Click to view extended abstract.

High Velocity Zones in Deep Mini-Basin Miocene Sediments, Eugene Island, Northern Gulf of Mexico*

Fred F.C. Snyder[1]; N. Biles[2], L. Den Boer[2], P. Hooyman[2], G. Jamieson[2]; and C. Sayers[2]

Search and Discovery Article #40613 (2010)
Posted October 29, 2010

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, New Orleans, Louisiana, April 11-14, 2010.

[1]Integration Solutions, WesternGeco, Houston, TX (fsnyder@houston.westerngeco.slb.com)
[2]Schlumberger Data Consulting Services, Houston, TX

Abstract

Multi-azimuthal tomographic modeling and well check-shot validation of wide azimuth seismic data within an area of South Marsh Island, Eugene Island, and Ship Shoal Island, offshore Louisiana, has shown anomalously high velocity zones in Miocene sediments not associated with salt. These sediments, which can exhibit velocities up to 16,000 ft/sec, occur in mini-basins and rim synclines adjacent to salt diapirs in the northern half of the project and at depths of between 17,000 and 20,000 feet. Although well control is poor away from the salt, several wells were found to penetrate these velocity anomaly zones, in particular the Eugene Island 151 #1 well, drilled to a depth of 17,000 feet MD, the Eugene Island 152 #1 well drilled to a depth of 20,500 feet MD, and the South Marsh Island 23 #J001 well, drilled to over 20,000 feet MD. Sonic logs of all three wells clearly show evidence of an anomalously high velocity profile not directly associated with salt.

Although these mini-basin sediments can have anomalously high velocity characteristics, they should not to be confused with salt remnants, welds, feeders, or other salt structures. Indeed, these sediments exhibit seismic reflection characteristics more common to marine deposition, such as subparallel bedding, cross-cutting, and channel-levee systems. An explanation of what we see seismically may be found in this area's location on the shelf, rate of deposition, depth of burial, age, and salt influence, as well as consideration for the dynamics of fluid movement.

Within such an environment, it is thought that these high-velocity zones are accurately reflecting the geology, specifically well cemented, less porous, diagenetically altered sands of the lower to middle Miocene. This study reviews our methods (use of inversion-derived data volumes such as acoustic impedance, porosity, shale content, pore pressure, etc.), findings, and evidence supporting this hypothesis.

References

Galloway, W.E., P.E. Ganey-Curry, X. Li, and R. Buffler, 2000, Cenozoic depositional history of the Gulf of Mexico basin: AAPG Bulletin, v. 84/11, p. 1743-1774.

Sayers, C.M., M.J. Woodward, and R.C. Bartman, 2002, Seismic pore-pressure predicted using reflection tomography and 4-C seismic data: The Leading Edge, v. 21/2, p. 188-192.

High Velocity Zones in Deep Mini-Basin Miocene Sediments, Eugene Island, Northern Gulf of Mexico

Fred F. C. Snyder

WesternGeco – Houston

N. Biles, L. Den Boer, P. Hooyman, G. Jamieson, C. Sayers

Schlumberger Data Consulting Services - Houston

WesternGeco

Study observations:

- High-velocity sediment packages appear in the northern half of project area within deep mini-basins, rim synclines, adjacent to diapiric salt.
- Velocities are near those of salt.
- Velocity anomaly zones are also associated with reports of low porosity from operators.
- Likely associated with pressure and temperature anomalies.

E-Dragon Phase I Project Area

Vermilion

South Marsh Island North

Eugene Island

South Marsh Island

Ship Shoal

South Pelto

South Timbalier

Phase III

Phase I

Phase II

VR/SMI - *Depth 1*

EI - *Depth 3*

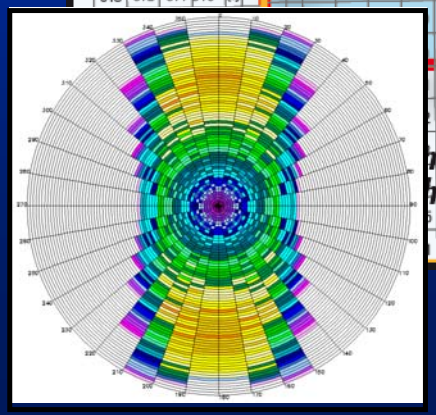
SS/ST - *Depth 2*

Eugene Island South Add

Ship Shoal South Add.

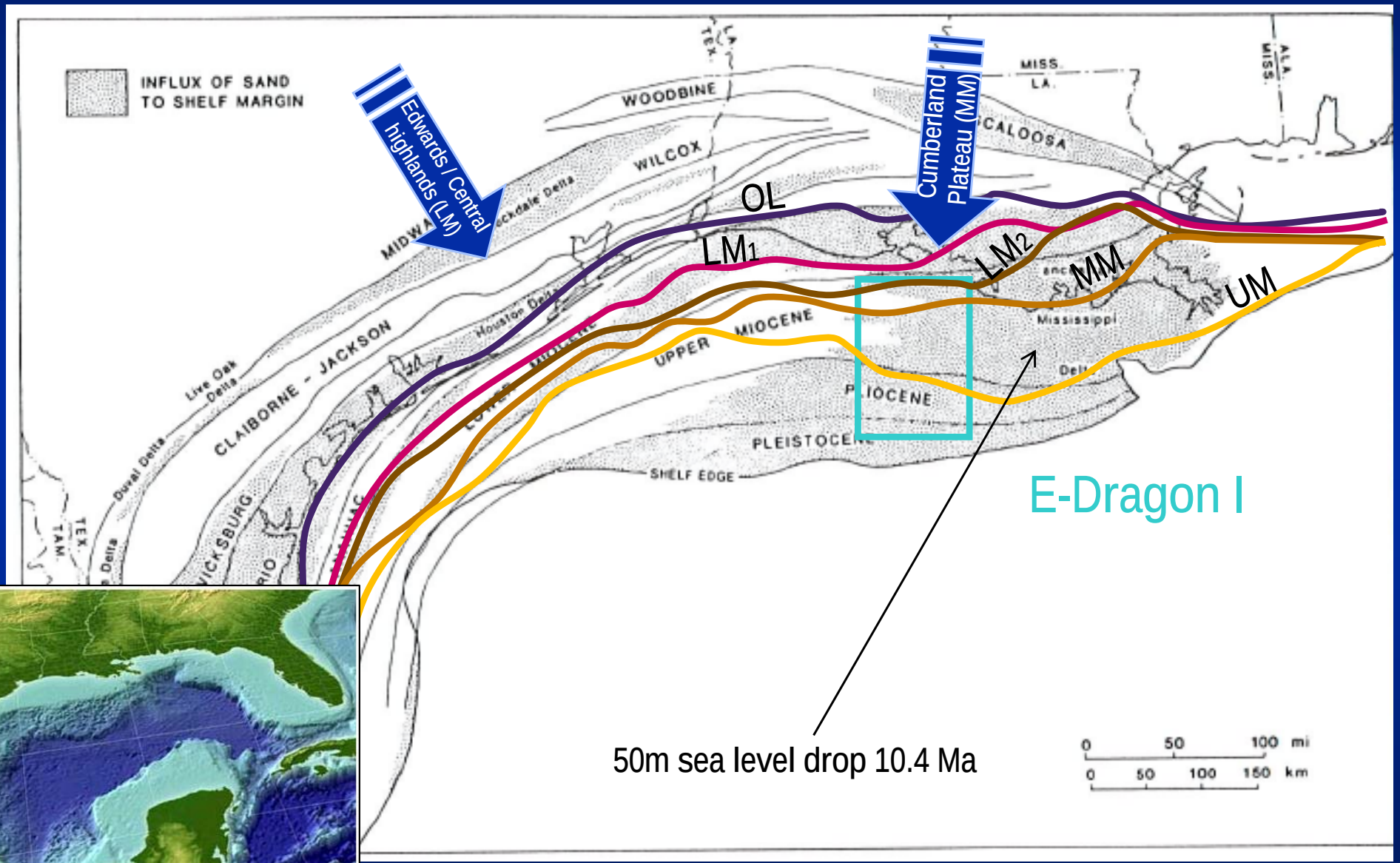
South Timbalier South Add

South Marsh Island South



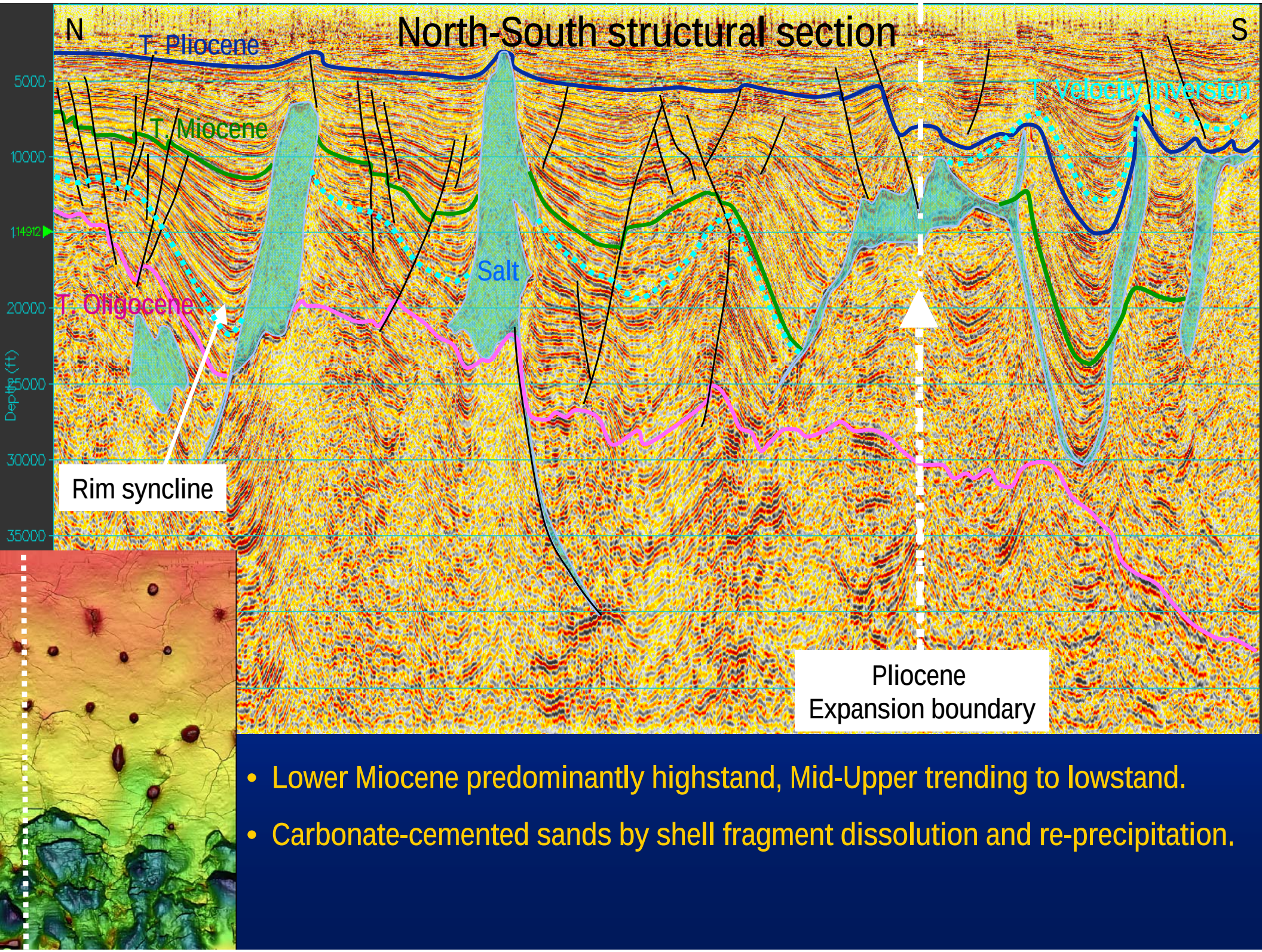
Rose diagram showing rich-azimuth geometry, acquired via cross-spread shooting, of original Ocean-Bottom Cable ("OBC") acquisition.

Influx of sand to shelf – Ancestral Mississippi



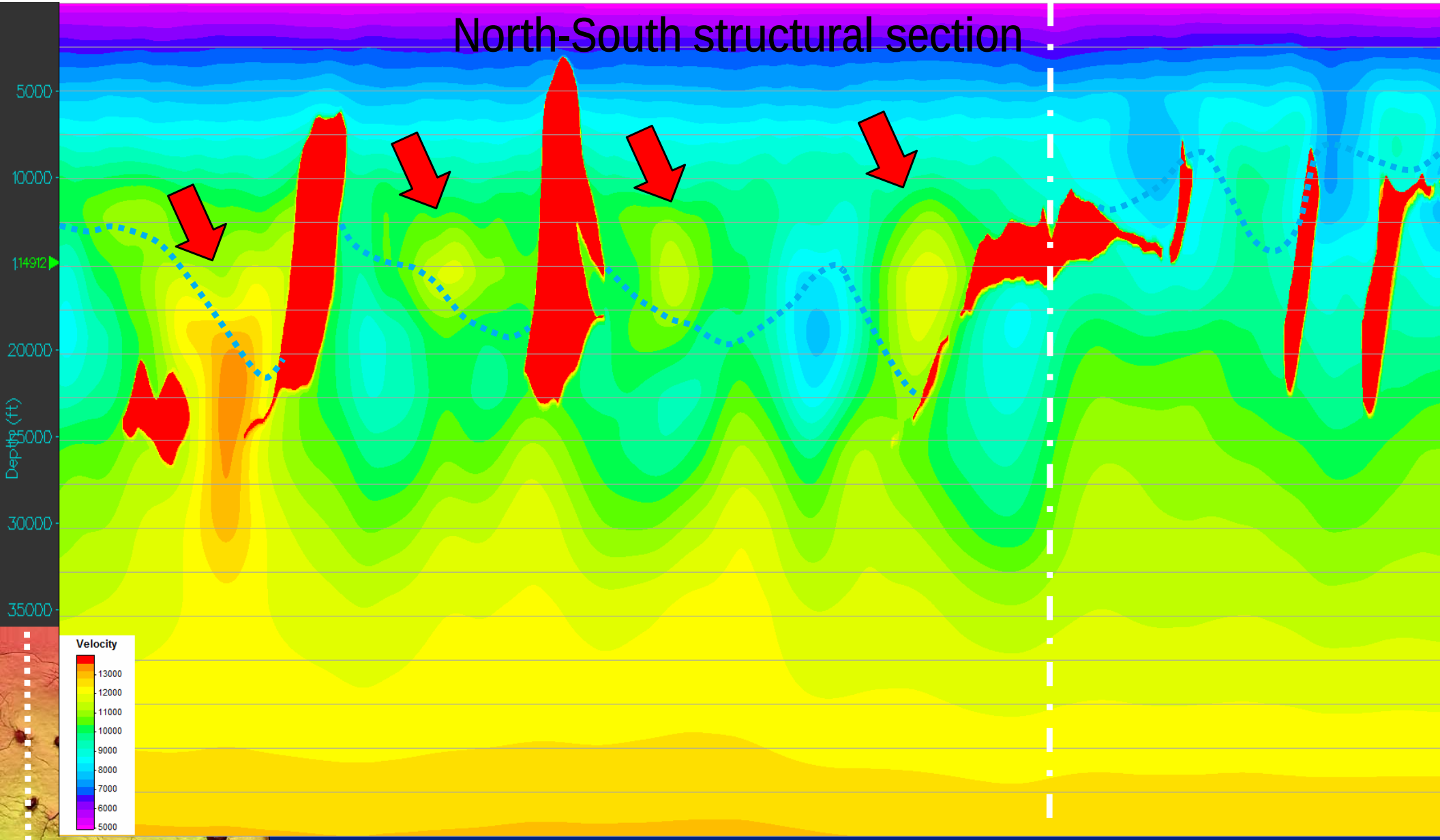
Depth gradient throughout the Gulf of Mexico.
Image modified from ESRI Data & Maps (2000).

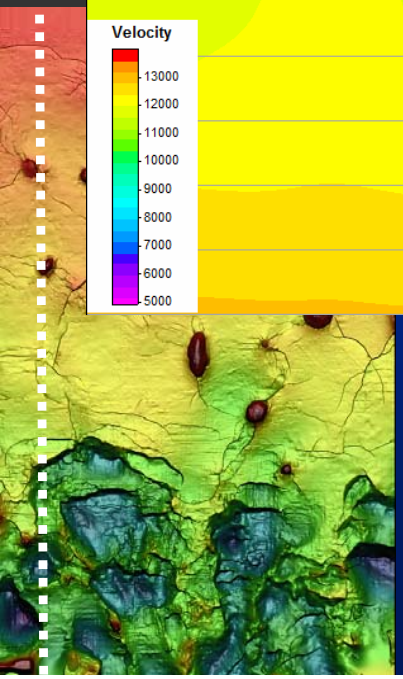
Source: Galloway et al. 2000



- Lower Miocene predominantly highstand, Mid-Upper trending to lowstand.
- Carbonate-cemented sands by shell fragment dissolution and re-precipitation.

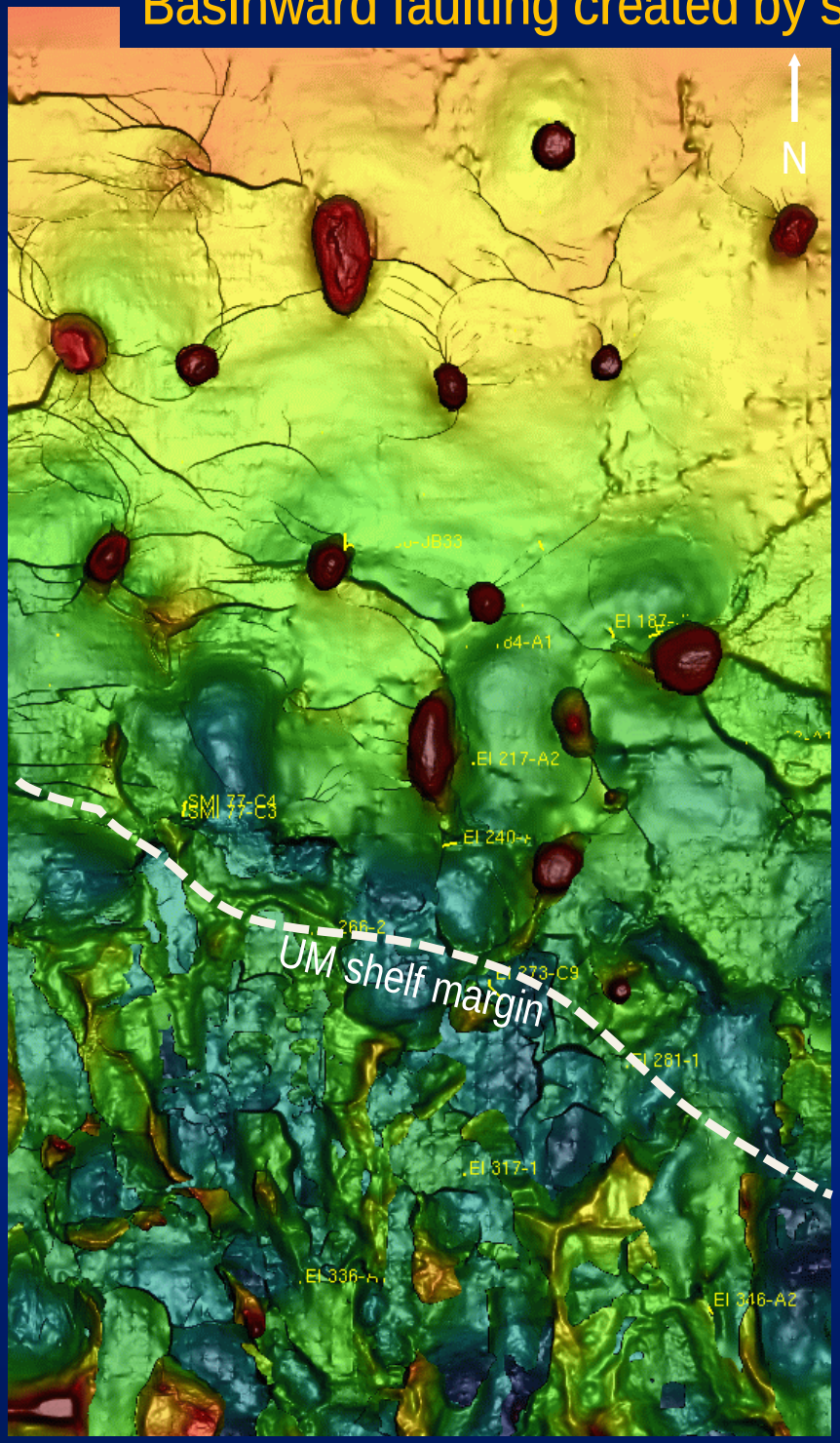
North-South structural section



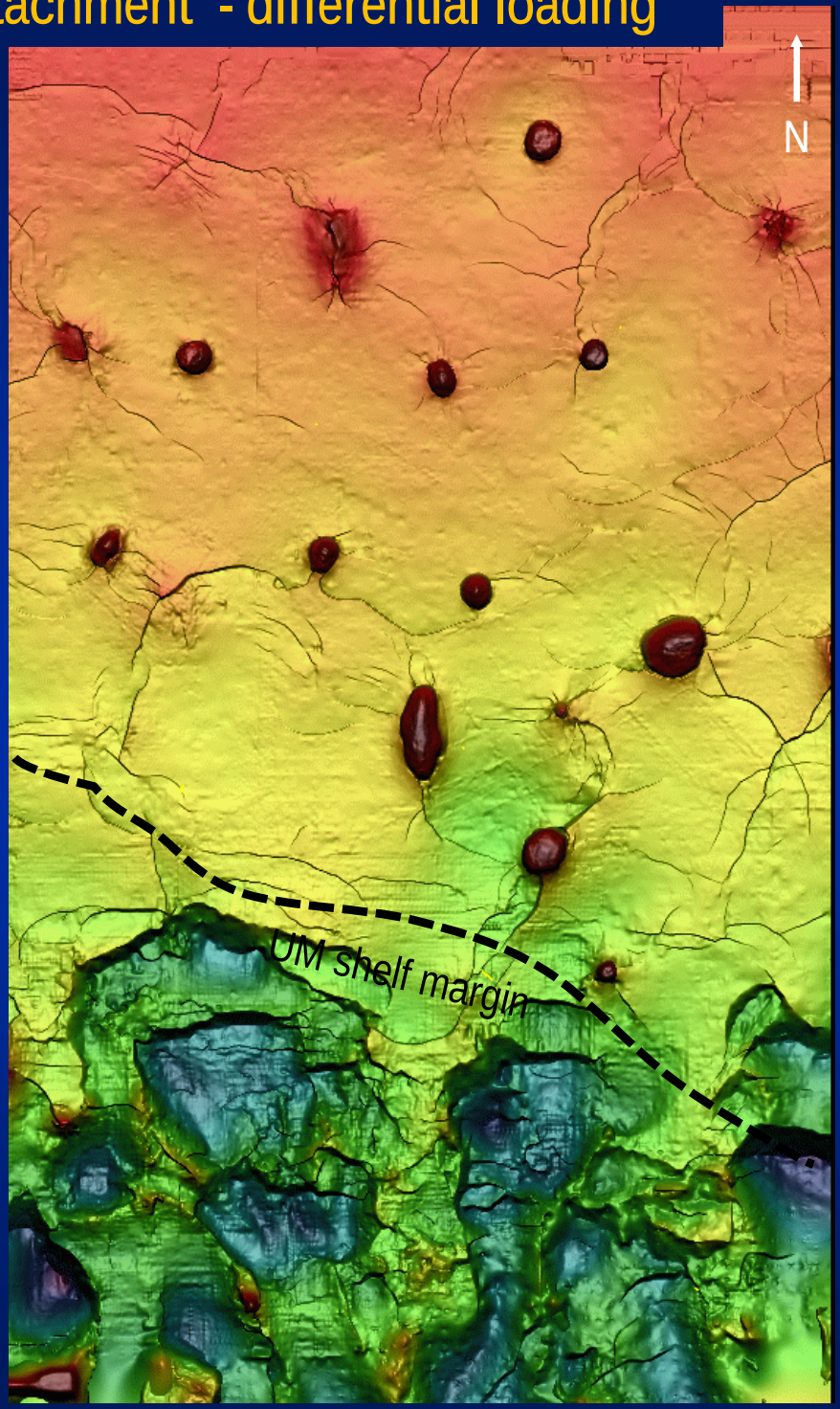


- Lower Miocene predominantly highstand, Mid-Upper trending to lowstand.
- Carbonate-cemented sands by shell fragment dissolution and re-precipitation.

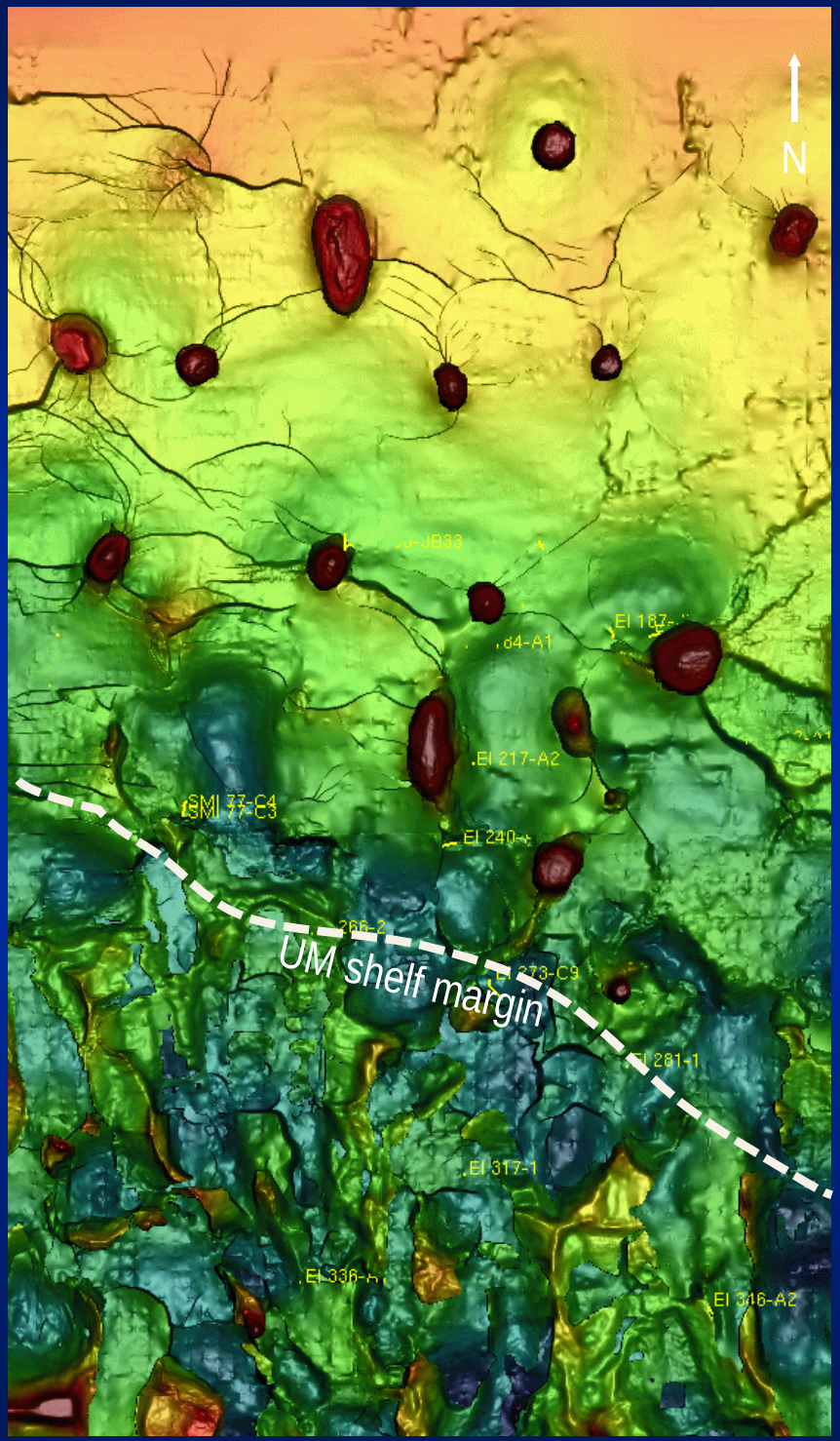
Basinward faulting created by salt detachment - differential loading



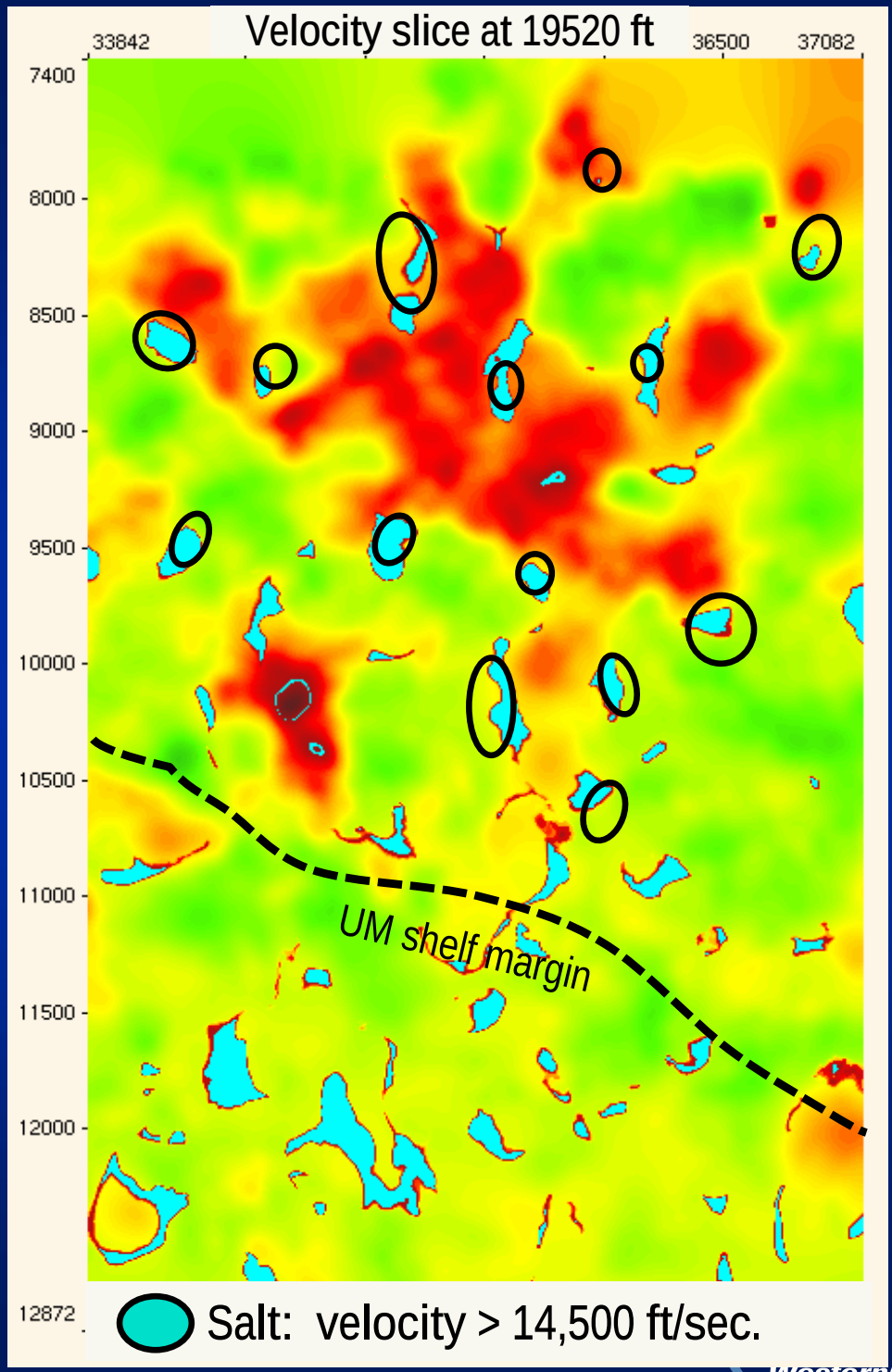
Top Miocene structure merged with Top Salt



Top Pliocene structure merged with Top Salt

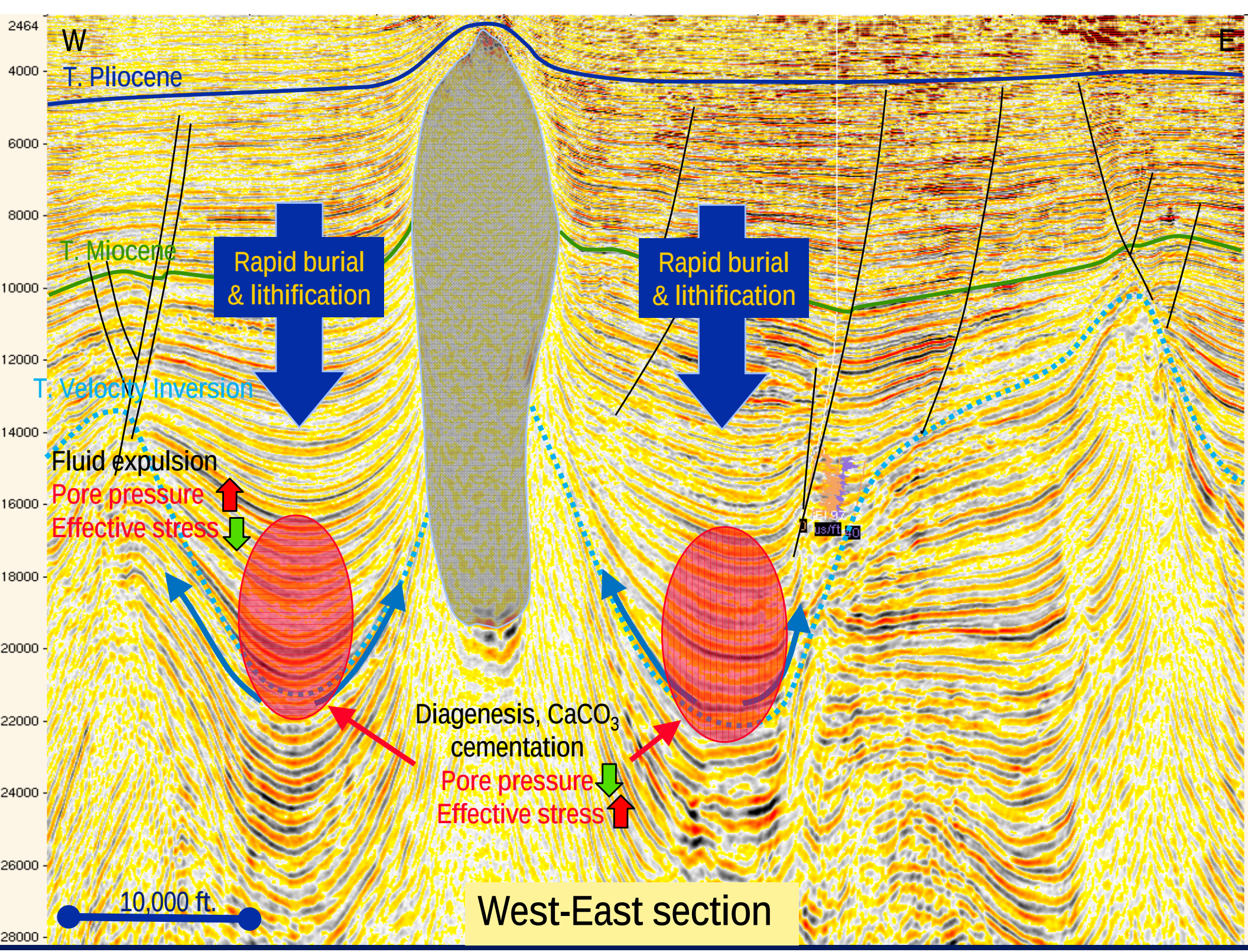


Top Miocene structure merged with Top Salt



Top Pliocene structure merged with Top Salt

WesternGeco


W
E
T. Pliocene
T. Miocene
T. Velocity Inversion
Rapid burial & lithification
Rapid burial & lithification
Fluid expulsion
Pore pressure
Effective stress
Diagenesis, $CaCO_3$ cementation
Pore pressure
Effective stress
10,000 ft.
West-East section
2464
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
26000
28000

E-Dragon key tomography differences

ORIGINAL DEPTH PRODUCT

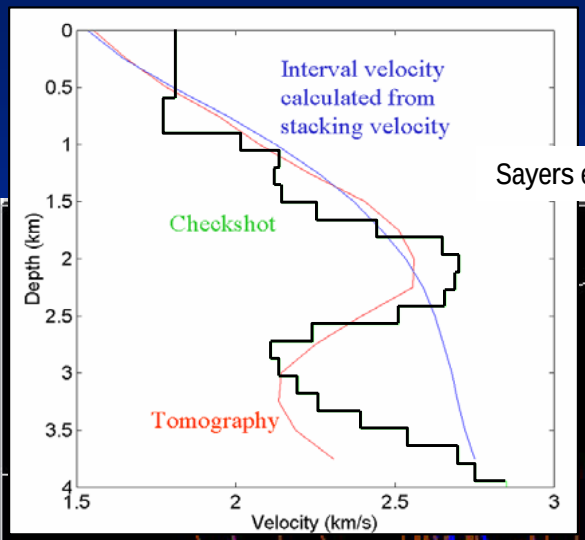
- 40 fold, 8 ms. input
- Tomography 1600/800/400 m.
- Final cell size 50x50 m.x6 m.

NEW DEPTH PRODUCT

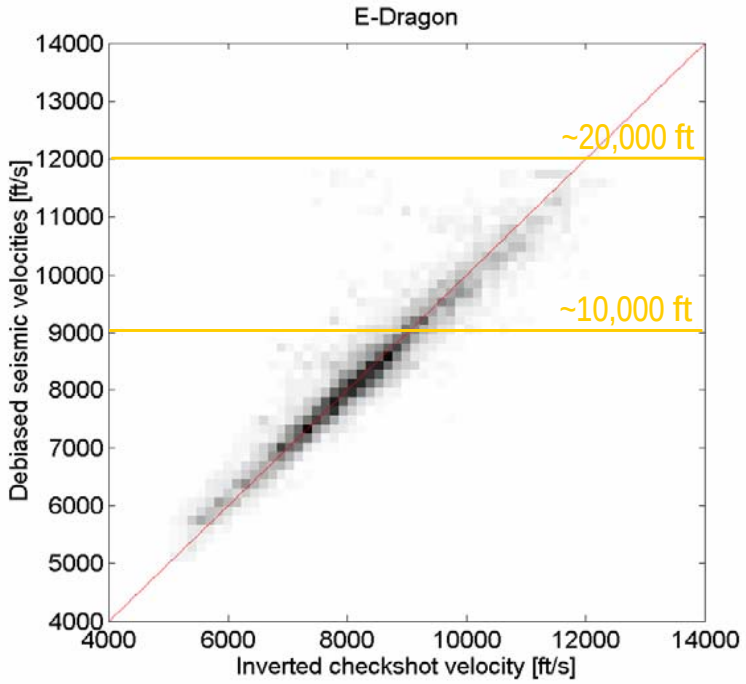
- 60 fold, 6 ms. Input
- Tomography 200/200/100
- Final cell size 25x25 m.x5 m.
- Improved salt definition
- Subsalt velocity update

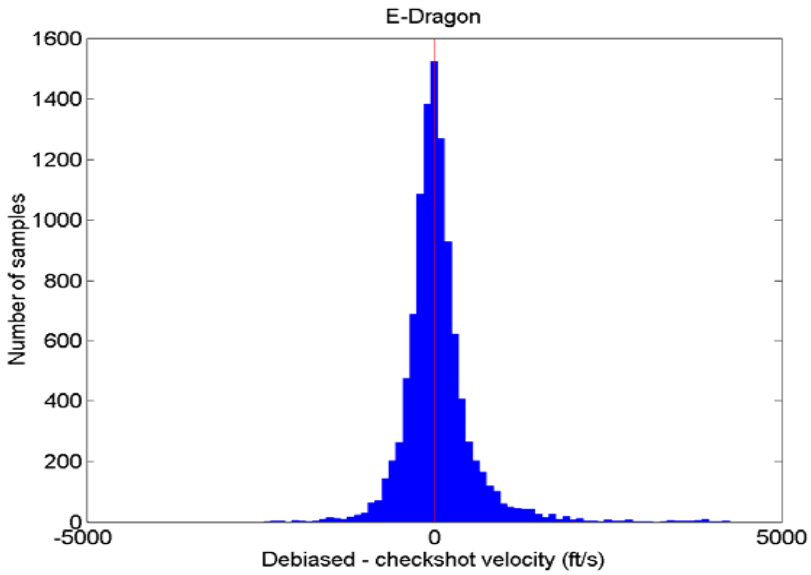
382 check-shot wells for multi-azimuthal tomography validation

Result: 5-10% error between wells and seismic velocity.

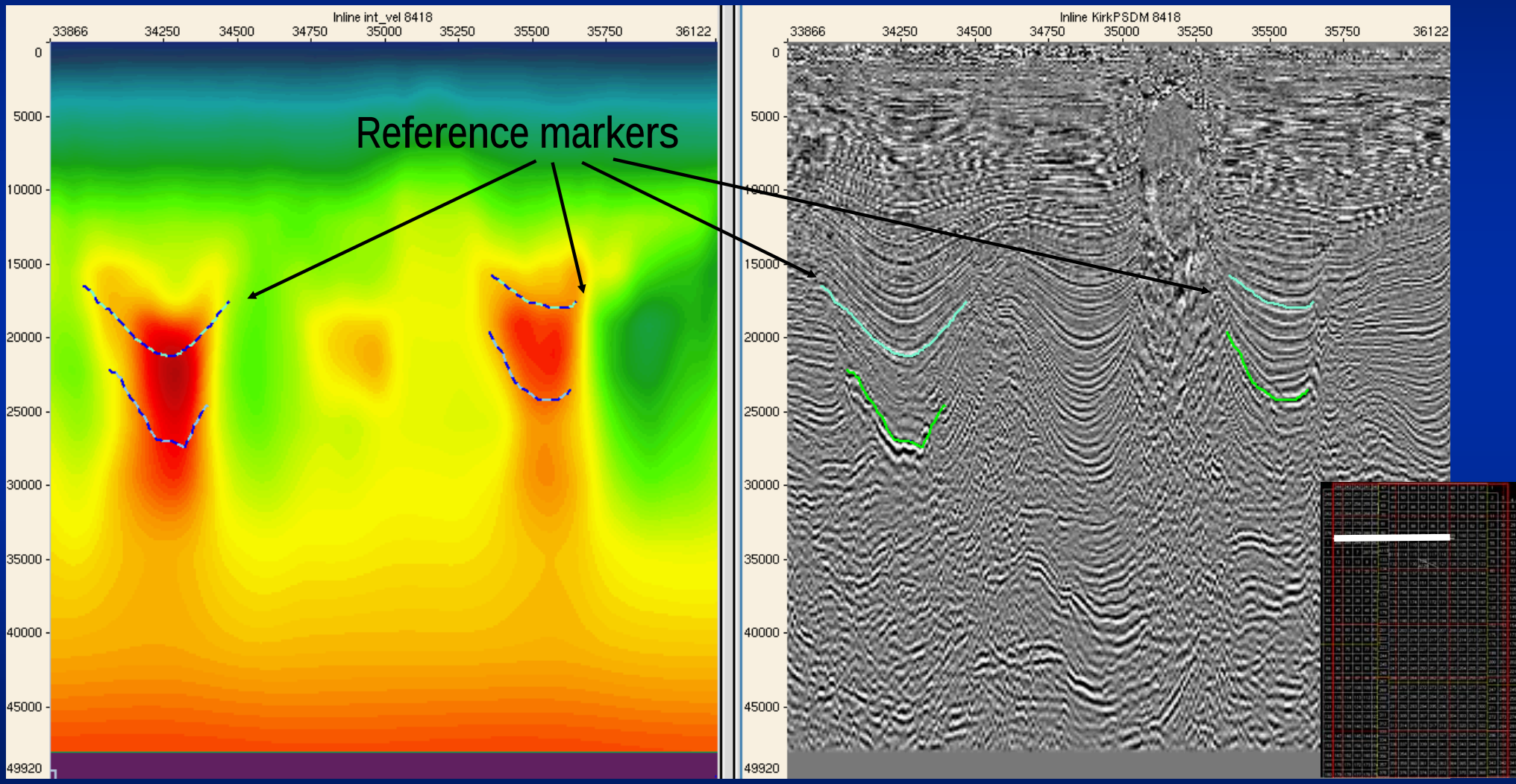


Sayers et al. (2002) *The Leading Edge*, 21, 188-192.



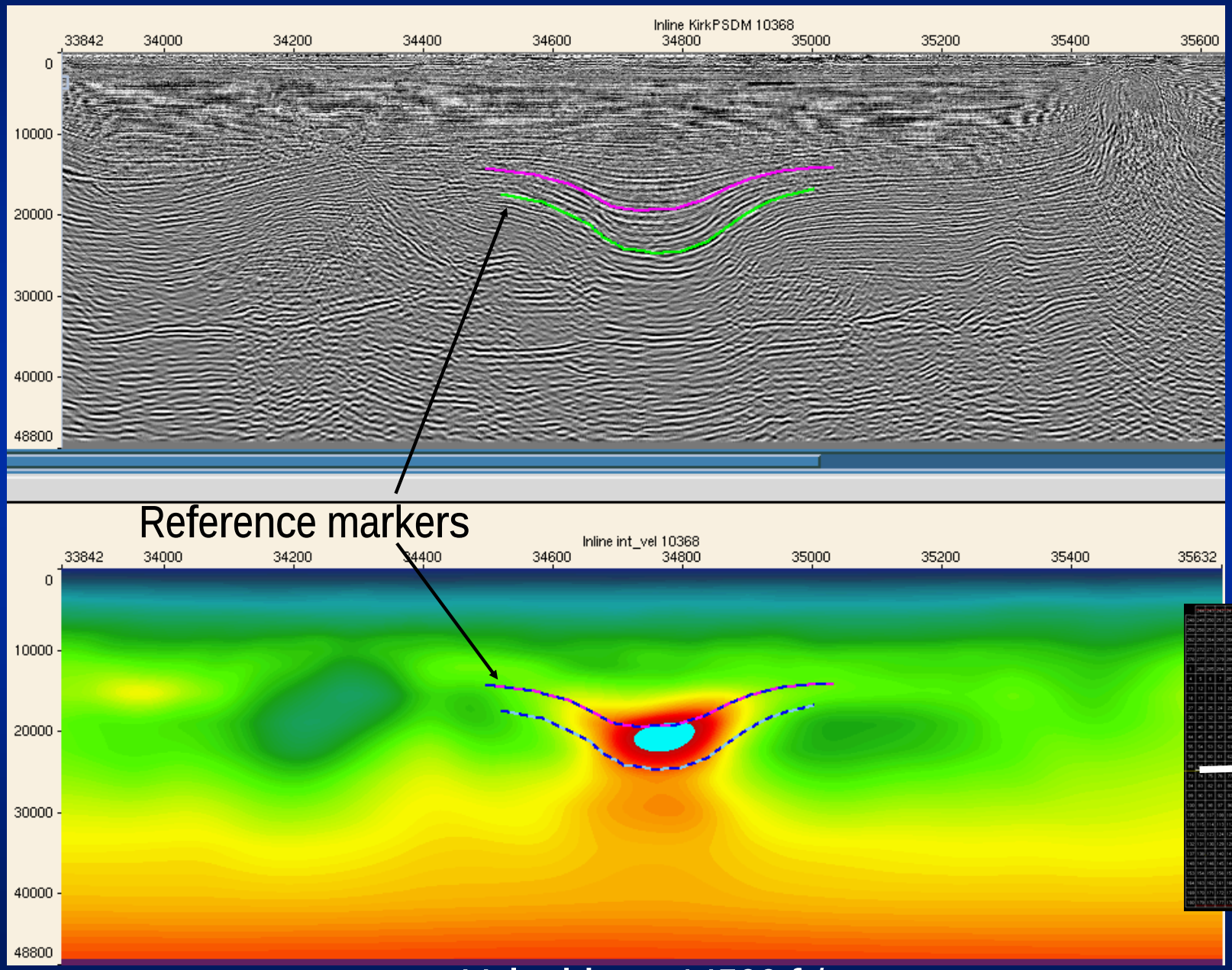


Velocity model and sediment flood migration - Inline 8418



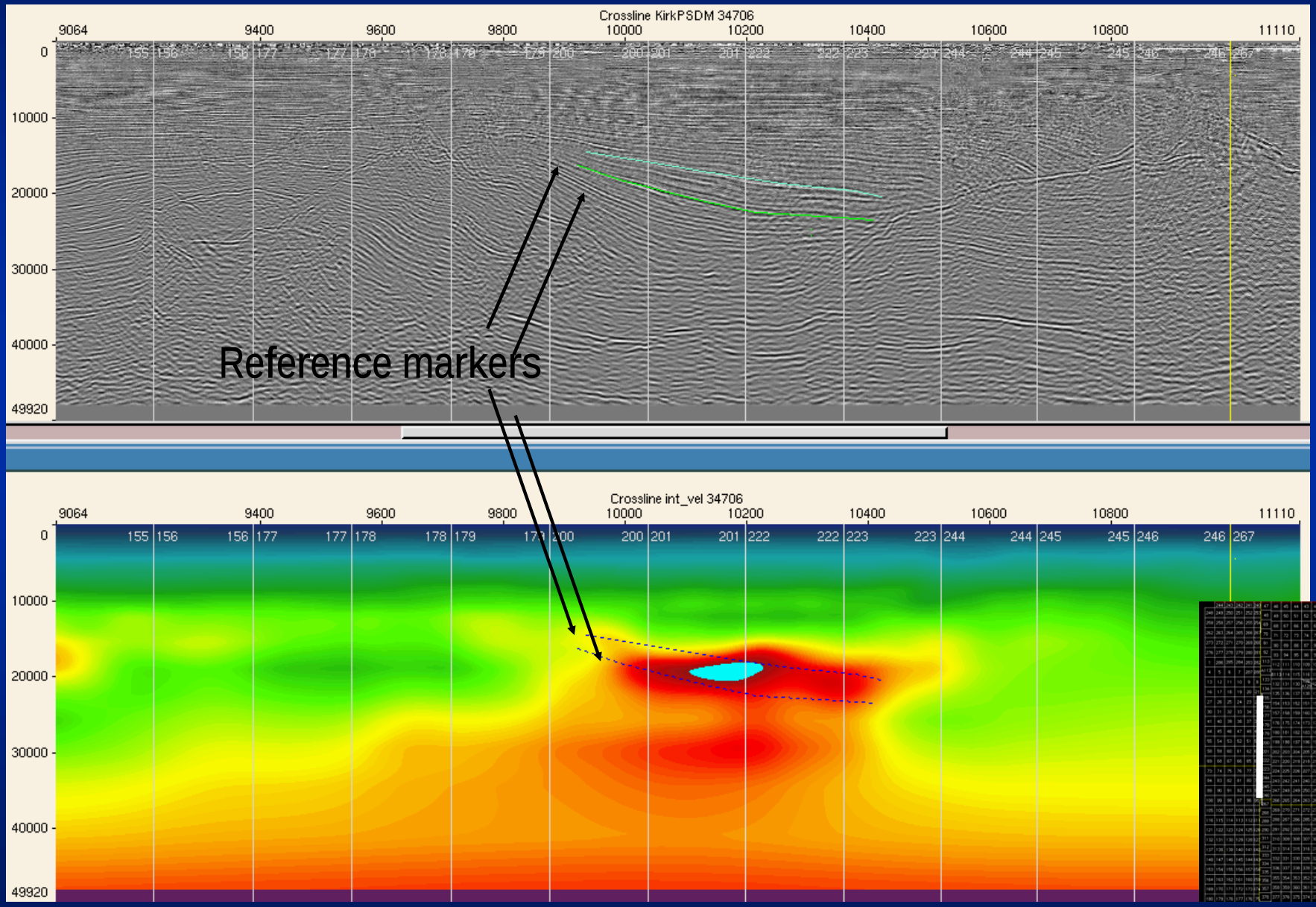
Anomalies located in sediment pods above salt or salt welds

Velocity model and sediment flood migration – Inline 10368



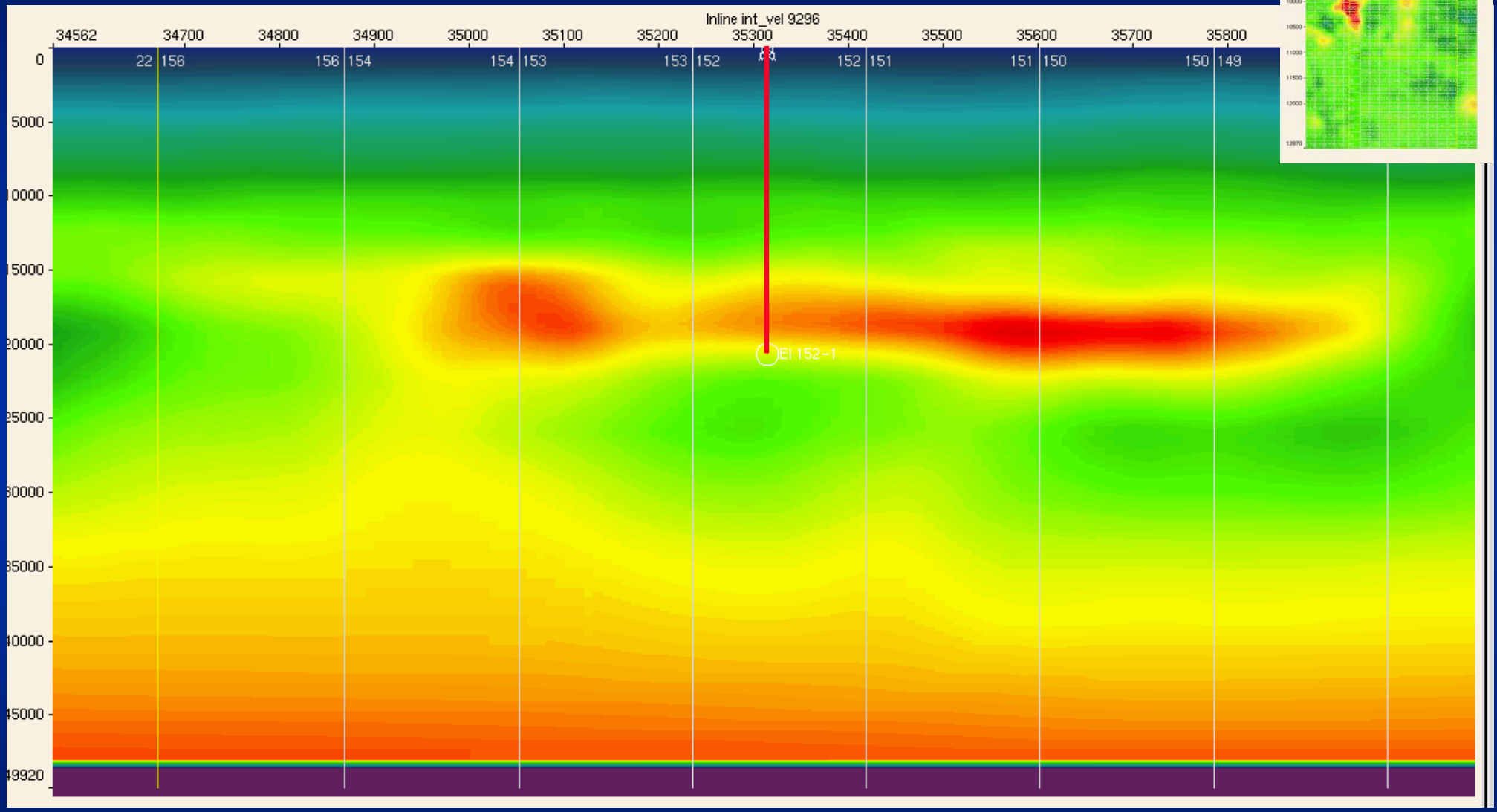
Velocities > 14500 ft/sec

Velocity model and sediment flood migration - Cross line 34706

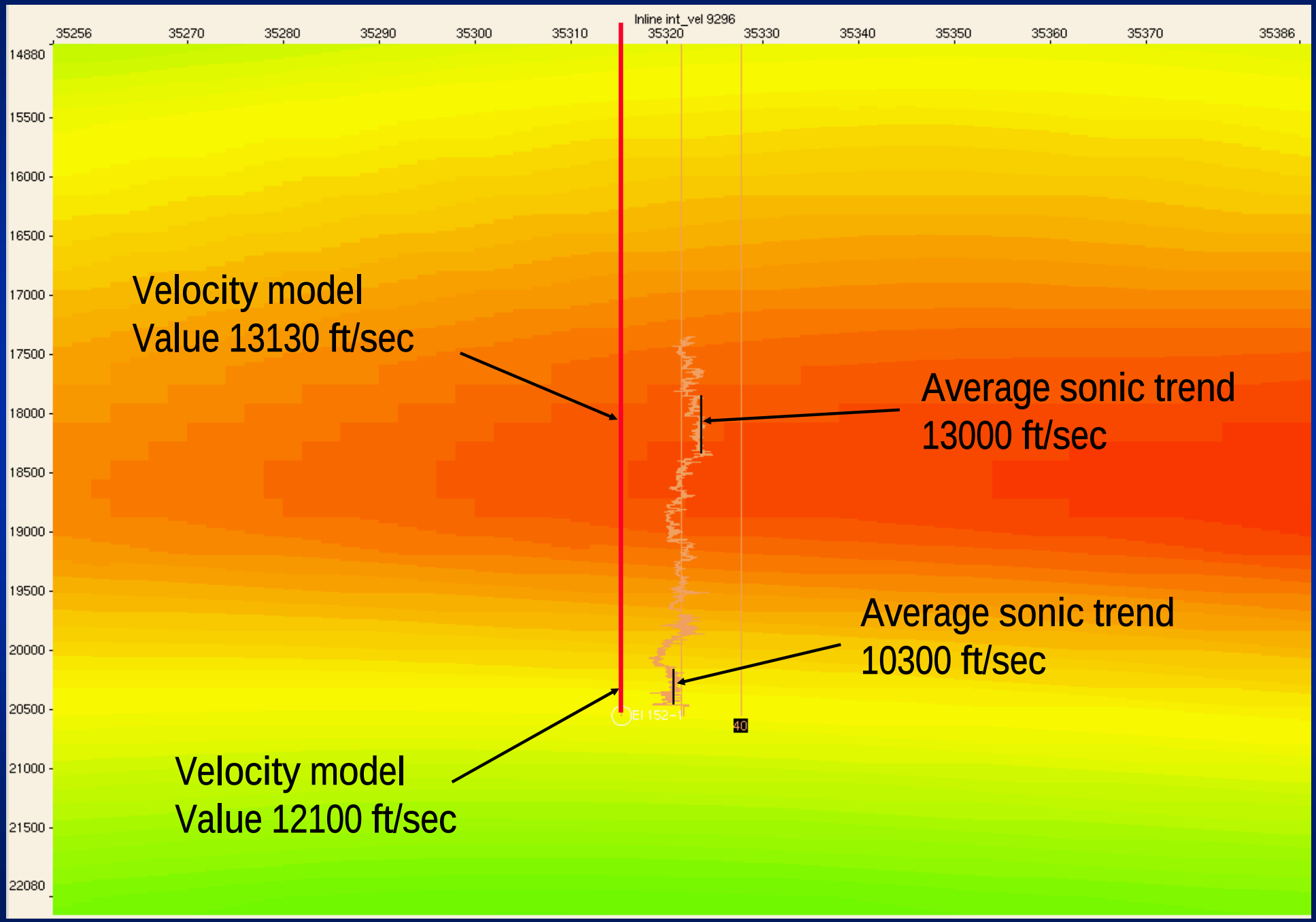


Velocities > 14500 ft/sec

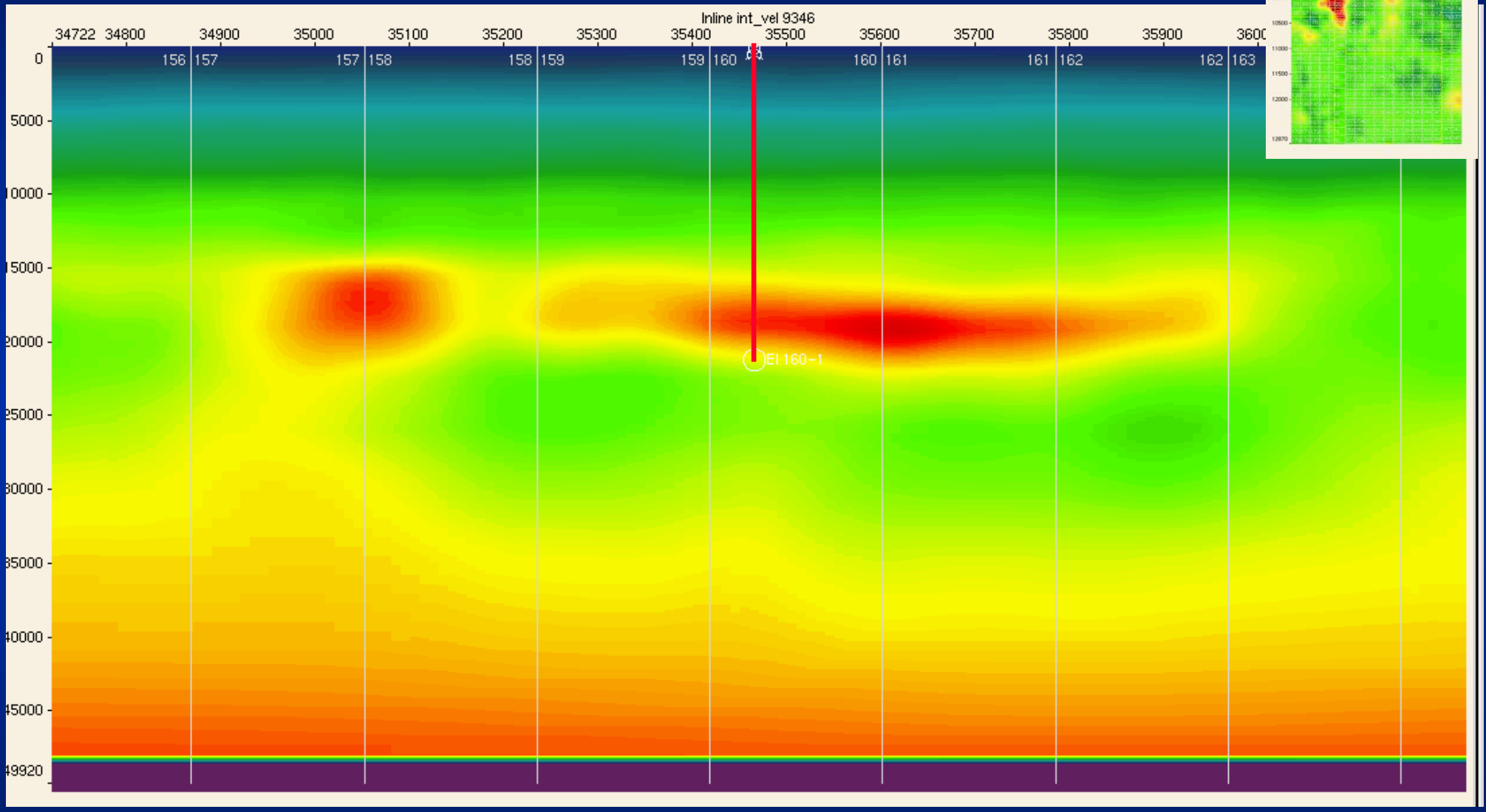
Velocity model at Well EI 152-1



Velocity model at Well EI 152-1

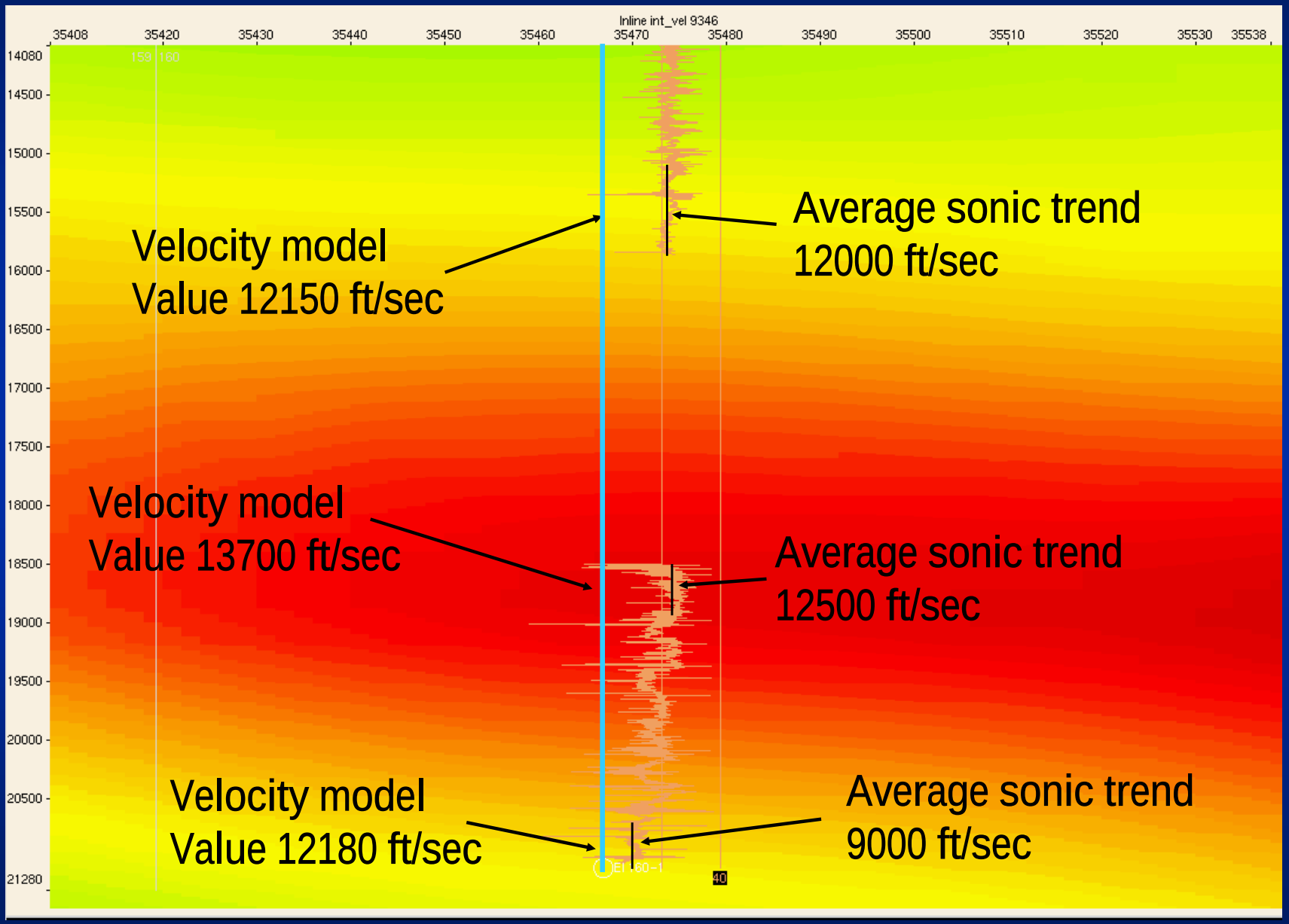


Velocity model at Well EI 160-1



WesternGeco

Velocity model at Well EI 160-1



Mud Log

SD: mod cmtd

SD: w/cmt

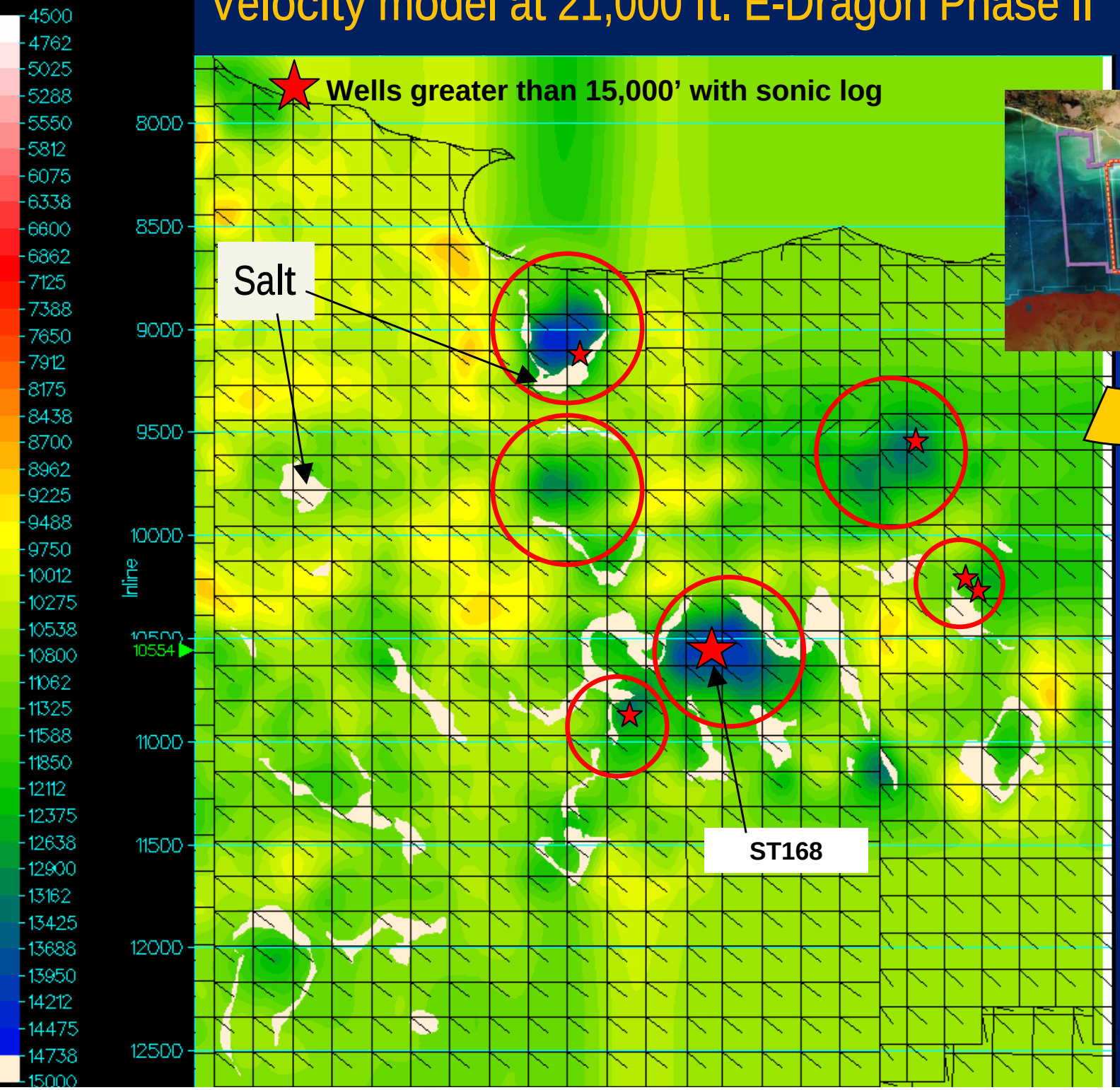
SD: mod cmtd

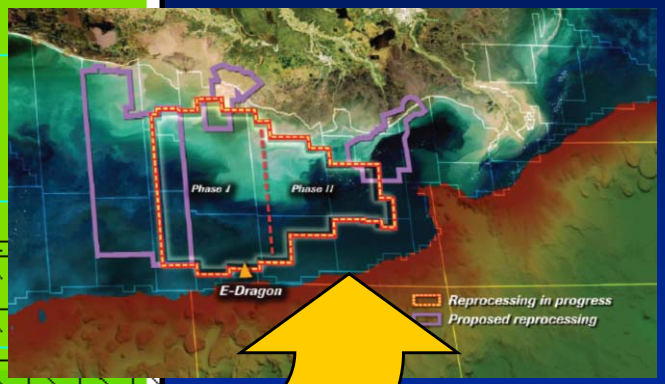
SS: Argill., calc

SS: calc cem

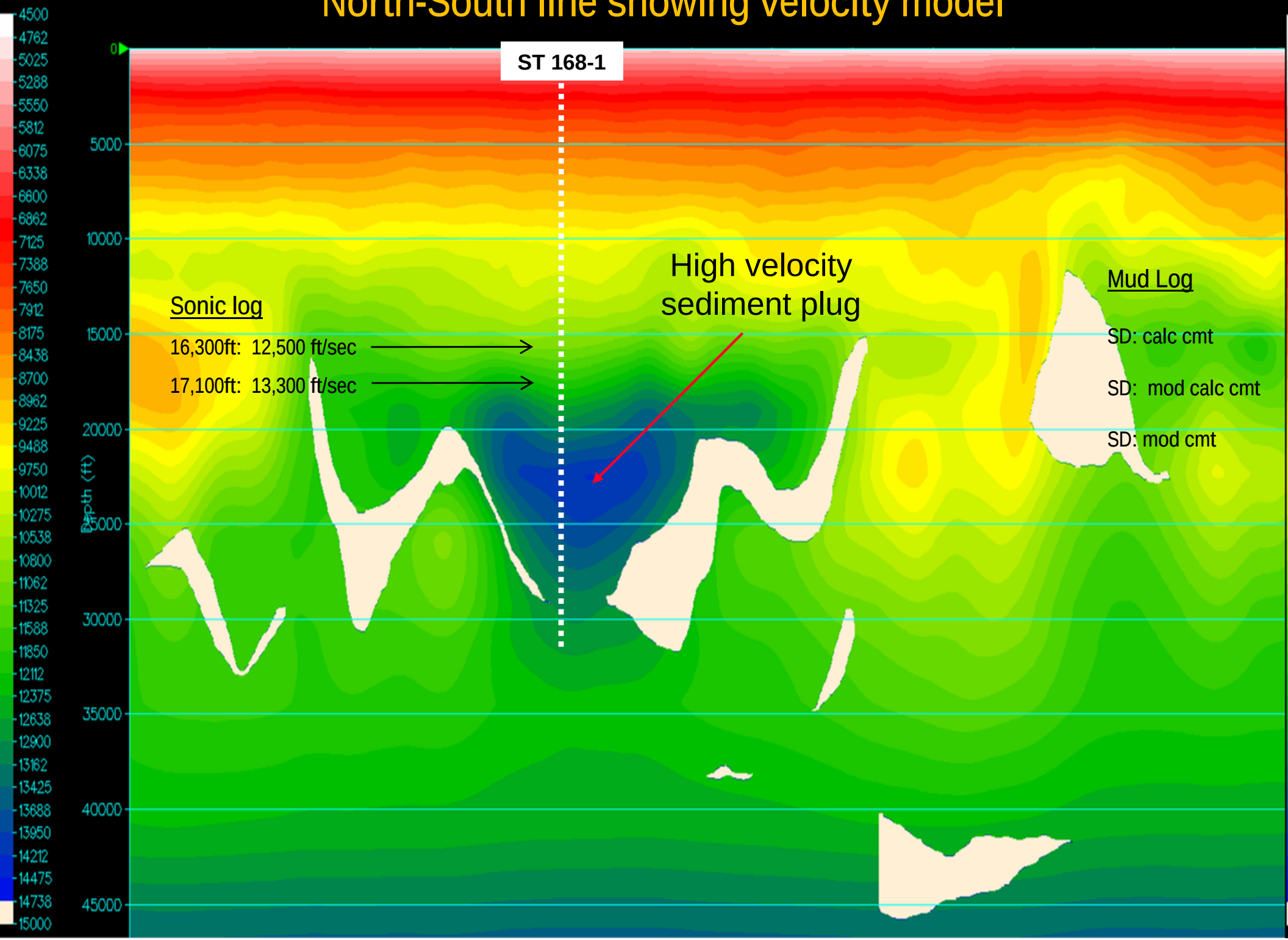
WesternGeco

Velocity model at 21,000 ft. E-Dragon Phase II

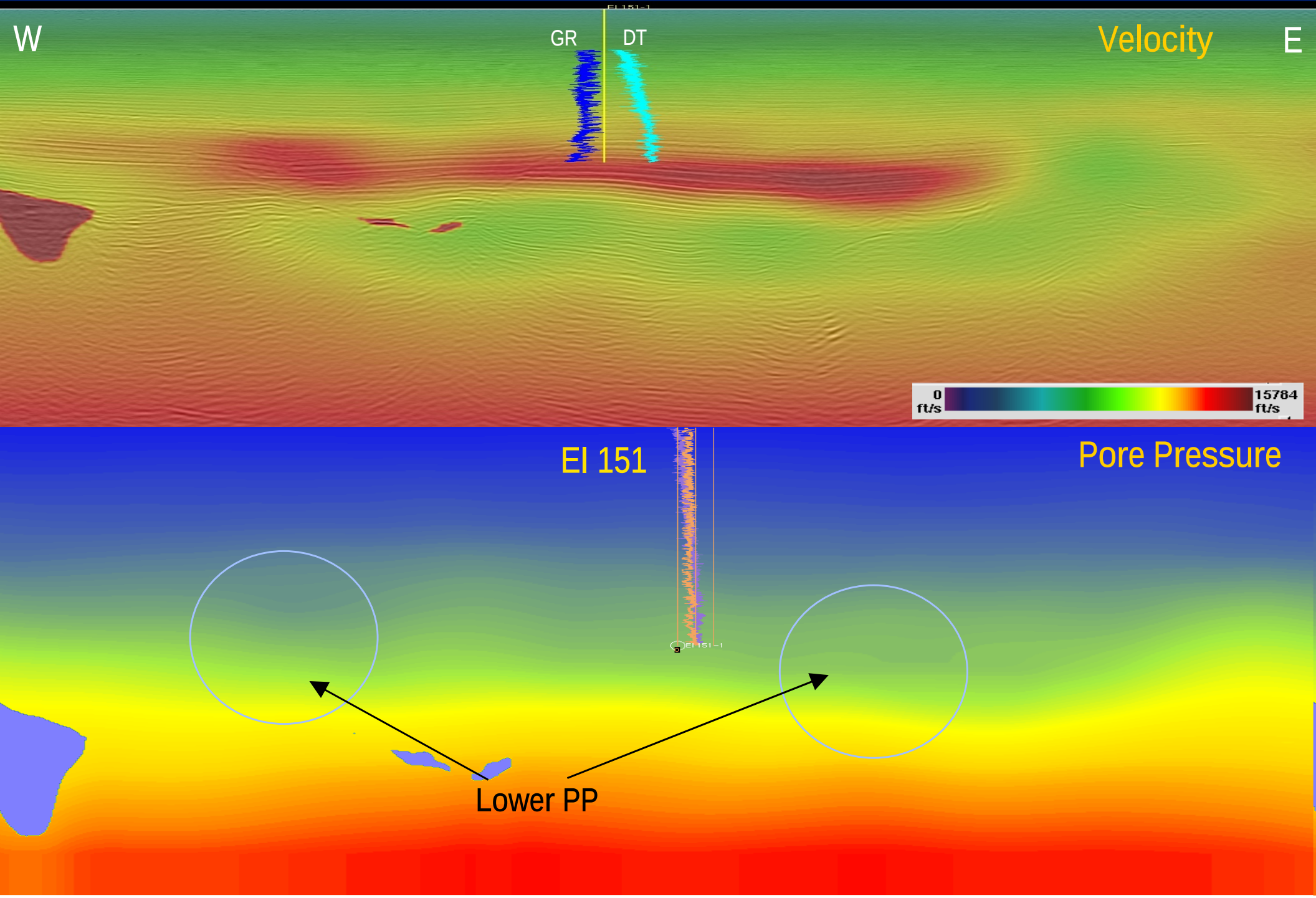




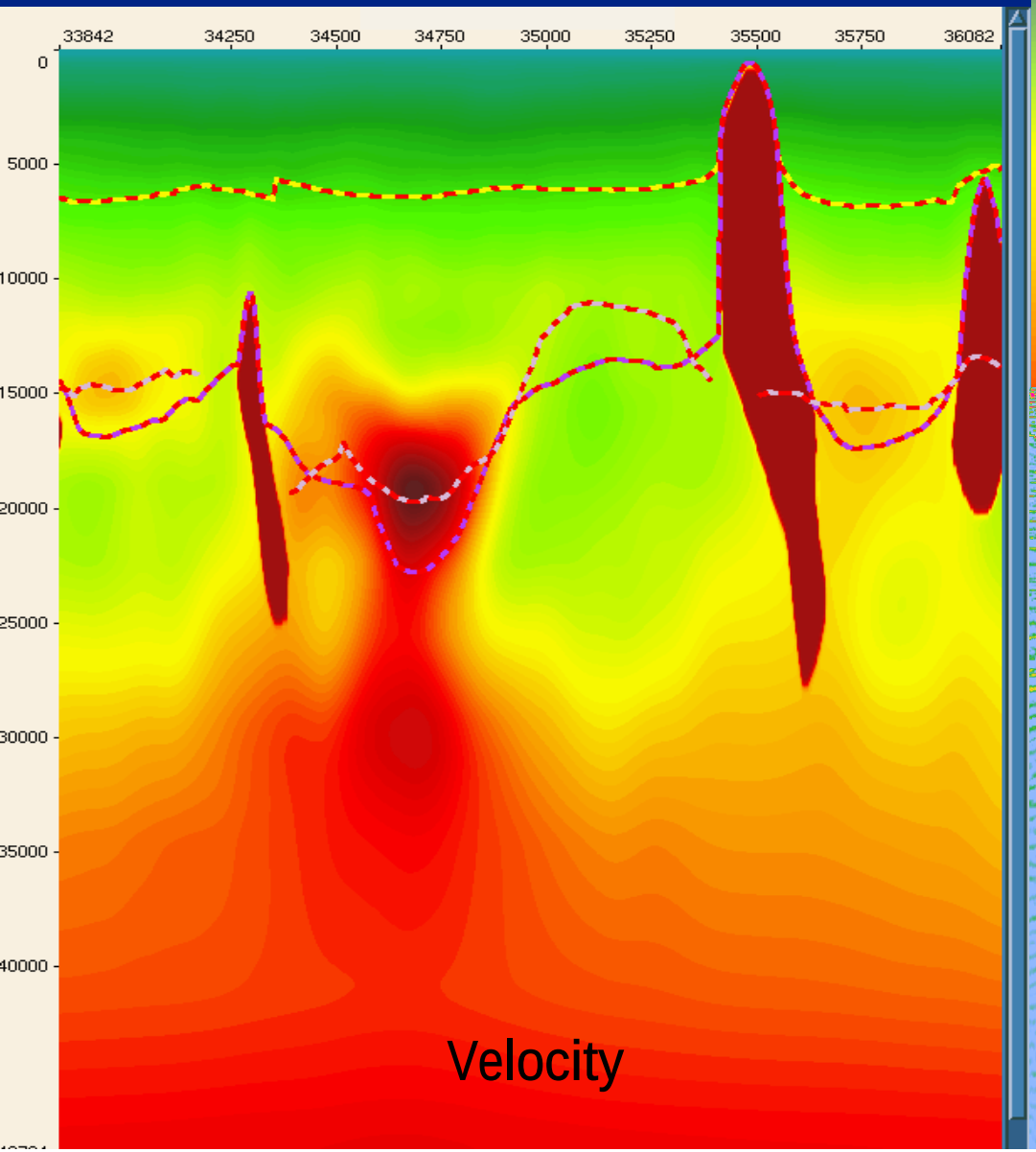
North-South line showing velocity model

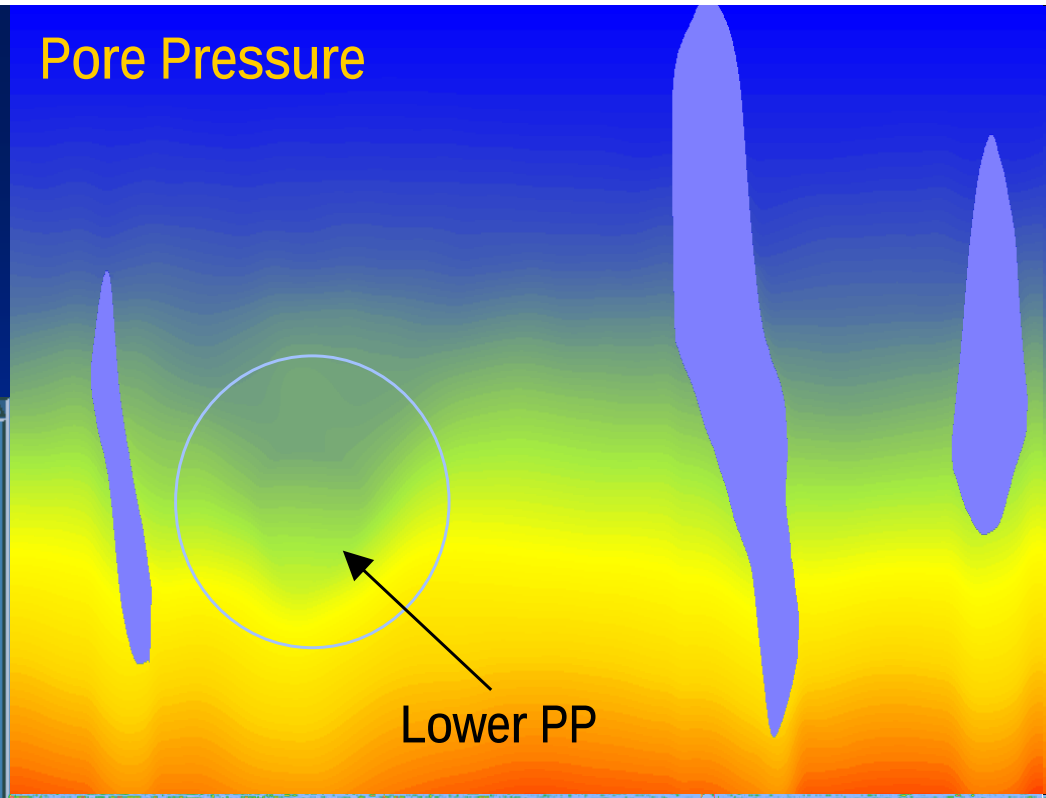


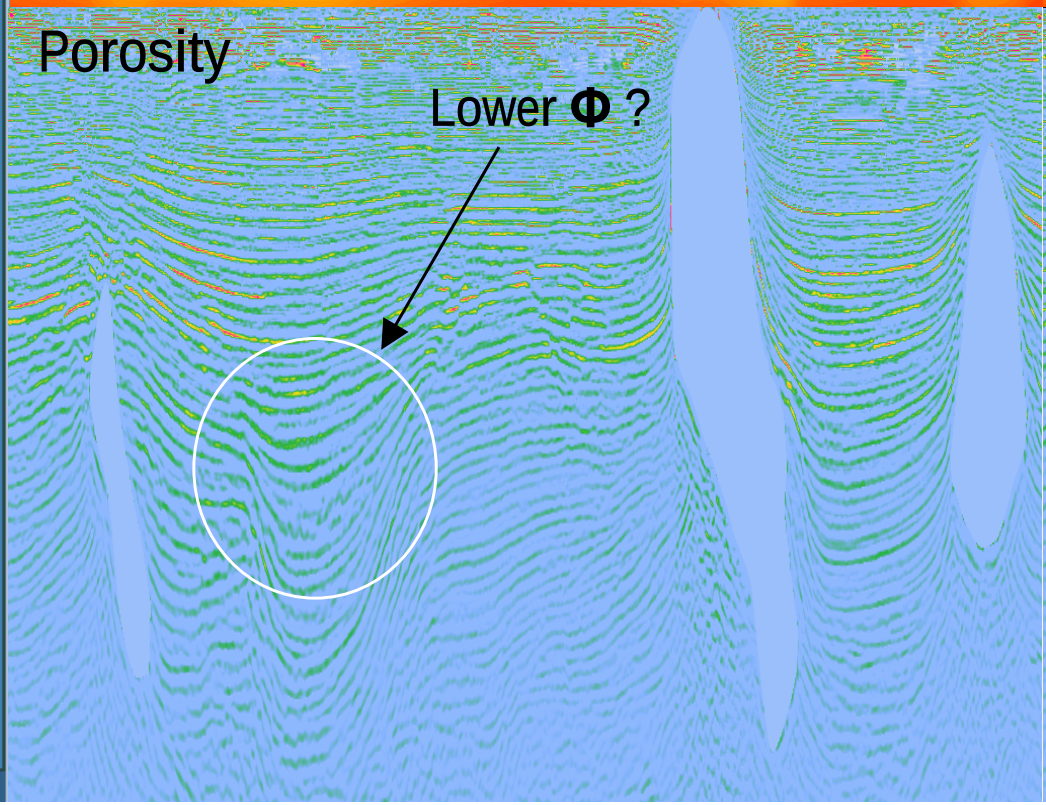
Cementation/velocity anomalies reflected in pore pressure



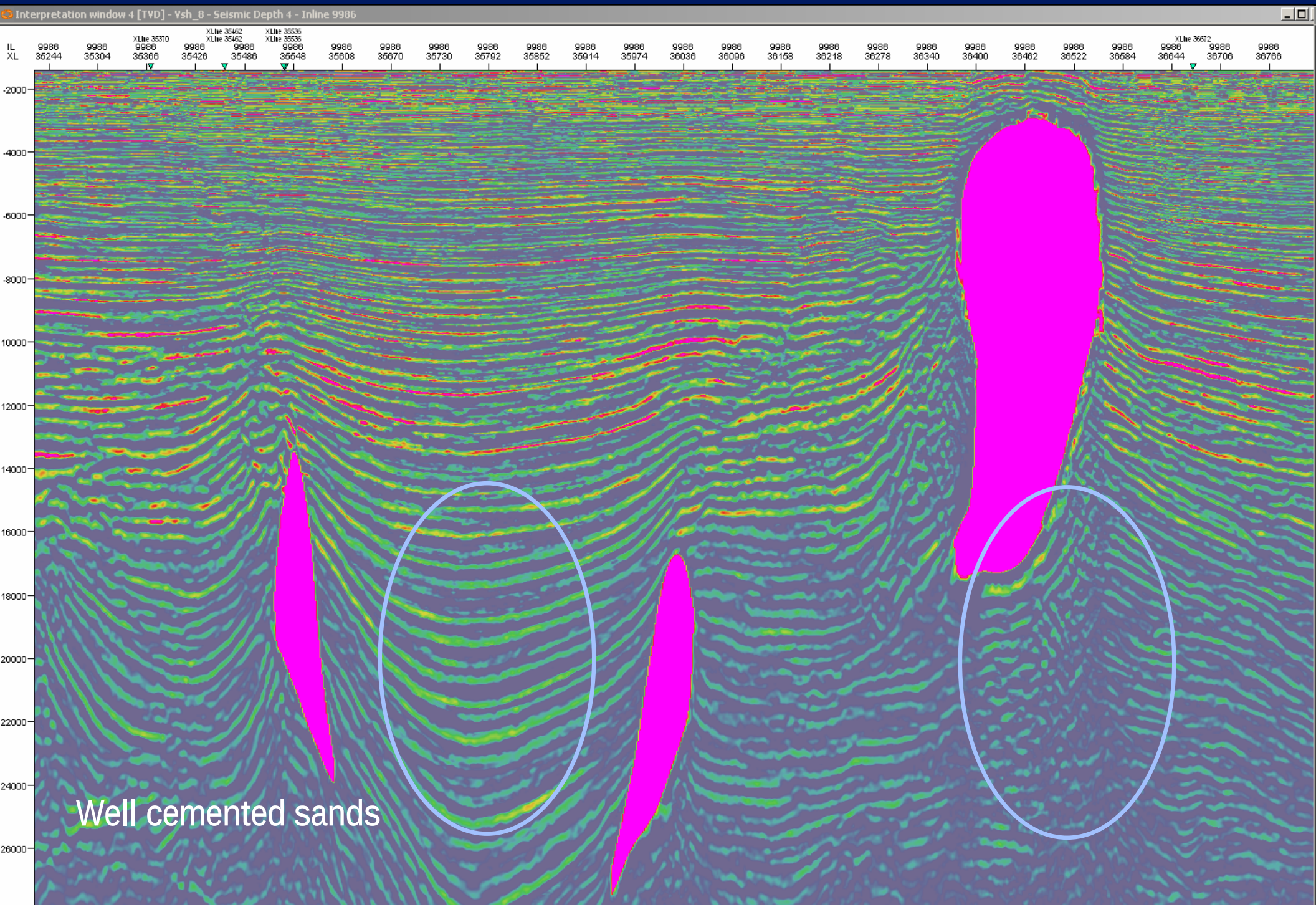
Velocity, pore pressure & porosity volumes



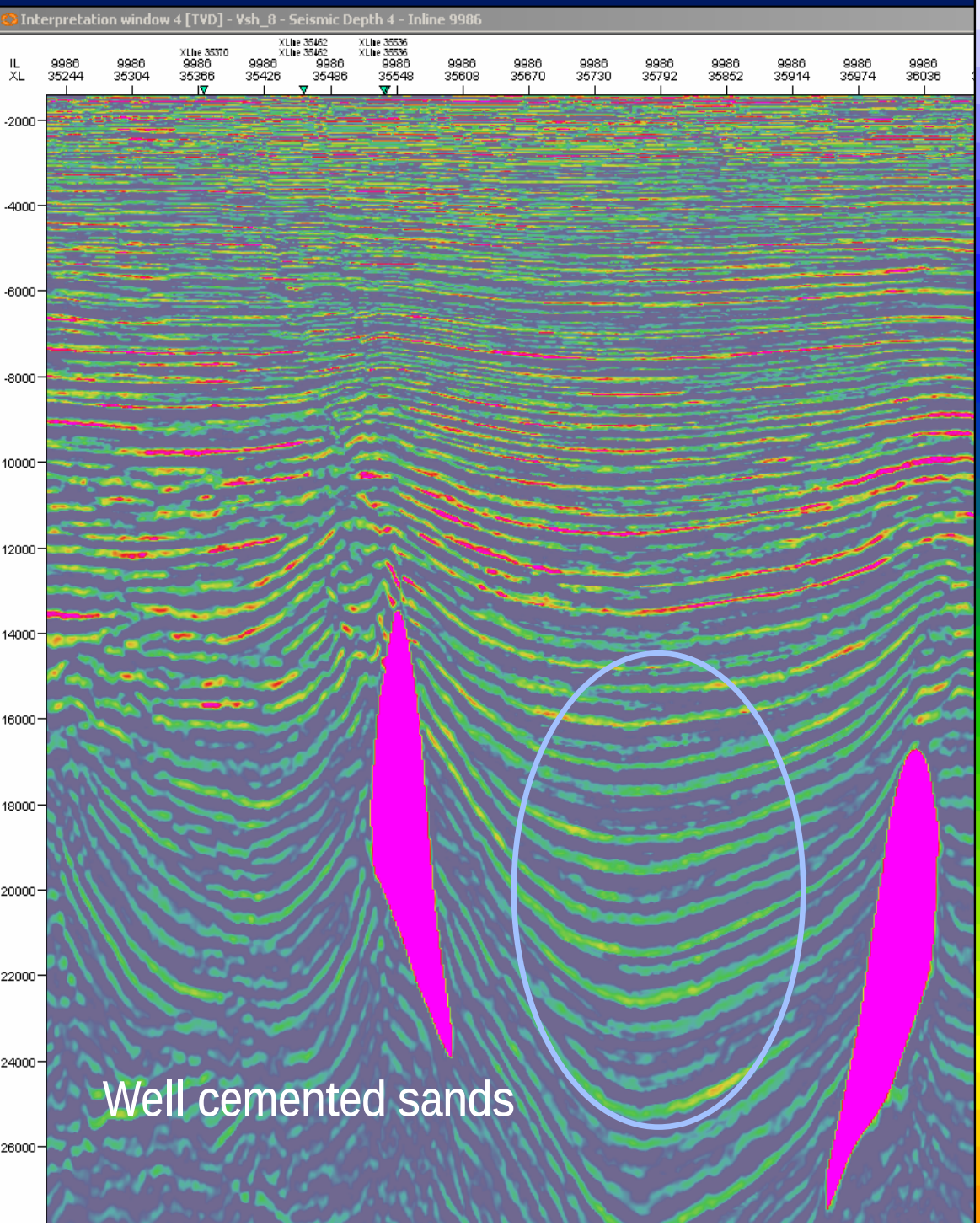


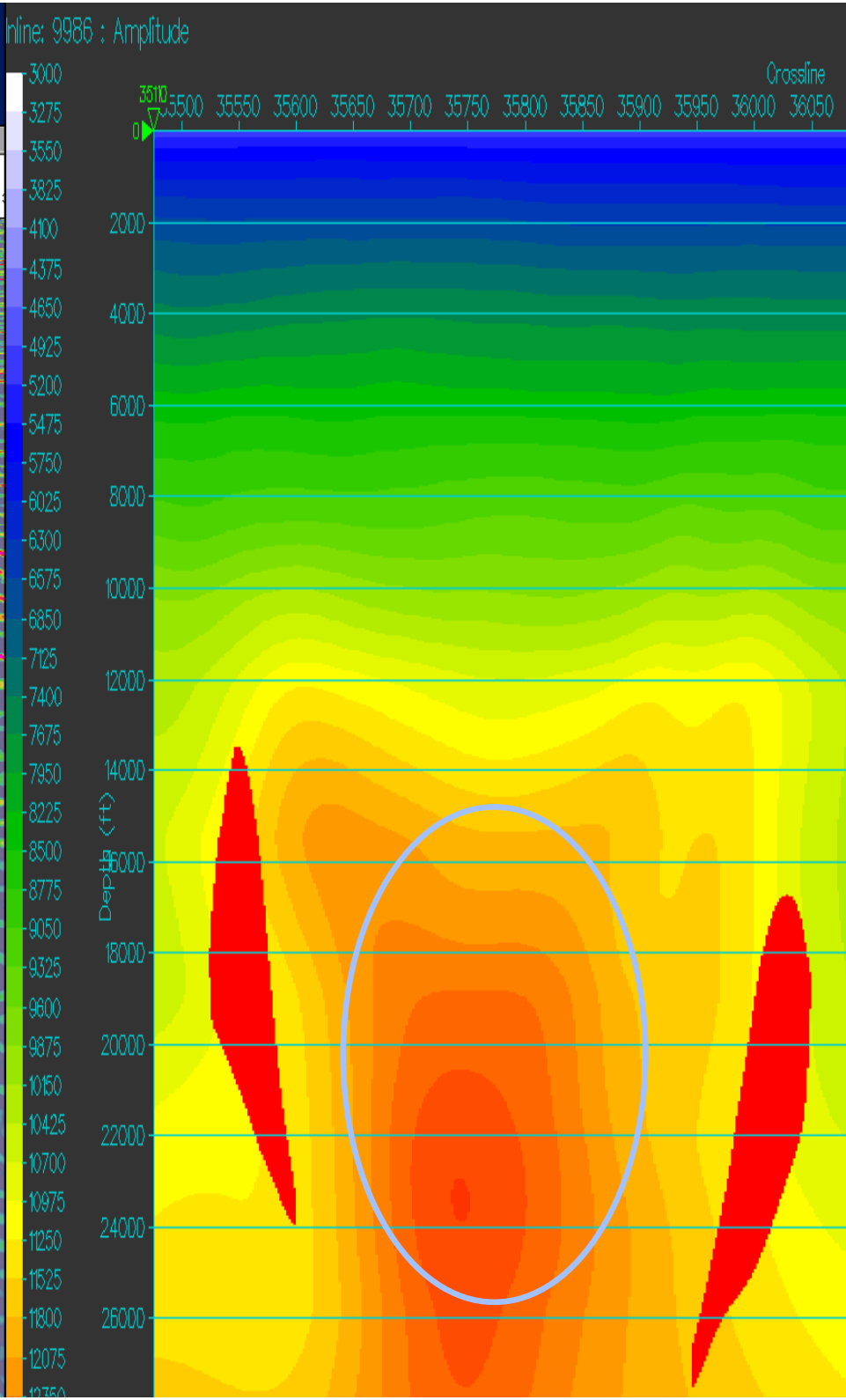


Vshale volume

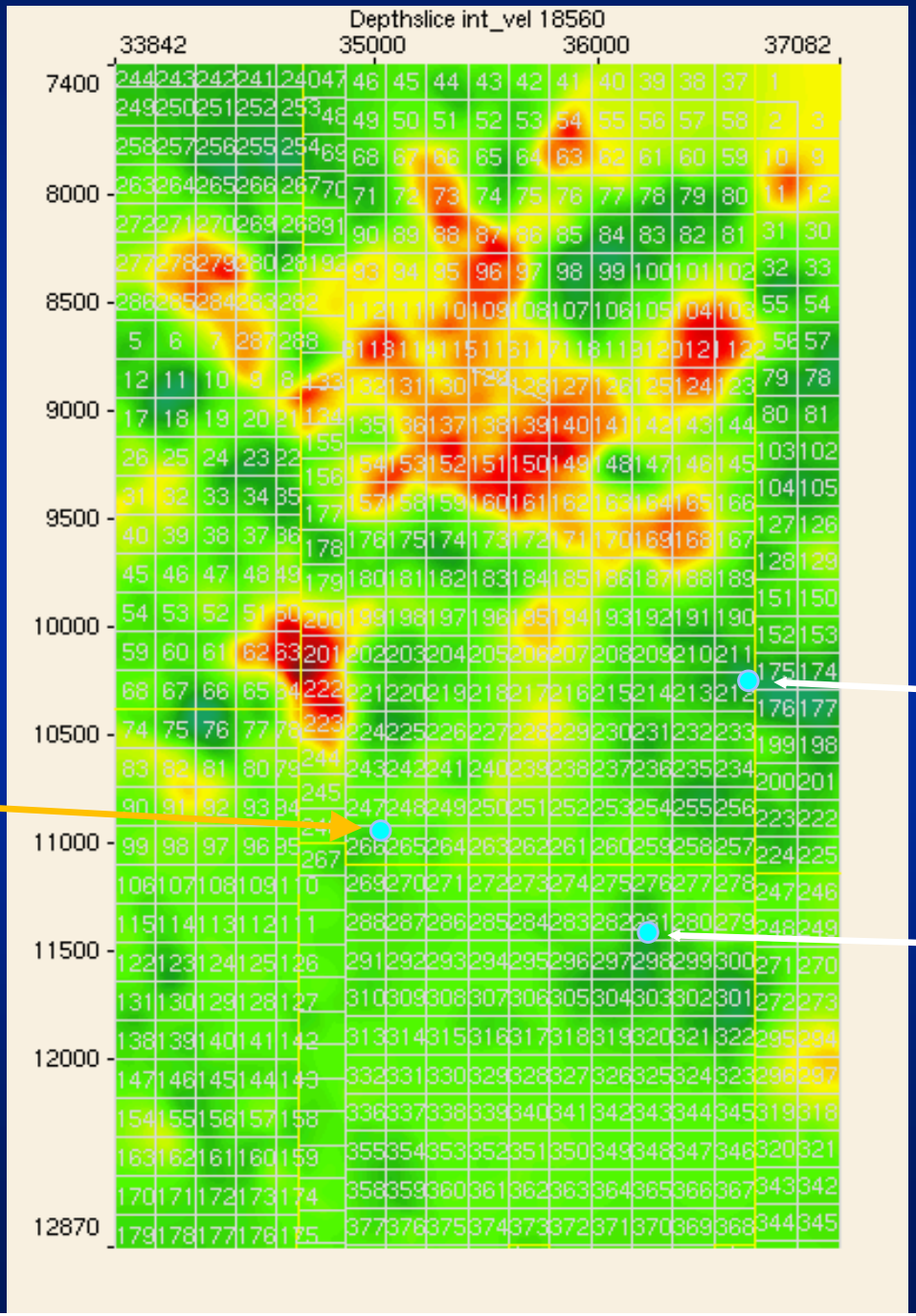


Vshale volume

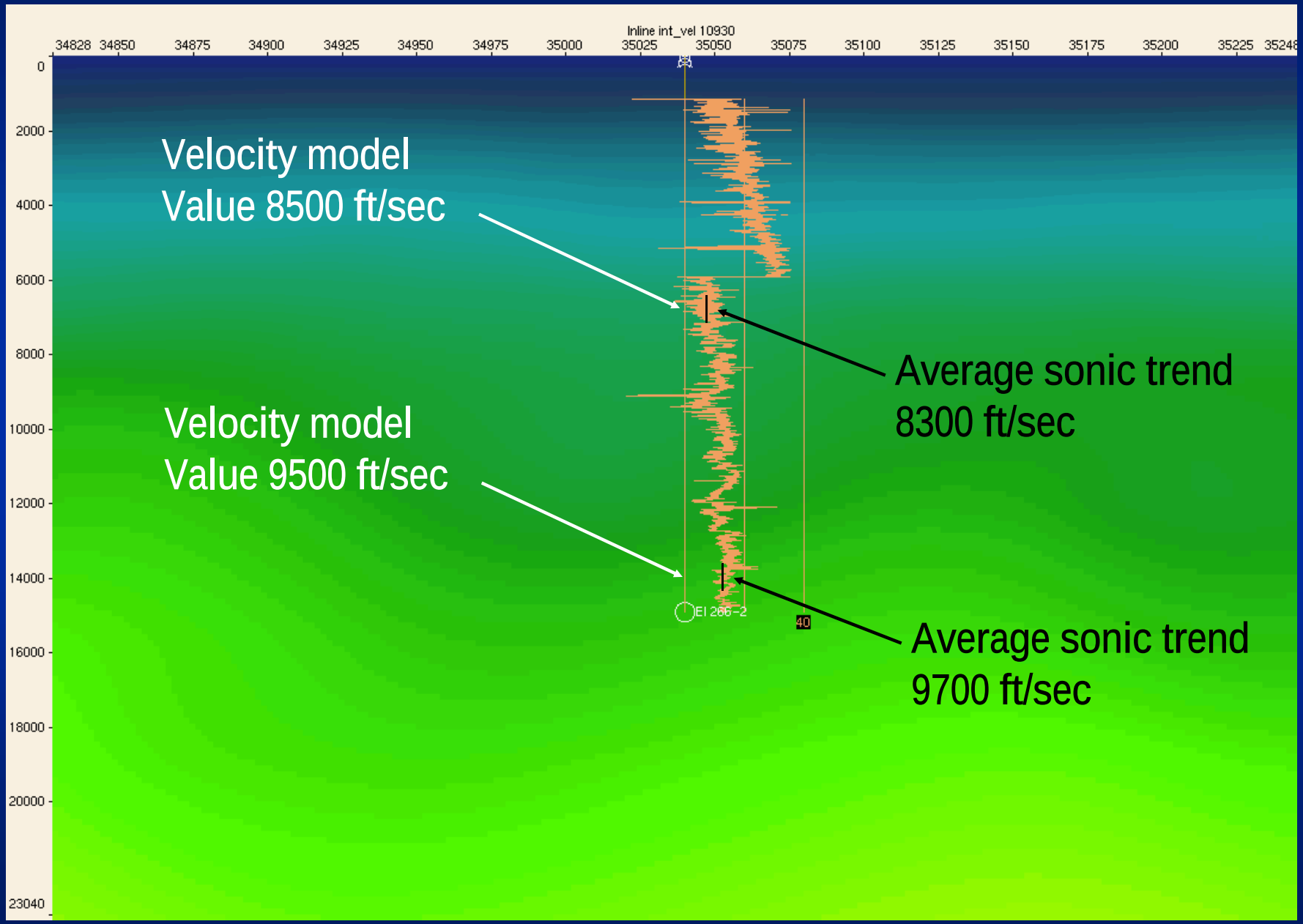




Depth slice at 18560 ft with wells in a "normal" seismic velocity region



Velocity model zoomed in at Well EI 266-2 with Sonic Log



Conclusions

- Anomalous high-velocity zones generally occur deep – below 15,000 ft and in large sediment-pile mini-basin depocenters.
- Velocity anomalies are occurring predominantly in Miocene sediments adjacent to salt structures (stepped counter-regional salt extension) and north of the Pliocene expansion boundary.
- High-velocity zones can be associated with evidence of lower pore pressure and lower porosity.
- Salt welds likely floor the mini-basins but these are below the velocity anomalies. High-velocity zones are *NOT* salt: Seismic character is not consistent with salt emplacement – *verified with well control*.

These high-velocity anomalies are real, can be mapped from higher resolution surface seismic and likely the result of well compacted diagenetic sands which have undergone rapid burial, de-watering and preferential carbonate cementation.

Knowing this is valuable not only for more geologically consistent model building, but also to better understand and mitigate exploration and drilling risk.

Acknowledgements

Thanks to Schlumberger Data Consulting Services (DCS) and Reservoir Seismic Services (RSS) for providing the geomechanical and reservoir characterization expertise necessary for this work. Also thanks to Parallel Data Systems (now a part of TGS) for the tomographic velocity model and re-processing efforts and to IHS Energy Log Services for the well log data.