Eustasy and tectonic control on facies and sedimentary environment of Upper Khami deposits in East and West Kazerun fault, SW Iran

Fatemeh Peyman[1]*, Davood Jahani[1], Amir Mohammad Jamali[2] & Mohammad Ali Kavoosi[3]

[1] Islamic Azad University, North Branch Tehran, Basic Sciences Faculty, Iran.

[2] Islamic Azad University of Mahallat, Department of Geology, Iran.

[3] National Iranian Oil Company, Exploration Directorate, Tehran, Iran.
E-mail address: peymanmitra@yahoo.com.

Abstract
Green-house is one of the most interesting phenomena in Cretaceous period, which has been caused by increasing the rate of sea floor spreading and increasing the amount of CO2 in atmosphere. Global sea level rise in Aptian-Turonian was more important than other stages in Phanerozoic. There are many different parameters which influence changing in sedimentary facies. One of the most items that affect facies distribution is eustasy. This phenomenon is controlled by climate changes and tectonic regime. Other parameters which control local facies variations are tectonic setting, rate of uplift/subsidence and carbonate production. In order to investigate the effect of eustasy in Aptian, Upper Khami sediments in Kuzeh Kuh and Fahliyan anticlines, east and west of Kazerun Fault were studied. Upper Khami sediments (Neocomian-Aptian) consist of Fahliyan, Gadvan and Dariyan formations. Comparison of relative depth of sedimentary environments of studied sections with global sea level curves corresponds to Arabian platform pattern. Identified microfacies of lower and upper part of the Gadvan Formation especially middle part of the Dariyan Formation, assign a global sea level rise. The lack of oxygen has caused an anoxic environment in deeper part of sea and dark gray to black shales have been deposited. This study reveals that the maximum of deepening in upper Aptian corresponded with dark gray argillaceous limestone deposition, which include cherty layers or adapted with Radiolaria flood zone. In dark sediment of this part, abundance of planktonic microfossils especially radiolaria, planktonic foraminifera and ammonite are observed. Lateral facies changes in the area and comparison with adjacent reigns, indicate the tectonic role along with sea level changes in making intra-shelf basin during this period. Intra-shelf basins were places for pelagic deposits which become thinner and pinches out laterally towards east of Kazerun Fault.

Keywords: *Eustasy; Sedimentary environment; Facies; Upper Khami; Fahliyan; Gadvan; Dariyan; Aptian;*

Introduction
One of the most interesting phenomena in Cretaceous period is green-house which has been caused by increasing the rate of sea floor spreading and increasing the amount of CO2 in atmosphere. Global sea level rise was consequence of sea floor spreading, which happened during the Aptian-Turonian stages. Sea level in these stages was higher than other periods in the phanerozoic. In order to investigate the effect of eustasy on the Neocomian-Aptian deposits, Upper Khami sediments in east (Kuzeh Kuh section) and west (Fahliyan section) of the Kazerun Fault were studied (Fig. 1). The study area is located in Zagros fold-thrust belt, south west Iran. Upper Khami deposits (Neocomian-Aptian) are important hydrocarbon reservoir, so the lateral and vertical reservoir facies changes are very important. Field surveys

and facies analyses were resulted in recognition several facies that assigns deep open marine, slope, shoal and lagoonal facies belts.

Stratigraphy and depositional environments

Upper Khami deposits consist of Fahliyan, Gadvan and Dariyan formations, which are composed mainly of limestones, argillaceous limestone, shale and marl (Fig. 3). The Fahliyan Formation consists of grey to brown, massive to very thick bedded limestones. Facies analyses lagoonal, shoal to open marine environments. Upper Fahliyan succession is separated from the lower Fahliyan carbonate by iron-staining and a karstic surface. This unit includes medium to thick bedded limestone that interbeds with marl. Increasing clay content and bioturbation are characteristic of these carbonates.

The lower contact of the Gadvan Formation with the Fahliyan Formation is conformable but with discontinuity surface, which is recognized by Fe-staing, Thalassinoides and sudden lithological changes. Gadvan Formation lithologically could be divided into lower Gadvan (Shale and marl), Khalij Member and upper Gadvan (upper shale and marl). From lithology point of view the sediments of lower Gadvan and upper Gadvan are similar together and in these parts, alternation of pelagic (calciturbidites and deeper marine sediments) and shallow marine carbonates. The Khalij Member is identified by massive-bedded limestones that composed of shallower environments facies in comparison with lower and upper parts of the Gadvan Formation. Thomas and Slinger (1951) introduced the Khalij Member as brown blocky beds, which are characterized by massive limestones containing iron nodules and trace fossils.

The Dariyan Formation is divided in to lower, middle and upper units in the studied area (Fig. 4A). Lower Dariyan carbonates consist mainly of light grey brown limestone that conformably overlies weathered shale of the Gadvan Formation. Lower and upper members of Dariyan are separated by middle Dariyan rock unit (shale and marl), which mostly is weathered and covered on surface.

In the upper most of lower Dariyan, light grey shales interbedded with black to brown cherty beds (Radiolaria flood zone) (Fig. 4B, C). At the upper part of these calcareous shales, lots of ammonite casts are observed (Fig. 4D, F).

Also in this part, planktonic organisms such as *Radiolaria* and planktonic foraminifera (*Hedbergella* and *Globigerinelloides*) have a conspicuous diversity (Fig. 5). Upper Dariyan carbonates include grey, fossiliferous compacted limestone accompanied with argillaceous *Orbitolina* limestones, limonitic limestones, and grey to brown, massive to thick bedded limestones and finally green to grey thin bedded fossiliferous limestones on top. The upper contact with the Kazhdumi Formation is accompanied with sharp lithological and facies changes.

Discussion

Deposition of upper Khami sediments was controlled and influenced by subsidence and carbonate production rates. However, basin configuration, paleogeography paleoclimate, regional tectonic and eustasy are the main controllers in the study area, but eustasy played as the main role. This parameter is controlled by climate changing and tectonic of Sea floor spreading caused sea level rise in the Aptian, so that most of continents were covered by marine deposits. Some of these sediments are related to deep environments.

At the beginning of Cretaceous system, the rate of continental drift was more than the other times and a lot of CO2 gas was spread in this period that was the main cause of increasing of temperature and green house (Larson, 1991; Tatsumi et al., 1998). Green house situation on the earth caused that the temperature variations in lower and upper latitudes reach to minimum and upper latitudes got high temperature. Oceanic currents, which are created by the different temperature of water in polars and equator and oceanic storms of middle Cretaceous, become weaker during this period. By these phenomena, water movement reduced and there was a calm and stability situation on the sea floors (Tatsumi et al., 1998). All mentioned parameters resulted in creation of oxygen minimum zone (OMZ). Due to lack of oxygen anoxic zone, black shales were deposited.

Conducted studies reveal that after a diastum at boundary of the Fahliyan and Dariyan formations, sea level raised. Lower part of Gadvan (Alternation of pelagic, turbidite and shallow-marine carbonates) related to deep and shallow open marine deposited. After sedimentation of lower Gadvan (shale, marl and grey to green marly limestones) Khalij member deposition suggest domination of carbonate production on sea level rise. Upper Gadvan deposits contain turbidites, pelagic and shallow-marine sediments related to deep and shallow marine facies belts resulted from retrogradation after Khalij Member sedimentation.

These sediments changed upward to lower Dariyan deposits. The maximum deepening of the Aptian is indicated by limestones and calcareous shale containing black cherty beds of the upper part of lower Dariyan. Middle Dariyan is followed by grey to green shale related to deep environments and in turn is underlain by shallow carbonates of upper Dariyan.

During deposition of Aptian deposits it might be a tectonic activity in the Zagros fold-thrust belt. Siliciclastic deposits of upper Gadvan Formation and its lateral changes to shales support this idea. Creation of seaways/intra shelf basin seems to occur during the Lower Dariyan Formation carbonates. The deepening-upward trend and drowning of carbonate platform and its transition to Aptian shales are other evidences. The lateral facies changes of the Dariyan carbonates to these shales and its continuation to Albian shales, suggest presence of intra-shelf basin. Intra-shelf basins were places for pelagic deposits which become thinner and pinches out laterally towards east of Kazerun Fault.

Conclusion

Lateral and vertical facie changes and comparison with recent sedimentary environments reveals that Gadvan and Dariyan formations deposited in a carbonate platform shelf in the area investigated. Identified facies in lower and upper Gadvan, especially upper part of lower Dariyan and middle part of Dariyan, are compatible to global sea level rise and spreading of sea floor. Conducted studies show, sedimentation of black to dark grey calcareous shale containing cherty layers with planktonic fauna of upper part of lower Dariyan Formation are adapted to maximum deepening in the Aptian. This study suggests that sea level changes during Upper Khami deposition in east and west of Kazerun Fault, is comparable with global sea-level changes, especially the Arabian platform pattern.

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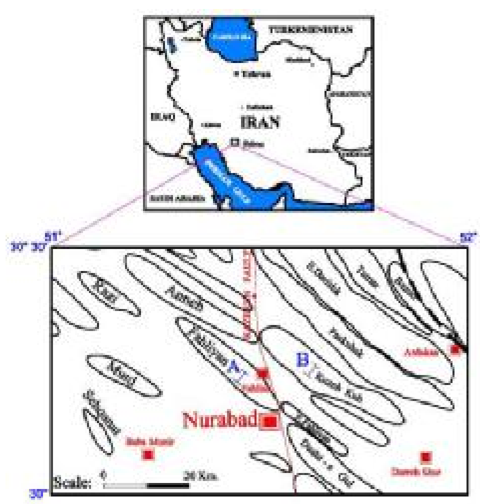

Fig. 1: Location map of studied area.

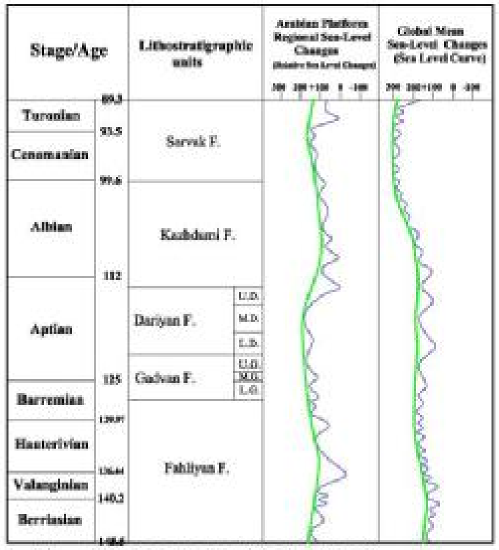

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Fig. 2: Sea level changes during Upper Khami deposition are comparable with global sea-level changes, especially the Arabian platform pattern.

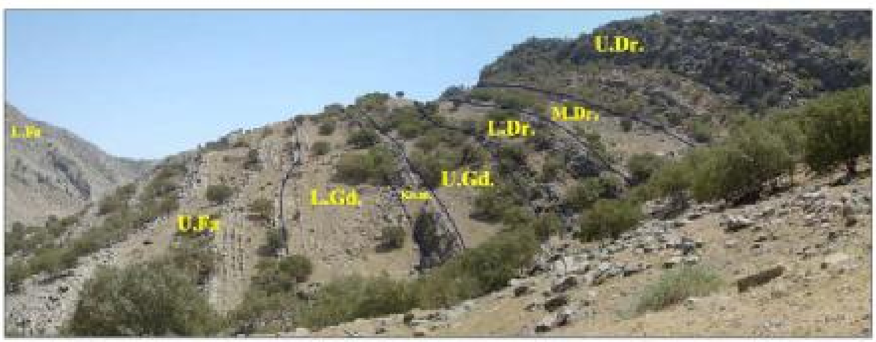

Fig. 3:The succession of upper Khami deposits at Fahliyan section, Upper Fahliyan (U.Fa.), Lower Gadvan (L.Gd.), Middle Gadvan (M.Gd.), Upper Gadvan (U.Gd.), Lower Dariyan (L.Dr.), Middle Dariyan (M.Dr.) and Upper Dariyan (U.Dr.), view toward southeast.

Fig. 4: (A) Lower, middle and upper members in the Dariyan Formation at Kuzeh Kuh section, view toward southwest, (B,C) light grey shales interbedded with black to brown cherty beds (Radiolaria flood zone), (D,E). Ammonite casts at the upper part of these calcareous shales.

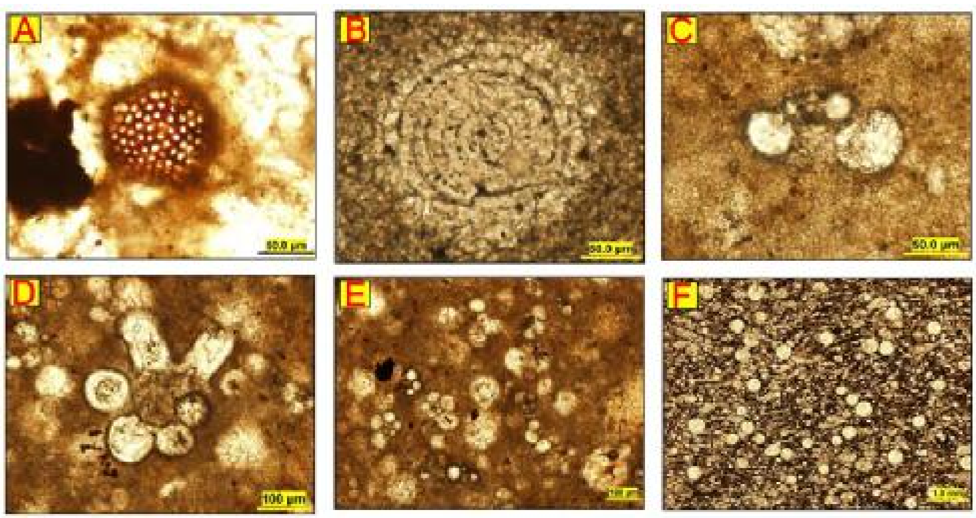

Fig. 5: Planktonic microfossils and deep marine microfacies in upper part of lower Dariyan (A, B) *Radiolaria*, (C) *Hedbergella* sp., (D) *Hedbergella roblesae*, (E) Radiolaria Planktonic Foraminifera Wackestone, (F) Radiolaria Packstone.