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Sedimentary fabrics and diagenetic features of the Late Triassic Kingriali Formation, Khisor-Marwat ranges, Pakistan

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The Triassic succession of Khisor-Marwat ranges exposed extensively in Pakistan is comprised of the Mianwali, Tredian and Kingriali formations, predominantly deposited in peritidal channels to superatidal zones of peritidal environment with influence of marine and meteoric water. The present research intends to present comprehensive studies on sedimentary fabrics of the upper most Kingriali Formation. Inclusive sedimentological and petrographical investigations were executed on the Late Triassic Kingriali Formation from the Chunda and Paniala area, where it is primarily composed of dolomite interbedded with sandstone. Field observation reveals that the light-grey to light-brown, sugary textured, crinoid dolomites sandy and marly at places whereas the sandstone is brownish at weathered surface, fine- to medium-grained, massive, friable and cross-bedded. The greenish to black colored dolomitic shale in the Chunda section is interbedded with dolomite. Based on lithological characteristics, the Kingriali Formation is classified into four units including; sandy dolomite, dolomitic limestone, thick-bedded dolomite with green shale, and thin-bedded dolomite with black shale. The whole rock analysis of Kingriali dolomite implies that the dolomite has been crystallized in mix water condition, however, re-crystallization and formation occurred in the mid-late diagenetic settings. The analyzed diagenetic features of the rock unit suggest Kingriali Formation as potential reservoir.

[**Keywords**: Diagenetic features, Khisor-Marwat ranges, Kingriali Formation, Late Triassic, Sedimentary fabrics]

Introduction

The Late Triassic Kingriali Formation exposed in Chunda and Paniala sections, Khisor-Marwat ranges, Pakistan is measured with thickness of 105 m and 108 m, respectively. The formation comprises of two members. The upper member composed of brown, purplish white, pinkish, sugary textured, crinoidal, dolomite interbedded with sandstone, whereas the lower member represents gray to brownish gray, weathering brown, thick-bedded to massive, hard, fractured, fine- to coarse- textured dolomite interbedded with marl and shale. The formation exhibits unconformable upper contact with the Jurassic Datta Formation and conformable with the Lower Tredian Formation.

The well-exposed Kingriali Formation in Chunda and Paniala sections form Kingriali peak is similar to the other sections of the Khisor range. Formation is well exposed in Zaluch Nala in the western Salt range, Landa Nala in the Surghar range and Tapan Wahan and Gori Tang Nala in the Khisor range[1,2]. According to Tectostrat[3], Kingriali Formation is deposited in a shallow marine carbonate platform environment and dominantly comprised of dolomite.

Previously slight deliberation has been rewarded to the sedimentological aspects of the Kingriali Formation such as geological mapping and stratigraphic study of the area was conducted by several researchers[1,4-6], however, comprehensive sedimentological portrayal of the Kingriali Formation on these sections is still lacking. Therefore, these aspects motivated the researchers to evaluate sedimentological attributes of the Kingriali Formation specifically its environment of deposition. This research work demonstrates the detail sedimentological study of the Kingriali Formation by enlightening the macro- and microscopic characteristics which will deliver substantial information regarding its depositional environment along with diagenetic overprints.

Geological Setting

The study areas "Chunda and Paniala sections" are located in Khisor-Marwat ranges, which represent central part of the Trans-Indus ranges and south-western portion of the foreland fold-and-thrust belt of the north-western Himalayas. These sections are product of the progressive south directed décollement-related thrusting of cover sequence of the Indian Plate during ongoing collision between Indian and Eurasian Plates[7-9] (Fig. 1a). Structural geometries of the Khisor range depict that décollement thrust played a significant character in its tectonic architecture that allowed north-south differential accommodation in the southeast margin of the western Khisor range[10]. The Cambrian strata that include Khewra Sandstone, Kussak Formation, Jutana Formation and Khisor Formation forming the base whereas Tertiary strata that composed of the Siwaliks group form the top of the stratigraphic succession[2] (Table 1). The intricate structural geometries and Paleozoic to Mesozoic strata suggests a vital petroleum system for the oil and gas generation and accumulation perspective.

Material and Methods

The study area is located in Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan ~250 km south-southwest of Peshawar and about 120 km from Bannu toward south-southeast (Fig. 1b). During the field work, sedimentary structures and stratigraphy of the Triassic strata particularly the Late Triassic Kingriali Formation in both sections were witnessed. The petrographic study of the Kingriali Formation was established by standard thin-section techniques. These were studied under microscope to evaluate diverse sedimentological aspects providing key source of

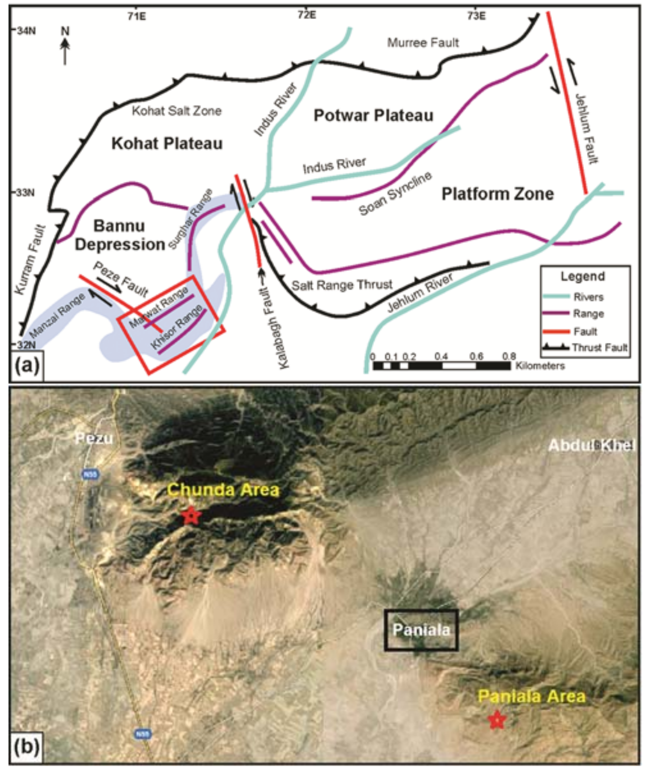

Fig. 1 — (a) Structural map of Khisor-Marwat ranges, Trans-Indus ranges (modified after Ghazi *et al.*[11]; Riaz *et al.*[12,13]). The study area is shown with red rectangle; (b) Satellite image indicating the location of Chunda section and Paniala section.

Table 1 — Generalized stratigraphic sequence of the Khisor-Marwat ranges (modified after Alam *et al.*[2])

Age		Group	Formation	Composite Thickness (m)
			Soan	44.0
	Tertiary	Siwaliks	Dhok Pathan	166.0
			Nagri	962.0
			Kingriali	108.0
Mesozoic	Triassic	Musa Khel	Tredian	46.0
			Mianwali	127.0
			Chhidru	92.0
		Zaluch	Wargal Limestone	156.0
			Amb	60.0
	Premain		Sardhai	42.0
Paleozoic		Nilawahan	Warchha	136.0
			Tobra	86.0
			Khisor	172.0
	Cambrian	Jhelum	Jutana	82.0
			Kussak	48.0
			Khewra Sandstone	64.0

information about paleoenvironments, sedimentation style and diagenesis.

Lithostratigraphy of the Kingriali Formation

The Kingriali Formation primarily comprises of dolomite and sandy dolomite with thin-beds of shale in middle and upper parts. The dolomite is off-white to light-brown on weathered whereas light-cream on a fresh surface and sandy dolomite is reddish to brownish on weathered and light-red on fresh surface. The medium- to thick-bedded dolomite and sandy dolomite are interbedded with greenish to blackish shale. Dolomite and sandy dolomite are fractured at places, cross-bedded and clay intercalations also perceived within dolomitic beds. Based on variable thicknesses of beddings along with several other characteristics, Kingriali Formation can be well explained by constructing lithostratigraphic units in both Chunda and Paniala sections.

Lithostratigraphic units in the Chunda section

The thickness of the Kingriali Formation in Chunda village is 105 m (Fig. 2a). A total of four litho-units have been identified in this section from bottom to top (Fig. 2b-e). The detailed descriptions of these rock units are presented in sequential orders as follows:

Sandy dolomite

Sandy dolomite is typically characterized by high percentage of clastic sediments. The unit is almost 15 m thick with individual bed thickness about 2-3 m thick (Fig. 2b). This unit is mainly composed of medium- to thick-bedded dolomite with sand influx. Planar cross-bedding was observed in this unit. The fresh color of the rock is cremish and it reveals light brown color on weathered surface. This unit developed in intertidal channels with some clastic influx that indicates the nearby exposed source area[14].

Bioturbated dolomitic limestone

The 13 m thick, medium to thick bedded grey- to dark-grey colored unit consists of bioturbated dolomitic limestone (Fig. 2c). The thickness of the individual beds is about 3-6 m. The beds are moderately to entirely bioturbated and intensity of bioturbation increases from bottom to top of bedding surface.

The bioturbation exhibits the activity of various organisms. The moderately to rigorous bioturbation suggested exposure of sediments for a protracted period of time in oxygenated setting with relatively slow sedimentation which happened probably in a marginal marine environment[15].

Thick bedded dolomite interbedded with shale

The thick-bedded dolomite unit is extensively distributed in the Kingriali Formation (Fig. 2d). The thickness of this unit is about 40 m and contains massive dolomite with interbedded green shale. The thickness of individual beds of dolomite and green shale are 3-7 m and 0.3-0.6 m, respectively. This unit was most probably developed in the supratidal zone of the marginal marine environment with some argillaceous clastic influx which is consistent with the findings of Mensink *et al.*[14].

Thin bedded dolomite

The 28 m thick unit is mainly comprised of thin-bedded, grey to light-brown dolomite with some clastic grains at the base and a thin layer of black shale interbedded between dolomite beds (Fig. 2e). The thickness of the individual dolomite beds is 1-2 m and the thickness of shale layer is around 0.3-0.5 cm. The presence of dolomite in this unit indicate supratidal zone in restricted marine environment whereas black shale indicate sublittoral anoxic conditions[15].

Lithostratigraphic units in the Paniala section

The thickness of the Kingriali Formation in Paniala area is 108 m (Fig. 3a). A total of four litho-units have been identified (Fig. 3b-e), which are described below:

Sandy dolomite

This unit is 20 m thick and mainly composed of medium to thick-bedded sandy dolomite. The color of sandy dolomite is light yellowish to cream and reddish at places on fresh surface, and brown on weathered surface. The individual beds are 1.5-5 m thick. Planar cross-bedding is also observed in this unit (Fig. 3b). The cross-bedding in sandy dolomite indicates the deposition of this unit in tidal channel with some clastic influx[15].

Dolomitic limestone

This unit is 18 m thick and consists of medium to thick-bedded dolomitic limestone with intercalation of some clay (Fig. 3c). The whole unit comprised of fractured dolomitic limestone with thinning-upward sequence. The color of dolomite is maroon to cream and

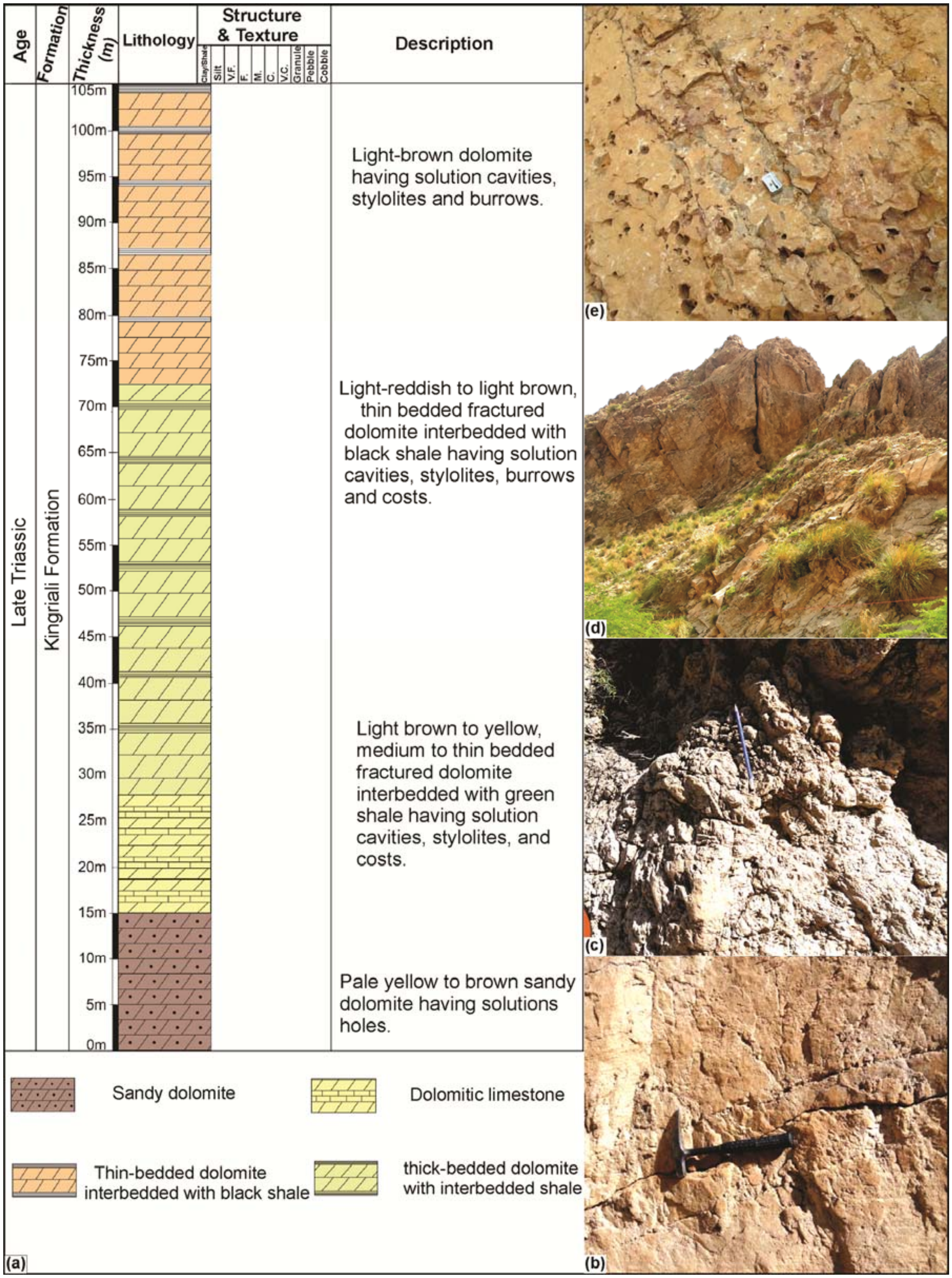

Fig. 2 — The Sedimentary characteristics of the Kingriali Formation in the Chunda section, Khisor-Marwat ranges, Pakistan: (a) Lithological log presenting variation in lithology, field photographs exhibiting; (b) Sandy dolomite unit containing cross-bedding; (c) Bioturbated dolomitic limestone unit; (d) Thick-bedded dolomite with minor amount of terrigenous sediments in the upper parts unit; and (e) Light-brown dolomite with some clastic grains unit portraying solution cavities, stylolites and burrows in the Kingriali Formation.

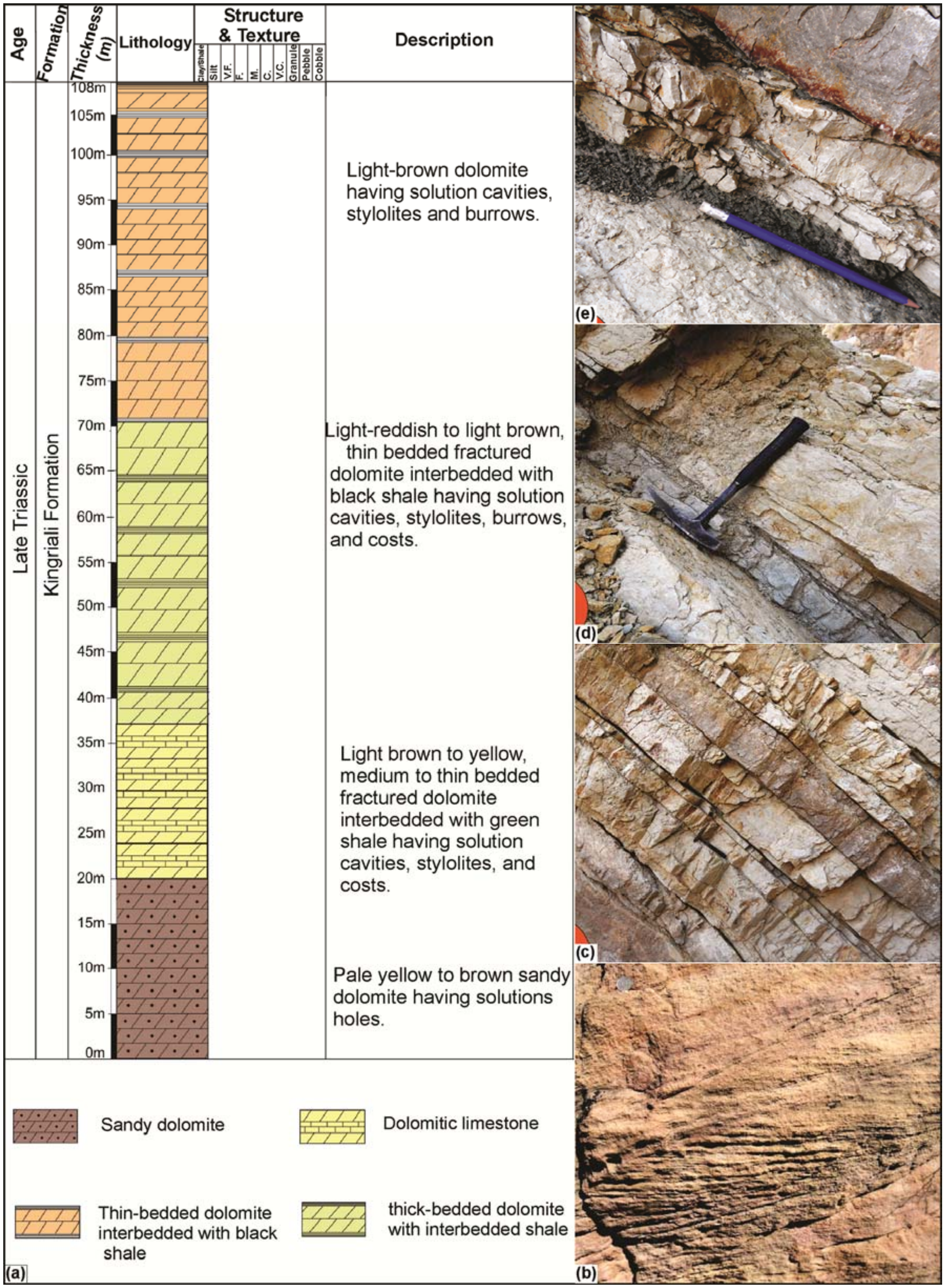

Fig. 3 — Sedimentary characteristics of the Kingriali Formation in the Paniala section, Khisor-Marwat ranges, Pakistan: (a) Lithological log shows variation in lithology and field photographs indicate; (b) Sandy dolomite with planar cross-bedding; (c) Bedding in dolomitic limestone unit; (d) Thick-bedded dolomite with green shale; and (e) Dolomite interbedded with black shale units in the Kingriali Formation, Paniala section.

reddish-grey. The thickness of individual bed in the unit is more than 1.5 m. The dolomitic material reveals the subtidal to intertidal zone of the peritidal environment whereas presence of some calcareous material shows the shallow environment.

Dolomite with green shale

This unit is 38 m thick and consists of dolomite interbedded with thin-bedded green shale. The unit shows cycles of fining-upward sequence. The color of dolomite is cream to reddish-brown with thin interbedded green shale (Fig. 3d). The thickness of dolomite beds is 1-3 m whereas thin layering of shale range up to 20 cm within those dolomitic beds. The unit has been interpreted to be deposited in the supratidal zone of the peritidal environment with some influx of argillaceous clastic material[6,14].

Dolomite with black shale

This unit is 35 m thick and composed of thin- to medium-bedded dolomite with interbedded black shale (20-30 cm) dominantly occurred in the top of rock unit. The color of dolomite is cream to reddish-brown and the color of shale is black (Fig. 3e). The black shale in this unit indicates deposition in anoxic conditions[15].

The regional distribution of the Late Triassic Kingriali Formation has been investigated in both sections (Chunda, Paniala) where they exhibit slight variations in thicknesses (Fig. 4). The overall color of the formation is light-cream, green, reddish-brown and black, predominantly composed of medium- to thick-bedded of dolomite representing finning upward sequence in both sections. The comparisons of litho-units of both sections are presented in Figure 4.

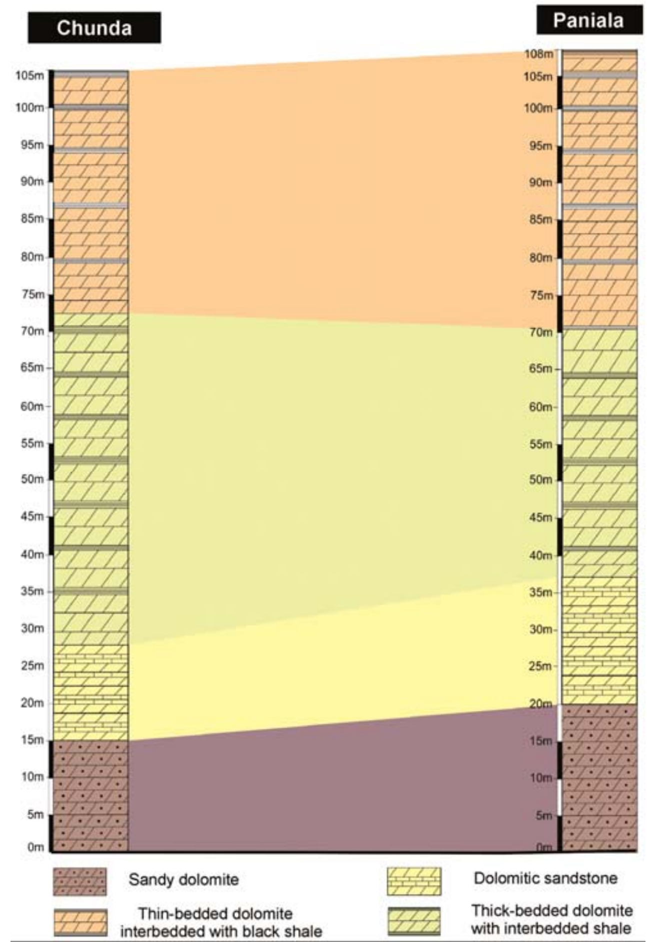

Fig. 4 — Lithological correlation of the exposed Kingriali Formation in Chunda and Paniala sections, Khisor-Marwat ranges, Pakistan

Results and Discussion

Petrographic analysis

The detailed petrographic characteristics of the Kingriali Formation have been observed to delineate microfacies that used to interpret the depositional environment. The microfacies are divided on the basis of cement content, dolomite fabric and dolomite crystal size.

Microfacies of the Chunda section

The microfacies of the Chunda section are classified into four microfacies (Fig. 5). The detailed descriptions and their interpretations are given below:

Crypto- to microcrystalline dolomite (KFM 1)

This microfacies is observed in the lower parts of the Kingrial Formation and comprises crystals of dolomite (Fig. 5a, b), which are tightly packed. The dolomite crystals are composed mainly of euhedral to subhedral crystals. The size of the crystals ranges from 15 µm to 30 µm. The percentage of dolomite is from 85-90 %. The texture is mostly hypidiotopic, rarely idiotopic and parts of anhedral crystals are also presenting xenotopic texture. The dolomite crystals are formed as a result of replacement of small calcite crystals indicating cloudy appearance in the center and clear rims. Sucrosic texture represented by some euhedral dolomite crystals in calcite cement is present occasionally (Fig. 5a, b).

The size of the crystals, hypidiotopic to xenotopic texture of crystals suggests the replacement of dolomite in mix zone of marine and meteoric water and recrystallization during early stage burial diagenesis[14].

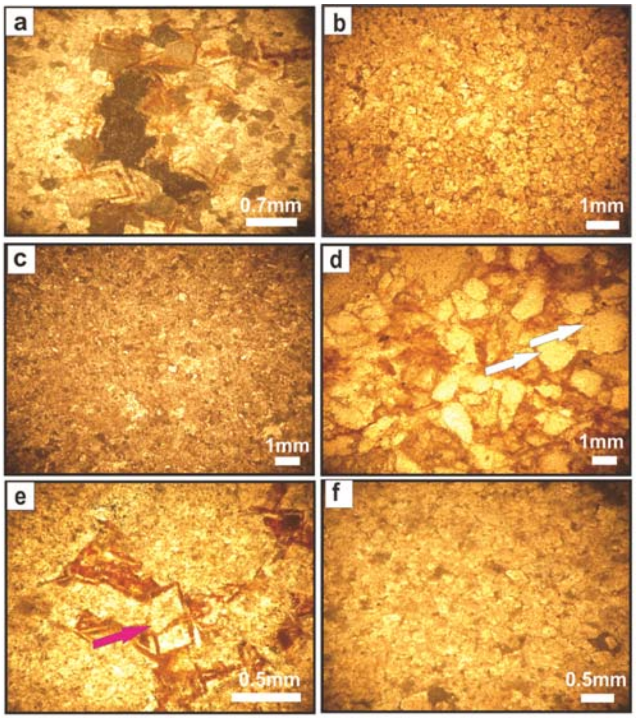

Fig. 5 — Photomicrographs indicate the microfacies of the Kingriali Formation in the Chunda section: (a, b) Crypto- to microcrystalline dolomite signifying hypidiotopic fabric and surcosic texture of subhedral and euhedral dolomite crystals with calcite cement; (c, d) Microcrystalline dolomite revealing sugary texture of anhedral-subhedral crystals and quartz grain (white arrow); (e) Zoned dolomite crystals (pink arrow) with some clay cement; and (f) Xenotopic fabric of replace dolomite. All photomicrograph are taken from in cross polarized light except (e) which is in plane polarized light.

Microcrystalline dolomite (KFM2)

This microfacies is composed of tightly packed, very fine crystals of dolomite, representing typical sugary texture of dolomite crystals. It is hard to identify them as typical rhombic crystals of dolomite. The crystals have a grain size from 40 µm to 200 µm. These crystals represent hypidiotopic fabric (Fig. 5c, d). The percentage of dolomite is 90-95 %. Some quartz grains have also been observed in this microfacies (Fig. 5c).

The marine and meteoric water dolomitization is dominant in this microfacies, which is also supported by the observations of Mensink *et al.*[14]. The few sand grains indicate some clastic influx and very fine crystalline nature of the crystals represents replacement of fine calcite matrix and cement.

Zoned dolomite (KFM3)

This microfacies has been recognized by xenotopic to idiotopic texture of finely crystalline dolomite. Some coarse crystals have also identified which have cloudy appearance in the internal and clear zone on the outer part within the crystal. These crystals portray idiotopic fabric with planar contacts between crystals. The finely crystalline xenotopic crystals are closely packed having non-planar contacts among them. The zones in the idiotopic crystals show that the dolomite has been formed as a result of partial replacement in the calcite crystals (internal blurry zone). The crystal sizes vary noticeably from very fine- to coarse-grains (25 µm to 700 µm) of dolomite (Fig. 5e).

The euhedral nature of crystals implies the replacement of limestone crystals into dolomite at normal surface temperature[14]. The larger crystals and xenotopic fabric have been developed as consequence of shallow burial dolomitization and recrystallization of minute dolomite crystals. This microfacies represents dolomitization in normal Mg^{+2} rich fluid and then in shallow burial conditions.

Replacive dolomite (KFM4)

This microfacies is associated with anhedral crystals of tightly packed dolomite cemented by sparry calcite. The percentage of dolomite is about 95 % and crystals exhibit xenotopic fabric (Fig. 5f). The size of the crystals ranges from 200 µm to 600 µm. The boundaries between the crystals are irregular, lobate, curved with irregular edges. The dolomite has been replaced in fine- to medium-crystals of calcite keeping the texture of the crystals intact.

The early burial replacement dolomitization has been depicted by xenotopic fabric[12]. The tightly packed dolomite is indicative of compaction.

Microfacies of the Paniala section

The detailed petrographic studies of the Kingriali Formation in the Paniala section has been executed (Fig. 6) that showed slightly variation in microfacies from the Chunda section (Fig. 5). The microfacies of the section are defined as follows:

Microcrystalline dolomite (KFM)

The microfacies consist of abundant dolomite crystals tightly packed together with calcite cement that forms lower parts of the formation. The percentage of dolomite is from 85 to 90 %. The dolomite composed of euhedral and subhedral crystals that vary in size from 35 µm to 300 µm (Fig. 6a). The texture is mostly hypidiotopic but in parts anhedral crystals are also present forming xenotopic texture.

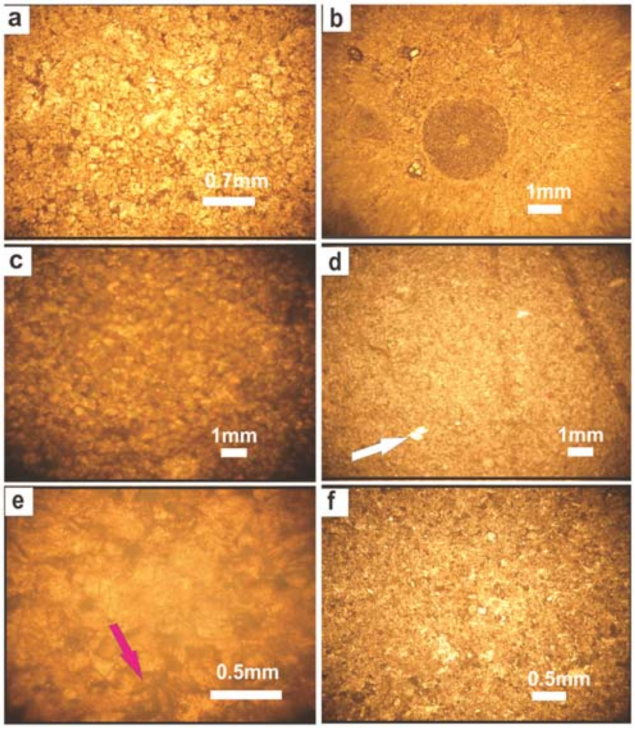

Fig. 6 — Photomicrographs showing the microfacies of the Kingriali Formation in the Paniala section: (a, b) Microcrystalline dolomite portraying surcosic texture of euhedral dolomite crystals with calcite cement and bioclast replaced by lime mud; (c, d) Crypto- to microcrystalline dolomite depicting sugary texture of anhedral-subhedral crystals and quartz grain (white arrow); (e) Dolomite crystals in microcrystalline calcite (pink arrow) in dolomitic carbonate mudstone facies; and (f) Xenotopic fabric of replace dolomite. All photomicrograph are taken from in cross polarized light.

The dolomite crystals are formed as a result of replacement of small calcite crystals indicating cloudy appearance in the center and clear rims. Sucrosic texture represented by some euhedral dolomite crystals in calcite cement (Fig. 6a). The crystal edges are mostly straight (planar-s) but crystals having irregular planes are shown by xenotopic fabric. In few cases, a secondary rim is also developed around the dolomite crystals. Furthermore, some shells of echinoderm are replaced by carbonate mud (Fig. 6b).

The size of crystals and echinoderm's shells suggest that microfacies may be deposited with influence of marine conditions in meteoric waters, depositing very fine crystals of dolomite. Then, gradually replacement and recrystallization of larger crystals occurred during early stage of burial showing hypidiotopic and xenotopic fabric. Fine- to medium-crystals of dolomite indicate replacement of fine-grained calcite matrix and cement[15].

Crypto- to microcrystalline dolomite (KFM2)

This microfacies consists of very fine-grained crystals of dolomite which are tightly packed together, represents typical sugary texture of dolomite crystals (Fig. 6c) and hardly identified as rhombic crystals. The crystals have grain size of less than 20 µm with lobate to straight boundaries, composed of anhedral-subhedral crystals with hypidiotopic fabric that contain 90-95 % dolomite. Few quartz grains are also observed in this microfacies (Fig. 6d).

The type of fabric indicates development of this microfacies during replacement dolomitization of calcite crystals in mixing zone of marine and meteoric waters[14]. The sand grains indicate some clastic influx from the meteoric water and very fine crystalline nature of the crystals represents replacement of fine calcite matrix and cement in these environments.

Dolomitic carbonate mudstone (KFM3)

This microfacies originally consists of predominantly carbonate mudstone as there is abundance of microcrystalline calcite, characterized by less than 50 % dolomite (Fig. 6e). The mosaics dolomite crystals have been formed into all it matrix as host. The crystal size ranges from 100 µm to more than 400 µm. The intercrystalline boundaries are irregular and curved. The dolomite crystal size and have xenotopic textures of anhedral crystal with few euhedral crystals are also observed.

The presence of dolomite crystals represents the replacement of calcite crystals but occurrence of xenotopic fabric indicates that this replacement took place during early stage of burial dolomitization. Since the original fabric and calcite content is intact in the microfacies, therefore this dolomitization process was not initiated on the surface where calcite was originally deposited in marine influence[14,15].

Replacive dolomite (KFM4)

This microfacies consists of abundant dolomite, tightly packed anhedral crystals with some calcite cement. The percentage of dolomite varies from 90 to 95 %. The crystals are non-rhombic in equigranular having xenotopic fabric (Fig. 6f). The size of the crystals ranges up to 800 µm. The crystal edges are irregular and boundaries between the crystals are irregular, lobate and curved. The dolomite has been replaced with fine- to medium-crystals of calcite keeping the texture of the crystals intact.

This type of microfacies formed in a replacement process of calcite crystal at the surface during the sulfate reduction because of mixing of marine and meteoric water and increase of magnesium ions due to formation of calcium sulfate[14]. The xenotopic fabric is a result of early burial replacement of dolomite[15].

Diagenetic features of the Kingriali Formation

The diagenetic features identified in the Kingriali Formation are dedolomitization, stylolitization and dissolution (Fig. 7). Dedolomitization is the main process which is not only responsible for the changes in dolomite during early and late stages of burial however, also responsible for making a dolomite rock as reservoir[16]. So, the petroleum industry is very keen to see dedolomitization in any dolomite rock.

Dedolomitization

Dedolomitization is a replacement process in which dolomite replaced with calcite in the presence of meteoric water. It is mainly a diagenetic process that happens in two steps (early and late diagenetic). This two-step process can be clearly observed in zoned dolomite facies of the Chunda section in which coarse crystals of dolomite appear cloudy and unstable in the central part where it is replaced by calcite and outer part of the crystal remain clear and stable (Fig. 7a). The other dominant process is near surface re-crystallization in the meteoric conditions results the dedolomitization and dissolution in meteoric conditions in micritic dolomite and infilling to make molds. The variation in salinity of the pore water is the main cause of the deep burial dedolomitization. The deep burial process involves Ca-dolomite instability and formation of calcite within the intracrystalline pores by corrosion of dolomite crystal[16].

Dedolomitization process is very imperative in dolomite and keeps high significance for geologists in the petroleum industry which is used for the identification of subarial exposures and unconformities. This process primarily creates secondary porosity and making a non-reservoir rock a reservoir[16].

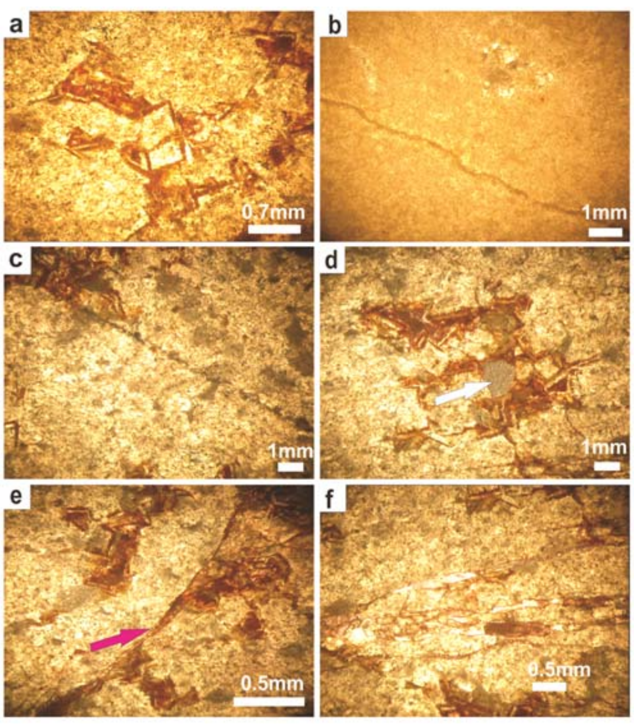

Fig. 7 — Photomicrographs showing the diagenetic and reservoir characteristics of the Kingriali Formation: (a) Dolomite crystals showing the effect of dedolomitization; (b, c) Stylolites filled with micrite and dolomite crystals; (d) Void made by dissolution responsible for the development of secondary porosity; and (e, f) Fracture in the dolomite responsible for the development of secondary porosity and reservoir characteristics. All photomicrograph are taken from in cross polarized light except (a) which is in plane polarized light.

Stylolitization

Stylolitization is another dominant process in the Kingriali Formation which is closely related to the dolomite. The stylolites formed due to pressure solution in burial conditions and forming same environment where the dolomite has been crystallizing, therefore, often they filled with dolomite crystals. However, this process reduces the porosity, which is not important in oil industry but valuable for the diagenetic history of the rock (Fig. 7b, c).

Dissolution

Dissolution process is also observed in the Kingriali Formation, which is liable for making it an interesting rock for petroleum industry. Dissolution is primarily a component of dedolomitization in which dolomite crystal has been removed leaving a void in its place which has been filled sometimes by calcite[15] but at some instance it remains as void creating a secondary porosity in the rock (Fig. 7d). This process is very good for developing a good reservoir potential.

Fracturing

Fracturing is also a diagenetic process that occurred mainly due to secondary porosity and permeability usually attributed to deformational fractures in carbonates rocks. The fractures system occurs in the carbonate rocks at various stages of sedimentation and diagenesis. Overburden and lithification are the main causes of developing fracturing in the Kingriali Formation (Fig. 7e, f).

Depositional Model

Different points of views[17-19] have been presented regarding origin and formation of dolomite. Strakhov[17] and Chilingar[18] believed that high concentration of carbon dioxide in the atmosphere during the Precambrian and the Phanerozoic that caused high concentrations of Ca^{2+} and Mg^{2+} in sea water. Consequently, direct precipitation of dolomite occurred in sea water. However, the dolomite has not been formed at surface temperature during the modern environment. Therefore, most of the geologists believe that dolomite is of diagenetic origin.

The depositional model of the Kingriali Formation has been identified on the bases of field and petrographic analysis (Fig. 8). Field observations show the sandy dolomite and dolomitic limestone are present in both sections that indicate intertidal, and subtidal to intertidal zone of peritidal setting of these facies, respectively. Presence of black and green shale indicates anoxic conditions which represent the deposition in sublittoral zone (Fig. 8). Bioturbated dolomitic limestone only present in the Chunda section that depict the marginal marine environment. The petrographic studies represent the replacive dolomites in the Kingriali Formaion that deposited in intertidal to subtidal zones showing xenotopic fabric where sulfate ions react with calcium ions to form gypsum and magnesium ions leading to increase in the fluid that make replacive dolomites of the Kingriali Formation. The sand influx indicates that the dolomites have been deposited in the tidal channels while large dolomite crystals represent the recrystallization of the early formed crystals during burial[20].

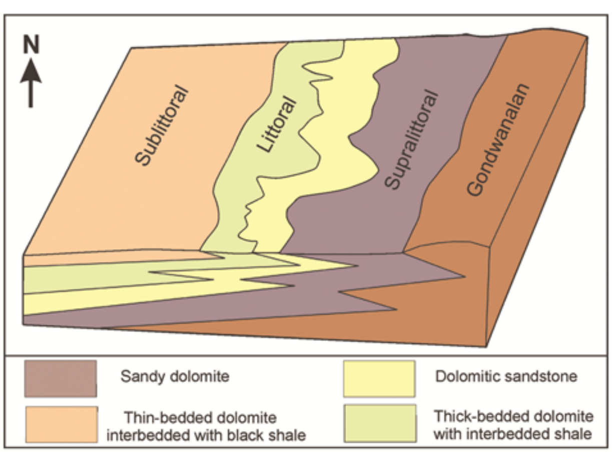

Fig. 8 — Schematic depositional model of the Late Triassic Kingriali Formation based on various lithostratigraphic units and their sub-depositional settings.

The diagenetic characteristics of the Kingriali Formation make it vital in exploration industry. Although due to stylolitization, the reservoir characteristics of the Kingriali Formation has been badly affected but dedolomitization, dissolution and fracturing are the process which are combined together to develop the secondary porosity in the formation. These processes produce voids in the rock (Fig. 7) making the visual porosity higher than the normal. So percentage of the visual porosity observed during microscopic petrography is about 6-8 %. Because of this visual porosity, the Kingriali Formation is reflected as a good reservoir rock.

Conclusions

The field work and petrographic analyses of the Late Triassic Kingriali Formation Khisor-Marwat ranges, Pakistan from the Chunda and Paniala sections indicate its deposition marine and meteoric water. Most of the lithofacies deposited in peritidal channels to supratidal zone of peritidal environment. Petrographic studies of the microfacies depict the shallow burial condition of the Kingriali dolomite. Furthermore, petrographic studies of the Kingriali Formation suggests the characteristics diagenetic features are dedolomitization, stylolitization, dissolution, and fracturing indicate a significant candidate for hydrocarbon potential.

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Conflict of Interest

There is no conflict of interest among the authors.

Author contributions

All the authors have actively involved in this manuscript. SG and AA proposed the main concept of the manuscript. MR and TZ involved in write up and prepared the lithological logs and depositional model on the CorelDraw. SG and MR reviewed the manuscript and replied to the reviewers comments.

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