Cretaceous cyclostratigraphy and prominent unconformities of the Jeza-Qamar Basin, southern Oman

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Summary

The stratigraphic succession of the Jeza-Qamar Basin in southern Oman (Dhofar Region) is filled by Cretaceous rocks that include, in an ascending order, Qishn, Kharfot, Dhalqut, Samhan and Sharwayn formations. The stratigraphic column is punctuated by extensive unconformities that correlate with coeval hiatuses in other parts of the Arabian Peninsula. Five of such unconformities are recognized and include (1) pre-Qishn, (2) Qishn-Kharfot, (3) Dhalqut-Samhan, (4) Samhan-Sharwayn and (5) Sharwayn-Umm er Radhuma (Tertiary) unconformities. The erosional vacuities generated by these unconformities reach different depths although the cuts of different unconformities may get combined and thus remove significant portions of the affected formations. For instance, deeply cut unconformity that puts the Tertiary Umm er Radhuma Formation on the Qishn Formation. The stratigraphic breaks observed in the studied stratigraphic sequence can be mainly attributed to intermittent subaerial exposures accompanied by pronounced erosional and non-depositional periods. These subaerial exposures were due to both eustatic sea level drop and regional uplifting. Correlation between the inferred hiatuses with the global sea level changes reveals that such changes had their toll on the formation of these unconformities.

Introduction

The Jeza – Qamar Basin is a rift basin filled by Jurassic to Recent sedimentary succession. The basin was a funnel-shaped and straddles across the Oman-Yemen border. The Jurassic strata is confined in the central part of the basin which occurs the Yemeni side of the basin. The eastern one-third of the basin is in Oman where Cretaceous succession represents the Mesozoic fill of this part of the basin. The sedimentary fill onlaps uplifted flanks of the basin, namely the Fartaq High in Yemen (FH in Fig. 1) to the west and the Marbat High (MH, Fig. 1) to the east.

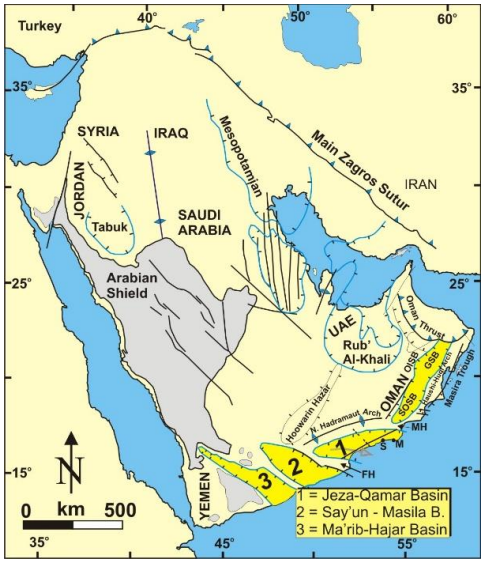

Fig. 1 Sedimentary basins of the Arabian Peninsula and location of the Jeza-Qamar Basin. S = Salalah, M = Marbat, SOSB = South Oman Sedimentary Basin, GSB = Ghaba Sedimentary Basin.

The Cretaceous succession is dominated by carbonate rocks with subordinate siliciclastic interbeds. These Cretaceous sequence consists of five formations that are, in an ascending order, Qishn, Kharfot, Dhalqut, Samhan & Sharwayn formations (Fig. 2, Salad Hersi et al., 2012). These formations correlate with hydrocarbon-producing units in the region and their sedimentologic properties are documented by previous researchers (Roger et al. 1987, 1989; Salad Hersi et al., 2014, 2016). The Cretaceous strata of this part of the Jeza-Qamar Basin are punctuated by prominent stratigraphic breaks and this study intends to document such hiatuses and shed some light on their genesis. The study area is located in the southernmost Dhofar Region of the Sultanate of Oman (Fig. 3).

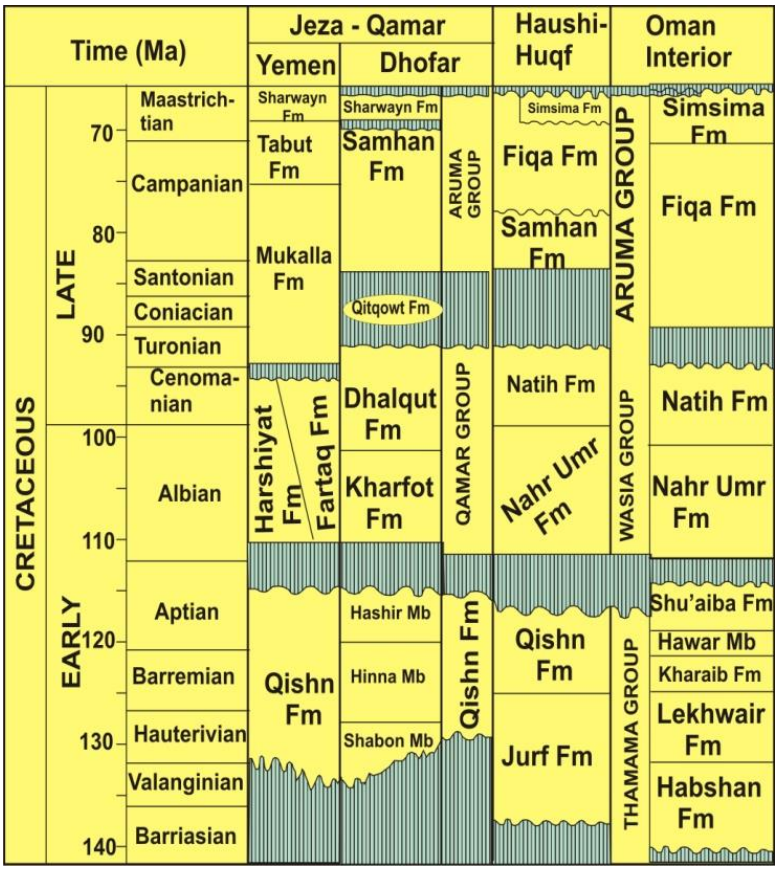

Fig. 2 Stratigraphic correlation among Cretaceous sequence in southern Yemen, Dhofar, Haushi-Huqf and Oman interior regions. Note the extension of the unconformities that separate the formations of the sequence. Their regional continuity suggests genetical relationship as being the results of regional tectonic and/or eustatic products.

The stratigraphic breaks

Five prominent stratigraphic breaks are recognized and they include: 1-pre-Qishn unconformity, 2-Qishn-Kharfot unconformity, 3-Dhalqut-Samhan unconformity, 4-Samhan-Sharwayn unconformity and 5-Sharwayn-Umm Er Radhuma unconformity. (Fig. 4). (1) Pre-Qishn Formation unconformity**:** In the study area, the Qishn Formation (Barremian to Aptian) lies on different Mesoproterozoic to Neoproterozoic rocks (Locs. 1, 4 and 5, Fig. 3) with non-conformity to pronounced angular unconformity (Roger et al., 1987; Platel et al,, 1987). The formation is characterized by basal sandstones that grade into shallow marine carbonates. (2) Qishn Formation – Kharfot Formation unconformity (Loc. 2, Fig. 3): The Qishn Formation shoals upward, indicating a relative sea level drop that terminated with

wide platform exposure and development of an unconformable contact marked by the Qishn-Kharfot contact. This contact is a type-1 sequence boundary that resulted from a regionally to globally recognized, late Aptian eustatic sea level drop (Salad Hersi et al., 2012, 2014). (3) Dhalqut Fomation – Samhan Formation unconformity (Loc. 6, Fig. 3): A long hiatus separates between the Dhalqut and Samhan formations. The two formations are locally intervened by very thin kaolinitic paleosol ("Qitqawt Fm." Roger et al. 1987) which is not mapable and thus not acknowledged as formal unit.

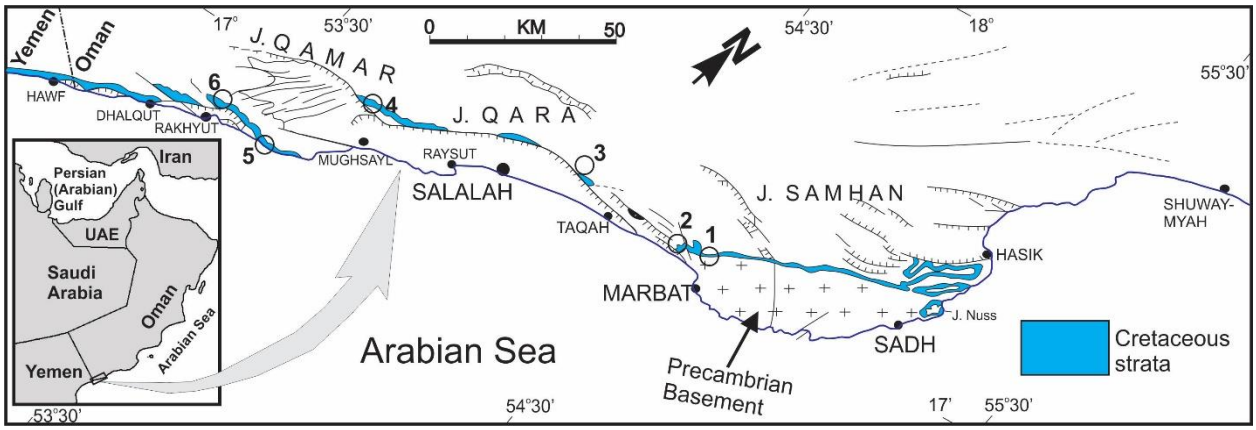

Fig. 3 Simplified map showing outcrop exposures of the Cretaceous strata in the studied area and locations of the studied sections. 1- Qitqawt section, 2-Dahq Aw-Teen section, 3-Ain Hamra'a section, 4-North Maghsayl section, 5-Ras Sajir section, 6-Shirashiti section.

(4) Samhan Formation – Sharwayn Formation unconoformity: No section exposing the contact between Samhan and Sharwayn formations was mapped during this study. This is due to the difficult in accessing sections showing the contact. However, in the eastern end of the Jabal Samhan, Roger et al (1987) logged a section across the contact. They indicate that the contact lies across an erosional surface separting rudist-bearing, bioclastic mudstone to packstone lithofacies (top Samhan Formation) from breccia and sandy mudrock beds forming the basal portion of the Sharwayn Formation. The pre-Sharwayn unconformity has removed the Samhan Formation from many places of the study area, thus causing Sharwayn Formation succeeding strata older than Samhan Formation (e.g., Dhalqut Formation in several localities). The Dhalqut-Sharwayn unconfrmable contact is well exposed in the eastern end of the Jabal Samhan outcrops (e.g. Locs. 1 and 2, Fig. 3). (5) Sharwayn Formation – Umm Er Radhuma Formation (Paleocene) unconformity**:** This unconformity separates Maastrichtian Sharwayn Formation from lower Tertiary (upper Paleocene) Umm Er Radhuma Formation (Loc. 1, Fig. 3). The subaerially-exposed surface at the top of the Sharwayn Formation is underlain by coarse-crystalline dolostone unit which is interpreted as the production of mixing zone dolomitization (Salad Hersi, 2011; Salad Hersi et al. 2012).

Deeply-cutting erosional unconformities and their genesis

The depths reached by the downward erosional cuts on exposed surfaces and the nature of the rugged topography created by the erosion can be inferred from the stratigraphic juxtaposition and correlation of the different formations and their lateral thickness changes. The depths of the unconformably-generated paleotopographic surfaces among the different formations in the study area vary from place to place. However, the apparent inferred depths may be the result of combination of various epoisoids of unconformity generations. The most intense erosionally-generated unconformities appear to be the Dhalqut-Samhan unconformity (Unconformity 3, Fig. 4) and the Sharwayn – Umm Er Radhuma unconformity (Unconformity 5, Fig. 4). Pre-Qishn unconformity can be generally considered as a result of a long term of non-deposition and erosion prior to the marine incursion in to this eastern flank of the Jeza-Qamar basin. The formation of unconformities is commonly attributed to periods of non-deposition or periods of active erosion or the combination of both processes. The most prominent unconformities in the geologic record were developed by subaerial exposure followed by intensive erosion. This subaerial exposure can be recognized by deciphering the extent of missing strata by correlation with other coeval sections and also by diagenetic signatures preserved in the pre-unconformity rocks (Salad Hersi, 2011). The erosional vacuities generated by these unconformities reach different depths although the cuts of different unconformities may get combined and thus remove significant portions of the affected formations. For instance, deeply cut unconformity that puts the Tertiary Umm er Radhuma Formation on the Qishn Formation at Locality 4. The unconformity at Loc. 3 is also a deeply-cut one where the Tertiay strata lie on top of the Kharfot Formation. The stratigraphic breaks observed in the studied stratigraphic sequence can be mainly attributed to intermittent subaerial exposures accompanied by pronounced erosional and non-depositional periods. These subaerial exposures were due to both eustatic sea level drop and regional uplifting. Correlation between the inferred hiatuses with the global sea level changes (Haq and Al-Qahtani, 2005) reveals that such changes had their toll on the formation of these unconformities.

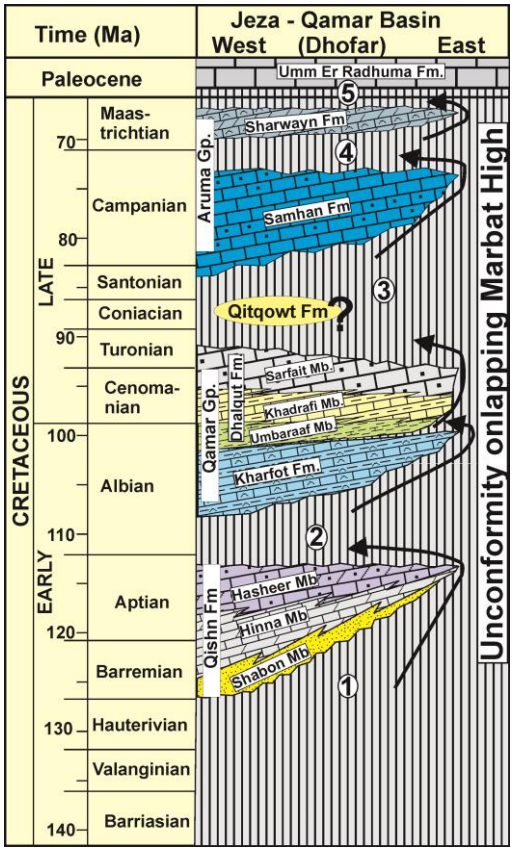

Fig. 4 Stratigrphic column of the Cretaceous sequence of Dhofar and the five prominent unconformities separating among the various formations. 1 = Pre-Qishn Formation unconformity, 2 =Qishn Fm. – Kharfot Fm. unconformity, 3 = Dhalqut Fm. – Samhan Fm. unconformity, 4 = Samhan Fm. – Sharwayn Fm. unconformity, 5 = Sharwyan Fm. – Umm Er Radhuma Fm. unconformity. The Qitqawt Formation is a thin kaolinitic layer that is laterally discontinuous and not mappable. Due to deep erosional cuttings and possible amalgamation of several events of kaolinite formation, the Qitqawt Formation is not considered an actual formation in this study.

Conclusion

There are five prominent unconformities that separate the Cretaceous succession preserved in the eastern flank of the Jeza-Qamar Basin, Oman. The unconformities correlated with prominent hiatuses recognized in the Arabian Peninsula. They are envisaged to have genetical kinship with these regional unconformities and interpreted to be generated by combined effects of tectonic disturbances and sea level fluctuations.

Acknowledgements

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