[PS]Facies, Stratigraphy and Lateral Stratigraphic Continuity in Lower Jurassic Reservoir Analogue Outcrops at Wadi Naqab, United Arab Emirates*

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Abstract

The Lower Jurassic succession at Wadi Naqab (United Arab Emirates) was analysed in detail. The objectives were (1) to update the depositional age through biostratigraphy, (2) identify the main facies types and interpret the depositional environment, and (3) quantify the lateral continuity and bed-thickness changes and pinch outs of carbonate beds. The properties of the exposed rocks are well known in the subsurface, however little is known on the lateral facies changes. The latter potentially has important impact on subsurface correlation and estimating sweep efficiency. Detailed biostratigraphy analysis shows the presence of dasycladalean algae and foraminifera that indicate a Hettangian-Upper Pliensbachian age. The Upper Sinemurian-Lower Pliensbachian limit was identified with confidence. In terms of depositional environment, there is a distinct transition from inter-bedded inner ramp tidal flats and ramp barrier shoal type deposits towards shallower, restricted lagoons in the upper part of the succession. Based on our data, the Hettangian-Upper Sinemurian succession from Wadi Naqab was recognized/suggested as a new facies analogue for e.g. the Bathonian Uwainat Member (Araej Formation) in Qatar. This part of the Wadi Naqab succession consists of interbedded wackestones and grainstone, which were deposited in ramp barrier shoals and inner ramp tidal flats. Similar wackestone/grainstone alternating layers can be found in the Uwainat Member, for which the environment of deposition is represented by ramp barriers and inner ramp areas with some outer ramp depositional features. By contrast, at Wadi Naqab outer ramp deposits occur only at higher stratigraphic levels. A detailed 3D digital outcrop model is used to quantify lateral changes by measuring bed thickness variation at cm-resolution. At first sight, it appears all beds are completely continuous with constant thickness. Detailed measurements indicate the lateral continuity of the upper part of the succession showing two different thickness trends in the SW-NE direction. Some of these beds are thinning towards NE (by as much as 2.00 m per 100 m) while the other category includes beds which are thicker towards NE and thinner in the SW. Pinch-outs are common for several SW-NE thinning beds with the pinch-out occurring towards the NE. Such changes and pinch outs often are not identified in the subsurface and their impact on well correlation and flow behaviour are overlooked.

Reference Cited

Hönig, M., and C.M. John, 2015, Sedimentological and isotopic heterogeneities within a Jurassic carbonate ramp (UAE) and implications for reservoirs in the Middle East: Marine and Petroleum Geology, v. 68, p. 240-257.

Facies, Stratigraphy and Lateral Stratigraphic Continuity in Lower Jurassic Reservoir Analogue Outcrops at Wadi Naqab, United Arab Emirates

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1. Introduction

1.1 Aims

Outcrops in the north of the UAE are known reservoir analogues for hydrocarbon reservoirs. However little is known on carbonate lateral facies variation and flow zone thickness changes. The latter has potential important impact on subsurface correlation and estimating sweep efficiency.

The main objectives were to:

- refine the depositional age through biostratigraphy
- identify the main facies types and interpret the depositional environment
- quantify the lateral continuity and bed-thickness changes and pinch outs

1.2 Study area and outcrop description

- Wadi Naqab outcrop is located in the Musandam Peninsula (northern UAE).
- The outcrop has a total length of approximately 1400 m and a height of 900 m (**Fig. 1**).
- The Lower Jurassic succession consists of peritidal limestones which are stratified in centimetre to decimetre thick beds (**Fig. 2**) rich in bivalve fragments and oncoids.

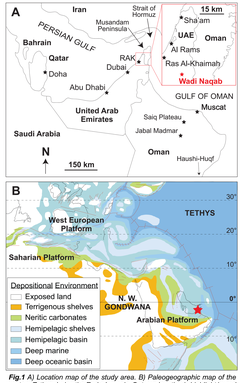


Fig.1 A) Location map of the study area. B) Paleogeographic map of the western Tethys during the Early Jurassic. Outcrop location is highlight by red stars. Modified from Hönig & John (2015).

Fig.2 A) Decimetre-centimetre thick peritidal carbonate beds from the lower part of the Lower Jurassic succession. B) Decimetre thick bed C) Peritidal carbonate beds which are decimetre-metre thick D-F, H) Lithiotis sp., accumulation in a muddy, wackestone G-H) Oncoids and bioclasts

2. Facies analysis and biostratigraphy

Facies analysis indicates the presence of four facies types (Fig3A):
(1) peloidal fenestral wackestone,
(2) coarse bioclastic grainstone-rudstone,
(3) wackestone-floatstone with gastropods and bivalves and
(4) peloidal bioclastic packstone.

Detailed biostratigraphy analysis shows the presence of dasycladalean algae and foraminifera that indicate a Hettangian-Upper Pliensbachian age (Fig. 3B).

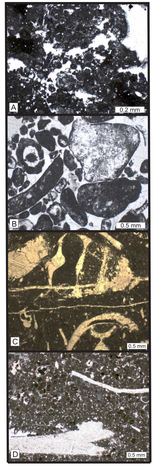


Fig.3A
A) Peloidal fenestral wackestone
B) Coarse bioclastic grainstone-rudstone;
C) Wackestone with gastropods and bivalves
D) Peloidal bioclastic packstone with echinoderm plates

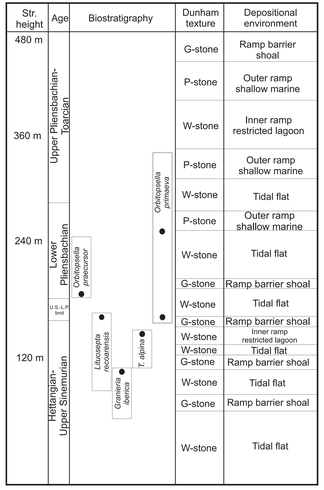


Fig.3B Facies stacking patterns within the Lower Jurassic succession from Wadi Naqab. The occurrence of the most important microfossils is indicated together with the stratigraphic thickness of the entire succession

3. Depositional environment

- The upper part of the succession shows a broad deepening upwards trend from a tidal flat environment to more open-marine, outer ramp deposits (Fig. 3B).
- Direct evidence for grain shoals is absent their presence is inferred from restricted-environment, lagoonal deposits (Fig. 4).

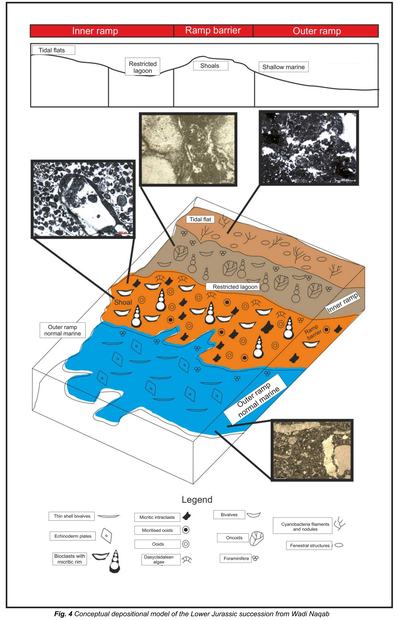


Fig. 4 Conceptual depositional model of the Lower Jurassic succession from Wadi Naqab

4. Lateral thickness variation and pinch outs

- A detailed 3D digital outcrop model (Fig.6A-B) is used to quantify lateral changes by tracing bed boundaries (Fig.6C).
- Thickness variation between successive bed boundaries is calculated (Fig7).
- Overall thickness change follows a normal distribution with average 0.1m thinning to NE and standard deviation of 1.5m.
- 45% of beds show thickening towards NE, 35% show thinning, 25% have a constant thickness

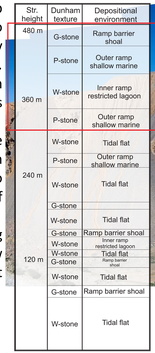
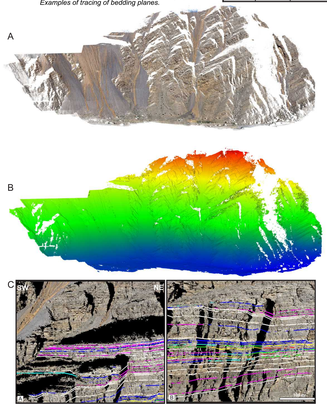
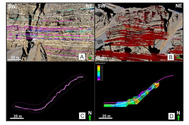


Fig. 5 A) Panorama of the studied section. The studied succession corresponds to the uppermost part of the biostratigraphic framework.

Fig. 6 A-B) 3D digital outcrop model at 5-10cm resolution, coloured by outcrop colour and elevation respectively C) Examples of tracing of bedding planes.





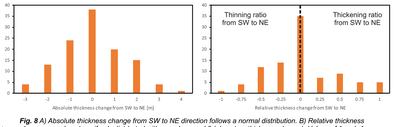


Fig. 7 A) Bedding plane traces. B) locally traces are expanded to form surfaces. C) top view of two successive traces. D) Isochore map between two traces coloured by thickness.

Fig. 8 A) Absolute thickness change from SW to NE direction follows a normal distribution. B) Relative thickness changes are close to uniformly distributed with a peak around 0 (almost no thickness change). Values of 1 and -1 indicate pinchouts in SW and NE directions respectively.

5. Conclusions

- The Lower Jurassic succession from Wadi Naqab is confidently refined to the Hettangian-Upper Pliensbachian interval.
- The carbonate sediment was deposited in a carbonate ramp system generally exhibiting a change to deeper environments.
- Most traced beds are continuous over the studied area (200-500 meter).
- Lateral thickness changes are observed in 75% of measured beds and bed sets.

6. References

- Hönig and John, 2015. Sedimentological and isotopic heterogeneities within a Jurassic carbonate ramp (UAE) and implications for reservoirs in the Middle East. Marine and Petroleum Geology, 68, 240-257.