Boundary, Lyon-Neuchatel, September 1973. Bureau de Recherches Géologique et Minières Bulletin (deuxieme serie), Section IV, no. 3, p. 165-197.
Jassim, S.Z. and J.C. Goff 2006. Geology of Iraq. Dolin, Prague and Moravian Museure, Brno, Czech Republic, 341 p.
Krasheninnov, V.A., J.K. Hall, F. Hirsch, C. Benjamini and A. Flexer 2005. Geological Framework of the Levant Volume 1: Cyprus and Syria. Historical Productions-Hall, 508 p.
McGuire, M.D., R.B. Koepnick, J.R. Markello, M.L. Stockton, L.E. Waite, G.S. Kompanik, M.J. Al-Shammery and M.O. Al-Amoudi 1993. Importance of sequence stratigraphic concepts in development of reservoir architecture in Upper Jurassic grainstones, Hadriya and Hanifa reservoirs, Saudi Arabia. Proceedings of the 8th Society of Petroleum Engineers Middle East Oil Show, SPE paper 25578, p. 489-499.
Rousseau, M., G. Dromart, J.-P. Garcia, F. Atrops and F. Guillochau 2005. Jurassic evolution of the Arabian Platform edge in the central Oman Mountains. Journal of the Geological Society of London, v. 162, p. 349-362.
Rousseau, M., G. Dromart, H. Droste and P. Homewood 2006. Stratigraphic organisation of the Jurassic sequence in Interior Oman, Arabian Peninsula. GeoArabia, v. 11, no. 1, p. 17-50.
Sachsenhofer, R.F., A. Bechtel, R.W. Dellmour, A.F. Mobarakabad, R. Gratzer and A. Salman 2012. Upper Jurassic source rocks in the Sab'atayn Basin, Yemen: Depositional environment, source potential and hydrocarbon generation. GeoArabia, v. 17, no. 4, p. 161-186.
Sadooni, F.N. 1993. Stratigraphic sequence, microfacies, and petroleum potential of the Yamama Formation, Lower Cretaceous, Southern Iraq. Bulletin of the American Association of Petroleum Geologists, v. 77, p. 1971-1988.
Setudehnia, A. 1978. The Mesozoic sequence in southwest Iran and adjacent areas. Journal of Petroleum Geology, v. 1, p. 3-42.
Sharland, P.R., R. Archer, D.M. Casey, R.B. Davies, S. Hall, A. Heward, A. Horbury and M.D. Simmons 2001. Arabian Plate Sequence Stratigraphy. GeoArabia Special Publication 2, Gulf PetroLink, Bahrain, 371 p., with 3 charts.
Sharland, P.R., D.M. Casey, R.B. Davies, M.D. Simmons and O.E. Sutcliffe 2004. Arabian Plate Sequence Stratigraphy. GeoArabia, v. 9, no. 2, p. 199-214.
Simmons, M.D., P.R. Sharland, D.M. Casey, R.B. Davies and O.E. Sutcliffe 2007. Arabian Plate sequence stratigraphy: Potential implications for global chronostratigraphy. GeoArabia, v. 12 no. 4, p.101-130.
Tanoli, S.K., M.D. Al-Ajmi, H. Al-Ammar and N. Banik 2011. Where to find the Reservoir. Late Valanginian Unconformity associated play in Kuwait. Search and Discovery Article #40683, 38 p.
Vahrenkamp, V.C., F. al Katheeri, P. van Laer, D. Popa, P. Razin and C. Grélaud. 2012. Re-evaluation of the Late Jurassic Stratigraphy of Abu Dhabi – A Different Tack on a Carbonate-Evaporite System and Its Implication for Exploration Plays. Search and Discovery Article #50652, 35 p.
van Bellen, R.C., H.V. Dunnington, R. Wetzel, and D.M. Morton 1959-2005. Lexique Stratigraphique International. 03 10 Asie, (Iraq), 333 pages. Reprinted by permission of CNRS by Gulf PetroLink, Bahrain.

Upper Jurassic to Lower Cretaceous stratigraphic model for the eastern Arabian Plate

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The Upper Jurassic to Lower Cretaceous interval along the eastern edge of the Arabian Plate is a stratigraphic puzzle with many missing pieces. In the United Arab Emirates (UAE) and Saudi Arabia this interval contains the prolific Arab reservoirs sealed by the Hith anhydrite. These were the main target of the first exploration well in northern Oman, but unfortunately this reservoir-seal pair was found to be absent, and the well was abandoned as a hugely disappointing dry hole. It became apparent that in Oman Middle Jurassic shallow-water carbonates are overlain by deep-water deposits of poorly defined Late Jurassic–Early Cretaceous age.

The nature of the lateral change has been a point of discussion for many years. In the subsurface stratigraphic thinning of the Upper Jurassic towards the east has been observed, while in the

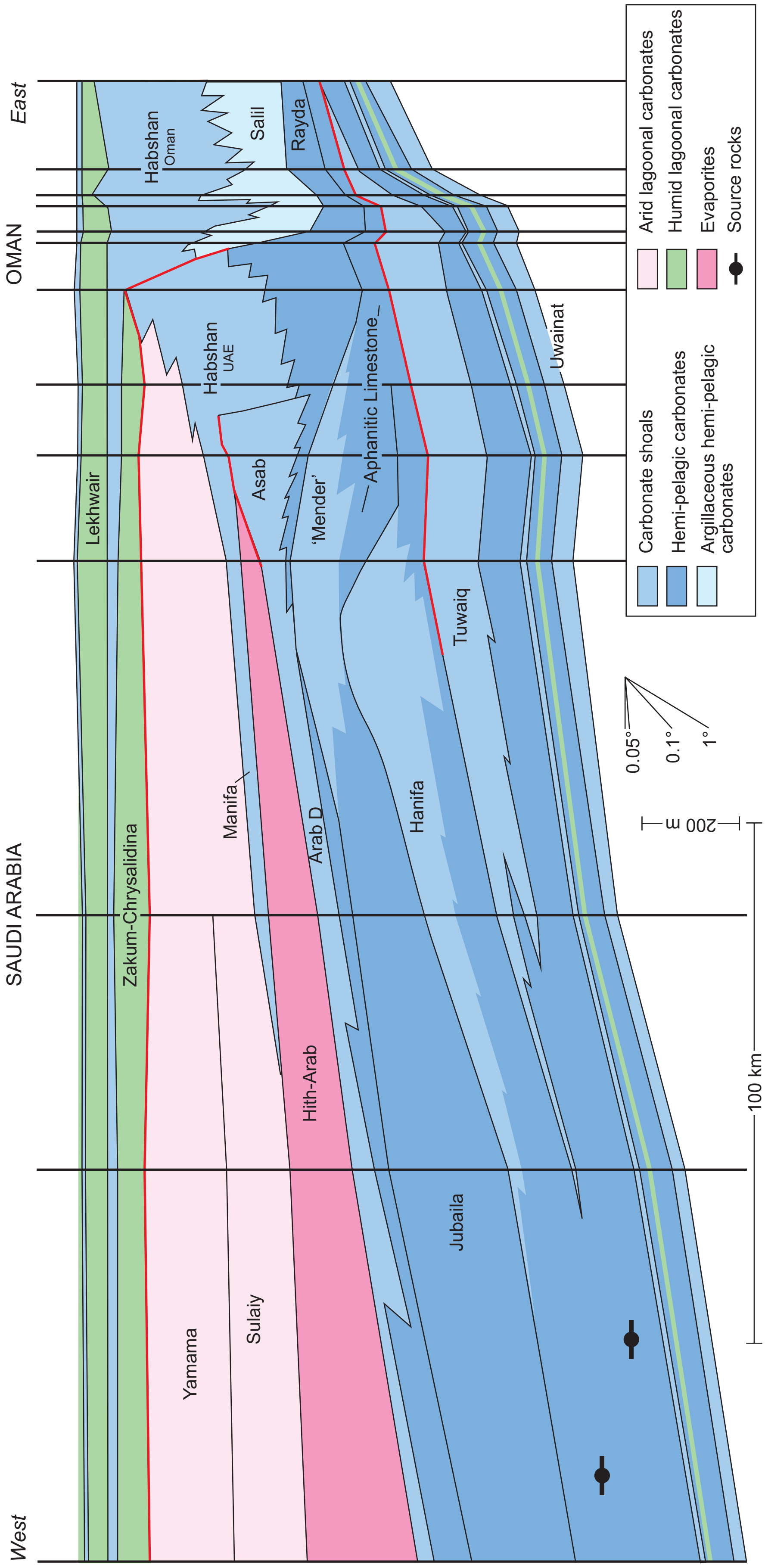

Figure 1: Well correlation panel for Middle Jurassic to Lower Cretaceous in eastern Saudi Arabia and Oman.

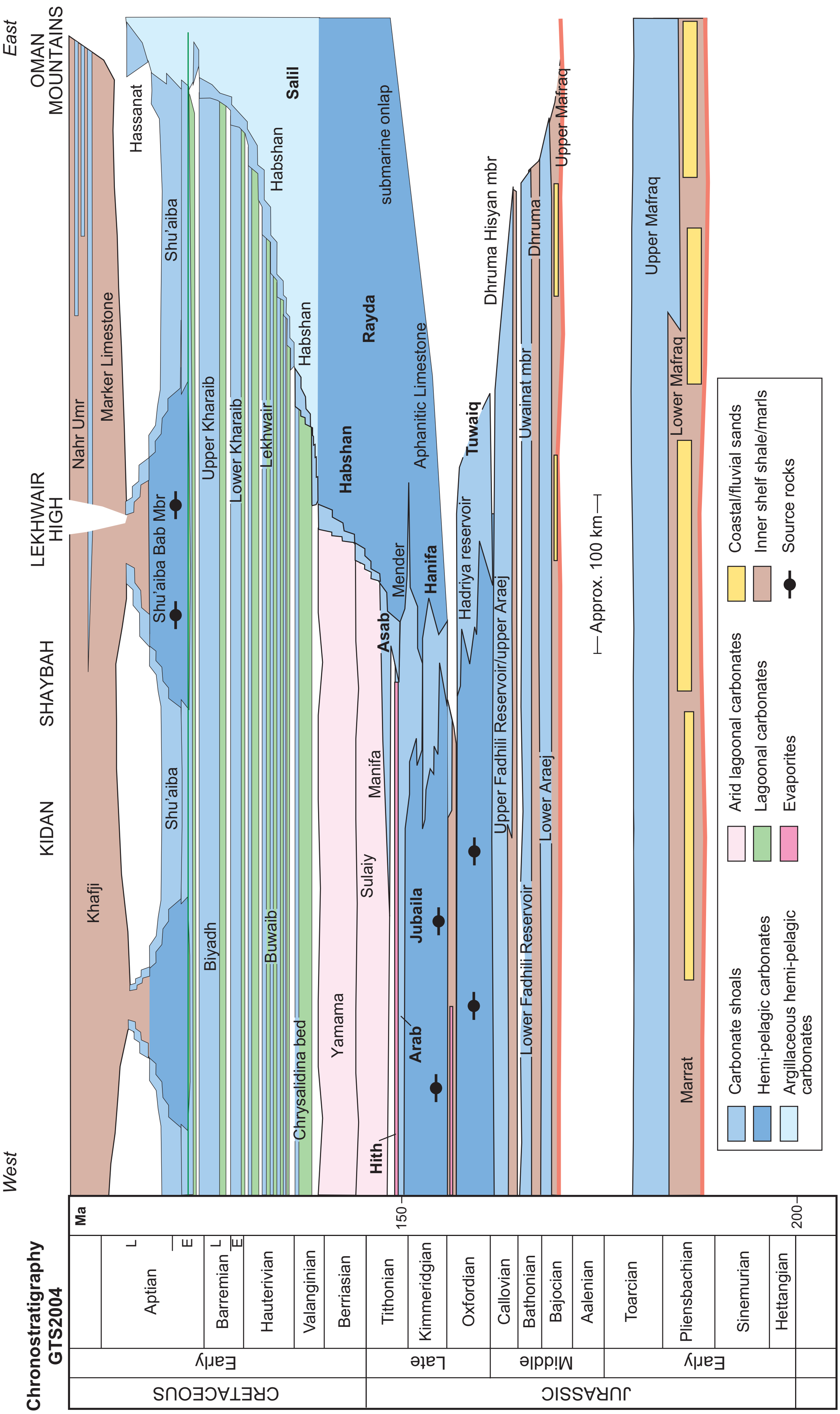

Figure 2: Schematic chronostratigraphic cross section for the Jurassic to Middle Cretaceous from eastern Saudi Arabia to Oman.

outcrops of the Oman Mountains there is evidence of erosion and truncation of the Middle Jurassic. Interpretations were hampered by:
(1) differences-in and inconsistent-use-of stratigraphic nomenclature across political boundaries;
(2) sharp lateral changes in stratigraphy due to the presence of depositional wedges; and most importantly;
(3) very poor biostratigraphic age control.
Furthermore correlations are hampered by the fact that the only horizons that can be correlated confidently on a regional scale (Zakum-Chrysalidina and top Dhruma) are quite some distance above and below the interval of interest.

Several models have been proposed:
(1) lateral facies change to condensed deep-water facies;
(2) latest Jurassic uplift and subaerial erosion followed by drowning; or
(3) submarine erosion associated with block faulting.
Recent biostratigraphic data combined with seismic observations allowed the construction of a new stratigraphic model, which will help to define the stratigraphic trapping potential within this interval.

The Lower to Middle Jurassic starts with an overall transgressive sequence of fluvial to coastal siliciclastics and shallow-marine to lagoonal carbonates, which onlap the uplifted eastern plate margin in Oman. This is overlain by a complex of carbonate sand shoals that prograded towards the west into the Rub' Al-Khali Basin.

The truncation of the Middle Jurassic carbonate platform is related to uplift and subaerial exposure of the eastern plate margin at the end of the Middle Jurassic. A karstic surface with extraclasts has been recognised in cores. The Tuwaiq and Dhruma formations are progressively truncated towards the east; at least some 250 m has been removed. The surface is overlain by "aphanitic" limestones, interbedded massive and laminated lime mudstones deposited by low-density turbidites in an offshore setting, with rare skeletal debris, calcispheres and shell fragments. This suggests that uplift was followed by major collapse of the eastern margin of the Arabian Plate and the development of drowning unconformity overlain by deep-water condensed sediments. The collapse, as well as the preceding uplift may be related to the initiation of the transform fault margin located offshore eastern Oman in the Arabian Sea, or isostatic sagging of the underlying Triassic to Lower Jurassic interior platform carbonates. Biostratigraphy suggest an Early Kimmeridgian age for this unconformity, much older than the base Cretaceous as has been suggested in other studies.

Following the early Late Jurassic flooding event, seismic shows that a stacked complex of eastward prograding carbonate platforms was established in Saudi Arabia and the UAE consisting of the Arab, Hith, Asab and the Sulaiy/Yamama formations, while in northern Oman deposition took place in a deep basinal setting. There are some indications on seismic and in well correlations that the initiation of this platform may have been triggered by a shallowing event due to structural uplift in the eastern UAE and Saudi Arabia. Westward of the platform margin a deeper intra-shelf basin was initially present, where, during a base-level fall, the Arab and Hith evaporites were deposited. The upper parts of the Upper Jurassic platform interior consist of shallow-marine to intertidal carbonates with locally evaporites of the Sulaiy and Yamama.

It was only by Early Cretaceous times that the platform reached North Oman with deposition of the Salil/Habshan formations. Unlike the Jurassic platforms more argillaceous hemipelagic carbonates (Salil Formation) form the lower part of the slope and the basinal sediments in front of the Habshan oolite margin. Also the time-equivalent lagoonal deposits of the Zakum-Lekhwair Formation show more clastic influence and absence of evaporites. This suggests a climatic change from an overall arid setting during the Jurassic to a humid setting in the Cretaceous. During the Early Cretaceous this platform prograded more than 250 km to the east to a position of approximately the present-day northern Oman coastline. Seismic shows a spectacular system of laterally stacked belts of clinoform sets separated by discontinuities.

Evidence of glacio-eustasy during the Late Berriasian to Late Valanginian: Record in the Lekhwair/Habshan/Salil prograding geometries, Rayda Basin, Sultanate of Oman

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The Lekhwair/Habshan/Salil (or LHS) system is a carbonate succession that prograded by 300 km toward the northeast across the eastern part of the Arabian Plate (Rayda Basin) from Berriasian to Early Barremian. The system is organized as a series of large prograding clinoforms with amplitudes ranging from 200 to 350 m.

The three formations that compose this system correspond respectively to the inner platform (Lekhwair Formation), platform margin (Habshan Formation) and slope-to-basin facies associations (Salil Formation). On seismic sections, this system shows a conspicuous prograding character with well-expressed clinoforms (Berriasian to Valanginian). The formations imaged on the seismic section are exposed at outcrop in the Oman Mountains (Upper Valanginian to Lower Barremian) to the north, making it possible to study the system at different scales: basin, depositional system and reservoir.

This study focuses on the basin-scale evolution from Berriasian to Valanginian. It is based on the stratigraphic interpretation of a regional 2-D/3-D seismic dataset. It covers a region located in the northern part of Oman, extending 140 km from north to south and 280 km from east to west.

Calpionellids biostratigraphic study from core data allowed a time-calibration for the interpreted seismic sequences. Four sequence groups have been defined for the period from the Berriasian to the Late Valanginian.

(1) The Upper Berriasian sequence group, which records cycles of high-amplitude relative sea-level variations.
(2) The Uppermost Berriasian–Base Valanginian sequence group records cycles of lowest amplitude relative sea-level variations.
(3) The Lower to Mid-Valanginian sequence group, records a cycle of high-amplitude relative sea-level variation, in which the rising sea-level phase is manifested as large aggrading-prograding wedges. This unit is characterized by the preservation of vast inner-platform deposits covering the whole of the underlying sequence groups (equivalent of the Zakum Member in the United Arab Emirates).
(4) The Mid- to Upper Valanginian sequence group records a series of cycles of lower-amplitude relative sea-level variations, which are generally manifested as a regional phase of pure progradation.

Based on seismic stratigraphy and geomorphology, relative sea-level changes were interpreted as the main factor controlling the geometries. The good correlation between the interpreted relative sea level cycles and eustatic curve published by Haq et al. (1988) suggests eustasy as the main controlling factor for the architecture of the LHS clinoform system. The alternation between high- and low-amplitude cycles suggests a climatic control for these eustatic cycles.

References

Haq, B.U., J. Hardenbol and P.R. Vail 1988. Mesozoic and Cenozoic chronostratigraphy and eustatic cycles. In C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, J.C. Van Wagoner (Eds.), Sealevel Changes: An Integrated Approach. Society of Economic Palaeontologists and Mineralogists, Special Publication no. 42, p. 71-108.