Tectonic Evolution and Depositional System Analysis of the Mesozoic Section in Browse Basin, NW Shelf Australia

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ABSTRACT

The Browse basin is one of the NW Australian shelf extensional super basin; it is one of the richest hydrocarbon-bearing basins in Australia. This study dealt with the relationship between tectonic and sedimentation and how the tectonic control the sedimentation, in order to reconstruct the basin evolution, with their tectonic style and to understand the depositional system stages of the Mesozoic interval. The Mesozoic interval defines at least Late Triassic and Jurassic syn-rift mega-sequence and post-rift mega-sequence from at least Aptian-Albian and Late Cretaceous post-rift megasequence. The area of interest (AOI) represents a Late Triassic and Jurassic NE-SW to NNE-SSW major normal fault system. It reconstructs the AOI as successive half grabens controlled at least the Late Triassic and the Jurassic sedimentation. It is represented by lateral thickness and facies change. Compared to previous fault system the AOI defined an E-W to ENE-WSW complex fault system represented by normal and lateral components, reconstructed the AOI as a half grabens, affected and shifted the previous fault system and controlled at least the Jurassic sedimentation.

The upper Triassic sedimentary sequence characterizes an upper to lower shoreface depositional environment. During the Late and Middle Jurassic, this shoreface environment is structured by the tilted blocks geometry filled by the sandstone, which is considered as gas bearing reservoir potential in the AOI. The upper Jurassic and the base of Late Cretaceous intervals define a local tectonic reactivation in the Northeastern part of the AOI. This faulting affects the sedimentation and shows a lateral thickness variation in successive Half Grabens despite the other part of the AOI. The Post-rift mega-sequences cover all inherited topography from the previous Late Triassic and Jurassic tectonic events and define the principal seal for the Jurassic targets. This sequence predominately represents deep marine depositional environments to Late Cretaceous submarine channel system.

Keywords: Browse basin, Australian Super Basin, Half-graben Structures Syn-rift, Post-rift, Mega-sequence

INTRODUCTION

The Browse basin is one of NW Australian shelf extensional basins, it covers an area of approximately 140 000 km2 and it is one of the richest hydrocarbon-bearing basins in Australia and on the NW Australian shelf super basin. It contains numerous productive petroleum systems with principally a significant gas accumulations and discoveries and a lesser extent of oil. According Edwards (2005), The Browse basin continues to be a premier exploration target in the NW Australian shelf and four hydrocarbon petroleum systems have been identified and the overall petroleum resources are estimated at 33 MMbbl (5.2 GL) of crude oil, 1214 MMbbl (193 GL) of condensate, 404 MMbbl (64 GL) of LPG, and 41.3 Tcf of gas in the Browse Basin.

Today, the petroleum industries are under great pressure to comprehend and reconstruct structural evolution as well as the depositional system and the relationship between tectonic history and depositional system. This steep provides more direct insight into the formation of the basin and the factors controlling sedimentation, as well as the depositional evolution of the different elements of the petroleum system. It is a key slope in both the exploration and development stages.

The objectives for this study are to comprehend the tectonic style, reconstruct the 3D structural model, and determine the depositional system by creating Gross depositional environments maps (GDE) of the various stages of the Mesozoic interval in our area of interest. Finally, concluding the relationship between tectonic and sedimentation of the Mesozoic stages.

LITERATURE REVIEW

Tectonic evolution History of Browse Basin, NW Australia

The Browse Basin is a significant hydrocarbon-bearing

The authors wish to thank NNPC Limited, NNPC Upstream Investment Management Services (NUIMS), Sedimentary Basin and Petroleum Geology Laboratory – University of Tunis El Manar- Tunisia. Geodynamic, Geomaterials and Geodigital Laboratory – University of Tunis El Manar- Tunisia. Libyan Petroleum Institute and Zallaf Libya and NAPE for providing the platform to present the paper during the Annual Conference.

basin located on the North West Australian shelf. It is part of the larger Westralian Superbasin (Fig 1) and it has been the target of extensive exploration and production activities (Edwards, 2005), The basin has undergone a complex tectonic evolution, consisting of six major phases and smaller scale structural events.

The tectonic evolution of the Browse Basin can be divided into different phases:

- The first phase occurred during Late Devonian to Early Permian extension (Fig 2), initiated the formation of an intracontinental rift along the future Australian margin. (Baillie *et al.* 1994). This extensional phase resulted in the development of northeast-trending intracratonic extensional half-grabens (Baillie, 1994; Struckmeyer *et al.* 1997; Struckmeyer *et al.* 1998; Longley *et al.* 2002).
- The second phase, Late Permian to Late Triassic thermal subsidence, followed the major extensional event and allowed for thermal relaxation within the basin (Etheridge and O'Brien, 1994). This phase was characterized by subsidence and the accumulation of sediment (Struckmeyer *et al.* 1998).
- The third phase, Late Triassic to Early Jurassic inversion (Fig 2), marked the termination of the thermal subsidence phase and resulted in the formation of inversion structures and regional unconformities, (Struckmeyer *et al.* 1998). The inversion of Paleozoic and Triassic strata occurred along major faults; numerous synclines and anticlines were formed in the hanging-walls of the major Paleozoic faults to form the Scott Reef and Brecknock Trends (Willis, 1988)
- The fourth phase, Early to Middle Jurassic extension (Fig 2), witnessed the reactivation of faults and the occurrence of smaller normal faults (Struckmeyer et al. 1998). This phase was concentrated in the northeast part of the Caswell Sub-basin and along the outer margin of the Prudhoe Terrace, (Struckmeyer *et al.* 1998).
- The fifth phase, Late Jurassic to Early Middle Miocene thermal subsidence, saw the onset of sea floor spreading and the termination of continental rifting, (Veevers *et al.* 1991). This phase was marked by smoothing of basin topography and the transition to a passive margin, (Struckmeyer *et al.* 1998).
- The sixth and final phase, Early Middle Miocene to Late Miocene inversion (Fig 2), was characterized by the continued convergence of the Australian and Eurasian plates, (Baillie *et al.* 1994). This phase resulted in the reactivation of Paleozoic faults and the formation of anticlines, (Struckmeyer *et al.* 1998).

Much of the present-day structural architecture of the Browse Basin results from the Miocene to recent tectonic evolution of the region, which was dominated by the collision of the Australian plate with the Banda Arc (Saqab and Bourget, 2015).

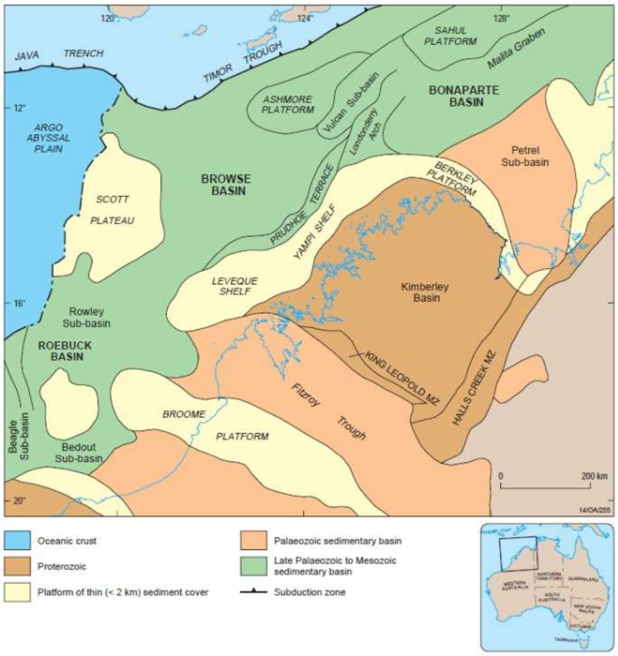


Figure 1: Regional structural elements map, (Hocking *et al.,* 1994; and Symonds *et al.,* 1994).

Browse Basin stratigraphic evolution

The stratigraphy of the Browse Basin is complex and consists of various sedimentary units. These units provide valuable insights into the depositional history and potential hydrocarbon resources of the basin.

The Carboniferous section in the Browse Basin is dominated by fluvio-deltaic deposits (Fig 2), indicating the presence of ancient river systems that transported sediments into the basin, (Kasira Laitrakull, 2012). Overlying the Carboniferous deposits, the Lower Permian strata consist of interbedded limestones, mudstones, siltstones, and minor sandstones (Fig 2). These sediments were primarily deposited in a marine environment, suggesting a transition from fluvial to marine conditions (Kasira Laitrakull, 2012).

The Upper Permian section is characterized by sandstones that grade into shales and limestones (Fig 2). These sediments were deposited in marine environments, including shallow shelf areas, (Kasira Laitrakull, 2012). The Upper Permian deposits are of particular interest as they may contain potential reservoir rocks for hydrocarbon accumulation, (Boreham, 1997).

The Triassic rocks in the Browse Basin comprise a diverse range of sedimentary facies. Interbedded marine mudstones, siltstones, and volcaniclastic strata (Fig 2), indicate a regional marine transgression during the Lower Triassic, (Kasira Laitrakull, 2012).

As we move into the Middle to Upper Triassic, fluvial and marginal to shallow marine sandstones (Fig 2), shales, and minor carbonates become more prevalent. These sediments suggest a transition to more terrestrial and nearshore environments, (Kasira Laitrakull, 2012: Blevin and all. 1998)

The Jurassic section in the Browse Basin is characterized by a combination of marine and fluvio-deltaic deposits. The Lower to Middle Jurassic strata, known as the Plover Formation (Fig 2), consist of fluvial-deltaic sandstones, mudstone, and coals. These sediments were deposited in a variety of coastal and deltaic environments, (Kasira Laitrakull, 2012). The Plover Formation is of significant interest as it contains potential reservoir rocks for hydrocarbon accumulation (Boreham and all, 1997).

The Cretaceous section in the Browse Basin is characterized by a series of marine supersequences, including the Echuca Shoals Formation, Jamieson Formation, and Asterias Member (Fig 2), (Kasira Laitrakull, 2012). These formations consist of mudstones, shales, and sandstones, with the potential for both source and reservoir rocks, (Boreham and all, 1997).

Overall, the stratigraphy literatures of the Browse Basin provide valuable information about the depositional environments and potential hydrocarbon resources. Understanding the distribution and characteristics of these sedimentary layers in very crucial to Understand the characterize the distribution of these petroleum systems in our Area of interest.

Overall, the tectonic and depositional system evolution of the Browse Basin has shaped its geological characteristics and contributed to its hydrocarbon potential. Understanding these processes is crucial for further exploration and development in the basin.

Browse Basin Petroleum systems

According to ROLLET, N., GROSJEAN, E., EDWARDS, D., PALU, T., ABBOTT, S., TOTTERDELL, J., LECH, M., KHIDER, K., HALL, L., ORLOV, C., NGUYEN, D., NICHOLSON, C., HIGGINS, K. AND MCLENNAN, S., (2016), the Browse Basin has been the site of several petroleum systems, with four hydrocarbon petroleum systems identified. The basin is known for its significant gas accumulations (Fig 3), although there have also been discoveries of oil. The presence of these petroleum systems makes the Browse Basin an attractive target for exploration and production activities.

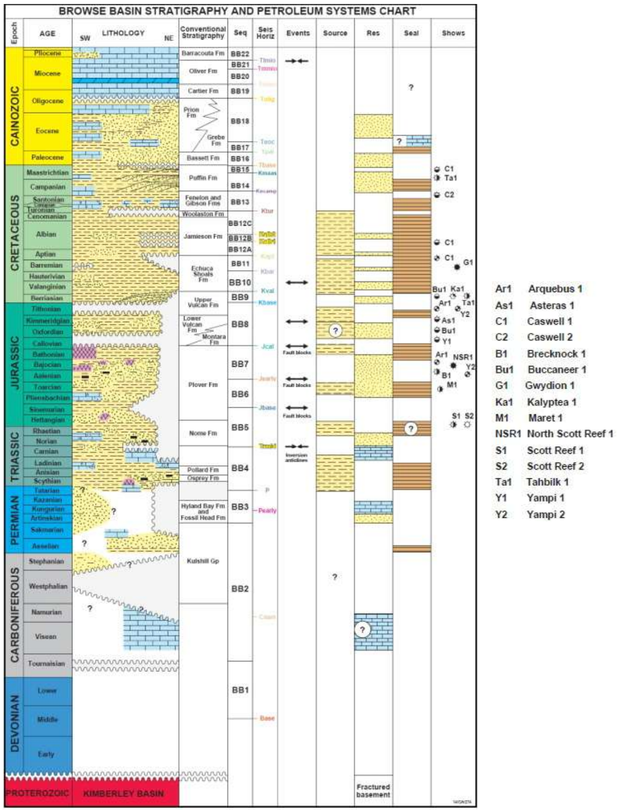


Figure 2: Browse Basin stratigraphy and petroleum systems chart with hydrocarbon shows, (BOREHAM and All, 1997).

1. Dry Gas-Prone System: This petroleum system is basin-wide and primarily consists of dry gas reservoirs within the Plover Formation. The gas is sourced from mixed terrestrial and marine organic matter deposited in a fluvio-deltaic environment. The Jurassic reservoirs on the Scott Reef Trend, such as Brecknock and Torosa, as well as other potential accumulations like Crown/Proteus and Poseidon, belong to this system. The condensate to gas ratios in these reservoirs range from 39 cm3/m3 to 196 cm3/m3.

2. Wet Gas-Prone System: This system is found in the central sub-basin of the Browse Basin and is characterized by wet gas reservoirs within the Brewster Member of the upper Vulcan Formation. The Ichthys and Prelude/Concerto accumulations are part of this system, with a condensate to gas ratio of 337 cm3/m3. The hydrocarbons in this system are primarily sourced from marine Jurassic source rocks.

3. Oil and Gas-Prone System: This petroleum system is sourced from mixed marine and terrestrial organic matter within the Lower Cretaceous sediments of the Echuca Shoals Formation. It is believed to have sourced the oil within the Caswell structure in the Caswell Sub-basin and the greater Cornea and Gwydion structures on the Yampi

Shelf. The presence of both oil and gas indicates the potential for a mixed hydrocarbon system.

4. Gas Condensate System: The Crux gas condensate discovery in the far northeastern portion of the basin is part of this system. It is sourced from predominantly terrestrial organic matter within Jurassic source rocks. The Crux field represents a distinct hydrocarbon family within the basin.

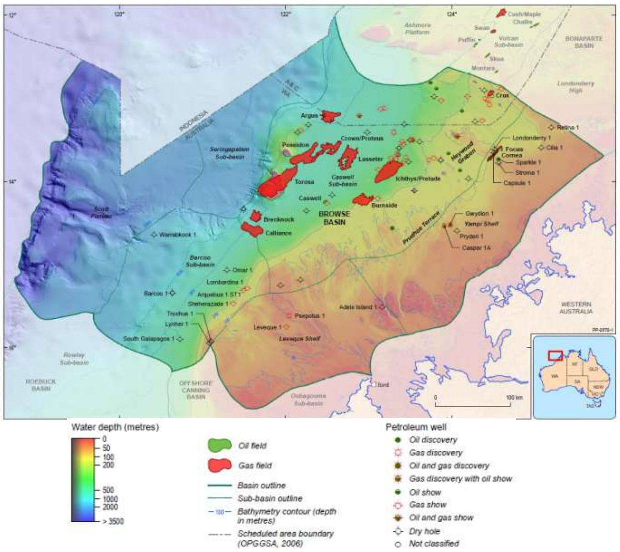


Figure 3: Map of the Browse Basin with oil and gas fields.

Work Methodology

1. Research date set

The 3D seismic data, are provided by ConocoPhillips (Browse Basin) Pty Ltd (2011) the processing reports carried out by CGGVeritas, the seismic data represent a Pre-Stack Time Migration. The Poseidon 3D Marine Surface Seismic Survey (Poseidon 3D) was acquired during the period of October 2009 to March 2010 within Browse Basin exploration permits WA-315-P and WA-398-P, Operated by ConocoPhillips Pty Ltd (Tab.1).

Two exploration well data in this work were provided by ConocoPhillips, karoon Gas Australia industry (2011) and Woodside (2007). This data set includes well log, check-shots surveys, lithology reports and well-completions report.

Reconstruct the structural evolution of the area of interest (AOI) for the Mesozoic interval and determine the main tectonic elements and the structural style.

1. Data Quality Control (QC): The first phase involved conducting quality control on the seismic data, well tops, cutting descriptions, wireline logs, and completion reports. This step ensured the reliability and accuracy of the data.

2. Mapping the major mega-sequences and faults: After the QC, the major mega-sequences (pre, syn, and post-rift) and the major faults ware interpreted using the seismic volume of 1900 km2. This helped in understanding the geological history and structural framework of the area of interest (AOI).

3. Seismic to well tie and synthetic generation: in order to map the horizons, the density and sonic logs and the check shot date ware used to generate synthetic seismograms and to tie our well. These synthetic seismograms ware then compared with the seismic volume to assess the predictability of the generated data.

4. Minor faults and horizon mapping: Minor faults ware interpreted, and four key horizons (Top Triassic, Intra-Jurassic, Middle Cretaceous, and Top Cretaceous) ware mapped. This leads to the generation of a time structural map and an isochronos map, which provided insights into the tectonic evolution of the AOI.

5. Variance and Coherence Seismic Attribute generation and analysis: Seismic attributes ware used to enhance the structural interpretation and gain a better understanding of the AOI's structural evolution.

6. Reconstruction of the Tectonic Evolution Model: Based on the integration of previous results, the tectonic evolution of the AOI was reconstructed, and the main tectonic elements and structural style was determined.

Depositional system reconstruction and GDE map generation.

1. Shale Volume (Vsh) display and QC: Due to the complex lithology, particularly in the Jurassic interval, the shale volume is calculated using the Neutron Density logs. This provides a better estimation of the shale volume compared to the Gamma Ray (GR) method.

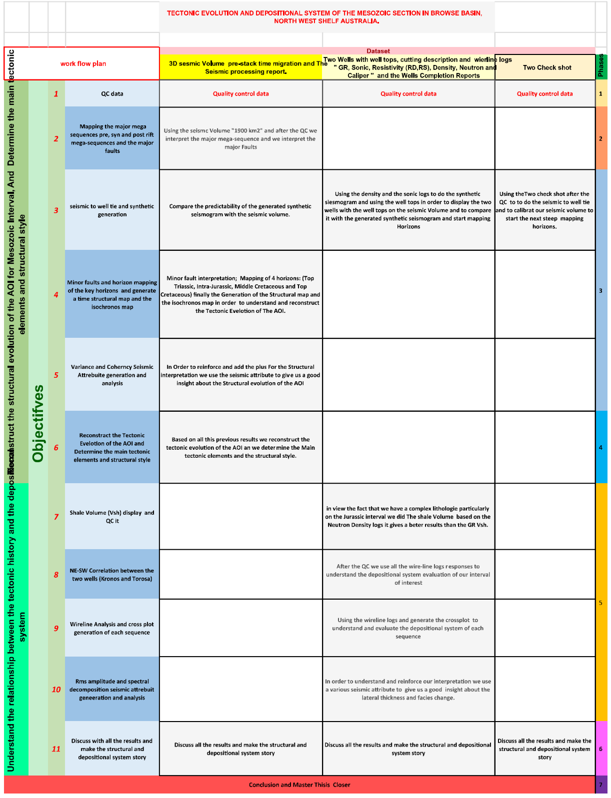
2. NE-SW Correlation between the two wells: After QC, the wireline logs responses from the Kronos and Torosa wells are used to understand the depositional system evaluation of the Mesozoic interval of interest.

3. Wireline Analysis and cross-plot generation: The wireline logs are analyzed, and crossplots are generated to evaluate the depositional system of each sequence.

4. Rms amplitude and spectral decomposition seismic attribute generation and analysis: Various seismic attributes are used to understand lateral thickness and facies changes, in order to reinforcing the interpretation and to generate the GDE map.

5. Discussion and story development: Based on the findings, a structural and depositional system story is constructed.

Table 1: Research project Work Flow



TECTONIC EVOLUTION AND DEPOSITIONAL SYSTEM OF THE MESOZOIC SECTION IN BROWSE BASIN, NORTH WEST SHELF AUSTRALIA.

Objectifves		work flow plan	Dataset 3D sesmic Volume pre-stack time migration and The Seismic processing report.	Two Wells with well tops, cutting description and wierline logs " GR, Sonic, Resistivity (RD,RS), Density, Neutron and Caliper " and the Wells Completion Reports	Two Check shot	Phases
Reconstruct the structural evolution of the AOI for Mesozoic Interval, And Determine the main tectonic elements and structural style	1	QC data	Quality control data	Quality control data	Quality control data	1
	2	Mapping the major mega sequences pre, syn and post rift mega-sequences and the major faults	Using the seismc Volume "1900 km2" and after the QC we interpret the major mega-sequence and we interpret the major Faults			2
	3	seismic to well tie and synthetic generation	Compare the predictability of the generated synthetic seismogram with the seismic volume.	Using the density and the sonic logs to do the synthetic siesmogram and using the well tops in order to display the two wells with the well tops on the seismic Volume and to compare it with the generated synthetic seismogram and start mapping Horizons	Using theTwo check shot after the QC to to do the seismic to well tie and to calibrat our seismic volume to start the next steep mapping horizons.	3
	4	Minor faults and horizon mapping of the key horizons and generate a time structural map and the isochronos map	Minor fault interpretation; Mapping of 4 horizons: (Top Triassic, Intra-Jurassic, Middle Cretaceous and Top Cretaceous) finally the Generation of the Structural map and the isochronos map in order to understand and reconstruct the Tectonic Evelotion of The AOI.			
	5	Variance and Coherncy Seismic Attrebuite generation and analysis	In Order to reinforce and add the plus For the Structural interpretation we use the seismic attribute to give us a good insight about the Structural evolution of the AOI			
	6	Reconstract the Tectonic Evelotion of the AOI and Determine the main tectonic elements and structural style	Based on all this previous results we reconstruct the tectonic evolution of the AOI an we determine the Main tectonic elements and the structural style.			4
Understand the relationship between the tectonic history and the depositional system	7	Shale Volume (Vsh) display and QC it		in view the fact that we have a complex lithologie particularly on the Jurassic interval we did The shale Volume based on the Neutron Density logs it gives a beter results than the GR Vsh.		5
	8	NE-SW Correlation between the two wells (Kronos and Torosa)		After the QC we use all the wire-line logs responses to understand the depositional system evaluation of our interval of interest		
	9	Wireline Analysis and cross plot generation of each sequence		Using the wireline logs and generate the crossplot to understand and evaluate the depositional system of each sequence		
	10	Rms amplitude and spectral decomposition seismic attrebuit geneeration and analysis		In order to understand and reinforce our interpretation we use a various seismic attribute to give us a good insight about the lateral thickness and facies change.		
	11	Discuss with all the results and make the structural and depositional system story	Discuss all the results and make the structural and depositional system story	Discuss all the results and make the structural and depositional system story	Discuss all the results and make the structural and depositional system story	6
Conclusion and Master Thisis Closer						7

6. Conclusion and study Closure: Conclusion with a summary of the findings and the completion of the project.

RESULTS AND FINDINGS

1. Mega sequence Analysis of the Area of interest for the Mesozoic interval

In this chapter we start by the interpretation of the mega sequences to make a general idea about our interval of interest. Us a results, we interpret tree major mega-sequence the Pre-Rift, the syn-rift and the post Rift mega-sequences.

a. The Pre-Rift Mega Sequence

The pre-rift mega sequence characterizes generally by a thickness conservation, no observed lateral thickness change. As it is indicated on the (Fig 4 and 5) the pre-rift mega sequence truncated the syn-rift mega sequence, and it is highly affected by a deep normal fault system which is created an accommodation space for the next mega sequence.

b. The syn-rift mega-sequence

The syn-rift mega-sequence is instantaneous with the tectonic events, deposited when the tectonic affected the pre-rift mega-sequences. It is characterized by a huge lateral thickness change in successive half Grabens structuration. Us we can see the passage from the pre and the syn-rift mega-sequence represented by a major unconformity (Fig 4 and 5). The seismic reflector of this sequence characterized by a frequent lateral amplitude change and it onlapped the erosive surface on the top of the pre rift mega-sequence. The syn-rift mega sequence is represented by at least Late Triassic and Jurassic sequences.

c. The post rift mega-sequence

The post rift mega-sequence deposited in tectonically stable period after the syn-rift mega-sequences and cover all the inherited topography from the previous tectonic episode. As it is represented in the (Fig 4 and 5). The passage from the syn-rift to the post rift mega-sequence represented by an inconformity. This interval characterises by no presence of fault, (major faults) and does not show a major lateral reflector amplitude change.

The late Jurassic and the Lower Cretaceous sequence are a part of the post-rift mega sequence in the Northern part of the AOI (Fig 4 and 5), on the other hand they are a part of the syn-rift mega sequence in the southern part of the AOI (Fig 4 and 5).

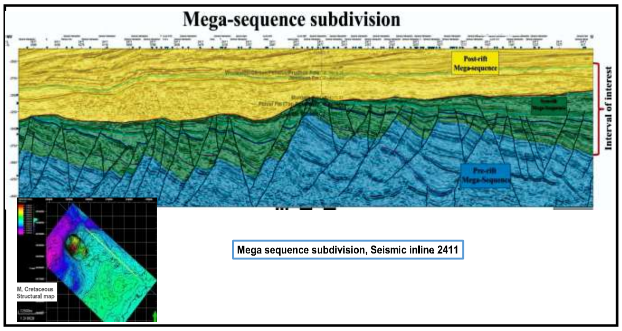


Figure 4: Mega-Sequence in the AOI, Seismic line 2411.

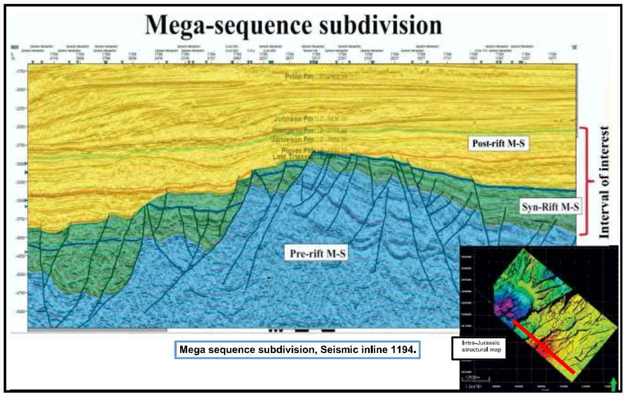


Figure 5: Mega sequence subdivision, Seismic inline 1194.

Tectonic elements and structural style analysis of the AOI

This analysis tectonic elements and structural style of the AOI is done using seismic lines and random lines in different directions (Fig 6, 7, 8 and 9). The seismic lines reveal the presence of:

1. Deep Normal Faults: The seismic lines reveal the presence of deep normal faults that affect the Triassic and Jurassic sequences. These faults create a ridge in the middle of the AOI and two basins on the SE and NW flanks. They are characterized by high angles and variable offsets, indicating a tectonic intensity variation (Fig 6 and 7).

2. NW-Dipping Faults: In the NW part of the AOI, there are major NW-dipping faults. These faults have the maximum offset in the basin and represent a sharp transition from the ridge to the NW basin. In the SE part, the NW-dipping faults have lower offsets and show a smoother transition from the ridge to the second basin (Fig 6 and 7).

3. SE-Dipping Faults: SE-dipping faults are also observed in the seismic lines. These faults sometimes act as antithetic faults to the major NW-dipping faults and sometimes represent deep inherited faults (Fig 6, 7, 8 and 9). They have low offsets and follow the same dipping direction as the carboniferous major faults that initiated the Browse Basin.

4. Fault Angle Variation: The seismic lines show variations in fault angles, ranging from high angles representing major faults with sharp discontinuities, to low angles representing antithetic faults with minimal offsets.

5. Rollover Structure: A rollover structure is observed in the NW part of the seismic section. This structure represents a good target for the petroleum industry (Fig 6).

6. Igneous Intrusions: The seismic lines indicate the presence of igneous intrusions, characterized by high amplitudes. These intrusions cross the ancient sedimentary rock as inclined planes, suggesting the presence of igneous dykes and sills (Fig 6).

Overall, the tectonic elements and structural style observed in the seismic lines indicate a complex tectonic history with multiple fault systems and variations in fault angles and offsets.

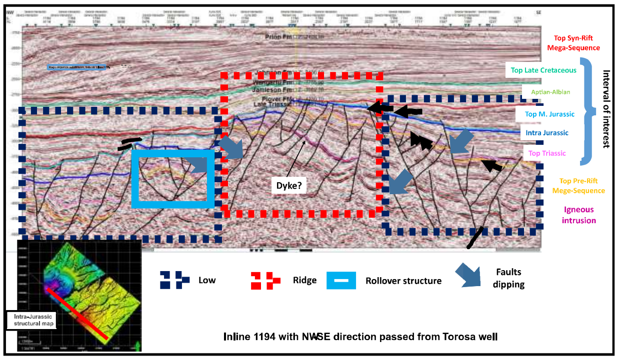


Figure 6: Inline 1194 with NW-SE direction passed from Torosa well.

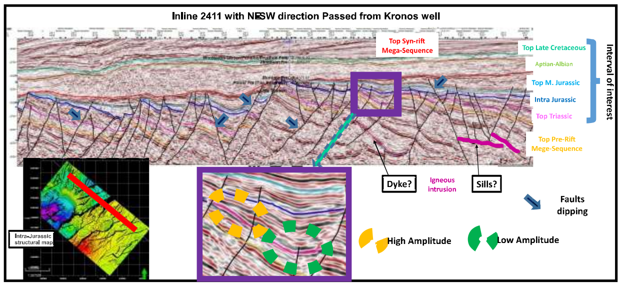


Figure 1: Inline 2411 with NE-SW direction Passed from Kronos well.

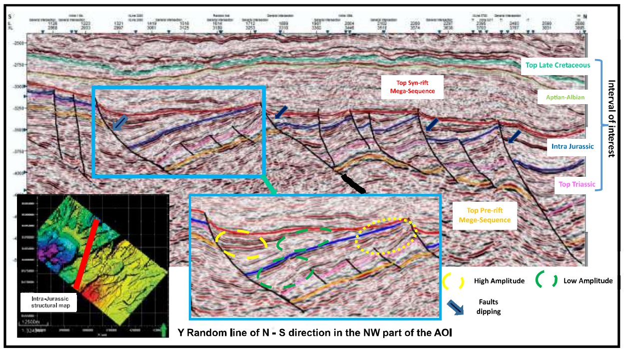


Figure 2: Y Random line of N-S direction in the NW part of the AOI.

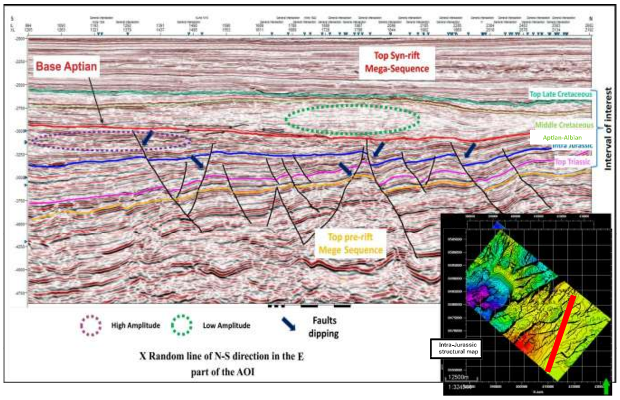


Figure 3: X Random line of N-S direction in the E part of the AOI.

Tectonic evolution and reconstruction model of the AOI for the Mesozoic interval

The late Triassic and the Jurassic sequence well define the syn-rift mega sequence indicate a syn-sedimentation tectonic control represented by a clear and net lateral thickness change on a successive Half Graben structuration. Those Graben Well represent the lateral seismic amplitude change indicates a lateral lithology change (Fig 6 and 7). The passage from the Triassic to the Jurassic sequence defined by a major inconformity probably define a lower Jurassic rifting reactivation.

The Middle and the Late Cretaceous interval cover and fill all the inherited Jurassic topography and well represent the Post rift mega-sequence.

Our AOI well represent and define a Late-Triassic and Jurassic NE-SW to NNE-SSW major faults system, affects the Pre-rift mega sequence and reconstruct our AOI as a Successive Half Graben (Fig 10). This opening controlled principally the Jurassic sedimentation which is represented by a lateral thickness change.

Instantaneously with the NE-SW faults system our AOI define also at least a Jurassic E-W to ENE-WSW faults system with normal offset control at least the Jurassic sequence and reconstruct also our AOI as a Half Graben. Clearly appear in the seismic that this fault system affects the previous NE-SW faults system and decal them and complicate the tectonic evolution of our AOI (Fig 8 and 11).

On the Triassic and Jurassic structural map, the AOI, which is generally defined by a high angle of normal fault systems that affect the Jurassic and Triassic sequence with an offset variation that reaches a maximum in the NW region of our AOI, provides us with strong insight into the variation in tectonic intensity (Fig 6 and 7).

The Aptian-Albian and late Cretaceous structural maps show a stable tectonic phase and a slight lateral thickness variation it strongly suggests the influence of the Jurassic tectonic phase's heritage structure. It shows the presence of two submarine channel systems, the first one overlapped the Aptian-Albian sequence and the second one altered and eroded the Late Cretaceous sequence.

Our AOI defines the existence of salt distant on the NW portion of our AOI and affects the entire Mesozoic interval up to the surface, causing the planification of the fault behind the sault and generating a radial system fault in all directions surrounding it.
We conclude this chapter with a summary that takes into

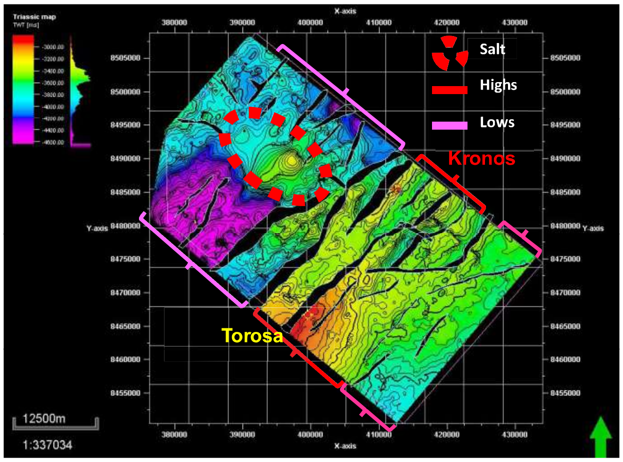


Figure 4: Late Triassic structural TWT map.

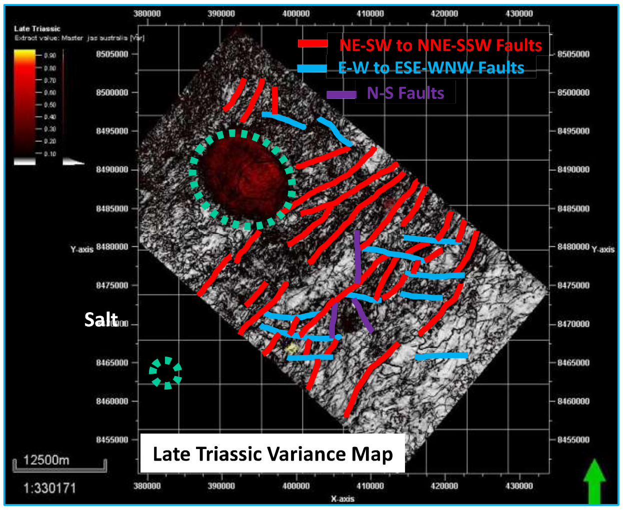


Figure 11: Interpreted Late Triassic Variance Map.

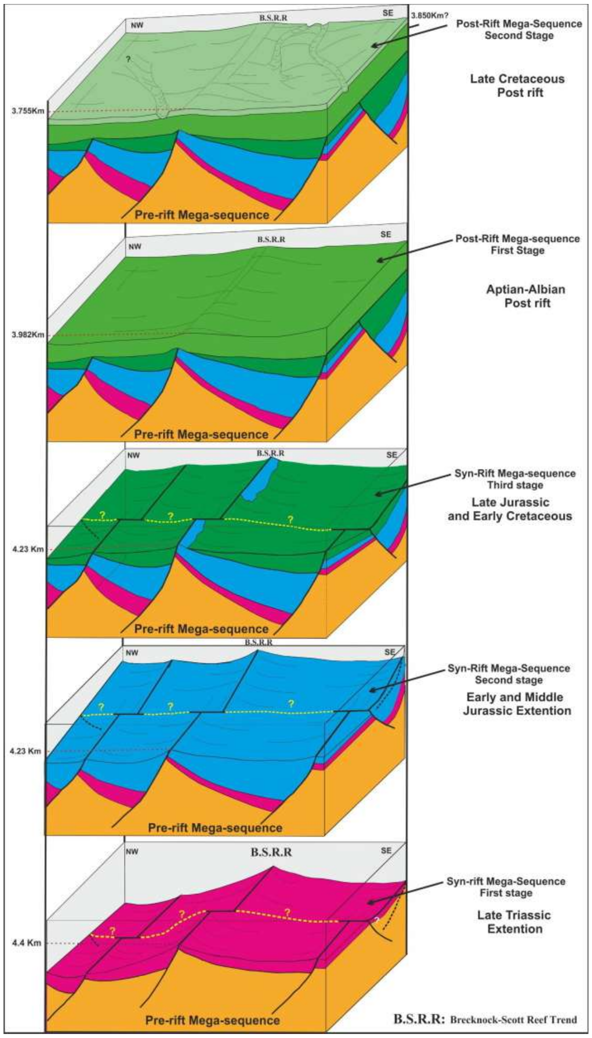


Figure 12: Unscaled 3D structural model Restoration for the Mesozoic interval of the AOI.

account 3D structural models in order to recreate the structural evolution of the AOI for the Mesozoic Interval, identify the key tectonic components and structural characteristics, and describe the syn-sedimentation tectonic control (Fig 12).

Depositional System Analysis of the Area of interest for the Mesozoic interval.

1. NE-SW Correlation between the Torosa and Kronos well

The correlation between the Torosa and Kronos wells is done using various well log data, including GR (gamma ray), RD (deep resistivity), RS (shallow resistivity), RHOB and RHOZ (density), TNPH and HTNP (neutron), (Fig 13). The correlation is based on the Mesozoic mega-sequence, specifically the late Triassic sequence, Lower and Middle Jurassic, Aptian-Albian, and late Cretaceous sequences (Fig 13).

The key messages revealed by the correlation are as follows:

1. Late Triassic Sequence: The Torosa well represents a Carnian sequence, while the Kronos well represents a Norian sequence. The Norian sequence is missing in the Torosa well.

2. Lower and Middle Jurassic: The Torosa well shows a thickening of the Lower and Middle Jurassic sequences compared to the Kronos well. This indicates that the Torosa well represents the highest part of the area of interest (AOI) in terms of these sequences. The Montara Formation, which is Upper Jurassic in age, is present in the Kronos well but absent in the Torosa well.

3. Late Cretaceous: There is a thinning of the late Cretaceous sequence from the Torosa to Kronos well. The Wangerlo Formation, which is Maastrichtian to Cenomanian in age, is present in the Torosa well but the Cenomanian-Santonian sequence is missing in the Kronos well.

4. Late Jurassic and Lower Cretaceous: The Torosa well does not have the late Jurassic and lower part of the lower Cretaceous sequences, while the Kronos well has the late Jurassic sequence represented by the Montara Formation.

5. Lateral Lithology and Thickness Variation: The correlation reveals clear lateral lithology and thickness variations in all the Mesozoic mega-sequences. This is indicated by the GR and Neutron-Density logs.

V shale Calculation

The Jurassic characterize by the presence of radioactive minerals and the it represents a complexity of the Jurassic and Triassic section with the presence of the volcanoclastic sediment. As a result, we choose the N-D V shale rather that GR V shale but we have to take in on Consideration that in gas bearing interval the Neutron and density tool affected by the gas and the neutron tool gives an overestimated value and the density gives an underestimating value so the N-D Vsh will give a non-confidence value of shale percentage so the correction of gas effect will be an obligation.

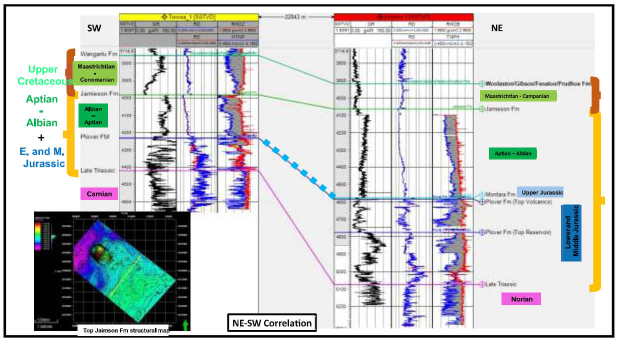


Figure 13: NE-SW correlation between the Torosa and Kronos well.

Stratigraphic Sequences Analysis

a. The Late Triasic sequence 3

The Late Triassic Sequence in the Torosa well consists of Carnian sediments, while the Kronos well contains Norian sediments. The Norian sequence is missing in the Torosa welland it is is characterized by sandstone, siltstone, and calcilutite interbeds. The Torosa well shows a shale-dominant lithology in the lower interval and a carbonate-dominant lithology in the upper interval. The Norian sequence in the Kronos well is retrogradational and has the potential to be a source rock.

In order to understand the lateral distribution of the Late Triassic sequence, we generated an RMS amplitude stratigraphic attribute map. The RMS amplitude map shows a generally low amplitude in all the AOI, but in the SE part of the AOI, it shows an increase of the amplitude to 50 and 60. This high amplitude in the SE part of the AOI is interpreted to be the effect of the Late Triassic unconformity.

Integrating all of the available data, the authors generated a GDE map for the upper Triassic sequence, Norian sequence (Fig 14). The GDE map shows an upper to lower shoreface depositional environment that becomes deeper to the NW part in the AOI.

a. Lower and Middle Jurassic Sequence

The Lower and Middle Jurassic interval in the AOI is a complex system with a strong tectonic control. The deposition of sedimentary and volcaniclastic rocks in the Jurassic Plover Formation is controlled by volcanic events, which are in turn controlled by the tectonic activity.

The paleogeography map shows that the NW Australian shelf was in the carbonate window deposition during the early Jurassic. The generated cross-plots confirms that and shows in the Kronos and Torosa wells a potential for limestone and dolomite deposition.

However, the Jurassic Plover Formation has a complex lithology due to the presence of volcaniclastic sediments.

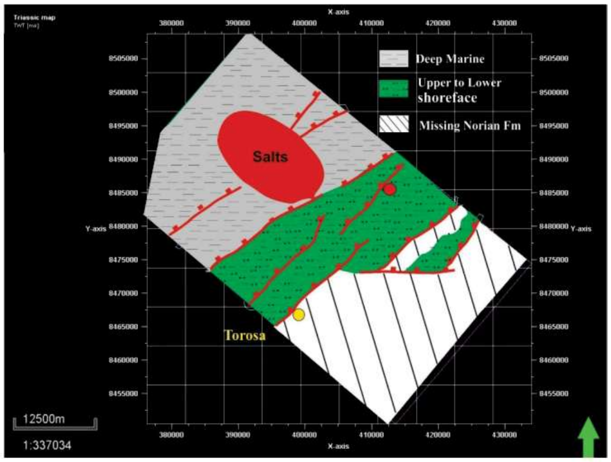


Figure 14: GDI map of the late Triassic, Norian sequence.

There is a huge thickness change in the Jurassic sequence, with the Kronos well to the north being 2.5 times thicker than the Torosa well to the south. This is due to the syn-rift mega sequence and the syn-sedimentation tectonic control. The Kronos well is also closer to the source of the volcaniclastic sediments.

The top of the Jurassic Plover sequence is represented by a regional unconformity, which may explain the thinning of the upper volcaniclastic sequence in the Torosa well. The middle volcaniclastic interval also shows a thickness change, being 14m in the Torosa well and 40m in the Kronos well.

The sandstone packages are better developed in the Torosa well than the Kronos well, which has a higher potential for shale deposits. This is due to the deepening of the Kronos well compared to the Torosa well.

The GDE map for the lower and middle Jurassic sequence (Fig 15) shows a shoreface depositional environment, with sand facies in the up thrown block and shale facies in the downthrown block, becoming deeper to the NW part of the AOI.

b. Upper Jurassic Lower Cretaceous Sequence:

The Upper Jurassic and the lower part of the lower Cretaceous sequences, Montara and Vulcan Fms, are not present in the Torosa well, but are present in the Kronos well, where they are poorly developed.

The Upper Jurassic and lower Cretaceous sequences were deposited on the SE and on the NW Flank of the middle ridge as a wedges and onlapped the lower and middle Jurassic sequence and does not exist above the NE-SW ridge in the middle part of the AOI.

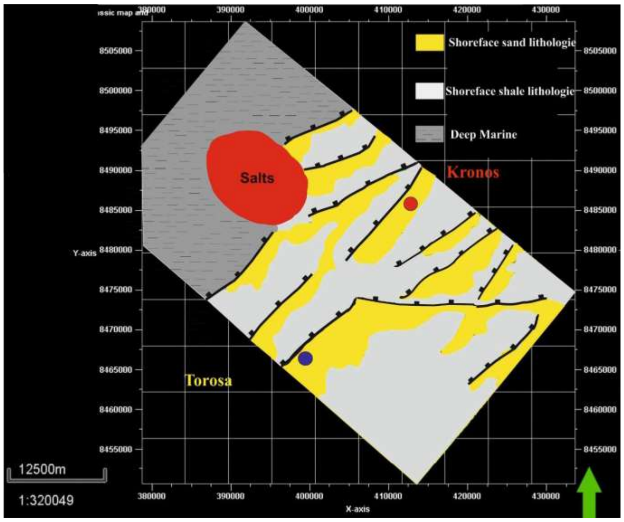


Figure 15: GDE map for the Lower and Middle Jurassic sequence.

In the western part of the AOI, the Upper Jurassic and the lower Cretaceous sequence onlapped the middle and Early Jurassic sequence. To the North, the Vulcan and Montara Fms deposited in a successive small half Graben represented by a lateral thickness change and marked the syn-sedimentation tectonic control. However, In the Eastern part of the AOI, the Vulcan and Montara Fms well define a lateral thickness change but does not show a considered thickness variation from the South to the North as well as the NW part of our AOI.

c. The Aptian-Albian sequence

The Aptian-Albian sequence is represented by the Jaimson Formation. The Torosa well shows a shale-dominant lithology, while the Kronos well shows a sandstone-dominant lithology. The Jaimson Formation is characterized by high gamma ray (GR) values, high shale volume (Vsh), and a positive neutron-density (N-D) separation. The presence of small volcanoclastic intervals is indicated by successive picks of density coinciding with a decreasing GR and a positive N-D separation.

The agradational Atian-Albian sequence onlapped the lower intervals of lower cretaceous sequence and filled the inherited topography form the Previous Jurassic and Triassic Tectonic events, represent the post rift mega sequence and indicate a small thickness variation due to the inherited structure define the principal seal for the Principal Jurassic targets in our AOI. Represent an offshore depositional environment became deeper to the NW part of the AOI.

d. The Late Cretaceous Sequence

The Late Cretaceous Sequence in the Torosa well is the

Wangarlu Formation, while in the Kronos well is the Woolaston/Gibson/Fenalon/Prudhoe Groups formations. The Wangarlu Formation is calcareous claystone interbedded with calcilutite, while the upper Cretaceous formations consist of calcareous claystone with trace claystone and sandstone. The Torosa well shows a dolomite-dominant lithology in the lower interval and a shale-dominant lithology in the upper interval. The Kronos well shows a sandstone-dominant lithology.

The Late cretaceous sequence represent a major sea level fall defined by an inconformity and onlapped the Atian-Albian sequence and represent a lateral thickness and facies change due to the late Cretaceous and Tertiary sub-marine channel erosion (Fig 16).

The late cretaceous interval s well define the presence of U shape sinuous submarine channel system verified by different methods probably sand filled, erode and remove the Cenomanian-Santonian sequence (Fig 16). Also a second Tertiary sinuous sub-marine channel system affect and erode the late cretaceous sequence and sometimes remove all of it and reach the Atian-Albian sequence (Fig 17). We subdivide the late cretaceous interval into two intervals a Cenomanian-Santonian interval represent a carbonate platform depositional environment and Campanian-Mastrichtian represent a deep marine and submarine channel depositional environments.

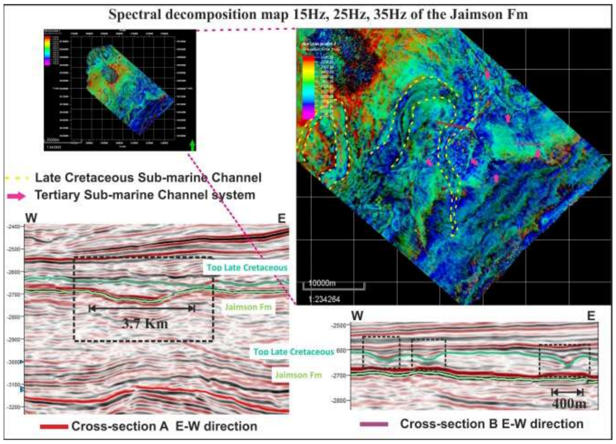


Figure 16: Spectral decomposition Of the Top of Jaimson Fm, Aptian-Albian age.

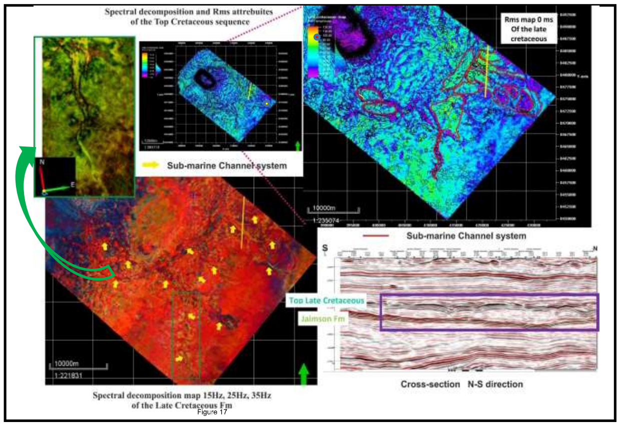


Figure 17: Spectral decomposition and Rms attrebuites for the Top Cretaceous map.

CONCLUSION AND DISCUSSION

The Mesozoic section represent our interval of interest in this research project. The late Triassic and the Jurassic are a part of the syn-rift mega-sequence and the Aptian-Albian and the upper cretaceous are a part of the Post rift mega-sequence.

Our area of interest in the Browse basin well represent a Late Triassic and Jurassic NE-SW to NNE-SSW major normal faults system affect at least the Triassic sequence and reconstruct the AOI as a Successive Half Graben controlled at least the Late Triassic and Jurassic sedimentation represented by a lateral facies and thickness change. Instantaneously with the NE-SW faults system our AOI define also an E-W to ENE-WSW complex fault system.

The pre-Rift mega sequence highly affected by the normal faults system from the Late Triassic and Jurassic rifting events and may define an igneous intrusion dyke and sills system. The late Triassic sequence well define a lateral thickness change represent a syn sedimentation extensive tectonic control, represent the rift initiation and deposited in upper to lower shoreface depositional environment in the Norian age, become deeper to the NW part. This Late Triassic sequence represent a progradational sequence from the Carnian to the Norian age with a good organic matter richness in the Carnian sequence. It well indicates an unconformity in the top of the Triassic sequence strongly effect the SE part of the AOI and caused the remove of the Norian sequence in the Torosa well and represent the passage to the next Jurassic rifting stage.

The Jurassic sequence well define the syn-rift mega sequence indicate an extensional tectonic control sedimentation represented by a clear lateral thickness change on a successive Half Graben structuration. It well represents a lateral amplitude change indicate the lateral facies change, it represents a shoreface depositional environment in the lower Jurassic interval and it became more deep to the NW part.

The Lower and Middle Jurassic sequence, Plover Fm, well represent the first potential of sandstone gas bearing reservoir of our AOI it defines a good potential in the Torosa well compared to the Kronos well. The syn-sedimentary lower and Middle Jurassic sequence, controlled also by the volcanic events activity which is directly controlled by the tectonic, for each tectonic reactivation we have volcanic events enhancement and as a result the deposition of volcanoclasic sediment.

The interval of Upper Jurassic and the lower cretaceous sequences Montara and Vulcan Fms, dose not well developed to absent on the NE-SW ridge. It represents a thickening to the NW and SW flank, also it onlapped the middle and lower Jurassic sequence. This interval well defines a local late Jurassic tectonic reactivation to the North eastern part of the AOI affect the sedimentation and well define a lateral thickness variation in a successive Half Graben structuration.

The Atian-Albian post rift mega sequence, onlapped the lower cretaceous sequence, filled all the inherited topography and indicate a small thickness variation due to the inherited topography from the previous tectonic events, deposited in an offshore depositional environment and define the principal seal for the principal Jurassic targets in the AOI.

The late cretaceous sequence onlapped the Aptian-Albian sequence and well indicate a lateral thickness and facies change. The Cenomanian-Santonian interval represent a carbonate platform depositional environment and the Campanian-Mastrichtian represent a deep marine and submarine channel depositional environments probably sand filled.

This sequence highly affected by the Tertiary sub-marine channel system caused the erosion of the late cretaceous sequence and sometimes the total remove of the sequence reaching the Albian-Aptian sequence.

The AOI shows the presence of salt remote on the NW part affected the Mesozoic interval, and reach the surface, and caused the planification of fault behind the sault and generate a radial fault system in all directions around it. Which is clear that the salt remote affect the basin evolution and affect all the Mesozoic and Cainozoic sequences. This salt mechanism not well defined so far so understanding this salt mechanism is a good topic to focalize on it and to understand how this salt affect the basin evolution and their impact on the petroleum system.

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