



Geological and Stratigraphical Studies of Dimension and Cut Stone Deposits Around Khanu Brohi and Khadhar Areas, District Jamshoro, Sindh. Pakistan

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Abstract: The Geological and stratigraphical studies belonging to Ranikot Group and Laki Formation, ranging in age from upper Paleocene (Lakhra Formation) to Early-Middle Eocene (Meting limestone) of Laki Formation, have been carried out with special reference to Dimension and Cutstone potential of the lower Tertiary rocks exposed in Khanu Brohi and Khadhar areas of Jamshoro district. These rocks are of mixed Lithology of detritus and non-detritus rocks. Three undisturbed sections from the studied areas were selected for detailed studies, section measurement and correlation of Dimension and cut stone quality rocks. The Dimension and cut stone quality limestone occur in Lakhra Formation. It is very hard, thick to massive bedded showing sugary texture and its color varies from orange yellow to pinkish yellow. It is of Medium quality. This limestone bed plays an important marker bed in distinguishing Paleocene and Eocene boundary of the area.

Lithofacies variation among the sections has been studied and possible divisions of various facies have also been made. The quality of the rocks for Dimension and Cutstone for their economic use is discussed. On the basis of hardness and chemical composition the limestones are classified into different classes for their valuable use in decoration and construction. In addition to that structure, joint pattern, faults, tectonics and economical importance of the studied area is also discussed.

Keywords: Geological, Stratigraphical, Dimension, Cutstone, Economical, Tertiary rocks

1. INTRODUCTION

The studied area where the Dimension and Cut stone are exposed is located about 16 km in the southwest of University of Sindh, Jamshoro and 11 km in the west of Liaquat University of Medical and Health sciences, Jamshoro. The area of study is easily accessible and lies in the toposheet No. 40 C/3 in between Latitude: 25°, 25', 24" N to 25°, 26'.06" and Longitude: 68°, 09' 10" E to 68°, 11', 05" E (Fig. 1)

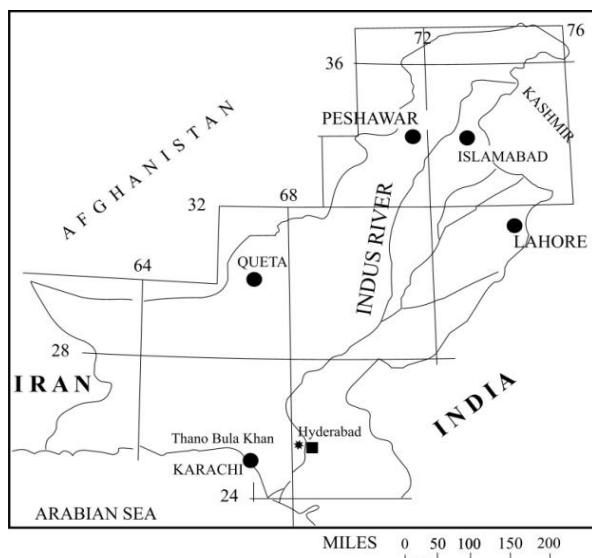


Fig. 1. Index map of Pakistan showing the studied area

The main purpose of this work was to carry out the research focusing on the Dimension and Cut stone

deposits. For this purpose, geological mapping on 1: 50,000 to 1:20,000 scale was carried out. In order to describe the detailed lithofacies variation undisturbed and ideal sections exposed in the Northwest and Southwest of Khanu Brohi were chosen for lithological description. Besides, the structure, tectonics and economic importance of the area were also studied. The ages to the formation were assigned from the fossils record of Hunting Survey Corporation (HSC 1961). The pioneer geological work regarding this area is that of HSC (1961), but the study on Dimension and Cut stone is carried out for the first time in this area.

Geological setting

Geologically, the area consists of two formations belonging to Lakhra Formation of (Paleocene age) and is top of the Ranikot Group which consists of Khadro, Bara and Lakhra Formations. Whereas the Laki Formation is of (Eocene age) and consists of Sohnari and Meting limestone members. On the basis of lithological variations the Lakhra Formation has been redefined and is subdivided into Lower, Middle and Upper members consisting of different units, while the Laki Formation has also been divided into six units.

2. MATERIALS AND METHODS

The mapping was carried out on topographic map at scale 1:50,000 and 1:20,000 for showing the dimension and cut stones exposed in the research area. For marking the contacts and sample horizons direct use

of GPS was applied. Finally, the map was digitized (Fig.7). The section measurement was carried out by three methods; Jacob's staff method, slope distance method and direct methods which were used specially for measuring a few centimeter thin layers where ever necessary. To get the maximum thickness for preparing the columnar lithological logs, sometimes offsets for completing the section, were used during the section measurements. The samples were collected from different facies of the limestone at an interval of 5 to 25 feet for further Geochemical analysis. The Geochemical analysis from some selected limestone samples of Lakhra Formation were carried by XRF technique.

The Indian plate after separating from the African plate during Jurassic–early cretaceous started moving in the northeast direction and collided with Eurasian plate in Paleocene–early Eocene, (Powell, 1979). Pakistan comprises of two sedimentary basins, the Indus basin and Balochistan basin, these two basins are separated by a major fractured zone (axial belt), collectively occupying an area of about 8, 28,000 sq. Km (Shah 1977). The Indus basin is divided into large longitudinal oriented parallel tectonic features, which are further subdivided by sub–longitudinal basement highs and transverse uplift into smaller tectonic zones. (Fig.3).

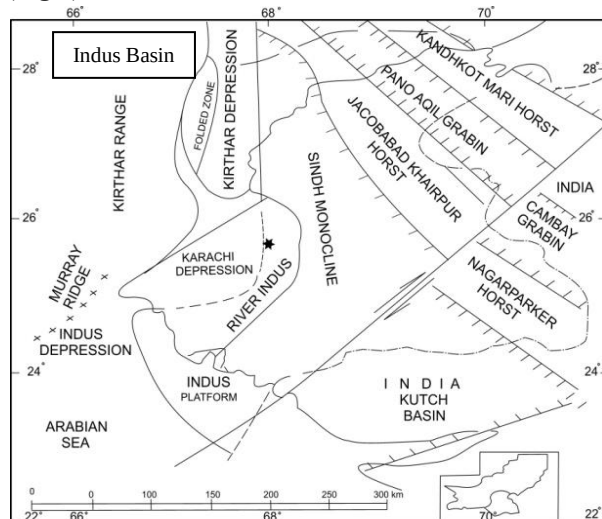


Fig. 3. Tectonic map of Lower Indus Basin showing the studied area (after Raza *et al.* 1990)

The main tectonic features of the Indus basin are the platform, the foredeep, comprising depression an inner fold zone. The platform known as Indian platform coincided with the present Indus plain and is subdivided into Punjab monocline, Sukkur rift zone and Sindhi monocline. The Lower Indus basin includes the Sukkur rift zone, Thar platform, Karachi trough, Kirthar fore deep, Kirthar fold belt and off shore Indus. (Raza *et al.*,

1990). During the Paleocene-Pliocene times, Himalayan orogeny took place by continent to continent collision, between Indian and Eurasian plates which gave rise to the tectonic pulses, generating compressional forces in northeastern direction, which folded the sedimentary layers and gave rise to the Ranikot Group, Laki and Kirthar Ranges together with major anticlinal, synclinal and fault structures in Sindh. The tectonic structures of studied area most probably were formed during the Paleocene-Pliocene times of the Himalayan Orogeny. The studied area is a part of Laki Range representing one major fault in the Lakhra Formation which is a thrust fault and is associated with other minor faults. The other faults are strike slip faults which are mostly present in the limestone of the Lakhra Formation. The area of research also displays joints of different types which are noted as oblique, square, parallel and horizontal joints.

Lakhra Formation:

The name Lakhra Formation for the first time was proposed by Ahmed and Ghani (1971), after Lakhra Laki range, for the “Upper Ranikot (limestone)” of Vredenburg (1906) and “upper Ranikot” of later workers. This formation also represent the “upper Ranikot formation” and upper parts of the “Bad Kachu”, “Rattaro” and “Thar” formations and lower part of the “Jakker Group” of HSC (1961). The formation is widely disturbed in the Kirthar province and in the axial belt. It is 242 m thick at the type section, 135 m at the northern flank of the Lakhra anticline and 50 m at the Bara nai. The formation is unconformably overlain by the Laki formation in the axial belt while its upper contact is conformable and transitional with overlying Nissai formation. On the basis of faunal study late Paleocene age is assigned to the formation. Khan (Lexique, 1956, Davies, 1927; Nuttall 1931, Duncan, 1880, Vredenburg, 1909, 1928, Duncan and Sladen, 1882 and Iqbal, 1972). In the studied area the Lakhra formation is divisible in three members, consisting of 18 units which include different types of shale and limestone in the north west of Khanu Brohi. mostly, the Limestone marked as Dimension stone is exposed in Lakhra Formation which is very hard, thick to massive bedded showing sugary texture and its color varies from orange yellow to pinkish yellow and is of medium quality. The lower contact of Lakhra Formation at the studied area is not exposed and is supposed to be conformable with Bara Formation in the sub-surface while its upper contact is conformable with Sohnari member of laki formation.

Laki Formation:

The term “Laki series” was proposed by (Noetting 1903) for the lower part of Blanford’s “Kirthar Series” (1876). Later (HSC, 1961) redefined the unit as “Laki group” It is named as Laki

Formation which also represent the “Sui main Limestone” of (Tainsh *et al.* 1959) and the “Tiyon formation” of (HSC, 1961). In parts of the Khirthar province, two distinct members are identified in the lower part of the formation. The basal member here named as Sonhari member, after Sonhari south of the Meting which represent “Basal Laki laterite” of (Nuttall, 1925). The Sonhari member, which overlies Ranikot group, is itself overlain by the “meting Shale and Limestone” of (Vredenburg, 1906) which are here formally named meting limestone and Shale member. Mari Nai (lat: 26° 06' N: long 67° 51' E) south west, of Bara nai of the northern Laki range, is here designated as the type section of the formation. A section exposed about 5km south-west of the Meting (lat: 25° 12' N: long: 68° 10' E) is designated as the type section of the Sohnari member and meting limestone and shale member.

In the studied area its lower contact is conformable with Lakhra Formation while its upper contact is Erosional. In the studied area the Laki Formation consists of shale and nodular limestone with full of larger Forams mostly *Alveolinia spp.* and other Mollusks in this area the two members (Sonhari shale and Meting limestone) of Laki Formation are well exposed. These members of the Laki Formation are of Lower Eocene age. The upper contact of the members is conformable with each other while their lower contact with Lakhra is also conformable.

Sohnari Member:

The Sohnari Member consists of multi coloured laeritic clay and shale with locally developed beds of yellow arenaceous limestone, pockets of limonite or ochre and lignite seams. Lenticular beds of variegated, ferrogenous sandstone and white calcareous are common in the member. In the studied area the Sohnari member consists of reddish brown to dark brown loose shale with common occurrence of iron concretions, towards the top of the member shale becomes blackish brown to khaki in colour. On the whole the shale is loose and micro jointed.

Meting limestone: In the studied area it consists of thinly bedded limestone in the basal part and its upper part is totally nodular. The nodules are soft and full of larger Forams and it also contains Gastropods, Bivalves and Echinoderms. The individual measured sections from different localities of the studied area are described as under:

Lithological Description of the studied sections

North West of Khanu Brohi section

(Lat: 25°, 25', 32" N long: 68°, 10', 50" E)

This section on the basis of lithological variations has been divided into three, Lower, Middle

and Upper members which are further subdivided in units. The lower member consists of 1-8 units, the middle member consists of 9-16 units while the upper member is from 16-24 which are shown in the columnar section, and are discussed as under

Lower Member: It consists of alternate beds of shale and limestone where the percentage of shale facies is greater than limestone. In the lower part the shale is maroon to brown in color and weathers almost in brown colour. It is loose, gypsiferous and iron concretions are commonly found. But in the middle part the shale becomes reddish brown to brick red in color and weathers into khaki yellow, this shale is fossiliferous, loose, flakey and gypsiferous and is rich in iron concretions and oxidized clay balls while shale of upper part of the member is orange yellow and weathers into grey to yellowish grey. It is loose, calcareous and contains calcite veins and gypsum bands. The total thickness of shale is 40 feet. The limestone of this member shows different type of limestone in its basal part. It is yellowish buff in color and weathers into dark grey color. It is thick bedded, blocky, hard. It is compacted and contains larger forams and mollusks shell. It is highly jointed and is of medium quality for cut stone.

Middle member: It consists of interbedded limestone and shale and limestone facies is dominant. The limestone is dominant in the lower part whereas the shale is more in the upper part. The limestone is yellow in color and weathers into grey color. Iron concretion and Chemical weathering showing small cavities are commonly present. The fractured zones of limestone of are filled with secondary calcite veins. It is medium to thick bedded, jointed, highly fractured and breaks into large blocks. The limestone in the middle part is highly fossiliferous mainly full of larger forams and is of poor to medium quality for cut stone. The limestone of the upper part of this member is orange yellow in color and weathers into buff grey to dirty grey and is rough surfaced. It is gritty and is not much compacted. It is highly fractured and jointed.

Upper Member: This member mainly consists of shale and some limestone beds are interbedded with it. The shale is Khaki to maroon and weathers into yellowish brown color. It is loose and gypsiferous. Iron concretions are common these may be driven from the overlying Sonhari Member of Laki Formation. At the top of the basal part of this shale a limestone bed of medium quality for Dimension stone is exposed and is a marker bed in between Lakhra (Paleocene) and Sohnari (Eocene). This limestone is orange yellow to brownish yellow and weathers into yellowish orange to Yellowish maroon in color in places it is

pinkish yellow. It is massive and thick bedded, very hard well compacted and gives sugary texture and is jointed. The rest of the part this member belongs to Sohnari shale which is dark maroon to reddish brown in color and weathers into dark brown. It is loose and commonly shows brick red colour. Further the shale is underlain by the Meting limestone of Laki Formation

which is yellow in color and weathers into buff yellow. It is thinly bedded and is highly fossiliferous, mostly full of larger forams. The top of the limestone is grey to off white in color and weathers into dark grey. It is shelly and nodular. It is full of larger forams, mollusks shells and echinoids.



Fig. 4. Columnar section of Lakhra and Laki Formations in the west of Khanu Brohi

Rahim Dino Section

(Lat: 25°, 25', 06" N log : 68°, 10', 13" E)

On the basis of lithology this section is also divided into three members, lower, middle and upper.

Lower Member: This mainly consists of Limestone which is camel color and weathers into dark brown. It is of poor quality for cut stone. This lime stone is overlain by another limestone which is camel colored and weathers into grey. It is hard and thick bedded with worm burrows. It is of moderate quality for cut stone. Following this limestone there is another bed of limestone which is yellowish buff in color and weathers into orange yellow. In some places its color is pinkish yellow. It is hard and is highly jointed of rectangular, vertical, horizontal and oblique type of joints. The top of the unit is of medium quality of Dimension stone.

Middle Member: It only consists of shale of Sohnari Member. The Shale is maroon in color and weathers into grey. It is loose, iron concretions are common. This unit consists of shale which is dark brown in color and weathers into reddish brown in its basal part but in upper part it is orange yellow to brownish yellow in color and weathers into dark brown in color. It is loose and flakey.

Upper Member: This member consists of shale interbedded with limestone, the limestone is reddish brown to pinkish brown and weathers into dark brown in color. It is thinly bedded, highly fractured and jointed. It is of poor quality of cut stone. The Shale is whitish yellow in color and weathers into dark yellow containing gypsum and is overlain by the Meting limestone.

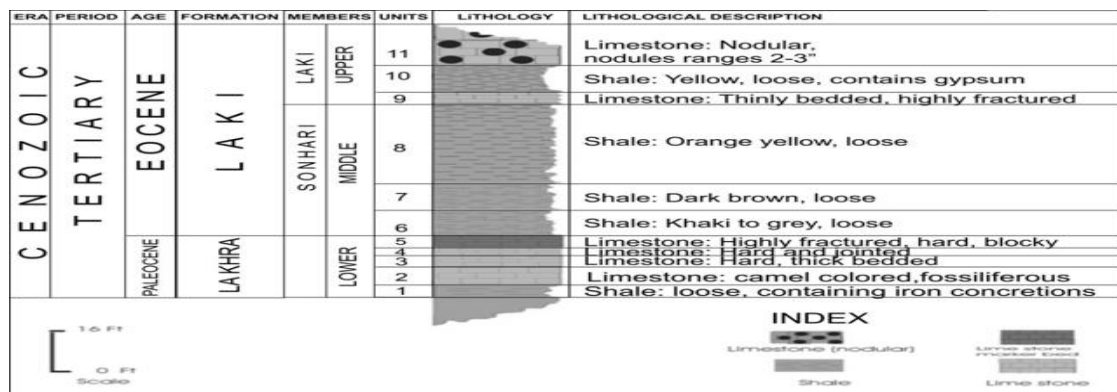


Fig. 5. Columnar section of Lakhra and Laki Formations at Rahim Dino

West of Khanu Brohi Section

(Lat: 25° 25' 02" N log: 68° 10' 09" E)

This section on the basis of lithological variations has been divided into three members and 10 units out of these 1-4 belongs to Lakhra Formation and are included in lower member, 5-8 belong to Sohnari Formation of middle member and 9-10 belong to upper member and are of Laki Formation.

Lower Member: This is of alternate shale and limestone. The shale is brown and loose. It weathers yellowish brown. It contains Iron concretions and Gypsum flakes. While the limestone is yellowish grey to orange yellow it is hard well compacted with sugary texture and contains fossils. It is blocky and jointed. This limestone is of Dimension quality.

Middle Member: This member consists of Shale and limestone and belongs to Sohnari Formation: The shale is maroon and weathers into dark brown in color. It is loose and contains iron concretions. The limestone is yellow in color and weathers into dark grey. Gastropods are present. It is used for crushing purpose.

Upper Member: This member is of shale and Limestone of Laki Formation. The shale is khaki to grey in color and dark brown. It is loose and flakey in places while the limestone nodular. It is whitish grey and weathers into dark grey. The nodules are sub rounded to subangular and full of larger Forams and Gastropods.

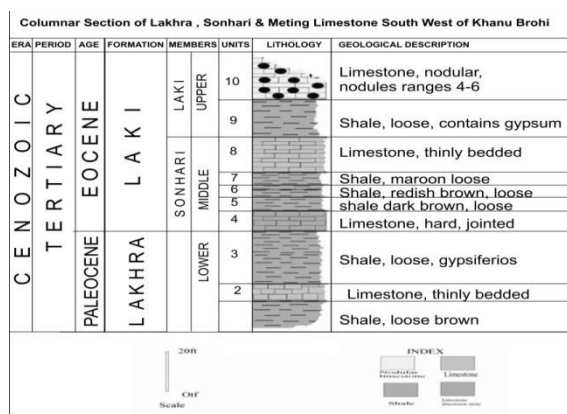


Fig. 6. Columnar section of Lakhra and Laki Formations in the west of Khanu Borhi

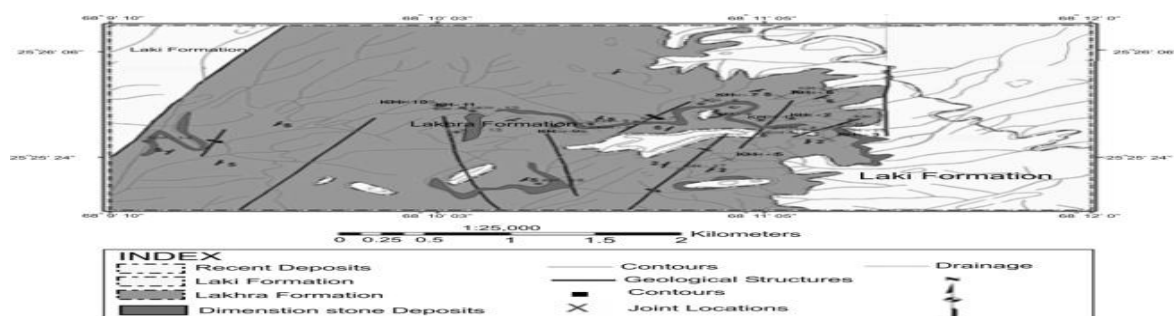


Fig. 7. Showing the Digitized Geological map of the studied area.

3. RESULTS AND DISCUSSION

Structures Of The Area

The area of study had been under the effect of Himalayan orogeny and have produced extensive folding and faulting. The studied area is a part of an anticline named here as Khanu Brohi Anticline and it lies in southern part of famous Lakhra anticline. This anticline is dissected by a main Nala formed along the strike slip Fault. Besides this, there is a major thrust Fault within the Lakhra Formation which is also named as Khanu Brohi Fault. In the eastern side of the Block coal is being drilled from Lakhra formation

Dimension and Cut Stone

Dimension stone: It is a natural stone or rock and is used for different purposes of buildings, Statues and decorations. Igneous, sedimentary and metamorphic rocks or gemstone could be the source material. The principal rock types used for Dimension stone are Granite, Limestone, Sandstone, Marble, Slate, Travertine and Quartzite. Among these Granite, Marble and limestone are the main materials because of their hardness and possessing polishing nature.

Cut stone: It is defined as any stone which is hard, compact and can be trimmed, sawed but cannot be polished and can only be used to make blocks for different purposes of construction. The area where the research work is carried out the rocks are mostly of cut stone quality. However, one bed of limestone at the top of Lakhra formation which is 10 feet thick can be used as Dimension stone.

History: History of dimension and cut stones is as old as the human existence. It was used as hunting and cutting tools. The Egyptian pyramids were built in about 2800 BC, Babylonians used this type of stone in 600BC. Greeks and Romans used these stones in 447BC in the buildings of the past times, they made thousands of various types of statues and dolls from these stones. They also used this type of stone for the ornaments and ammunitions. In the days of Mughal emperors the dimension stones were specially preferred for the construction of Mosques and Tombs. Currently these are used for tiles and decoration pieces of buildings both inside and outside as well.

Table 1. Evaluation of Khadaha Lime stone

Rock type	Geo chemistry	Mineralogy	Geotechnical	Joint Pattern	Estimated Reserves	Use
Limestone (Lakhra Formation)	CaO 55.43-60.43%, MgO 9.33-	Calcite, Dolomite and Ankerite	CS 1332-8804, SG 2.19-2.36, WA. 2.53-8.74	Oblique towards Strike (5-20 ft)	20 million tones	Design Brick and Pitching

CS = Compressive Strength
H = Hardness

SG = Specific Gravity
WA= Water Absorption

4. **CONCLUSION AND RECOMMENDATIONS**

The present research work on the basis of Geochemical and Geotechnical studies has proved that the exposed limestones of the studied area are of good quality either for Dimension or for Cut stones. Based on the faunal study, the age of Lakhra and Laki Formations are from upper Paleocene (Thanitian) and early Eocene (Ypresion) respectively. The lithological and faunal study suggests that the environment of deposition of the area is shallow marine with some fluctuations of the Sea level. The geotechnical study of limestone from different locations in study area also suggests that the limestone has economical value and is important for dimension and cut stones. Specially, 10 feet thick bed of Limestone exposed in Lakhra Formation is of medium quality for dimension stone. The other exposed units of limestone are of medium to low quality and can be used as cut stones. As Pakistan is facing economical crises and the other natural resources are decreasing day by day and the Country is very rich with the occurrence high Mountains and Ranges of all types of Rocks. So it is suggested that these stones may be focused for economical use. And by using proper methods with the collaboration of Local drilling and excavation authorities of particular area where the Dimension and cut stones are exposed.

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