 2006



Atlas field
beneath salt wall

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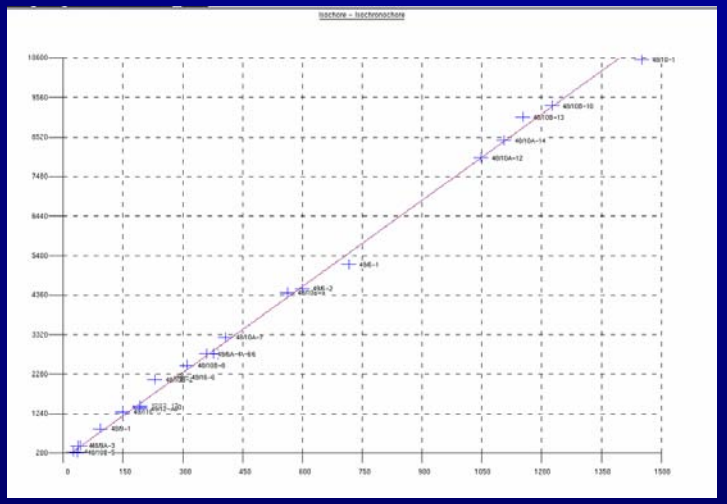
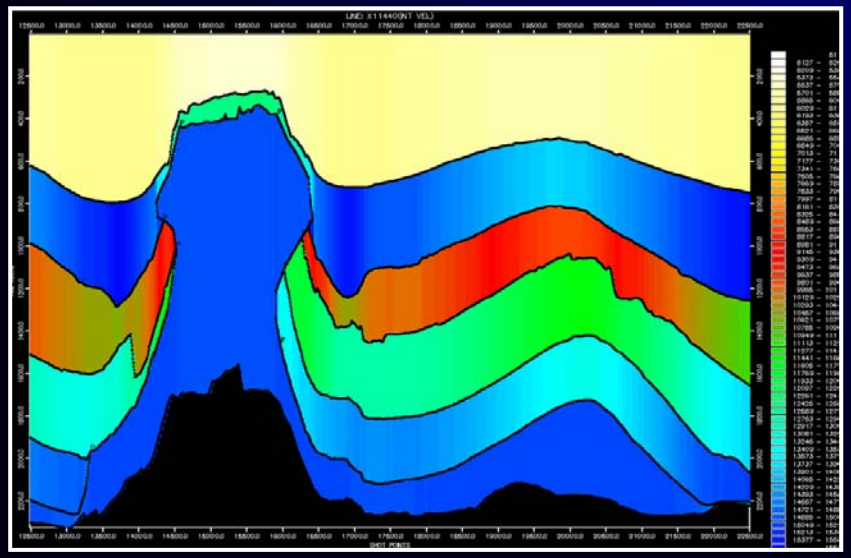
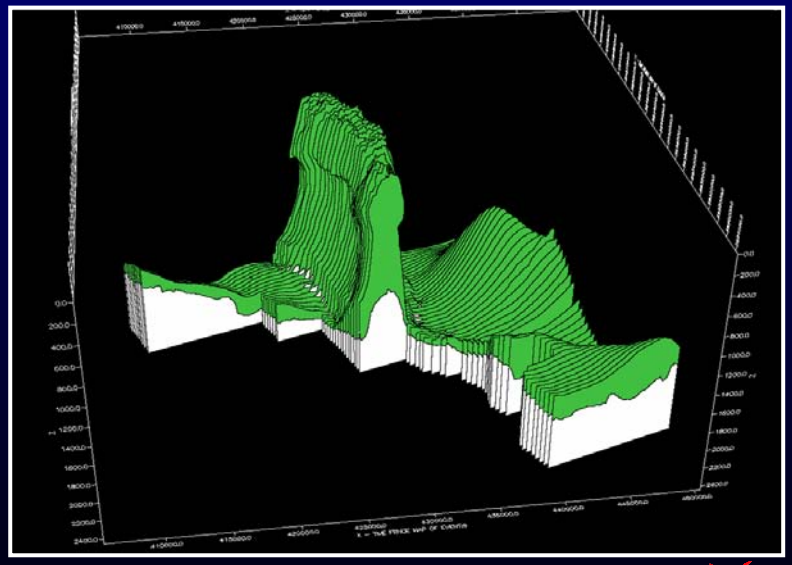
Conversion to True Depth in section mode

Isotropic depth migration depth does not give true depth, so the interpretation was done in the "seismic" depth domain and stretched to time. It was then depth converted "properly".

Layer	Vo	k
Tertiary	5337.4	0.7581
Chalk	8263.2	1.0151
Jurassic	5638.3	0.7434
U Trias	8180.3	0.5851
L Trias	9803.1	0.4566
Zech	M=7.558	C=41.08







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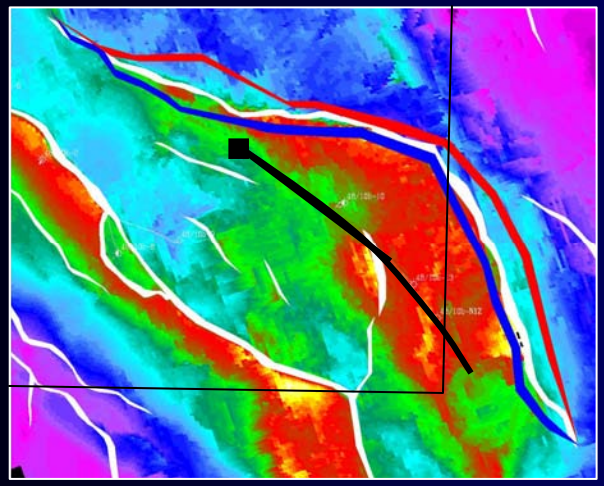
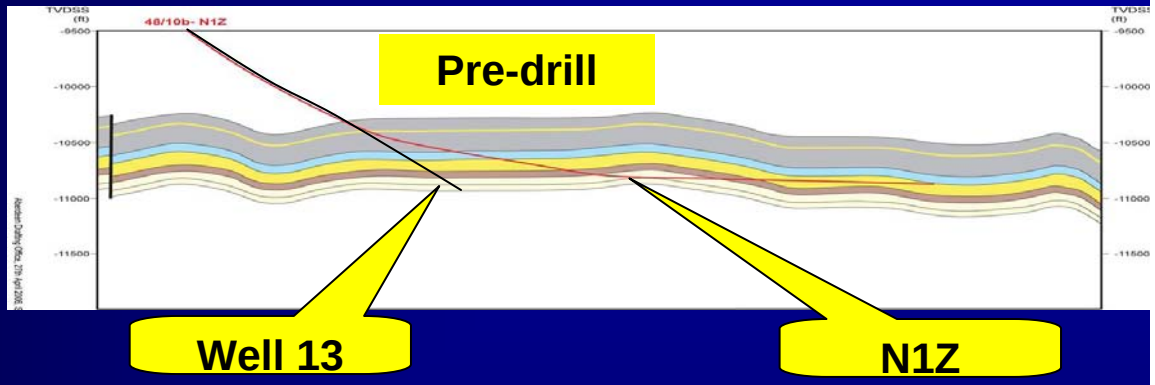
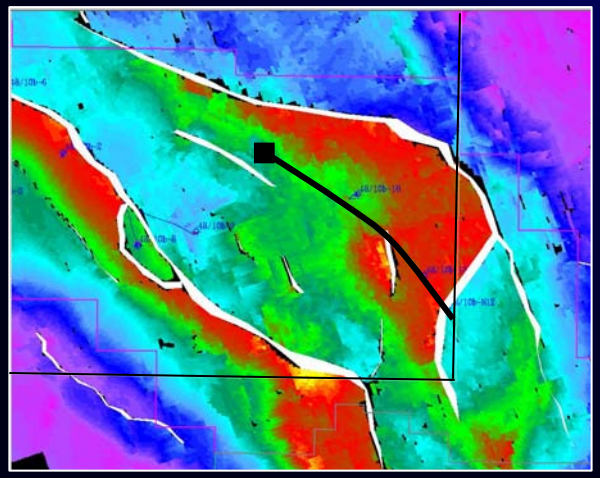
48/10b-N1Z, the last appraisal and 1st producer.

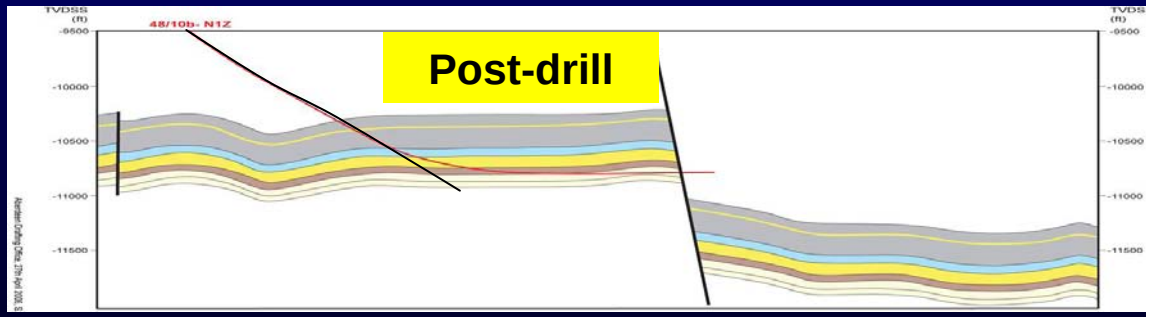




Confidence was built with the results of the 48/10b-13 well, so after Platform installation this well was sidetracked as the 48/10b-N1z producer.

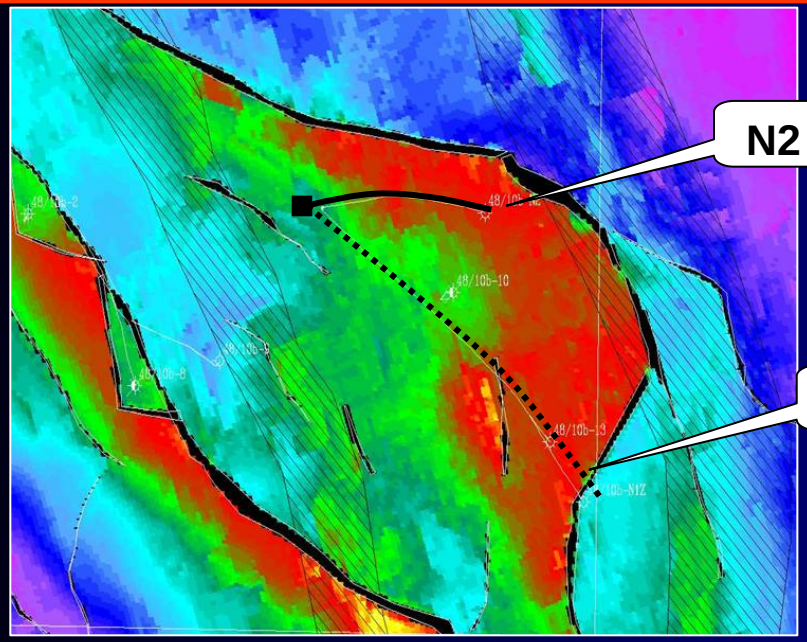
What could go wrong now?



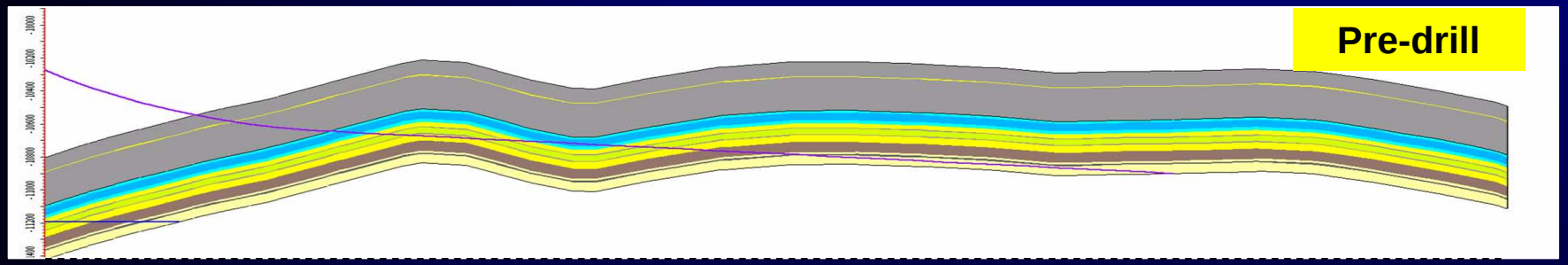


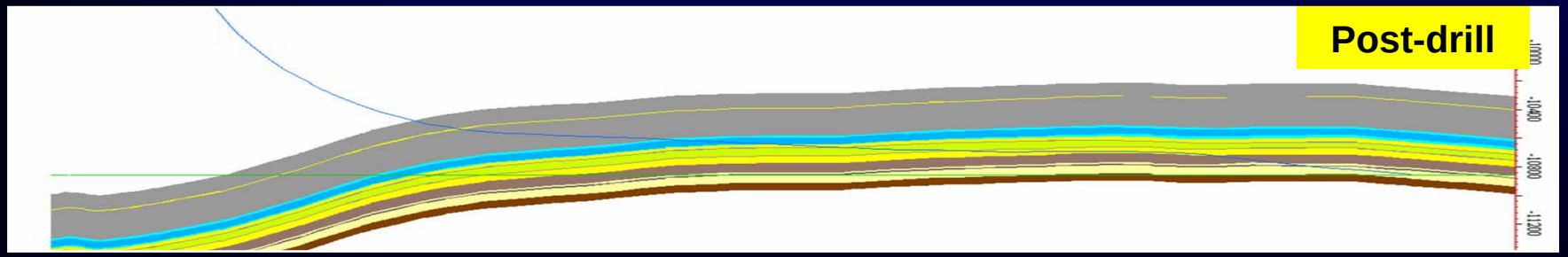
A “sub-seismic” fault with 800 ft throw !!

Atlas 48/10b-N2

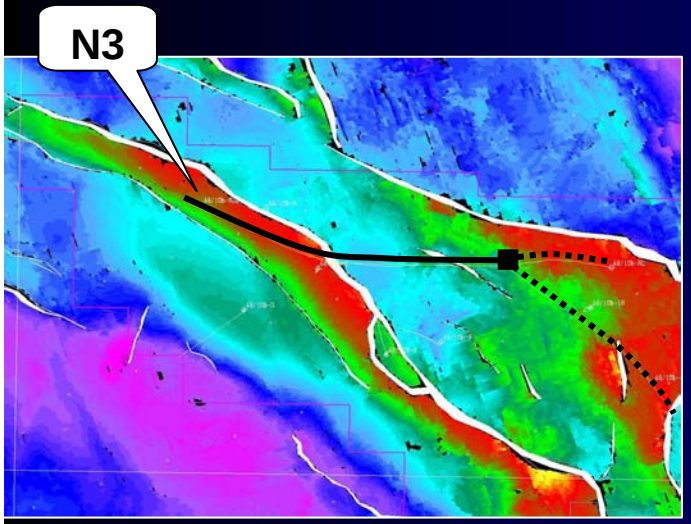


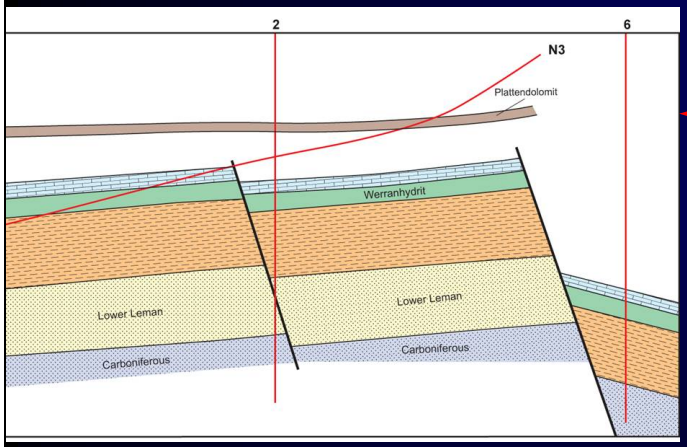
This time the flow only just exceeded that predicted

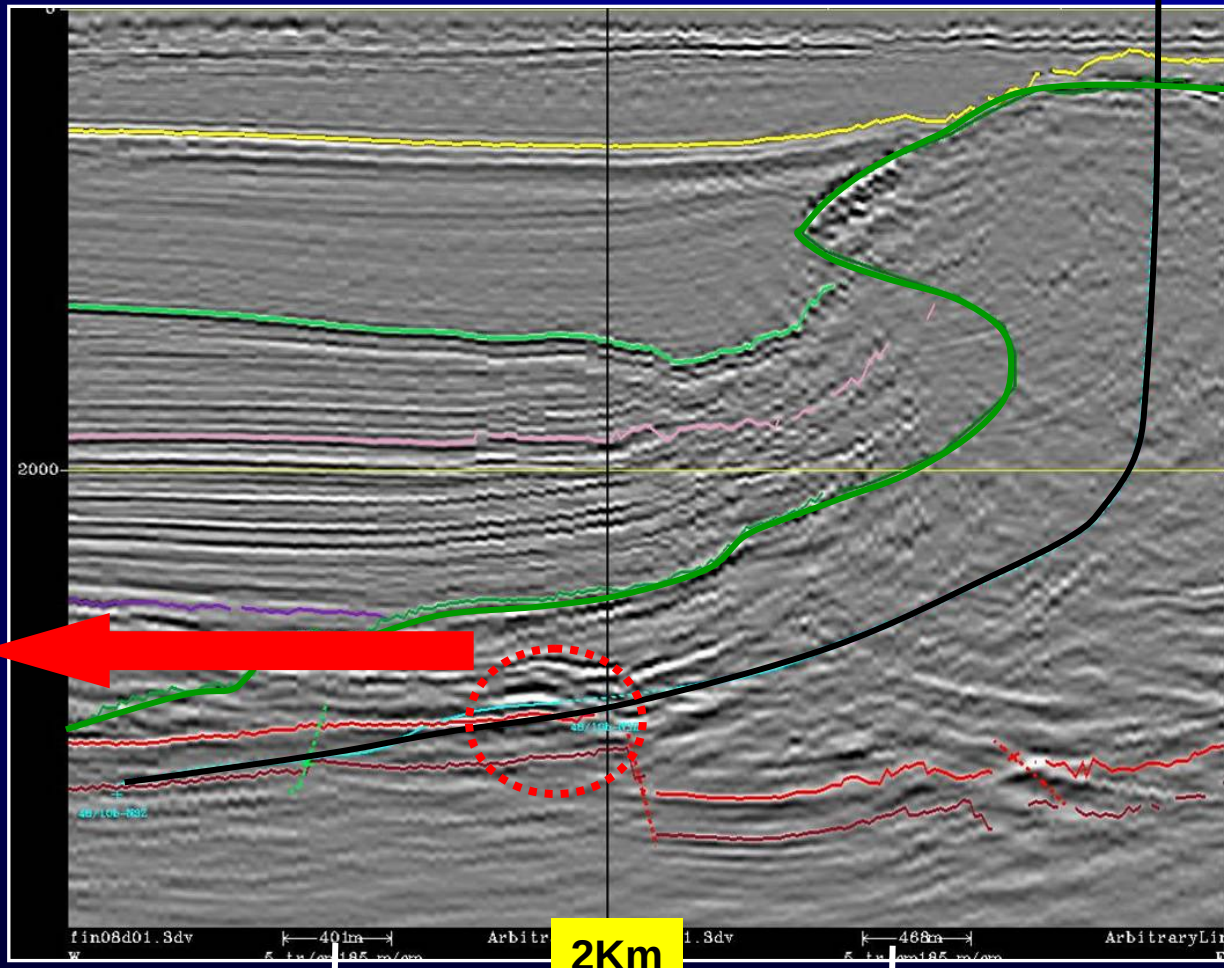




48/10b-N3 Bi-Lateral Leg 1 (Hyperion horst) Plan







The platform was located to allow the development wells to be drilled through the salt wall

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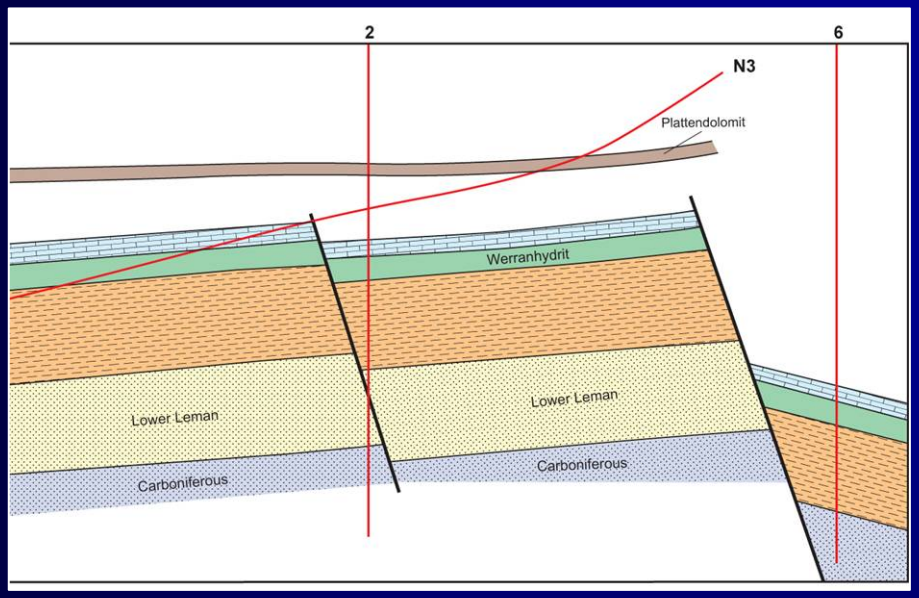
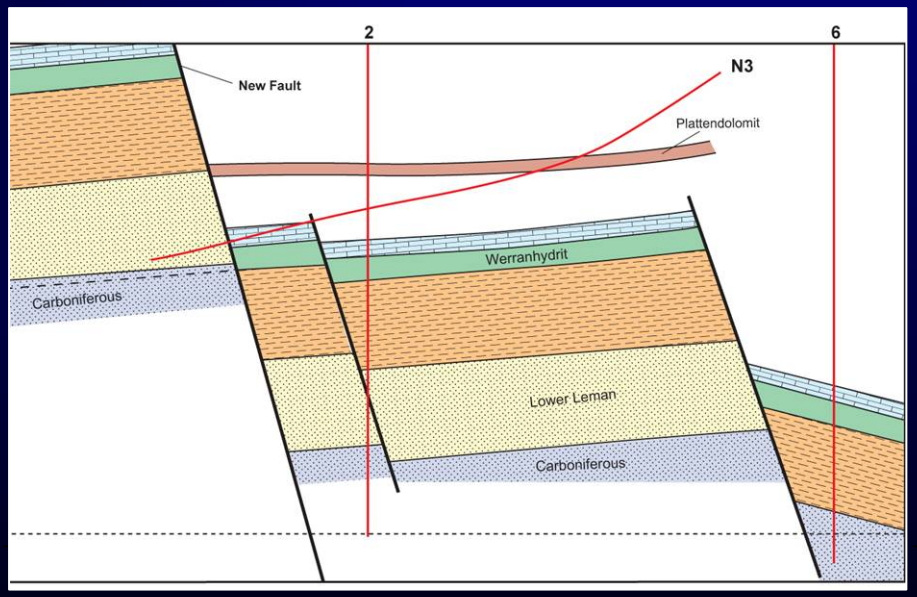
Pre & Post Drill Schematic of 48/10b-N3 Well





Another sub-seismic fault, this time with only 550 ft of throw. Even though a surprise was expected, this was not!

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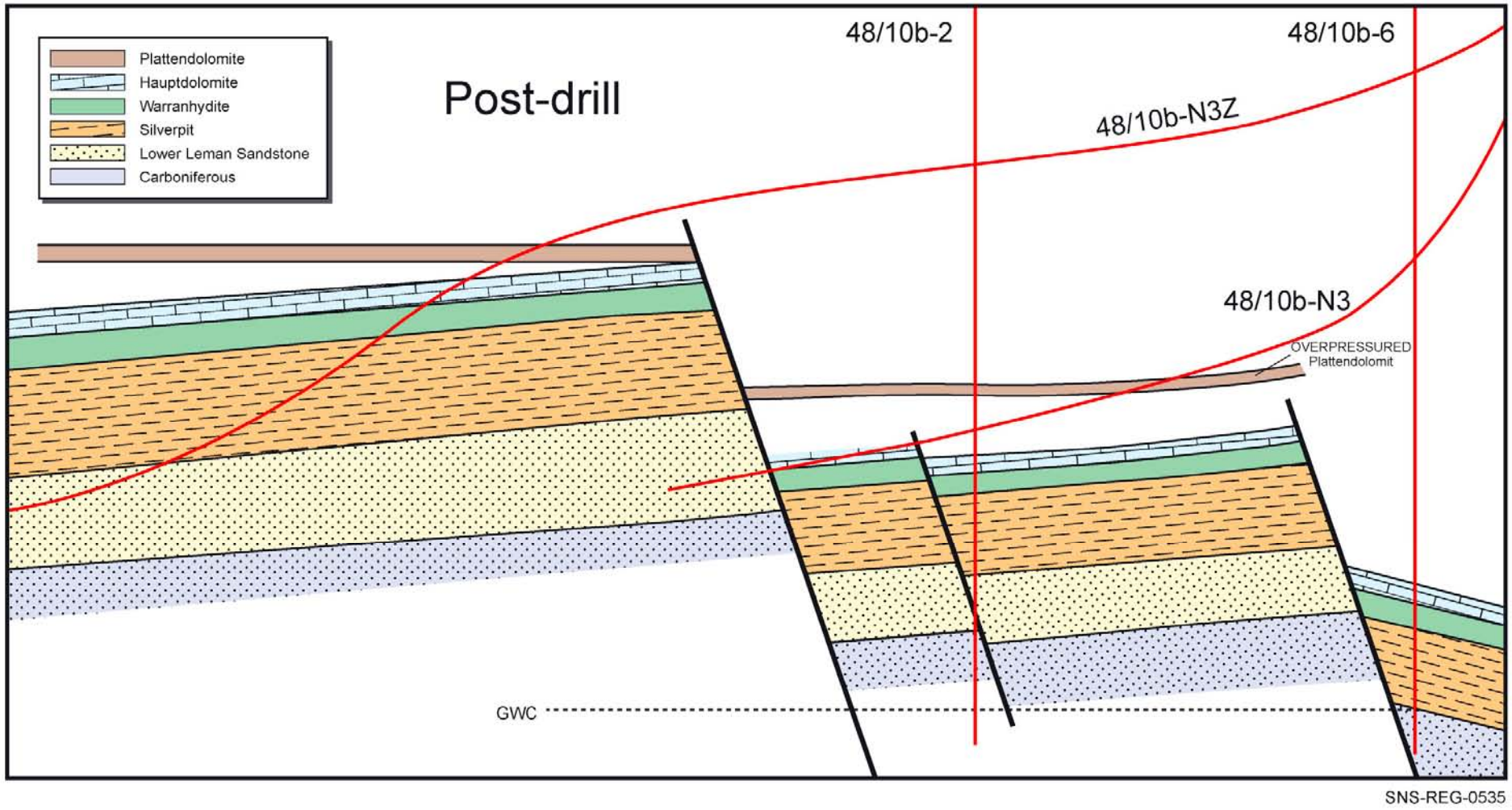
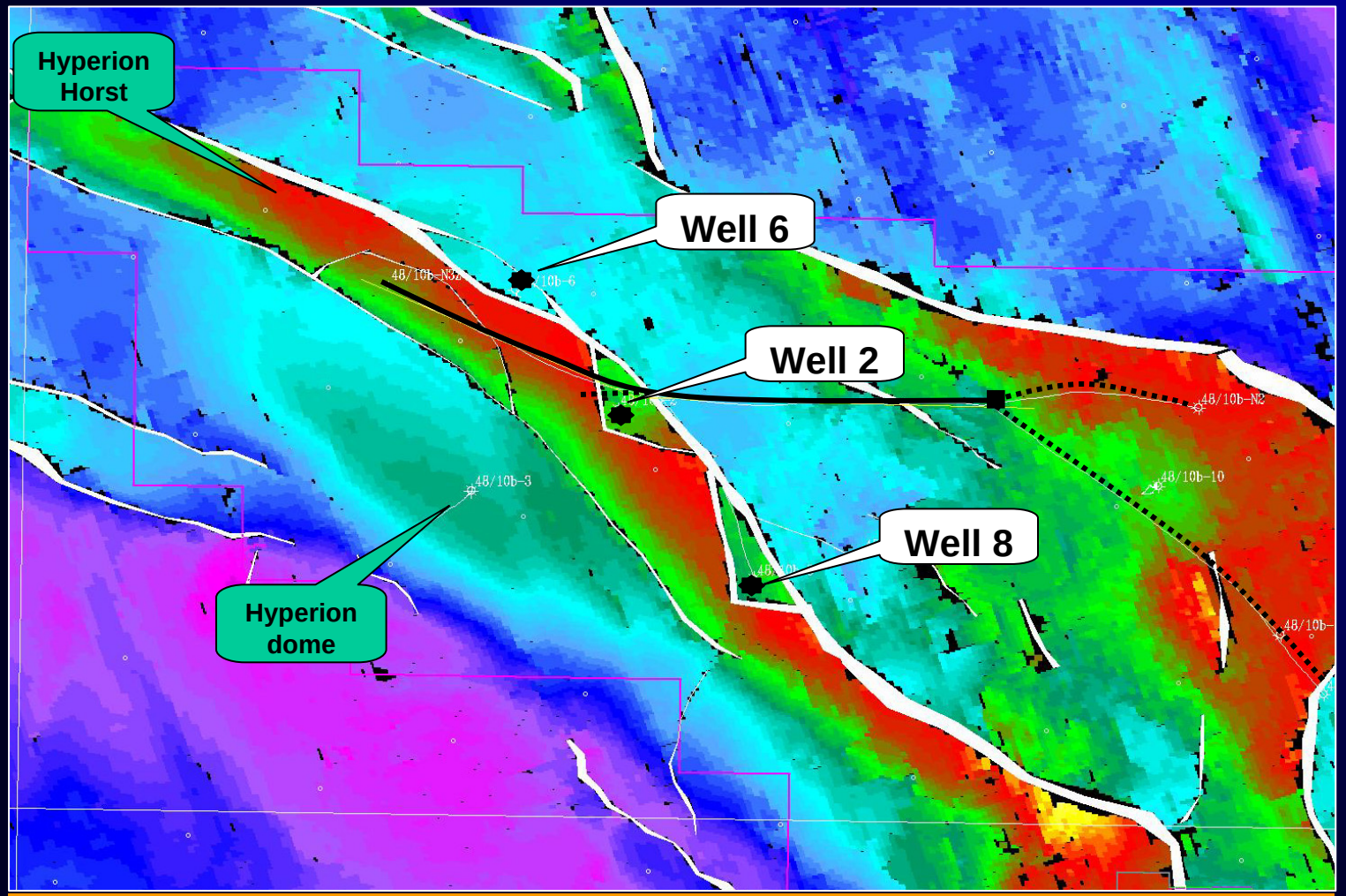
Schematic cross section with 48/10b-N3Z



New Seismic Depth Map with 48/10b-N3Z well



Could we have been that unlucky during appraisal?

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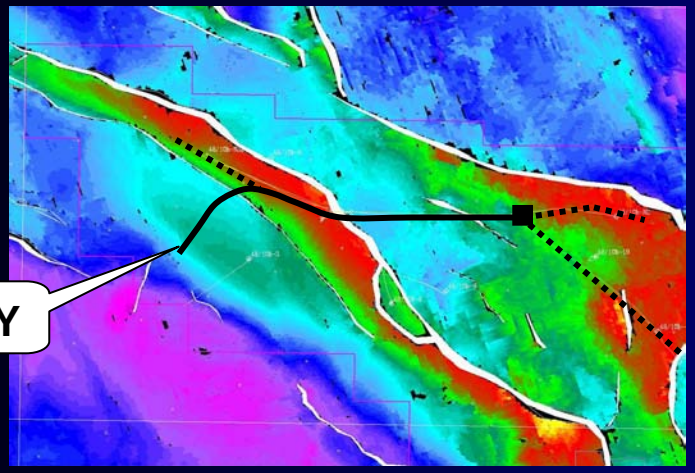
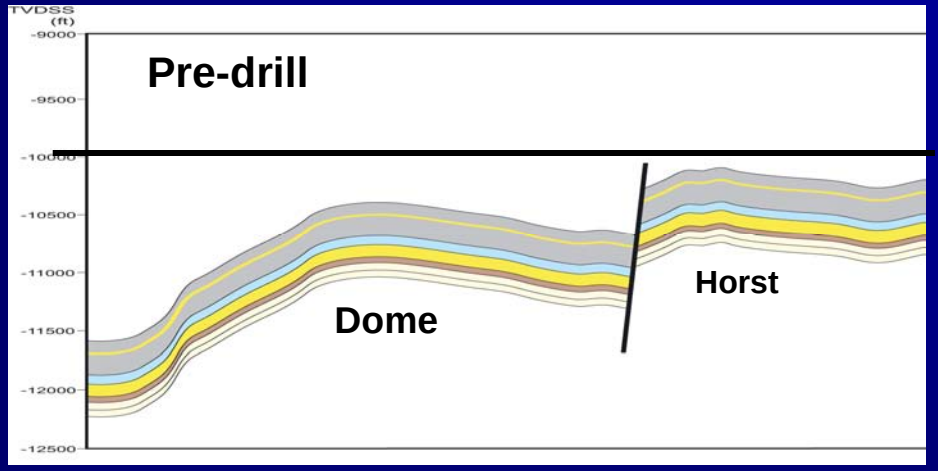
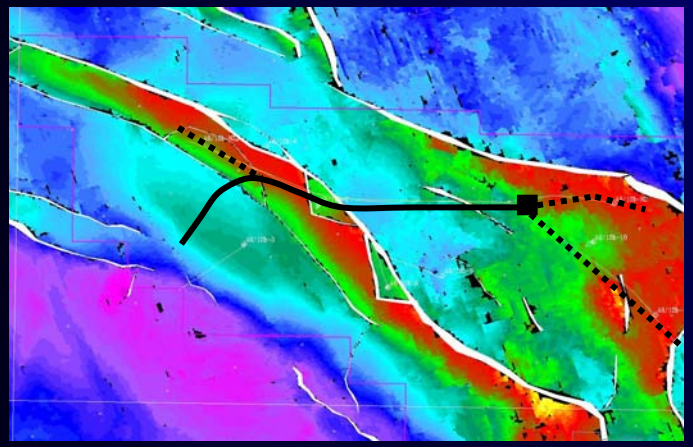
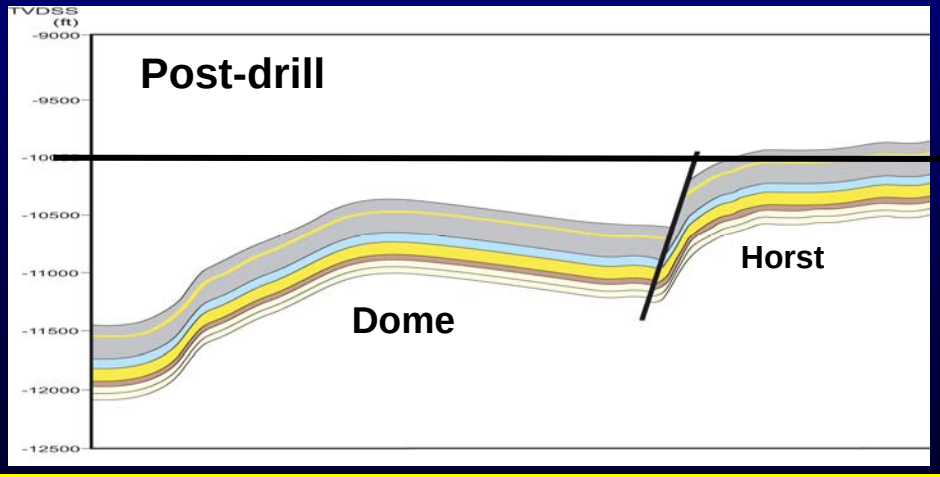
Pre and Post 48/10b-N3Y Dome Cross-sections



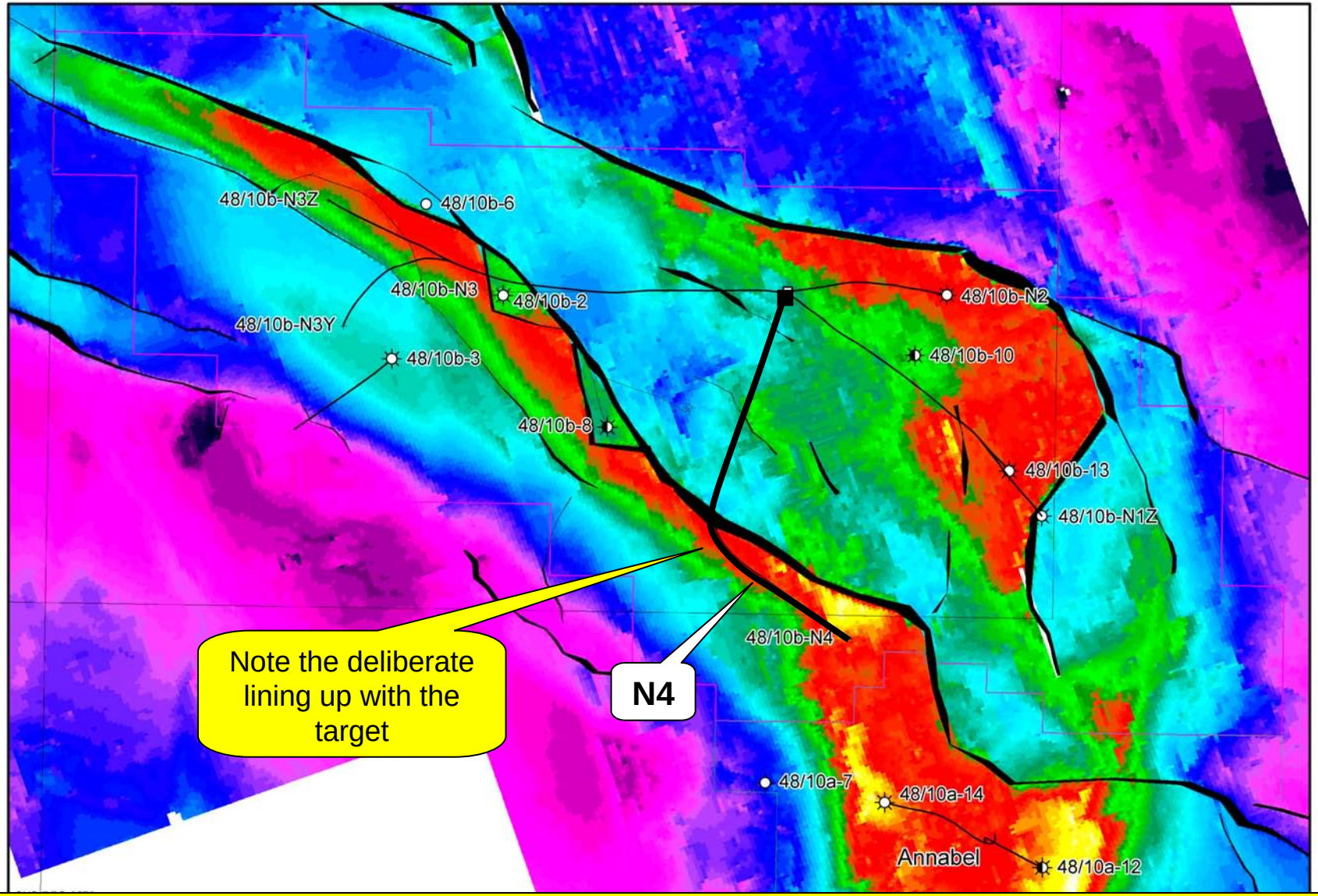






The dome part of the planned bi-lateral well, was sidetracked from 48/10b-N3Z, and encountered the dome structure with no further structural surprises.

Rhea well (48/10b-N4) on seismic depth map



This well was planned to line up was the target, to mitigate against depth conversion errors

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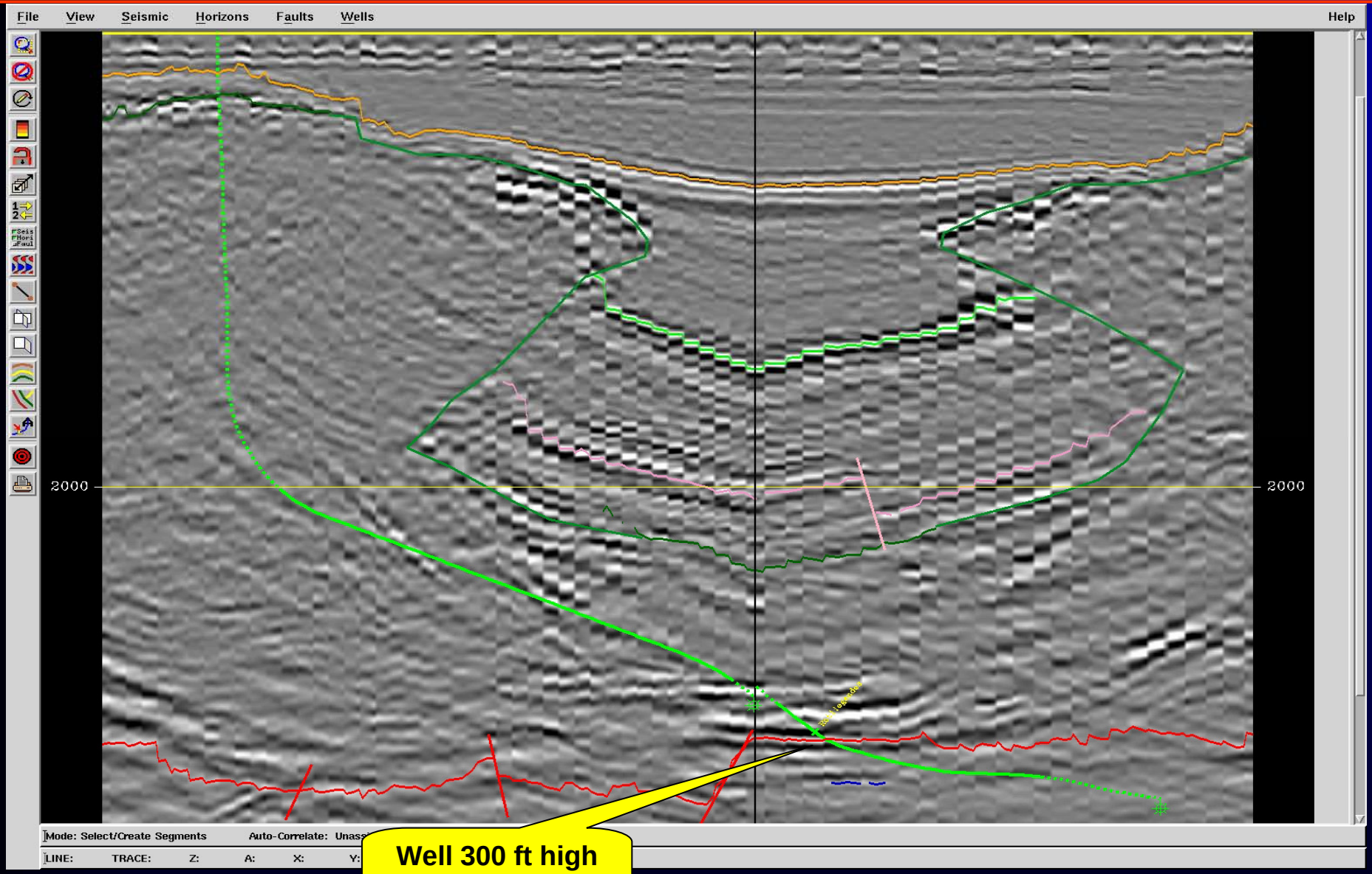
Seismic depth data along N4 well path



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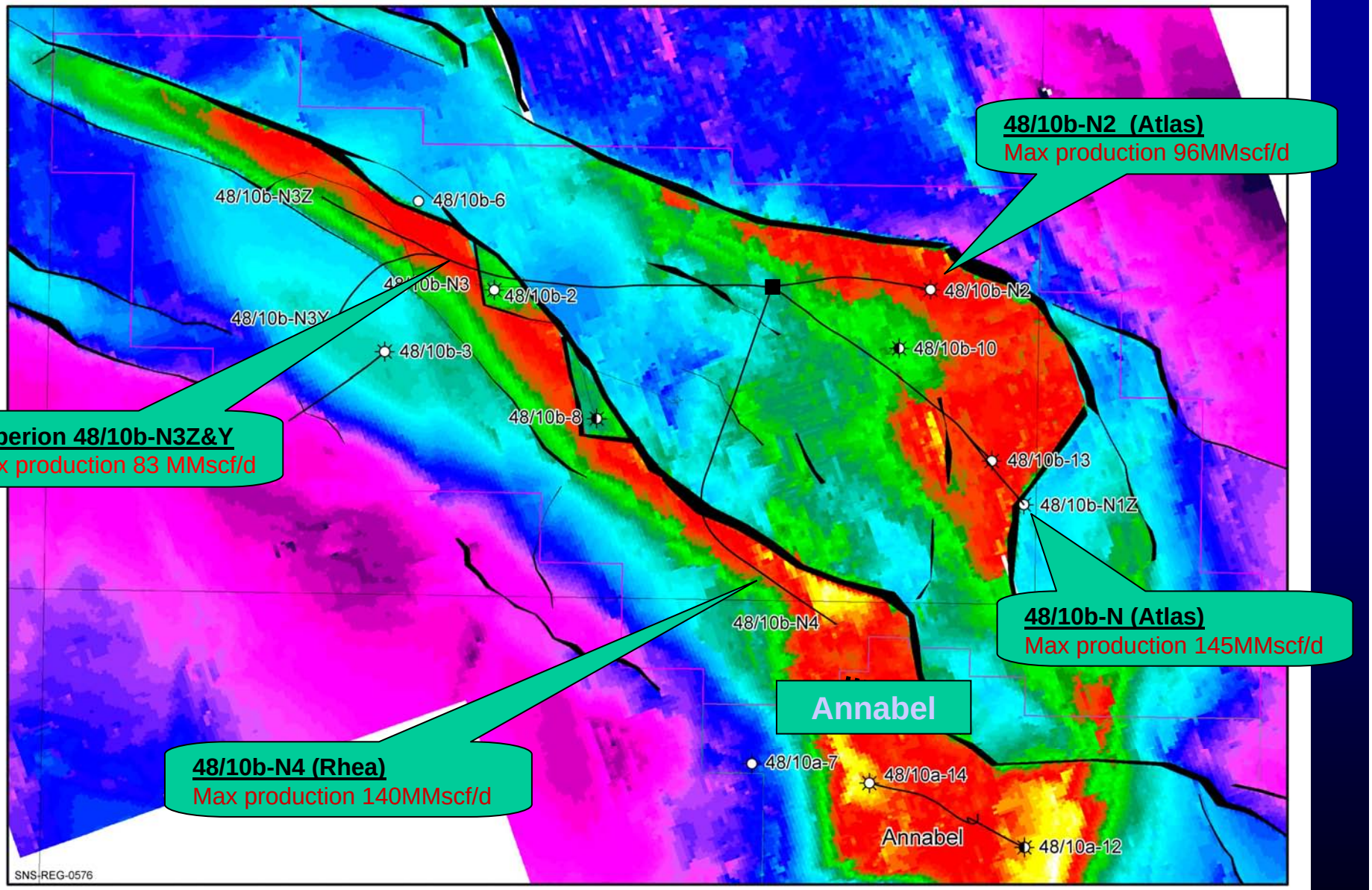
Production rate summary



48/10b-N2 (Atlas)
Max production 96MMscf/d

Hyperion 48/10b-N3Z&Y
max production 83 MMscf/d

48/10b-N (Atlas)
Max production 145MMscf/d

48/10b-N4 (Rhea)
Max production 140MMscf/d

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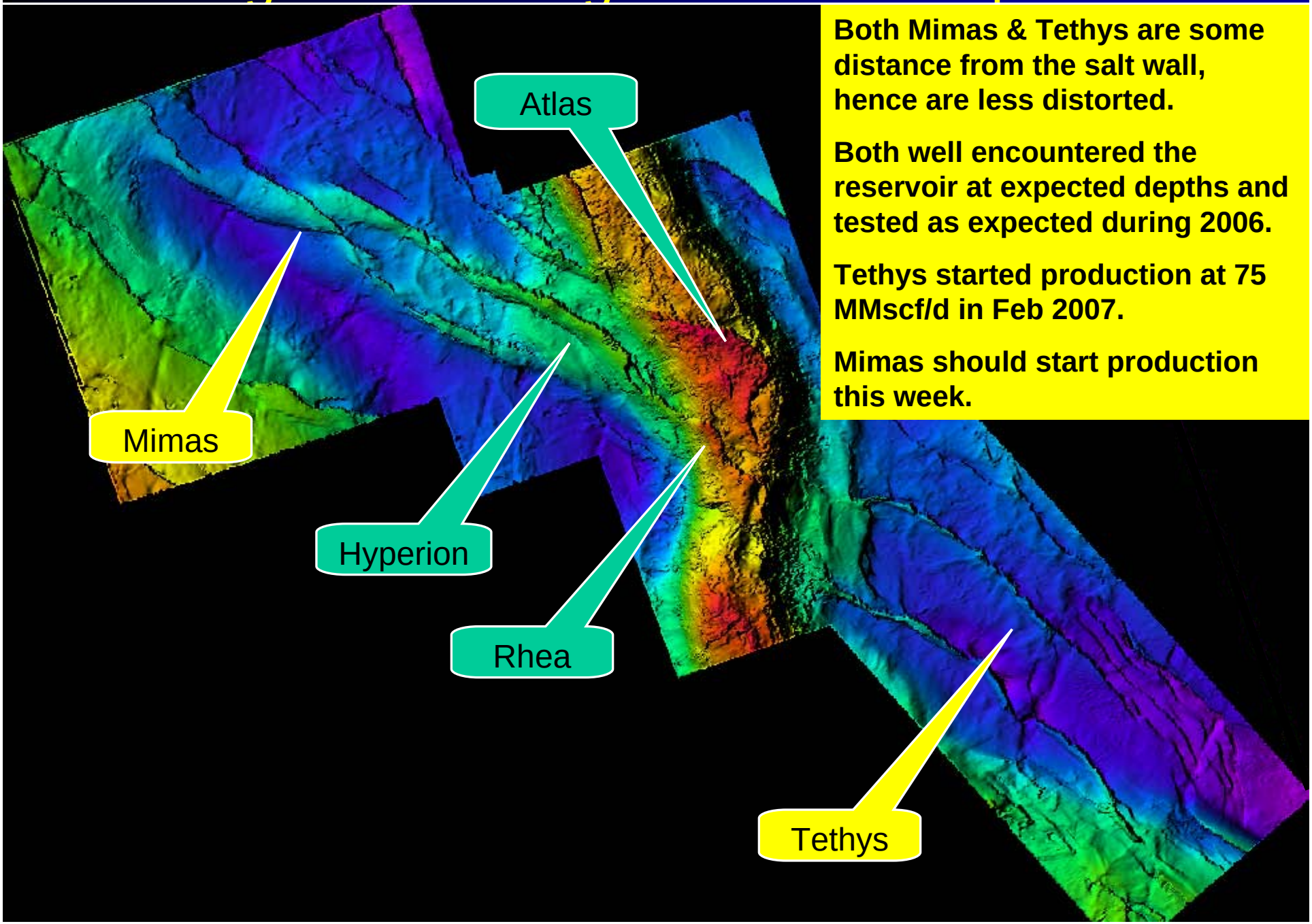
Rotliegend semi-regional time interpretation



Both Mimas & Tethys are some distance from the salt wall, hence are less distorted.

Both well encountered the reservoir at expected depths and tested as expected during 2006.

Tethys started production at 75 MMscf/d in Feb 2007.

Mimas should start production this week.

Was it appropriate to delay the project till now ?

On balance probably yes, because:

Seismic imaging was poor, it has improved over the years, first with 3D and later with PreSDM. Hence we gained more confidence in the structural configuration. However remember it is still only an image.

Drilling has progressed so more flexibility can now be built into well design, allowing this project to be completed with less wells then previously envisioned, including ConocoPhillips' longest North Sea bi-lateral well.

The Mimas and Tethys developments depended on getting the Saturn infrastructure in place to make this stranded gas viable.

Finally, importantly we did catch recent high gas price in the UK.

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Comments and conclusions

- In complex structures, plan wells which retain flexibility. Here our driller get A+.
- In poor seismic data areas “expect the unexpected”. Here I get a B-. I had started to believe my own maps.
- To conclude with a little luck we have a very profitable investment.

Acknowledgements

To ConocoPhillips and partners RWE Dea development (Ltd) & Venture Production plc. for permission to present this paper.

To the Saturn geologist David Oliver & the Saturn reservoir engineer Kevin Ashton, for many fruitful discussions.

To Equipoise Solutions for their geophysical interpretation and depth conversion during 2002 / 2003.

To all my colleagues past & present who have worked this area for the last 40 years.

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The End

Thank you and any Questions?

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