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Microfacies Analysis and Depositional Environment of Middle Jurassic Samana Suk Formation, Chichali Nala Section, Surghar Range, Pakistan.

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Abstract: The Middle Jurassic age Samana Suk Formation, exposed in Chichali Nala section of Surghar ranges has been investigated by field work, petrographic study and XRD analysis to understand the microfacies, depositional environment and fault related dolomitization of the Samana Suk Formation. This formation is widely distributed in the upper Indus basin of Pakistan and considered the most prominent stratigraphic unit of the Jurassic period. The project area lies in the Chichali Nala Section of Surghar range (Trans Indus Salt Ranges). In this section, Samana Suk Formation constitutes the lithology of carbonate having $CaCo_3$ as a major mineral, where dolomite is present in minor amount, which is restricted to fluids along fault zone. During the study two major microfacies have been identified including the Grainstone microfacies and Mudstone-Wackestone microfacies. Samana Suk. Formation was formed under stormy influence in the environment of deposition of Formation. Its depositional environment is the inner-middle shelf which suggests the marine shelf depositional environment.

Keywords: Samana Suk Formation, diagenesis, microfacies, XRD, dolomitization.

Introduction

The term microfacies in sedimentary rocks refers to all the sedimentological and paleontological standards which can be characterized and categorized within thin section (Flugel, 2004). The sedimentary rocks deposited in widespread depositional setting, which include the marine transitional, shallow marine to deep marine with slope and reef, and lacustrine environments. There are some factors which control these environments and determine the thickness, distribution, and nature of rocks with compositional variations. The controlling factors for the compositional variations of carbonate rocks include energy, salinity, water depth, light, temperature, and clastic input with organic production. In the origin of carbonate rocks, organisms plays a vital role. Each depositional environment has certain chemical, physical, and biological features which are replicated in the form of carbonate rock type or in its facies association. Microfacies analysis play an important role to understand the environment of deposition based on field observation, textural and faunal parameters. Flügel (1985), have given several criteria for the analysis of microfacies. The Samana Suk Formation forms an essential part of Mesozoic strata of the TIS (Trans Indus range), CIS (Cis Indus Salt range), Samana range, Hazara-Hill range, Kohat Tribal range and Kala Chitta range. The Samana Suk Formation is interrelated with Chilton Formation of Lower Indus basin (Nizami and Sheikh, 2007). In the Surghar range the Samana Suk Formation constitutes the dominant lithologic entity which is best exposed in Chichali Nala section. The current study area of Chichali Nala is located in the vicinity of Chapri village in Mianwali district. It lies within latitude (32° 30' 00" to 33° 00' 01" N) and longitude (71° 05' 00" to 71° 46' 00" E). Chichali Nala section is easily accessible with metaled road.

Geology of the Area

The study area lies in the Surghar range which is the part of Trans Indus Salt range. The Trans Indus Salt range characterizes the prominent deformational front of Kohat fold and Thrust belt in north Pakistan. (Sajjad and Khan 2005). The structural and stratigraphic set up of Trans Indus range and Salt range has been extensively studied by various workers (Gee, 1989; Abbasi, and McElroy, 1991; Danilchik, 1961). The geology of Surghar range has been comprehensively studied by (Danilchik and Shah, 1987). Whereas Chichali pass has been mapped by (Meissner et al., 1974). The Surghar fault is south verging thrust fault in the forelimb of Surghar anticline. The rocks from Precambrian to Recent are well exposed in the study area. The Samana Formation in the study area mainly comprises of limestone, dolomites and dolomitic limestone with interbedded marls. The limestone is thin to medium and thick bedded, which are mostly compact, hard, dark and grey in color. Oolitic limestone bed is also present in the Chichali Nala section (Fig 2D). Samana Suk Formation exposed in Chichali section has a lower transitional contact with the Shinawri Formation and disconformable upper contact with the Chichali Formation.

Materials and Methods

Present study is based on the field observations and photographs, section measurements, petrography and XRD analysis.

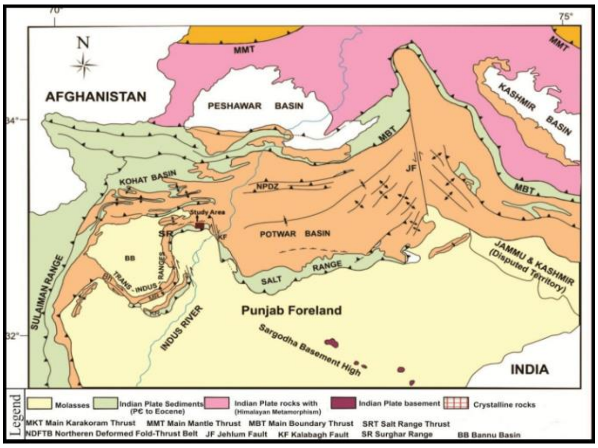

Fig. 1 Generalized geological map of the NW Himalayan foreland fold and thrust belt (modified after Kazmi and Rana, 1982; Lillie et al., 1987; Yeats and Lawrence, 1984 and Coward et al., 1986). Inset shows the location of the study area.

Results and Discussion

Based on the Dunham classification (1962) the microfacies of Samana Suk Formation have been carried out. The detailed petrography marked the two major microfacies in the current study, i.e Grainstone microfacies and mudstone microfacies which are further divided into the sub microfacies. The detailed microfacies have been compared with the Standard Microfacies of Flugel (1982) and Wilson (1975).

Field Observations

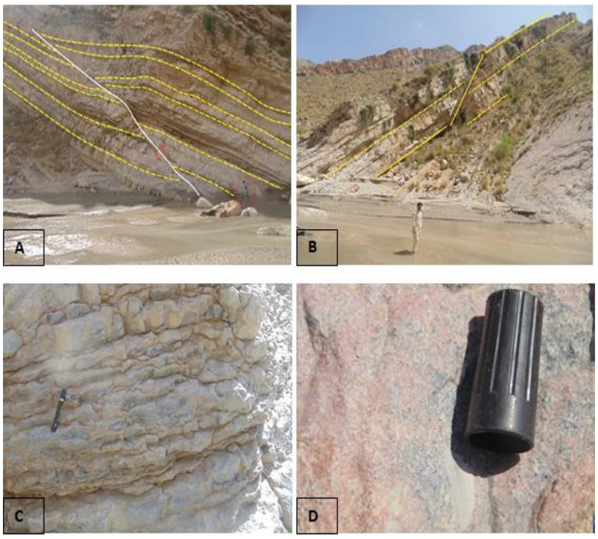

Fig. 2 A. Showing the Strike slip faulting with in the Samana Suk Formation. B. Thrust Faulting with in the Samana Suk Formation. C. Thin to medium bedded limestone of Samana Suk Formation. D. Oolitic Limestone of Samana Suk Formation.

Grainstone Microfacies

SMF-1 Skeletal/Algal Grainstone sub microfacies

This microfacies comprises of 67% bioclasts, and the remaining 33% are the cement spars. Bioclast of this microfacies mostly contains algae, gastropods, echinoids and the bivalve fragments. The algae found in this microfacies are the dasycladacean type. The abundant bioclast of this sub microfacies indicates the highly agitated environment which shows that this submicrofacies was deposited in the inner shelf environment (Plate 1).

SMF-1 Ooidal grainstone submicrofacies

This sub microfacies is composed of the 72% grains and the remaining are the cement spars. The grains are mostly composed of the ooids, pelloids and bioclast fragments. This sub microfacies represents an agitated environment which removes mud from the intervening pore space during deposition. The ooids present suggest that it is deposited in the shoals and beach environments. The stretched ooids shows the tectonic activities (Plate 2).

SMF-1 Peloidal grainstone submicrofacies

The 80% grains of this sub microfacies are composed of the pelloids and bioclast fragments, while the remaining 20% are cement spar. Besides the bioclast comprises the bivalves and gastropod fragments but some clasts are micritized. The micritization of the peloidal grains shows a lagoonal beach environment. This microfacies also represents the agitated environments (Plate 3).

SMF-1 Dolomitized Pelloidal Grainstone

This microfacies is composed of 60% grains, and the remaining is the cement (spar). The grains are mostly composed of pelloids. The dolomitization took place along these pelloids. The dolomite formed is fabric selective and fine grained (Plate 4). The coated grains were formed earlier and later selective dolomitization occurred during digenetic history through replacement phenomenon. The spar shows high energy agitated depositional condition.

Mudstone-Wackestone Microfacies

SMF-2 Peloidal mudstone-Wackestone

The peloidal mudstone-Wackestone sub microfacies comprises of 80% matrix and 20% bioclastic and peloidal grains. The bioclasts have the brachiopod fragments and the rest are pelloids. The matrix of this facies is lime mud which is dull in color and is fine grained (Plate 5). This microfacies has been interpreted in the environment which seems to have been deposited the hypersaline condition due to less diverse biota. The environment is interpreted as sub tidal lagoon with less current and waves circulation.

SMF-2 Bioclastic Mudstone-Wackestone sub

This sub-microfacies is also composed of 70% matrix of lime mud and 30% grains. The grains involve bioclasts and pelloids. The bioclast are brachiopod shell fragments, which are broken, and the pelloid are rounded in shape. The matrix is fine grained showing dull appearance (Plate 6). This sub-microfacies has bioclast fragments which are surrounded in micritic matrix the sub tidal inner shelf environment. Mostly the mixing of the fauna suggests the stormy condition on the shelf.

Plate 1

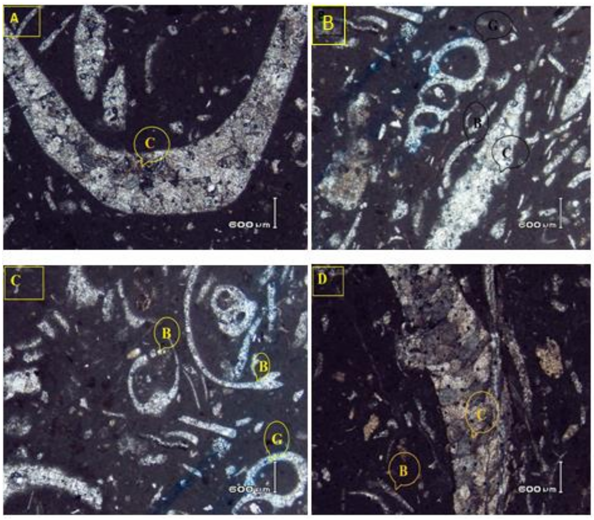

Plate 1. Photo micrograph shows the algal/skeletal grainstone microfacies. Fig A = Calcite vien, Fig. B = C (calcite) and G (gastropod). Fig C = B (bivalve), and G = gastropod. Fig D, showing B (bivalves) and C(calcite).

Plate: 2

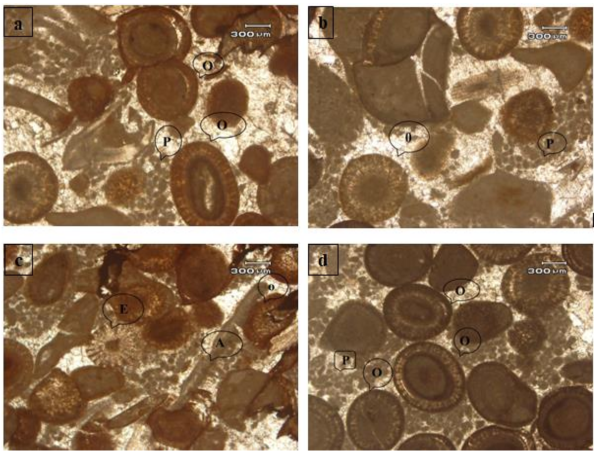

Plate 2. Photo micrograph shows the ooidal grainstone microfacies, concentric and stretched ooids are present. Fig a, showing the O (ooids) P (Pelloids). Fig b, showing the O (ooids) and P (pelloids). Fig c, showing E (echinoid) A (algae). Fig d, Showing O (ooids), and P (pelloids).

Plate 3

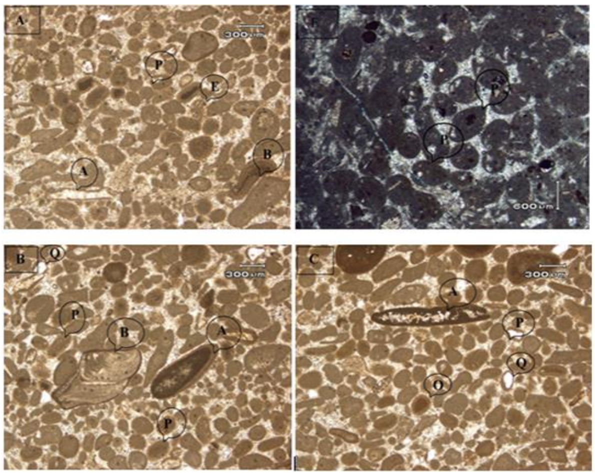

Plate 3. Showing the pelloidal grainstone microfacies. Fig A, showing the A (algae), B (bivalve fragment), P (pelloids) and E (echinoid). Fig B showing the P (pelloids). Fig C and D showing B (bivalves) and A (algae).

Plate = 4

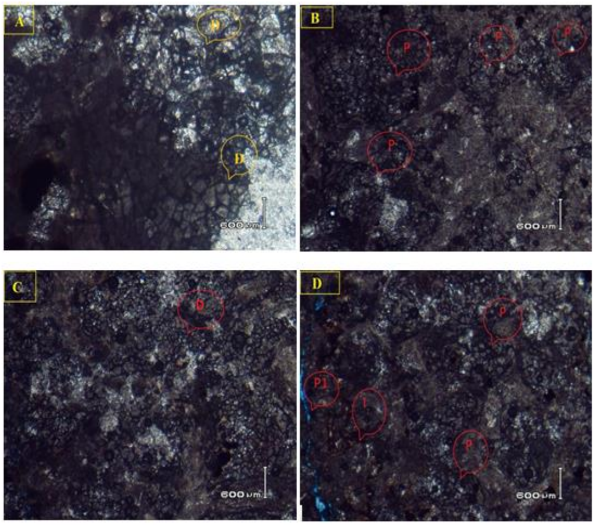

Plate 4. Photo micrograph shows dolomitized pelloidal grainstone microfacies. Fig A, showing the D (dolomite). Fig B, showing P= pelloids having dolomites. Fig C, showing the D (dolomites). Fig D, showing the P1= porosity.

Plate 5

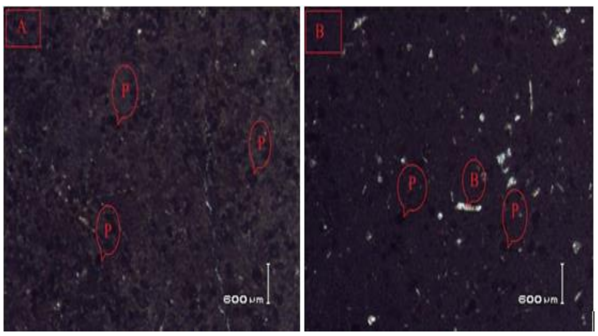

Plate 5 (Fig. A and B). Shows the pelloidal mudstone to wackstone microfacies. P= pelloids, B= bioclast fragment.

Plate 6

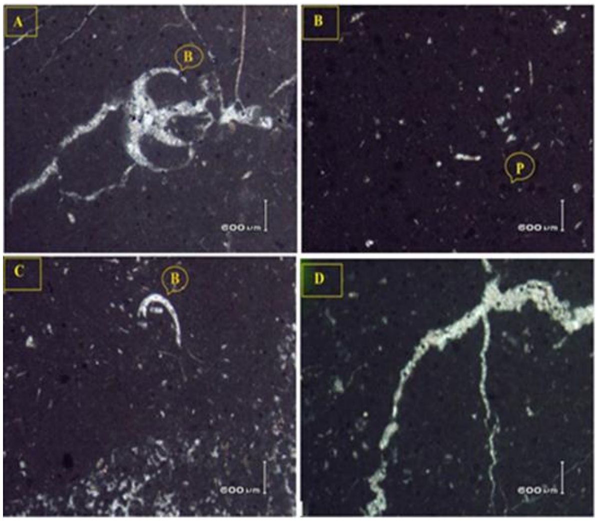

Plate 6. (Fig A, B, C, D) shows the bioclastic mudstone to wackstone microfacies= pelloid, B= Brachipod.

Depositional Environment

In the carbonate settings, local deviations in topography, water depth, salinity, temperature and energy condition are liable for microfacies variations (Wilson, 1975). The Grainstone microfacies of the studied carbonate strata represent the near shore, high energy, and shallow water bar, beach and shoal environments. The Wackestone microfacies of this formation represents inner shelf environment below fair weather wave base. The highly bioclast fragments of Grainstone and Wackestone microfacies of this formation represents stormy influence in the environment of deposition. Based on flora, fauna and physical factors the overall environment of deposition of the Samana Suk Formation in Surghar range is perceived to be inner to middle shelf environment (Fig. 3).

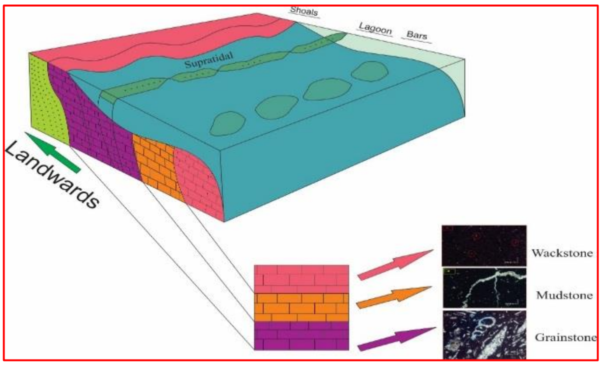

Fig. 3 Depositional model of Samana Suk Formation.

XRD Results

XRD is most broadly applied to explain the existence of minerals and mineral proportions, composition of minerals and mineralogical structures of rocks, soils and sediments. Tables 1,2 values in terms of d_{104} and $CaCo_3$ were used to interpret various XRD graphs of the selected samples. Each graph has its concentration intensity value plotted on y-axis and the value of 2θ on x-axis. Maximum peak values range up to d_{104} and give the molar concentration by Lumsden Equation. The molar concentration of $CaCo_3$ was formulated from the Lumsden Equation. (Lumsden, 1979). The result of the overall selected samples with peak ratios is given in Figure 4.

Graphs detail

Table 1. Mole concentration of $CaCO_3$ by using the Lumsden equation.

Sample No	d_{104}	$CaCo_3$%
SSS#5	3.035	99.66%
SSS#9	3.025	96.34%
SSS#11	3.041	100%
SSS#13	3.025	99.66%
SSS#14	3.025	99.66%
SSS#16	3.025	99.66%

Table 2. Sample data with matched PDF data.

SAMPLE	Sample SS5		Sample SS9		Sample SS11		Sample SS13		Sample SS14		Sample SS16		Pdf#3-593		Pdf4-637	
No	d-valves	I/I_0	d-valves	I/I_0	d-valves	I/I_0	d-valves	I/I_0	d-valves	I/I_0	d-valves	I/I_0	d-valves	I/I_0	d-valves	I/I_0
1	3.864	17	3.839	31	3.872	31	3.839	29	3.839	26	3.839	26			3.86	60
2	3.361	22	3.355	35	3.367	33	3.348	31	3.355	29	3.342	30	3.32	100		
3	3.035	100	3.025	100	3.041	100	3.025	100	3.025	100	3.025	100			3.04	100
4	2.493	18	2.489	35	2.493	33	2.486	31	2.489	30	2.486	32	2.44	40	2.49	60
5	2.285	20	2.279	36	2.285	36	2.27	35	2.289	32	2.274	36	2.27	40		
6	2.095	19	2.08	35	2.095	35	2.086	34	2.09	32	2.088	34				
7	1.909	21	1.909	36	1.914	36	2.907	34	1.907	32	1.905	37	1.97	30	1.91	
8	1.874	20	1.872	37	1.875	35	1.87	36	1.87	32	1.868	38	1.84	10		
9			1.6	32	1.52	33	1.6	31	1.599	27	1.599	32	1.6	10	1.6	60
10			1.438	30	1.438	33	1.438	29	1.522	26	1.517	32			1.43	60

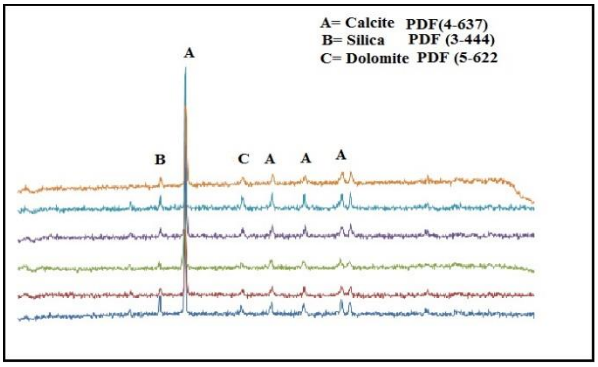

Fig. 4 Combined XRD pattern of the selected samples from Samana Suk Formation having the major phase of calcite (A), SiO_2 (B) and minor phase of dolomite (C) poorly developed.

The present study focuses on the microfacies and geochemical analyses to know the behavior of fluids related to the faults which causes dolomitization within the Samana Suk Formation. Based on the microfacies analysis the Samana Suk Formation is exposed in Chichali Nala section. X-Ray Diffraction analysis of the selected samples affected by the dolomitizing fluids show major and minor peaks, indicating that these samples are mainly composed of the $CaCO_3$ which marks the highest peak in the graphs. Silica has been identified which forms minor peaks. The XRD analysis shows that the dolomite crystals are rarely developed and show the minor peaks in graphs (Fig. 4). The present study suggests that Samana Suk Formation exposed in Chichali Nala section mainly composed of the $CaCO_3$ and the dolomitization has taken place along the fractures and faults plane (Fig. 2).

Conclusion

The Jurassic Samana Suk Formation exposed in Chichali Nala section of Trans Indus range is predominantly comprised of fine-coarse grained compacted limestone and dolomitic limestone. The microfacies have been identified which are mostly Grainstone microfacies and mudstone to Wackestone microfacies. Microfacies analysis of Samana Suk Formation has been placed in the inner-middle shelf carbonate environment under open marine and restricted marine conditions. In the Chichali Nala section the Samana Suk Formation has been dissected by two Intraformational thrust faults which provide the migration pathways for fluids responsible for the dolomitization of limestone beds.

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