Latest Jurassic to Early Barremian carbonate systems from the United Arab Emirates to Oman: Regional stratigraphic architecture and controlling factors

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The latest Jurassic–Early Barremian carbonate systems of the United Arab Emirates (UAE) and Oman are organized as a succession of prograding wedges over almost 300 km towards the northeast. The integration of outcrop and subsurface data allows the definition of clinoform architecture, the proposal of regional correlations, and the characterization of the main stages of evolution of this part of the Arabian Plate (Figure 1).

During the Late Jurassic, the eastern margin of Oman was affected by an uplift responsible for an important erosion of the Jurassic series in the Oman Mountains. This tectonic movement may have caused the restriction of the platform and the development of evaporitic systems (Arab A, B, C members and Hith Formation) in the still subsiding UAE domain. The progressive wedge of these units towards the east could be related to this uplift (Figure 2).

A reversal of this tilting and regional subsidence increasing towards the east started in the Late Tithonian. In the UAE, the subsidence led to the development of transgressive systems (Manifa Formation) and then to a thick aggradation of inner platform deposits (Habshan Formation), which grade towards the north to oolitic platform-margin deposits (Habshan oolite), and then to condensed facies at the toe of clinoforms (Mender Glauconite) (see also Grélaud et al., 2013). These important movements (uplift and subsequent subsidence) are interpreted as related to the Proto-Indian Ocean opening mechanisms on the eastern margin of the Arabian Plate during Late Jurassic times.

After this major flooding episode, the carbonate platform prograded towards the northeast over several hundreds of kilometers between the Middle Berriasian and the Middle Valanginian. Until the Mid-Valanginian, the clinoforms architecture was mainly controlled by eustatic sea-level variations, which present high-frequency fluctuations of alternatively low and high amplitude. In this latter case, variations of the order of hundreds of meters are interpreted as the record of a global "icehouse" context during the Late Berriasian and during the Early Valanginian (Figure 3; Dujoncquoy, 2011).

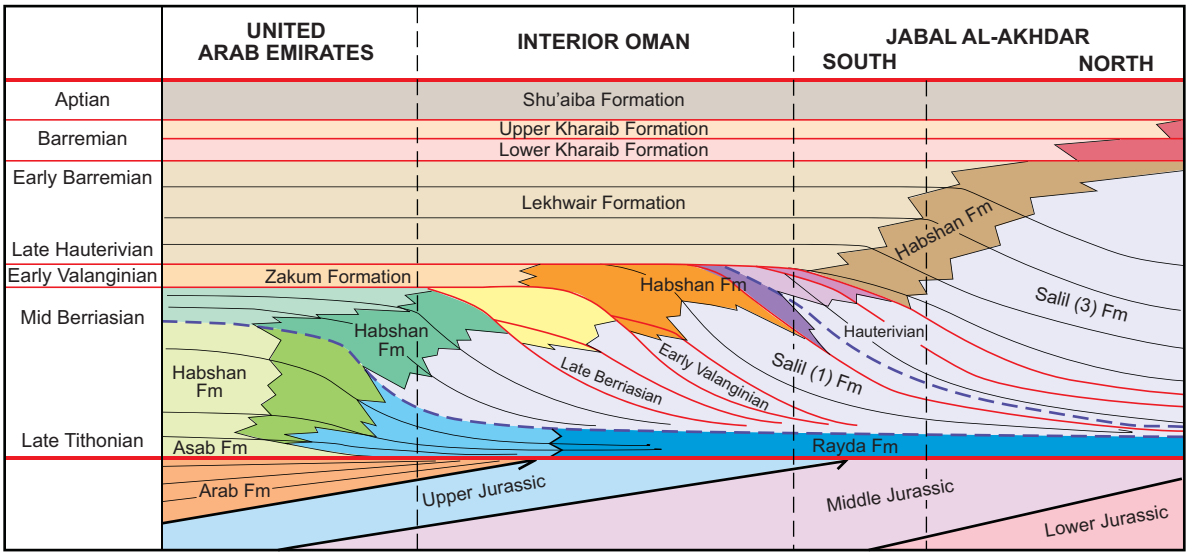


Figure 1: Schematic organisation of the Late Jurassic–Early Cretaceous sequence from the United Arab Emirates to Oman.

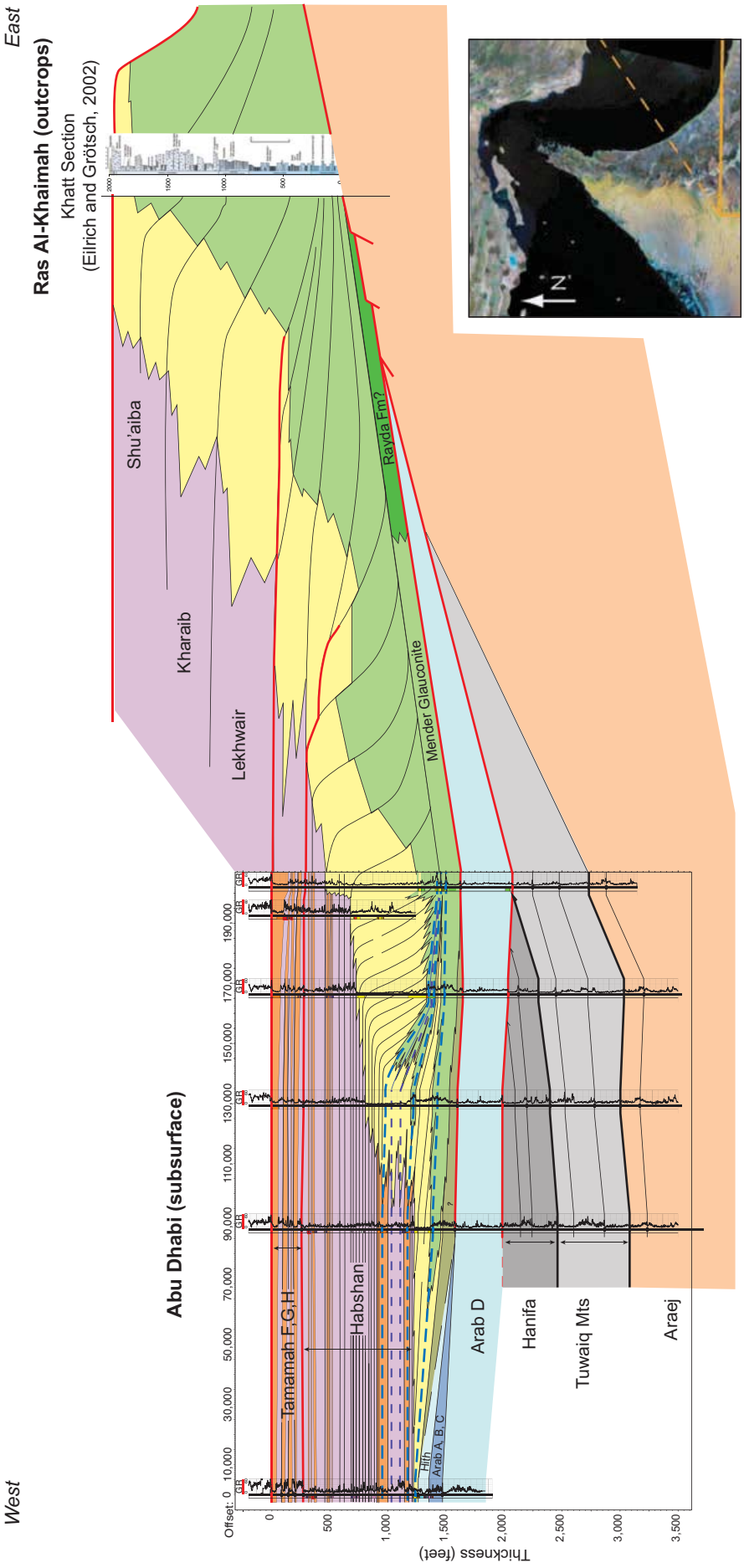


Figure 2: Tentative correlation between the Late Jurassic–Early Cretaceous sequence in Abu Dhabi (subsurface data) and in the Oman Mountains in Ras Al-Khaimah area (outcrop data). Noteworthy are the successive truncations of the Late Jurassic sequence towards the east related to a major uplift of the eastern margin on the Arabian Plate during Late Jurassic.

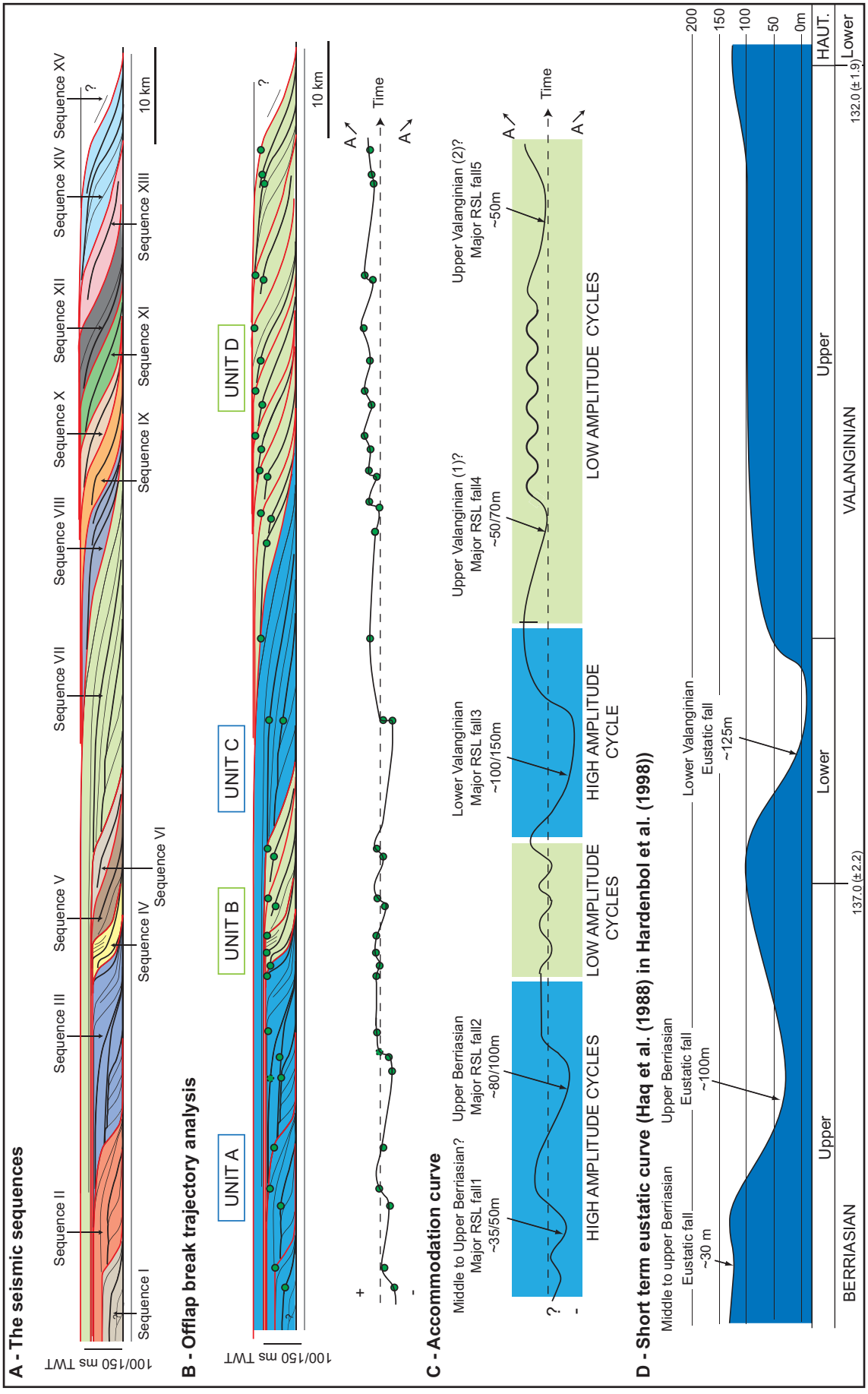
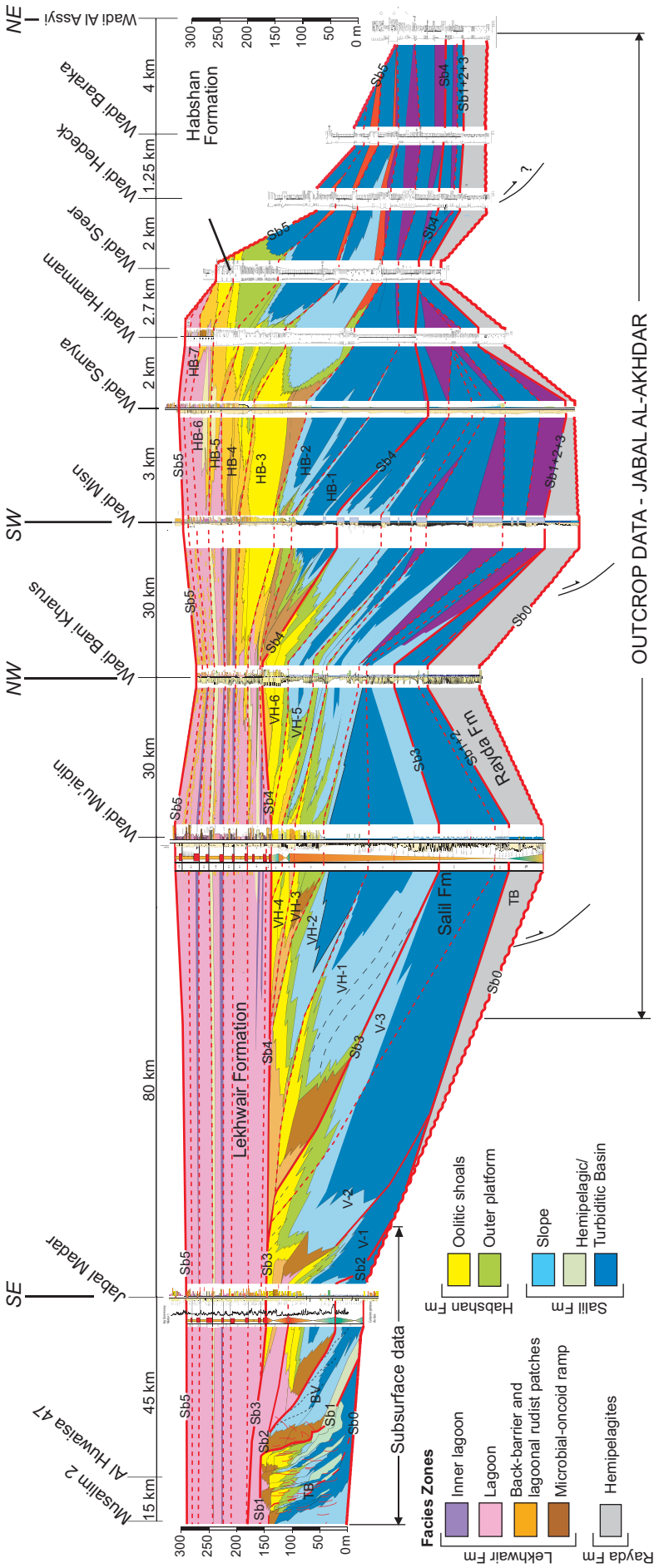


Figure 3: Architecture of the Late Berriasian–Valanginian prograding system in the Interior Oman from seismic data. The analysis of the off-lap break trajectories permits the reconstruction of an accommodation curve, which can be compared to the eustatic chart of Haq et al. (1988). This accommodation curve indicates an alternation of high-frequency, low and high amplitude (100 to 150 m) sea-level variations, which can be related to greenhouse (units B and D) and icehouse (units A and C) climates, respectively (Dujoncquoy, 2011).



Sequences set TB: Late Tithonian - Mid Berriasian - Seq. set BV: Late Berriasian - Early Valanginian - Seq. set V : Valanginian - Seq. set VH: Late Valanginian - Hauterivian - Seq. set HB: Late Hauterivian - Early Barremian

Figure 4: Detailed architecture of the Early Cretaceous clinoforms in the Oman Mountains based on outcrop data. Note (1) the pure progradational low-angle clinoforms during Late Valanginian and Hauterivian related to tectonic forcing (sequences sets V and VH), and (2) the aggradational-progradational higher-angle sigmoid clinoforms during Late Hauterivian to Early Barremian recording a stage of regional subsidence (sequences set HB).

During the Late Valanginian–Early Hauterivian, a regional uplift, locally associated with normal faulting, was responsible for the subaerial exposure of a large part of the platform and for the development of forced regressive wedges on its margin, localized at this time in the Oman Mountains area.

In this distal domain of the Arabian Platform, the initial stage of subsidence that occured during Late Tithonian and Berriasian is recorded by hemipelagic mudstone corresponding to the Rayda Formation. These mudstones were deposited unconformably on the Lower to Middle Jurassic formations, which are more and more eroded towards the east or northeast in response to the Late Jurassic uplift of the eastern Oman margin. This relatively tabular transgressive unit was deposited below a water depth of approximately 300 m. The top of this unit is marked by a succession of condensed horizons, which represent the distal end of the Late Berriasian–Middle Valanginian prograding clinoforms, recognized in subsurface data in the Interior Oman and in the UAE.

The overlying unit, dated as Middle–Late Valanginian to Early Barremian was formed by an overall shallowing-up succession, which started with slope/basin carbonate deposits made of more-or-less argillaceous mudstone (Salil Formation), overlain by grainy or bio-constructed platform-margin deposits (Habshan Formation). These deposits are organized along extensive low-angle clinoforms of 250 to 300 m of amplitude that record a pure and/or forced progradation of the system under tectonic control towards the northeast (Figure 4; Lebec, 2004).

This tectonic event ended during the Hauterivian. It was followed by a phase of regional subsidence, which controlled the thick aggradation and slowed progradation of the platform. It is recorded by the development of large sigmoid clinoforms steeper than the previous ones. This regional subsidence allowed the preservation of extensive lagoonal deposits (Lekhwair Formation) behind the well-developed oolitic barrier (Habshan Formation). During the Late Hauterivian to the Early Barremian, this lagoonal domain covered the previously exposed platform from the UAE to Oman.

In detail, this prograding system presents at outcrops a large variety of carbonate depositional systems and complex geometries controlled by environmental parameters, relative sea-level variations, tectonics, etc. During the Late Valanginian, muddy carbonate systems with microbial production and bioconstructions were dominant, favored by global anoxic conditions. During the Hauterivian, oolitic systems developed. Depositional geometries, and especially the architecture of clinoforms, are mainly controlled by variations of accommodation potential. The oolitic and associated back-barrier rudist-rich geobodies, which correspond potentially to reservoirs, developed in various geometrical and stratigraphical contexts, mainly during periods of increasing accommodation rate.

The study of this Lower Cretaceous sequence at outcrops provides interesting information for the interpretation of prograding systems in the subsurface, and also on the evolution of the Arabian Platform margin during the Late Jurassic–Early Cretaceous. The Late Jurassic and Late Valanginian tectonic events, the Late Berriasian and Early Valanginian eustatic events, and the Late Tithonian–Early Berriasian and Late Hauterivian–Early Barremian stages of regional subsidence are the main controlling factors on the complex architecture of such a huge aggrading and prograding carbonate system.

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