Seismic Imaging of the Jonah High – a New Look at an Old Enigma

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Seismic Imaging of the Jonah High, Levant Basin – a New Look at an Old Enigma

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Abstract

The prominent Jonah High, located in the deep water Levant Basin, was drilled by the Myra-1 well down to 4,659m where circulation was lost before reaching its core; it was then side-tracked to the eastern rim and penetrated Early Miocene wet Tamar Sands at about 4,900m with TD at 5,200m TVDss.

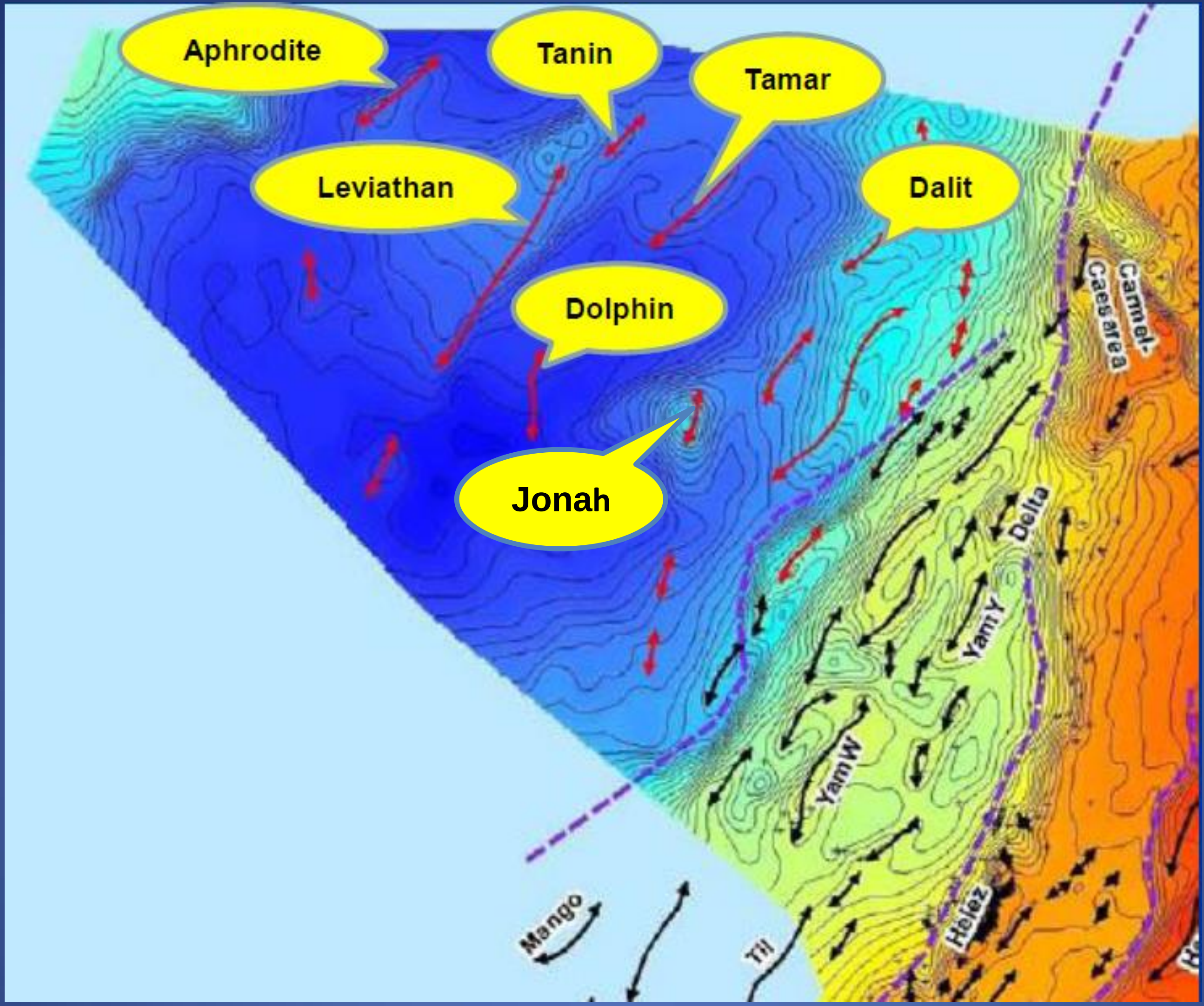
The Jonah seismic feature was first presented, in 2004, as a shale structure underlain by deep magmatic intrusion, which is implied from the magnetic field. It was later interpreted as an Early Miocene carbonate build-up, a giant volcanic cone, an ancient horst forming a prominent seamount and as an analogue to the 2014 Zohr discovery in Egypt.

Post-drilling, attempts were made to improve the seismic image. The first step was to apply basic signal processing tools available in most interpretation workstations. Next, a reprocessing through pre-stack time and depth migration was performed on a restricted data volume. The results show that the Jonah High is actually a low-relief feature, at least at the Tertiary level. The core is not at all reflection-free as previously assumed and seismic markers of the surrounding strata, including the Tamar Sands and deeper Oligocene markers, can be correlated into the core.

A set of maps produced based on these markers reveals that (a) the onset of the structural phase is of late Early Miocene age, identical to that observed in the other Levant Basin Miocene structures like Tamar. This phase is diminishing during the Late Miocene and is almost unrecognized on the Base Messinian Salt map (b) the map of the Top Early Miocene shows a seemingly bifurcated intrusion. The intrusions, suggested to consist of Mesozoic unconsolidated mud or alternatively associated with the positive magnetic anomaly, define Jonah's eastern and southwestern rim and are characterized by steeply dipping events. This setting formed the structure's enigmatic triangular shape.

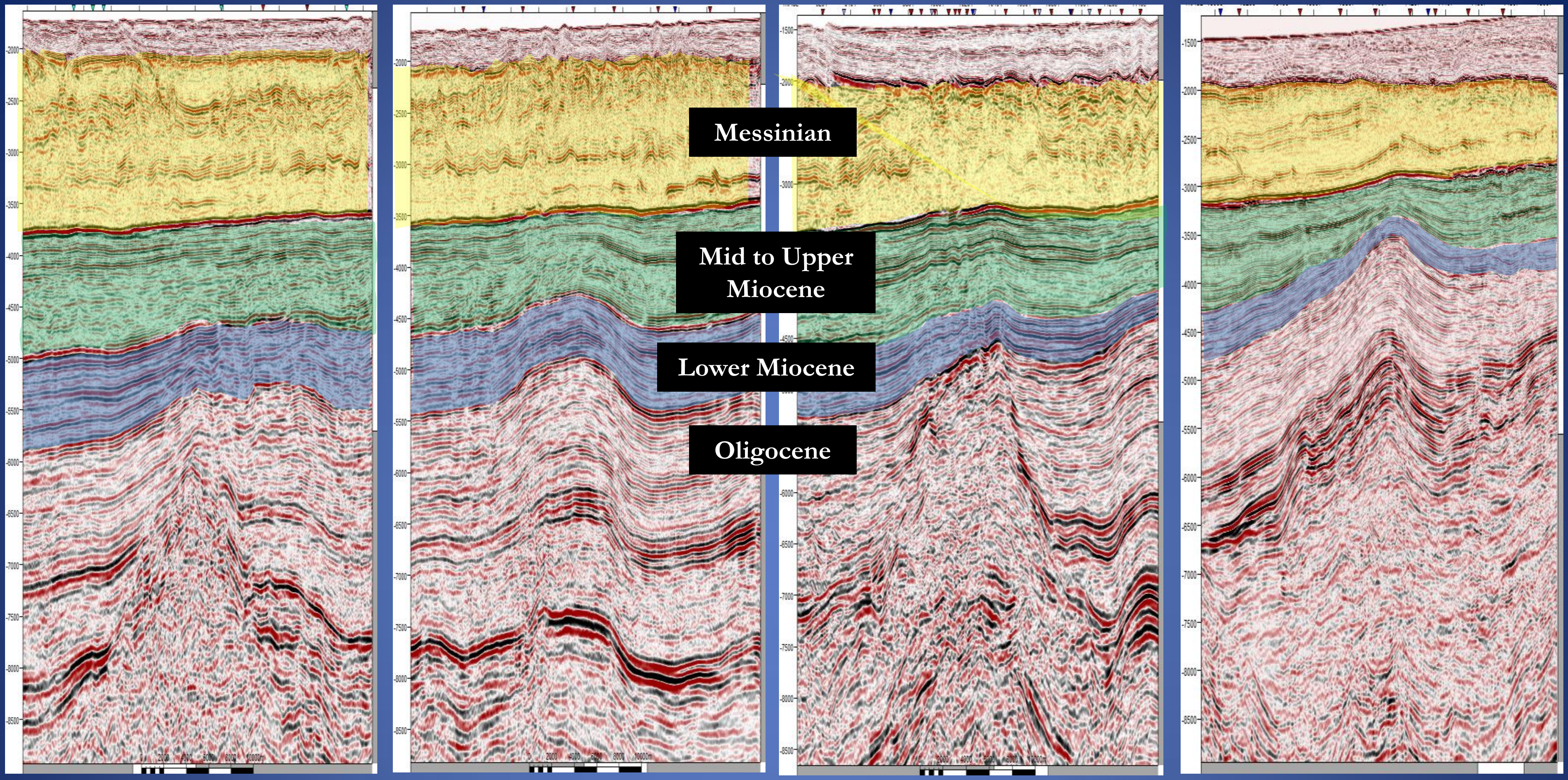
The section penetrated by the Myra-1 ST well, similar to findings in all the other deep Levant Basin wells, suggests that the Late Oligocene through the Late Miocene is of deep water palaeoenvironment. This setting, coupled with the above seismic interpretation, further suggests that the Jonah High's core consists, as its surroundings, of deep water sediments. Such environment avoids the formation of a carbonate build-up during this period. Furthermore, there is no evidence for the core being an old seamount.

The implications of this study are that the Jonah High is different from most of the suggested models. As of hydrocarbon exploration, it may form a gas prospect at the Early Miocene level due to the presence of the Tamar Sands, subject to structural and attributes analyses. More so, potential for thermogenic hydrocarbons in the deep part of the Jonah High should be considered, not before improved seismic data are applied to decipher its strong and complex reflections. A better understanding of the entire petroleum system is also desired. The resemblance of the Deep Leviathan prospect with the deep part of the Jonah High, which is herein suggested, may also be encouraging.



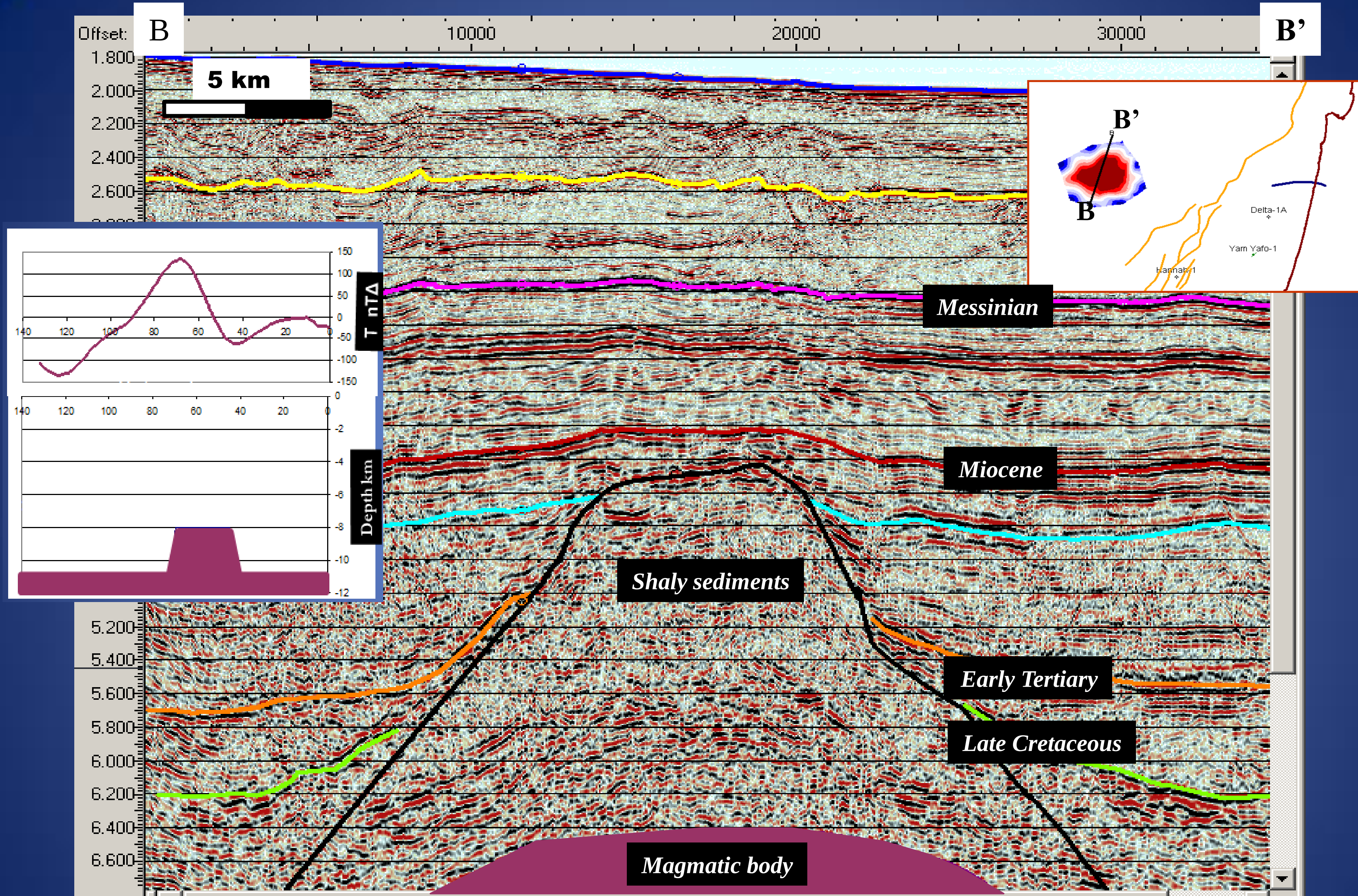
The Levant Basin offshore Israel is characterized by structures that can broadly be divided by the shelf margin: the Syrian Arc to the east (in black) and the Miocene folds to the west (Gardosh et al, 2008). The latter include the Tamar, Leviathan and other gas-bearing structures. Jonah High is part of this system.

Leviathan Tamar Jonah Dalit

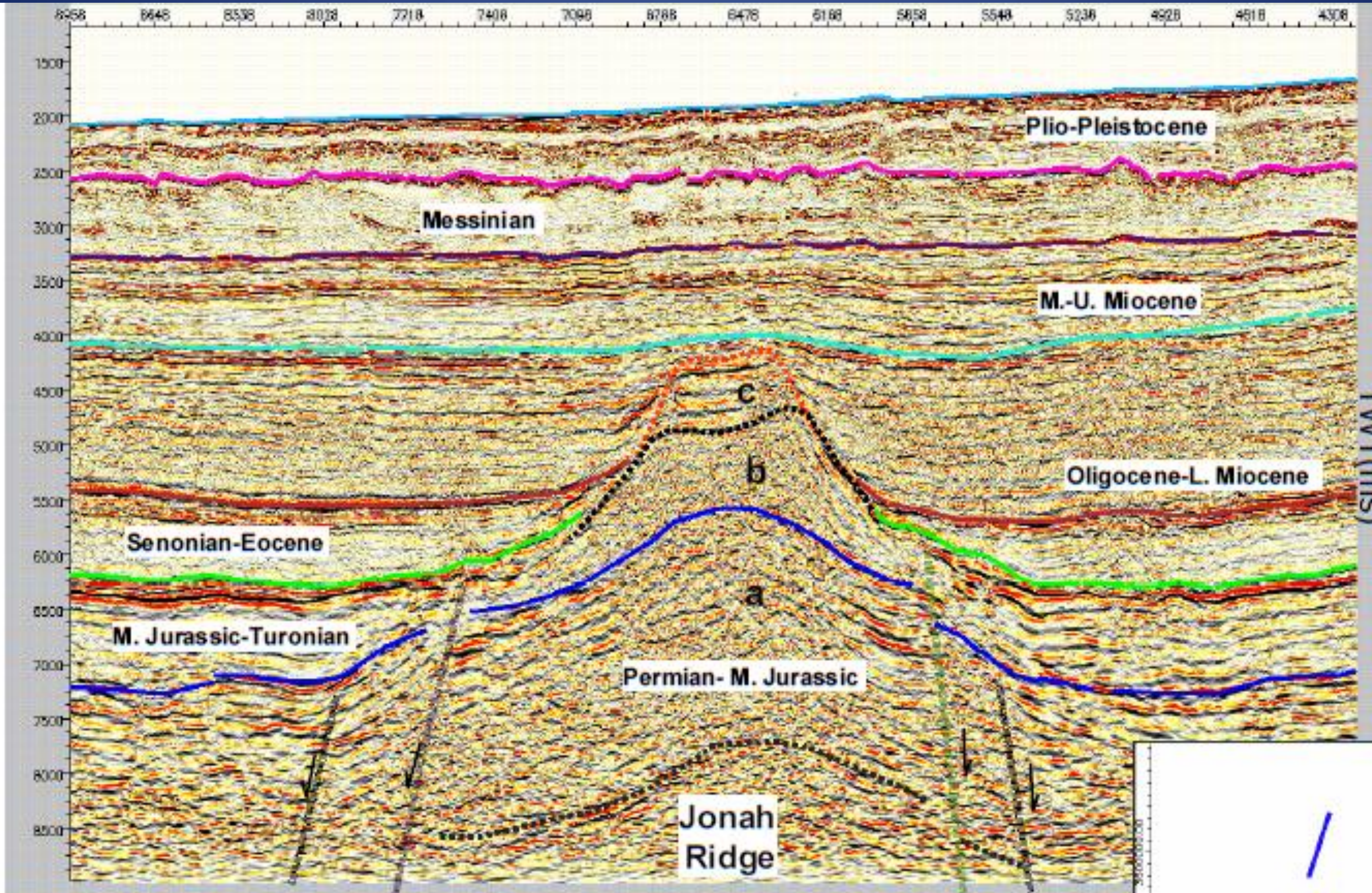


The Working Hypothesis:

The deep basin structures, including Jonah, have a common onset of a Late Lower Miocene age that is verified by drilling. The Syrian Arc and the Miocene structures are separated in time, space and style. They were named “the Tamar Folding Phase” by Ben-Gai and Druckman (2013), as opposed to “Syrian Arc II” as marked by Gardosh et al. (2008), for example.



Jonah High was first presented and named by Folkman and Ben-Gai (2004). They suggested that the deep-water shale section was uplifted by a magmatic intrusion, based on interpretation of the magnetic field.



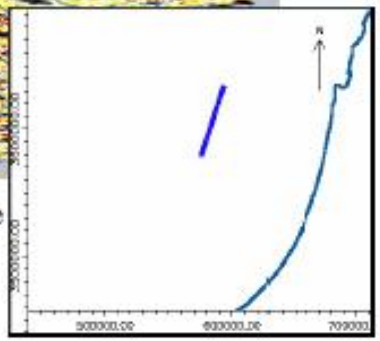
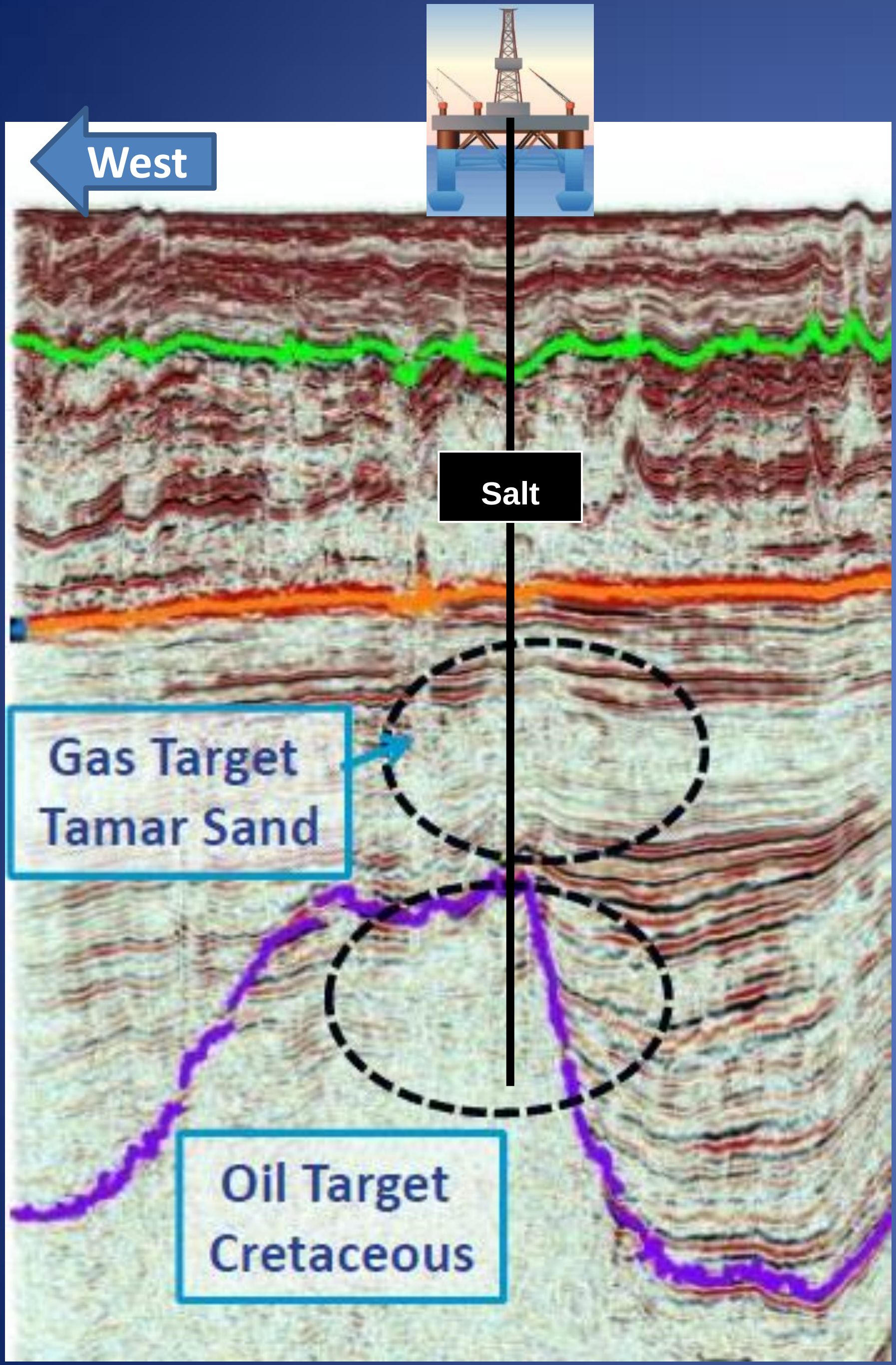
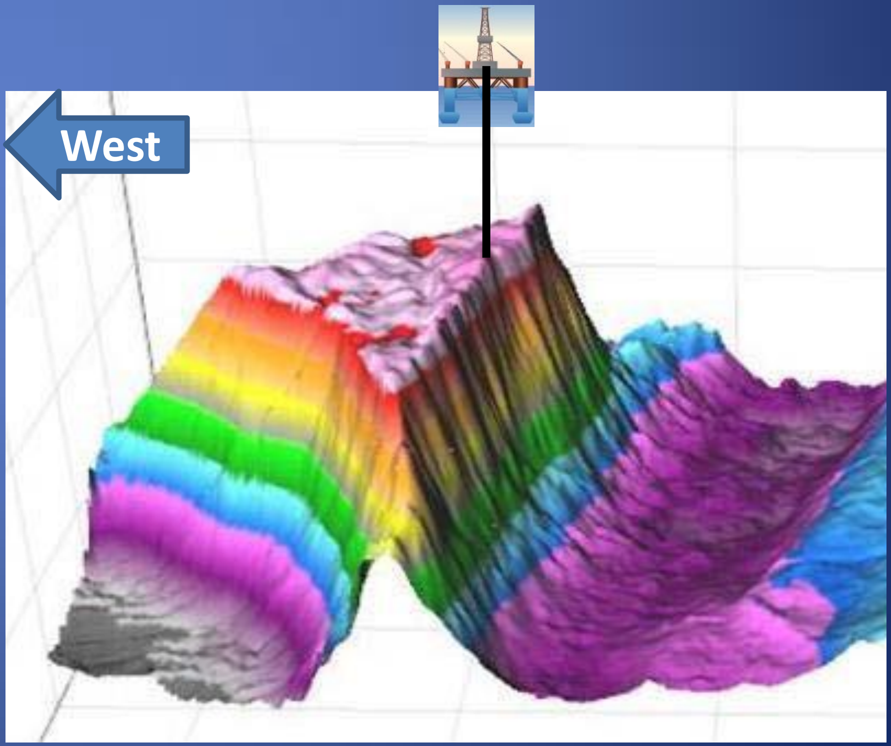


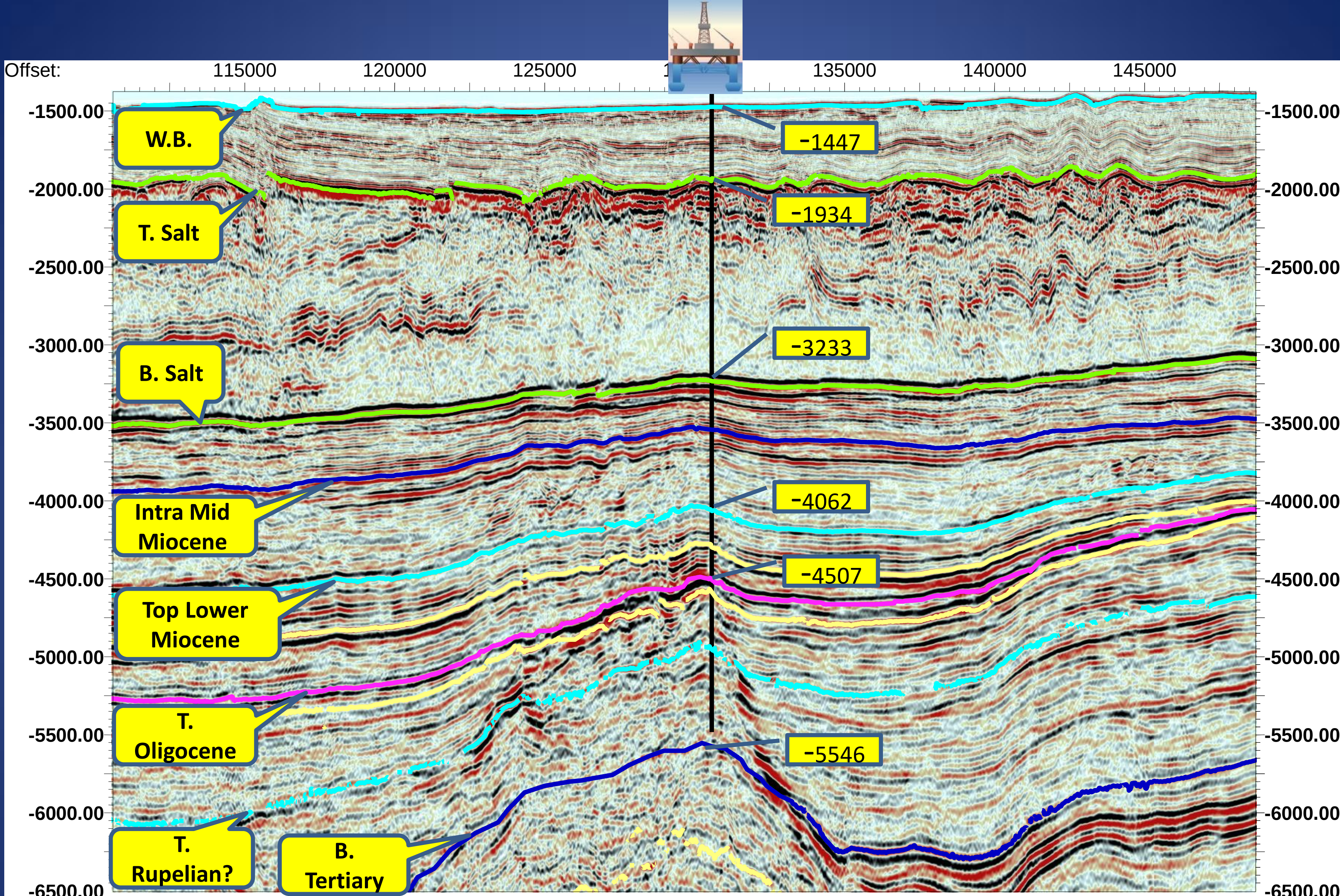
Fig 5.11- Interpreted SW-NE seismic profile showing the southern part of the Jonah Ridge. The ridge is composed of three units: (a) an Early Jurassic horst block, (b) a chaotic seismic package interpreted as a volcanic cone with highly dipping slopes, of Late Cretaceous to Early Tertiary age and, (c) a series of parallel, high-amplitude reflections interpreted as a carbonate buildup of Lower Miocene age.

Gardosh et al. (2008) suggested a more shallow causative body over a Mesozoic high and an atoll type Miocene carbonate build-up. Later, Gardosh and Lipman (2017) made an analogy between Jonah and Zohr.

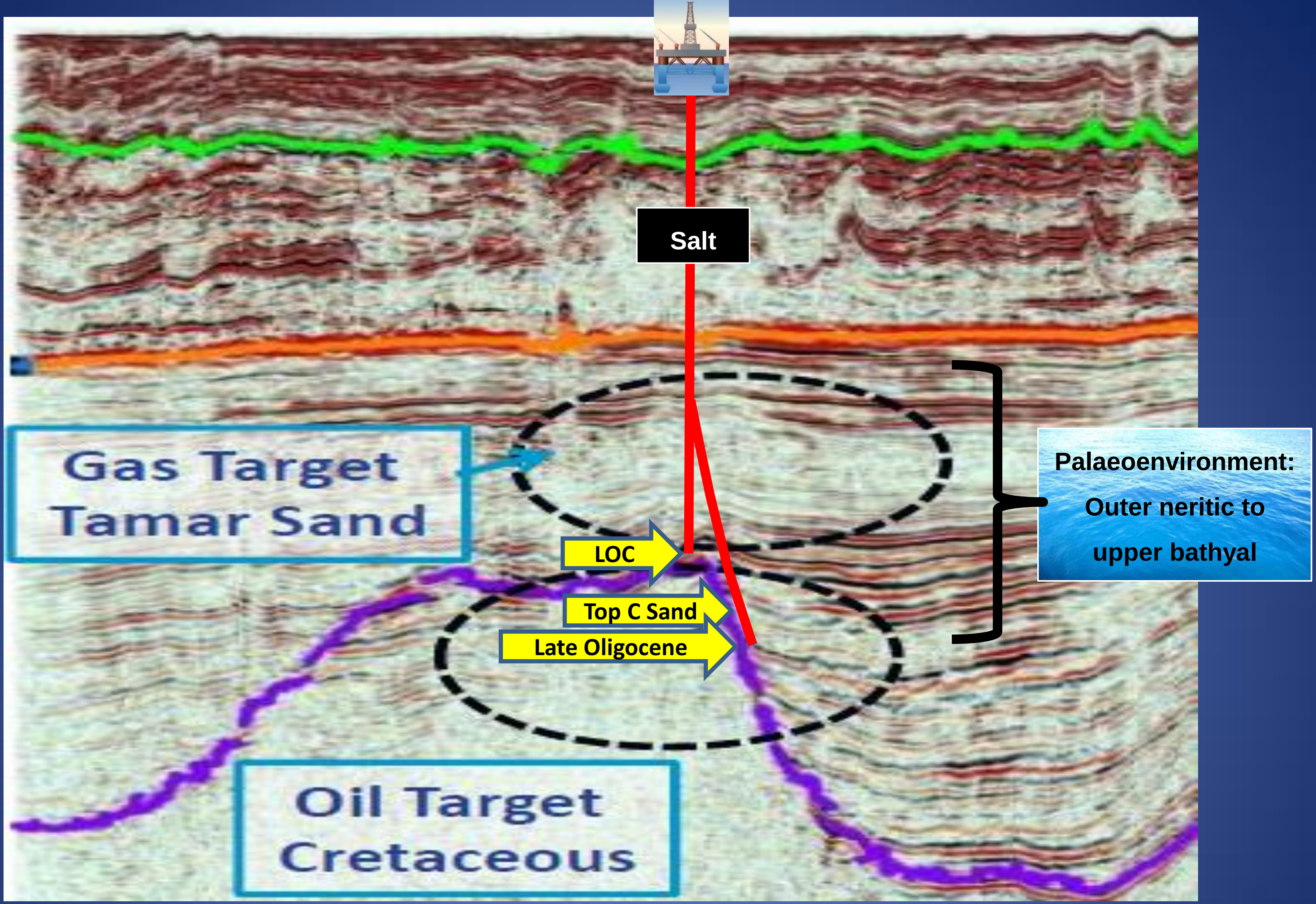


In 2012, the Jonah High, now in the Myra License, was about to be drilled with this model presented by the partners. It was suggested to be a Mesozoic seamount, elevated by about 2.5 km above the background. A similar model was suggested by Sagy et al. (2015, 2017). Having a 3D survey in place, a detailed enigmatic triangular shape was mapped.

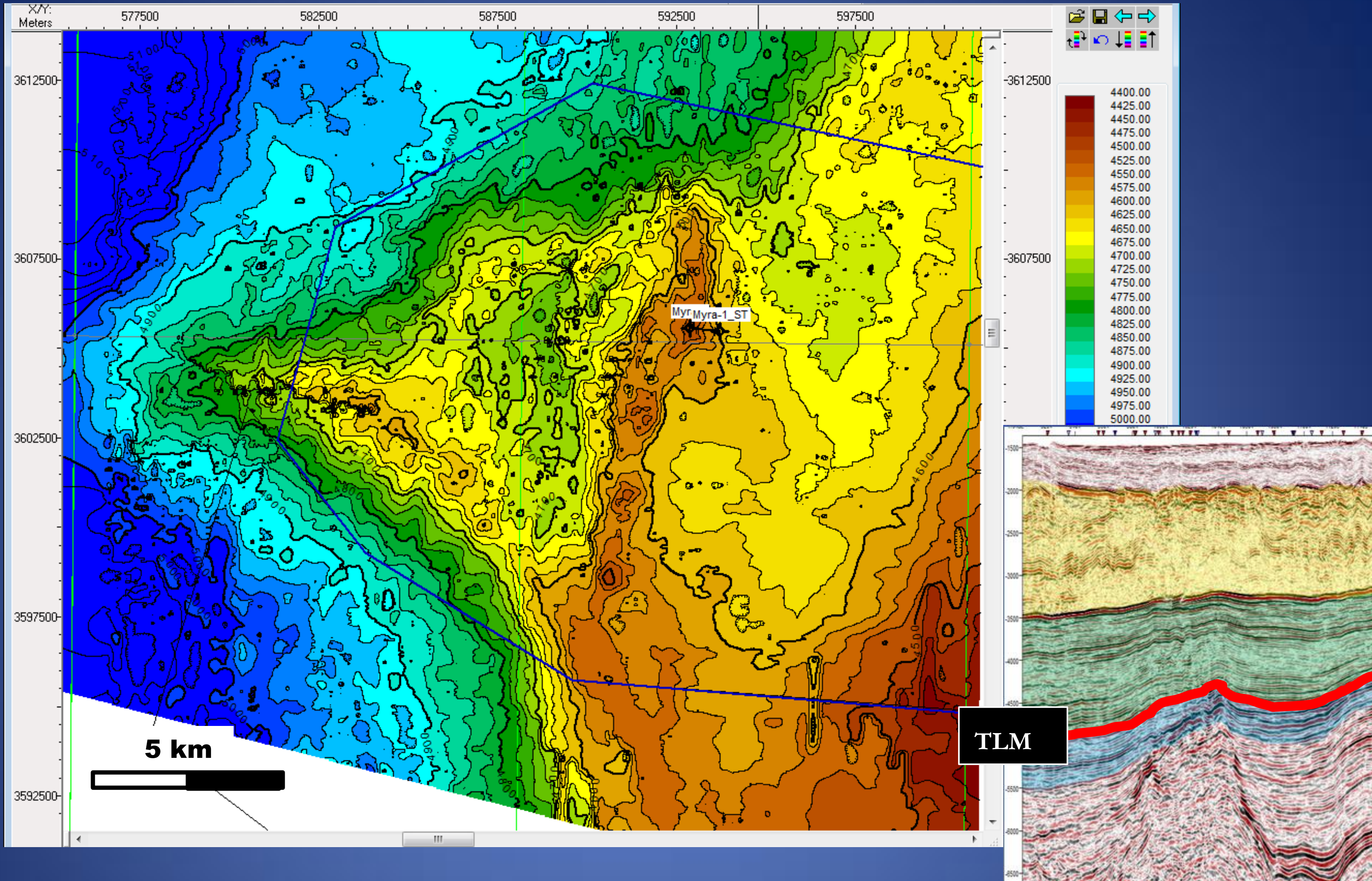




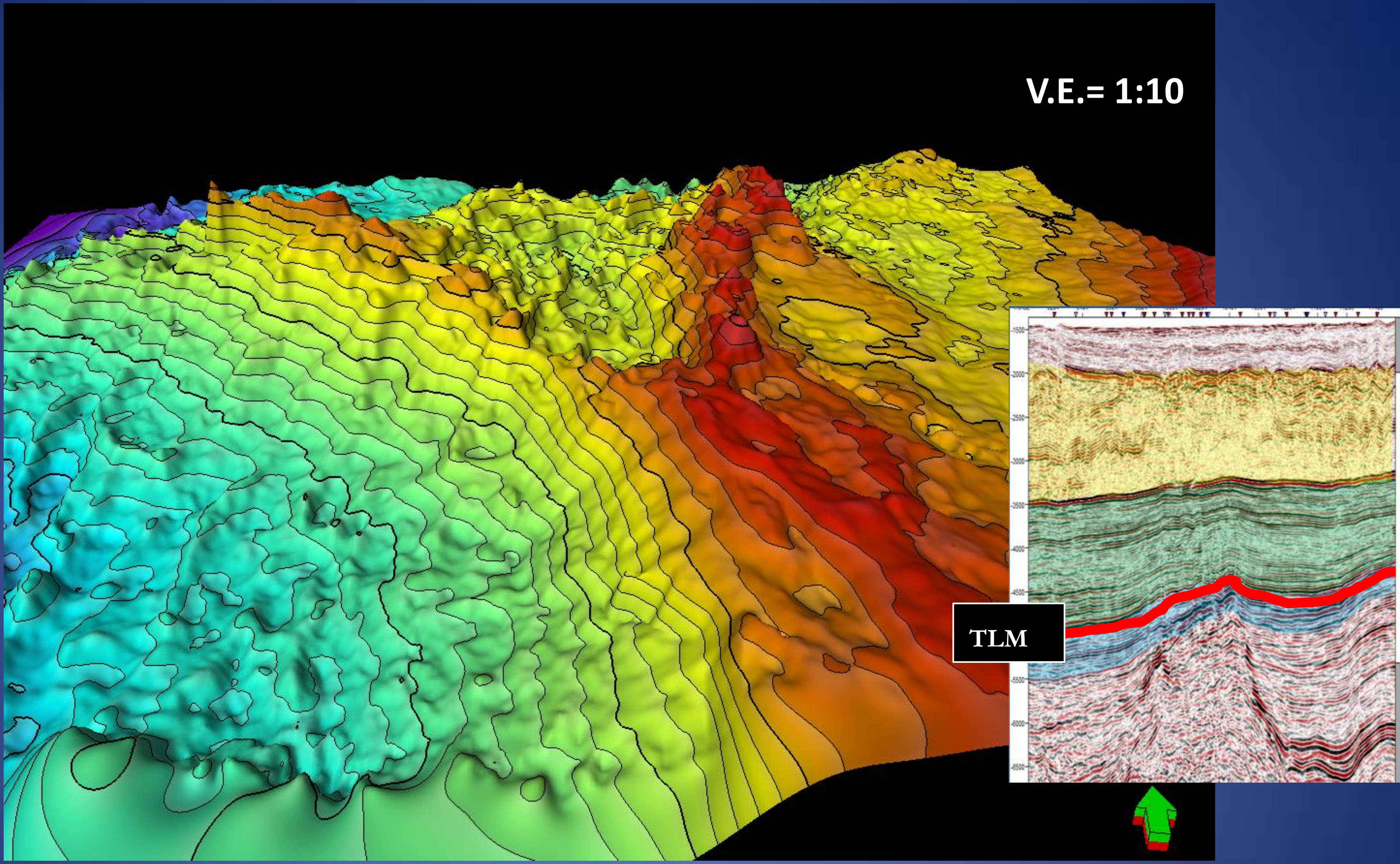
A different prediction, based on 2D line, was presented by Ben-Gai (2012, Genesis Oil and Gas internal report), following the working hypothesis as stated above. The well was expected to penetrate an Oligo-Miocene section inside the “core”.



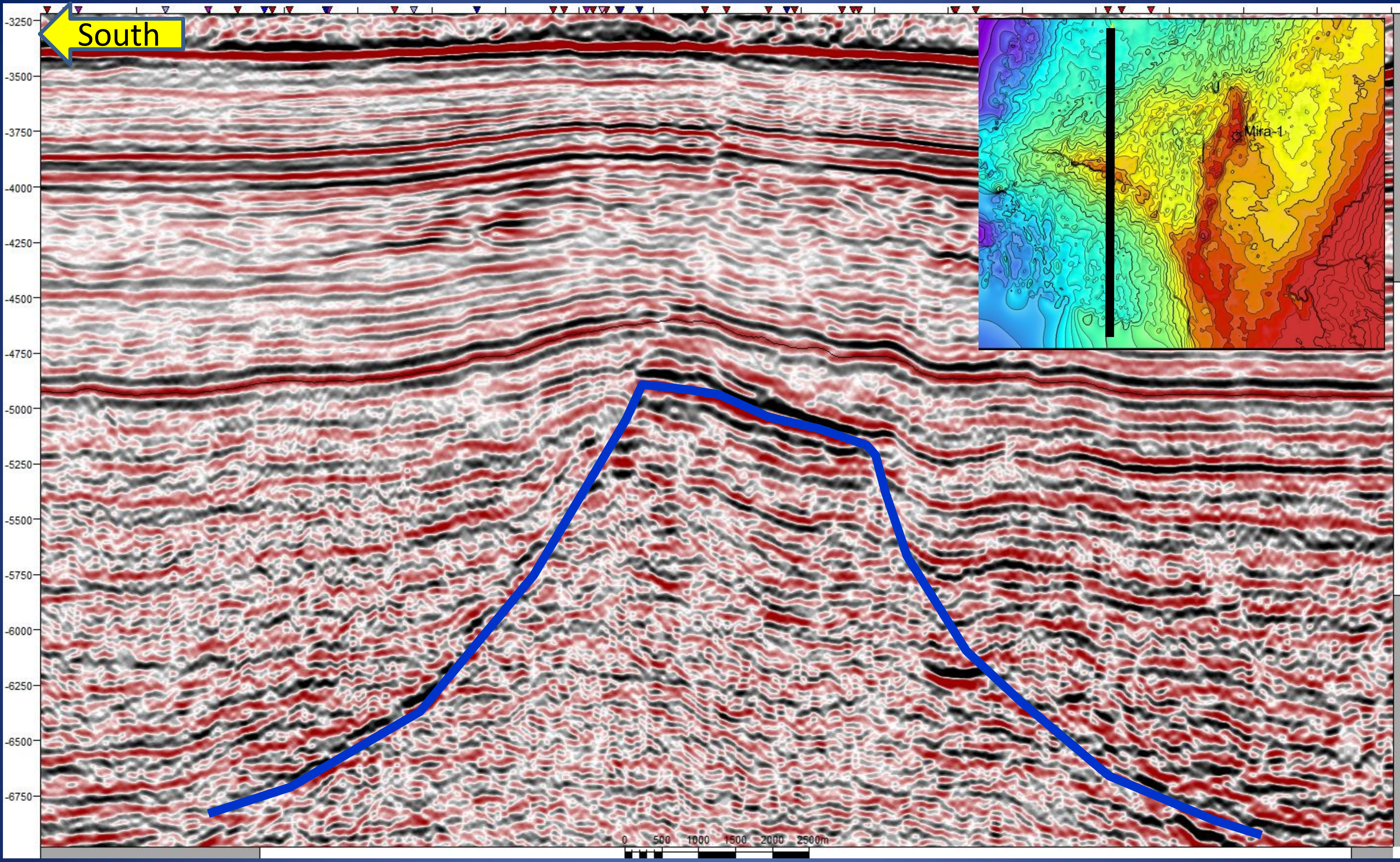
Myra-1 was eventually drilled in Q3 2012, but the vertical well encountered Loss of Circulation just above the seamount core. The well was side-tracked to the flank, and found the normal section of the Lower Miocene Tamar sand, unfortunately water wet. The palaeoenvironment for the entire Miocene was defined as deep water.



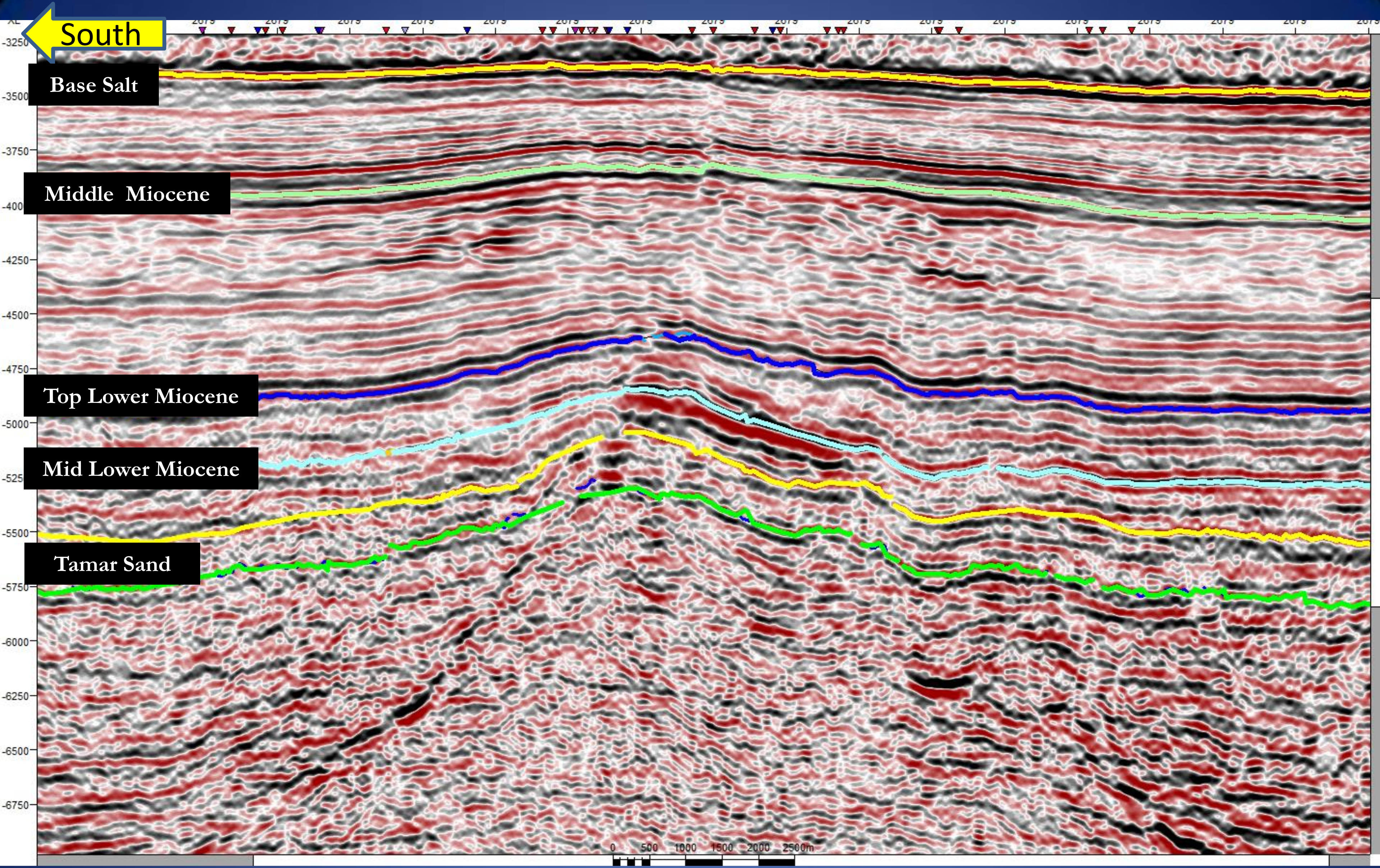
The following slides are based on post-drilling analysis of the Myra 3D survey, initiated by the author in 2013. This slide shows the structural map of the Top Lower Miocene, a prominent reflector in the Levant basin.



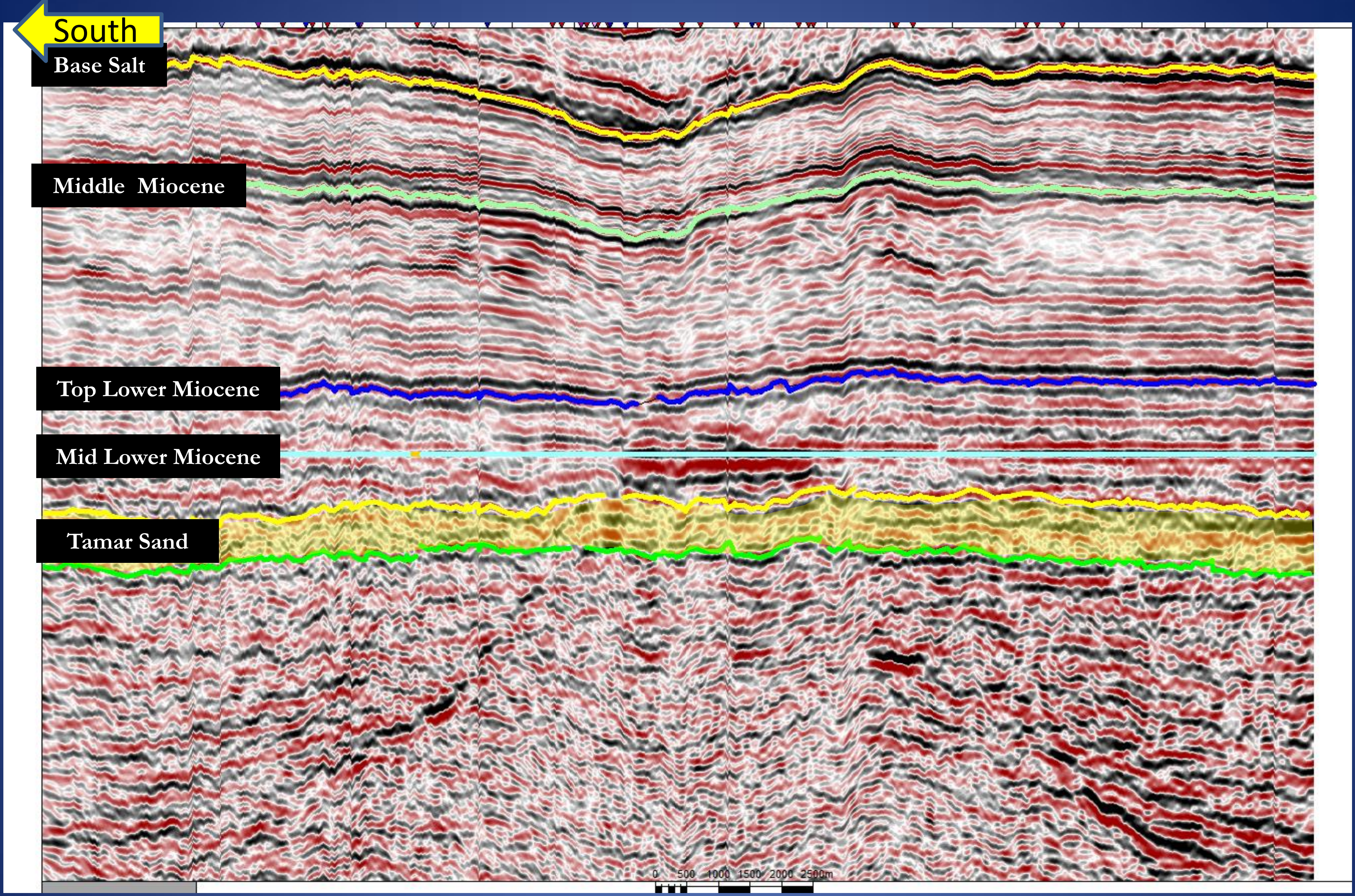
The same map is shown here in a 3D mode, with a highly exaggerated vertical scale. It is suggested to reflect a bifurcated intrusion that may explain the structure's enigmatic triangular shape.



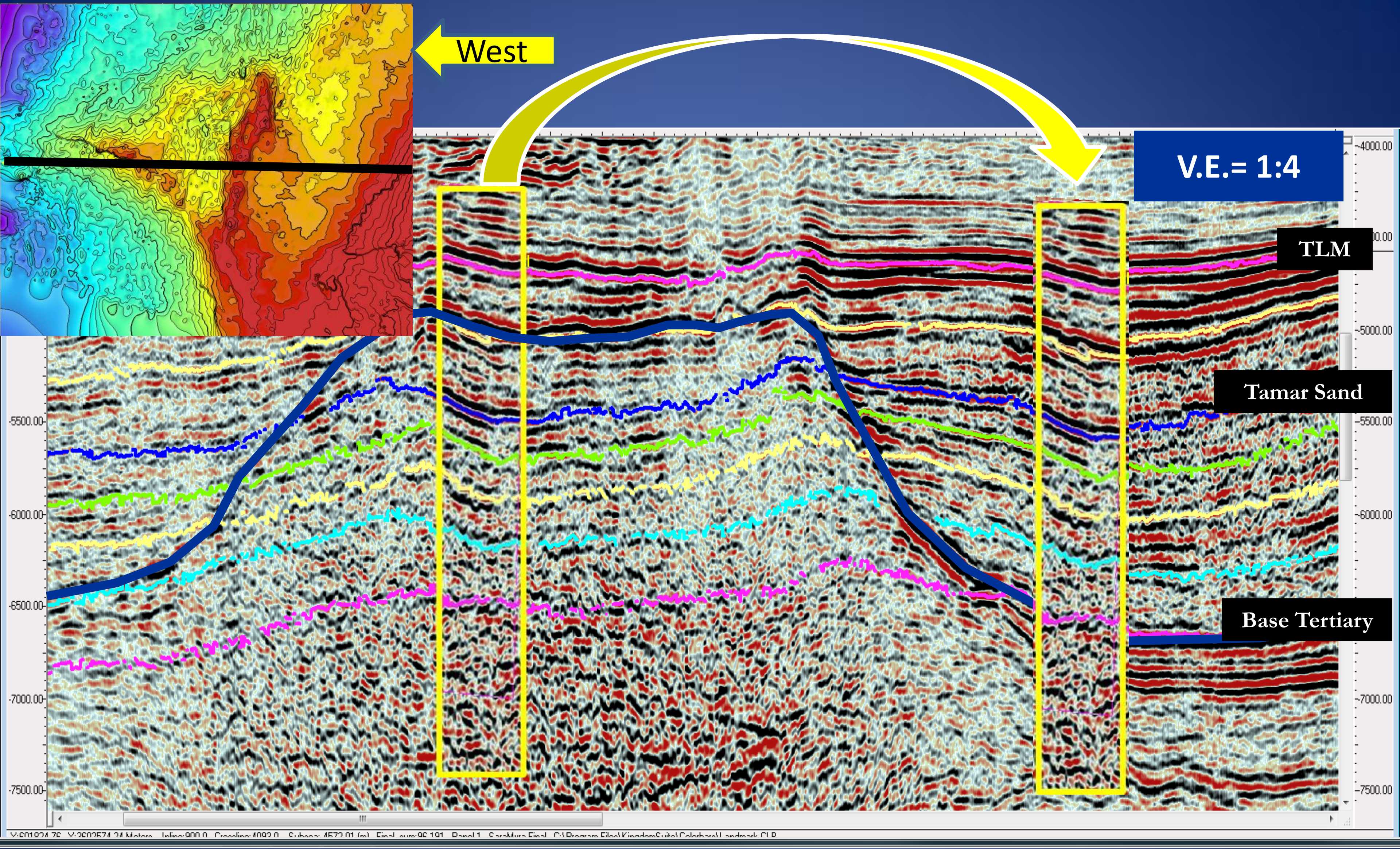
This is a line across the western arm of the suggested intrusion. The traditional Jonah High is outlined in blue.



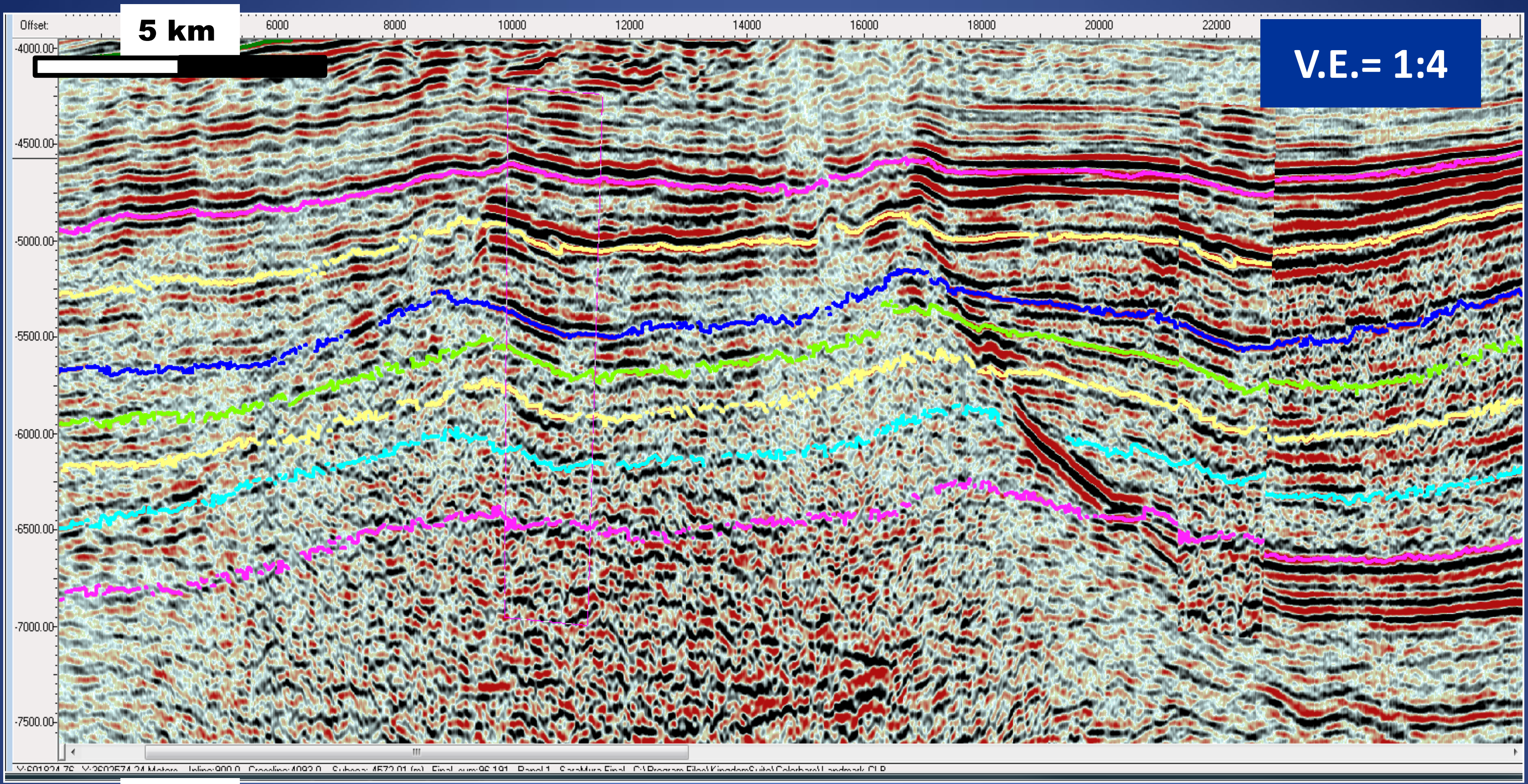
Removing the blue outline reveals a low-profile asymmetric structure; while the southern flank is marked by steep reflectors, none are observed to the north. Note the conformity of the seismic markers prior to the Top Lower Miocene.

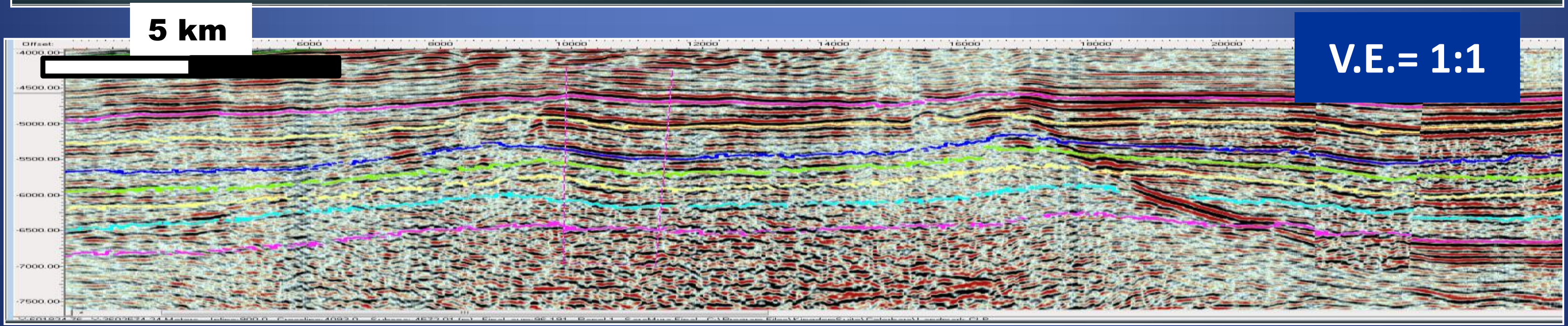


The section is reconstructed to the Mid Lower Miocene, prior to the structural onset. It indicates that the Tamar Sand Complex was evenly deposited all over the basin, including in the future Jonah High.

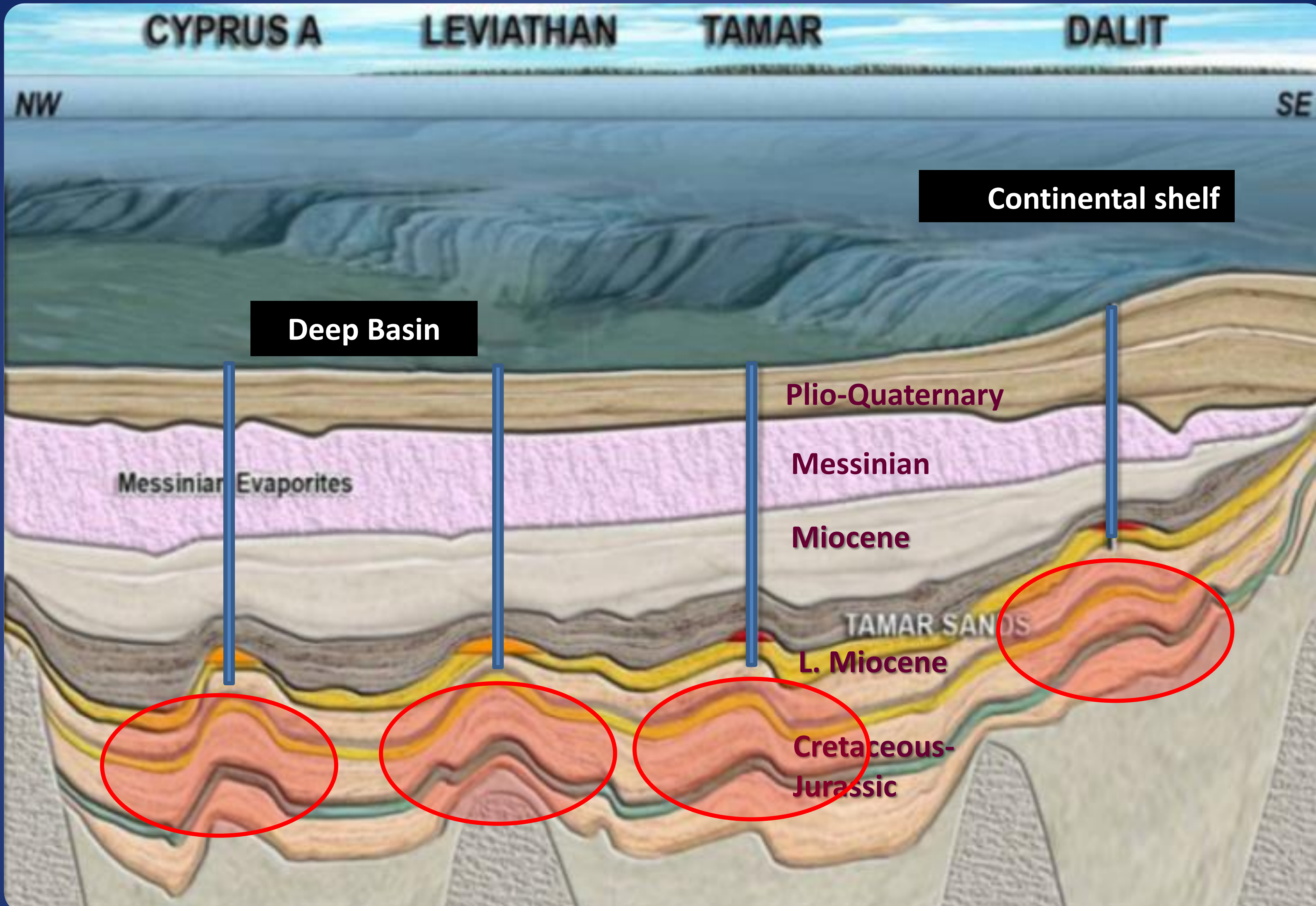


This is a line across both arms. The correlation polygon shows a remarkable fit in and out the Jonah High, outlined in blue. The marked horizons cover the Lower Miocene to probably the Lower Oligocene section. The PSDM volume underwent some simple post-stack processing on the Kingdom workstation to enhance the core's internal reflectors.



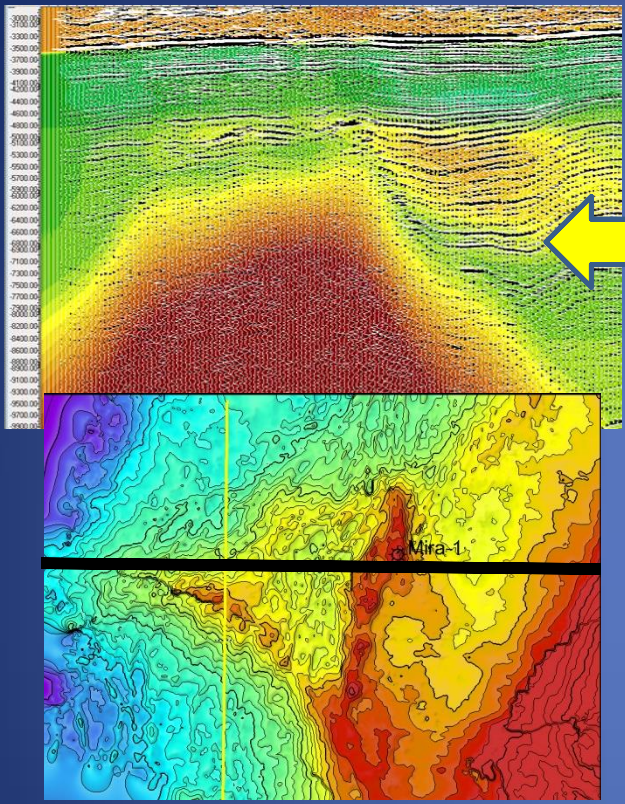


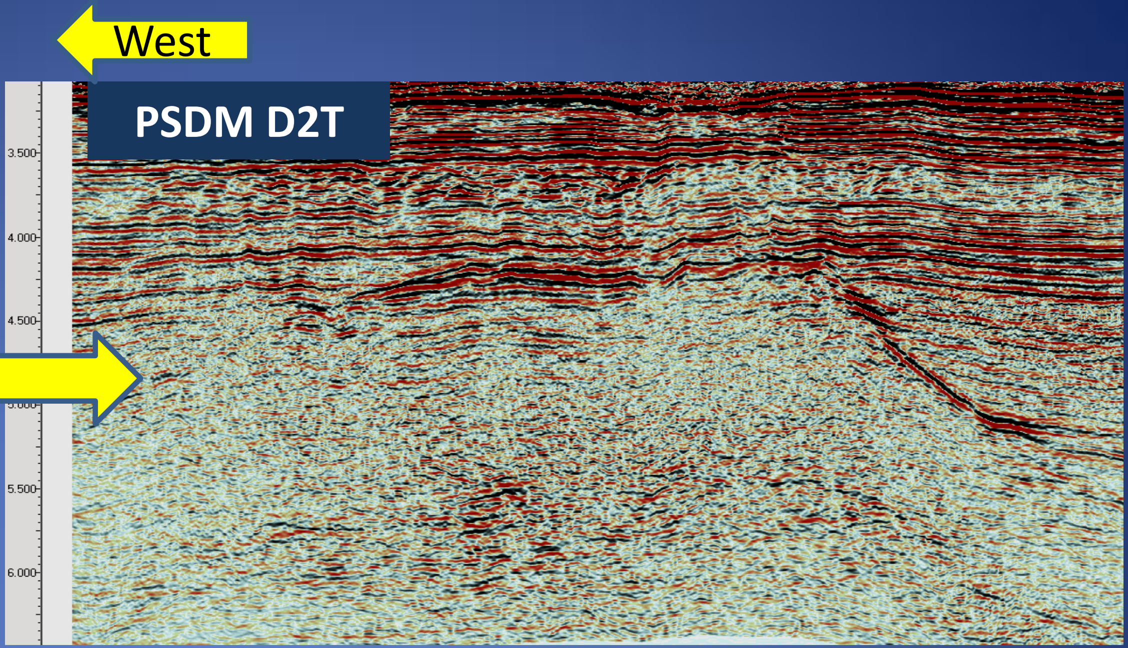
To put things in proportion, the above section is plotted with and without vertical exaggeration.



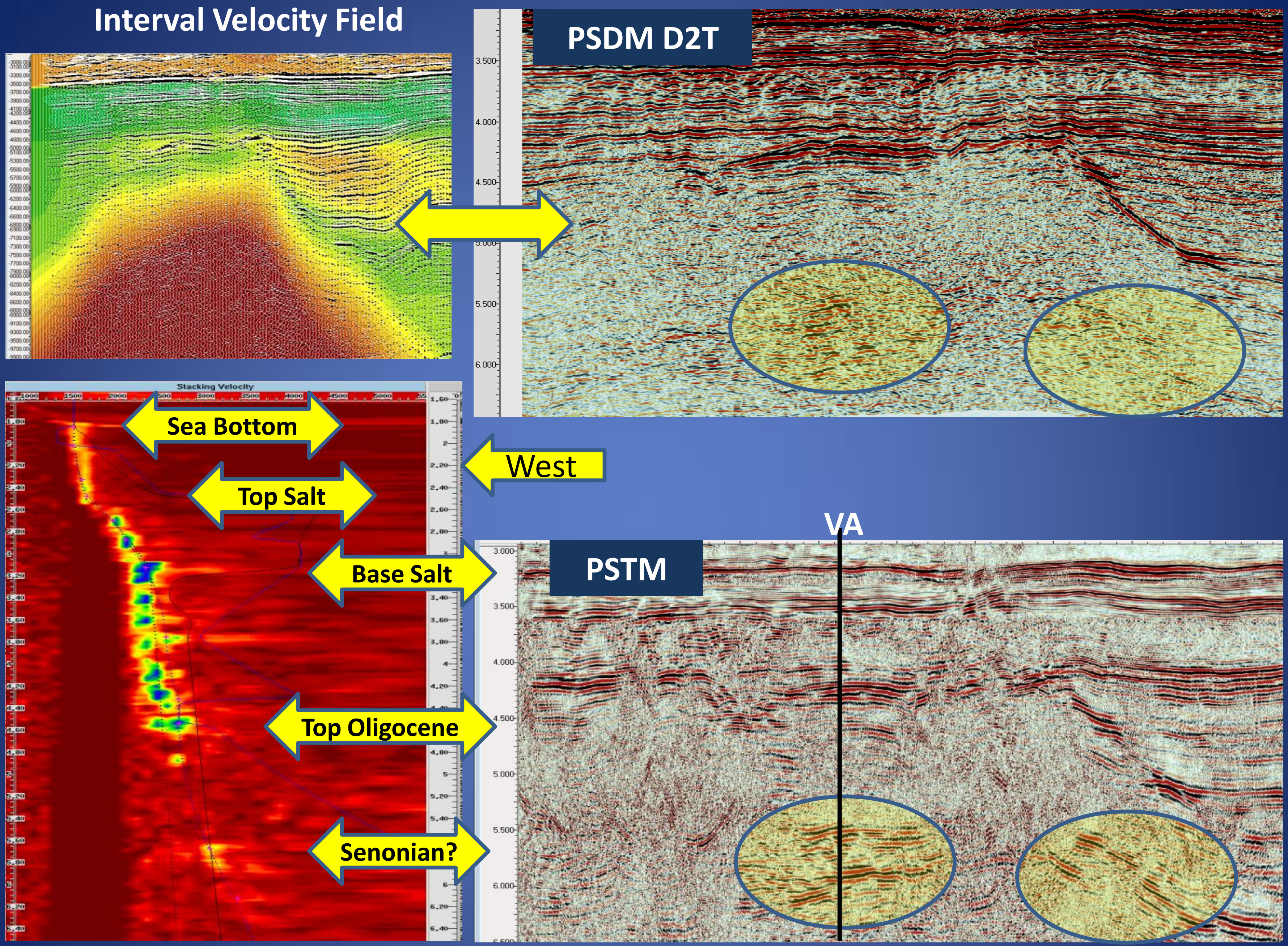
The next generation of exploration in the basin will deal with the potential for thermogenic hydrocarbons. The deep structures below the gas level are the immediate candidates (section modified from Noble Energy).

Interval Velocity Field



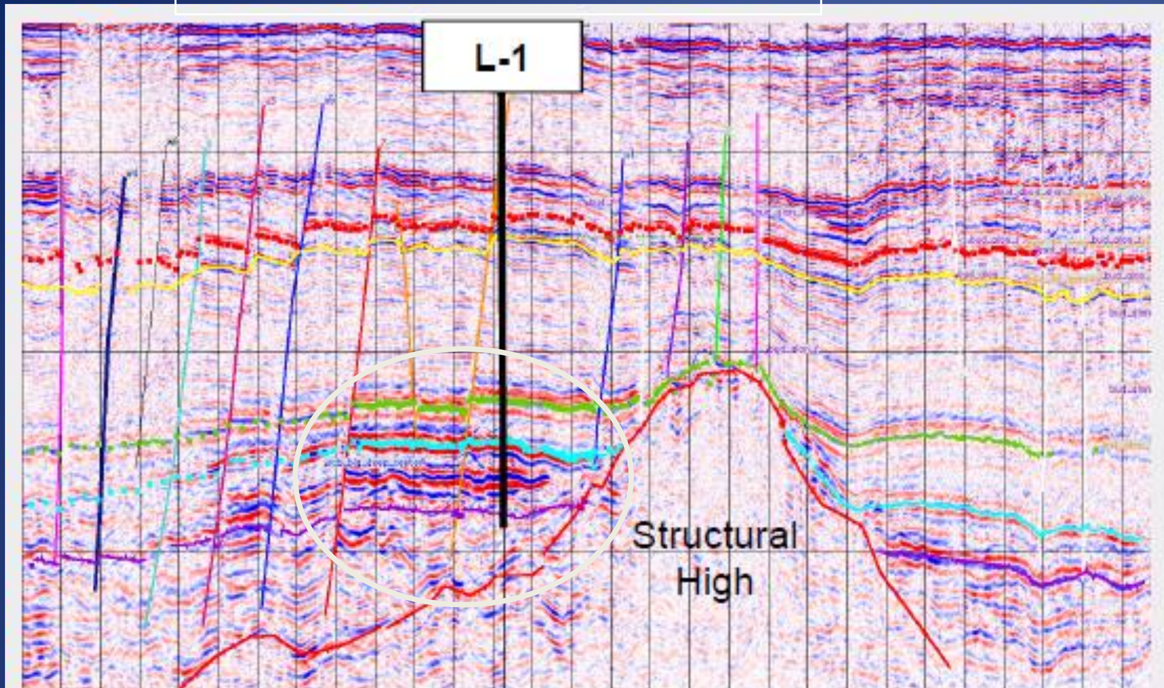


The original PSDM processing of the Myra 3D used a velocity model that follows the Mesozoic seamount assumption. The poor image at depth may imply that the velocity model is wrong. In order to check this observation, a small budget was allocated for reprocessing, yielding the PSTM section in the next slide. Comparing both, improvement was achieved at the bottom part. Note that steep reflectors are altogether missing on the western side, as the section passes north of the western arm of the intrusion.

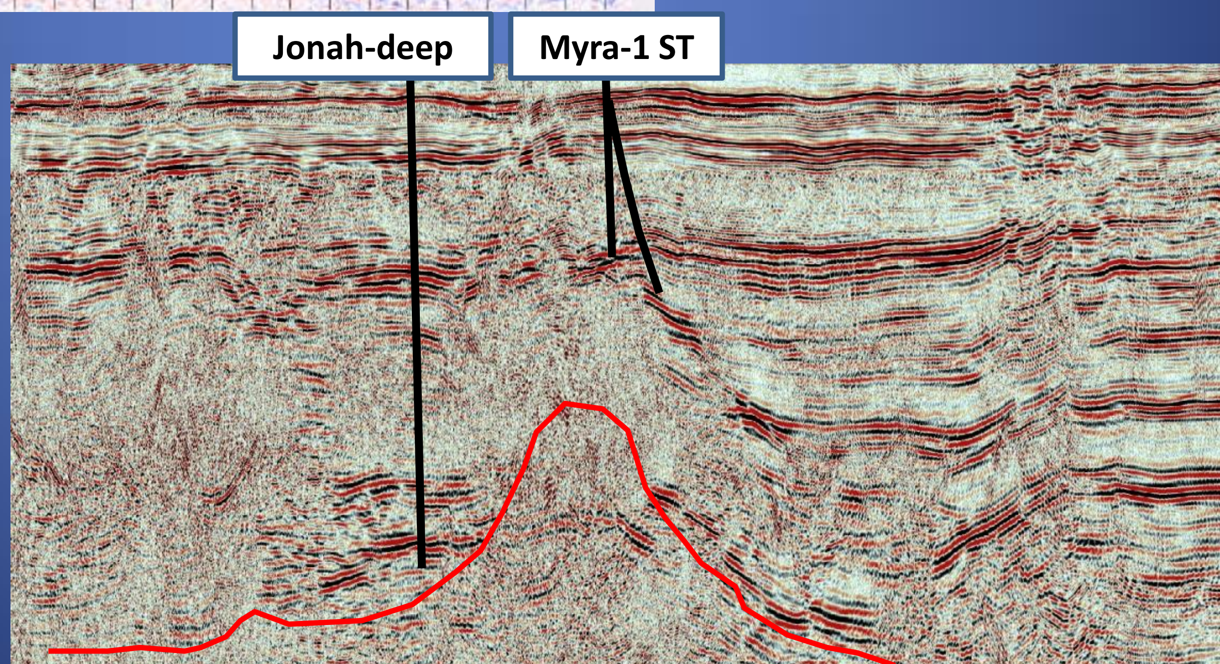


Semblance velocities on the PSTM suggest a normal deep water compacted section.

Leviathan Deep Prospect

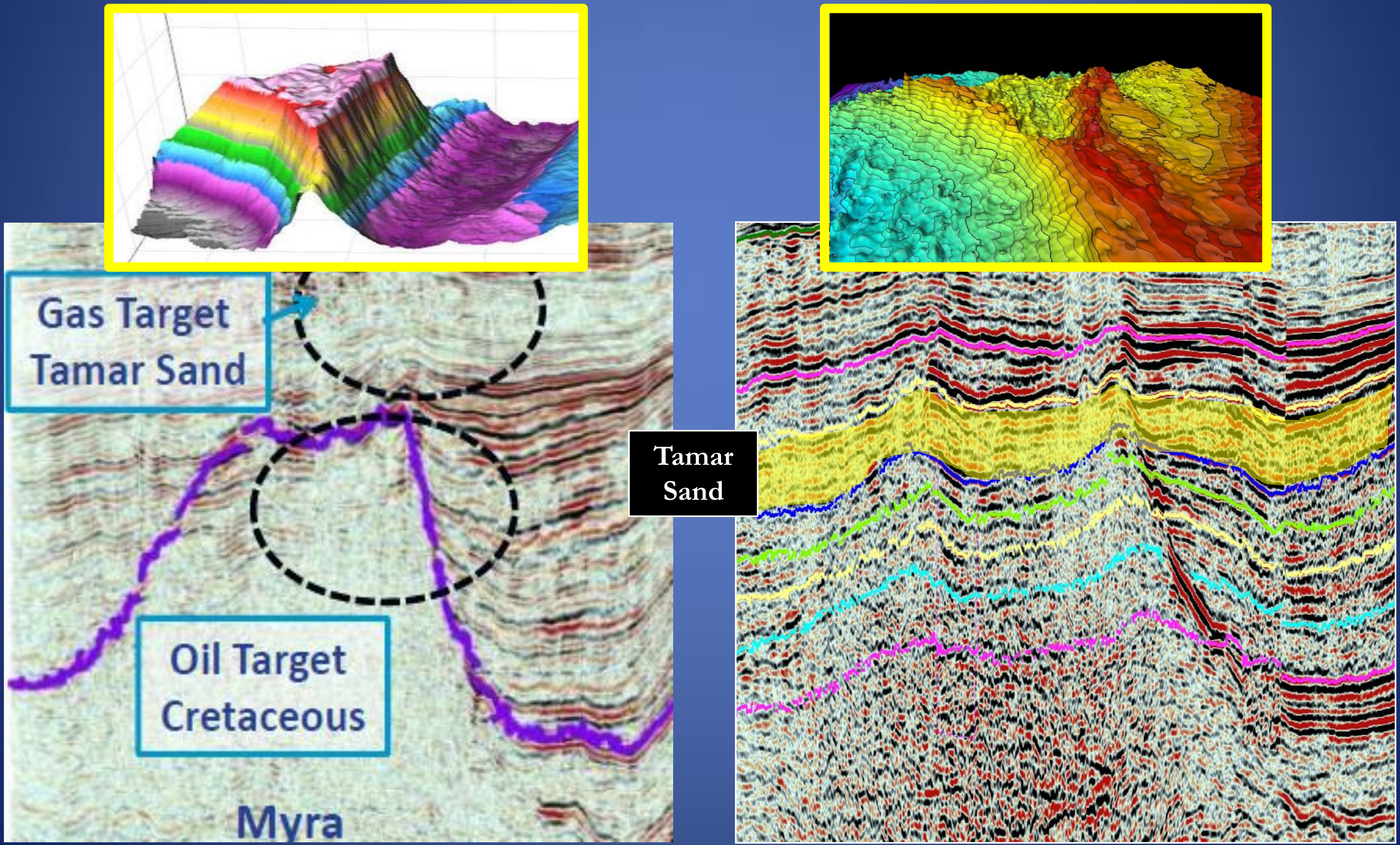


The reprocessed section is displayed vis-à-vis the Leviathan deep prospect, as it was shown by Noble Energy. Both prospects are associated with a seemingly intrusive body and display high amplitude reflectors at depth.



Conclusion #1 - Structure

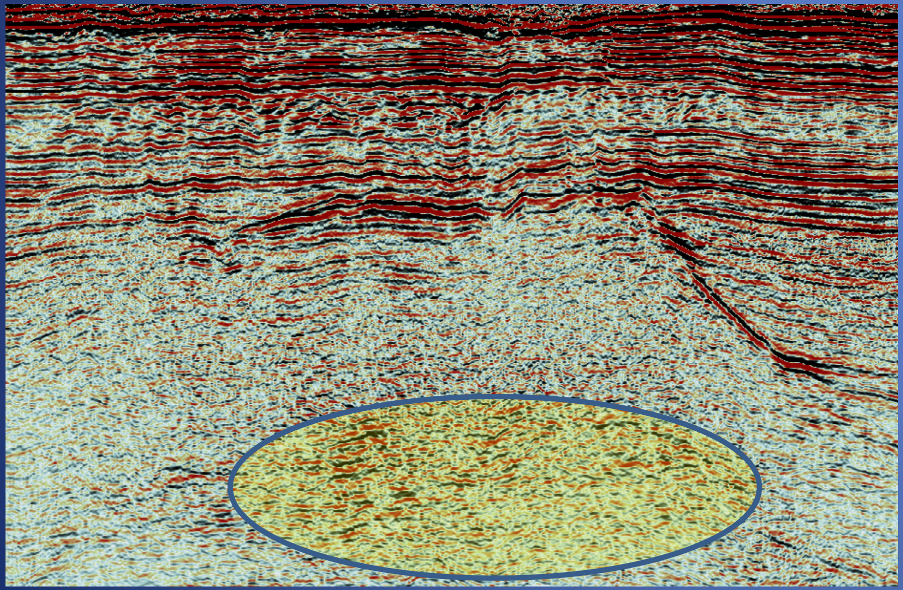
There is no evidence that Jonah High is an old seamount or a carbonate build-up. It is rather a low-relief feature of Lower to Middle Miocene age. A seemingly bifurcated intrusion formed its triangular shape.



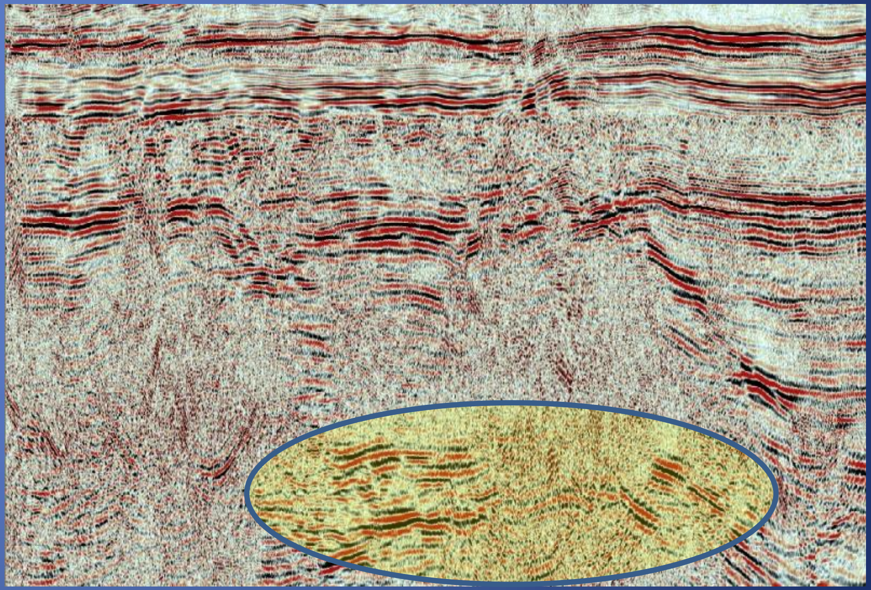
Conclusion #2 - Imaging

Pre-Stack Depth Migrated image quality is highly dependent on the velocity model. The structural model suggested here may assist in constraining the velocity field in future reprocessing, either in depth or in time domain.

Original 3D Processing



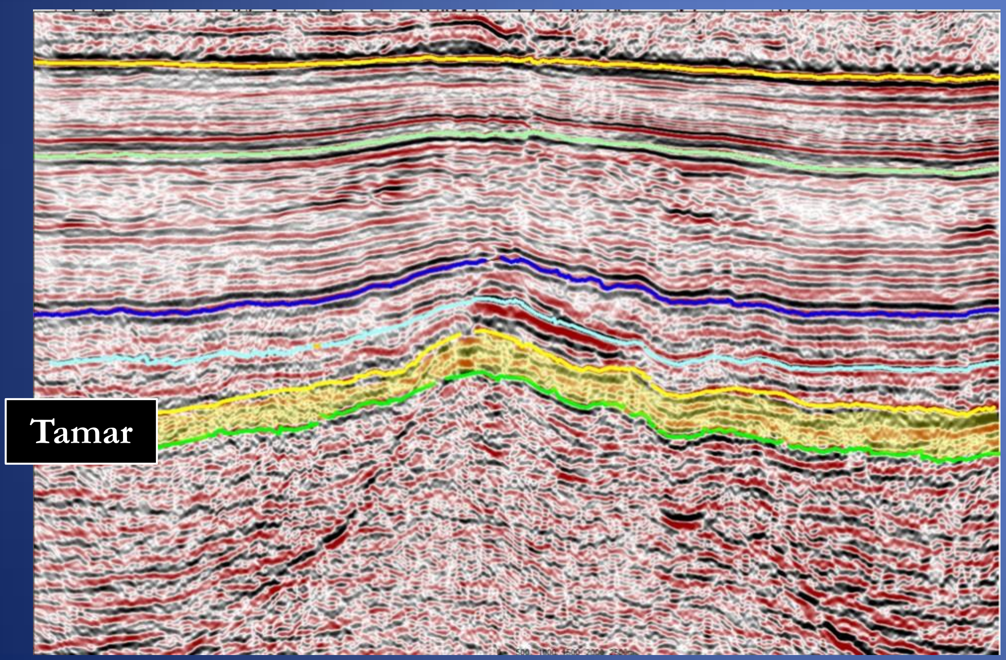
Reprocessing



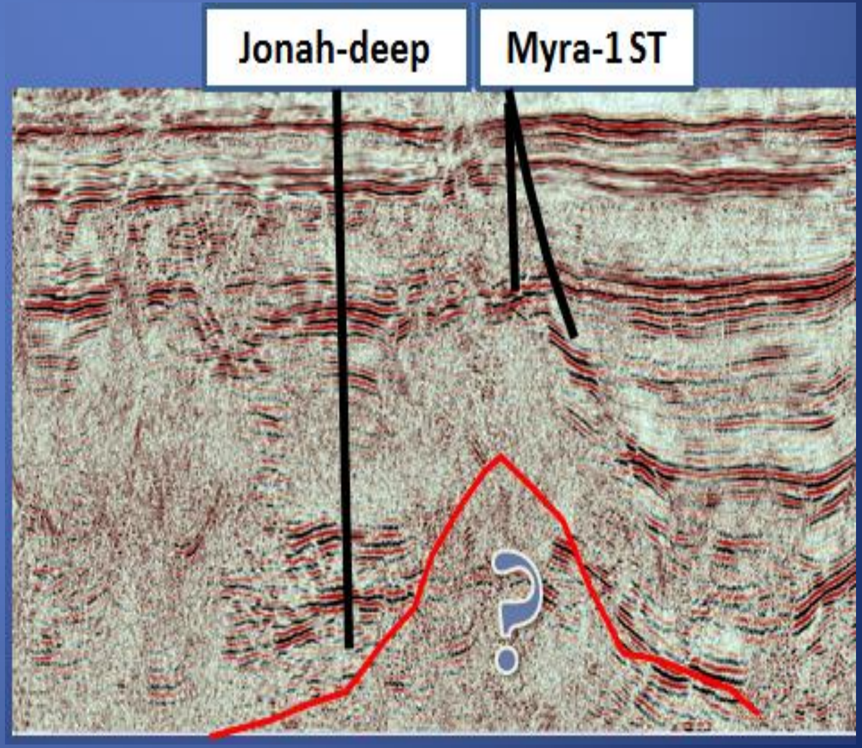
Conclusion #3 – Prospective Leads

Prospective leads of Jonah may reside in the Tamar Sands and in the deep section, an equivalent to the Leviathan Deep prospect.

Lower Miocene Sand

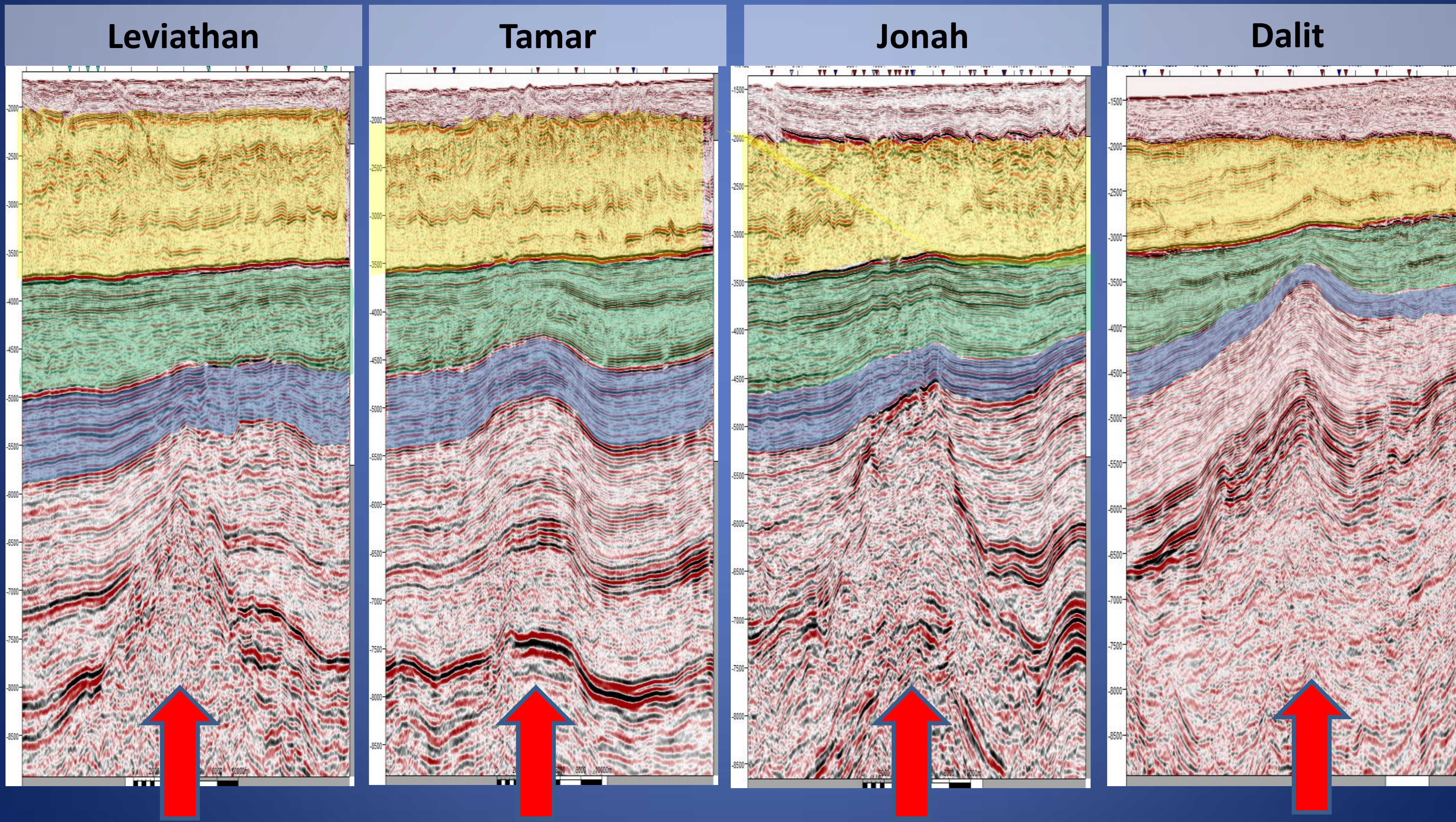


Mesozoic



Conclusion #4 – The enigma

What mechanism created Jonah High? Intrusion? Is it common to all the structures?



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