Scientific Research Publishing

Open Journal of Geology, 2016, 6, 1401-1422
http://www.scirp.org/journal/ojg
ISSN Online: 2161-7589
ISSN Print: 2161-7570

Sedimentology and Depositional Environment of the Kazhdumi Formation Sandstones in the Northwestern Area of the Persian Gulf

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How to cite this paper: Noori, B., Ghadimvand, N.K., Movahed, B. and Yousefpour, M. (2016) Sedimentology and Depositional Environment of the Kazhdumi Formation Sandstones in the Northwestern Area of the Persian Gulf. *Open Journal of Geology*, **6**, 1401-1422.
http://dx.doi.org/10.4236/ojg.2016.611100

Received: October 12, 2016
Accepted: November 14, 2016
Published: November 17, 2016

Abstract

Kazhdumi is one of the Bangestan Group formations aging late early Cretaceous (Albian). Three subsurface sections of the sandstone bearing part of Kazhdumi in the studied area located at northwest of the Persian Gulf are assessed for determining sedimentary facies and depositional environment. Based on the recognized facies, the sandstone bearing zones of Kazhdumi and their relevant paleoenvironments can be addressed as: the first one is the B sandstone zone which is deposited by river influenced conditions. The second one, the A sandstone zone which is deposited under a key limestone layer, is a transition interval showing the changes of river-dominated condition to marine one. The third one is the A sandstone zone deposited above the key limestone layer deposited in reduction condition in estuarine environment. Applying facies analyses results, isopach maps, porosity distribution maps and sandstone grain size study, the paleocurrent pattern is determined from the southwest to northeast.

Keywords

Kazhdumi Formation, Sedimentary Facies, Paleoenvironment, Paleocurrent, Persian Gulf

1. Introduction

The sandstone bearing part of the Kazhdumi Formation with a sandstone-shale lithology in type-section in Kuwait is recognized as a gigantic reservoir (the Great Burgan, the second gigantic hydrocarbon reservoir in the world) and reservoir sandy layers of Kazhdumi Formation are also formed in some Iranian offshore oil fields [1] (**Figure 1**). The Burgan Formation was introduced and described by Owen and Nasr [2] in the Burgan Field (well No. 113) and mostly composed of sandstone which was enriched

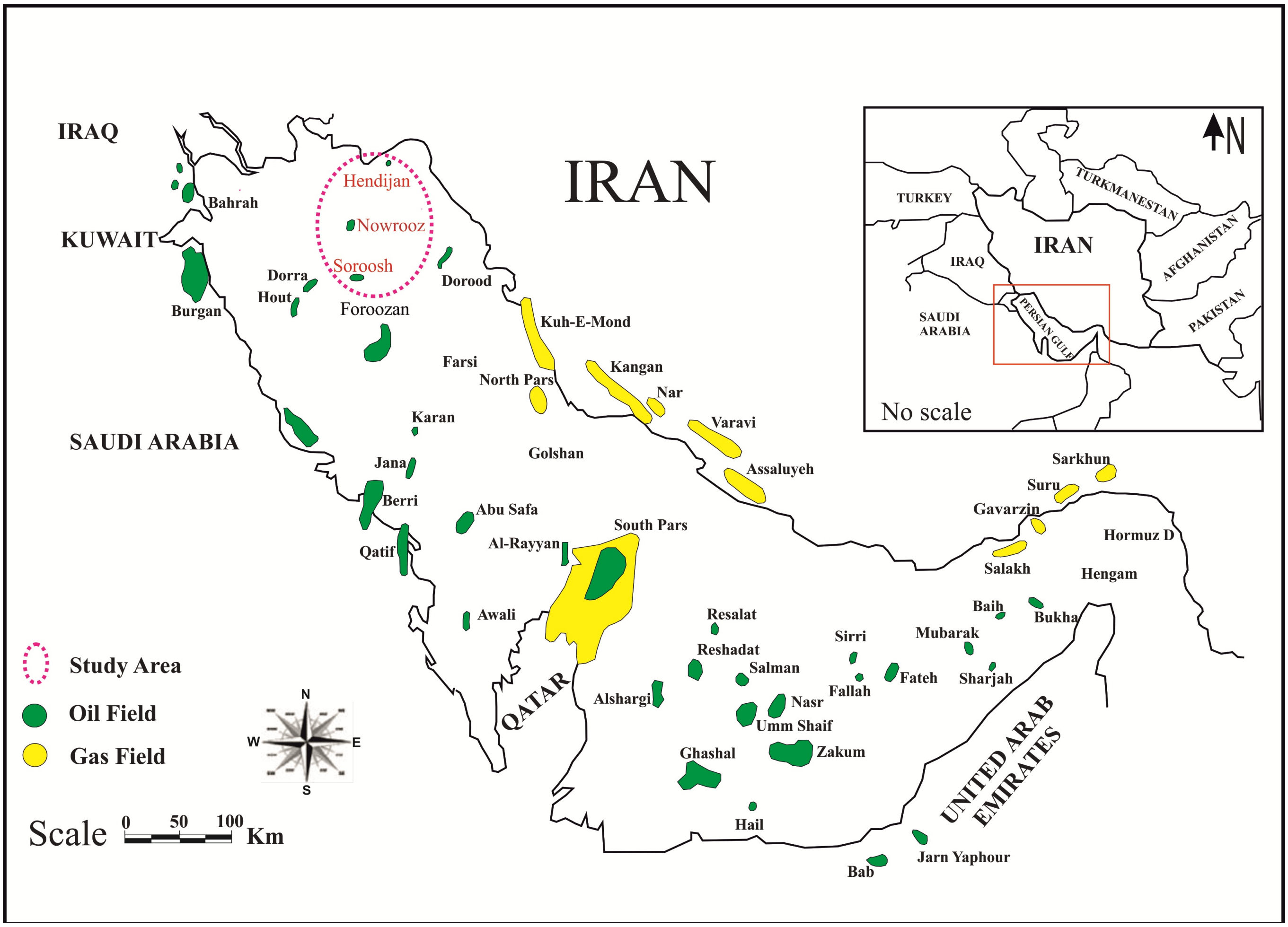


Figure 1. Location map of the Persian Gulf, study area showed on the map (modified after Mashhadi *et al*. [4]).

with hydrocarbon [1] [3]. While toward Iran, shale bearing intervals emplace into the sandstone layers and observed that approaching deeper parts of the basin in Iranian coastline, in addition to the fine grained shale, the sandstone is finer and toward the north of studied area (Hendijan oil field), siliclastic facies turn into carbonate ones (**Figure 2**).

The Kazhdumi Formation thickness in the study area changes from 189 meters in Hendijan oil field to 238 meters in the Soroosh oil field. Kazhdumi is divided into four main lithological units in this area. The first one is the Kazhdumi shale composed of shale and a little limestone and siltstone. Argillaceous limestone of the Dair Member is the second unit. The "A" sandstone zone is the third one with a lithology of shale and sandstone and siltstone interlayers. The forth unit is the "B" sandstone zone dominantly containing sandstone with shale interlayers.

Presence of the porous sandstone unit is one of the main factors for enhancing the quality of Kazhdumi sandstone reservoir in the research area which is located in northwest of the Persian Gulf. Consequently, detecting the processes which have significant influence on the sediment unit deposition is necessary for understanding this

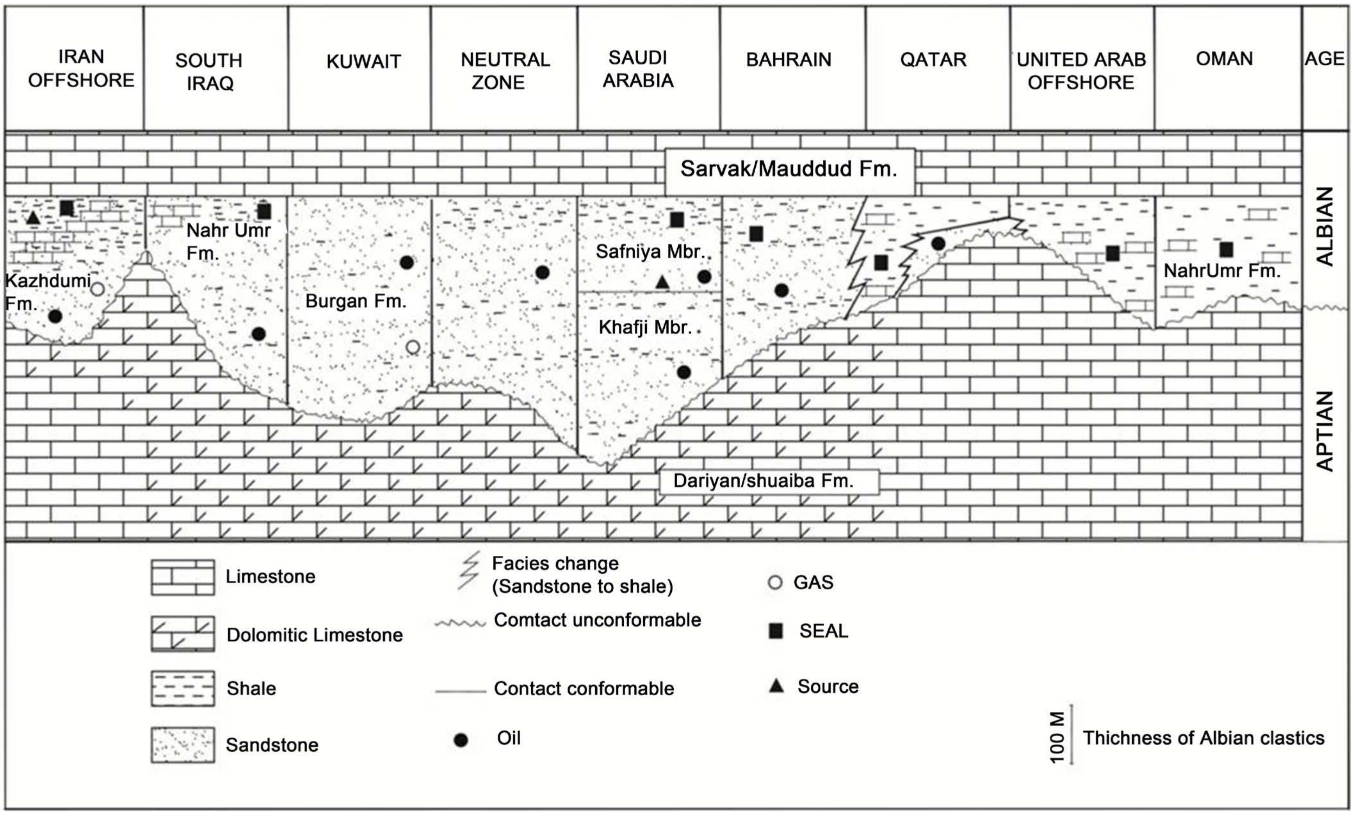


Figure 2. Lithostratigraphy of the Albian sequence in the Persian Gulf which is extended to Iran offshore based on this study (modified after Alsharhan [1]).

sandy unit geographic distribution. Then, detailed petrographic studies, depositional environment analyses and paleoclimate descriptions have been used to understand the processes of the sandstone unit deposition.

2. Methodology

Facies determination and depositional environment interpretation of Kazhdumi Formation sandstone deposits in studies wells, S, N and H (located at Soroosh, Nowrooz and Hendijan oil fields, respectively) is carried out based on sieve analysis of 51 loose sandstone samples, core in some intervals, thickness maps of Kazhdumi Formation and its zones at well location, extracted porosity distribution map of Kazhdumi sand in the northwest of the Persian Gulf and analyzing 670 thin section samples including 470 thin sections from a core interval (150 meters) of Well S, 105 thin sections from a core interval (28 meters) of Well N and 95 thin sections delivered from 6 meters cored interval and drilling cuttings in Well H. Depositional environment interpretation and conceptual model is achieved regarding the vertical changes in discriminated facies, Walters law and comparing recent environments to the earlier ones.

3. Sedimentary Facies

The Kazhdumi Formation thin sections study is carried out using polarizing microscope and the fossil content and textural assessment of components (both skeletal and non-skeletal), cement and matrix led to determining 10 facies. Determined facies were categorized in five facies associations. Facies distribution at each well location is prepared in Table 1.

3.1. Marine Carbonate Facies Association

3.1.1. Orbitolina/Bioclast Limestone

An important characteristic of this facies is its limy lithology. Different lithology compared to siliciclastic facies and also the fossil contents make it special. Its texture is wackestone to packstone. The most notable constituents can be addressed as orbitolina, echinoderm debris and shell fragments. In some samples, quartz grains frequency is up to 30 percent. Glauconite is observed as a minor mineral and bioturbation can be mentioned as a notable characteristic of this facies. Filled fracture with calcite, mechanical and chemical compaction are diagegnetic processes occurred (Figure 3A).

This facies is not common in the Kazhdumi sandstone. As the core studies reveal, its thickness is about one meter and known as a key bed in the middle parts of the "A" sandstone. Limy lithology, glauconite, bioturbation and fossil content in this facies represent marine condition in deposition process. Large bentic foraminifera (Orbitolina) and echinoderm existence and also absence of green algae and other photic biota confirm the open marine or mid ramp setting for it [5] [6]. It seems that this facies is formed during the relative sea level rise and can be an evidence for maximum flooding surface (MFS). Similar facies are also reported in the equivalent interval in Kuwaiti oil fields [7].

3.1.2. Silty Lime-Mudstone

In this facies, quartz frequency is about 20 percent and the limy mud matrix is 70 percent on average. Quartz grains in silt size forms silt-bearing limy mudstone and almost monocrystalline and less polycrystalline. Grains are well-rounded to sub-rounded.

Table 1. Facies distribution of Kazhdumi formation sandstones at Soroosh, Nowrooz and Hendijan oil fields (the wells s, n and h respectively).

Facies Group	Facies	"S" Well	"N" Well	"H" Well
I) Marine carbonate facies	**1.** Orbitolina/bioclast limestone	√	√	√
	2. Silty lime-mudstone			√
	3. Marl			√
II) Marine Mudstone facies	**4.** Laminated shale/silty shale	√	√	
III) Distal channel facies	**5.** Sideritic ooid sandstone	√	√	√
	6. Bioturbated siltstone/very fine sandstone	√	√	
IV) Proximal channel facies	**7.** Cross-bedded moderately/poorly sorted sand/sandstone	√		√
	8. Well sorted medium/fine sand/sandstone	√	√	
V) Fluvial facies	**9.** Poorly sorted-organic rich sand/sandstone	√	√	
	10. Rooted sandy/silty shale	√	√	

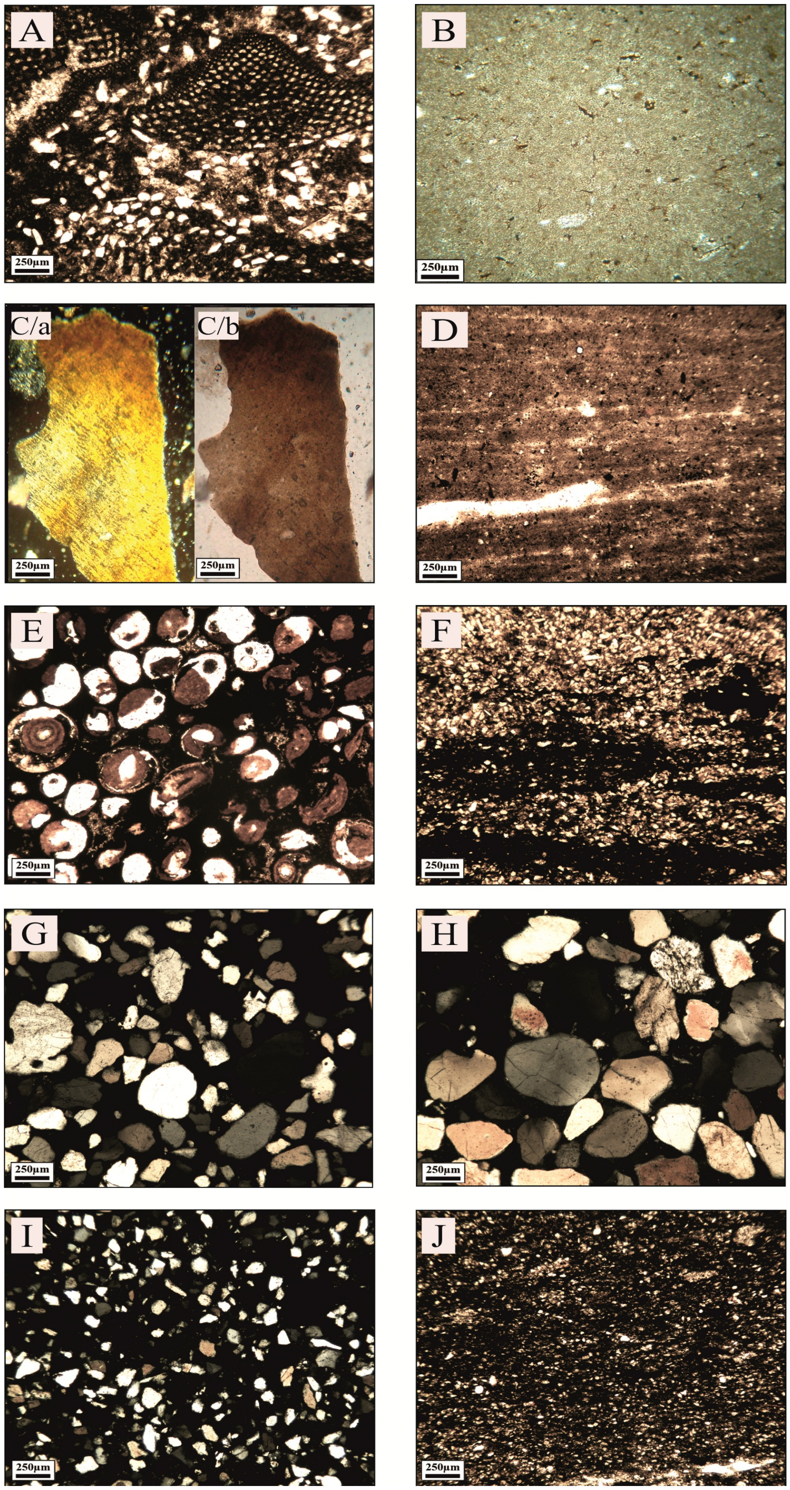


Figure 3. (A) Orbitolina/bioclast limestone facies; (B) Silty lime-mudstone facies; (C) Marl; (D) Laminated shale/silty shale facies; (E) Sideritic ooid sandstone facies; (F) Bioturbated siltstone/ very fine sandstone facies; (G) Cross-bedded moderately/poorly sorted sand/sandstone facies; (H) Well sorted medium/fine sand/ sandstone facies; (I) Poorly sorted-organic rich sand/sandstone facies; (J) Rooted sandy/silty shale facies.

Ferogenization and bioturbation are main diagenetic processes. Sand bearing limy mudstone lithology indicates the gentle condition over low energy environment of marine (Figure 3B).

3.1.3. Marl

Marl is recognized as this facies lithology and planktonic foraminifera are observed. In normal light the marl is dark brown and in polarized light is grey to cream. Marls containing planktonic foraminifera are related to the marine environment. The heterohelix fossil in the samples is a signature of deposition in marine realm (Figure 3C).

3.2. Marine Mudstone Facies Association

3.2.1. Laminated Shale/Silty Shale

This facies is composed of grey to brown shale with fissility and lamination. In some samples it has laminated silt and sand grains. This facies has relatively high amounts of organic matter and plants residuals. Marine fauna is rare in this facies but echinoderm debris while small foraminifera are dispersed. Siderite nodules and filled burrows are observed frequently. In the lower boundaries, facies are associated with amber, pyrite and glauconite (Figure 3D). This facies is mainly detected in the upper parts of the Kazhdumi Formation sandstone (the "A" sandstone).

Finely laminated mudstone and also silty mudstone with negligible bioturbation are indices for prodelta environment [8]. Sedimentary traits such as claystone lithology with lamination and paleontological features like rare marine fauna can be originated from the deposition in a gentle environment and suspended load sediments. Low diversity fauna of prodelta can be derived from turbulent condition, suspension load and also mixing of sea water with fresh water [8]. Presence of pyrite, glauconite, organic matter and absence of oxic phases and dark colored material indicate the deposition in a reduced environment. Prodelta shales sometimes incised by fluvial currents and resulted channels can be filled by sandstone rich facies which is limited by shaly layers. These processes occurred frequently in the upper and middle sandstone bearing parts of the Kazhdumi Formation. Regarding the mentioned features, it can be concluded that this facies is deposited in the distal prodelta environment. Similar facies was reported in Arabian area of the Persian Gulf [3] [7] [9] [10].

3.3. Distal Channel Facies Association

3.3.1. Sideritic Ooid Sandstone

Fe bearing lithology (siderite) and ooidic fabric are distinguished feature of this facies. Its thickness in the studied cores is low (1.5 meters utmost) and the color is light brown to green. Marine fauna such as echinoderm and small foraminifera are observed occasionally. Burrow shaped bioturbation and nodular fabric is detected frequently. Sideritic ooids formed 5 to 65 percent of this facies major constituent. Ooids have concentric structure and their dimension is between 0.2 to 0.5 millimeters. Quartz sands and occasionally silt are up to 30 percent and dispersed in the siderite matrix. Other components are less than 5 percent. Dissolution and compaction are the most notable diagenetic processes occurring in this facies. Ooids usually are dissolved and moldic porosity is resulted (**Figure 3E**). Deformed ooids are also observed frequently.

This facies is limited to the upper parts of the "A" sandstone zone. In geological record, Fe bearing ooid facies in non-marine sandstone are not common [11]. Sideritic ooids, nodules and bands are abundant in deltaic systems [11] [12] [13]. Coated grains and Fe rich ooid bearing clays are found in delta front, especially in hot, tropical and river dominated deltas [13]. These sediments expand in anoxic condition (Fe rich pore water and negligible sulfide creation) and where the sediment supply and deposition rate is low [11]. Based on the model proposed by Dalrymple *et al*. [14], this facies sedimentary environment is considered as estuarine or proximal delta. Regarding the stratigraphic position and facies relationship, this facies can extend in the deep parts of incised channels (channel filling). This interpretation is also confirmable based on the marine fauna and observed bioturbation.

3.3.2. Bioturbated Siltstone/Very Fine Sandstone

This facies contains grey to green siltstone to very fine sandstone with intense bioturbation and trace fossil. In some cases it shows alternation of siltstone and mudstone. Parallel laminations and sedimentary deformations are also occasionally recorded. Silt to sand size grains are mostly quartz but other minor grains also exist. Horizontal burrows (numerously Asterosoma) and escape structures are distinguishable as trace fossils (**Figure 3F**).

Scarce marine fauna and amber are present in this facies. Glauconite and siderite ooids are also observed. In some samples, carbonate, sideritic and Fe-bearing cements are exist. It is almost frequent in the "A" sandstone zone and upper parts of "B" zone. Features like horizontal bioturbation, carbonate clasts, glauconite, fossil content, carbonate cement and erosional contacts implicate the sedimentation in distal delta channels [12] [13]. Some authors [15] [16], mentioned that frequent bioturbation occurs in distal bar environment. The abundance of bioturbation is interpreted as the existence of living biota colonies after the deposition of feeding materials. Asterosoma is a simple trace of biota feeding from the sediments which implicates the marine condition and usually exists in distal delta front sediments [17].

Glauconite is a complex mineral formed from clay and mica (aluminosilicates) and merely generates autogenically in the earlier diagenesis steps of marine sediments. This mineral exists in the subaerial weathering zone and is not recognized as a detrital mineral resulted from the reworked cycles, except in some exceptional cases [18]. Therefore, the glauconite in sediments confirms the marine environment. The mentioned facies characteristics indicate the distal delta channel environment for this facies.

3.4. Proximal Channel Facies Association

3.4.1. Cross-Bedded Moderately/Poorly Sorted Sand/Sandstone

Sand size quartz grains with moderately to poorly sorting are the major component. Based on petrography studies, grain size varies from fine to medium and coarse but fine sand is dominated. Grains are angular to sub-angular. Sand is bimodal (rounded coarse sand and angular fine ones). Quartz grains form more than 95 percent of this facies. Other components such as feldspar, heavy minerals, amber, plant residuals and chert debris are present. The texture of sediments is sub-mature. Cross bedding, mud coatings, graded bedding and bioturbation can be named as the most important observed sedimentary structures in cores. This facies is mostly present as unconso-lidated or semi-consolidated sandstone. The marine fauna is negligible. Carbonate cement and matrix is detected but cementation rate is generally low (**Figure 3G**).

This facies is rarely seen in the lower part of the "A" sandstone zone while dominantly in the "B" zone. Coarse grains, cross bedding (related to high energy system), mud coatings, graded bedding and erosional surfaces indicate that this facies is deposited in a high energy setting like delta front or delta bar slop [12] [13] [16]. Spare bioturbation and other structure can be caused by high energy environment, high sedimentation rate, water turbulence, strong water salinity fluctuations and high energy storms events [17]. Presence of rock debris, sub-mature texture and the bimodal nature are persuasive signatures to decipher the turbulence degree and the depositional processes difference [19]. High mineralogical and chemical maturity probably originates from the sediments provenance properties (recycled quartz rich sediments). Al-Eidan *et al*. [10] and Strohmenger *et al*. [7] also presented correlated facies to this one in Kuwait.

3.4.2. Well Sorted Medium/Fine Sand/Sandstone

This facies composes of well sorted and massive, cross bedded, horizontal and wavy layered quartz bearing sand. Quartz grains and heavy minerals are rounded and mature in texture. Fine to medium size grains are well sorted and fossils are not observed. Lack of bioturbation, amber and plant debris is another characteristic of this facies. Opaque minerals (Fe oxides) are seen rarely. Frequency of rock fragments and feldspar debris is negligible (less than 2 percent). Quartz grains are almost fine size. No matrix is detected in thin sections. Loose sands of this facies have a loose and semi-consolidated appearance in the core samples. Heavy hydrocarbon components may cement sands in the reservoir (**Figure 3H**).

This facies forms the main reservoir interval of Kazhdumi sandstone. Evidence such as sand grains abundance (uni-mineralogical nature), well sorting, roundness, cross bedding and erosional surfaces confirm that these sediments are resulted from the recycling and deposition in high energy condition. High textural and mineralogical maturity of this facies is also indicating high energy level (tide or waves current) and provenance essence. Low frequency of terrestrial materials (plant residuals, amber and oxidized grains) can be a proof that these sediments are not formed in river-induced channels or in delta plain. Similar to it, some massive sands remained from the tidal currents and upper parts of mouth bar are also reported [8] [12] [20]. Lack of bioturbation and fossil can be directed from severe current of clastic materials, turbulent water, salinity oscillation and unfavorable conditions for living biota [17]. This facies can be an equivalent of well sorted sandstone, massive sandstone and quartzic sandstone introduced by Strohmenger *et al*. [7], Al-Eidan *et al*. [10] and Van Buchen *et al*. [3], respectively.

3.5. Fluvial Facies Association

3.5.1. Poorly Sorted-Organic Rich Sand/Sandstone

Almost high amount of plant residuals and red oxidic color are the most important features of this facies. Quartz grains are abundant (more than 90 percent) and their size ranges from fine to medium. Grains are rounded weakly to angular. The sorting is generally poor. Plant residuals, coal, amber and chert are other components of this facies (less than 10 percent). The most frequent sedimentary structures can be addressed as horizontal and wavy layering and also bioturbation. Core samples are usually loose and sometimes semi-consolidated (**Figure 3I**).

This facies in the studied formation is mainly observed in the "B" sandstone zone. Regarding red color, oxidized grains and plant residuals, it can be implicated that this facies is a paleosol resulted from the outcrop of underlying layers. Severe redness is a routine feature in most types of soils [21] [22]. Maturity of this soil is weak. Paleosol implicates the exposure of delta plain. In some cases, carbon and coal rich sediments indicate that the paleosol zone endured a period of high water saturation. Therefore, some parts of this facies are deposited in the river induced channels or delta channels. Lack of marine fauna, glauconite, pyrite and existence of red color and oxidized phases indicates proximity of facies to fluvial channels and delta plains.

3.5.2. Rooted Sandy/Silty Shale

Shale lithology, plant residuals and oxidized grains are main characteristics of this facies. This facies also has silt and sand grains (less than 50 percent) which their mineralogy is quartz. Amber exists in this facies but marine fauna and glauconite are not detected. Parallel and wavy layering, dark grey color, rootled fabric and coal are observed in core samples (**Figure 3J**). This facies mostly associates with fossil bearing paleosol and erosional surfaces and observed in the "B" sandstone zone and less detected in the "A" sand zone.

Based on the facies features such as lamination, fine grains and also paleontological properties like amber, plant residuals and fossil absence, it can be interpreted that this facies is deposited in delta plain. This can be regional equivalent to similar facies studied by Strohmenger *et al*. [7] named as "Hetrolithic siltstone to mudstone" in Kuwait. Facies characteristics and determined sedimentary environment for different zones of Kazhdumi sandstone are presented in **Figure 4** and **Figure 5**.

4. Paleoenvironment

Paleoenvironment of Kazhdumi Formation sandstones was evaluated using sieve analysis, petrography and sedimentary facies analyses, paleocurrent pattern and paleoclimate results which is described in details as follows.

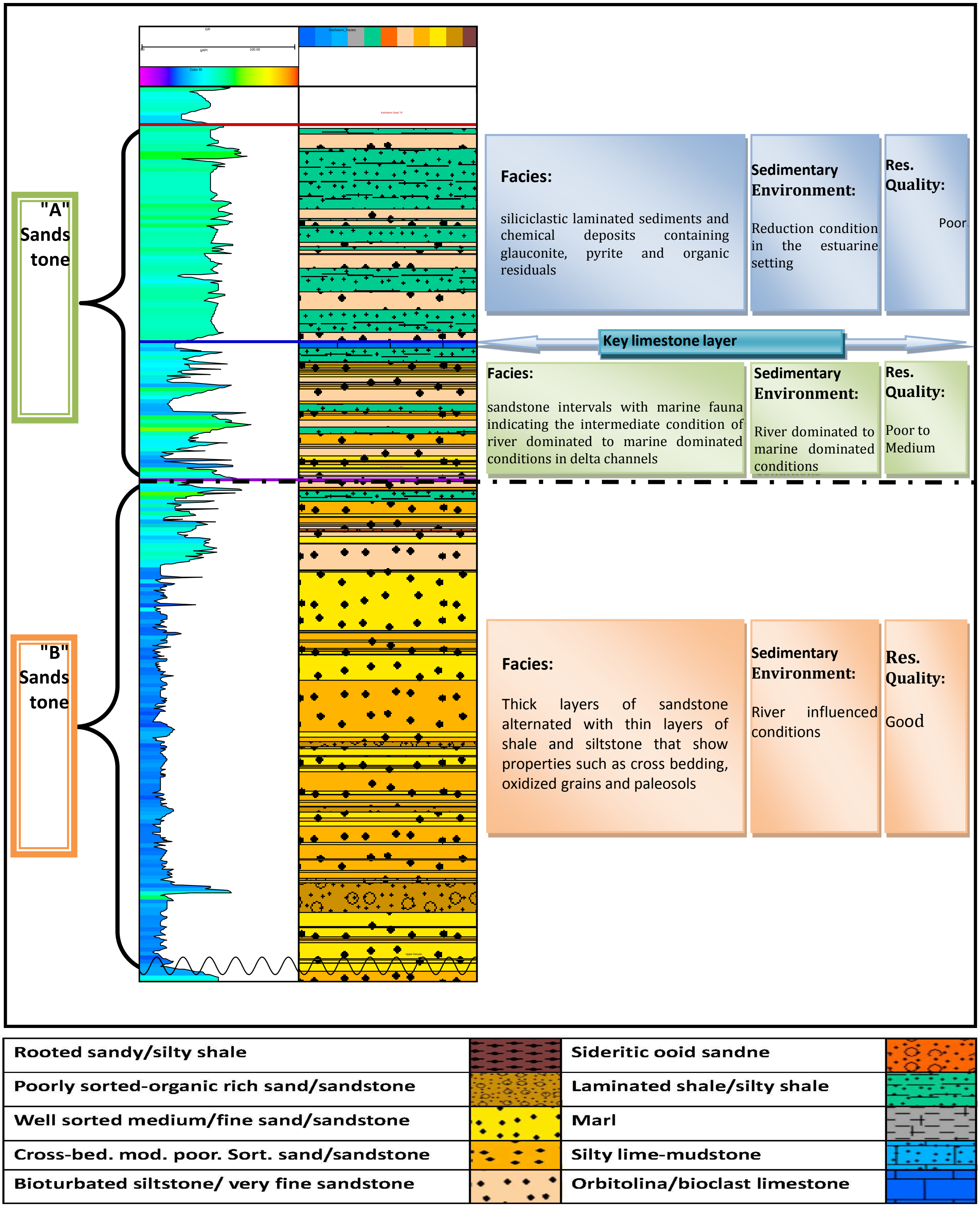


Figure 4. Kazhdumi formation sandstone zones based on facies characteristics, sedimentary environment and reservoir quality (well "S" is showed as an example).

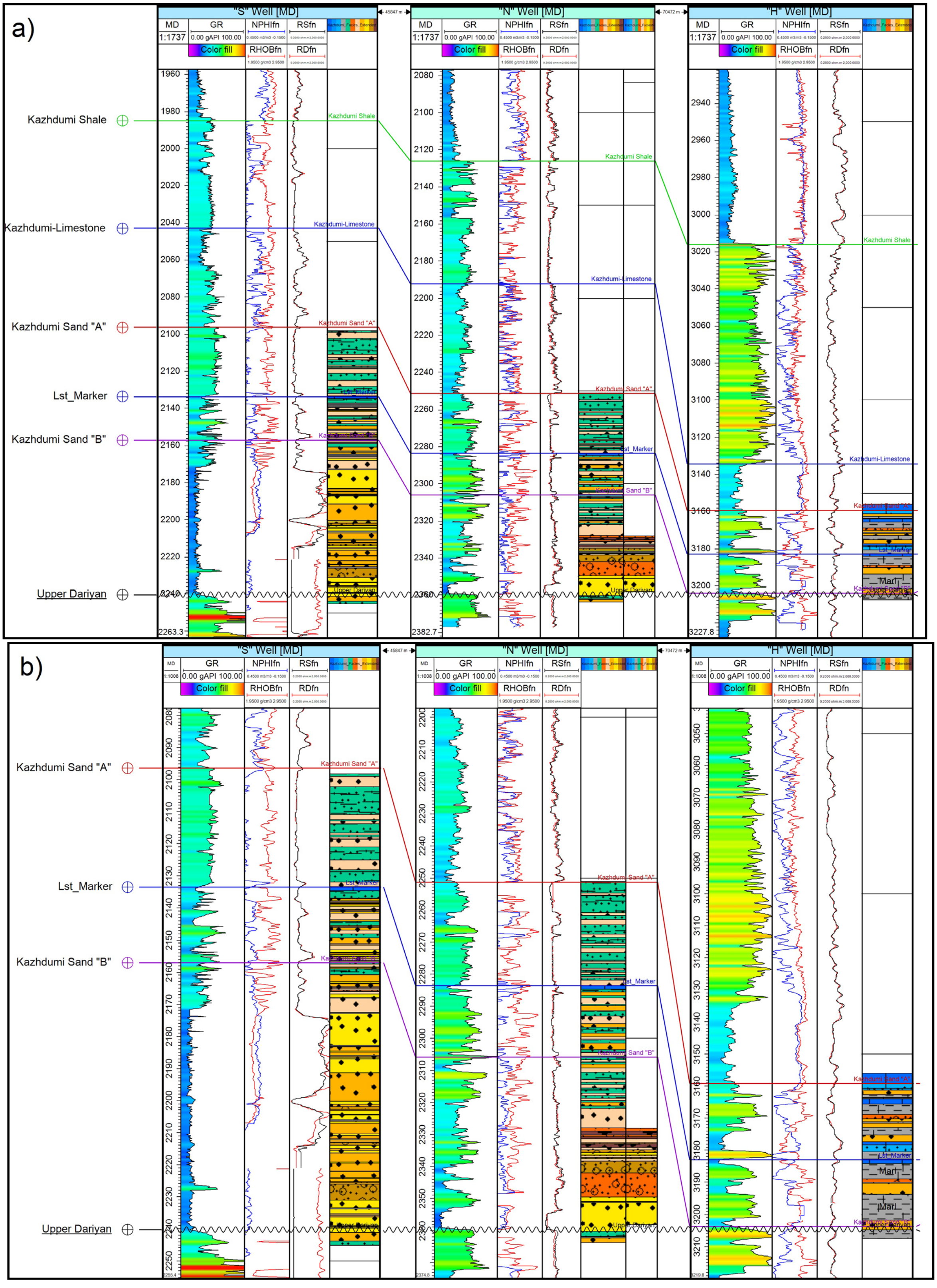


Figure 5. Stratigraphy and facies column of (a) whole the Kazhdumi Formation and (b) "A" and "B" sandstone zones in Soroosh, Nowrooz and Hendijan oil fields (the wells S, N and H respectively), legend as Figure 4.

4.1. Sieve Analysis Results

Sorting-skewness cross plot [23] was applied to determine the sedimentary environment of Kazhdumi sandstones (**Figure 6**). In this curve, the areas related to sands from different environments are presented. Sorting-skewness cross plot [23] of Soroosh and Nowrooz fields samples depicts that they are mostly categorized in river (fluvial) and beach (coastal) zones. Using the sorting-skewness cross plot [24] also proposes the river and beach setting for the sandstone samples of studied formation in both the fields (**Figure 7**). The cross plots illustrating sorting and skewness changes against the median for studied samples and also comparing them with standard curves [25] is another evidence confirming the river and wave (beach) setting as the depositional environment of Kazhdumi sandstone (**Figure 8** & **Figure 9**).

Kazhdumi Formation is separated from the underlying Dariyan (Shuaiba) Formation by a regional erosional unconformity of late Aptian age. This contact is detected applying palynological data [26]. Based on Al-Fares 1996, Kazhdumi sands deposited in lower intervals are in fact north/northeast tongues of fluvial-coastal sediments which are thick layers in south/southwest area. Thickness of this sand bearing interval varies from 40 meters in Hendijan (north part of the study area), 107 meters in Nowrooz, and 125 meters in Soorosh to 300 meters in Kuwait coast (well F).

4.2. Petrography and Sedimentary Facies Analyses Results

Based on the petrography results and distinguished facies in the studied wells, depositional setting of Kazhdumi sandstone including zones; "B" sandstone, the "A" sandstone below the key limestone layer and the "A" sandstone above the key limestone

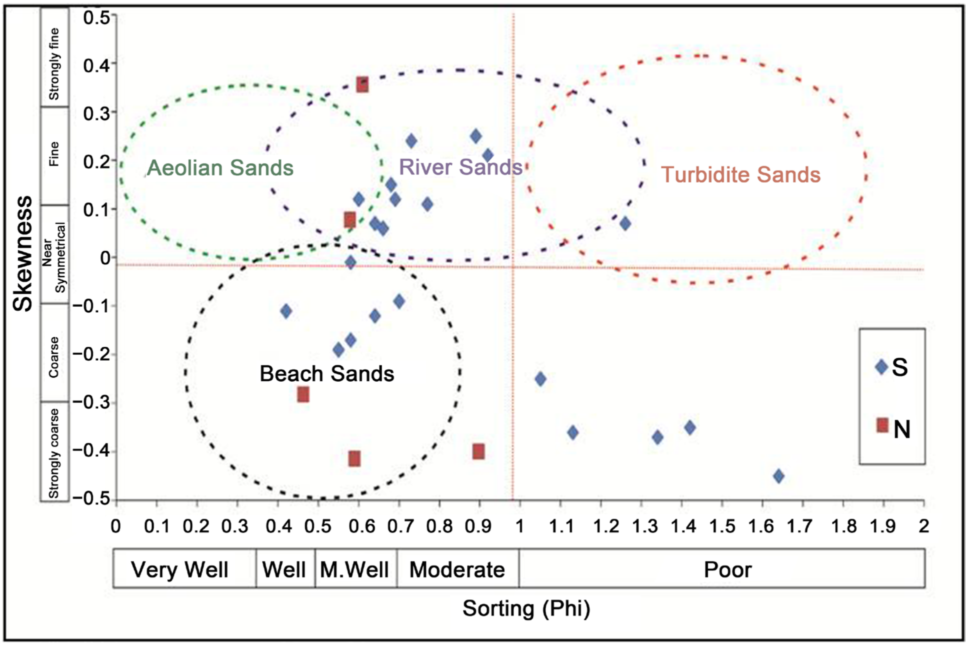


Figure 6. Sorting-skewness cross plot [23] of Soroosh and Nowrooz fields samples depicts that they are mostly categorized in river and beach zones.

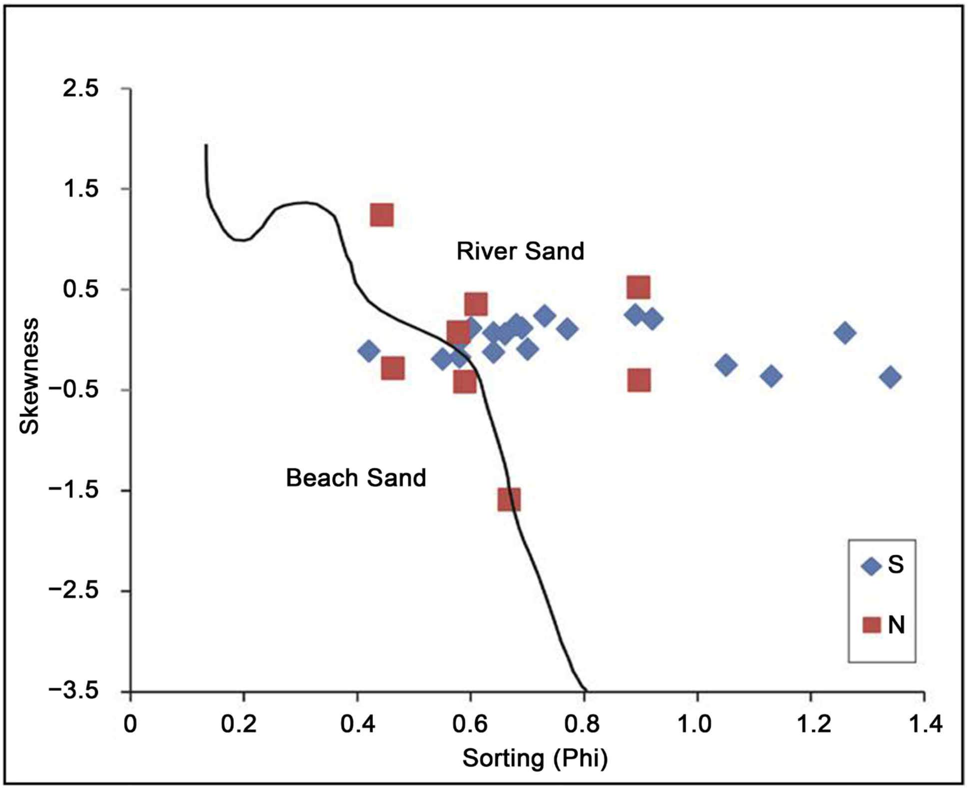


Figure 7. Sorting-skewness cross plot [24] proposes the river and beach setting for the sandstone samples of Soroosh and Nowrooz fields.

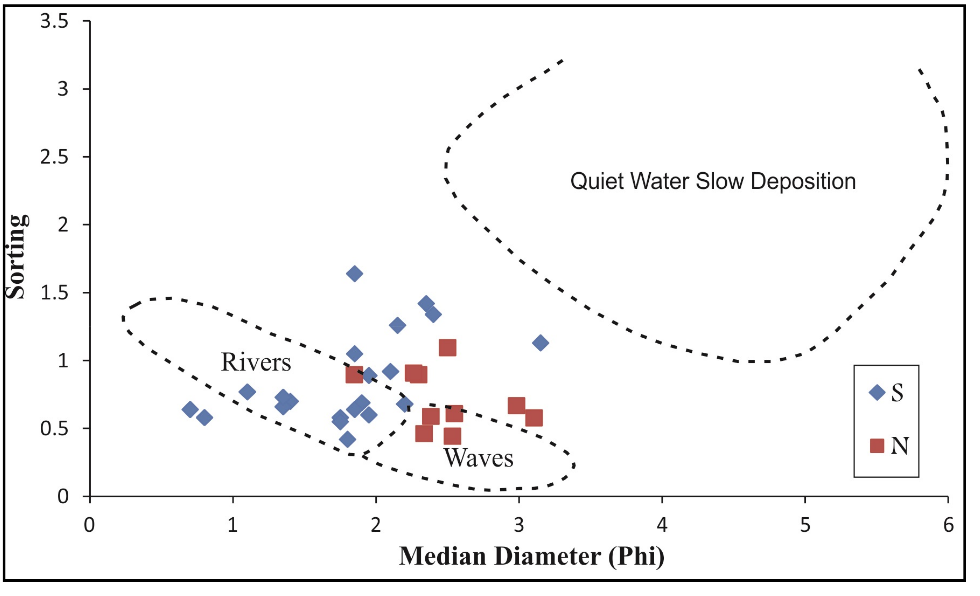


Figure 8. Sorting-median cross plot [25] is evidence confirming the river and wave setting as the depositional condition for the sandstone samples of Soroosh and Nowrooz fields.

layer is discussed in the following:

The "B" sandstone zone:

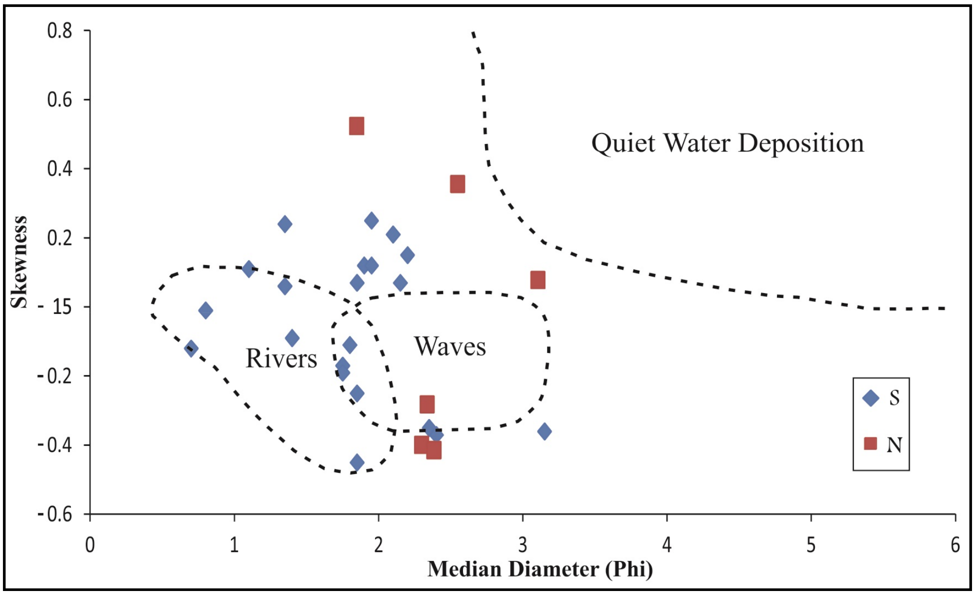


Figure 9. Skewness-median cross plot [25] is another evidence confirming the river and wave setting as the depositional condition for the sandstone samples of Soroosh and Nowrooz fields.

This interval has thick layers of sandstone alternated with thin layers of shale and siltstone that show properties such as cross bedding, oxidized grains and paleosols. Base on mentioned properties, it can be interpreted that this zone is deposited in river influenced conditions (**Figure 10a**).

The A sandstone zone, below the key limestone layer:

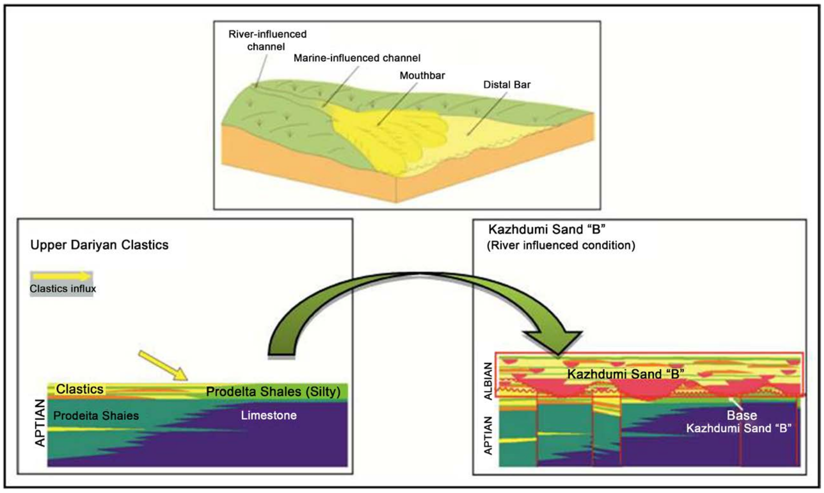
This section is composed of sandstone intervals with marine fauna indicating the intermediate condition of river dominated to marine dominated conditions in delta channels (**Figure 10b**).

The A sandstone zone, above the key limestone layer:

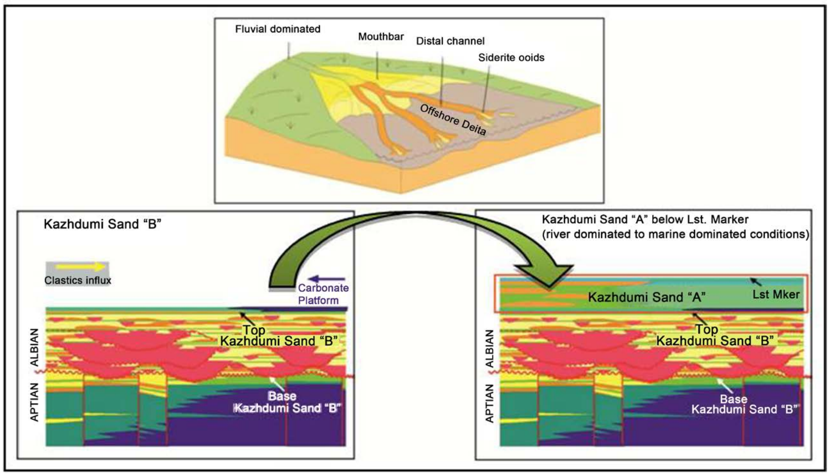
This zone is composed of fine siliciclastic laminated sediments and chemical deposits. Alternation of distal delta channel facies and green offshore delta shales containing glauconite, pyrite and organic residuals confirm the reduction condition in the estuarine setting (**Figure 10c**).

4.3. Paleocurrent Pattern

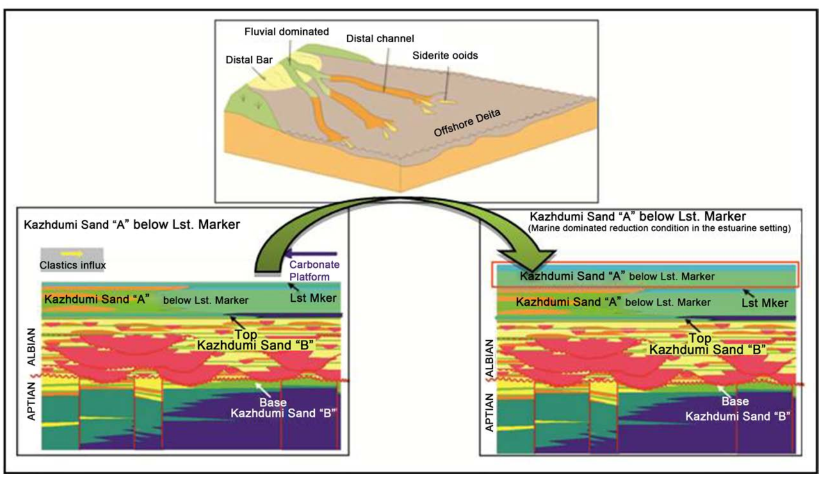
Inspecting the thickness change trends of Kazhdumi intervals named as the “A” sandstone, the “B” one and finally whole formation (**Figure 11**), implicates that mentioned intervals in the studied fields (northwest of the Persian Gulf), show decreasing trend from southwest to northeast. Thickness changes of shale zone of Kazhdumi shows different trend and thicken in mentioned direction. Regarding the changes in the thickness of shale and sandstone bearing intervals of Kazhdumi appears that the sandstone thickness decreases in a similar direction to the paleocurrent pattern and faring from the provenance, while the shale thickness increases. Kazhdumi sand “B” porosity distribution pattern in study area also confirms proposed direction for Kazhdumi sand deposition (**Figure 12**).



(a)



(b)



(c)

Figure 10. Conceptual model of sedimentary environments for Kazhdumi formation sands zones in study area, (a) Kazhdumi sand "b"; (b) Kazhdumi sandstone "a" below lst. marker; (c) Kazhdumi sandstone "a" above lst. Marker.

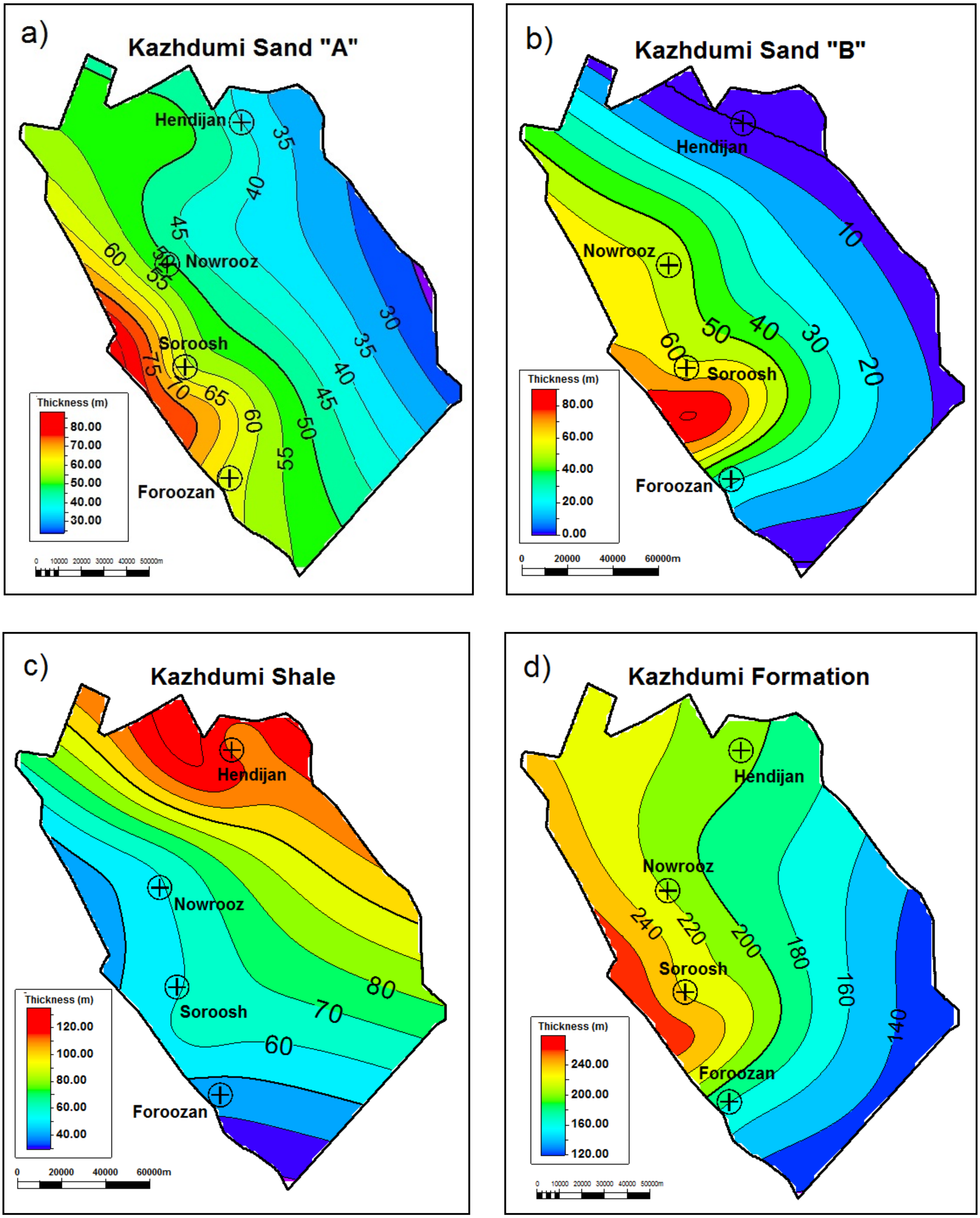


Figure 11. Isopach maps of Kazhdumi formation zones in study area, (a) Kazhdumi sand "A"; (b) Kazhdumi sandstone "B"; (c) Kazhdumi shale; (d) whole Kazhdumi formation.

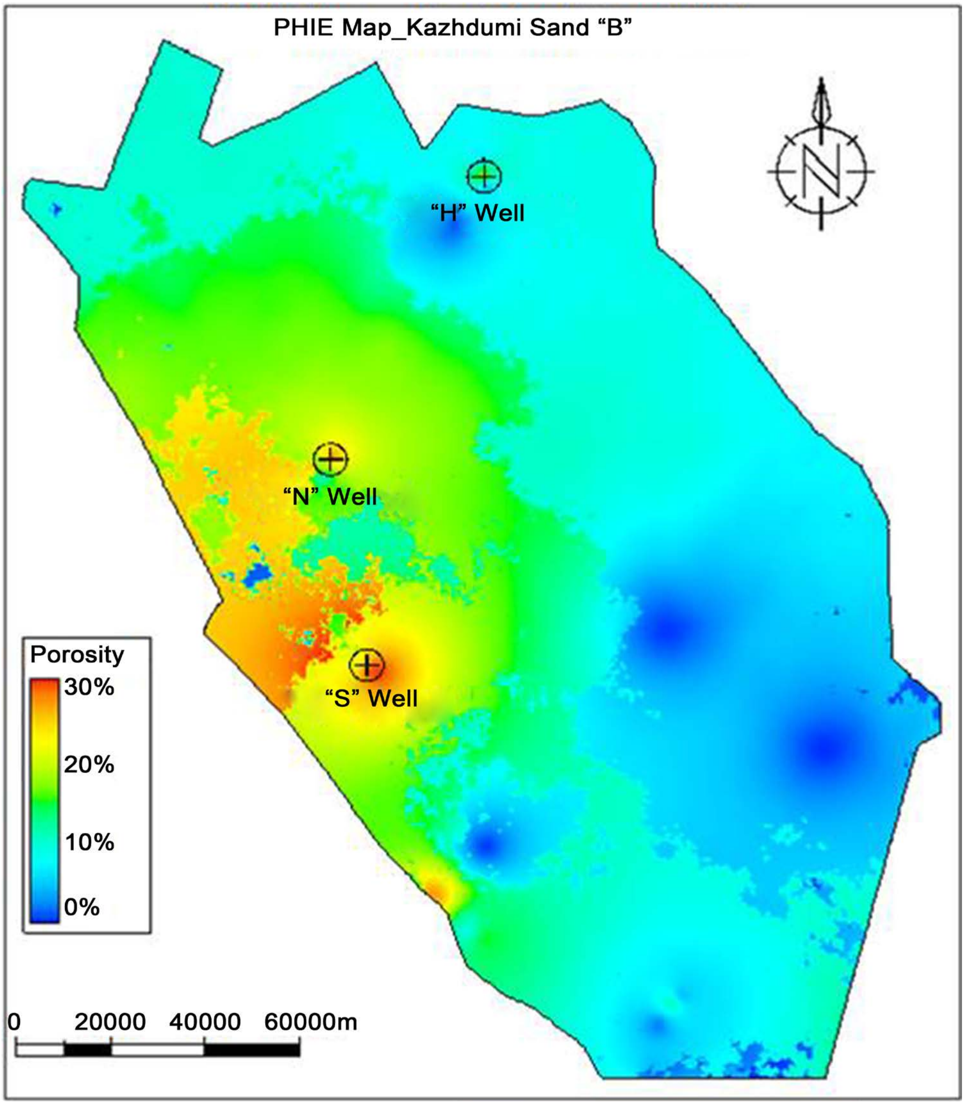


Figure 12. Kazhdumi Sand "B" porosity distribution pattern in study area, porosity decreases from southwest toward northeast supporting the paleocurrent direction from southwest to northeast.

Comparing the sieve analysis results of Kazhdumi sands in Soorosh and Nowrooz Fields implicate that grain sizes in the Soroosh Field ranges from very fine to coarse while in the Nowrooz Field, grains are mostly very fine to medium (Figure 13). Regarding the principle that siliciclastic grain sizes decrease from the provenance alongside the paleocurrent direction, it can concluded that Soroosh Field with coarser grains in closer to the provenance which is absolute accordance with the Kazhdumi sands paleocurrent direction from southwest toward northeast (no sample is available from Hendijan Field for sieve analysis).

Checking sedimentary facies of Kazhdumi sand in Soroosh, Nowrooz and Hendijan Fields (Table 1) proved that the Soroosh Field having fluvial, channel and marine facies located at proximal delta and the Hendijan Field having just channel and marine facies

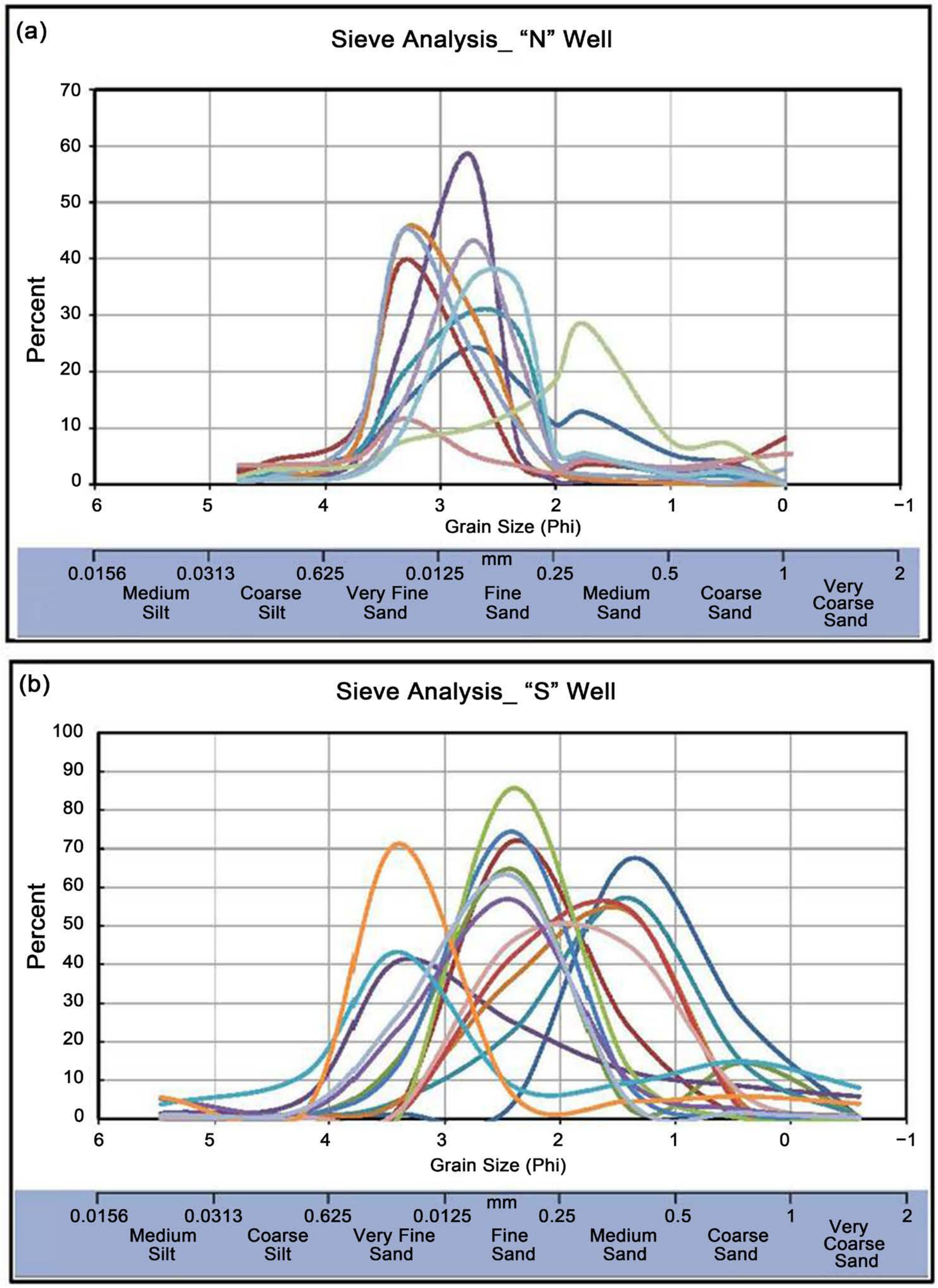


Figure 13. Sieve analysis of Kazhdumi sands in (a) Nowrooz and (b) Soorosh fields implicate that Soroosh field with coarser grains in closer to the provenance.

without any fluvial facies is located at the distal delta environment. The Nowrooz Field can be addressed between these two fields and has transitional condition (**Figure 14**).

4.4. Paleoclimate

Cuulers [27] formulated chemical index of weathering (CIW) to calculate the degree of chemical weathering for the sandstones with high CaO content, which can be calculated by the following equation:

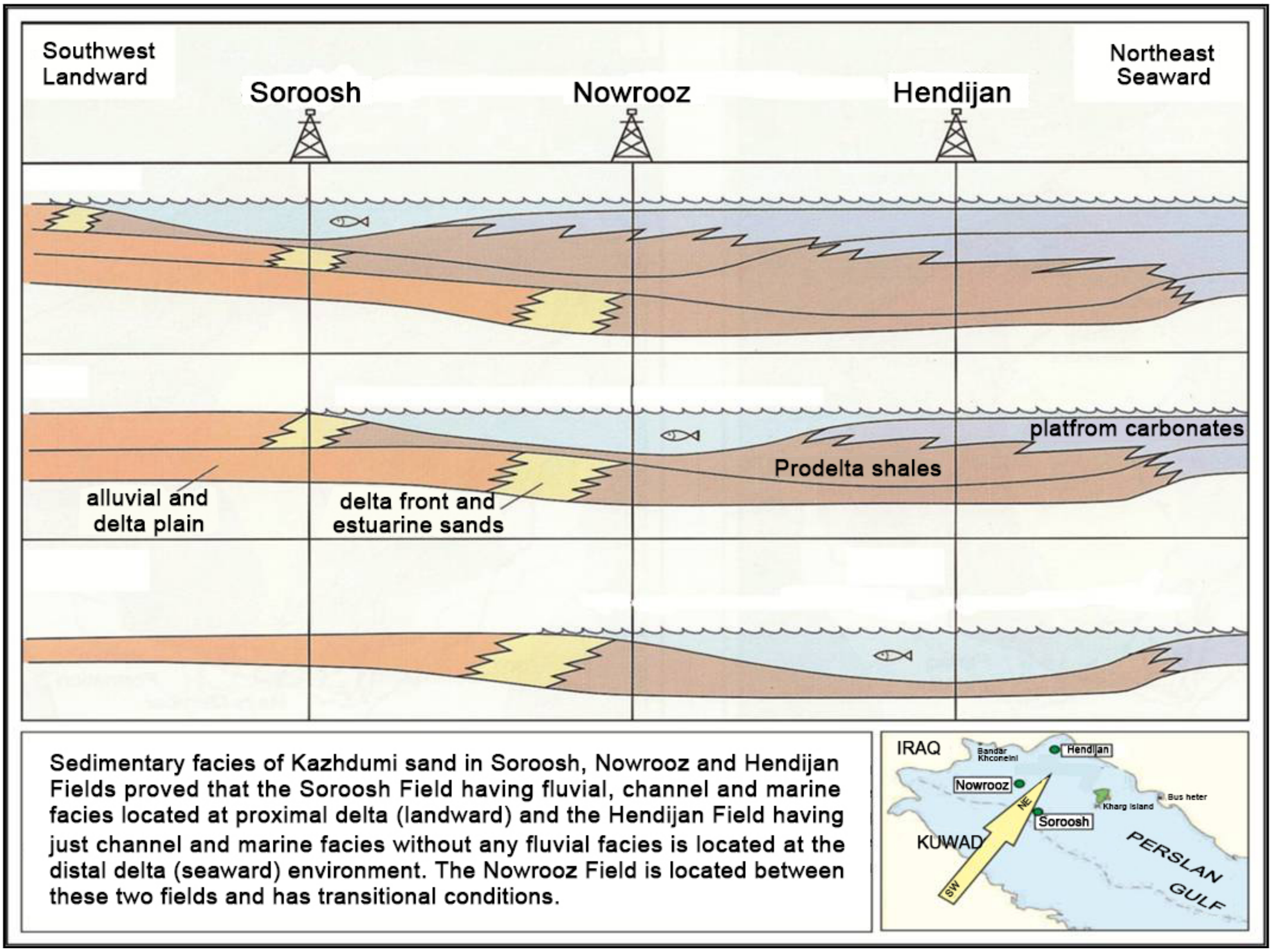


Figure 14. Stratigraphy schematic model for the mixed clastic-carbonate sediments of Kazhdumi Formation in study area.

$$CIW = [Al_2O_3/(Al_2O_3 + Na_2O)] \times 100$$

where the oxides are expressed as molar proportion. CIW is variable form 50 in non-weathered sediments to 100 in intense weathered sediments. The high CIW values in the Soroosh, Nowrooz and Hendijan samples (90.8, 96.7 and 96.4 respectively) indicate a moderate to intense weathering of first cycle sediments, or it may alternatively reflect recycling under semi-arid to semi-humid climate conditions [28].

5. Conclusion

Based on this study, Kazhdumi sandstone was divided into three zones. The "B" sandstone zone was probably formed by river influenced conditions. The "A" sandstone zone, below the key limestone layer, was deposited in river dominated to marine dominated conditions in delta channels. The "A" sandstone zone, above the limestone key layer, was deposited in reduction condition in the estuarine setting. Comparing sedimentary facies proved that the Soroosh Field having fluvial, channel and marine facies located at proximal delta while Hendijan Field having just channel and marine facies without any fluvial facies situated at the distal delta environment. The Nowrooz Field can be addressed between these two fields and has transitional condition. Based on sieve analysis Soroosh has coarse grains in comparison to Nowrooz that has been closer to the provenance and also confirms the paleocurrent of these sands from southwest toward northeast. The zones of "A" and "B" sandstone and eventually Kazhdumi Formation in northwest of Persian Gulf get thinner from southwest to northeast. This thickness change trend is also in accordance with proposed paleocurrent pattern. According to porosity distribution pattern, porosity decreases from southwest toward northeast supporting the paleocurrent direction. The high CIW values in the Soroosh, Nowrooz and Hendijan samples indicate a moderate to intense weathering of first cycle sediments, or it may alternatively reflect recycling under semi-arid to semi-humid climate conditions.

Acknowledgements

Authors thank the R&T department and Geology section of Iranian offshore Oil Company for their supporting.

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