Sequence Stratigraphic Analysis of the Mauddud Formation, Central Iraq

Prof. Dr. Ali D. Gayara

Retired, Previosly of the Dept. of Geology, University of Baghdad, Iraq

Abstract— *The Mauddud Formation of central Iraq was deposited within different shallow and deep marine subenviroments on a distally steepend ramp setting, Local tectonism greatly affected the sequence development where the different rates of subsidence of the different tectonic provinces were the major control on the nature of 4^{th} order cyclicity of the succession (thickness, symmetry, and facies stacking pattern). Subsidence analysis (R2 curves) revealed the effect of local tectonism, and the vertical and lateral variations in accommodation. The effect of the eustatic component was clear in the stable area to the West where there was no or very low rate of subsidence.*

Keywords— Sequences stratigraphy, Mauddud Formation, Central Iraq.

I. INRODUCTION

The Mauddud Formation (Upper Albian-Lower Cenomanian) of Central Iraq was deposited on a shallow carbonate platform on the northeastern passive margin of the Arabian Plate. The studied area extends along the stable shelf and westward to the unstable shelf (Fig. 1). The Mauddud Formation was studied by many workers like Van Bellen et. al. (1959) and Jassimet. al. (1984), Al-Eisa (1997), and lately Al Yassery (2015), they among others studied the starigraphy and paleontology of the formation but none of them dealt with the type of depositional setting and basin development in detail.

The lower boundary of the formation is conformable with the underlying Nahr Umr Formation, this boundary can be correlated with K110 MFS of Sharland et. al. (2001) Reflecting the widespread transgression of the Mauddud sea during the Late Albian. The upper boundary on the other hand is unconformable with the overlying spicular and Pelagic limestone of the Ahmadi Formation. Data from seven subsurface sections were analyzed and studied in detail where microfacies analysis of cores and cuttings provided the necessary information for facies analysis and pale environment interpretation, and this is the first step of determining the different parasequences and sequence stratigraphic subdivsions and consequently the final interpretation of depositional setting, sequence development and, cyclicity of the succession.

The second reduction (R2 curve) of the cumulative subsidence curve was calculated by subtracting the best fit (calculated by least square method) from the backstripped curve (R1) in order to remove the accommodation space provided by tectonic subsidence, the net subsidence remaining reflect changes in accommodation generated solely by eustasy or local tectonism. R2 curve can be useful in intrabasinal correlation especially passive margin basins (Bond et. al. 1988).

II. PALEOENVIRONMENTS

On the basis of depositional texture, types of carbonate grains, and faunal content and diversity; several microfacies were recognized within the Mauddud succession in the studied sections. These microfacies can be grouped into five facies associations reflecting five major subenvironments.

Facies Association 1: Nonfossiliferous mudstones, bioclastic mudstones to wackestones. This association reflects a shallow restricted marine environment where the pure micrite represent depositon in quiet bays and ponds within the tidal flat whereas mudstones with few shell fragments and bioclastic wackestones with abundant molluscs fragments reflecte deposition in tidal flat to low energy shallow subtidal environment. The mudstones are often dolomitized.

Facies Association 2: Fossiliferous packstones to grainstones, ooidal peloidal Grainstones. Abundant and diverse fauna and numerous bioclasts as well as abundant ooids and peloid characterizes this association indicating a high energy environment where the shoal facies were deposited.

Facies Association 3: Mixed fauna wackestones to packstones, bioclastic wackestones to packstones. This association is typical of medium to high energy shallow subtidal environment with open circulation where orbitolina, alveolina, pralveolina, nezzazata, and miliolids are abundant as well as echinoderm and shell fragments. Echinoderm fragments constitute the main component of the of the bioclastic wackestones and packstones of this association

Facies Association 4: Spicules wackestones, spicules bioclastic wackestones to Packstones. The association of fine bioclasts, disoriented sponge spicules, some echinoderm fragments, and few planktons may reflect deposition in deep outer ramp area where fine bioclasts and echinoderm fragments were driven downslope into this oligophotic (poor light) deep, non-wave agitated environment and mixed with sponge spicules and planktons.

Facies Association 5: Planktonic wackestones to packstones. The abundance of planktons as well as sponge spicules in this facies may indicate deposition in deep toe of slope to basinal enviroment.

III. DEPOSITIONAL SETTING

The depositional profile can be reconstructed from facies geometry, type of skeletal components and their dependence on the presence of light, as well as the amount of carbonate production. The Mauddud succession in the study area is characterized by a thick inner platform - thin marginal and outer platform facies, gradual lateral facies changes, and absence of distinct slope facies (Fig. 2) such characteristics are typical of ramp setting (Ahr, 1989, Flugel, 2010), higher carbonate production characterizes the inner ramp area where the predominantly euphotic zone was dominated with mollusks and small benthos gradually changes into deep oligophotic environments of the deep ramp and then deep basinal area eastward. The depositional profile seems to have changed from homoclinal ramp during the early stages of the Mauddud deposition into distally steepened ramp setting at later stages of sequence development.

IV. SEQUENCE DEVELOPMENT

Facies associations were related to systems tracts and attributes of key surfaces were defined in order to study the nature of cyclicity and sequence development of the Mauddud Formation of Central Iraq. The lower boundary of the succession with the underlying Nahr Umr Formation is represented by a transgressive surface (TS) where the sudden deepening reflects the major sea level rise at the Late Albian and the start of a new carbonate platform. Four 4th order cycles can be recognized (Fig.2), Cycle A is asymmetrical with a relatively thick transgressive systems tract (TST) and thin highstand systems tract (HST) reflecting a short episode of stillstand after the initial sea level rise; It can be divided into two small subcycles in the west (Section at 7/7) in the west since the minor short term eustatic fluctuations are best represented in such a stable area with a very low rate of subsidence, this fluctuation is masked by higher rates of subsidence in the unstable towards the unstable shelf area where sections Fj-1, Eb-1, and Bd-1 lies. Cycle B is shorter, and the fluctuation between the transgressive open marine facies and highstand restricted marine facies is manifested basinward (Section at Bd-1) by basinal deep marine and open marine facies respectively (Fig. 2). This may show the beginning of higher rates of subsidence at the West where lower carbonate production due to flooding of the distal part of the ramp produced a thin basinal deep ramp facies succession. Cycles C & D are different, they reflect short episodes of sea level rises followed by long stillstands where thin transgrssive deep marine facies are followed by thick progradational to aggradational shallow open marine highstand parasequences at Bd-1 in the East, and correlated in the west by shallow open and restricted marine facies respectively. Cycle D is incomplete and eroded completely in the West by the major sea withdrawal at the Early Cenomanian forming Type 1 sequence boundary (SB1) where the rate of sea level fall was greater than the rate of subsidence.

V. SUBSIDENCE ANALYSIS

After decompaction, backstripping, and removing the tectonic component of Subsidence, the remaining net subsidence reflects changes in accommodation generated by eustasy or local tectonism. The R2 curve (Fig. 3) is calculated by taking the difference between the backstripped curve and its best fit exponential . R2 curves reflects changes in accommodation through time as well as the directions of its minimum and maximum, it is useful in intrabasinal correlation showing the different degrees of eustatic effect due to local tectonism throughout different tectonic provinces. Analysis of R2 curves (Fig. 3) shows the effect of local tectonism on accommodation during deposition of cycle A in the unstable
Mesopotamian Zone whereas decreasing rates of subsidence at section 7/7 allowed the reflection of the eustatic component in the West. Higher carbonate production within the inner ramp area produced a relatively thick succession in cycle B at sections Nf-1 & Fj-1, The lower rate of subsidence was concomitant with the sea level fall producing thick progradational to aggradation succession of restricted marine facies of cycle C. The trend of these curves shows an

eastward increase in accommodation, the lateral change in accommodation and the response of facies tracts to this change reflects the effect of local which differ by different locations within the stable shelf area and the Mesopotamian Zone of the unstable shelf area, also the vertical variations in R2 curves shows the effect on the nature of facies stacking pattern and cyclicity due to accommodation changes through time.

VI. CONCLUSIONS

The Mauddud Formation of Central Iraq was deposited through different subevironments within a homoclinal ramp during the first stage of platform development then changed into distally steepened ramp setting .

Four 4th order cycles were recognized , the nature of these cycles (thickness, symmetry, and facies stacking pattern) was affected by local tectonism at different tectonic provinces. Higher rates of subsidence to the East was manifested by deeper facies of cycle B and thicker successions of cycles C & D, The eustatic component was the main controlling factor on sequence development in the stable area to the West.

Calculation of R2 curves were useful in determining the vertical and lateral variations in accommodation due to eustasy or local tectonism. The trend of these curves shows an eastward increase in accommodation, This may reflect the effect of local tectonism, the vertical variations in R2 curves shows the effect on the nature of facies stacking pattern and sequence development due to accommodation changes through time.

REFERENCES

[1] Ahr, W.M., 1989, Sedimentary and tectonic controls on the development of an Early Mississippian carbonate ramp, Sacramento Mountains area, New Mexico. In: Controls on Carbonate Platform and Basin Development (Ed. by P.D. Crevello, Petro.Co., Baghdad.

[2] Al-Eisa, M.A.S., 1997, Stratigraphy of Early Cretaceous subsurface sections from middle Iraq, Unpub. Ph.D., Thesis University of Mosul, 194 p.

[3] Al Yassery, N.H.N., 2015, Biostratigraphy and Microfacies Analysis of Mauddud Formation in Badra Oil Field, Eastern Iraq. Unpub. MSc. Thesis, Uiversity of Baghdad, 94 p.

[4] Bond, G.C., Kominz, M.A., and Grotzinger, J.P., 1988, Cambro-Ordovician eustasy: evidence from geophysical modeling of subsidence in Cordilleran and Appalachian passive margins, in Paola, C., and Kleinsephn, K., ed., New Perspectives in Basin Analysis: New York, Springer Verlag, p.129-161.

[5] Flugel, E., 2010. Microfacies of carbonate rocks, Second Edition, Springer, PP.1-984.

[6] Jassim, S.Z., Karim, S., Basi, M., Al-Mubarak, M.A., and Munir, J., 1984, The final report on the regional survey of Iraq, Strarigraphy, S.O.M. library, Baghdad, Unpub.

[7] Sharland, P.R., Archer, R., Casey, D.M., Davies, R.B., Hall, S.H., Heward, A.P., Horbury, A.D., and Simmons, M.D., 2001, Arabian Plate Sequence Stratigraphy: GeoArabia Special Publication 2, Gulf PetroLink, Bahrain,371 p.

[8] Van Bellen, R.C., Dunnington, H.V., Wetzel, R., and Morton, D.M., 1959, Lexique Stratigraphic Internationa, Asie, V.3, Fasc, 10a, Iraq, Paris, 333 p.

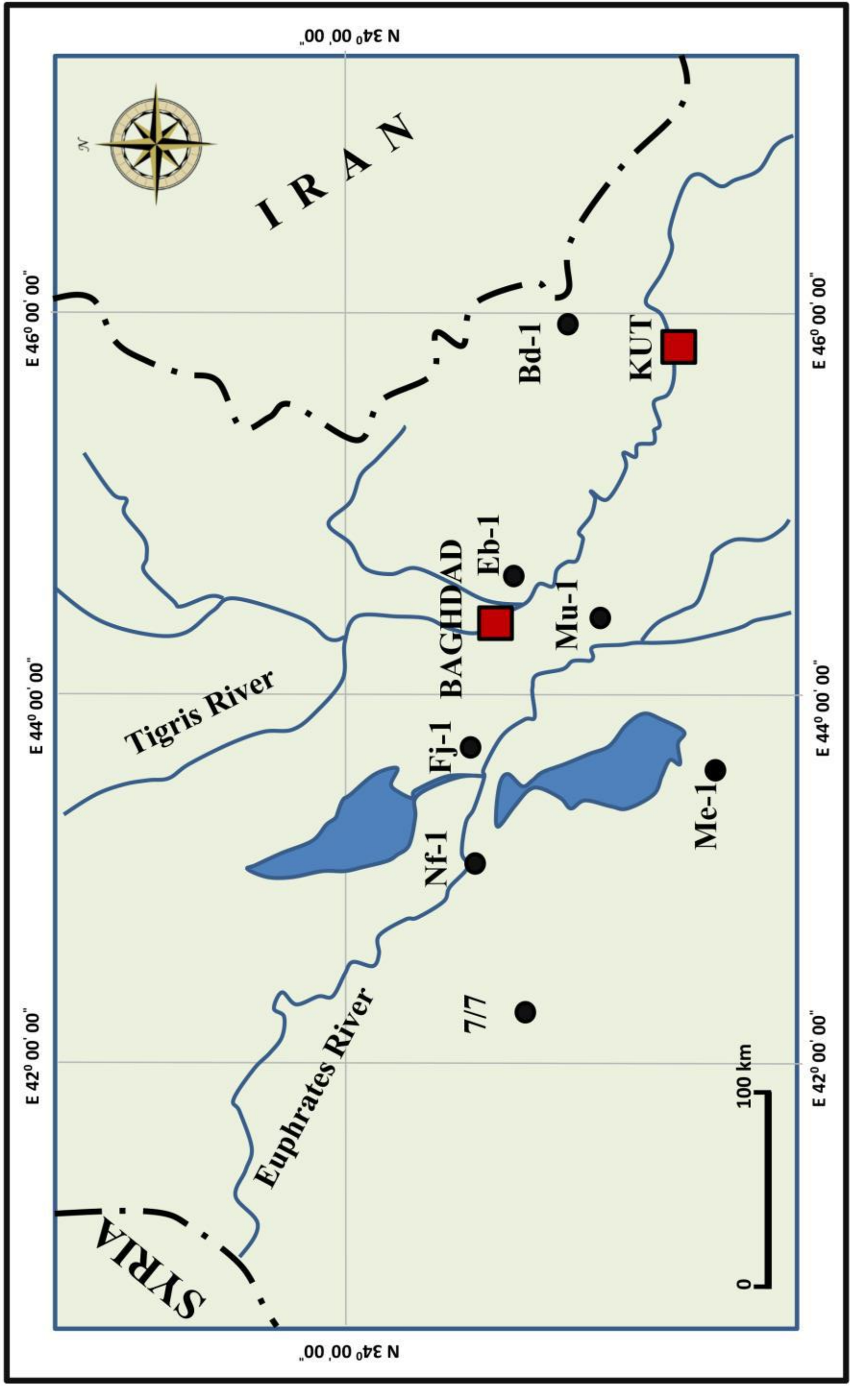

Fig.1: Location map of the study area.

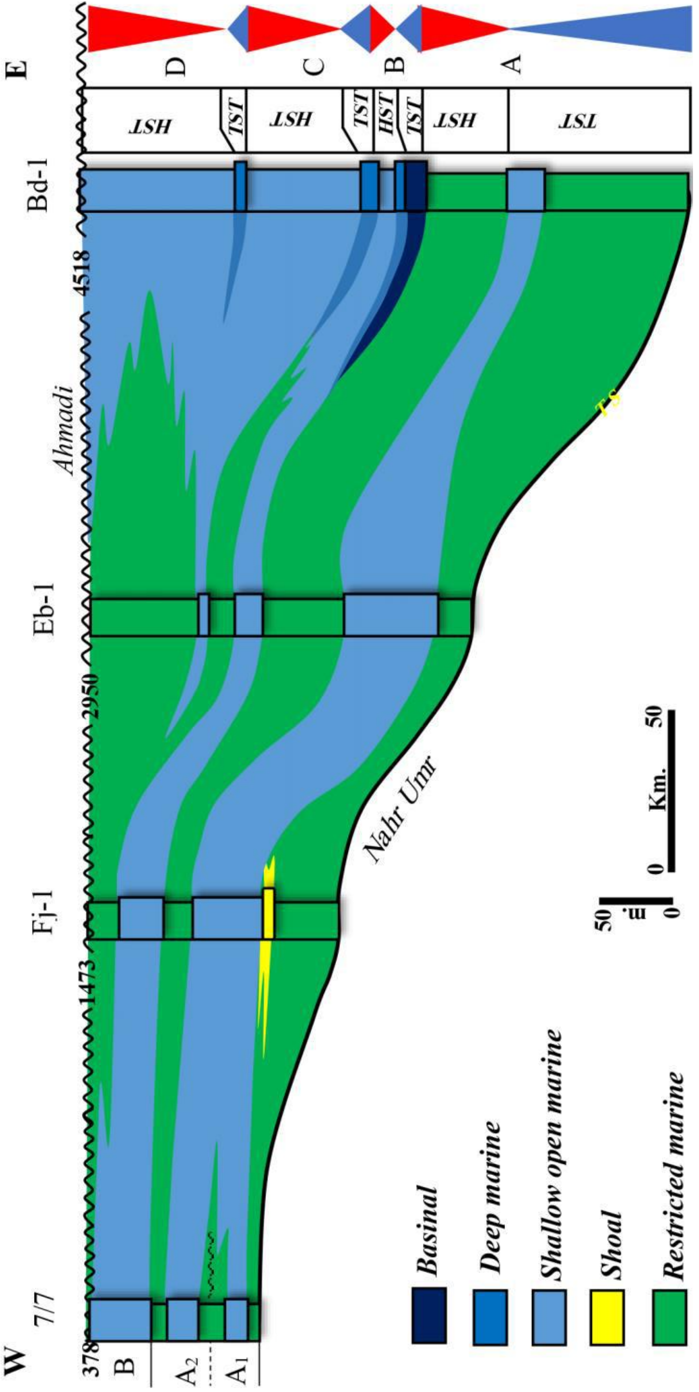

Fig.2: Stratigraphic cross section showing vertical and lateral facies changes and sequence stratigrapuic subdivisions of the Mauddud Formation in the study area.

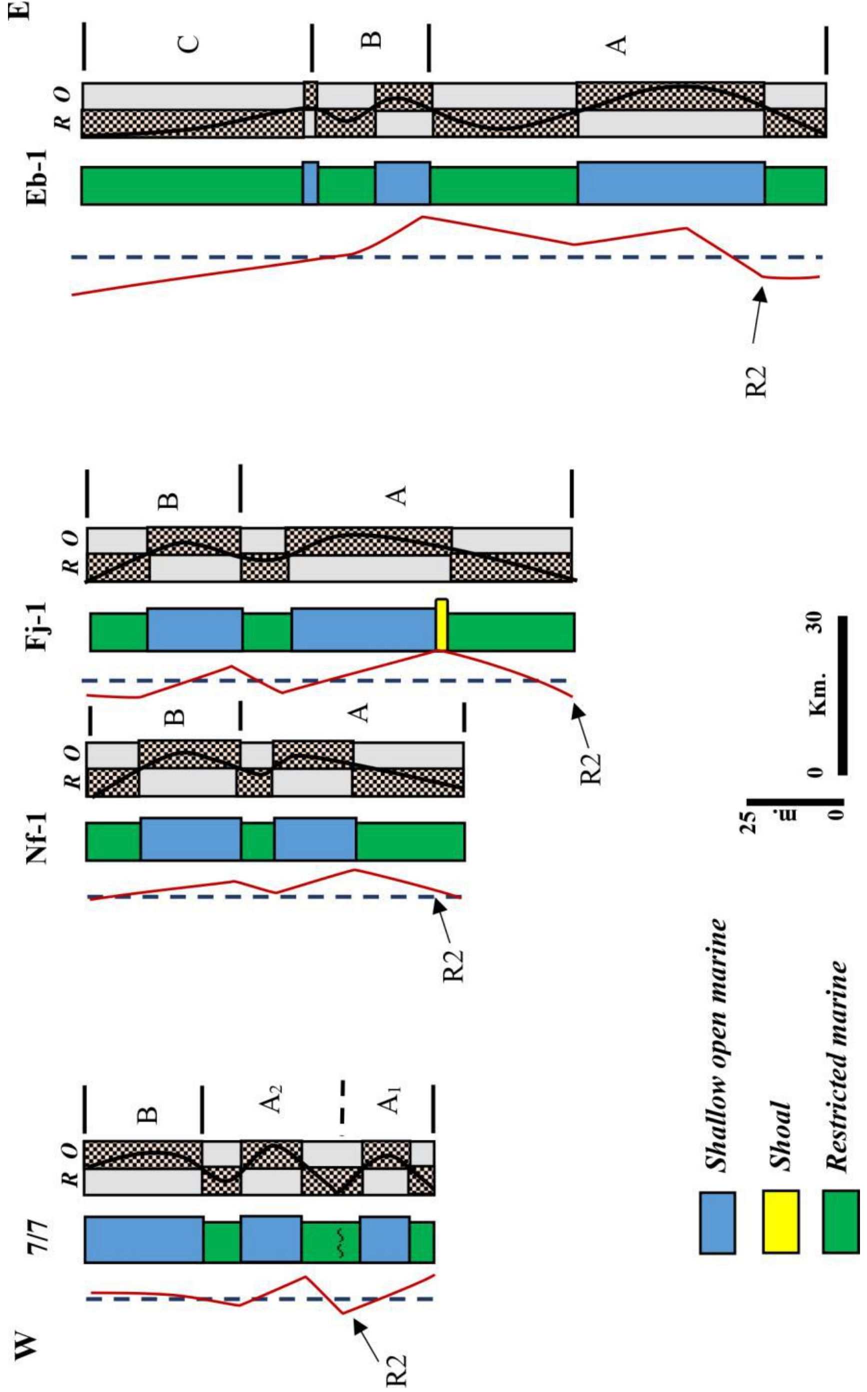

Fig.3: R2 curves of selected sections throughout different settings within the study Area.