Microfacies and Depositional Environments of the Bathonian-Bajocian Middle Dhruma Carbonates, Central Saudi Arabia

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Abstract

During the Middle Jurassic, an ancient carbonate ramp was extensively developed on the western margin of the Tethys Sea, in Central Saudi Arabia. Three cliff-forming outcrops of the Dhruma Formation, representing the platform, near Khashm Ad-Dhibi, the Riyadh region, were investigated to identify and understand their microfacies variability. Detailed field investigations, petrographic (thin section, XRD and SEM) and biofacies analyses were utilized to identify and quantify bulk mineralogy, and construct and interpret the depositional model of the identified facies of the Units 2 to Unit 4 of the Dhruma Formation in the study locality.

Eight microfacies comprising of peloidal-skeletal wackestone, skeletal-peloidal packstone, peloidal grainstone, oolitic grainstone and skeletal oolitic packstone, skeletal floatstone, burrowed wackestone, and mudstone were identified in the investigated outcrop sections. These facies are interpreted to have been deposited in a lagoonal (i.e., peloidal skeletal wackestone, skeletal peloidal packstone), shoal complex (i.e., peloidal grainstone, oolitic grainstone, and skeletal oolitic packstone) to open marine environment (i.e., skeletal floatstone, burrowed wackestone, and mudstone). The presence of benthic foraminiferal species *Redmondoides lugeoni* and *Nautiloculina oolithica* throughout the intervals of the studied sections, indicates deposition in shallow warm water environments and the prevalence of warm climatic conditions in the Middle Jurassic. A shift in the depositional environments from mainly lagoonal and shoal complex as indicated by the microfacies belonging to the D2 and D3 Units to dominantly shoal complex and open marine settings in the D4 Unit, suggests a seaward shift towards the top of the D4 Unit. Another line of evidence to support the shift in deposition setting is the decrease in microfossil contents towards the top of stratigraphic sections.

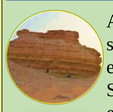
Introduction

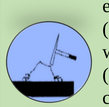
The Jurassic ancient carbonate succession of Saudi Arabia, named the Shaqra Group, provides an excellent carbonate ramp model along the western margin of Neo-Tethys Ocean. The group which hosts eight reservoirs is economically important containing large volumes of hydrocarbon (Cantrell et al. 2014). The D2-D4 are equivalents to Faridah reservoirs (Hughes 2004, 2009a). The formation was deposited in a semi-isolated basin that contained many endemic species of ammonites, brachiopods, echinoderms and foraminifera.

Objectives

Sedimentological, stratigraphical, petrographical and biofacies analyses of the outcropping D2, D3, and D4 Units of the Dhruma were used to identify and characterize their microfacies, develop and interpret the deposition model of the identified facies.

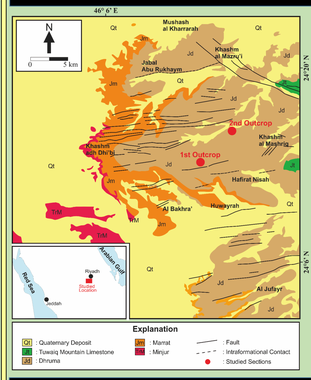
Methodology





A total of 107 samples were collected from three outcrop sections of the Dhruma Formation (D2, D3 and D4 Units) exposed in the Hafrat Nisah district of the Riyadh region, Saudi Arabia (Figs. 1 & 2). Thin section petrography, scanning electron microscope (SEM) imaging and x-ray diffraction (XRD) analyses were conducted on the samples. Thin sections were used for the microfacies and biofacies identification (Figs. 3 & 4) using an Olympus petrographic microscope with camera attached. Bulk mineralogy of the samples were determined with XRD analysis. The outcome of the laboratory analyses were integrated with the field sedimentological description to infer the depositional setting of the identified microfacies.

Study Area



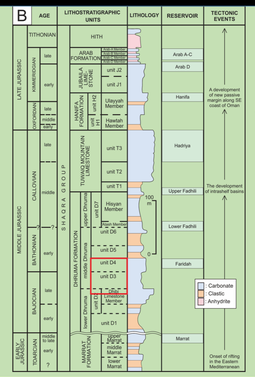
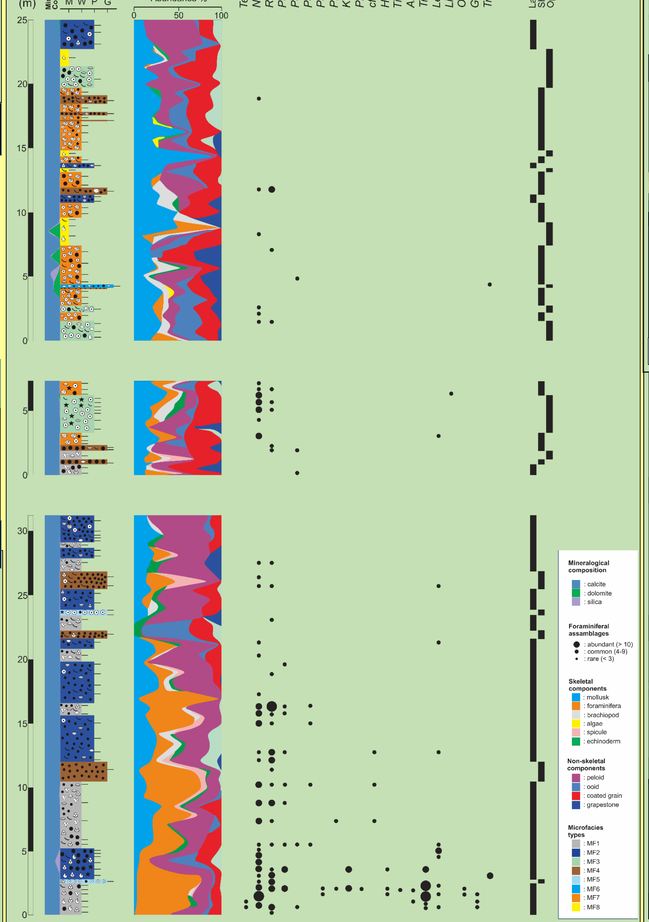


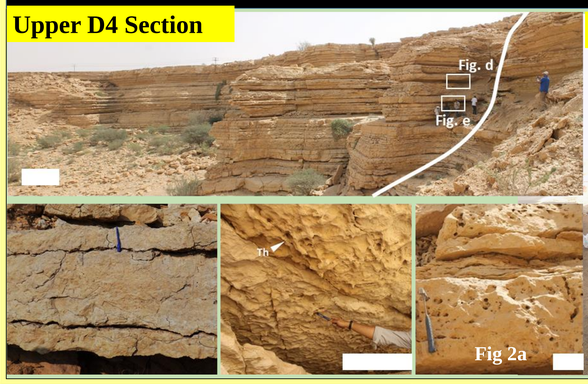
Fig 1.

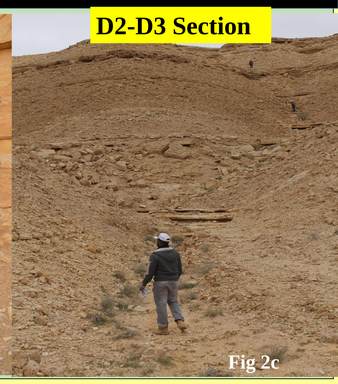
Results

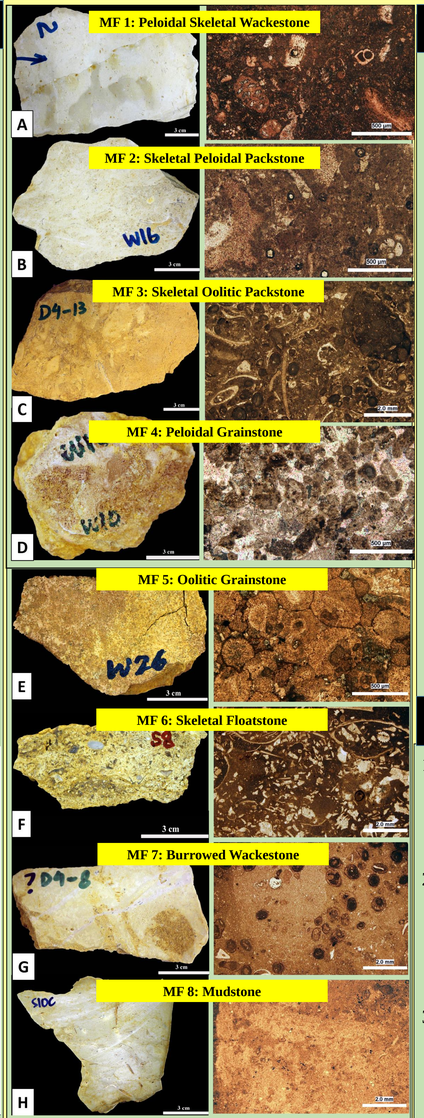
Fig. 3



Results







Discussion

Integration of the petrographic and foraminiferal data facilitated the interpretation of the deposition environments of the facies identified. All the microfacies were deposited in a shallow marine environment, mostly inner ramp setting. The D2-lower D4 outcrop sections are characterized by a coarsening upward sequence that commences with the deposition of lagoonal facies; consisting of MF1 and MF2 at the base and capped by MF4 or MF5 at the top. The upper D4 section which is characterized by either the the MF8 or MF7 facies at the base, and capped by MF4 or MF5 facies at the top, mostly represents open marine to shoal complex environments. Conceptual 2D and 3D models of the interpreted depositional environment show the distribution of these facies (Fig. 5). The depositional setting inferred is consistent with the earlier studies which documented that the Middle Dhruma Formation in the study area was deposited in a shallow marine environment. (e.g., Powers et al., 1966; Manivit et al., 1985).

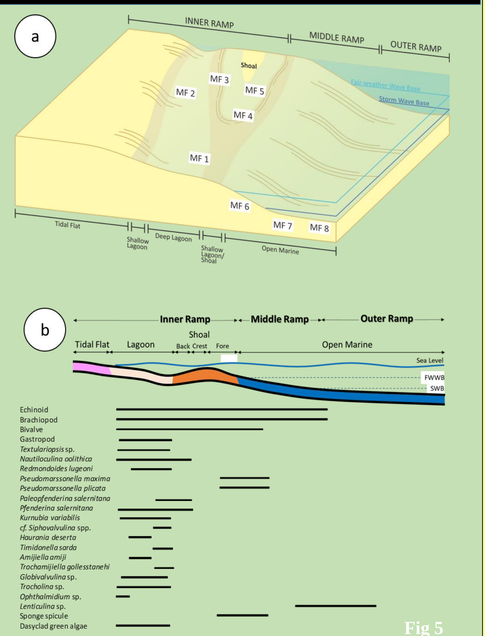


Fig 5

Conclusion

1. Eight microfacies including the skeletal peloidal packstone, peloidal skeletal wackestone, skeletal oolitic packstone, peloidal grainstone, oolitic mudstone, skeletal floatstone, and burrowed wackestone were identified.
2. Grouped into three Facies Associations: lagoonal (i.e., skeletal peloidal packstone, peloidal skeletal wackestone), shoal complex (i.e., skeletal oolitic packstone, peloidal grainstone, oolitic grainstone), and open marine (i.e., mudstone, skeletal floatstone, burrowed wackestone).
3. These facies were deposited in an inner ramp carbonate platform shallow marine (peritidal to open marine) without pronounced abrupt clastic influx.

Selected References

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