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STRATIGRAPHY OF THE DUNGAN GROUP IN KACH-ZIARAT AREA, N.E. BALOCHISTAN

ALI H. KAZMI

Geological Survey of Pakistan, Quetta

ABSTRACT

A sequence of thick bedded to massive foraminiferal limestone inter-bedded with shale, underlain by argillaceous beds, commonly referred to as "Dungan limestone" or "Dungan Group" and ranging in age from Late Cretaceous to Palaeocene, occurs extensively in the northeastern Balochistan. The lithostratigraphy of this group is fairly consistent in the Harpai, Ziarat and Quetta areas, but changes laterally when traced east and southwest of this region. These variations in its lithology have led to the coining of several formation names within this group by various workers and has caused much confusion. It is, therefore, proposed that the Kach-Ziarat area be taken as the standard area for the Dungan Group because not only these rocks attain their maximum thickness here but are also easily accessible and entire sequence can be seen along a flat nearly horizontal footpath that follows the Anagan Gat nala just south of Ziarat.

The lithostratigraphy and biostratigraphy of the Dungan Group has been studied and traced laterally over a large area. It is proposed that more detailed litho- and bio-stratigraphic studies are needed before a satisfactory division of this group into smaller units (formations and members) can be evolved. Pending such studies it is suggested that the Dungan Group may be considered to comprise essentially two main formations — the Dungan Limestone (Maestrichtian to Palaeocene, at places ranging upto Lower Eocene) and the Bibai Formation (Companian to Maestrichtian). The Dungan Limestone may, however, be further sub-divided into an upper and a lower member.

INTRODUCTION

Thick bedded to massive foraminiferal limestone, interbedded with subordinate shale, was first noted in northeastern Balochistan and described by Griesbach (1881) as "Alveolina Limestone". However, credit must go to Oldham (1890) for correctly reading the stratigraphic position of these rocks and naming these as "Dungan Limestone" after the Dungan hill, 50 km southeast of Harnai, where this limestone forms a large anticline. Oldham's "Dungan Limestone" comprised all the strata lying between two distinct formations, the overlying Ghazij Shale (Eocene) and the underlying Parh Formation (Cretaceous). He described the Dungan Limestone as "compact, bedded, blue or dark grey limestones, generally unfossiliferous in lower portion but upper beds contain numerous fossil....."

Later Oldham (1892) noted that the lower part of the Dungan Limestone abruptly changes from calcareous to argillaceous facies in the Marri area, where the limestone is underlain by 61 m of sandstone and 305 m of shale. According to Oldham these shales yielded *Nummulites,* with Cretaceous echinoids, *Crioceras, Baculites,* and ammonites. Oldham, therefore, correctly assigned a Late Cretaceous to Eocene age to the Dungan Limestone.

The "Dungan Limestone" of Oldham extends over a vast area in northeastern Balochistan and may be identified from near Khuzdar northward to the Bolan Pass and Quetta area, then eastward through the Marri-Bugti and Loralai region all the way upto the Sulaiman Range, extending as far northeast as the Gomal River in Dera Ismail Khan. Since Oldham, many geologists have studied the Dungan Limestone, notably Davies (1941), Eames (1952), Kazmi (1955, 1961), Williams (1959) and Hunting Survey Corporation (HSC) (1960). OLdham (1890) and Davies (1940) proposed Dungan Hill as the type area for the Dungan Limestone. Williams (1959) proposed the Mehrab Tangi Section near Harnai as the type area. Based on the study of stratigraphy of the Dungan Limestone in Ziarat area as well as in other areas, the author herein proposes that the Anagan Gat Section, at Ziarat, should also be considered as an important area for the Dungan Limestone. The details and discussion that follow seek to justify this suggestion.

The author supports the HSC (1960) in naming the Dungan Limestone as the "Dungan Group". Apart from its interesting stratigraphic features, this stratigraphic unit is of considerable interest because it is a potential host rock for hydrocarbons as it contains oil at Khatan (Harnai Valley) and gas it Pirkoh and Sui. East of Quetta there are many structures in which the Dungan Limestone may be containing commercial quantities of oil.

GEOLOGICAL FRAME WORK OF THE KACH-ZIARAT AREA

The Kach-Ziarat area is situated geologically at a very critical location, at the contact of two distinct tectonic zones. South of the east-west trending Ziarat Valley is the autochthonous folded zone which comprises east-west trending simple folds. The northern part of the valley is truncated by an allochthonous zone of nappes and overthrusts (Kazmi, 1955, 1979). This imbricate zone is largely comprised of east-west trending thrust slices of Jurassic to Paleocene rocks, unconformably overlain by Neogene molasse (Fig. 1).

The rock sequence exposed in the Kach-Ziarat area (Table 1) suggests that in the autochthonous zone the Dungan Group overlies a conspicuous laterite bed at the top of the Parh Formation. Whereas in the allochthonous zone it conformably overlies the Bibai Formation (Kazmi, 1979), and apparently unconformably underlies the Ghazij Formation (HSC, 1960). In the autochthonous zone the laterite formed through alteration of the Bibai volcanics. An understanding of the stratigraphy of the Bibai Formation is key to an understanding of the stratigraphy of the Dungan Group, because laterally the Bibai Formation grades into sandstone, shale and marl (Fort Monro Formation of Williams, 1959; Moro Formation of HSC, 1960) or the Pab Sandstone (Vredenburg, 1909; Williams, 1959). A detailed study of the foraminifera of the Parh, Bibai and Dungan Formations (Kazmi, 1955) resulted in establishing their biostratigraphy. The results indicate lateral changes in lithology, whereas the biostratigraphy remains constant and tends to remove some of the confusion that has prevailed concerning the stratigraphy of the Dungan Group. It is hoped that stratigraphy of the Dungan Group of the Kach-Ziarat area, as described in this paper, will help in resolving this issue.

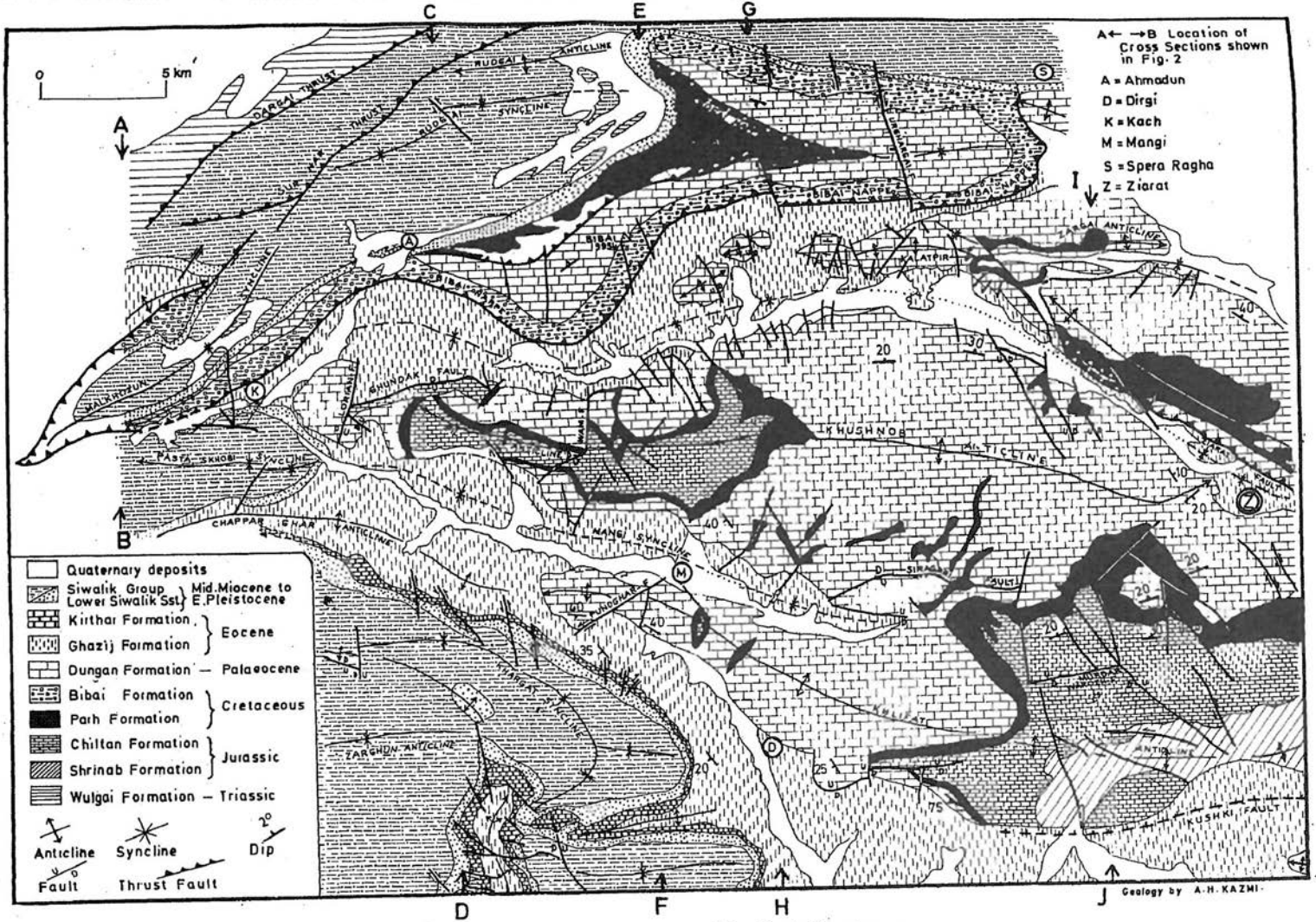

Fig. 1. Geological map of the Kach-Ziarat area.

TABLE 1. STRATIGRAPHIC SEQUENCE IN KACH-ZIARAT AREA

Autochthonous zone	Allochthonous zone	Age
Siwalik Group	Siwalik Group	Mid. Miocene to Pliocene
----------Unconformity----------		
Kirthar Formation	(Missing or as unconformable outliers)	Mid. Eocene
Ghazij Formation	Ghazij Formation	Early Eocene
----------Unconformity----------		
Dungan Group	Dungan Group	Maestrichtian to Palaeocene
Laterite	Bibai Formation	Campanion to Maestrichtian
Parh Formation	Parh Formation	Barremian to Campanian
Sembar Formation	(Thrust)	Neocomian
----------Unconformity----------		
Chiltan Limestone		Mid. Jurassic

DISTRIBUTION AND EXTENT OF THE DUNGAN GROUP IN ZIARAT AREA

The Dungan Group forms anticlinal hill ranges of Nishpa, Ramu, Chappar Ghar, Pil Aghbarg-Khushnob, Kalat Pir and Batsargi. It also caps the Sra Lar and Tsut cuestas, the homoclinal ridge, Les Tsuka, between Kach and Ahmadun and the Saru Ghar-Mazhu Ghar Range. Two small domes of the Dungan Group are seen north of Kahan (Fig. 1).

The Anagan Gat Nala south of Ziarat, leading to the Prospect Point, provides an excellent section across the Dungan Group. An almost level footpath has been excavated in the limestones, above the nala. Along this path one can easily study and sample every bed of this group from top to bottom. It is in fact one of the best sections of this Group and, because of its easy accessibilities, bound to become one of the classical sections for the Dungan Group. The Anagan Gat Section is much thicker and more complete than the Brewery Section near Quetta or sections seen elsewhere. The section seen at Anagan Gat has been summarised in Table 2.

TABLE 2. LITHOSTRATIGRAPHIC UNITS OF THE DUNGAN GROUP IN KACH ZIARAT AREA

Anagan Gat Section		
DUNGAN LIMESTONE — Upper Member		
—	Grey porcellainous limestone	65 m
—	Massive limestone	98 m
	— Lower Member	
—	Rubbly limestone interbedded with shale & sandy beds	109 m
—	Argillaceous limestone and shale	58 m
—	Nodular limestone, dark grey	56 m
BIBAI FORMATION		
—	Carbonaceous shale interbedded with marl. Laterite at base	31 m

The lithostratigraphic units of the Dungan Group, as seen at Anagan Gat Section, extend throughout the Pil Range and the Khushnob Range south of Ziarat valley. Five to seven kilometers northward, north of the Ziarat valley, in the Saru Ghar and Maru Ghar Ranges, the lithostratigraphy of the upper part of the Dungan Group is similar to that of the Anagan Gat Section, whereas there is a significant change in the lithology of the Bibai Formation. In fact, the type area for the Bibai Formation is east of Kach in the Saru Ghar Range (Kazmi, 1955).

Study of the larger foraminifera from Anagan Gat Section indicates definite biostratigraphic zones of the Dungan Group which coincide conveniently with the lithostratigraphic units (Table 3).

The following foraminifera have been identified in the Dungan Group from the Anagan Gat Section.

Orbitoides sp., Omphalocyclus macropora, Lituonella sp., Coskinolina sp., Dictyoconus cf. indicus, Lockhartia Haimei, Lockhartia conditi, Lockhartia cf. newboldi, Kathina sp., Rotalia trochidiformis, Orbitolina cf. discoides, Miscellania miscella, Siderolites sp., Alveolina globosa, Alveolina sp., Flosculina, Nummulites nuttalli, Nummulites thalicus, Nummulites mamilla, Nummulites cf. globosa, Nummulites cf. irregularis, Operculinoides sindensis, Operculina sp., Discocyclina sp., Assilina subspinosa, Assilina cf. dandotica, Assilina granulosa, Saudia sp.

Besides these, the Dungan Group contains mullusc shells, algae, ostracods and abundant micro-foraminifera such as *quinqurloculina, triloculina, pyrgo, nummuloculina, textularia* and some other *lituolids, lagenids* and *buliminids. Ostracods, Lituonella, Coskinolina, Dictyoconus, Kathina, Assilina subspinosa* and *Assilina dandotica* were first recorded from the Dungan Group by Kazmi (1955). Based on the distribution and relative abundance of these foraminifera in the various beds, it is possible to subdivide the Dungan Group in the Anagan Gat section into definite biostratigraphic zones as shown in Table 3.

The lithostratigraphy and biostratigraphy of the Dungan Group from the Ziarat area are described in the following sections.

THE ANAGAN GAT SECTION

Bibai Formation

This formation overlies the laterite, at the top of Cretaceous Parh Group, and consists of thin beds of dark carbonaceous shale which are bituminous at places. These shales locally contain sufficient carbonaceous matter so as to burn easily. Often, they are in the form of paper-thin shales. The surfaces of their cleaved laminae are stained by sulphur or iron oxide due to reduction of pyrite. These beds vary in thickness from a few cm to a meter and are interbedded with thin beds of calcareous mudstone or marl.

In the Anagan Gat section this formation is not well exposed by vintue of being covered with scree, but is best seen just beneath the Prospect Point, where it is thick and well exposed. This formation is exposed in the Pil Aghbarg and Batsargi Ranges and as far as Quetta, where it consists of 2-3 m thick bed of dark carbonaceous mudstone at the base of the massive Dungan Limestone.

In this section, and at other localities south of Ziarat valley, the Bibai Formation constitutes a distinct biostratigraphic zone and contains *Orbitoides, Omphalocudus macropora* and *Siderolites* with abundant small foraminifera. A large fossil assemblage has been collected from the Bibai Formation from Kach. The Bibai Formation overlies Parh Formation, which at the contact contains *Globotruncana lapparenti* and *Globotruncana linnei* (Kazmi, 1955), whereas most of the fossils in the middle or upper part are of Maestrichtian affinity. The age of the Bibai Formation thus ranges from Campanian to Maestrichtian.

DUNGAN LIMESTONE — UPPER MEMBER

Nodular limestone

This unit consists of medium- to thick-bedded limestone with a peculiar rubby appearance. The bedding planes are very uneven, containing even sized, regular lenticular troughs and saddles. The diameter of these lenses may exceed 30 cm. Thin layers of calcareous sandstone commonly alternate with these nodular limestone beds.

Agrillaceous limestone and shale

The nodular limestone grades into this unit, which consists of medium- to thick-bedded, grey, fine-grained limestone. The limestone is argillaceous and platy, breaks up easily along the smooth bedding planes and easily weathers into a chalk-like mass. The limestone is interbedded with calcareous shale, calcareous mudstone, siltstone and arenaceous mudstone–largely composed of calcite grains or the foraminiferal tests.

The nodular limestone and the argillaceous limestone described above together constitute a distinct biostratigraphic zone, i.e. zone with abundant *Lockhartia, Dictyoconus* and *Miscellania.* This zone is 30 to 144 m above the base (laterite) and contains the following foraminifera (Table 3).

Lituonella, Coskinolina, Dictyoconus, Lockhartia haimei, Lockhartia conditi, Lockhartia newboldi, Kathina Sp., Orbitolina cf. *discoidea, Miscellanea miscella, Miscellanea stampi.* Together with these abundant micro-foraminifera, ostracods and algae are also found.

The lower 56 m of this bio-zone contain only *Lituonella, Coskinolina, Dictyoconus, Lockhartia* and *Kathina.* Micro-foraminifera, ostracods and algae are found in great abundance in these beds. *Dictyoconus, Coskinolina* and *Lituonella* are confined to the lower 8 m. Thus it appears that these 56 m strata form a distinct subzone A of Zone 2 and are, therefore, designated as the subzone with *Lockhartia, Kathina* and abundant microforaminifera, ostracods and algae.

Miscellanea appears for the first time in the beds above subzone A and is particularly abundant in beds 87 to 144 m above the base of the Dungan Group. These beds also contain *Lituonella, Coskinolina, Dictyoconus, Lochkhartia, Kathina,* micro-foraminifera, ostracods and algae. Due to the presence of *Miscellanea* in great abundance these beds have been grouped as subzone B, with abundant *Miscellanea.*

Rubbly limestone

The argillaceous limestone grades upward into rubbly limestone with gradual decrease in the argillaceous matter and increase in the calcareous material. This unit consists of almost

TABLE 3: LITHOSTRATIGRAPHIC AND BIOSTRATIGRAPHIC DIVISIONS OF THE DUNGAN GROUP.

LITHOSTRATIGRAPHIC UNITS			BIOSTRATIGRAPHIC ZONES		Fossiliferous Beds (and Sample nos.)	ORBITOIDES	OMPHALOCYLUS MACROPORA	LITUONELLA SP	COSKINOLINA SP	DICTYOCONUS SP	LOCKHARTIA	LOCKHARTIA CONDITI	LOCKHARTIA OF NEWBOLDI	KATHINA SP	ROTALIA SP	ORBITOLINA SP	MISCELLANEA SP	ALVEOLINA GLOBOSA	ALVEOLINA SP	NUMMULITES NUTTALLI	NUMMULITES THALICUS	NUMMULITES MAMILLA	OPERCULINOIDES SINDENSIS	OPERCULINA SP	DISCOCYCLINA SP	ASSILINA SUBSPINOSA	ASSILINA DANDOTICA	NUMMULITES IRREGULARIS	SAUDIA	MILIOLIDS	OSTRACODS	AIGAE
DUNGAN GROUP	BOLAN LIMESTONE	Grey Porcellainous Limestone	5. ZONE WITHOUT FOSSILS		D47																											
					D46																											
					D45																											
		Massive Limestone	4. ZONE WITH NUMMULITES ALVEOLINA OPERCULINA DISCOCYCLINA & ASSILINA	Subzone D	D44																											
					D43																											
					D42															●	●	—			o	X	X	—				
					D41						—				—			—	—	o	—	—		—	o							
					D40								—	—					—	o	—	?	X	—		—						
					D39							—			X		—	—	—	X	—	—		X								
					D38						—	o		—			?	—	—	o	?	—	X	—								
					D37																											
				Subzone C	D36					X	X	X			X		?	—		—		—						—	—			
					D35					X	—	—		—	—			X		—		—							—			
					D34						—					—	?	X		—		?	o						—			
					D33					X	—	—		X		—	?	X		X		X								X		
	DUNGAN LIMESTONE	Rubbly Limestone	3. INTERMEDIATE ZONE WITH ALVEOLINA, N. MAMILLA LOCKHARTIA ROTALIA ETC.		D32																											
					D31			X	?	X	—	—		—	—	—						—							—			
					D30			—		X																				X		
					D29			—		X	X	?	—	—	—														—	X		
					D28					X		?	—	—	—			X				—								X		
					D27						X	X	?	?	?		—													—		
					D26					—	?	?	?	—	X	—														X		
					D25			—		X	X	—	—	—	?	—	?	—												X	X	—
					D24					—		—	?	—		—	?													X		
					D23					X		—	?	—	—	—	?	X												X	X	—
					D22					X	—	—	?	—	—	—	—													X		
					D21					o	—	—		—		X	X													o		
					D20					—							—													X	X	
																														●	●	
		Argillaceous Limestone & Shale	2. ZONE WITH ABUNDANT LOCKHARTIA DICTYOCONUS AND MISCELLANIA	Subzone B	D18					—																						
					D17					—	—	—		—			●													●		
					D16			X	X	X	o	—		—			●													X		
					D15																											
					D14					—	—	—		—			●														—	
					D13						—	—		—			●													X	—	—
					D12							—		—			●													—		
					D11							X		X			X															—
					D10							X		X			X													X		
					D9					—		X		X			o													o		
					D8							—		—			—													o	●	
		Nodular Limestone		Subzone A	D7							—		—																X		
					D6									—																		
					D5						—	—		—																●	●	X
					D4							X		X																●	●	o
					D3																									●	●	X
					D2			X	X	o	X	X		X			—													●		
	BIBAI FM.	Carbonaceous shale & marl Laterite at base	1. ZONE WITH ORBITOIDES AND O. MACROPORA		D1	X	o o																							X		

— Present X Common o Very Common ● Abundant

entirely medium- to thick-bedded dark grey to bluish-grey, hard, fine-grained limestone. The bedding planes have an extremely uneven, wavy surface and produce a rubbly or nodular appearance. Some beds contain rolled pebbles and boulders (5-10 cm) of limestone containing more or less the same foraminifera which are common in these limestones. This highly characteristic feature may be noted over a large area. Blanford (1883) referred it as a "limestone breccia" consisting of "dark grey angular limestone fragments in a somewhat pale limestone matrix. Both the fragments and matrix contain small *nummulites* and sometimes *alveolina,* and no difference has been noted in the forms found in the matrix and those present in the enclosed rock fragments".

Oldham (1890) also noted this unit near the top of the Dungan Group in the Dungan Range and called these rocks as "psuedo-conglomerates". Due to "the local occurrence of this structure, the absence of any trace of such violent clastic action in the associated beds, the absence of any apparent distinction between the fauna of the matrix and of the fragments, and the fact that there is every gradation from a mere mottled limestone to the most conglomerate like variety". He concluded that "the structure is in reality of concretionary origin".

Grieshback (1893) also noted these limestones in the Harnai valley and considered them to be a "concretionary limestone which from a distance, and on weathered surfaces, strongly resembles a conglomerate". According to him, "the softer portion, which fills the space between the limestone concretions, disintegrates on the weathering surfaces and thus leaves the individual lumps of limestone isolated, giving the whole rock a conglomeratic appearance".

Present study favours the suggestion of Townsend (1886) according to which this limestone can neither be correctly said to be concretionary nor a breccia. In thin sections these limestones are found to be full of foraminifera tests and calcite grains or lime mud.

The nodular limestone forming the basal part of the Dungan Group somewhat resembles the rubbly limestone. The main difference is that the nodular limestone has not yet been noted to contain any pebbles. The rubbly limestone contains a foraminiferal fauna which overlaps the underlying and overlying bio-zones. However, this zone may be differentiated from the underlying zone 2 due to the abundance of *Dictyoconus* and presence of *Alveolina* and *Nummulites mamilla.* It differs from the overlying zone 4 due to the absence of *Nummulites nuttalli, Nummulites thalicus, Operculina asindensis* and other foraminifera (see Table 3).

DUNGAN LIMESTONE — LOWER MEMBER

Massive limestone

This unit is by far the most prominent part of the Dungan Group. Consisting of hard, compact and massive limestone, it forms the most conspicuous physical features–such as the spectacular cliffs, escarpments, canyons, gullies and gorges in the Ziarat area and elsewhere. This massive limestone is seen over a wide area in northeastern Balochistan and, in areas such as Mehrab Tangi an Bolan Pass, has been named as "Bolan Limestone" by some of the previous investigators. It contains a characteristics assemblage of larger foraminifera and comprises yet another distinct biostratigraphic zone of the Dungan Group.

This zone consists of beds 250 to 350 m above the base of the Dungan Group and contains a rich fauna consisting of the following species of foraminifera in addition to those found in the Zone 2.

Nummulites nuttalli, Nummulites thalicus, Nummulites mamilla, Nummulites globosa, Nummulites irregularis, Operculiniodes sindensis, Operculina sp., *Discocyclina* sp., *Assilina subspinosa, Assilina dandotica, Assilina granulosa, Saudia* sp.

It has been noted that *Dictyoconus* is quite common in the lower 408 m of this zone and becomes extinct higher up. Also these lower 48 m of strata do not contain any species of *Operculina, Discocylina* and *Assilina,* which are abundant in the upper 50 m of this unit. Hence the lower 48 m of strata of this unit may be grouped together as subzone C–with *Dictyoconus* and without *Operculina, Discocyclina* and *Assilina.* Whereas the upper 50 m of this zone may be designated as subzone D–with *Operculina, Discocyclina* and *Assilina* (Table 3).

Grey porcellainous limestone

This unit is apparently restricted to the Khushnob Range and not noted elsewhere in the Ziarat area. It probably represents a local variation in the lithology, because on being traced laterally it grades into the underlying massive limestone. In the Anagan Gat section, it consists of fine-grained, medium-bedded (15-30 cm), dark grey to bluish-grey porcellainous or platy to flaggy unfossiliferous limestone, which weathers to a dull white or cream colour. It forms excellent building stone and may be easily dressed into blocks of any desired size or shape. Most of the buildings at Ziarat have been built with this stone.

From the preceding account it may be noted that the biostratigraphic zones and subzones, more or less coincide with the lithological units described earlier (Table 3). Each lithological unit had been deposited under a different environment and the ecological changes have affected the distribution (and evolution) of the fauna. The biostratigraphic zones described above and shown in Table 3 have also been noted by the author in the Mehrab Tangi and Dungan Hill sections. It, therefore, appears that these units may be traced over a wide area in northeastern Balochistan.

SECTIONS ALONG NORTHERN EDGE OF ZIARAT-KACH VALLEY

Along the northern edge of the Ziarat-Kach valley, the stratigraphy of the upper part of the Dungan Group is similar to the Anagan Gat section described above. However, the Bibai Formation is thick here and reveals its true stratigraphic features.

In the Kach-Ahmadun area the Bibai Formation comprises a lower and an upper unit. The lower unit is variable in thickness, and best developed east of Ahmadun. It comprises thin, discontinuous wedges and lenses of agglomerate and lava flows lying on the eroded surface of the Parh Formation (Fig. 2). Interbedded with the lavas and agglomerates are thin isolated wedges of Parh Formation (Kazmi, 1955, 1978).

The upper unit of the Bibai Formation comprises thicker part of boulder conglomerate interbedded with ash beds and tuff. Descriptions of the following five geologic sections of the Bibai Formation (east to west) provide a fair picture of its lithostratigraphy (Fig. 2).

Narai Skhobai Pass

This section is exposed in the Saru Ghar Range. The Bibai Formation overlies the Parh Formation (zone of *Globoyruncana lapparenti* and *G. linnei:* Kazmi, 1955). Basaltic lava flows

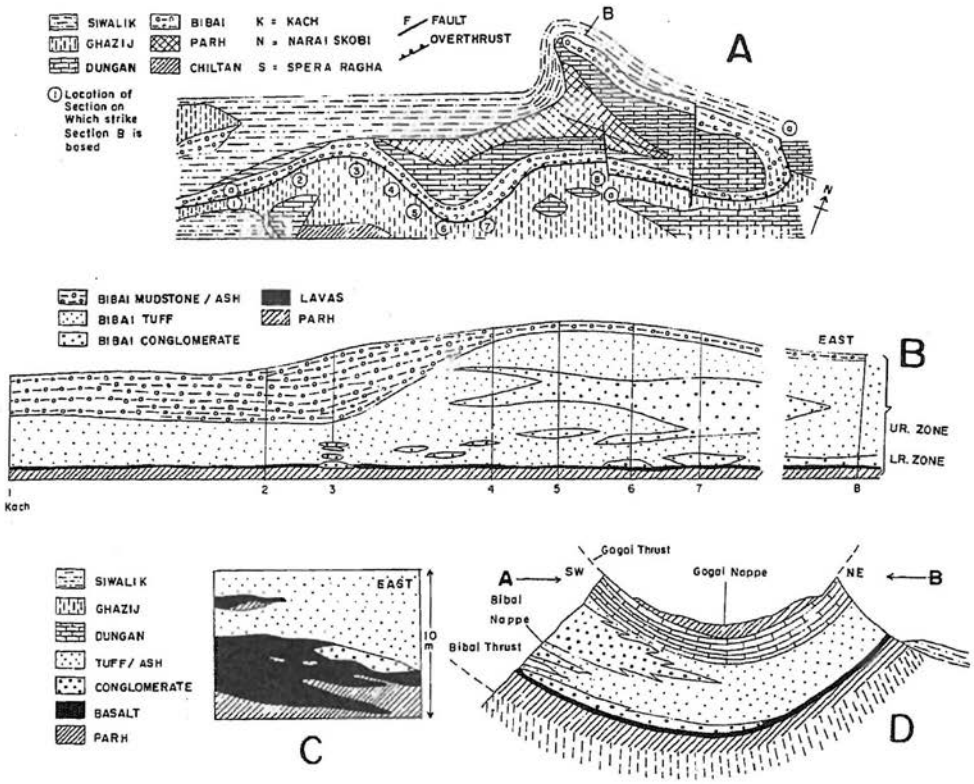

Fig. 2: Geological maps and cross sections of Ziarat-Kach valley.

and agglomerates (3–6 m thick) at the lower part are overlain by about 30 m thick boulder conglomerates, followed by about a 300 m of tuffs and ash beds. The latter are overlain by the Palaeocene Dungan Limestones.

Section from Narai Skhobai to Shna Khwar

When traced laterally, westward from Narai Skhobai, the conglomerates gradually increase in thickness. Above the lavas of the lower unit many beds and lenses of massive boulder conglomerates, a few meters thick, are interbedded with the tuffs and ash beds. The conglomerates have their maximum thickness east of Shna Khwar (Fig. 2).

Section between Shna Khwar and Ahmadun

Further westward from Shna Khwar, the lavas form thin discontinuous sheets, overlying the eroded surface of the Parh Formation. The conglomerates are also reduced to thin irregular lenses in the tuffs. Thus, between Shna Khwar and Ahmadun, the Babai Formation is largely represented by tuffs and ash beds of the upper part.

Section near Ahmadun

At Ahmadun the Parh Formation is overlain by a considerable thickness of hard compact, dark greenish-grey to black, bedded tuffs and agglomerates sparsely interbedded with

conglomerates. This unit is overlain by soft dark grey ash beds interbedded with hard and thin beds of agglomerates. Upwards, the ash beds and agglomerates are light khaki or light grey and are replaced by soft mudstones and sandstones, which still contain a considerable amount of volcanic material.

Section between Ahmadun and Kach

West of Ahmadun the lavas of the lower unit almost disappear. The tuffs are reduced in thickness to about 76 m and overlie the indurated and drag-folded Parh Formation. The lower 15 m of tuffs are dark grey to black overlain by about 61 m of light grey "argillaceous tuffs" with thin harder and more compact layers. Upwards these beds grade into 61 m of soft, dark greyish-brown, friable mudstones. The sandstones do not persist for a long distance and in the Kach section about 5 km westward no sandstone is found at this horizon. Overlying the sandstones and mudstones are about 61 m thick gypsiferous calcareous clays.

From the foregoing account of the lithostratigraphy it becomes evident that during the deposition of the Bibai Formation (Campanion to middle Maestrichtian) the following four processes were in progress in northeast Balochistan:

1. In one part of the area the volcanoes were active, and produced lavas and large amount of ash.
2. In another region, which probably formed a low flat plateau, alteration and lateritization of the basaltic lavas was in progress.
3. In the low lying areas a network of drainage system had been established. The streams were young, had steep gradient and drained into the sea.
4. There were repeated changes in the sea level due to frequent transgression and regression.

PALAEONTOLOGY AND CORRELATION

With the exception of lenses within the Parh Formation in the lower part and the upper most beds, between Ahmadun and Kach, fossils in the Bibai Formation are rare. The Parh Formation, underlying the Bibai Formation, belongs to the Zone of *Globotruncana lapparenti* and *Globotruncana linnei* (Kazmi, 1955). These fossils are also found in the limestone lenses interbedded with the lava flows in the lower part of this formation. Hence the age of the lava flows may be inferred as Campanian. The uppermost beds of this formation have yielded a rich molluscan fauna. Some of the fauna identified are following.

FORAMINIFERA: *Omphalocyclus macropora*, Orbitoides* sp.*

COELENTERATE: *Cyclolites* sp.*

GASTROPODA: *Turritella.* Acteonella* sp., *Oyula expansa* – d Archiac & Heime,* *Nerinea quettensis* – Noetling,* *Cerithium buddha* – Noetling,* *Trochus lartetianus* – Leymerie,**Volutillithes dubia* – Noetling,* *Volutonmorpha* sp.,**Polinices* (?) Montfort, *Volutilithes* sp.,* *Planorbis* sp.,**Conus* sp.

PELECYPODA: *Vola quinqueangularis* – Noetling,* *Nucula* sp., *Spondylus* sp.,* *Exogyra aff.* pyrenaica.*

ECHINODERMATA: *Hemipneustes* aff. Leymerie.*

CEPHALOPODA: *Schaphits, Turrilites, Baculites binodosus* – Noetling.*

Fifteen of these species (marked with asterisk) have been identified by Noetling (1897) from Hemipneustes Beds. Hence the upper part of the Bibai Formation may be correlated with the Hemipneustes Beds in Marri area and Kalat State, and is lower to middle Maestrichtian in age.

DISCUSSIONS

The strata overlying the Cretaceous Parh Formation and underlying the Eocene Ghazij Formation have been described as Dungan Limestone (Oldham, 1890). Williams (1959) and Hunting Survey Corporation (1960) have attempted to subdivide the Dungan Limestone. Their views and the author's suggestions have been summarised in Table 4.

William's (1959) work in northeast Balochistan is based on the study of selected sections between Quetta and the Sulaiman Range. The HSC (1960) work is based on more extensive regional, but reconnaissance type of photogeological work. Present studies are based on several sections between Loralai, Quetta and Kalat and it appears that at least in this region it would not be proper to designate the Dungan Group of rocks by many names as proposed by William(1959) and HSC (1960). Evidently the strata lying between the Parh Formation and the Ghazij Formation essentially comprise two major lithostratigraphic units. The upper unit is medium- to thick-bedded and massive limestone, commonly with nodular or rubbly character, with interbeds of shale, and a fauna of Paleocene to Lower Eocene larger foraminifera (cf. Dungan Limestone and Fort Monro Limestone of Williams, 1959), the Sanjawi Limestone, most of the Brewery Limestone and upper part of Moro Formation of HSC (1960), and the Dungan Limestone of present studies. The lower unit comprises interbedded dark grey mudstone, argillaceous limestone, and sandstone (orthoquartzitic) with conglomerate layers, breccia, lateritic shale, laterite or basalt at base (cf. Moghal Kot Formation and Kahan Conglomerate of Williams, 1959; lower part of Moro Formation of HSC, 1960); and the Bibai Formation of present studies). The lower unit is essentially characterized by a Maestrichtian foraminifera, largely comprised of *Omphalocyclys macropora, Orbitoides* sp. and *Siderolites* sp. It is proposed that the name Bibai Formation be adopted because it is near Kahan that the true nature of the lower unit is revealed and a clear picture of the prevailing environment can be obtained. The lithology of Moghal Kot Formation (William, 1959) and Moro Formation (HSC, 1960) are very similar to the Bibai Formation near Kahan, except that the sections north of Kahan (and east of Kach) contain basalt at the base and a vast thickness of boulder conglomerate higher up.

Present studies clearly signify the need of more comprehensive and systematic litho- and bio-stratigraphic studies of closely spaced section for an adequate subdivision of the Dungan Group (formations and members). Until such time it would be appropriate to subdivide these strata into two easily recogniseable and mappable units an upper Dungan Limestone, and a lower Bibai Formation.

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TABLE 4. CORRELATION OF LITHOSTRATIGRAPHIC UNITS OF THE DUNGAN (KALAT-QUETTA-ZIARAT-LORALAI AREA)

Williams (1959)	Hunting Survey Corporation (1960)				Kazmi (1955, 1978 & present paper)
Dungan Limestone (370 m) Grey, thick bedded, foraminiferal limestone. Lower part marly and silty. Basal part thin bedded, argillaceous and rubbly. Pseudocongolomerate often in upper part although it appears at different horizons at different places. Southward in Marri-Bugti Hills limestone thins out and lower part comprises thick sequence of shale.	Dungan Group Upper Part (30–305m) Mainly grey limestone, nodular structure characteristic, fossils mainly Alveolina sp.	Sanjawi Limestone (60–120m) Entirely limestone, cream white, light brown, soft. Upper Part consists of up to 1m thick beds. Middle part extremely nodular. Abundant forams. (Paleocene to Eocene - Omphalocyclus spp and Orbitoides not reported).	Brewery Limestone (24–61m) Almost entirely limestone, dark grey, thick bedded, lower contact unconformable. Upper beds contain Paleocene foraminifera.	Moro Formation (152–457m) Upper part Algal conglomerate.	Dungan Limestone Massive limestone member (162m) Grey, medium to thick bedded, lower part massive. Nummulites, Operculina, Discocylina and Assilina.
					Rubbly and nodular member (222m) Medium to thick bedded limestone, lower part massive and nodular, middle interbedded with shale, upper with siltstone interbeds. Lower part has abundant Lockhartia, Dictyosconus and Miscellania miscella and M. miscella. Upper beds with Lockhartia, Alveolina, Rotalia, Nummulites Mamilla etc.
	Dungan Group Middle Part (60–335m) Dark grey limestone, thick bedded.		Lower beds Contain Siderolites, Omphalocyclus, sp. Omphalocyclus macropora.	Middle part Marl and shale interbedded with sandstone at plaes.	
Unconformity					Bibai Formation (30–610m) Near Kahan upper part comprised of a few hundred meters thick sequence of boulder conglomerates interbedded with ash beds, tuff, mudstones and sandstone with calcareous clay/shale at top. Lower part comprises wedges and lenses of lavas and agglomerates interlayered with wedges of Parh Limestone and lying on eroded surface of the Parh Formation.
Pab Sandstone (Missing in the Quetta-Ziarat area). Fort Munro Limestone (45–100m) Dark grey, thick, hard limestone, bedding poor, upper part sandy, lower with argillaceous interbeds. Maestrichtian forams-Omphaocyclus marcopora, Oritoides sp. Kahan Conglomerate (850m) With boulder of basalt etc. Laterally thins rapidly and grades into shale. Seen near Kahan Village (main locality).	Dungan Group Lower Part (15–152m) Dark grey limestone, marl, clacareous, shale, thin bedded with orthoquartzitic sandstone (similar to Pab S. St). Sandstone associated with volcanic conglomerate. At base-breccia (Mehrab Tangi) red lateritic shale and sandstone (Panch Jhal).				
Moghal Kot Formation (1175m ±) Dark grey, calcareous mudstone interbedded with sandstone and argillaceous limestone. Sandstone quartose with conglomerate bands. Near Kahan a thick lenticular member comprised of igneous pebbles occurs. Sparingly fossiliferous. Limestone contains Omphalocyclus sp. and Orbitoides sps.		Lower contact residual conglomerate and lateritic weathering. Westward may be traced into Ziarat laterite.	At base - Laterite (Ziarat) at other places thin zone of sandy or pebbly limestone.		At other places Bibai Fm. comprises of carbonaceous shale, marl and porcellainous limestone (30m ±). Main fossils – Omphalocyclus macropora, Orbitoides sp.
Parh Formation	Parh Formation	Parh Formation	Parh Formation	Parh Formation	Parh Formation

Fifteen of these species (marked with asterisk) have been identified by Noetling (1897) from Hemipneustes Beds. Hence the upper part of the Bibai Formation may be correlated with the Hemipneustes Beds in Marri area and Kalat State, and is lower to middle Maestrichtian in age.

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