

PS Architectural Characterization of Turbidite Frontal Splays of the Miocene of Adana Basin, Southern Turkey*

Daniel Bayer da Silva¹, Benjamin Kneller², and Bryan T. Cronin³

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¹School of Earth Sciences, University of Aberdeen, United Kingdom (r03db15@abdn.ac.uk)

²School of Earth Sciences, University of Aberdeen, United Kingdom (b.kneller@abdn.ac.uk)

³Tullow Ghana Ltd, Plot 70, George Walker Bush Highway, North Dworzulu, Accra, Ghana (bryan.cronin@btinternet.com)

Abstract

Few studies have evaluated the formation, evolution, and dimensions of the furthest regions of turbidite systems such as the distal lobes. Techniques used for this purpose include seismic image analysis, physical and numerical modelling, but detailed observation of the building blocks of lobes is more effective in direct outcrop studies. This work is based on exposure of two submarine fans forming part of a complete turbidite system, from the canyon cutting the shelf to distal parts on the basin floor. It focuses on the Cingöz Formation, on the northern margin of the Adana Basin (Lower/Middle Miocene), one of several foreland basins in southern Turkey, marking the closing of Neotethys Ocean. This formation is interpreted as two coeval submarine fans with distinct feeder systems, which combine in their distal portions to form a single large system of about 40 km in length. Here, we report on the eastern part of the Eastern Fan, in outcrops occurring along a N-S highway, cutting the system from the slope onlap zone to the distal fringe. Through log analysis, photomosaic and palaeocurrent measurements, the main characteristics observed were amalgamated thick sandstone packages up to 5 m in thickness; various stacking patterns could be observed. Many observations of the horizontal extent of the sandstone beds were made, and analysis in the onlap regions to better understand the potential reservoir geometry. These sandstone packages are separated by units of thin-bedded turbidites (TBTs). Some of the TBT outcrops are of excellent quality and vertical continuity. In one of these it was possible to take palaeocurrent measurements in several beds, showing that the flow direction remained to the east along 12 m (TBT thickness). These TBT units also have abundant in hybrid beds with range of styles, thickness, and spatial and temporal distribution. There is a low abundance of mass transport deposits. There are rare thick beds of mud (50 cm thickness), whereas the more usual thickness maximum of mud layers is less than 5 cm. The deposit pattern is interpreted as a middle fan with the TBTs forming interlobe units. The system is inferred to have been very active, with frequent turbidity currents, but a low frequency of debris flows. These data help to characterize spatial changes in the architecture of turbidite lobes, including those system elements that can form stratigraphic traps, thus enabling a better understanding of the primary characteristics in a reservoir.

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ARCHITECTURAL
CHARACTERIZATION OF TURBIDITE
FRONTAL SPLAYS OF THE
MIOCENE ADANA BASIN,
SOUTHERN TURKEY

Bayer da Silva, D.; Kneller, B.; Cronin, B.T.

SUMMARY

- 1 - INTRODUCTION
- 2 - GEOLOGICAL CONTEXT
- 3 - BED THICKNESS
- 4 - THICKNESS TRENDS
- 5 - HIERARCHY
- 6 - LOG CORRELATION
- 7 - LATERAL CHANGES
- 8 - NEXT STEPS
- 9 - SPONSORSHIP
- 10 - REFERENCES

1 INTRODUCTION

Few studies have evaluated the formation, evolution and dimensions of the furthest regions of turbidite systems such as the lobes. Techniques used for this purpose include seismic image analysis, physical and numerical modelling, but detailed observation of the building blocks of lobes is more effective in direct outcrop studies. This work is based on exposure of two submarine fans forming part of a complete turbidite system, from the canyon cutting the shelf to distal parts on the basin floor. It focuses on the Cingöz Formation, on the northern margin of the Adana Basin (Lower/Middle Miocene), one of several foreland basins in southern Turkey, marking the closing of Neotethys Ocean. This formation is interpreted as two coeval submarine fans with distinct feeder systems, which combine in their distal portions to form a single large system of about 40 km in length. Here, we report on the eastern part of the Eastern Fan, in outcrops occurring along a N-S highway, cutting the system from the slope onlap zone to the distal fringe.

Limitations and aims

Some sedimentological studies were made in the region, but very few tried to established a formal hierarchy for elements of lobes. Probably the main reason was the poor quality of the outcrops, mainly because the region has vast vegetation covers and, in the previous time, few road cuts. Nowadays the situation has improved (many new roads cut outcrops), but still hard to complete the puzzle, because of the large number of faults (even small displacements) and the discontinuity of the exposure. Even the poor extension, what hinders the correlation, there are very good outcrops and the description of it is the best of this work.

We intended to use the knowledge from each outcrop to understand de facies distribution, the stacking patterns, the hierarchy, the relationship between facies and to understand the evolution of the system.

2 GEOLOGICAL
CONTEXT

The Adana Basin (Figure 1) is located in south-central region of Turkey (Central Anatolia) and is recognized as a foreland basin (Williams et al., 1985; Kelling et al., 1987), initiated with the closing of Neotethys Ocean, and the result of collision between the two lithospheric plates, Afro-arabia and Eurasia, in the Middle Miocene. During this period, eroded sediments from the tectonically active Eastern Tauride Mountains (North), were delivered into shallow and deep marine portions of the basin, to the south. The clastic sediments deposited in the deep-marine produced the Cingöz Formation (Schmidt, 1961), being the main focus of this study (Figure 2). The Cingöz Formation sediments were delivered by turbidity currents and debris flows over a narrow limestone/siliciclastic continental shelf (Karaisali and Kaplankaya Formation) (Figure 2), about 1 to 3 km wide (Satur et al. 2004). This material accumulated in deep water, creating two clastic systems with conical geometry, interpreted as submarine fans (Schmidt, 1961; Gürbüz, 1993).

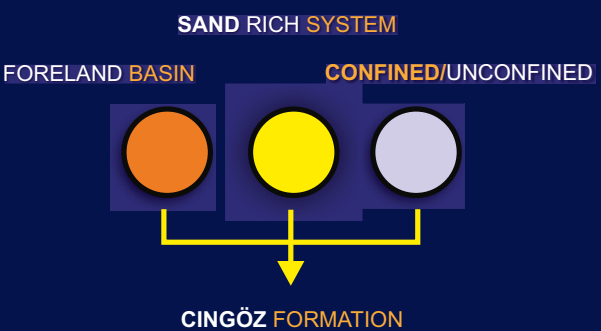


Figure 2 – Graph with stratigraphy of Cenozoic of Adana Basin (Satur et al. 2004). In the red square the time period of this work.

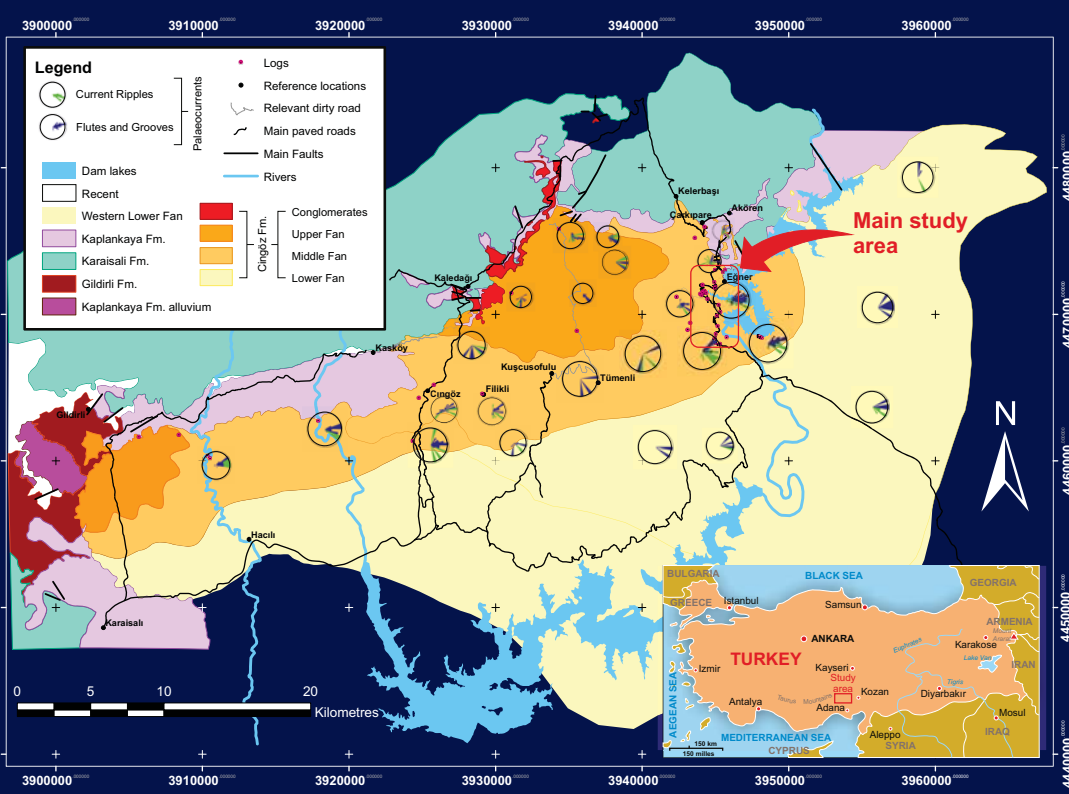
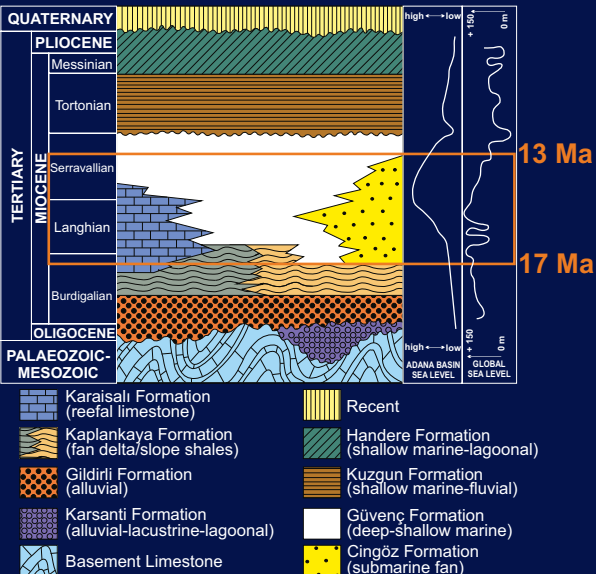
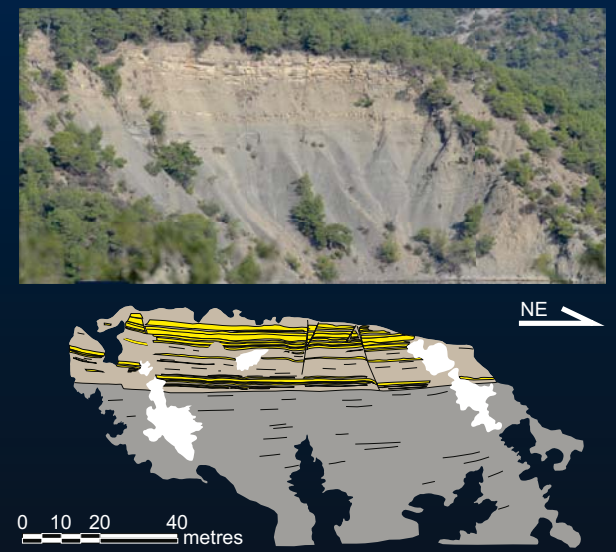


Figure 1 - Simplified geological map, focusing in the main formations related to the main study purpose (redraw from Gürbüz, 1993).

8 NEXT
STEPS

- Understand the asymmetries in cycles and how it reflects the stacking patterns;
- Create the evolution of lobe deposition in the eastern sector of the Eastern Fan with greater detail;
- Recognize the facies associations for each sector of the lobes;
- Analysis of the progradation of the sandstones onto slope (on lap), aiding in the understanding of the prediction of the geometry of the bodies;
- Improvement of the hierarchical scheme, including the nomenclature and scale.

Onlap analysis



Facies analysis



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ABSTRACT

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Architectural Characterization of Turbidite Frontal Splays of the Miocene Adana Basin, Southern Turkey

Daniel Bayer da Silva¹, Benjamin Kneller², Bryan T. Cronin³

¹PhD Student - School of Earth Sciences, University of Aberdeen AB24 3EA, UK - r03ab15@abdn.ac.uk; ²School of Earth Sciences, University of Aberdeen AB24 3EA, UK - b.kneller@abdn.ac.uk; ³Tullow Ghana Ltd, Plot 70, George Walker Bush Highway, North Dworzu, Accra, Ghana (no postcode) - bryan.cronin@btinternet.com

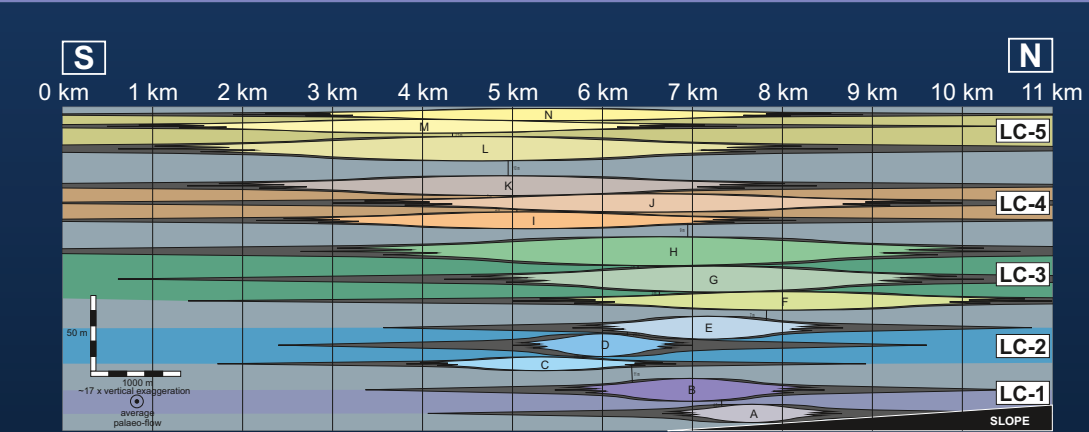


Figure 8 - Interpretation of the stacking pattern of the lobes (A-N) and lobe complexes (LC-1 to 5) identified in the study area.

INTERPRETATIONS

The Figure 8 shows our preliminary interpretation regarding the log correlation and all data collected in the field. Also, some references were used to "complete" the gaps and understand the relationship between the bodies (Deptuck et al., 2008; Prélát et al., 2009). According to the interpretation, it is possible to see that the extension of some of the lobe complexes exceeds 11 km of width and their thicknesses are not bigger than 50 m, what agree with our hierarchy (~40 m), the same as seen for the lobes (~16.5 m). Some lateral shift is also perceived.

Lobe Complex 1 - >30 m of thickness
Lobe A - ~12 m
Lobe B - ~15 m

Lobe Complex 2 - >30 m of thickness
Lobe C - 9 m
Lobe D - 15 m
Lobe E - 10 m

Lobe Complex 3 - ~50 m of thickness
Lobe F - >12 m
Lobe G - 19 m
Lobe H - 19 m

Lobe Complex 4 - >35 m of thickness
Lobe I - >11 m
Lobe J - >12 m
Lobe K - >13 m

Lobe Complex 5 - >35 m of thickness
Lobe L - 16 m
Lobe M - 9 m
Lobe N - >8 m

	LOBE axis	LOBE general	LOBE ELEMENT	BED
Lateral thinning rate (strike)	> 9 m km ⁻¹	3.6 to 4.5 m km ⁻¹	1.96 m km ⁻¹	1.32 m km ⁻¹
Proximal to distal thinning rate (dip)	-	-	1.0 m km ⁻¹	0.4 m km ⁻¹

Bed and lobe element

The table above shows some rates that were collected from the measurements in the field. The important thing here is that these rates were the average of some beds and lobe elements considering the main flow in the region, therefore the section (strike or dip) were estimated for each element.

We observed that the rates have:

In dip section:

The bed rate to the lobe element rate is 2.5x bigger;

In strike section:

The bed rate to the lobe element rate is 1.5x bigger.

In beds:

The rate from dip to strike section increase 3.3x;

In lobe elements:

The rate from dip to strike section increase 2x.

SE



Figure 9 - Photo showing a good example of lateral changing of a lobe element: 1.05 m of thickness in 80 m of distance.

LOG CORRELATION

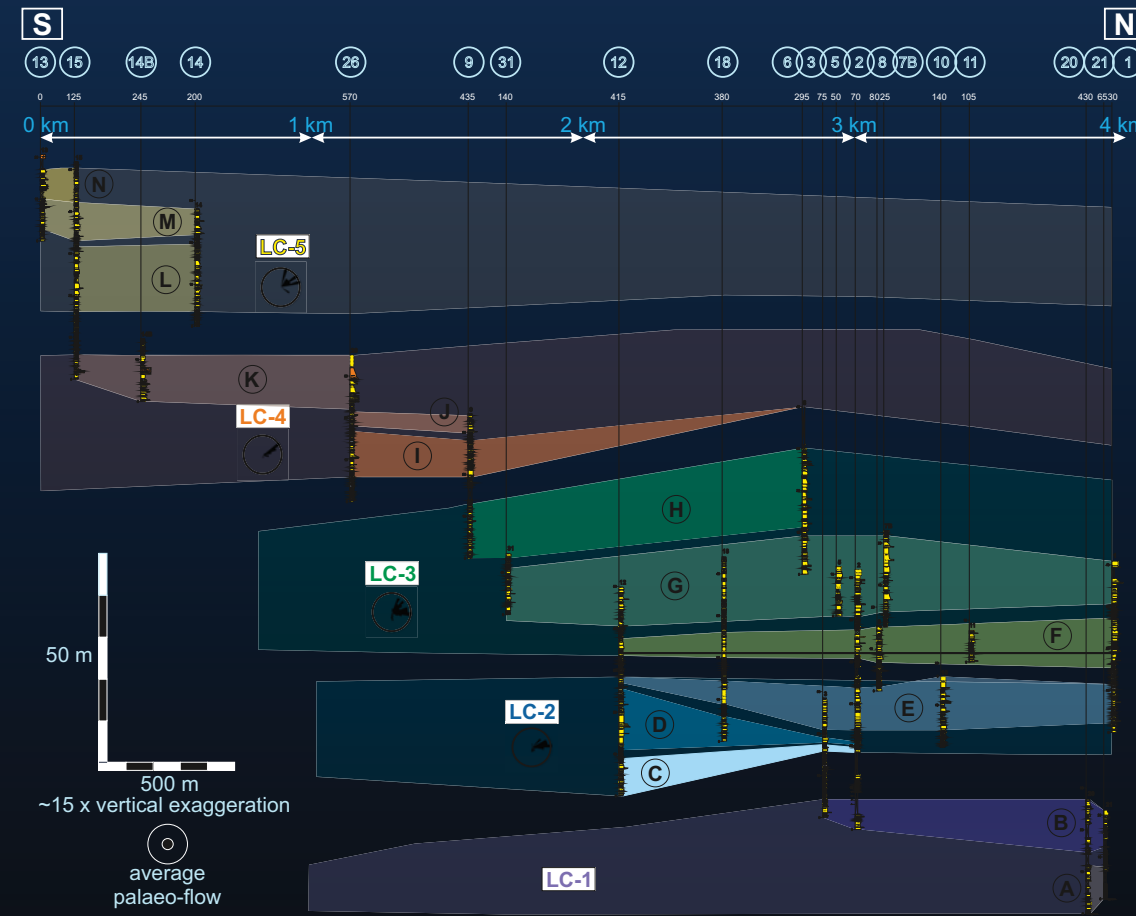


Figure 7 - Correlation made with 20 sedimentary logs spaced about 4 km.

In the log correlation (Figure 7), there is no clear datum bed to follow in the distance, but there is a thick shale (maximum 50 cm thick) in some of the logs with similar patterns of deposits that was used to correlate them with good confidence. This shale is clearly part of the lobe and not an "interlobe" because it is into a single cycle and not between two. Also, the best feature to use as a datum here is the thick packages of thin-bedded-turbidites (>7 m). Based on the correlation we divided the deposits in 14 bodies composed mainly of sandstones (A-N), that we called lobes. They form 5 groups of 3 lobes each that we called lobe complexes (LC), the exception is the LC-1, with 2 lobes, but we don't have enough data to say if there is another one.

THICKNESS TRENDS

The basic pattern recognized for lobes or frontal splays is thickening upward (Prélát and Hodgson, 2013), which would indicate a progradation of the system. Commonly this trend is overlapped by a thinning upward sequence, but it can also occur without it, which is normally interpreted as a lateral shift of the lobe. However, several variations were recognized in the study area, with a rare absence of the thinning upward sequence. What we can observe is that, very often, the sequences may be asymmetric, i.e., the lower sequence (e.g., thickening upwards) is composed of fewer layers than the sequence above.

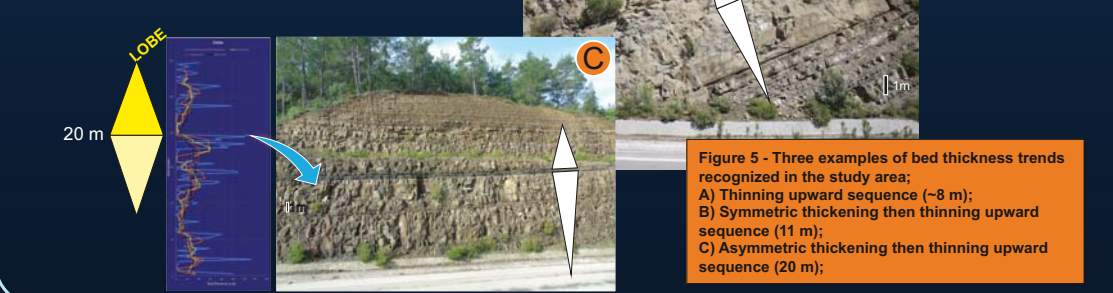


Figure 5 - Three examples of bed thickness trends recognized in the study area; A) Thinning upward sequence (~8 m); B) Symmetric thickening then thinning upward sequence (11 m); C) Asymmetric thickening then thinning upward sequence (20 m);

HIERARCHY

Based on what we see in the bed thickness analysis, log correlation, photomosaic, and some references, we created a hierarchy scale for bed, lobe element, lobe and lobe complex, from the small to large scale respectively. We keep the standard nomenclature to be more effective in our explanation. This preliminary study shows some significant associations between the scales. Figure 6 represents the average of the measurements from the components lobe and lobe elements (16.5 m and 5 m respectively) from the scheme in the Bed Thickness section. As there is not sufficient data to know average dimensions of the lobe complex, the best-described example of 40 m was assumed. Other data (currently in the study) suggest it to be a little larger. The average bed scale was taken from all data acquired.

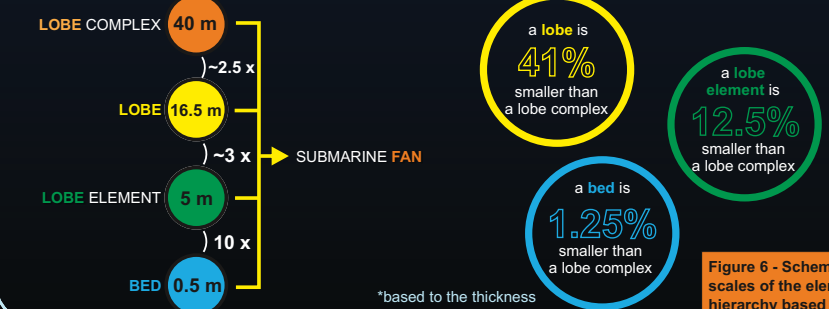


Figure 6 - Scheme representing the scales of the elements of the lobe hierarchy based on the thicknesses.

*based to the thickness

BED THICKNESS

An important tool for the lobe studies is the bed thickness evolution over time. Here we used 4 sedimentary logs as an example to examine the main characteristics of the patterns of the bed thicknesses. Firstly we used the longer sedimentary log as standard (log#19). This log shows a very good example of the largest cycle, about 40 m height and inside it, we separated 2 smaller hierarchy, associated here with lobes and lobe element, following the same nomenclature usually used by other authors (Prélát, et al., 2009; Grundvåg, et al., 2015; Spychala, et al., 2017).

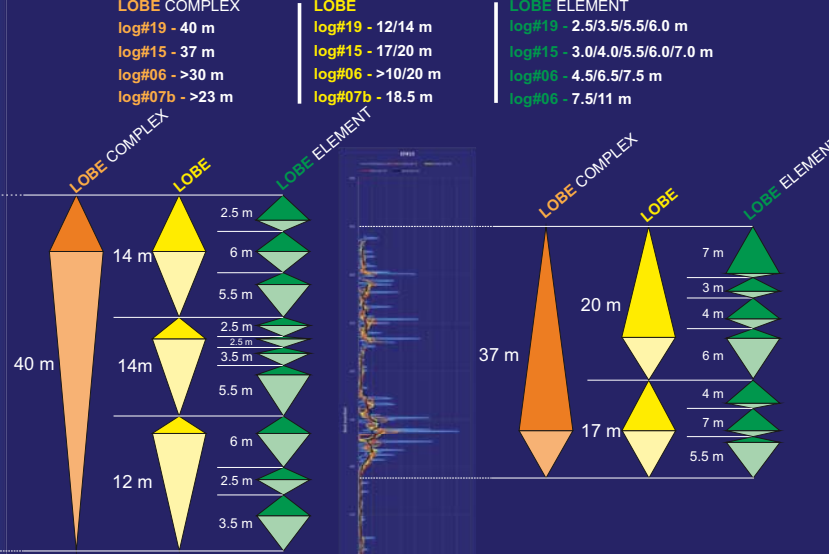


Figure 3 - A thinning upward sequence in a lobe element.

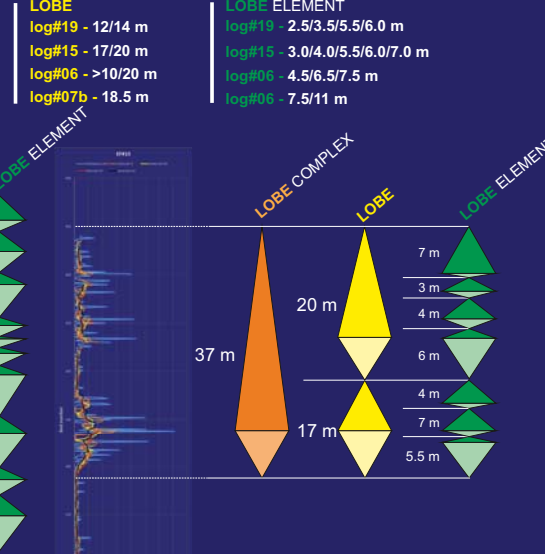


Figure 4 - A thick thin-bedded-turbidite sequence that separate lobe complexes.