ePS Diagenesis and Fracturing of a Lower Cretaceous Arabian Shallow Water Carbonate Platform: Towards a Better Assessment of Carbonate Reservoirs Heterogeneity*

Claire N.H. Sena[1], Cedric M. John[2], and John W. Cosgrove[2]

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Abstract

This study focuses on a Lower Cretaceous Arabian shallow water ramp. Geological models for these units traditionally assume a layer-cake stratigraphy and a high lateral continuity of facies. This is based on the assumption that epeiric platforms have low depositional gradients, broad facies belts, and gradual facies transitions. However the petrophysical properties of these units are mainly controlled by diagenesis that can be complex. Understanding how the depositional environment is linked to the early diagenetic history and deriving conceptual models linking the distribution of porosity with primary depositional factors is essential to assess the heterogeneities of these systems that are most of the time largely underestimated.

In this study, part of the Qatar Carbonates and Carbon Storage Research Center, we investigate the relationships between depositional cyclicity and variations in diagenesis of a Barremian-Aptian carbonate ramp in Southern Oman. Outcrops of the Jurf and Qishn formations (time equivalents to the Kharaib and Shu'aiba petroleum reservoirs) are structurally undeformed that allow interpretation of facies, stacking patterns and determination of diagenetic processes in a shallow burial context. A bed-by-bed sampling on two 45 meter thick sections was made. Petrography, mineralogy, carbon and oxygen isotopes, and trace elements were obtained for each sample. Facies distribution and the diagenetic history was reconstructed from the analysis of a 5 km long transect that records a transition from a restricted to an open marine depositional environment.

A contrasting diagenetic response from the different platform environments illustrates the role of primary sediment composition in controlling porosity and cement distribution. However, similar facies along a single bed show variations in the amount of dolomitization and porosity. The type of diagenetic fluids and their flow path play a major role on carbonate reservoir heterogeneity. Fractures may be one of the controls on flow path as they act as preferential conduits for diagenetic fluids. It is therefore essential to assess the fracture potential of a facies throughout its diagenetic history. We look at how diagenetic processes impact on the original and present-day mechanical properties of the rocks in order to better predict fracturing in carbonates. The combined analysis of structural and diagenetic features provides the best approach for predicting reservoir heterogeneity.

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Diagenesis and fracturing of a Lower Cretaceous Arabian shallow water carbonate platform: towards a better assessment of carbonate reservoirs heterogeneity.

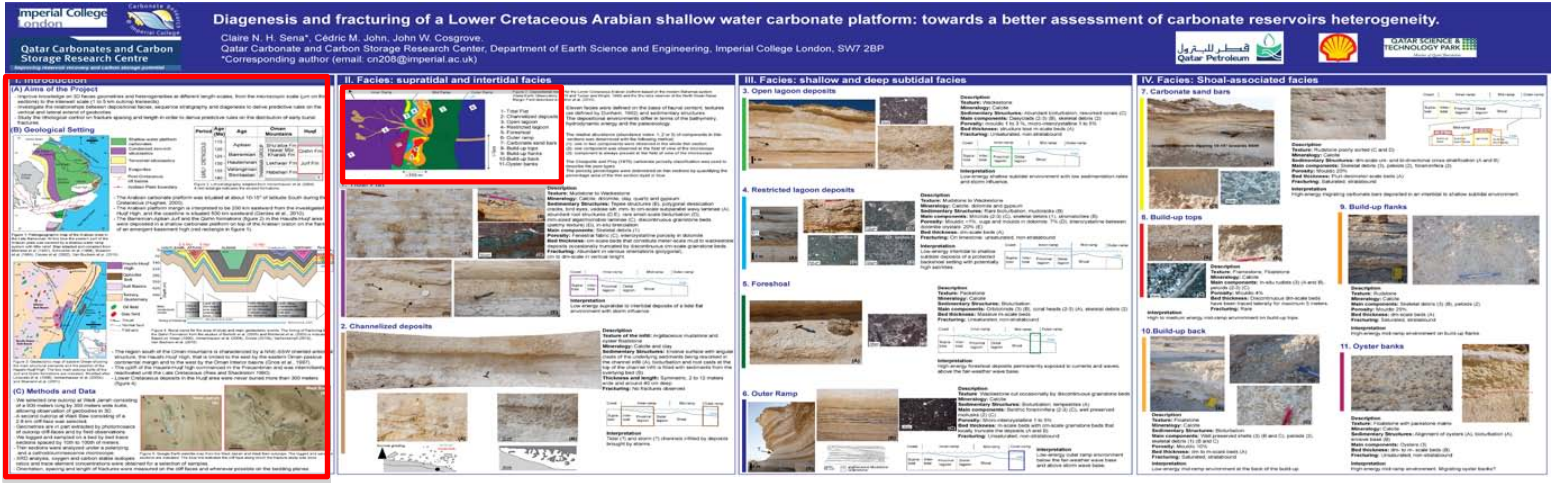
Claire N. H. Sena, *Cédric M. John, John W. Cosgrove*

Tuesday, all day, location: 17B

Carbonate Research @ Imperial College

Qatar Carbonate and Carbon Storage Research Center, Imperial College London

Panel 1: Introduction and Facies



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Panel 1: Geological Setting

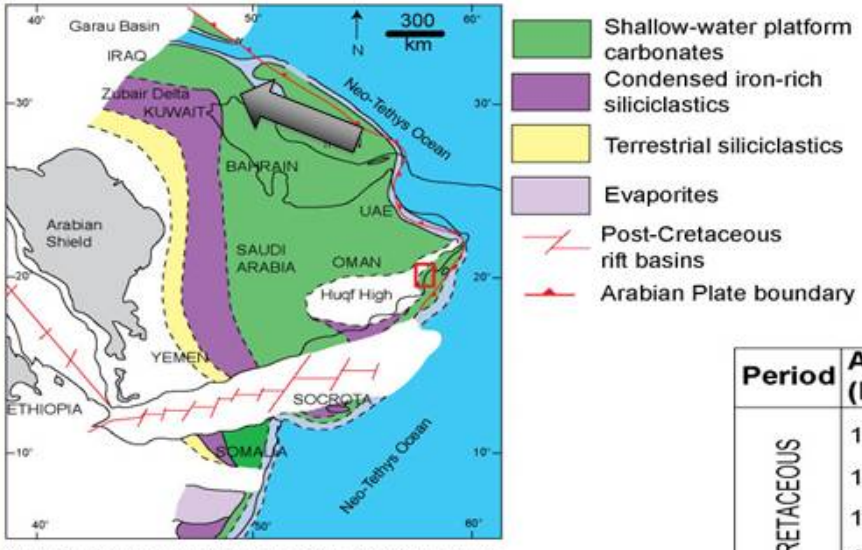

Figure 1: Paleogeographic map of the Arabian plate in the Late Barremian. At this time the eastern part of the Arabian plate was covered by a shallow-water ramp system with little relief. Map adapted and compiled from Morrison et al. (1997), Schroeder et al. (1998), Bosellini et al. (1999), Davies et al. (2002), Van Buchem et al. (2010).

Period	Age (Ma)	Age	Oman Mountains		Huqf
EARLY CRETACEOUS	115	Aptian	THAMAMA GROUP	Shu'aiba Fm	
	120			Hawar Mbr	Qishn Fm
	125	Barremian		Kharaib Fm	
	130	Hauterivian		Lekhwair Fm	Jurf Fm
	135	Valanginian		Habshan Fm	
	140	Berriasian			B

Figure 2: Lithostratigraphy adapted from Immenhauser et al. (2004). A red rectangle indicates the studied formations.

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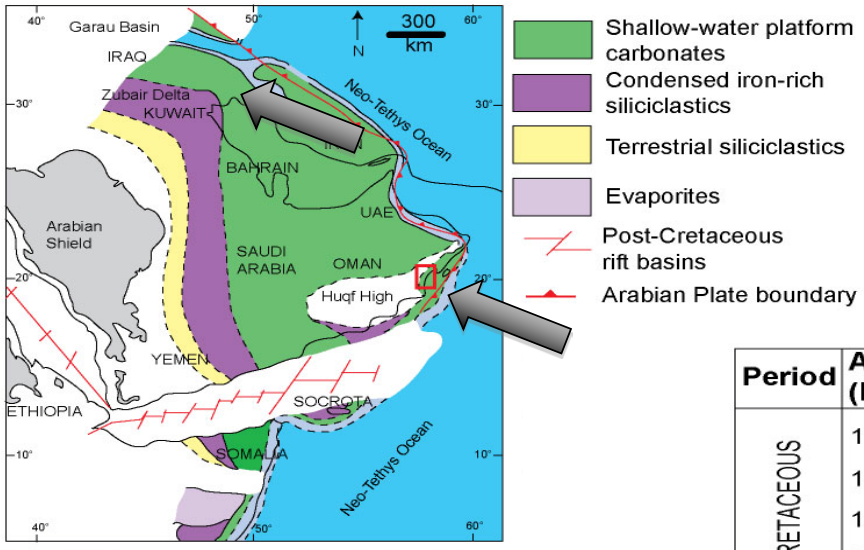

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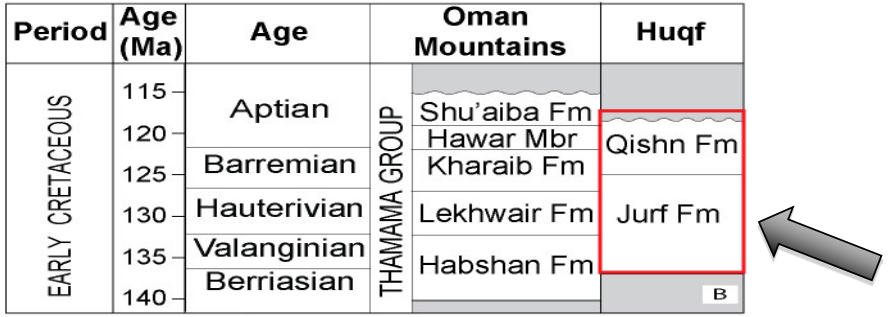

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Panel 1: Methods and data

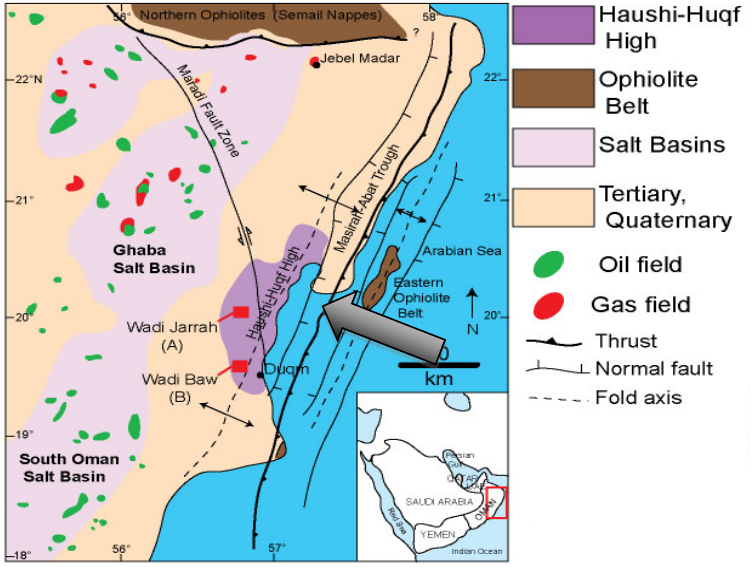
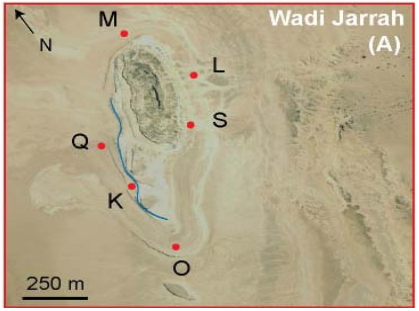
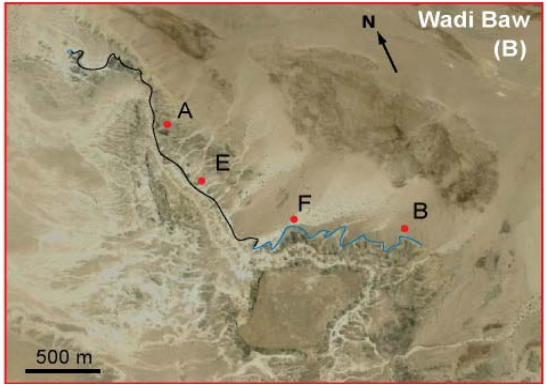


Figure 3: Geotectonic map of eastern Oman showing the main structural elements and the position of the Haushi-Huqf High. The two main outcrop belts of the Jurf and Qishn formations are indicated. Modified after Loosveld et al. (1996), Immenhauser et al. (2000c) and Sharland et al. (2001).





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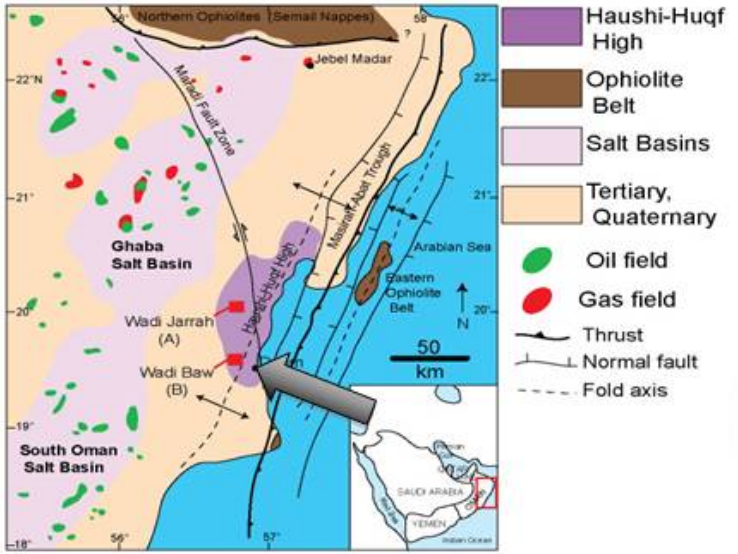

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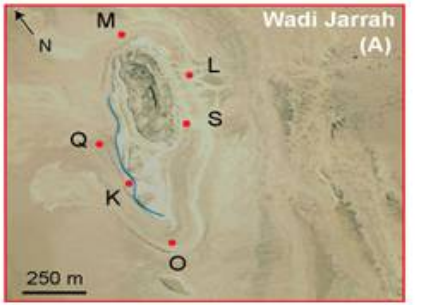

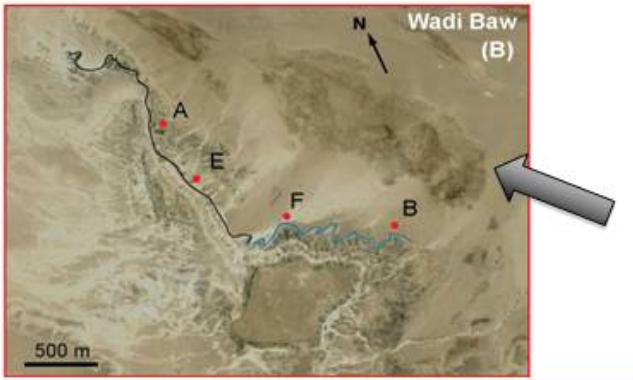

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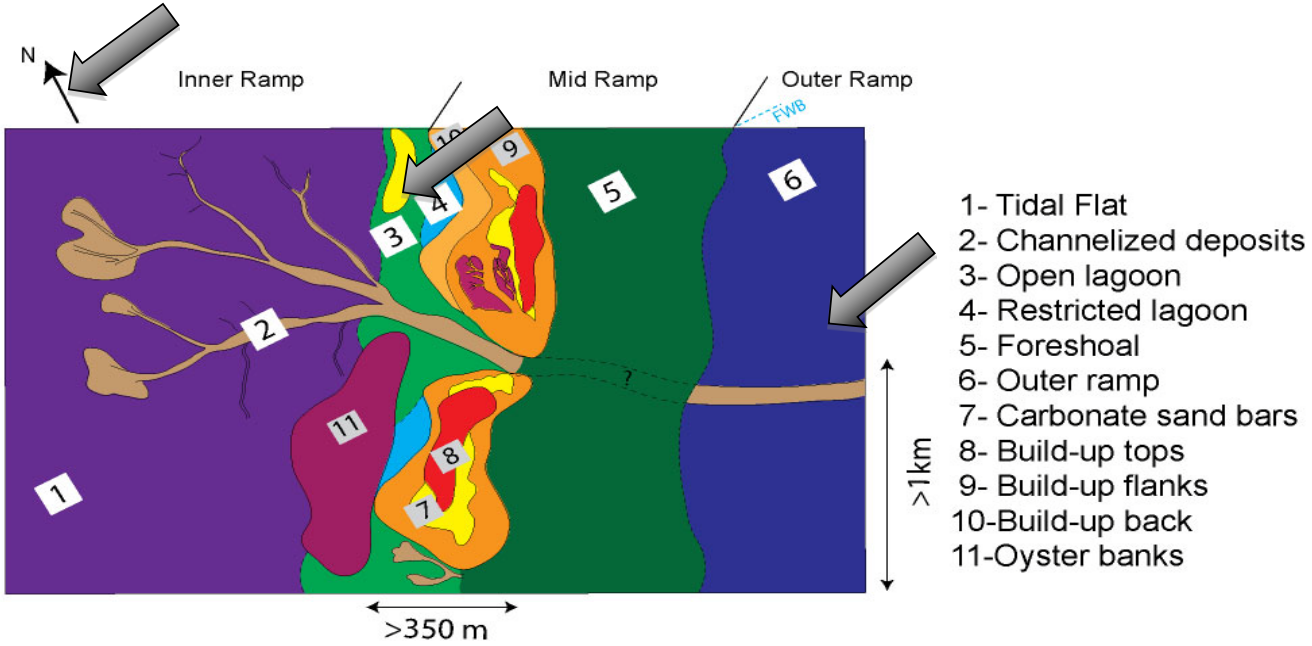
Panel 1: Facies and Depositional Model



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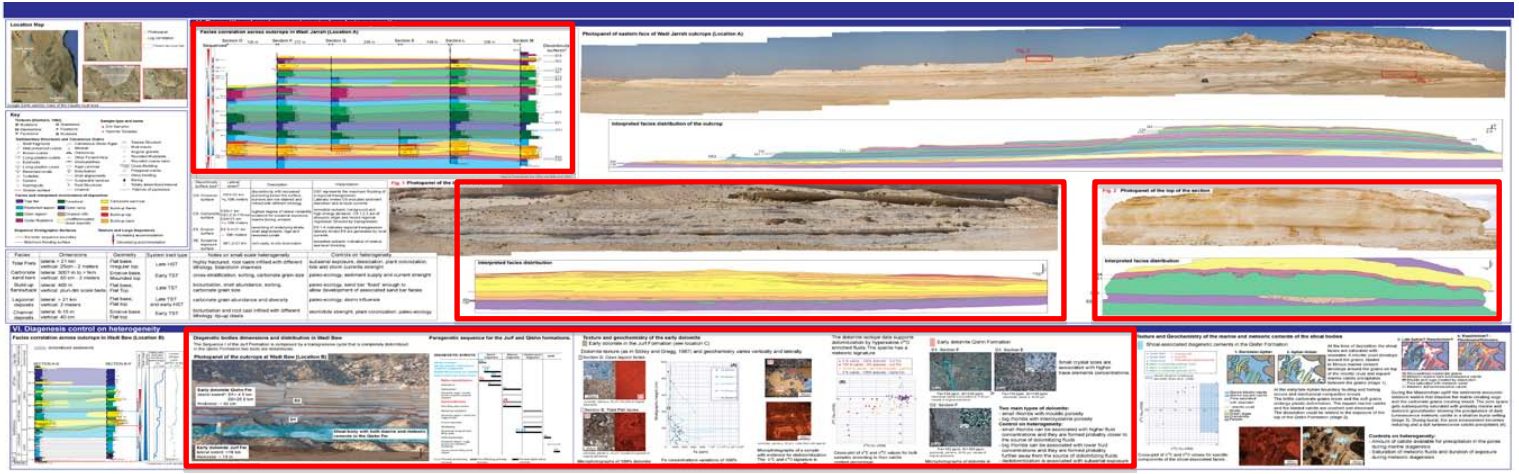
Panel 2: Facies and diagenesis control on heterogeneity



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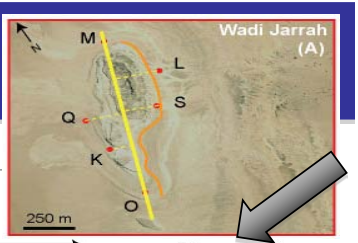
Panel 2: Facies control on heterogeneity



Facies correlation across outcrops in Wadi Jarrah (Location A)

Section O 126 m Section K 272 m Section Q 206 m Section S 106 m Section L 256 m

Sequences

Discontinuity surfaces^

SE2 CS4 SE1 CS3 ES3 CS2 CS1 ES2 ES1 OS1 ES0 CS0

Sequence III Sequence II

15 m 10 m 5 m 1 m 29 m 20 m 15 m 10 m 5 m 1 m

ES4 SE2 CS4 SE1 CS3 ES3 CS2 CS1 ES2 ES1 OS1 ES0 CS0

Facies and interpreted environment of deposition

- Tidal flat
- Restricted lagoon
- Open lagoon
- Oyster floatstone
- Foreshoal
- Outer ramp
- Channel infill
- Undifferenciated shoal deposits
- Carbonate sand bar
- Build-up flanks
- Build-up top
- Build-up back

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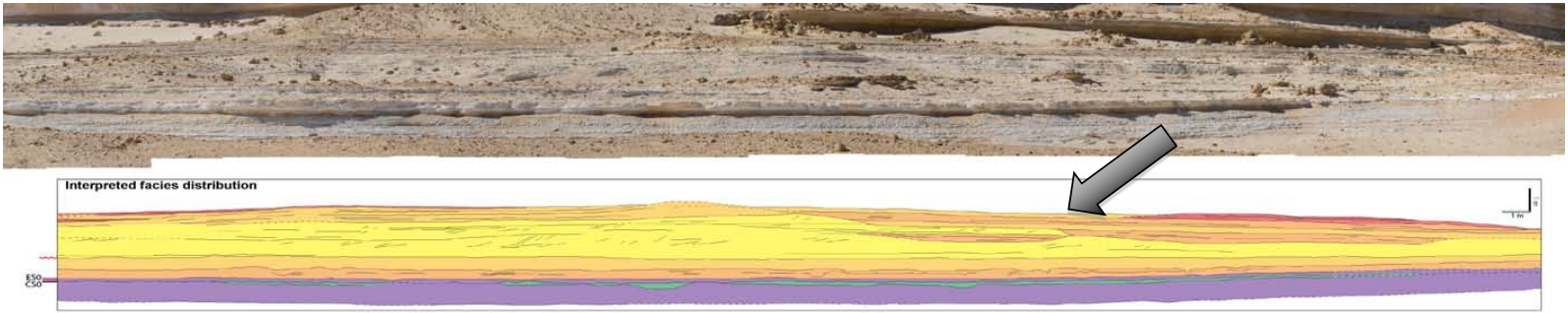
Panel 2: Lateral variability of shoal-associated facies



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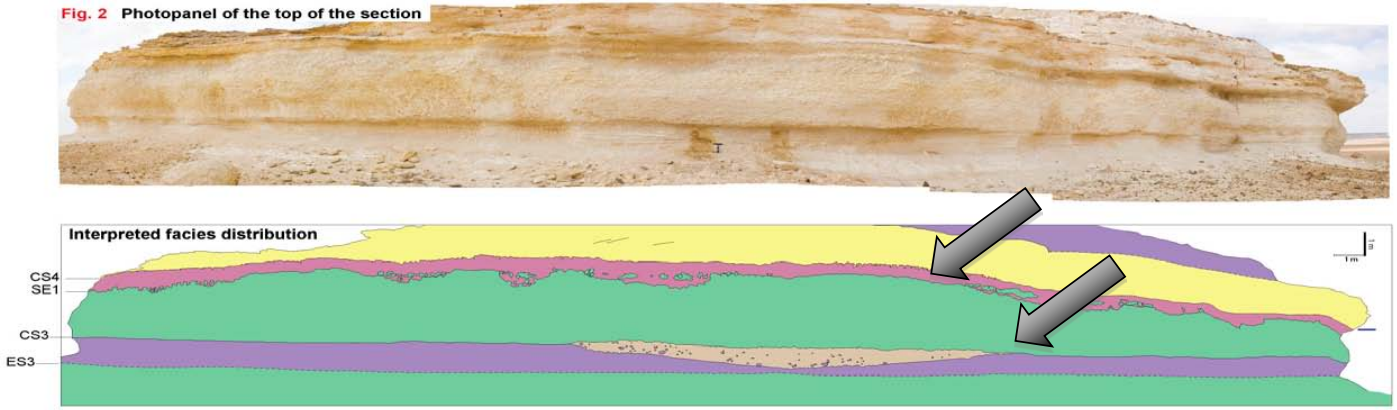
Panel 2: Lateral variability of discontinuity surfaces



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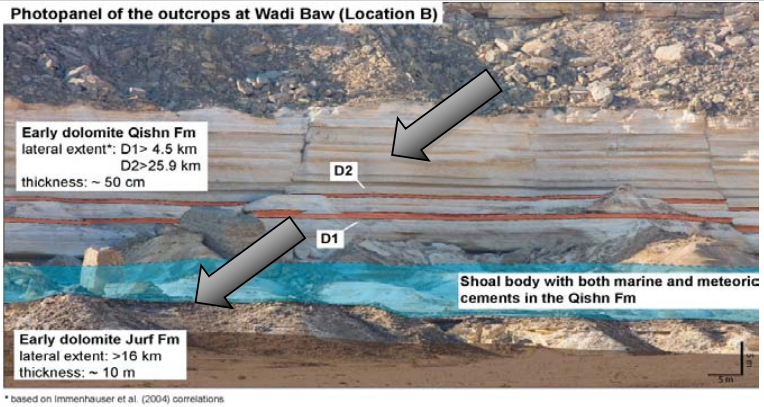
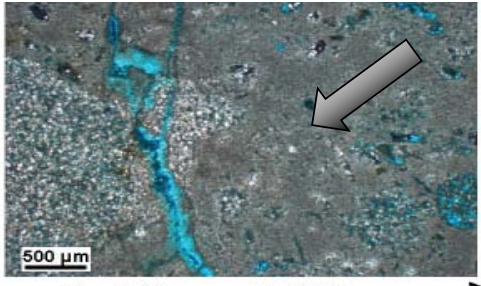
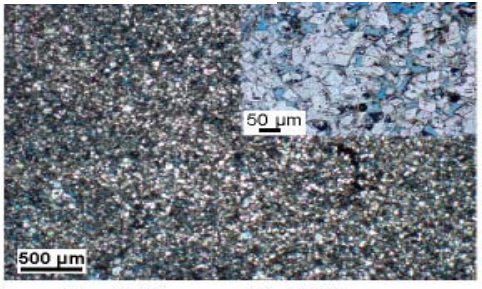
Panel 2: Diagenesis control on heterogeneity



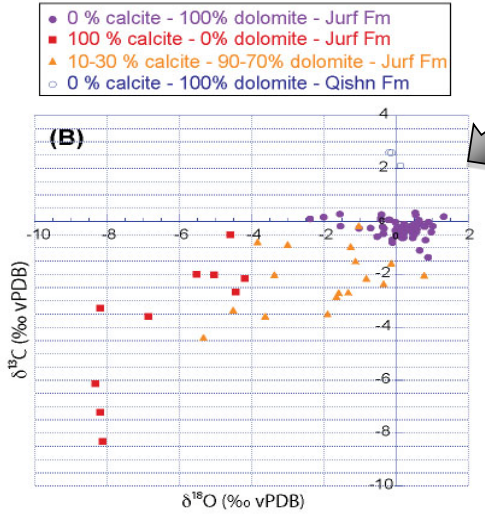


Fe=154 ppm, Sr=224 ppm
polymodal, planar-e and planar-s, 5-40 µm, moulds of original allochems

>



Fe=119 ppm, Sr=148 ppm
polymodal, planar-e, 50-80 µm



Cross-plot of $\delta^{13}C$ and $\delta^{18}O$ values for bulk samples according to their calcite content percentage.

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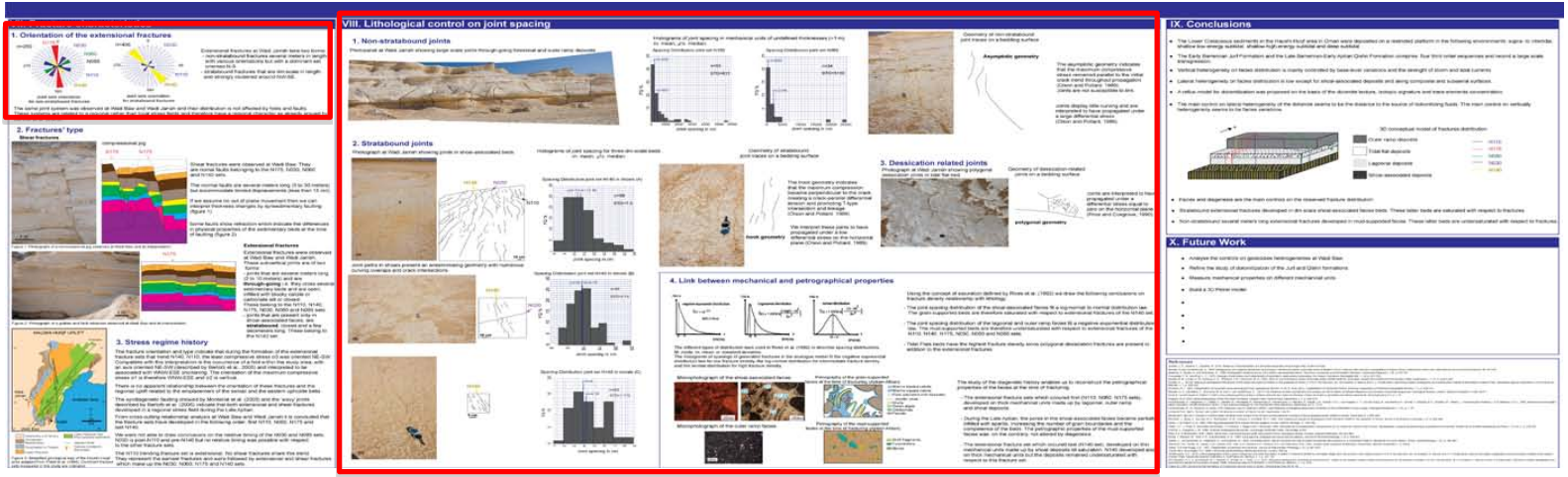
Panel 3: Fracture analysis



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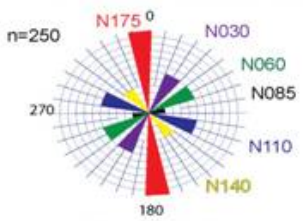
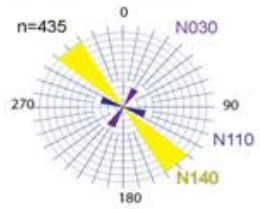
Panel 3: Lithological control on fracture distribution



Joint sets orientation
for non-stratabound fractures



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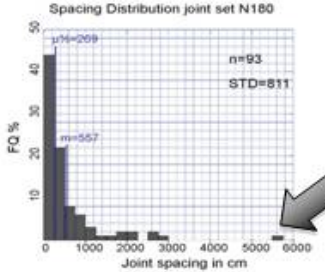
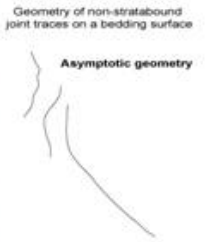
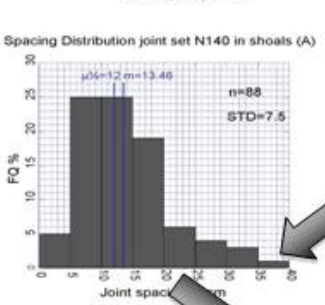
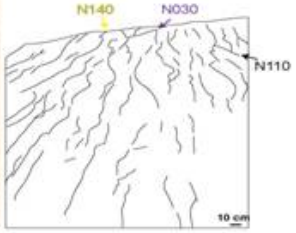
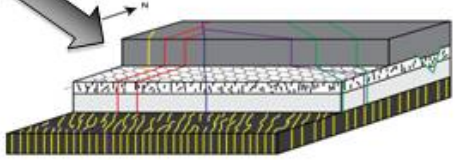








hook geometry

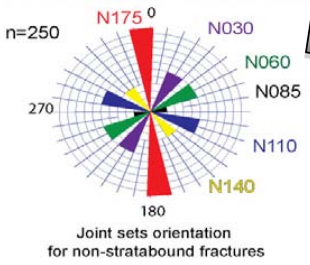


3D conceptual model of fractures distribution

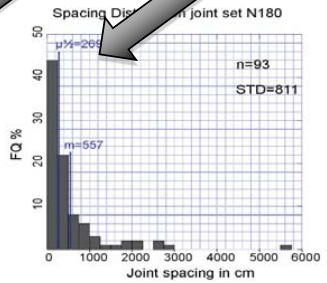
- Outer ramp deposits
- Tidal flat deposits
- Lagoonal deposits
- Shoal-associated deposits

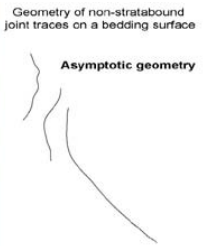
- N110
- N175
- N060
- N030
- N140

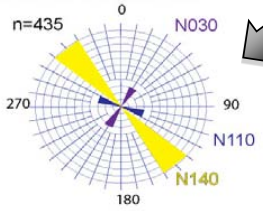
Panel 3: Lithological control on fracture distribution



Joint sets orientation
for non-stratabound fractures







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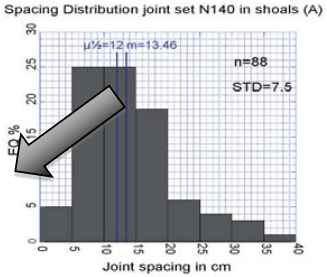
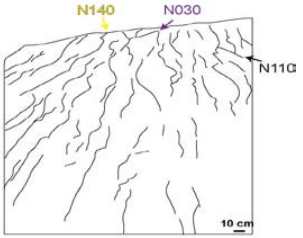
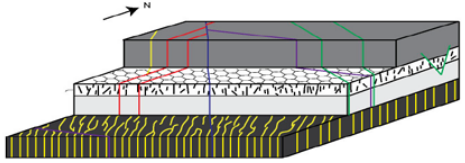
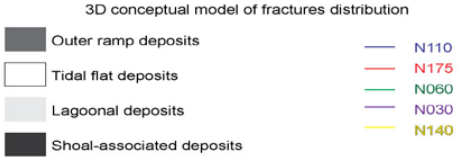




hook geometry





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Presentation:
Tuesday, all day, 17B

I look forward seeing you there!