

Prospective Carbonate Neocomian Trends (Makhul, Minagish and Ratawi Formations) in Southwest Kuwait*

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Abstract

Neocomian strata (Makhul, Minagish, and Ratawi Formations) of southwest Kuwait were studied to evaluate additional exploratory opportunities. Cores, well logs, and reports from over 50 key wells were used to identify stratigraphic trends and refine play concepts. Stratigraphic analysis and mapping resulted in better understanding of stratigraphic context and paleogeographic distribution of potential reservoirs.

Neocomian strata in Kuwait are interpreted as sequence comprised of a TST represented by the Makhul Formation and an HST represented by the Minagish and Ratawi Formations (Sharland et al., 2001). In this study, these strata are interpreted as multiple seaward-stepping cycles. The Makhul Formation represents a four-part asymmetric cycle, the lower three cycles stepping seaward and the upper cycle stepping landward. The Minagish Formation conformably overlies the Makhul Formation and is interpreted as a two-part asymmetric cycle, the lower fall hemicycle stepping landward and the upper rise hemicycle stepping seaward. Finally, the Ratawi Formation constitutes a two-part fall asymmetric cycle where the Ratawi Limestone cycle steps seaward and is overlain by a more “clastic” cycle which also steps seaward.

Using regional mapping, this study updated previous work and identified the following stratigraphic and paleodepositional trends that may control the distribution of reservoirs. The Makhul Formation changes facies from higher energy conditions in the SW to lower energy conditions in the NE (i.e. Middle ramp - inner ramp to outer ramp). The Minagish Formation shows oolitic facies only at the

Rugei, Minagish, Abdaliyah, and Umm-Gudair Fields. Facies change toward lower energy conditions from SW to NE. Finally, The Ratawi Formation changes from higher to lower energy facies from SW to NE.

Paleogeographic mapping of the Ratawi Shale member revealed an important reentrant feature. This feature is characterized by the presence of shaly facies located at the Minagish and Umm-Gudair Fields which are surrounded by sandy facies at the Rugei and Dharif Fields.

Selected References

Abreu, V.D., and G.A. Haddad, 1998, Glacioeustatic fluctuations: the mechanism linking stable isotope events and sequence stratigraphy from the early Oligocene to middle Miocene, *in* P.-C. de Graciansky, J. Hardenbol, T. Jacquin, and P.R. Vail, (eds.), *Mesozoic and Cenozoic sequence stratigraphy of European basins: Special Publication, Society for Sedimentary Geology*, v. 60, p. 245-259.

Haq, B.U., J. Hardenbol, and P.R. Vail, 1987, Chronology of fluctuating sea levels since the Triassic: *Science*, v. 235, p. 1156-1167.

Harris, P.M., and W.S. Kowalik, 1994, Satellite images of carbonate depositional settings; examples of reservoir- and exploration-scale geologic facies variation: *Methods in Exploration Series II*, 147 p.

Sharland, P.R., R. Archer, D.M. Casey, R.B. Davies, S.H. Hall, A.P. Heward, A.D. Horbury, and M.D. Simmons, 2001, Arabian Plate sequence stratigraphy: *GeoArabia Special Publication*, v. 2, 371 p.

PROSPECTIVE CARBONATE NEOCOMIAN TRENDS (MAKHUL, MINAGISH AND RATAWI FORMATIONS) IN SOUTHWEST KUWAIT

Presenter: Hanan Al-Owihan.

AAPG 2012 Annual Convention & Exhibition in Long Beach, California.
Abstract ID: 1236077

April 23rd , 2012

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- Kuwait Oil Company and Ministry of Kuwait Oil, for permission to present the informations.
- Kuwait Oil Company Management.
- The Team Leader Of Prospect Evaluation team.
- The Manager of Exploration group.

OUTLINE



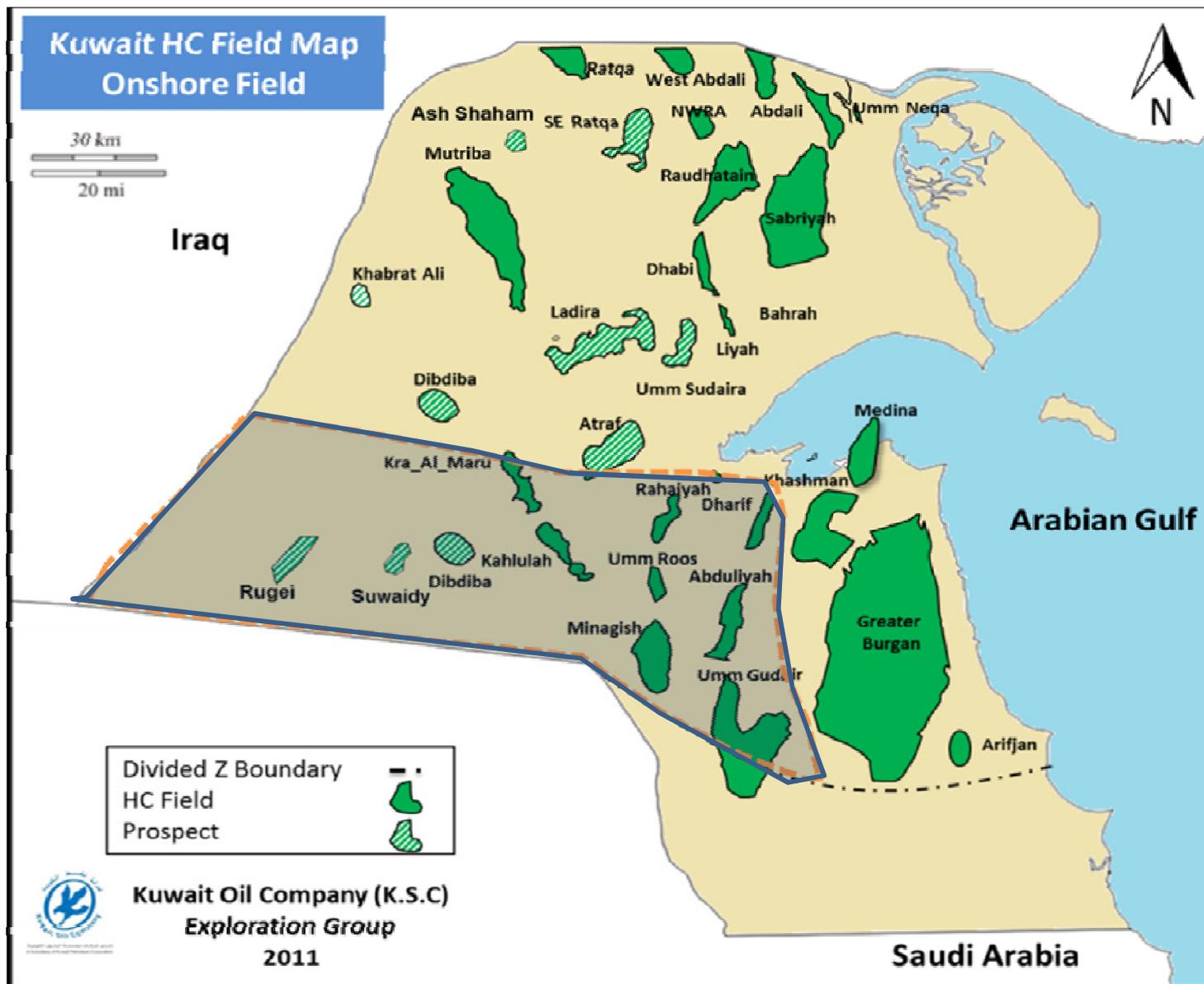
- Introduction
- Study Area
- Type Log
- Makhul , Minagish and Ratawi Formation
 - Stratigraphic Context and Synthesis
 - Hard Data, Paleogeographic and Depositional Models.
- Reservoir Mapping and Correlations for Lower Cretaceous units.
- Supporting Data: Petrophysics, Log Evaluation, Oil Shows and Production Data.
- Prospectivity Trends for Lower Cretaceous Units.
- Summary and Conclusions.

INTRODUCTION



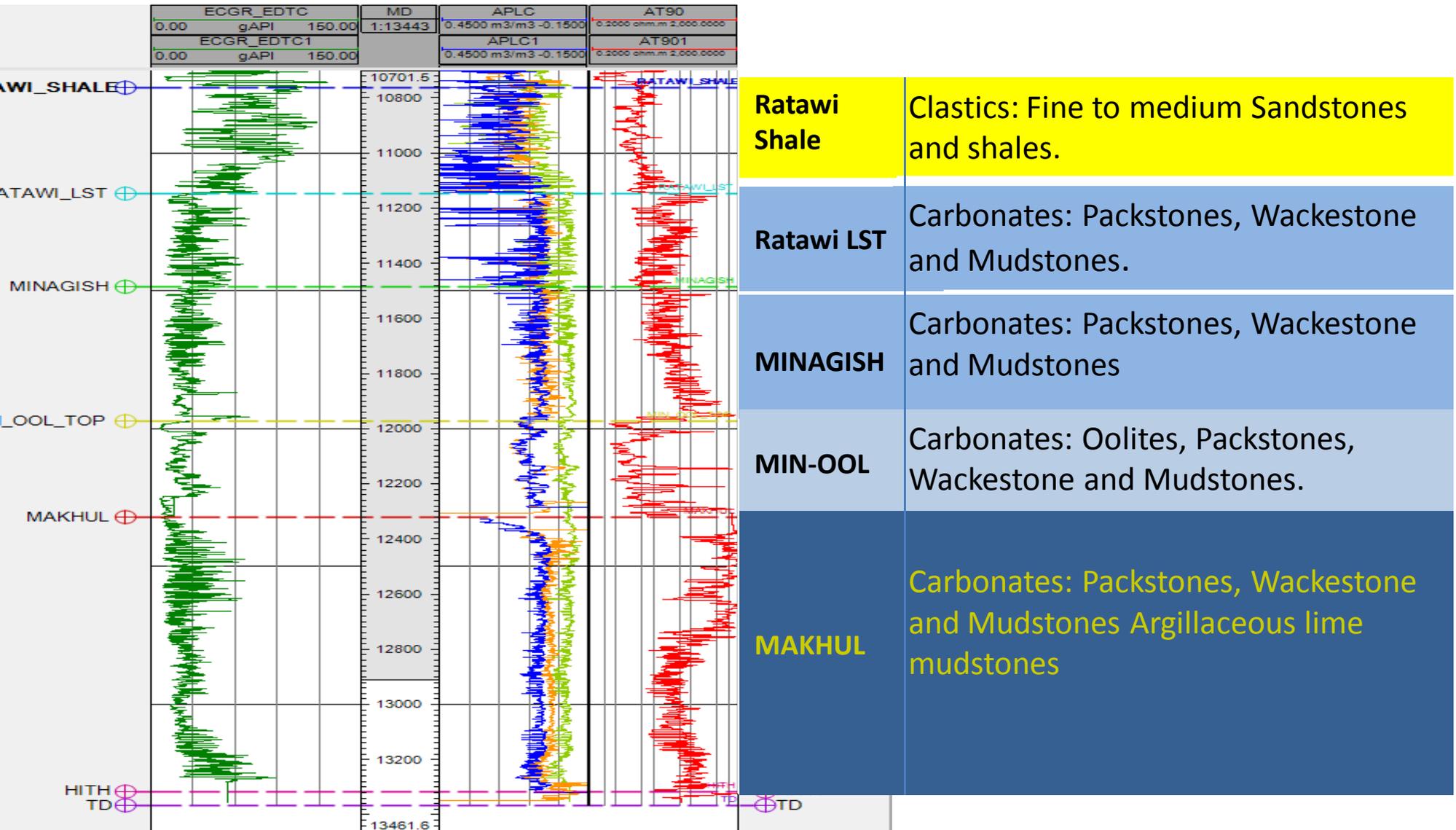
- Makhul, Minagish and Ratawi Formations: 16 Ma time span, and more than 2500' of section in SW Kuwait. Need for Higher resolution knowledge.
- **Makhul Formation**: Progressively recognized as non-conventional reservoir (Source and reservoir, plus dual porosity character).
- **Minagish Formation** : Vertical and lateral facies change from Oolitic to Shalier Limestones and patchy nature within Kuwait.
- **Ratawi Formation** : Change from Carbonate ramp to first deltaic pulse in Kuwait.
- Re-visiting the Lower Cretaceous prospectivity.
- Reviewing what we “Know” and defining questions for near future.
- Looking to KOC 2030 strategy.

STUDY AREA: SWK



Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22 -25 April , 2012.

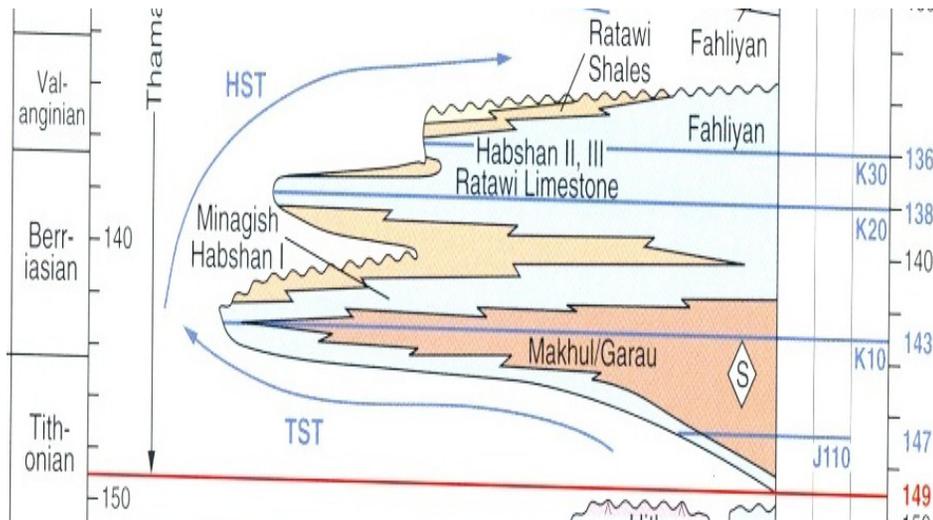
TYPE LOG FOR NEOCOMIAN (LOWER CRETACEOUS) UNIT



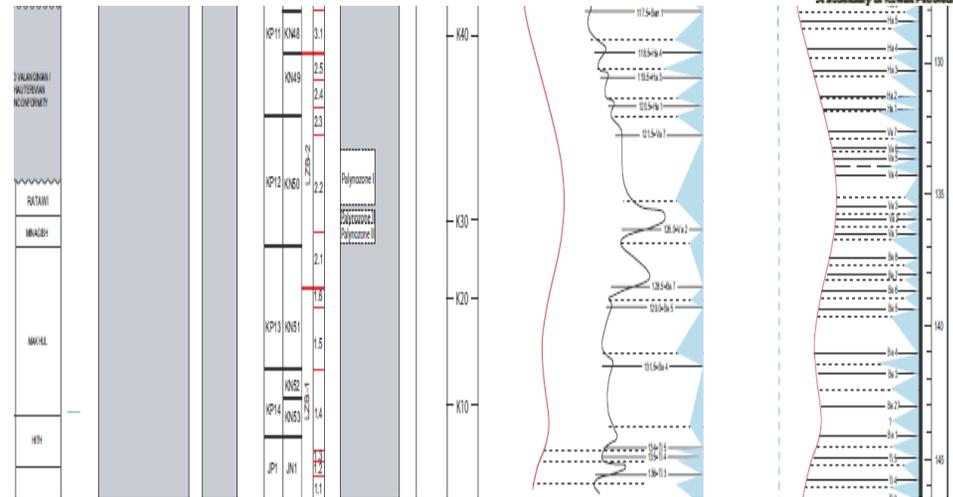
STRATIGRAPHIC CONTEXT AND SYNTHESIS



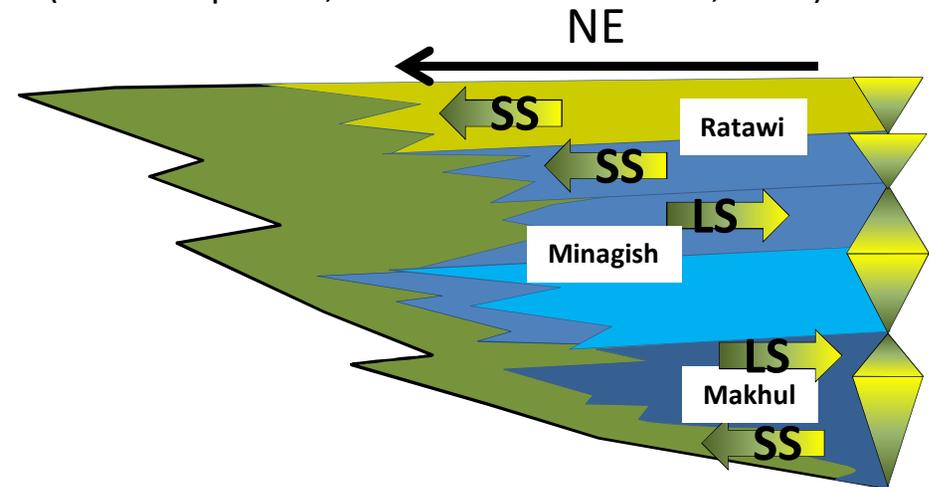
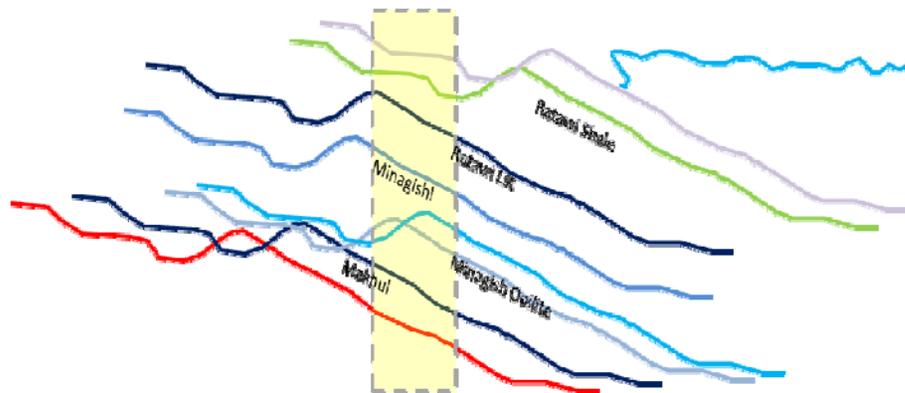
شركة نفط الكويت
Kuwait Oil Company
إحدى شركات مؤسسة البترول الكويتية
A Subsidiary of Kuwait Petroleum Corporation



(From Sharland et. al., 2001)



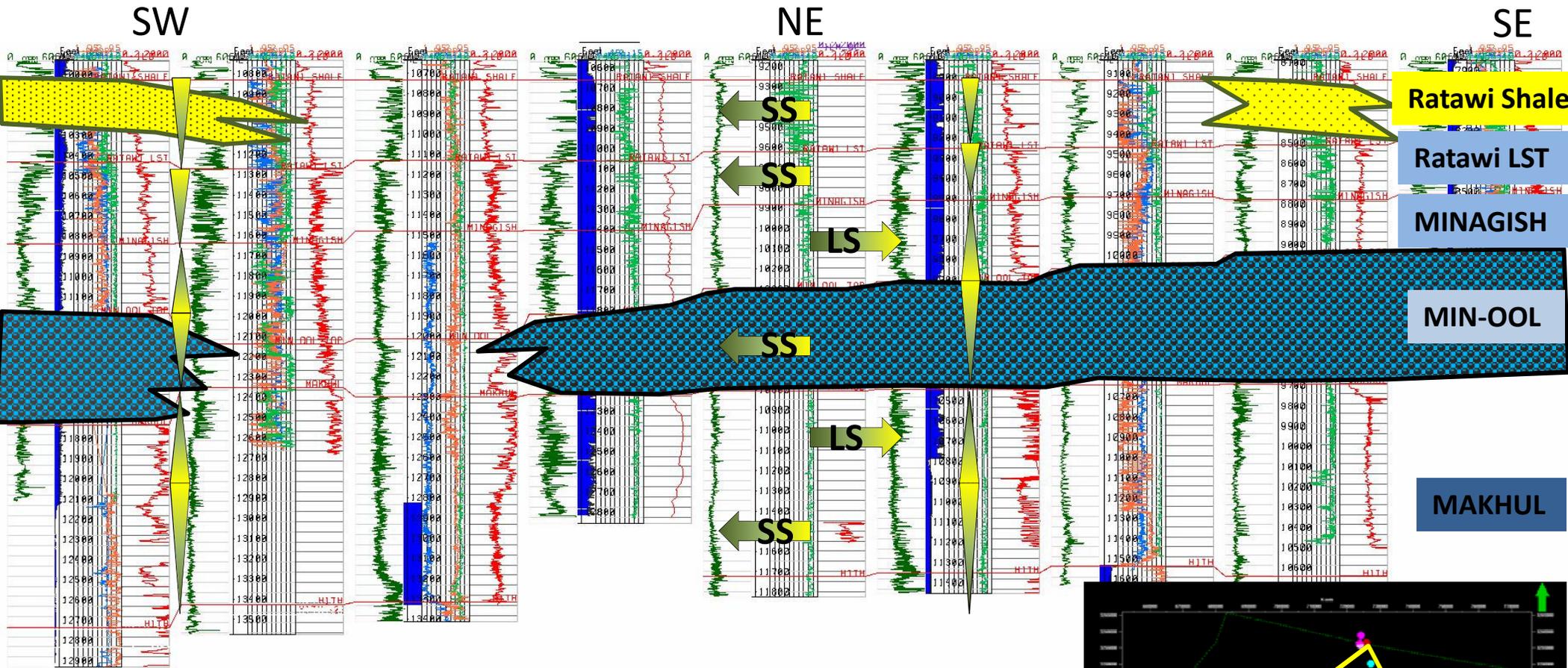
(From Haq et. Al., 1987 and Abreu et. al., 1998)



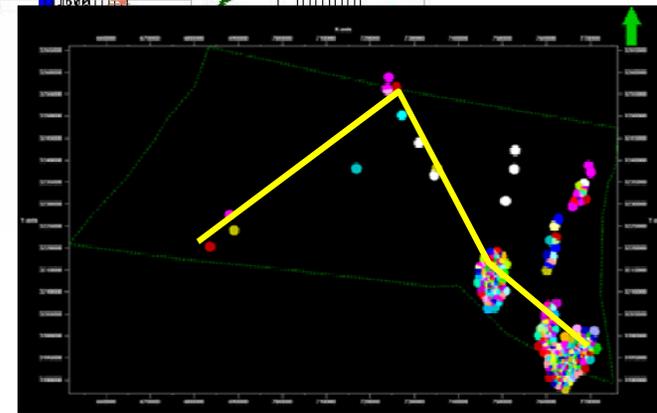
- Baselevel Rise
- Baselevel Fall
- LS Landward Stepping
- SS Seaward Stepping

Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22 -25 April , 2012.

STRATIGRAPHIC CONTEXT FOR LOWER CRETACEOUS PROSPECTIVITY

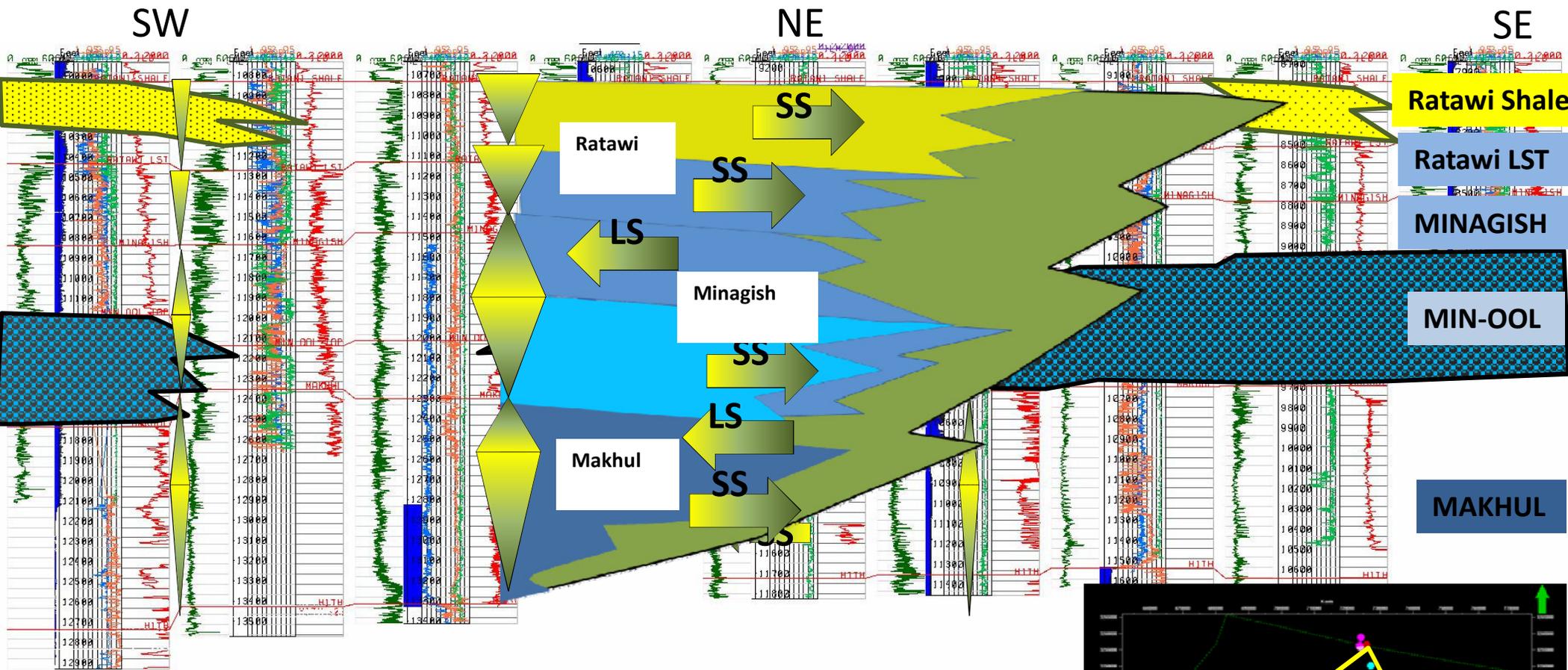


 Baselevel Rise  LS → Landward Stepping
 Baselevel Fall  SS ← Seaward Stepping

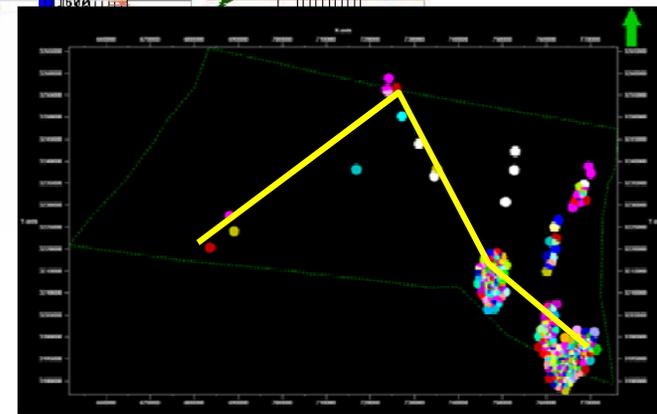


Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22 -25 April , 2012.

STRATIGRAPHIC CONTEXT FOR LOWER CRETACEOUS PROSPECTIVITY



-  Baselevel Rise
-  Baselevel Fall
-  LS Landward Stepping
-  SS Seaward Stepping

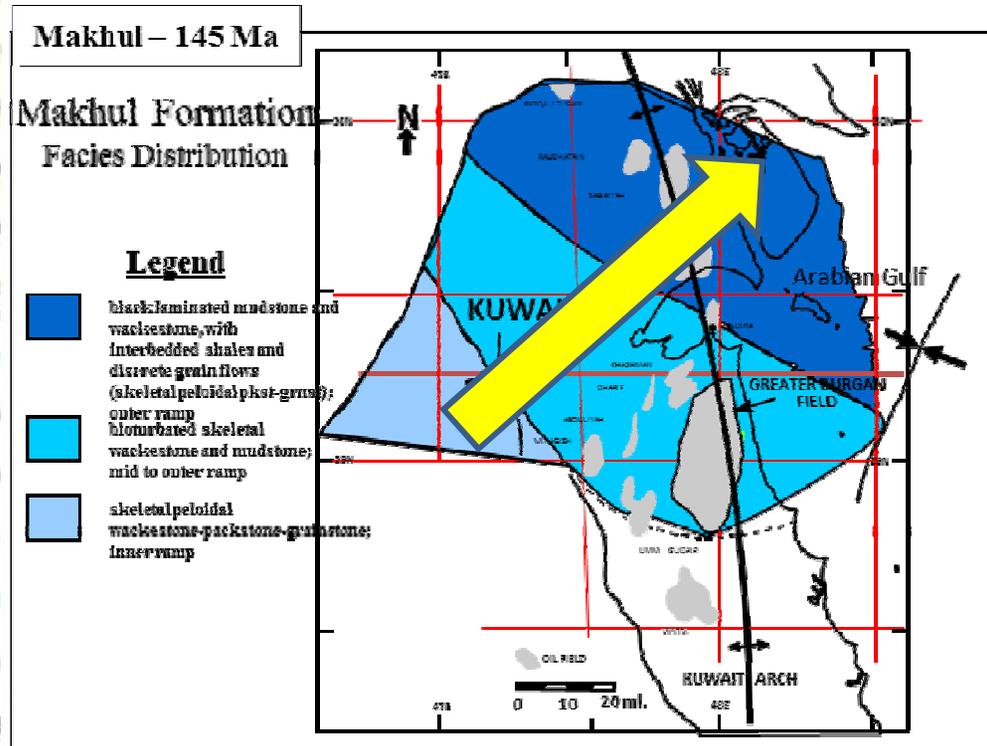
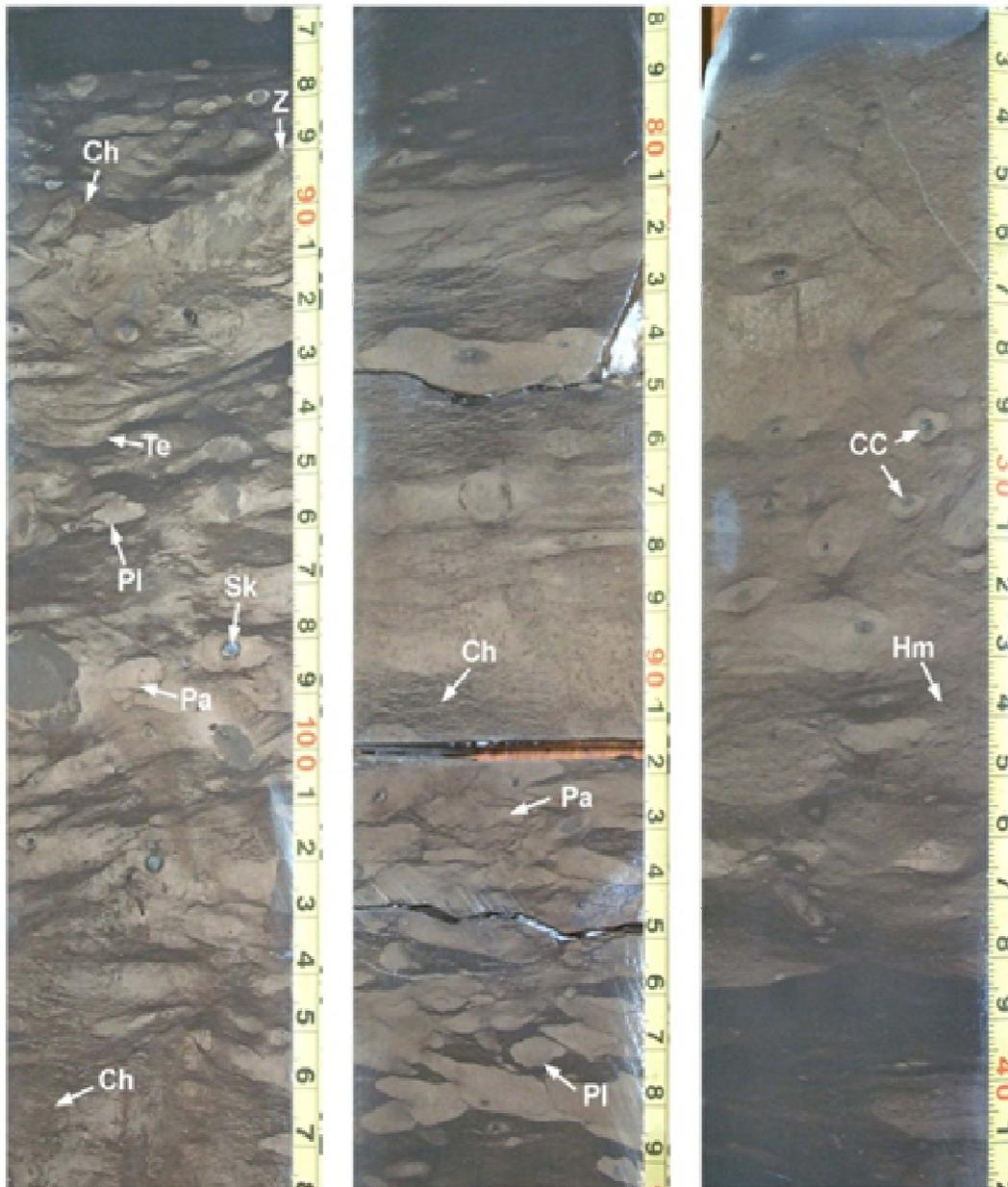


Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22 -25 April , 2012.

MAKHUL FORMATION

MAKHUL FORMATION

Lithology & Facies Distribution



(FROM: JACKSON, 2004)

Packstones, Wackestone, Mudstones and Argillaceous lime mudstones

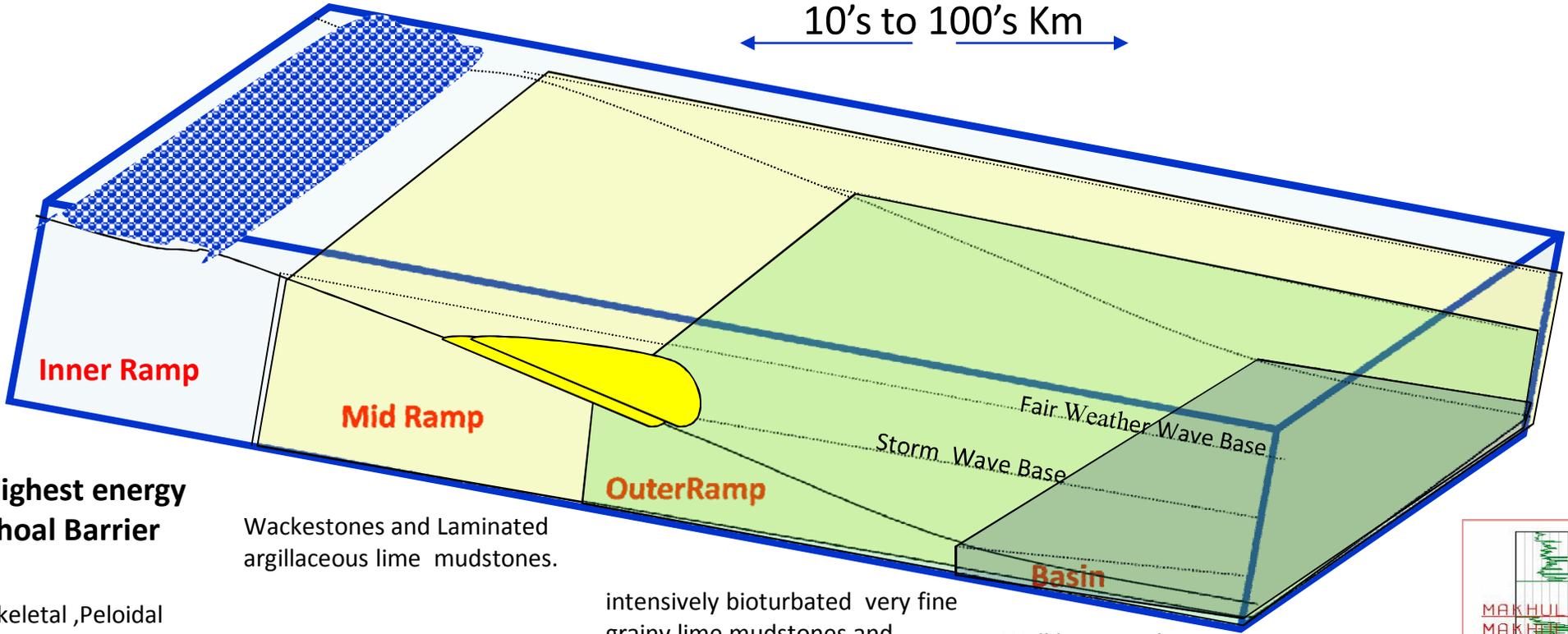
MAKHUL FORMATION

Depositional Model

LOWER MAKHUL

Lagoon, Tidal Flat
Sabkha

10's to 100's Km



Inner Ramp

Mid Ramp

Outer Ramp

Basin

Fair Weather Wave Base

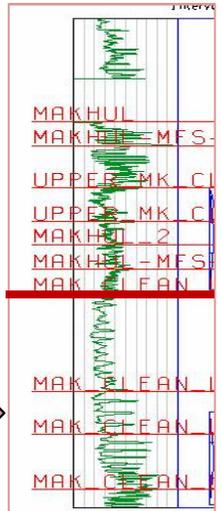
Storm Wave Base

**Highest energy
Shoal Barrier**

Wackestones and Laminated
argillaceous lime mudstones.

intensively bioturbated very fine
grainy lime mudstones and
wackestones.

Well laminated
argillaceous



Lower Makhul

- Lower Makhul
- Middle-Outer Ramp Settings

Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22 -25 April , 2012.

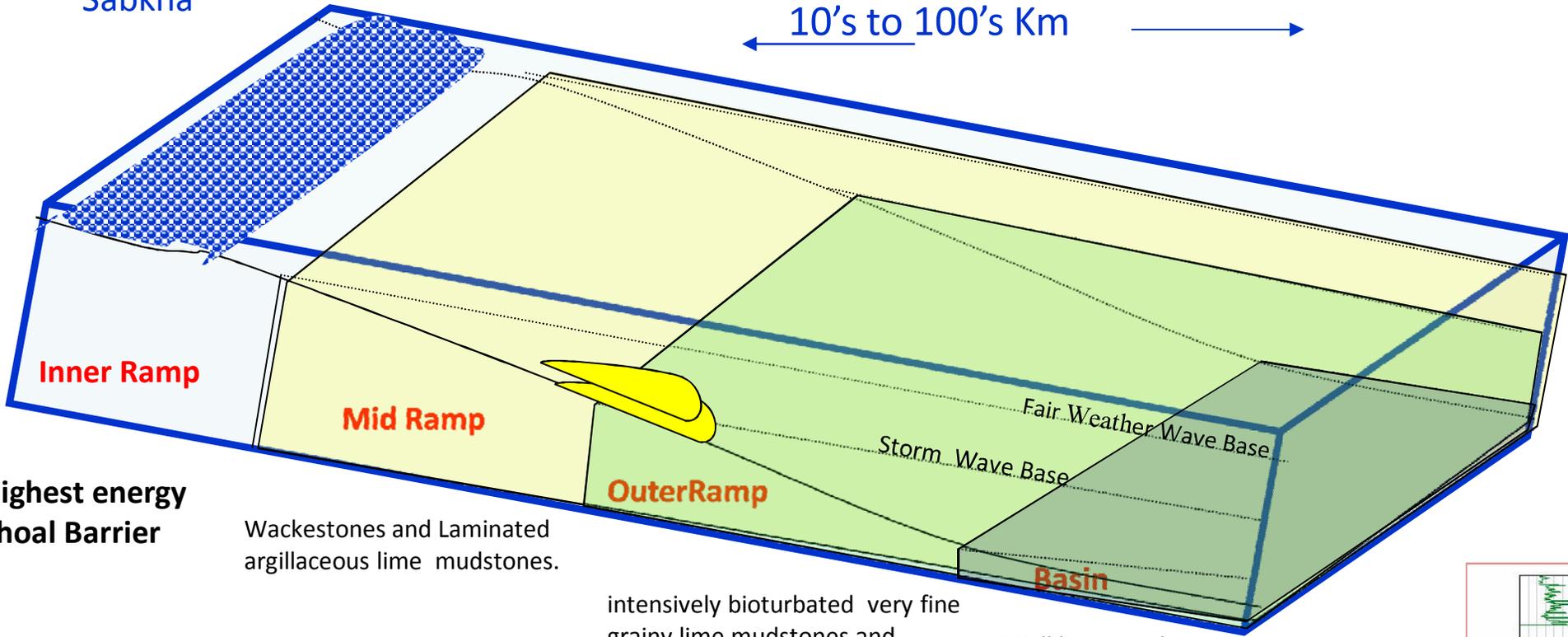
MAKHUL FORMATION

Depositional Model

UPPER MAKHUL

Lagoon, Tidal Flat
Sabkha

10's to 100's Km



Inner Ramp

Mid Ramp

Outer Ramp

Basin

Fair Weather Wave Base

Storm Wave Base

**Highest energy
Shoal Barrier**

Wackestones and Laminated
argillaceous lime mudstones.

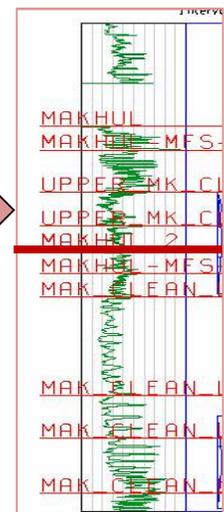
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Well laminated
argillaceous

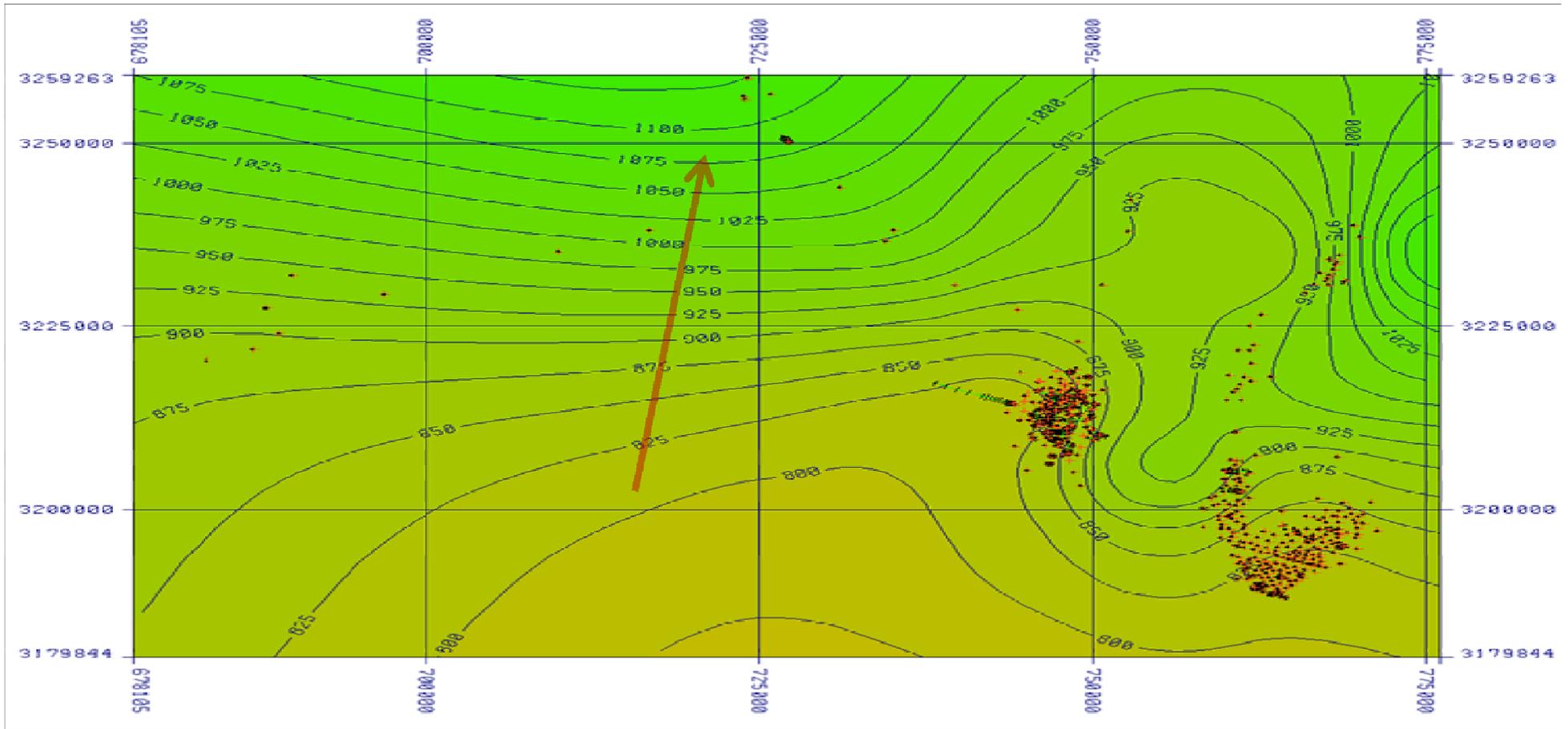
Skeletal ,Peloidal
Oolitic Shoals

Upper Makhul
Outer- Middle Ramp Settings

Upper Makhul



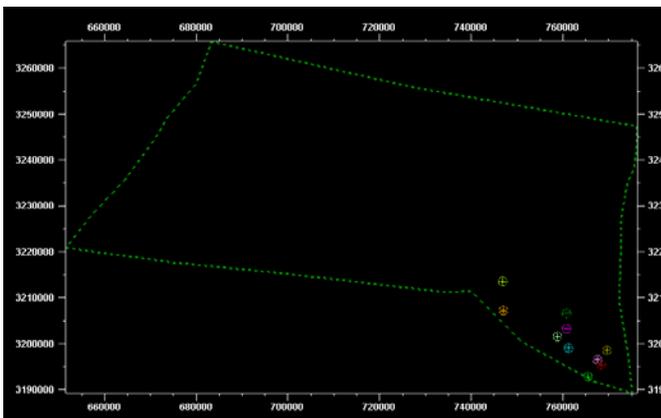
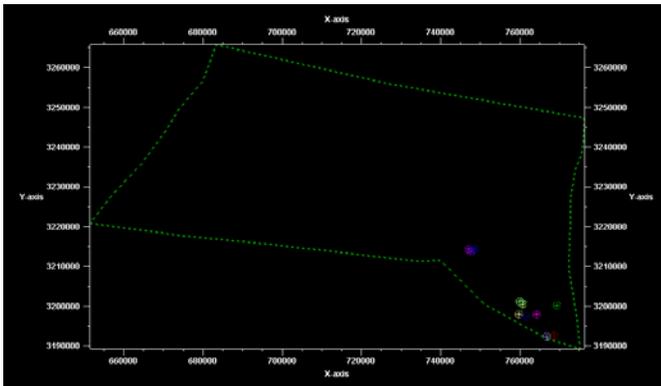
MAKHUL FORMATION THICKNESS MAP



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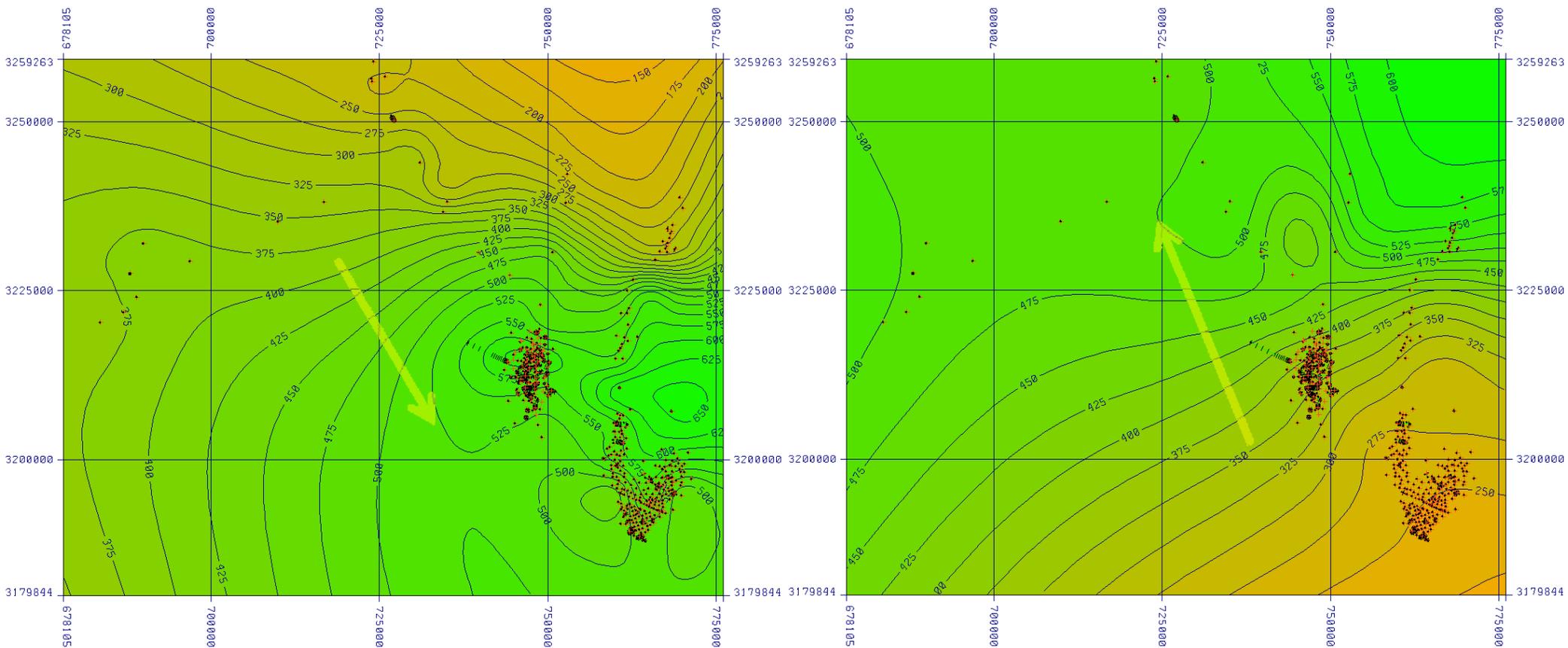
MINAGISH FORMATION

MINAGISH OOLITE AND MINAGISH CORE IN SWK AREA



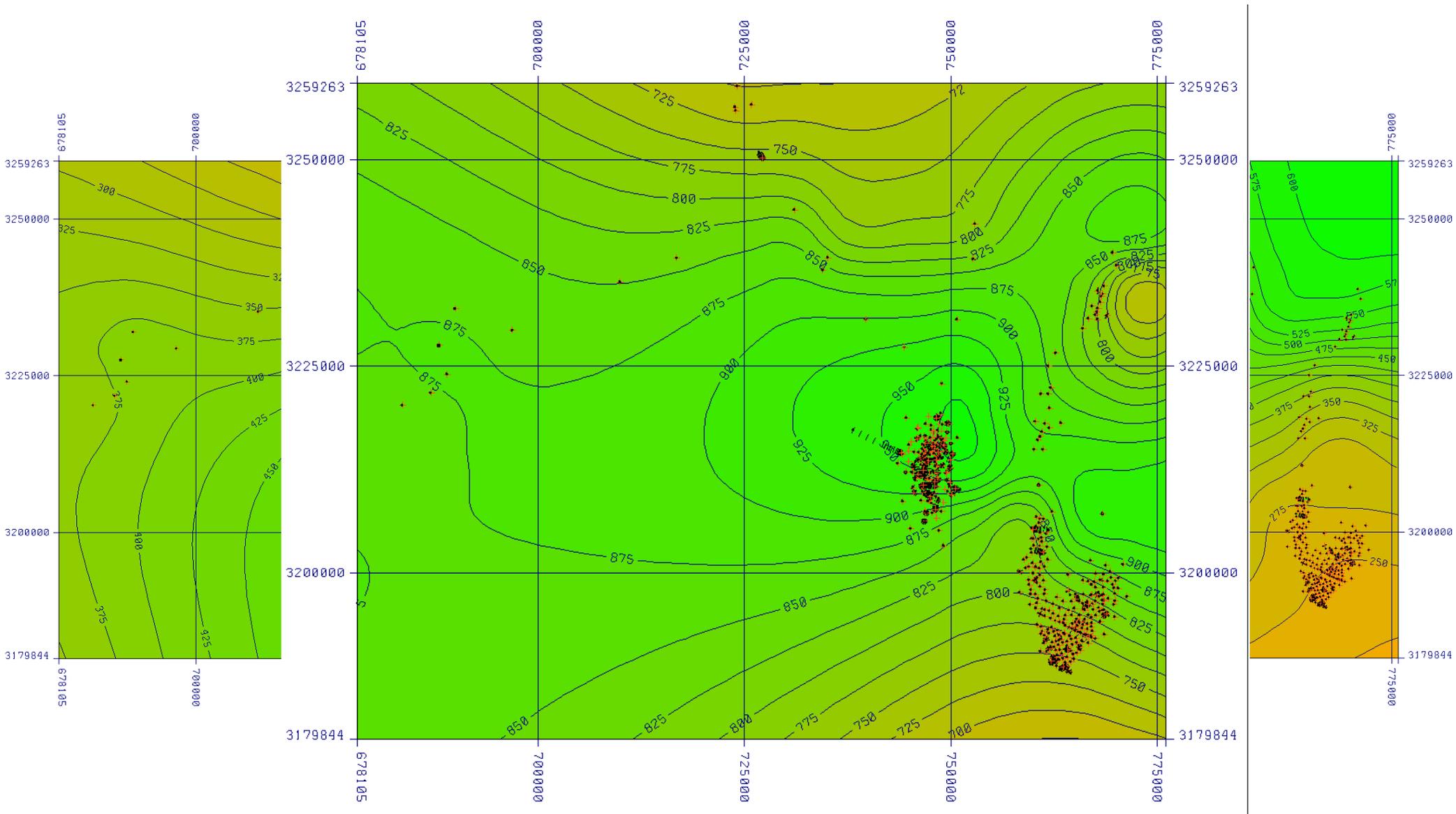
Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22 -25 April , 2012.

THICKNESS MAPS: MINAGISH OOLITE AND MINAGISH LIMESTONE



Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22 -25 April , 2012.

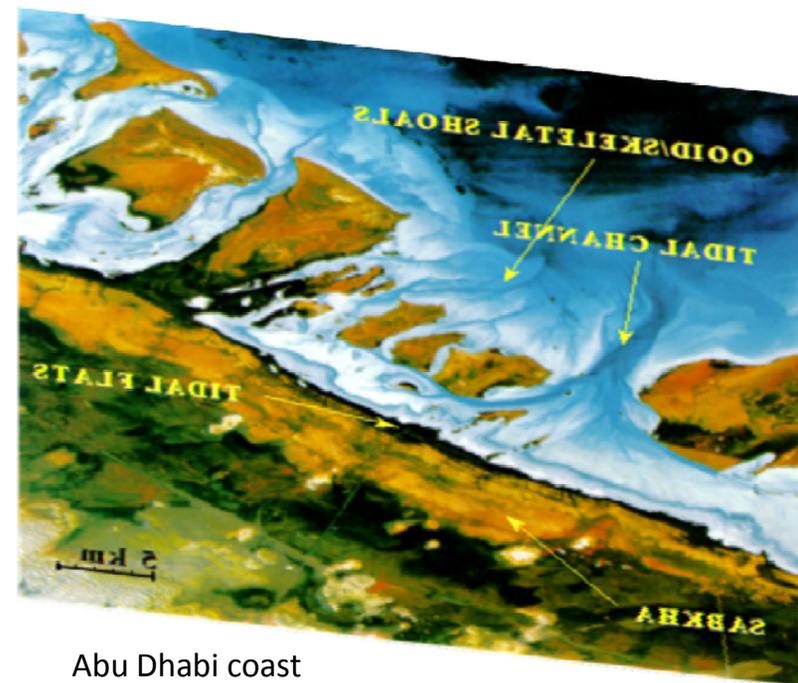
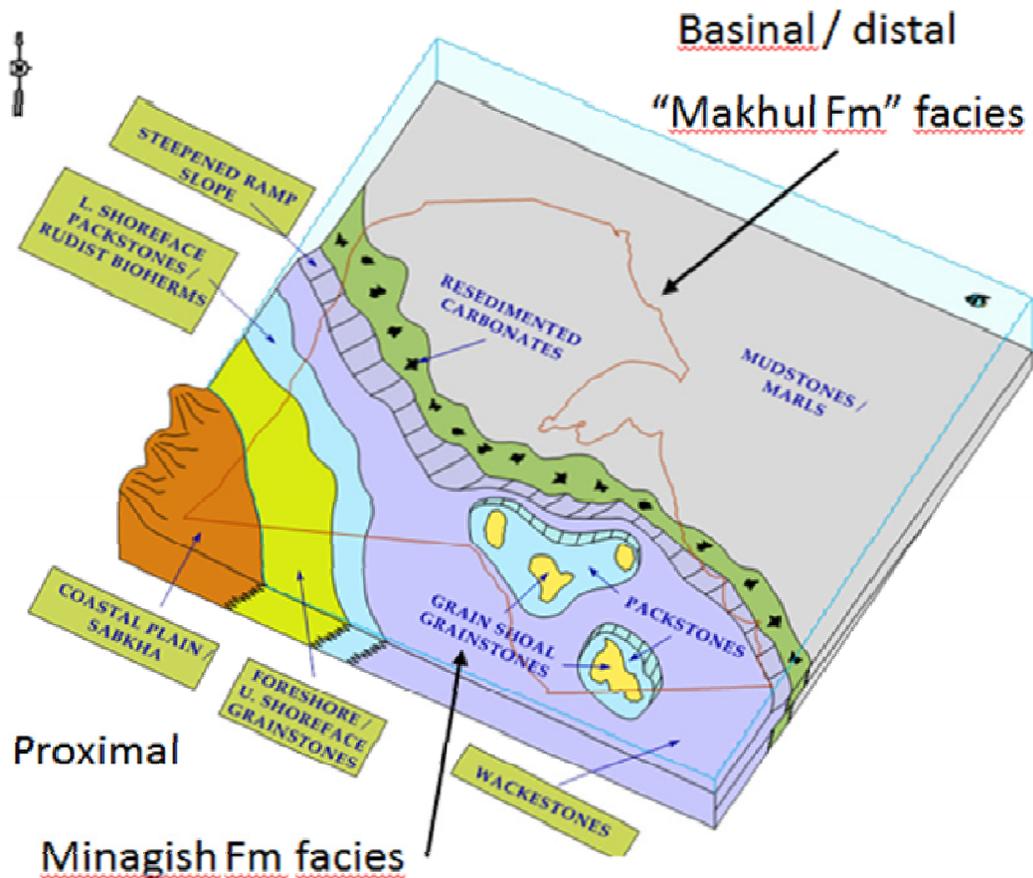
THICKNESS MAPS: MINAGISH OOLITE AND MINAGISH LIMESTONE



Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22 -25 April , 2012.

MINAGISH DEPOSITIONAL MODEL

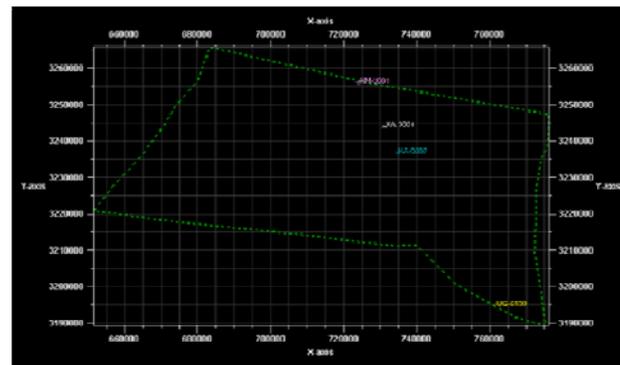
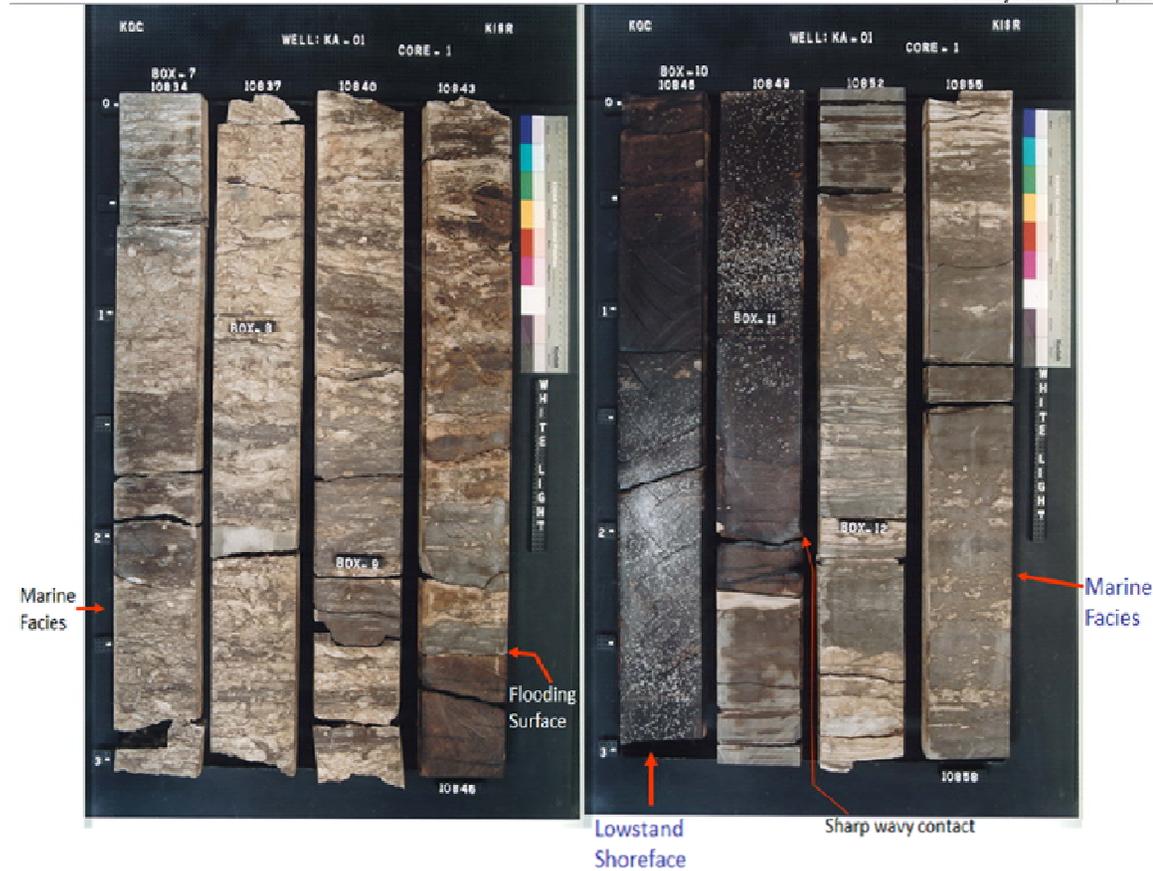
Conventional Model Play Concept – Minagish Fm
Berriasian Palaeogeography map of Kuwait



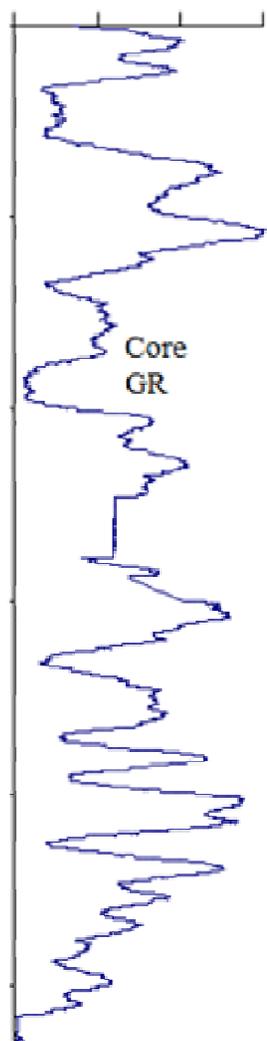
Abu Dhabi coast
(from Harris and Kowalik, 1994).

RATAWI FORMATION

RATAWI LIMESTONE AND RATAWI SHALE



RATAWI SHALE

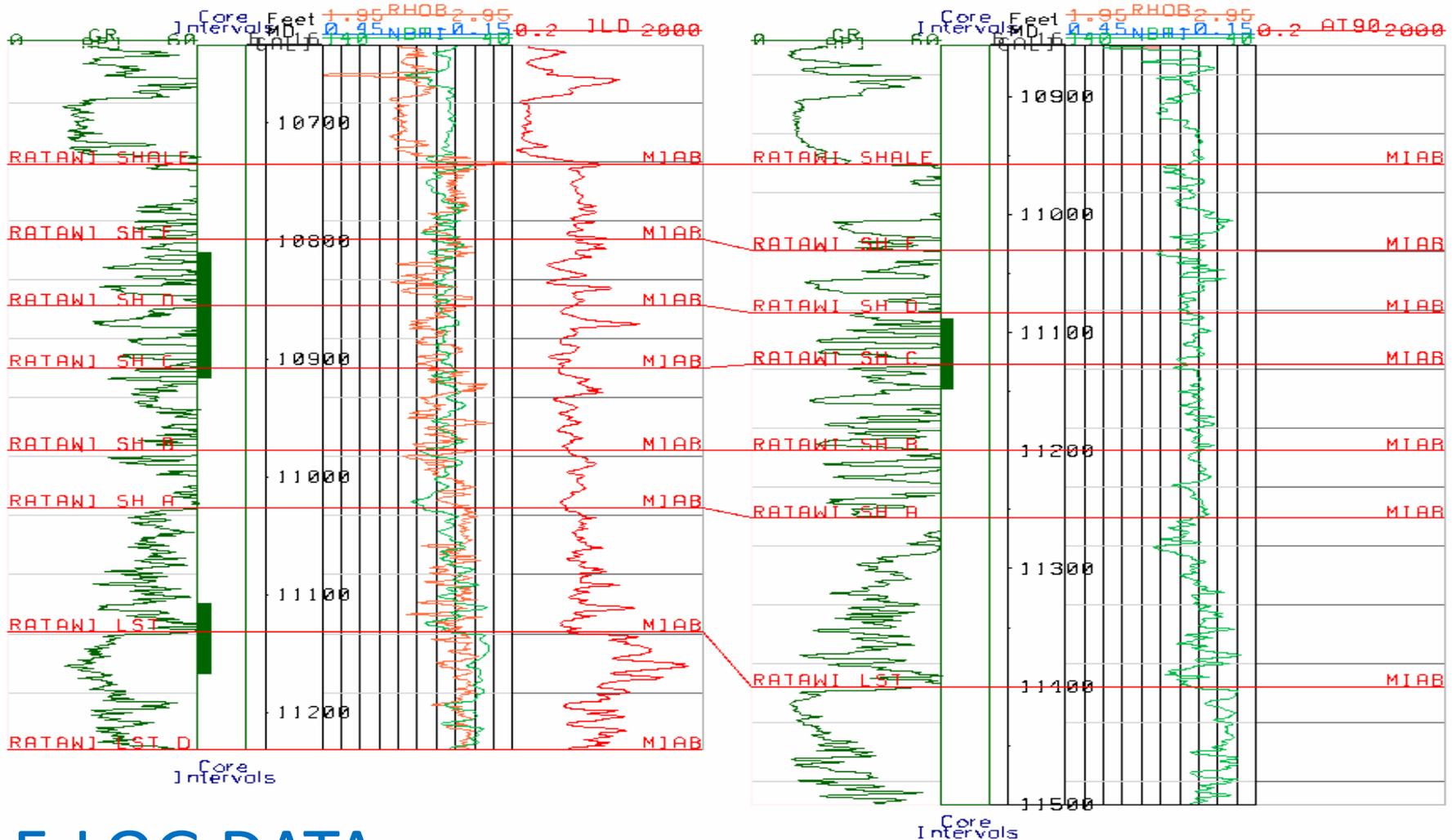


Depth (ft)	Description	Environments
10810'	Sandstone; light grey, calcareous, bioturbated.	Middle shoreface
10820'	Sandstone; light to medium grey, fine-grained, dark brown oil staining. Conglomerate; with 1-2cm diameter rounded likely clay pebbles.	Middle-upper shoreface
10830'	Shale; medium grey, smooth, calcareous.	Offshore
10840'	Sandstone; light greenish grey, fine-medium grained, nodular appearance due to bioturbation.	Middle shoreface
10850'	Sandstone; medium grey, dark brown oil staining, fine-medium grained, dark brown oil staining, homogenous with rare horizontal lamination, prominent white specks.	Upper shoreface
10860'	Sandstone; light yellowish grey, fine-grained, highly bioturbated, non-calcareous to slightly calcareous.	Middle-lower shoreface
10870'	Bundled mm-dcm thick sand-shale layers with mud cracks at base of beds. Shale; medium grey, mm-5cm thick beds, smooth in touch, sharp based.	Intertidal Below wave base offshore
10880'	Sandstone; light greenish grey, medium-grained, grain size increases and bioturbation decreases upward, gradational shale-sand zones.	Middle-upper shoreface
10890'	Bundled sand-shale layers, wavy, ripple laminated, some erosively based. Sandstone; medium grey, fine-medium grained, dark brown oil staining, speckled, horizontal lamination, coarsens upward.	Intertidal Upper shoreface
10900'	Shale; medium grey, fossiliferous, dense, very calcareous, locally grades to argillaceous limestone.	Offshore below wave base
10910'	Sandstone; light grey, ripple laminated sand drapes, low-fair bioturbation. Sandstone; light greenish grey, fine-medium grained, thoroughly bioturbated. Sandstone; thin bedded quartz arenite with weathered appearance.	Lower shoreface to offshore Middle-lower shoreface Beach-upper shoreface

(From Saif Tanoli)

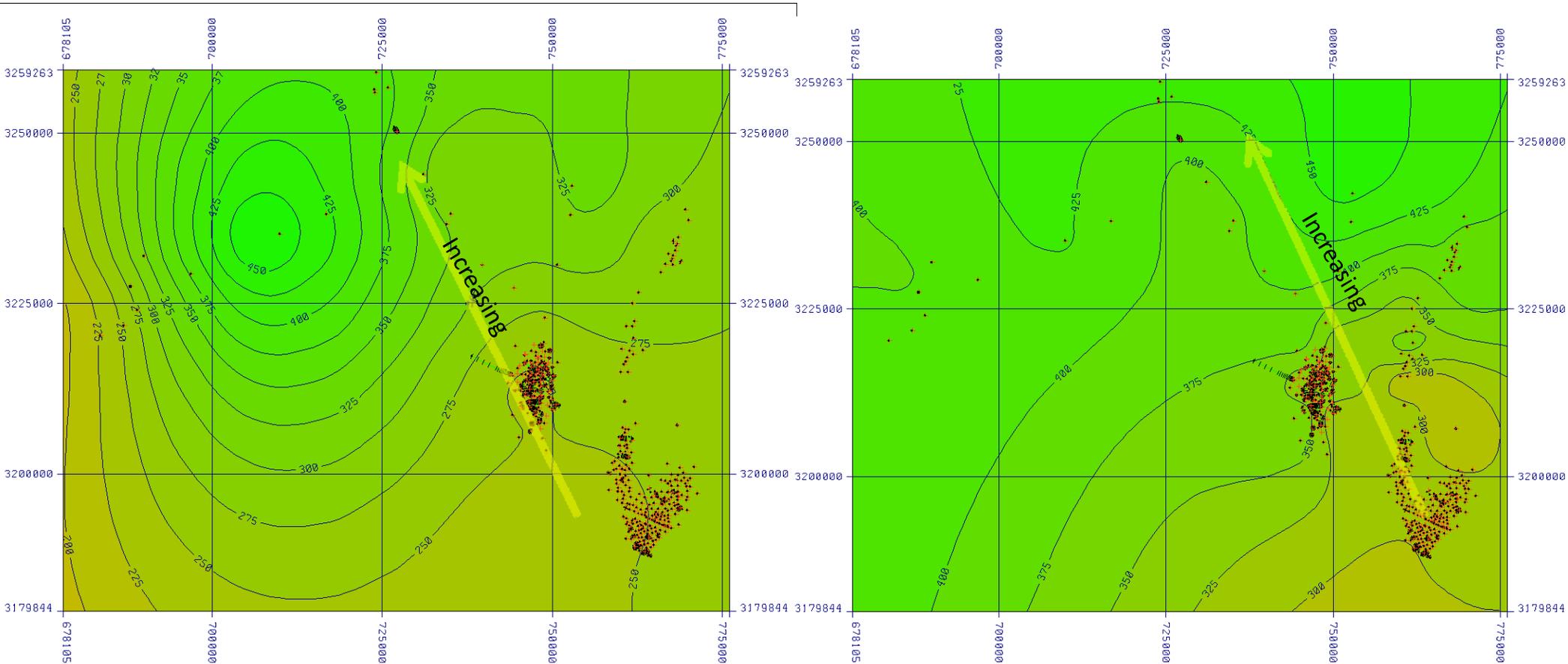
CORE DATA

RATAWI SHALE

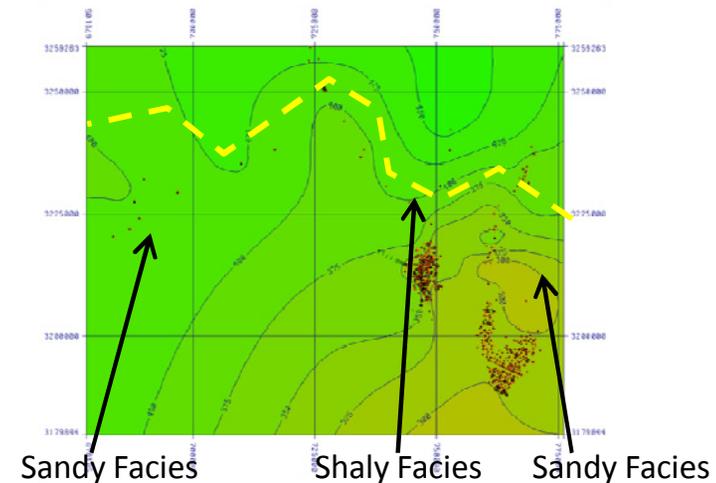
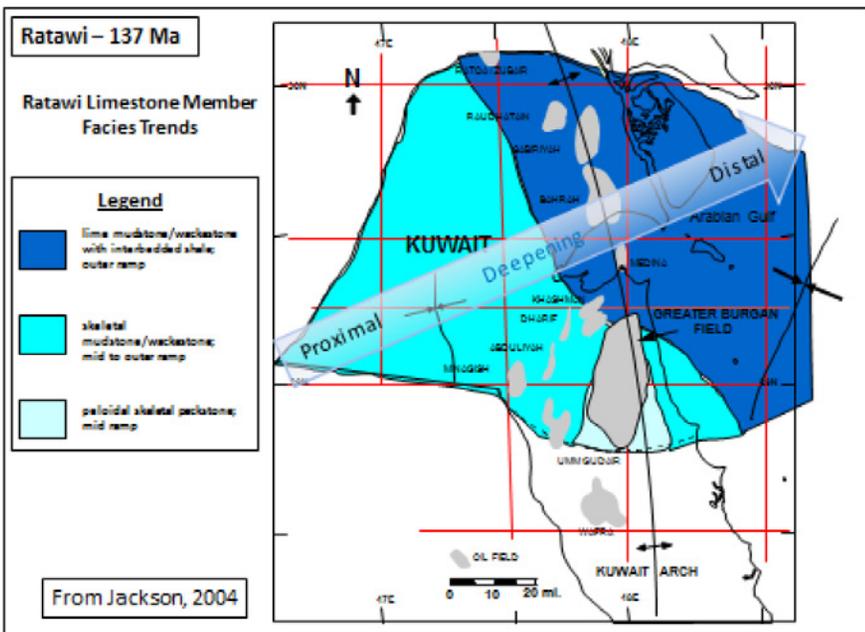
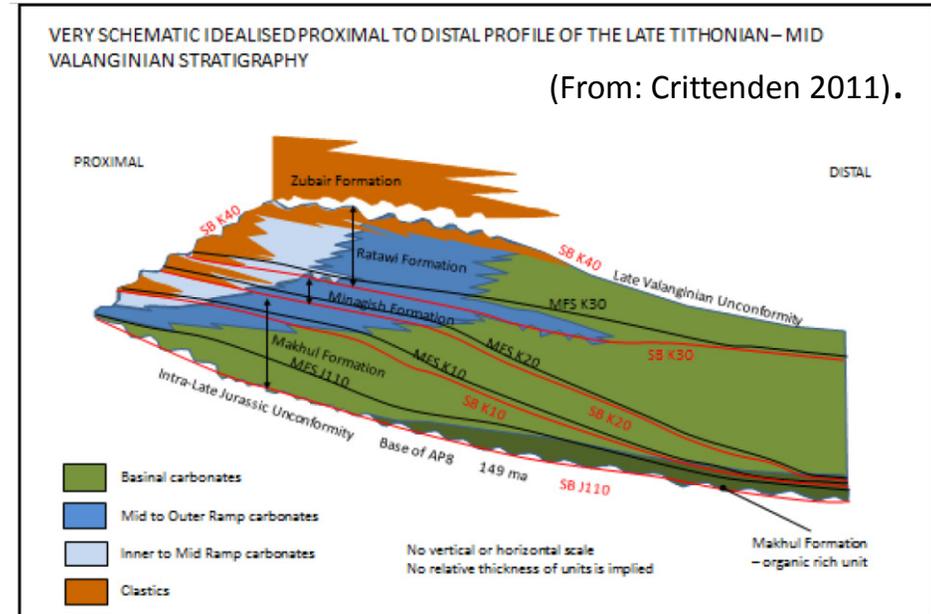
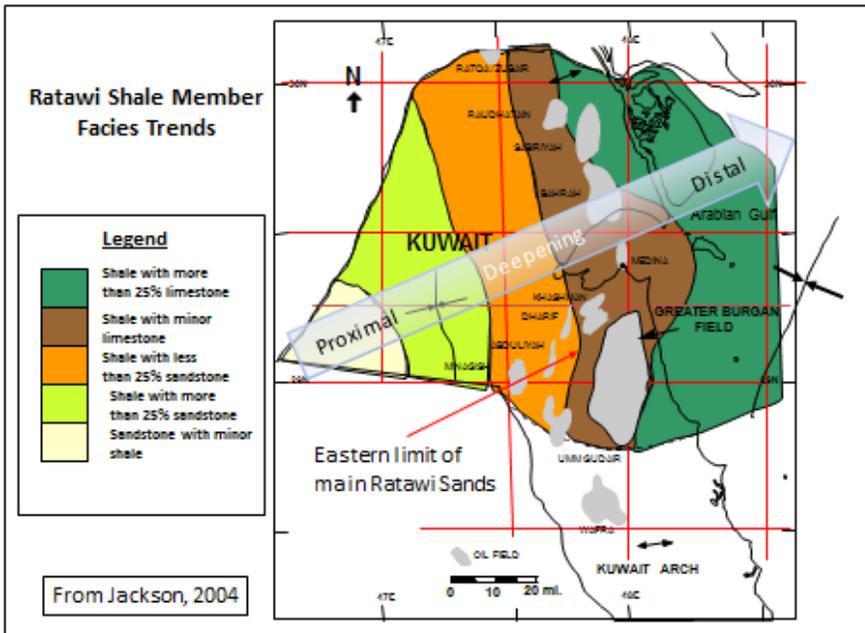


E-LOG DATA

RATAWI LST AND RATAWI SHALE THICKNESS MAP

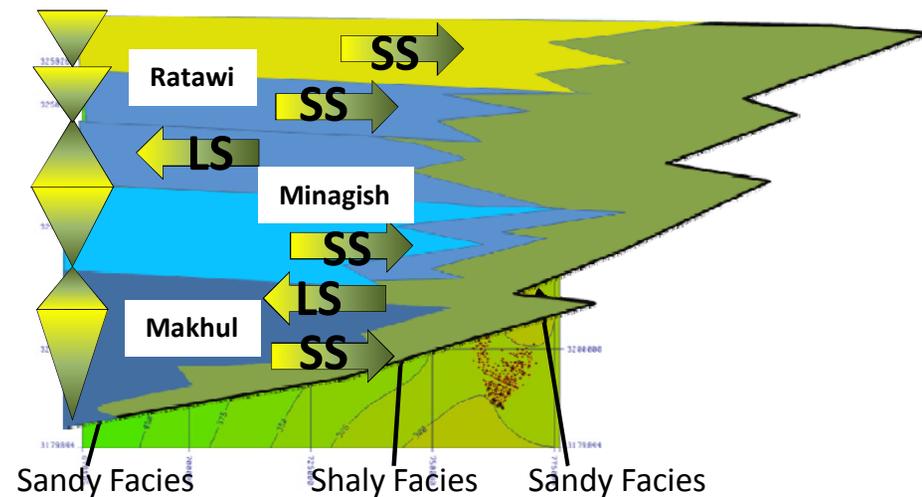
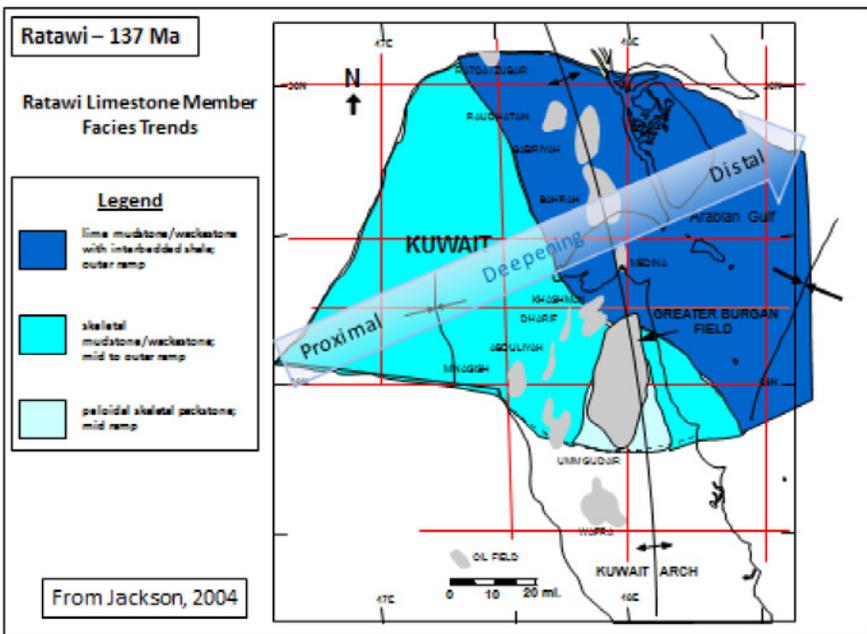
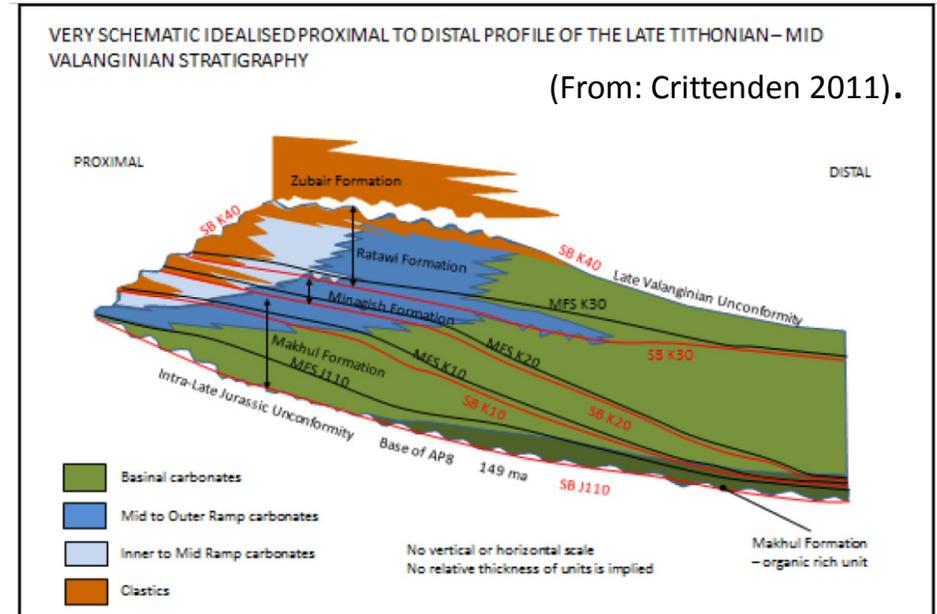
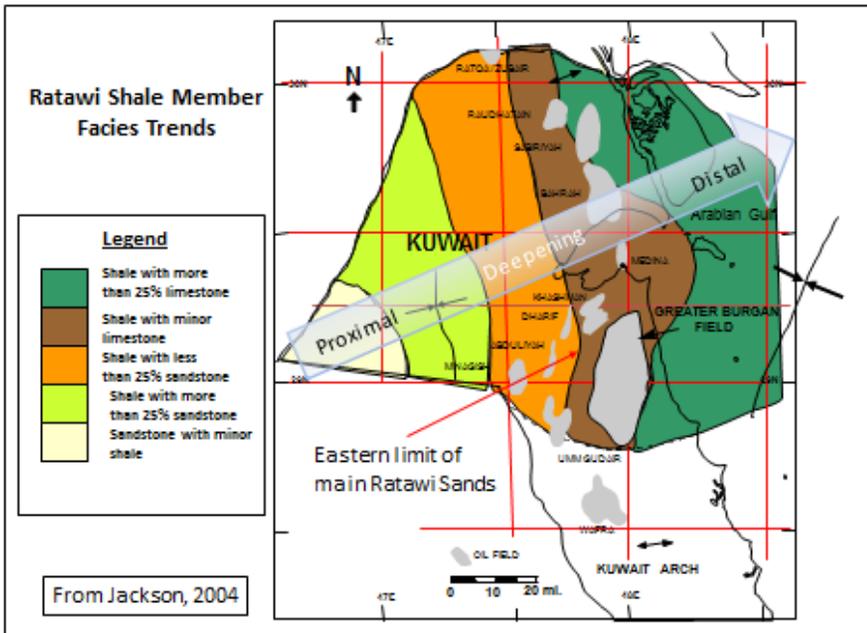


RATAWI FORMATION PALEODEPOSITIONAL MODEL



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RATAWI FORMATION PALEODEPOSITIONAL MODEL



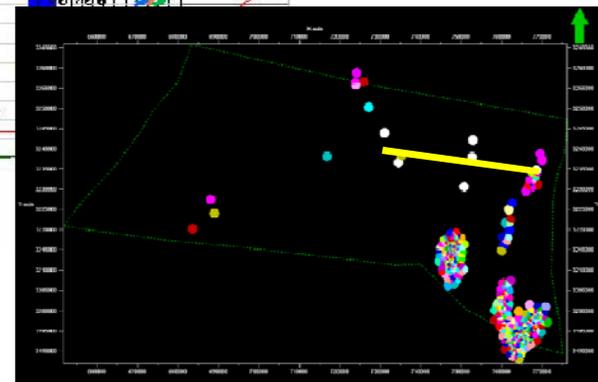
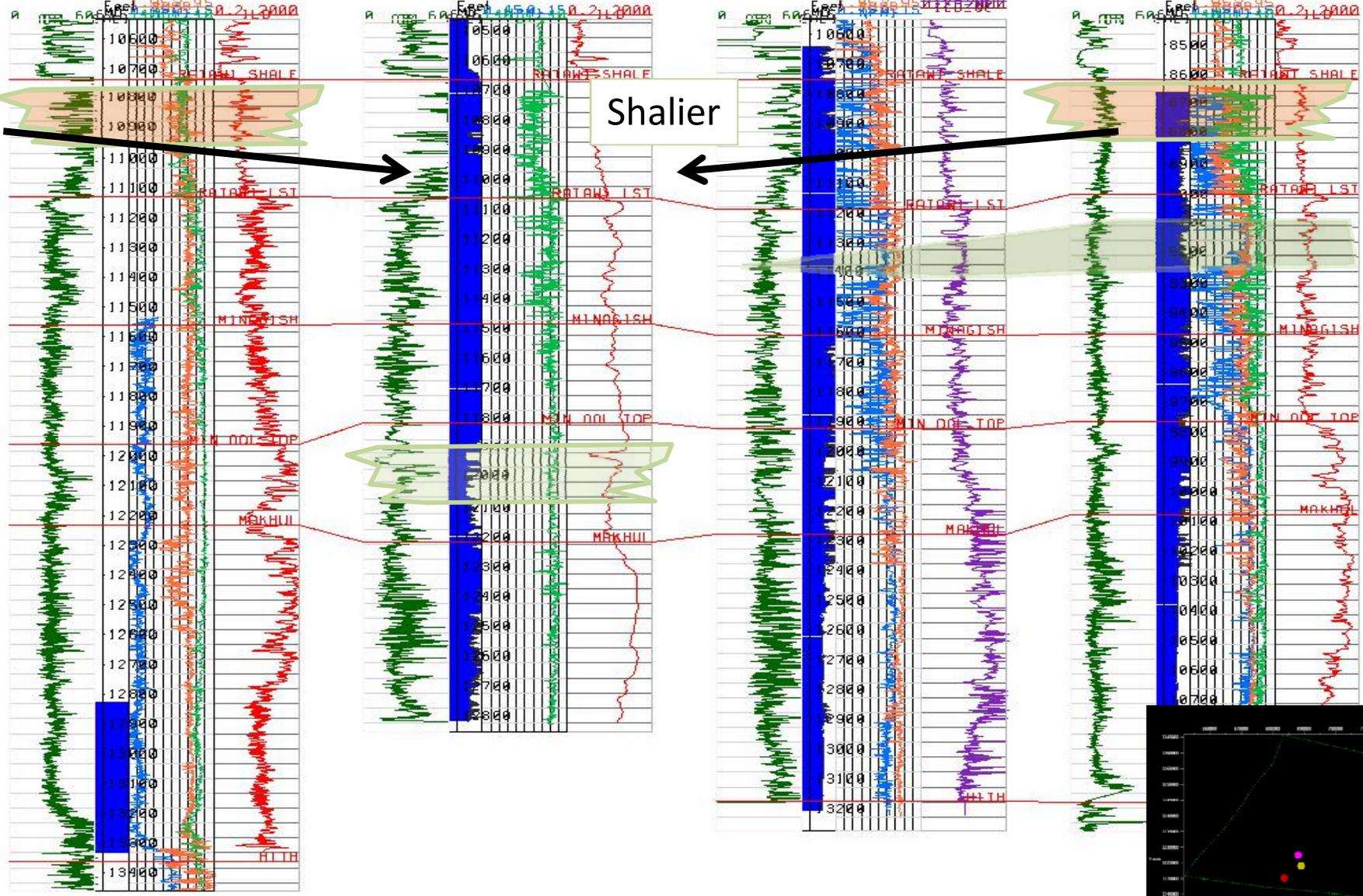
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- **RESERVOIR MAPPING AND CORRELATIONS
FOR LOWER CRETACEOUS UNITS.**

LOWER CRETACEOUS RESERVOIR MAPPING

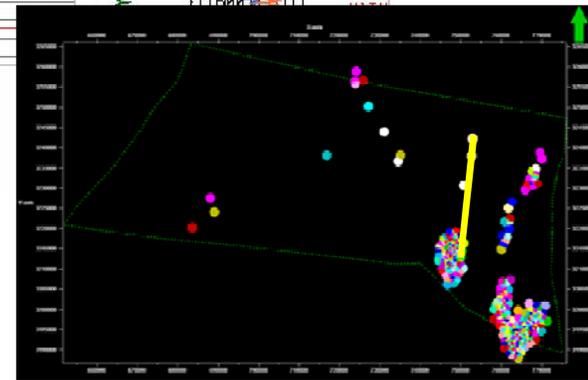
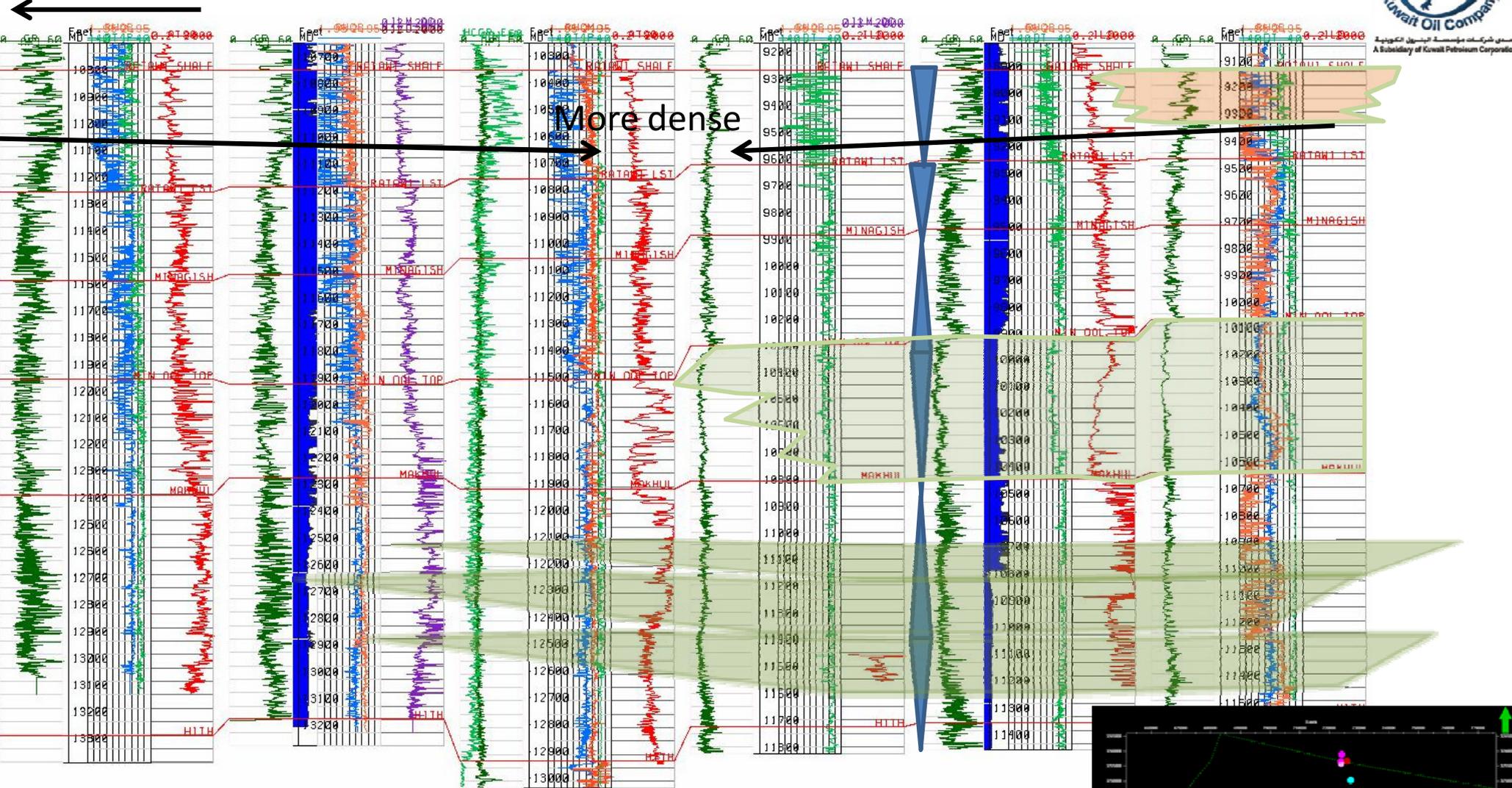


East West



LOWER CRETACEOUS RESERVOIR MAPPING

North

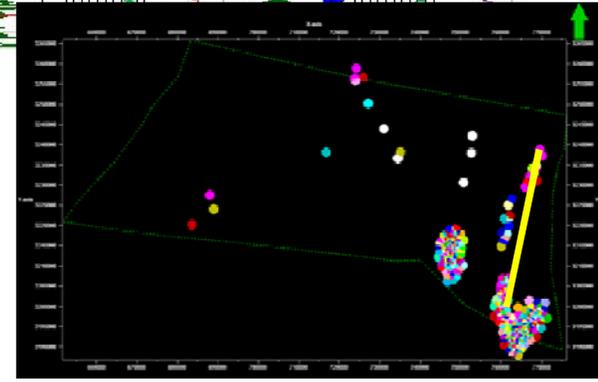
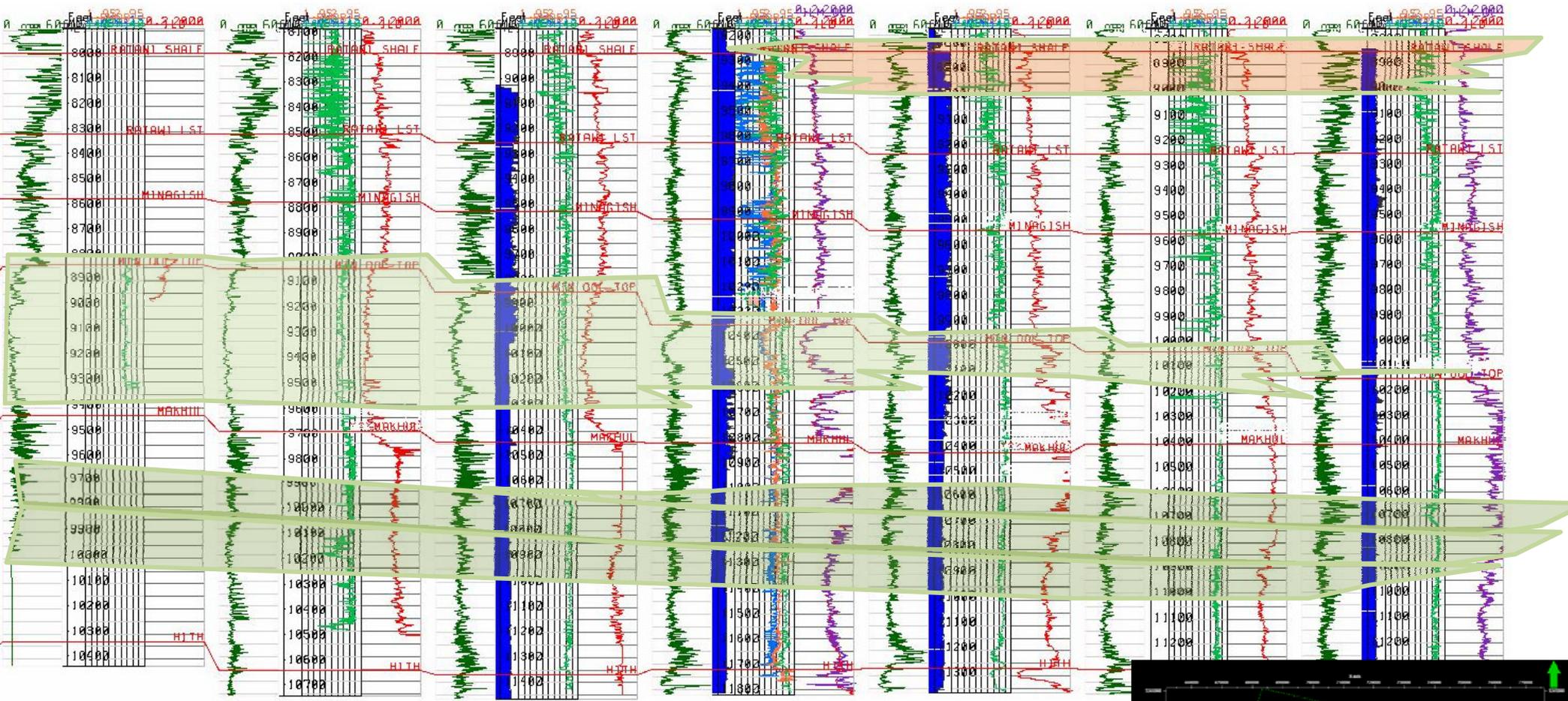


LOWER CRETACEOUS RESERVOIR MAPPING



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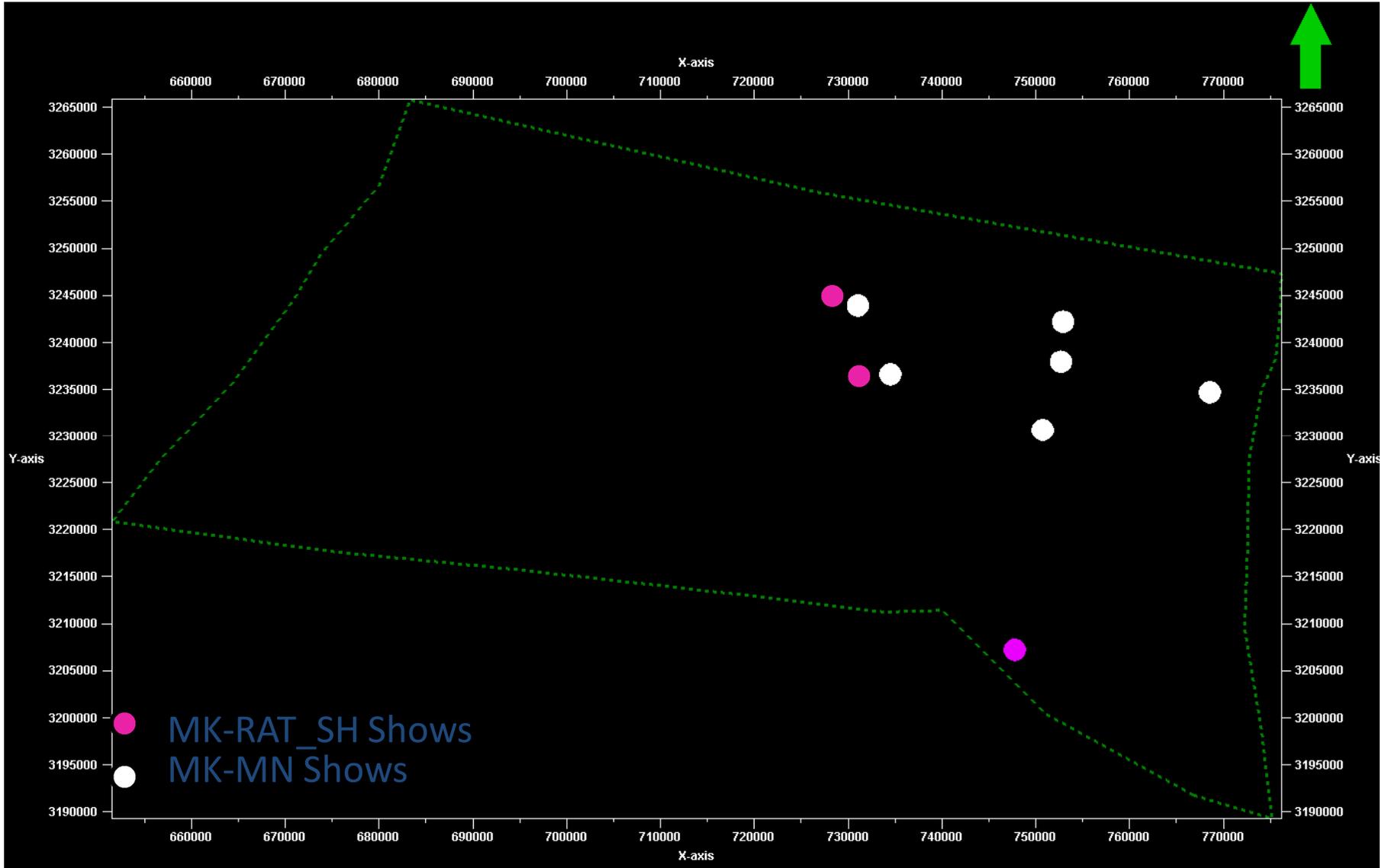
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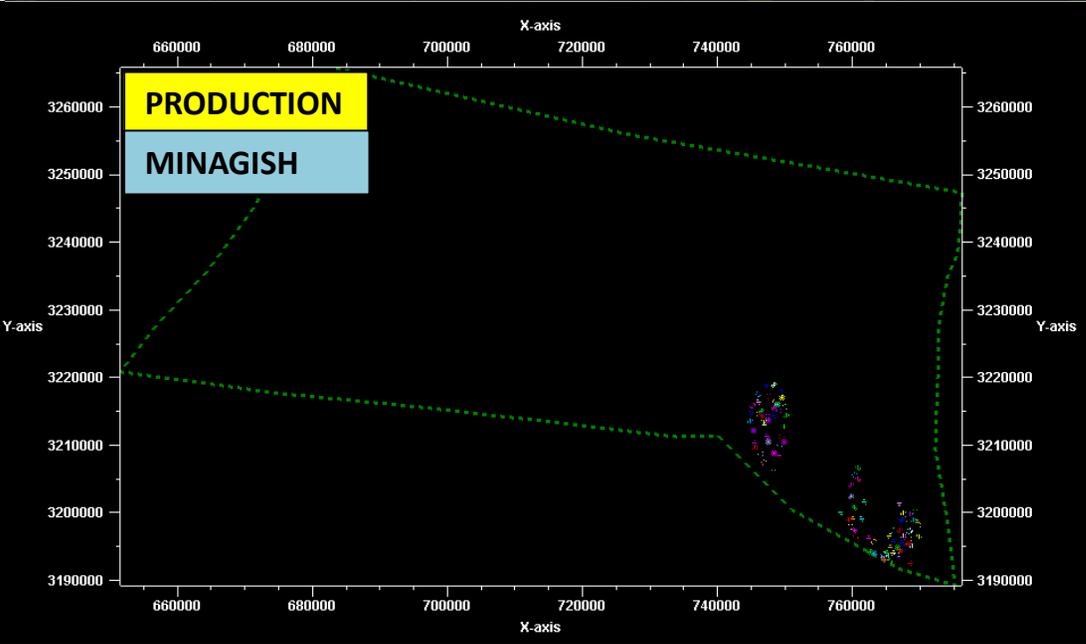
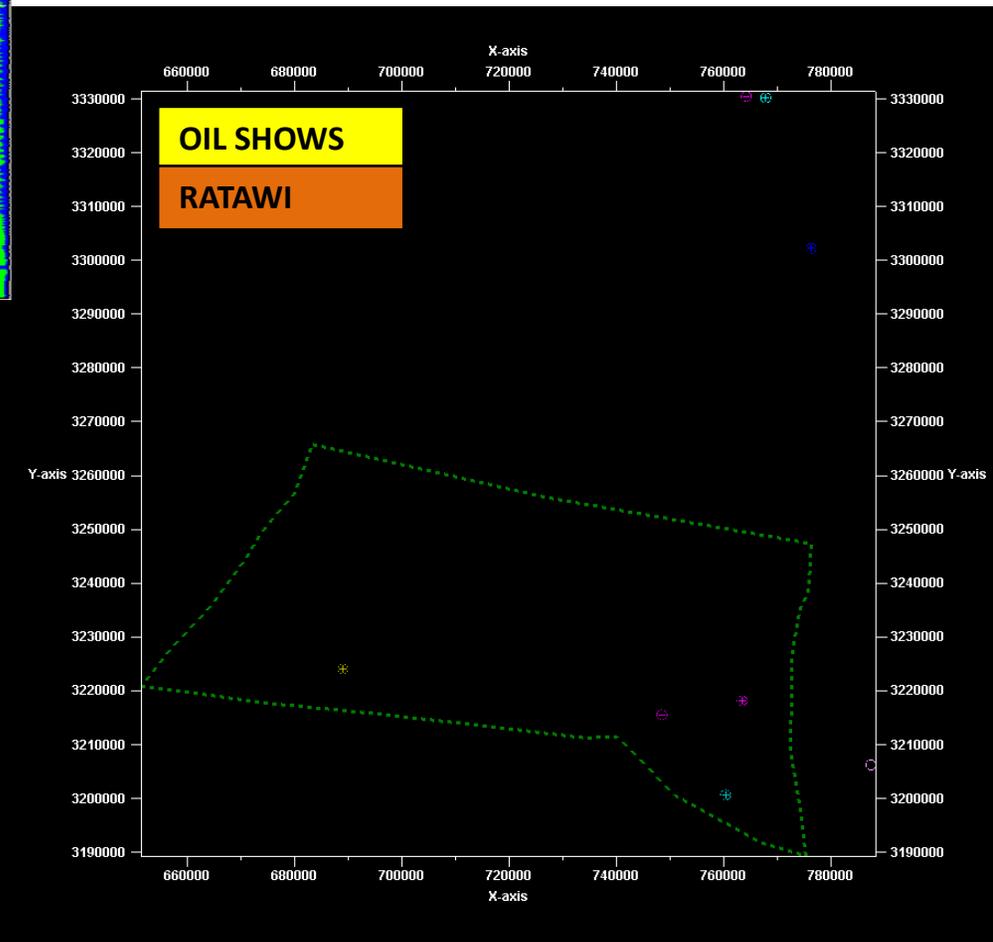
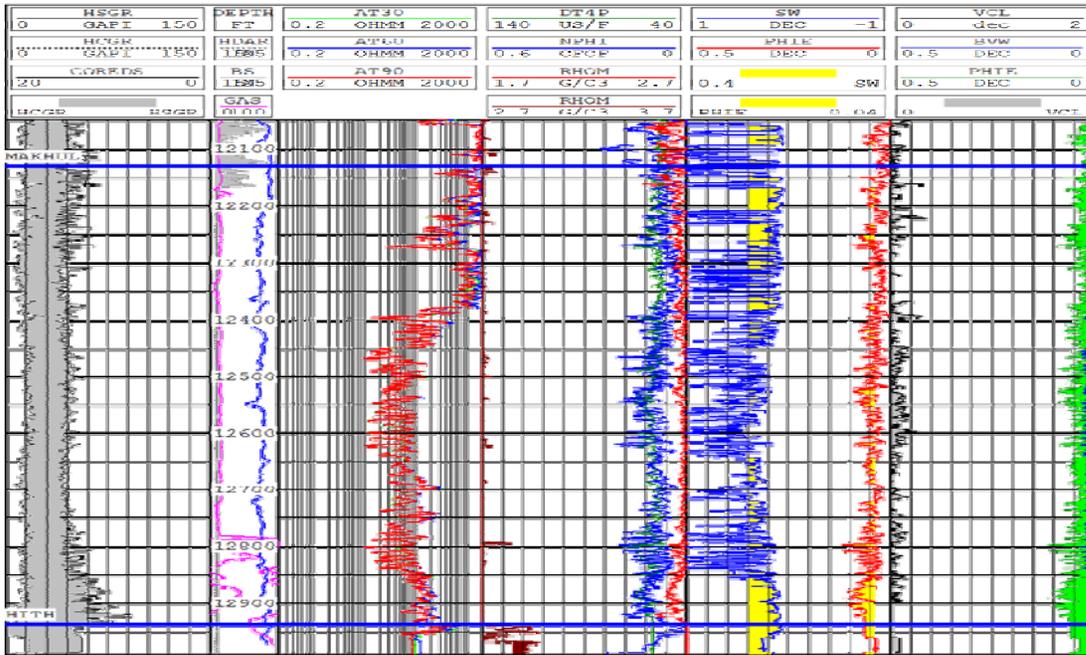
OIL SHOWS FOR LOWER CRETACEOUS



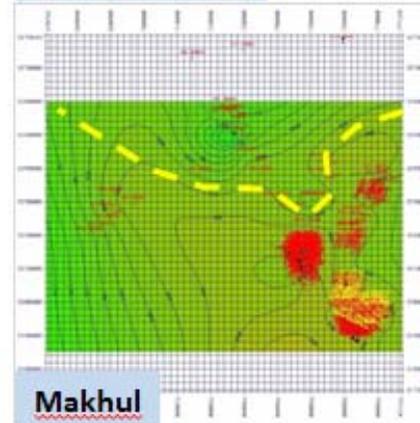
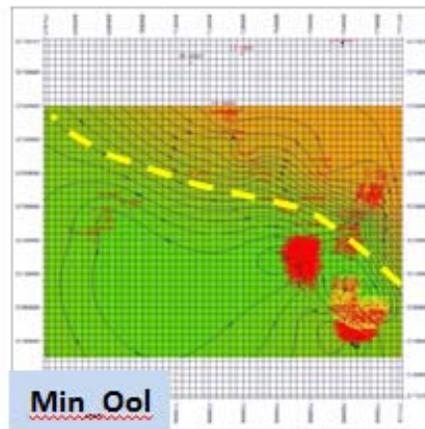
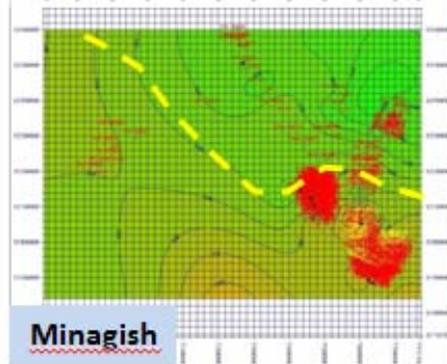
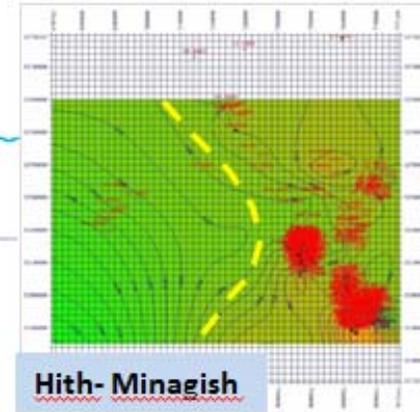
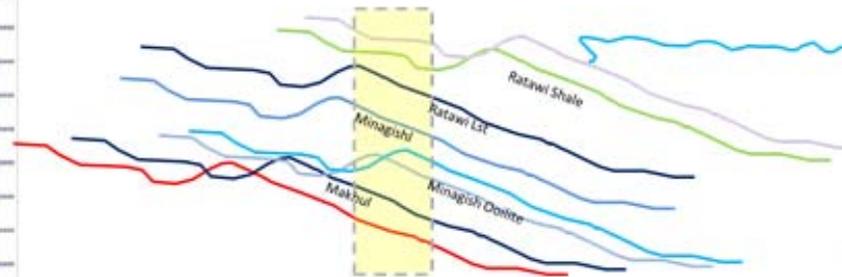
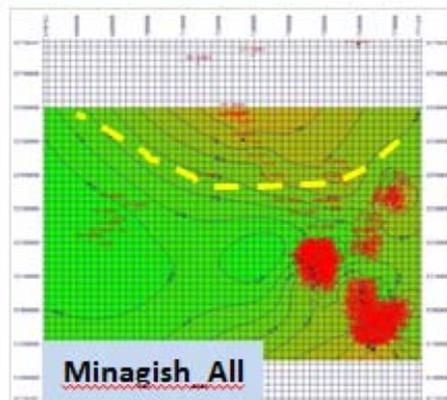
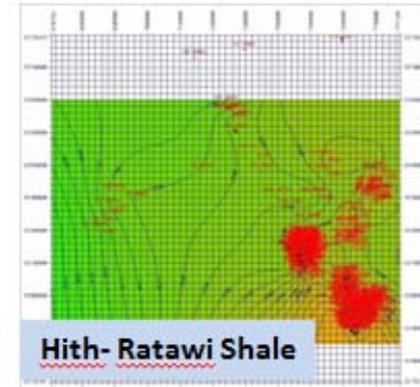
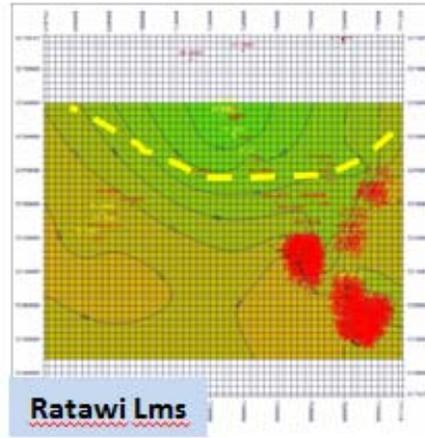
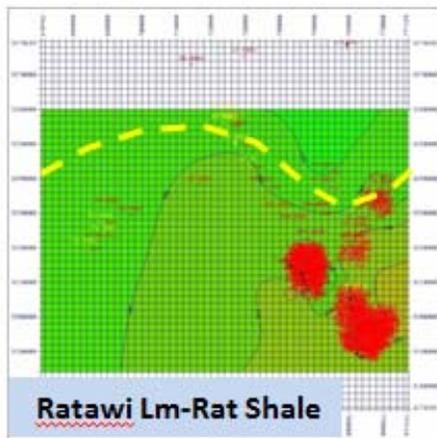
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SUPPORTING LOG AND PRODUCTION DATA



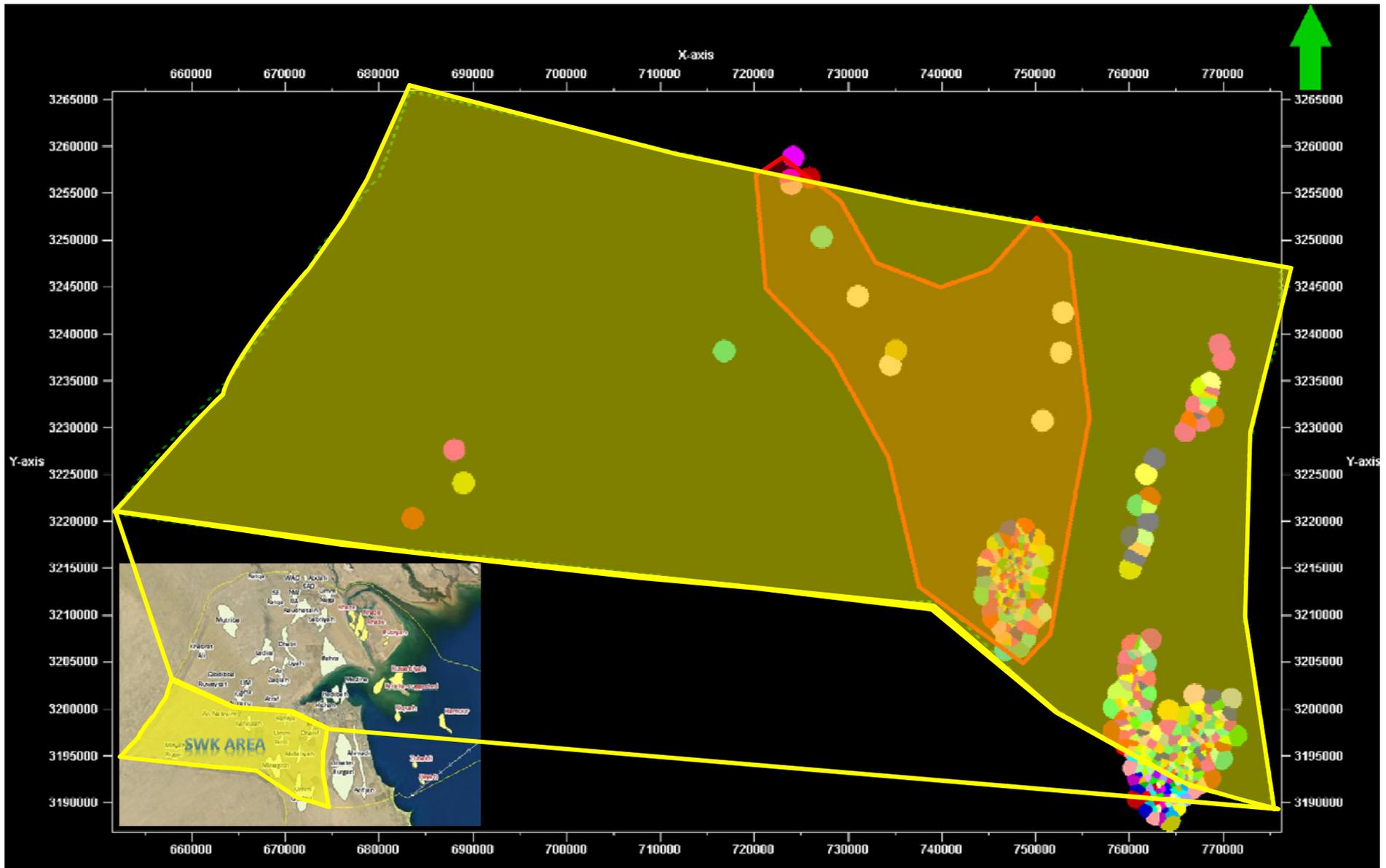
HIGHER RESOLUTION MAPPING AND STRATIGRAPHIC CONTEXT



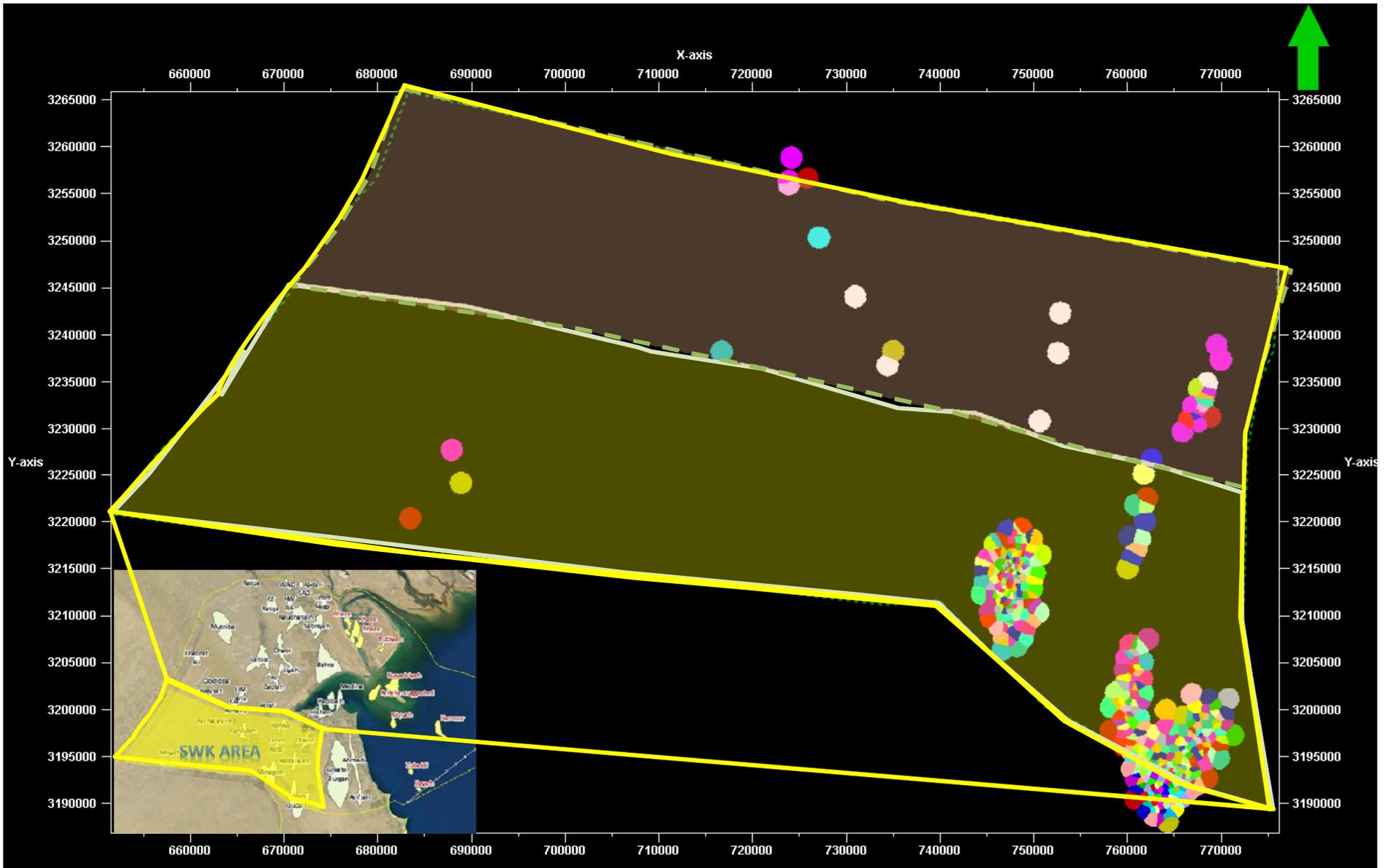
PROSPECTIVITY MAKHUL TOP STRUCTURAL MAP



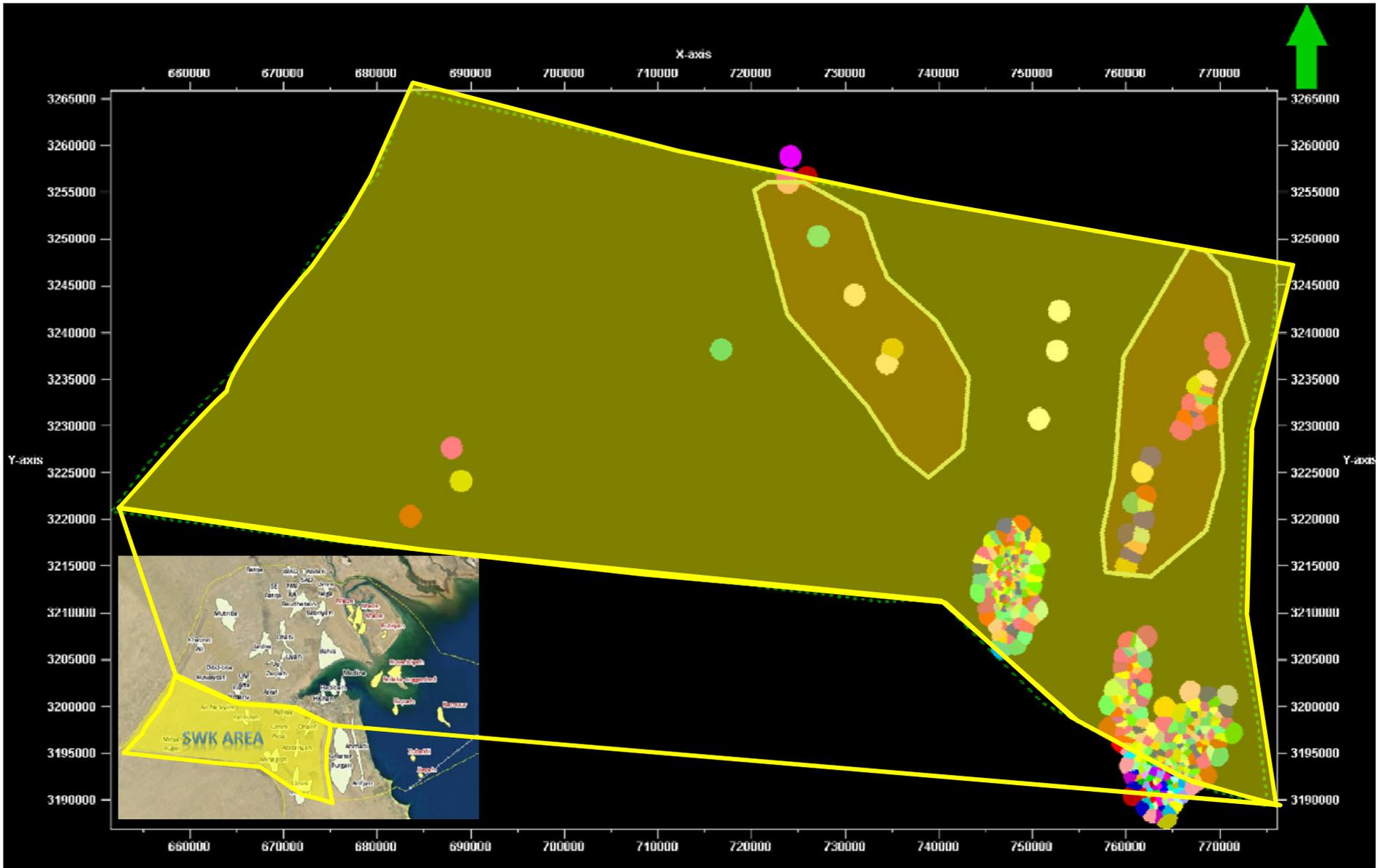
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PROSPECTIVITY OF MINAGISH AND MINAGISH OOLITE



PROSPECTIVITY OF RATAWI SHALE TOP STRUCTURE



SUMMARY AND CONCLUSIONS



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- Trends of Lower Cretaceous Units, Makhul-Minagish-Ratawi prospectivity from north wells (UR, DF) were extended to S (MN, UG) and further N.
- Depositional strike trends seem to go NE to SW, where Shallower facies are toward SW.
- Reservoir distribution is impacted by irregular shoreline and patchy nature of carbonate bodies. Definition of prospects will be helped for juxtaposition of mapped quality reservoir areas and fault bounded areas.
- Minagish Oolitic facies (Shoals) change north to Shalier Limestones facies (Middle-Outer ramp) but oil shows still favor the prospectivity of the area.
- Minagish Fm deposited on an embayed ramp. Deeper water (similar to Makhul) deposits are likely to occur within the facies trends, both as embayments, and perhaps in local bathymetric lows.
- Ratawi Shale is the first clastic unit after carbonate basin is poisoned. Detailed mapping of this reservoir is crucial to determine its true potential.
- Higher resolution work with improved data quantity and quality will help to find the subtle prospects of the future.

Prospective Carbonate Neocomian Trends in SW Kuwait, AAPG ACE, Long Beach 22-25 April, 2012.

Thank You...

QUESTIONS?