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RESEARCH ARTICLE

LITHOSTRATIGRAPHY OF THE NEWLY PROPOSED MIDDLE CRETACEOUS "BIBAI GROUP", WESTERN SULAIMAN FOLD-THRUST BELT, PAKISTAN

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ABSTRACT

The newly proposed Middle Cretaceous "Bibai Group", named after the Bibai peak, is exposed in Kach-Ziarat, Spera Ragha-Chingun areas of the Western Sulaiman Fold-Thrust Belt, Pakistan. It comprises thick succession of the mafic volcanic rocks, volcanic conglomerate, mudstone and sandstone. The stratigraphic nomenclature proposed by previous workers was not clear enough, as they used different names for the succession, such as "Kahan Conglomerate Member" of the Mughal Kot Formation, "Parh-related volcanics" by considering it as part of the "Parh Group, "Bibai Formation" and "Bela Volcanic Group", which were confusing and misleading. Also previous workers did not realize that the succession may be further classified into distinct mappable lithostratigraphic units and deserved the status of a "Group". Therefore, we carefully examined and mapped the area and hereby propose the name "Bibai Group" for the overall volcanic and volcaniclastic succession of the Middle Cretaceous age. Based on distinct lithostratigraphic characters we further subdivided the "Group" into two lithostratigraphic units of formation rank, for which we propose the names "Chinjun Volcanics" and "Bibai Formation". Also based on distinct lithostratigraphic characters we further propose to subdivide our "Babai Formation" into three lithostratigraphic units of member rank, which we named as the "Kahan Conglomerate Member", "Ahmadun Member" and "Kach Mudstone Member". In this paper we have defined and briefly described the Bibai Group, its constituent formations and their members. Also we examined and discussed the validity and status of the proposed subdivisions; e.g. formations and members, of the Bibai Group, and are fully satisfied that the proposed subdivisions are appropriate and comply with the Article 24 and 25 of the North American Stratigraphic Codes (2005) and that the previous nomenclatures are inconsistent, confusing and do not comply with the International Stratigraphic Codes.

KEYWORDS

Bibai Group, Kach-Ziarat, Lithostratigraphy, Volcanics, Siliciclastics

1. INTRODUCTION

The proposed Middle Cretaceous "Bibai Group", named after the Bibai peak, is exposed in Kach-Ziarat and Spera Ragha-Chingun valleys of the Western Sulaiman Fold-Thrust Belt (WSFTB, Bender and Raza, 1995), Pakistan (Fig. 1). It comprises mafic volcanic rocks, volcanic conglomerate, mudstone, sandstone and ash beds. In the Kach-Ziarat valley it is dominantly composed of volcaniclastic sediments and infrequently lava flows in lower part, whereas, in the Spera Ragha-Chinjun valley dominantly the *in-situ* basaltic volcanic rocks (Khan, 1986; McCormick, 1985). Initially Williams (1959) considered the group as "Kahan conglomerate member of the Mughal Kot Formation. The Hunting Survey Corporation (Jones, 1961) considered and mapped it as "Parh-related volcanics" i.e. as part of the "Parh Group". Kazmi (1955, 1979, 1984, 1988) further described the lithological characters of the volcaniclastic succession and termed the succession as the "Bibai Formation". Afterwards Shah (1977) termed the volcaniclastic succession of the Kach-Ziarat valley as the "Bela Volcanic Group". Previous workers (Williams, 1959; Kazmi, 1955, 1988; Jones, 1961; Shah, 1977; Khan, 1986; Kassi et al., 1993; Khan et al., 1999, 2000; Kassi et al., 2000a, Kassi et al., 2000b; Kassi et al., 2009), however, did not realize that the succession may actually be classified into distinct and mappable lithostratigraphic units and deserves the status of a "Group". They used different terminologies, such as the "Kahan Conglomerate Member of the Mughal Kot Formation", "Parh-related Volcanics", "Bibai Formation", "Bibai Volcanics", and "Bela Volcanic Group", for the same Middle Cretaceous volcanic and volcaniclastic succession of the WSFTB.

If the Stratigraphic Codes (Rahman, 1962; North American Stratigraphic Codes, 2004) are applied, the overall succession will clearly be entitled to the status of a "group", rather than "member", "formation" or "volcanic complex". The constituent lithostratigraphic units (formations and members) of the proposed Bibai Group, are mappable units, which have not been mentioned and/or properly named, nor have been mapped before. The geological mapping and proper nomenclature of these distinct lithostratigraphic units of the proposed Bibai Group is the basic requirement of the Stratigraphic Codes (Rahman, 1962; North American Stratigraphic Codes, 2004). This paper first time presents a map, classifies and describes the lithostratigraphic units of the proposed "Bibai Group" exposed in Kach-Ziarat and Spera Ragha-Chingun valleys of the WSFTB, Pakistan.

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2. Stratigraphy of the Surrounding Region

The study area is part of the WSFTB (Bender and Raza, 1995), Pakistan (Fig. 1), which comprises mostly sedimentary, and subordinatly volcanic and volcaniclastic succession of Triassic through Pleistocene age (Table 1, Fig. 2).

The Triassic Wulgai Formation comprises dark grey shale interbedded with limestone containing various types of *ammonites,* such as *Helorites, Jovites* and *Halobia*, which indicate early to Late Triassic age (Williams 1959; Jones, 1961; Fatmi 1977). It is conformably overlain by the Jurassic Shirinab Formation, which comprises light brownish grey, medium grey limestone. Based on various species of fossils Jones (1961) and Fathmi (1977) assigned Jurassic age. The Sember Formation of the Parh Group disconformably overlies the Sherinab Formation. The formation comprises shale with siltstone, limestone and sandstone. The Sember Formation is conformably and transitionally overlain by the Goru Formation, which comprises interbedded limestone, shale and siltstone. The limestone contains micro-planktonic foraminifera. The Parh Limestone is white, very light grey and very rich in micro-foraminifera of the *Globotruncana SP*. Its upper contact is transitional and conformable with Middle Cretaceous volcanic and volcaniclastic succession of the proposed "Bibai Group" (Table 1, Fig. 2), which is dominantly composed of volcaniclastic sediments and *in-situ* basaltic rocks. The "Group" is disconformably overlain by the Fort Munro Formation, which is composed of medium to dark grey, biomicritic limestone, containing abundant orbitoids. The Fort Munro Formation is overlain by the Moro Formation (Shah, 1977), which represents the lower part of the "Dungan and Jamboro Group" of Jones (1961). It comprises light brownish grey arenaceous limestone interbeded with dark brownish grey shale. The formation is highly fossiliferous, containing bivalves, gastropods, brachiopods and foraminifera. Jones (1961) assigned a Maastrichtian age on the basis of a foraminiferal assemblage that includes *Orbitoides*, *Orbitella* and *Derolites*. The formation is conformably and transitionally overlain by the Pab Formation of Maastrichtian age, comprising white and cream coloured quartzose sandstone, which weathers yellowish brown. The formation is overlain by the Palaeocene Dungan Formation (Table 1, Fig. 2), which comprises light grey, compact, hard, highly fossiliferous limestones containing gastropods, brachiopods, bivalves and foraminifera. Its upper contact with the Early Eocene Ghazij Formation is transitional and conformable. The Ghazij Formation, (Table 1), comprises sandstone, claystone, conglomerate, coal, and rarely limestone horizons. Various faunas, have been reported (Williams 1959; Jones, 1961), including foraminifera, bivalves and gastropods on the basis of which an Early Eocene age has been assigned. Its upper contact is conformable and transitional with the Kirther Formation, which comprises limestone and shale. Eames (1952) and Jones (1961) reported foraminifera, bivalves, gastropods and vertebrate remains, on the basis of which Middle to Late Eocene age has been assigned. The Urak Group within the mapped area (Table 1, Fig. 2) comprises sandstone, claystone and conglomerate. Elsewhere, Jones (1961) and Kazmi and Raza (1970) have reported vertebrate bones and wood fossils, on the basis of which a Miocene-Pleistocene age has been assigned.

Table 1: Stratigraphic succession of the Western Sulaiman Fold-Thrust Belt (modified after Kassi et al., 2009).

Age	Formation	Lithology
Pleistocene	Lei Conglomerate	Conglomerate, sandstone.
Miocene-Pleistocene	Siwalik Group	Sandstone, claystone and conglomerate.
Disconformity (Angular unconformity in some areas)		
Middle-Late Eocene	Spintangi Limestone	Limestone, shale and sandstone.
Early Eocene	Ghazij Formation	Claystone, sandstone, conglomerate, limestone and coal seams.
Palaeocene	Dungan formation	Limestone and shale.
Disconformity (in some areas)		
Middle-Late Cretaceous	Pab formation / Mughal Kot Formation / Fort Munro Formation / Hanna Lake limestone / **Bibai group**	Sandstone, siltstone, shale, limestone, ***in-situ* basic volcanic rocks, volcanic conglomerate, volcanic breccia and mudstone.**
Disconformity (in some areas)		
Early-Middle Cretaceous	Parh Limestone / Goru Formation / Sembar Formation	Limestone (bio-micritic), marl and shale.
Disconformity		
Jurassic	Shirinab Formation	Limestone and minor shale.
Triassic	Wulgai Formation	Shale and limestone.
Base not exposed		

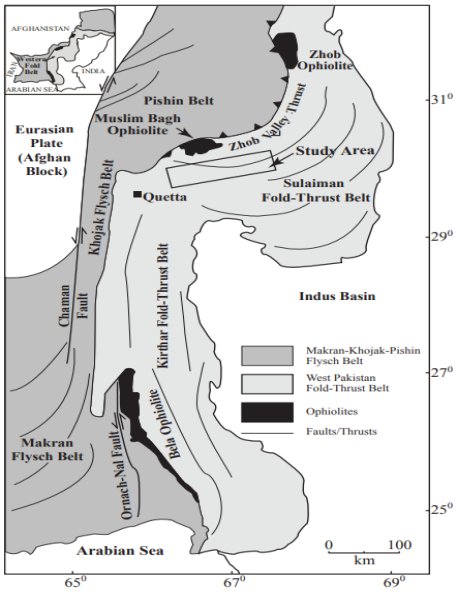
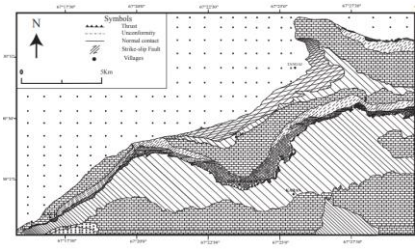
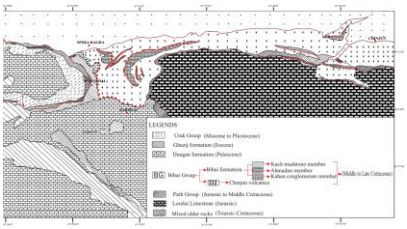


Figure 1: Generalized geological map of the western part of Pakistan showing the position of Sulaiman Fold-Thrust Belt and study area (modified after Bender and Raza, 1995)



Part 1



Part 2

Figure 2: Geological map of the study area and surrounding regions of the Sulaiman Fold-Thrust Belt, Pakistan.

Based on contrasting lithostratigraphic characters, the study area and surrounding region may be subdivided into two main segments (Kassi et al., 2009), which are described below:

2.1 Spera Ragha–Chinjun valley

The Spera Ragha–Chinjun valley comprises Triassic through Pleistocene succession (Fig. 2, Table 2), comprising the Wulgai Formation, Loralai Limestone, Parh Group, "Bibai Group", Fort Munro Formation, Moro Formation, Pab Formation, Dungan Formation, Ghazij Formation and Urak Group.

The striking feature of this area is that the Bibai Group is dominated by *in-situ* basic volcanic rocks; with very minor proportion of mudstones, conglomerates and sandstones in its upper part (our "Chinjun Volcanics"). The *in-situ* volcanic rocks in Spera Ragha–Chinjun valley are over 500 m thick, which conformably overlies the Parh Limestone and is nonconformably overlain by the Fort Munro Formation. The nonconformity is represented by an oxidized transition zone between the *in-situ* basic volcanic rocks of the Bibai group (the Chinjun volcanics) and the carbonate sediments of the Fort Munro Formation, which overlies the uppermost oxidized horizon with an undulatory and erosive contact.

Table 2: Cretaceous-Paleocene stratigraphic succession of the Spera Ragha-Chinjun Valley (modified after Kassi et al. (2009).

Age	Formation	Lithology
Middle-Upper Eocene	Spintangi Limestone	Limestone, shale and sandstone.
Early Eocene	Ghazij Formation	Claystone, sandstone, conglomerate, limestone and coal seams.
Palaeocene	Dungan formation	Compact light brownish grey limestone.
Late Maastrichtian	Pab formation	Cream coloured quartzose sandstone.
Late Maastrichtian	**Error! Not a valid link.**	Light brownish grey, arenaceous limestone and dark brownish grey shale
Disconformity		
Late Maastrichtian	Fort Munro Formation	Dark grey orbitoidal limestone.
Disconformity		
Late Campanian to Early Maastrichtian	**Bibai group (Chinjun volcanics)**	***In-situ* basaltic volcanic rocks.**
Albian-Campanian	Parh Limestone	Very light grey and cream coloured, biomicritic limestone, dolomitic in upper part.

2.2 Kach–Ziarat valley and Urghargai-Mazu Ghar area

Stratigraphy of the Late Cretaceous–Palaeocene in the Kach–Ziarat valley (Fig. 2, Table 3) is relatively simple, comprising Parh Group, "Bibai Group" (our "Bibai Formation"), Pab Formation and Dungan Formation. Near the Bibai Peak, east of Ahmadun up to 10 m thick sandstone succession of the Pab Formation separates the "Bibai Group" (the "Bibai Formation") from the Dungan Formation. The Pab Formation appears east of the Ahmadun village, near Tora Khezai and Bibai Peak, forming a thin wedge of quartzose sandstone in the Kach–Ziarat valley. It pinches out north-eastwards, towards Kawas, and also to the southwest, towards the Kach–Ahmadun area. The Pab Formation transitionally and conformably overlies the "Bibai Group" and passes transitionally upwards into the Dungan Formation. Near the Bibai Peak the Pab Formation is over 10 m thick.

Table 3: Cretaceous-Palaeocene stratigraphic succession of the Kach-Ziarat Valley and Urghargai-Mazu Ghar area (modified after Kassi et al., 2009).

Age	Formation	Lithology
Early Eocene	Ghazij Formation	Claystone, sandstone, conglomerate, limestone and coal seams.
Palaeocene	Dungan formation	Compact, light brownish grey limestone.
Late Maastrichtian	Pab formation	Light greenish grey shale, siltstone and cream coloured quartzose sandstone.
Late Campanian to Early Maastrichtian	**Bibai group (Bibai formation)**	**Volcanic conglomerate, sandstone and mudstone succession**
Albian-Campanian	Parh Limestone	Very light grey and cream coloured, biomicritic limestone.

In the Urghargai–Mazu Ghar area the "Bibai Group" (our "Bibai Formation") predominantly comprises mudstones (Figs. 2, 3c and 3d; Table 3), with minor volcanic conglomerates, volcanic breccias, rhythmically interbedded sandstone and mudstone successions and a few exposures lava flows in the lower part. Estimated thickness of the "Bibai Group" in the Urghargai–Mazu Ghar area is up to 185 m. Here the "Bibai Group" is conformably and transitionally overlain by the Pab Formation (Fig. 3).

3. Lithostratigraphy of the Bibai Group

Table 4: Lithostratigraphy of the Proposed "Bibai group" in Kach-Ziarat valley, Urghargai-Mazu Ghar area and Spera Ragha-Chinjun valley.

Age	Group	Formation	Member	Lithology
Late Campanian to Early Maastrichtian	Bibai group	Bibai formation	Kach Mudstone member	Dominantly mudstone, dark brownish grey to dark grey, fossiliferous with gastropods, bivalves and brachiopods, with occasional thin sandstone beds.
			Ahmadun member	Mixed sandstones, mudstone volcanic conglomerate and breccias, a few horizons of basaltic lava flows in lower part.
			Kahan Conglomerate member	Dominantly thick conglomerate horizons with very minor proportion of sandstone, mudstone and few horizons of basaltic lava flows in lower part.
		Chinjun volcanics	-------	Dominantly *in-situ* mafic volcanic rocks.

The Middle Cretaceous "Bibai Group" (Fig. 2, Table 4), named after the Bibai peak, comprises mafic volcanic rocks, volcanic conglomerate, mudstone, sandstone and ash beds. It is exposed in Kach-Ziarat and Spera Ragha-Chingun valleys of the WSFTB (Bender and Raza, 1995). In the Kach-Ziarat valley it is dominantly composed of volcaniclastic sediments and infrequently lava flows in lower part, whereas, in the Spera Ragha-Chinjun valley dominantly the *in-situ* basaltic volcanic rocks (McCormick, 1985; Khan, 1986; Siddiqui et al., 1994; Siddiqui et al., 1996). Based on distinctive lithostratigraphic characters the "Babai Group" is divisible into following lithostratigraphic units (Fig. 2, Table 4):

3.1 Chinjun Volcanics

We propose the name "Chinjun Volcanics" for the succession of *in-situ* basaltic volcanic rocks that conformably and transitionally overly the Parh Limestone of the Parh Group. They are exposed all over the Spera Ragha–Chinjun valley (Fig. 2, Table 4), i.e. around the villages of Chinjun in the Loralai District and Spera Ragha in the Ziarat District. They dominantly comprise the *in-situ* basic volcanic rocks (Fig. 3), with very minor proportion of mudstones, conglomerates and sandstones in its upper part. The basic volcanic rocks show spectacular flow banding, dolerite dikes and pillow structures. The volcanic rocks are and composed of alkali basalt, picrite, trachybasalt, tepherite/phonolite, trachyandesite, dolerite, diorite and granodiorite, which belong to the alkaline magma suite. Based on geochemistry, the volcanic rocks of the study area have been interpreted to be hotspot-related (McCormick, 1985, 1989, 1991; Sawada et al., 1992; Siddiqui et al., 1994, 1996, 2010; Khan, 1986; Khan, 1998; Khan et al., 1999, 2000). The *in-situ* volcanic rocks in Spera Ragha–Chinjun valley in places are over 500 m thick, which conformably overlies the Parh Limestone and is nonconformably overlain by the Fort Munro Formation.

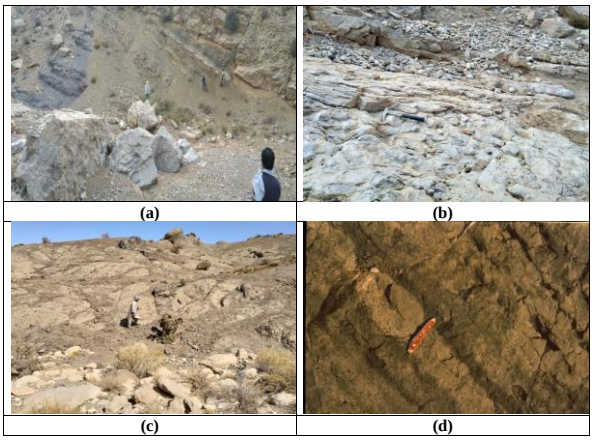


Figure 3: Photographs showing: a) geological succession of the of the Spera-Ragha-Chinjun area showing; b) close-up view of the *in-situ* volcanic rocks of Chinjun volcanics of the Bibai group; c) conglomerate of the Kahan Conglomerate Member; d) succession of sandstone interbedded with mudstone of the Ahmadun Member, and d) mudstone succession of the Kach Mudstone Member.

3.2 Bibai Formation

We propose the "Bibai Formation", named after the Bibai peak, with its status as a "formation" of the "Bibai Group" and not as a formation in the sense of Kazmi (1979). It is exposed in Kach-Ziarat valley and Urghargai-Mazu Ghar areas of the Ziarat District (Fig. 2, Table 4), WSFTB (Bender and Raza, 1995). The "Bibai Formation" comprises volcanic conglomerate, mudstone, sandstone and rarely mafic volcanic rocks, showing pillow lavas in its lower part. The formation has been assigned (Kazmi, 1955, 1979) a Campanian to Middle Maastrichtian age based on pelagic foraminifera found in the interbedded micritic limestone beds in its lower part. But if, as we believe, the upper part is the lateral equivalent of the Pab and Fort Munro Formations, then the "Bibai Formation" may extend up to the Late Maastrichtian age. Based on distinctive lithostratigraphic characters the "Babai Formation" is further divisible into following lithostratigraphic units of member status:

3.2.1 Kahan Conglomerate Member

The Kahan Conglomerate Member, named after the Kahan village in the Kach-Ziarat valley of the Ziarat District, is considered as a member of our "Bibai Formation" of the "Bibai Group" (Fig. 2, Table 4). The term is not used here in the sense of Williams (1959), who considered the whole "Group" as "Kahan Conglomerate Member" of the Mughal Kot Formation. Also we propose the section west of the Kahan village, as its reference section.

The Kahan Conglomerate Member dominantly comprises thick conglomerate horizons (Fig. 4), interbedded with very minor proportions of volcanic breccia, sandstone, mudstone and a few horizons of basaltic lava flows in lower part. Clasts in the conglomerates are moderately to well rounded, poorly sorted and some boulders are very large (up to 150 cm across). They are generally matrix-supported and rarely clast-supported. Sandstones are also dominantly composed of the basaltic rock fragments and pyroxene (Khan, 1998; Khan et al., 1999, 2000). Pebbles are mostly of alkali basalt, picrite, trachybasalt, tepherite/phonolite, trachyandesite, dolerite, diorite and granodiorite varieties of the alkaline magma suite, with minor amounts of granite and rhyolite, limestone (resembling the Parh Limestone) and rarely Mollusca fragments. Most of the volcanic conglomerate units display concave-up lenticular morphology, with highly erosive bases and fining-upward trends, locally grading to poorly-sorted pebbly sandstone (Khan, 1998; Khan et al., 1999, 2000). The Kahan Conglomerate Member conformably and transitionally overlies the Parh Limestone and conformably and transitionally underlies the Pab Formation. The Kahan Conglomerate Member in the reference section reaches up to over 1000 m in thickness.

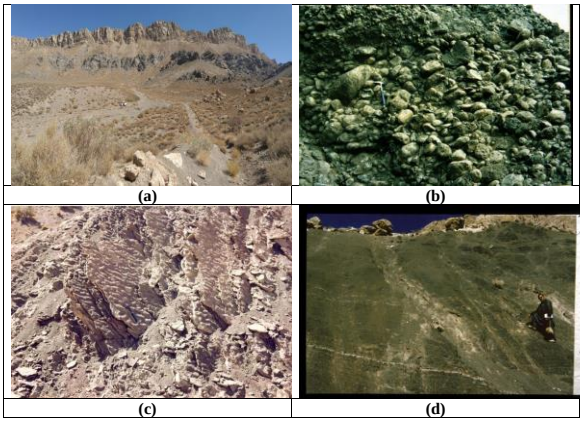


Figure 4

3.2.2 Ahmadun Member

The name "Ahmadun Member" is hereby proposed for the succession comprising mixed lithological characters (Fig. 4) composed of volcanic conglomerates, breccias and sandstones (Fig. 2, Table 4), mudstone and a few horizons of basaltic lava flows. The member is typically exposed near the village of Ahmadun village in the Kach-Ziarat valley, Ziarat District. The conglomerates possess characters similar to those of the Kahan Conglomerate Member, described in the previous section. Sandstone, rhythmically interbedded with mudstone, is common (Fig. 4), which display features like grading, parallel- and cross-lamination and sole marks. The thickness of this member in the Kach–Ziarat valley varies from a few tens of metres up to over 500 m. The Ahmadun Member transitionally and conformably overlies the Parh Limestone and also transitionally and conformably underlies the Pab Formation.

3.2.3 Kach Mudstone Member

The Kach Mudstone Member is named after the Kach village, situated near the old Kach Railway station in the Kach-Ziarat valley, Ziarat District. We consider it as a member of our "Bibai Formation" of the "Bibai Group". We propose the road section beside the old Kach Railway Station as its reference section. The member comprises mudstones with occasional thin sandstone beds (Fig. 4). Mudstone is dark brownish grey to dark grey, highly fossiliferous with gastropods, bivalves and brachiopods. The occasional thin sandstone beds are brownish grey and mostly very fine grained, which display parallel lamination, cross-lamination and sole marks. The Kach Mudstone Member in the road section near the old Kach Railway Station is over 500 m thick. The member transitionally and conformably overlies the Parh Limestone and is transitionally and conformably overlain by the Dungan Formation.

4. Discussion

The Middle Cretaceous "Bibai Group" (Late Campanian to Early Maastrichtian) and overlying Late Maastrichtian succession (Fort Munro, Moro and Pab formations) (Kassi et al., 2009) were not mapped separately by the Hunting Survey Corporation (Jones, 1961) in their reconnaissance map; and referred to as the ''Parh-related volcanics". Kazmi (1955, 1979, 1984, 1988) described the *in-situ* lavas and volcaniclastic succession of his "Bibai Formation" in the Kach–Ziarat valley, Urghargai–Mazu Ghar area and Spera Ragha–Chinjun valleys but did not differentiate or describe the Fort Munro and Pab formations in the area, which were later recognized and described by Kassi et al. (2009). Initially Williams (1959) considered the "Group" as "Kahan Conglomerate Member" of the Mughal Kot Formation. Afterwards Shah (1977) termed the volcaniclastic succession of the Kach-Ziarat valley as the "Bela Volcanic Group".

Previous workers (Williams, 1959; Kazmi, 1955, 1988; Jones, 1961; Shah, 1977, 2009; Khan, 1998; Khan et al., 1999; Khan, 1998; Khan et al., 2000 Khan et al., 2010) have used different terminologies like the "Kahan Conglomerate Member of the Mughal Kot Formation", "Parh-related volcanics", "Bibai Formation", "Bibai Volcanics", and "Bela Volcanic Group", for the Middle Cretaceous volcanic and volcaniclastic succession of the WSFTB. They did not realize that the succession is actually a mappable lithostratigraphic unit and is further divisible into distinct mapable lithostratigraphic units and deserves the status of a "Group". Kazmi (1978, 1984, 1988), McCormik, (1985, 1989, 1991), Khan (1986), Sawada et al., (1992) and Siddiqui et al. (1994, 1996, 2010) mostly worked on the petrology, petrogenesis and geochemistry of the volcanic rocks of the Bibai Group, using the term "Bibai Volcanics" and, did not consider the volcniclastic sedimentary succession of the Group. Kazmi (1979), Niamatullah et al. (1989) Otsuki et al. (1989) mainly discussed the structural and tectonic aspects of the area surrounding the Bibai Group, however, used the term "Bibai Formation" for the overall succession. Kerr et al. (2010b) studied the Late Cretaceous alkaline sills of the surrounding area and proposed them to be related with the initial melts of the "hotspot" volcanics (our "Chinjun Volcanics") of the "Bibai Group". Kerr et al., (2010a) and Kassi et al. (2012, 2013) worked on the eruption of basaltic magma at Tor Zawar, Ziarat District, during 2010 and 2011, within the "Kahan Conglomerate Member" of the "Bibai Group". Kerr et al., (2010) proposed them to be localized asthenospheric melting resulted in relatively depleted melts, which were substantially contaminated by fusible lithospheric mantle en route to the surface. However, Kassi et al. (2012, 2013) consider them to be actually the rock-fulgurites associated with steel pylons of the overhead electric transmission line.

We have re-visited and reflected on the Middle Cretaceous volcanic and volcaniclastic succession of the study area (our "Bibai Group") in view of the Stratigraphic Codes (Rahman, 1962; North American Stratigraphic Codes, 2005) and clearly consider them be entitled to the status of a "Group", rather than "Member", "formation" or "volcanic complex". The constituent lithostratigraphic units (formations) of our proposed "Bibai Group", are mappable units, which have not been mentioned and/or properly named nor have been mapped before, therefore, we prepared a geological map of the proposed Bibai Group and clearly defined and described the constituent formations and members of relevant formations, as per the Stratigraphic Codes (Rahman, 1962; North American Stratigraphic Codes, 2004).

The North American Stratigraphic Codes (2005) defines "lithostratigraphic unit" as a body of sedimentary, extrusive igneous, metasedimentary, or metavolcanic strata that is distinguished and delimited on the basis of lithic characteristics and stratigraphic position. A lithostratigraphic unit generally conforms to the Law of Superposition and commonly is stratified and tabular in form. The Codes define the "Group" (as per its Article 28, —Group) as "the lithostratigraphic unit next higher in rank to the formation". A "Group" may consist entirely of named formations, or alternatively, need not be composed entirely of named formations. "Groups" are defined to express the natural relations of associated formations. They are useful in small scale mapping and regional stratigraphic analysis. In some reconnaissance works, the term ''Group'' has been applied to lithostratigraphic units that appear to be divisible into formations, but have not yet been so divided. In such cases, formations may be erected subsequently for one or all of the practical divisions of the "Group". When a previously established formation is divided into two or more component units that are given formal formation rank, the old formation, with its old geographic name, should be raised to the status of "Group". Raising the rank of the unit is preferable to restricting the old name to a part of its former content, because a change in rank leaves the sense of a well established unit unchanged (Articles 19b, 19g). Therefore, in view of these Articles (28, 19b, 19g) of the North American Stratigraphic Codes (2005) our proposed "Bibai Group", deserves the status of a "Group".

As per the Article 24 of the North American Stratigraphic Codes (2005) a "formation" is the fundamental unit in lithostratigraphic classification. It is defined as "a body of rock identified by lithic characteristics and stratigraphic position; it is prevailingly, but not necessarily, tabular and is mappable at the Earth's surface or traceable in the subsurface". The limits of a formation normally are those surfaces of lithic change that give it the greatest practicable unity of constitution. A "formation" may represent a long or short time interval, may be composed of materials from one or several sources, and may include breaks in deposition (Article 23d). A "formation" should possess some degree of internal lithic homogeneity or distinctive lithic features. It may contain between its upper and lower limits (i) rock of one lithic type, (ii) repetitions of two or more lithic types, or (iii) extreme lithic heterogeneity that in it may constitute a form of unity when compared to the adjacent rock units. The proposal of a new "formation" must be based on tested mappability, however, thickness is not a determining parameter in dividing a rock succession into formations. The interbedded volcanic and sedimentary rock may be assembled into a formation under one name that should indicate the predominant or distinguishing lithology, such as in the case of our "Cinjun Volcanics". Mappable and distinguishable successions of stratified volcanic rock should be treated as formations or lithostratigraphic units of higher or lower rank. Both of the proposed constituent formations, i.e. the "Chinjun Volcanics" and "Bibai Formation", of our proposed "Bibai Group" fulfill the requirements of the Article 24 of the North American Stratigraphic Codes (2005).

Article 24 (—Formation) of the Codes further elaborates that well-established formations are commonly divisible into several widely recognizable lithostratigraphic units; where formal recognition of these smaller units serves a useful purpose, they may be established as "members" and "beds", for which the requirement of mappability is not mandatory. As per the Article 25 (—Member) of the Codes a "member" is defined as "the formal lithostratigraphic unit next in rank below a formation and is always a part of some formation". It is recognized as a "named entity within a formation" because it possesses characteristics distinguishing it from adjacent parts of the formation. A "member" is established when it is advantageous to recognize a particular part of a heterogeneous formation. A member, whether formally or informally designated, need not be mappable at the scale required for formations. Even if all members of a formation are locally mappable, it does not follow that they should be raised to formational rank, because proliferation of formation names may obscure rather than clarify relations with other areas. The member names should include a geographic term and the word ''member''; some have an intervening lithic designation, if useful; for example, our "Kahan Connglomerate Member", and Kach Mudstone Member. Our proposed subdivisions of the proposed "Bibai Formation", namely the "Kahan Conglomerate Member", the "Ahmadun Member" and the "Kach Mudstone Member" fully comply with the Article 24 and 25 of the North American Stratigraphic Codes (2005).

5. Conclusions

Based on detailed field investigation and geological mapping of the area we hereby propose the name "Bibai Group" for the succession of Middle Cretaceous age, named after the Bibai peak, exposed in Kach-Ziarat and Spera Ragha-Chingun valleys of the Western Sulaiman Fold-Thrust Belt, which comprises mafic volcanic rocks, volcanic conglomerate, mudstone, sandstone and ash beds. We consider that our proposed name is most appropriate, as the previously proposed nomenclature is inconsistent, confusing and do not comply with the North American Stratigraphic Codes (2005).

Based on distinct lithostratigraphic characters the "Babai Group" has further been subdivided into two lithostratigraphic units of "formation rank", namely the "Chinjun volcanics" and "Bibai Formation". Also based on distinguishing lithostratigraphic characters we further propose to subdivide the "Babai Formation" into three lithostratigraphic units of

"member rank"; and named them as the "Kahan Conglomerate Member", "Ahmadun Member" and "Kach Mudstone Member".

Our proposed "Bibai Group", its subdivisions of the "formation rank" and those of the "member rank" of the proposed "Bibai Formation", namely the "Kahan Conglomerate Member", "Ahmadun Member" and "Kach Mudstone Member" fully comply with the Article 23, 24, 25 and 28 of the North American Stratigraphic Codes (2005).

REFERENCES

Bender, F. K. and Raza, H. A., 1995. Geological framework, in: Bender, F. K., Raza, H. A., (Eds.), Geology of Pakistan. Gebruder Borntreager, 410 pp.

Fatmi, A. N., 1977. Mesozoic; in: Shah, S. M. (Ed.), Stratigraphy of Pakistan: Geological Survey of Pakistan, Memoir, Vol. 12, p. 29-56.

Jones, A.G., 1961. Reconnaissance Geology of part of West Pakistan: A Colombo Plan Corporation Project, 55Op, Toronto, Canada.

Kassi, A. M., Khan, A. S., Kakar, D. M., Qureshi, A. R., Durrani, K. H. and Khan, H., 1993. Preliminary Sedimentology of part of the Bibai Formation, Ahmadun-Gogai Area, Ziarat District, Balochistan: Geol. Bull. Punjab Univ., 28, p. 73-80.

Kassi, A.M., Kasi, A.K. and Khan, A.T. 2012. Comments on the Eruption of basaltic magma at Tor Zawar, Balochistan, Pakistan on 27 January 2010: geochemical and petrological constraints on petrogenesis: Discussion, Mineralogical Magazine, 76(3), 717-723.

Kassi, A.M., Kasi, A.K., Friis, H. and Kakar, D. M., 2013. Occurrences of the rock-fulgurites associated with steel pylons of the overhead electric transmission line at Tor Zawar, Ziarat District and Jang Tor Ghar, Muslimbagh, Pakistan: Turkish Journal of Earth Sciences, 22 (6) 1010-1019.

Kassi, A.M., Khan, A.S. and Sarwar, M. 2000a. Preliminary Sedimentology of the Newly Discovered Upper Cretaceous Mughal Kot Formation, Urghargai-Mazu Ghar Area, Western Sulaiman Thrust-Fold Belt, Pakistan: Acta Mineralogica Pakistanica, Vol. 11, 83-92.

Kassi, A.M., Khan, A.S. and Sarwar, M., 2000b. A new appraisal of the Lithostratigraphy of the Spera Ragha-Urghargai Region, Western Sulaiman Belt, Pakistan: Acta Mineralogica Pakistanica, Vol.11, 61-82.

Kassi, A.M., Khan, A.S., Umar, M, and Kasi A.K., 2009. Contrasting Upper Cretaceous – Paleocene Lithostratigraphic successions across the Bibai Thrust, Western Sulaiman Belt, Pakistan: their significance in deciphering the early-collisional history of the NW Indian Plate margin; Journal of Asian Earth Sciences, 35, 435-444.

Kazmi, A. H., 1955. Geology of the Ziarat-Kach-Zardalu area of Balochistan: D.l.e. thesis, Imperial College of Science and Technology, London (unpubl.), 157 p., London.

Kazmi, A. H., 1979. The Bibai and Gogai Nappes in the Kach-Ziarat area of northeastern Balochistan: Farah, A. & Delong, K. A., (eds.), GeodynamIc of Pakistan: Geological Survey of Pakistan, Quetta, 333-340.

Kazmi, A. H., 1984. Petrology of the Bibai Volcanics, northeastern Balochistan: (I Geol. Bull. Univ. Peshawar, 17, 34-51.

Kazmi, A. H., 1988. Stratigraphy of the Dungan Group in Kach-Ziarat area, northeastern Balochistan: Geol. Bull. Univ. Peshawar, 21, 117-130.

Kerr, A.C., Khan, M. and McDonald, I., 2010a. Eruption of basaltic magma at Tor Zawar, Balochistan, Pakistan on 27 January 2010: geochemical and petrological constrains on petrogenesis. Mineralogical Magazine, 74 (6), 1027-1036.

Kerr, A.C., Khan, M., Mahoney, J.J., Nicholson, K.N. and Hall, C.M. 2010b Late Cretaceous alkaline sills of the south Tethyan suture zone, Pakistan: Initial melts of the Re´union hotspot? Lithos, 117, 161-171.

Khan A. T., Kassi, A.M. and Khan, A.S., 2000. The Upper Cretaceous Submarine Fan (Bibai Formation), Kach-Ziarat valley, Western Sulaiman Thrust-Fold Belt, Pakistan: Acta Mineralogica Pakistanica, Vol. 11, 1-24.

Khan, A. T. 1998. Sedimentology and petrology of the volcaniclastic rocks of the BibaiFormation, Ziarat District, Balochistan, Pakistan: Ph. D. thesis (Unpubl.), Center of Excellence in Mineralogy, University of Balochistan, Quetta.

Khan, A. T.,Khan, A. S. and Kassi, A.M., 1999. Petrology, geochemistry and provenance of the volcanic conglomerate and sandstone of the Upper Cretaceous BibaiFormtion, Kach-Ziarat Valley, Balochistan: ActaMineralogicaPakistanica, Vol. 10, p. 103-123.

Khan, W., 1986, Geology and petrochemistry of part of the Parh Group Volcanics near Chingun: M. Phil. Dissertation, Centre of Excellence in Mineralogy, University of Balochistan, Quetta (unpubl.).

McCormick, G. R., 1985. Preliminary study of the volcanic rocks of the South Tethyan suture in Balochistan, Pakistan: Acta Minralogica Pakistanica, 1, p. 2-9.

McCormick, G. R., 1989. Geology Of The Baluchistan (Pakistan) Portion Of The Southern Margin Of The Tethys Sea: in Sengeor, A.M.C. (ed.):Tectonic Evolution of the Tethyan Region, Springer.

McCormick, G. R., 1991. Origin of Volcanics in theTethyan Suture Zone of Pakistan: Opjiolite Genesis and Evolution of the Oceanic Lithosphere: in Petrology and Structural Geology, book series, Vol. 5, pp 715-722.

Niamatullah, M., Durrani K.H., Qureshi, A.R., Khan, Z., Kakar, D.M., Jan, M.R., Ghaffar, A., 1989: Emplacement of the Bibai and Gogai Nappes, northeast of Quetta: Geol. Bull. Univ. Peshawar, 22, 153-158.

North American Stratigraphic Code, 2005. North American Commission on Stratigraphic Nomenclature, AAPG Bulletin, v. 89, no. 11 (November 2005), pp. 1547–1591.

Otsuki, K., Anwar, M., Mengal, J. M., Brohi, J. A., Hohino, K., Fatmi, A. N. and Okimura, Y., 1989. Break-up of Gondwanaland and emplacement of ophiolitic complex in Muslim Bagh area of Balochistan: Geol. Bull. Univ. Peshawar, 22, p. 103-126.

Rahman, H., 1962. Stratigraphic code of Pakistan, Memoirs of the Geological Survey of Pakistan. Stratigraphy of Pakistan, v. 4, pt. 1.

Sawada, Y., Siddiqui, R. H., Khan, S. R. and Aziz, A., 1992. Mesozoic igneous activity in the Muslim Bagh area, Pakistan with special reference to hotspot magmatism related to break-up of Gondwanaland: Proc. Geosci. Colloq., 1, p. 21-70.

Shah, S. M. I., (ed.), 1977. Stratigraphy of Pakistan: Geological Survey of Pakistan, Mem. 12, 138p.

Shah, S. M. I., 2009. Stratigraphy of Pakistan. Geological Survey of Pakistan, Memoir, 22, 1-381.

Siddiqui, R. H., Brohi, I. A.and Haidar, N., 2010. Geochemistry, Petrogenesis and Crustal Contamination of Hotspot Related Volcanism on The North Western Margin of Indian Continent And Its Implications For Paleosedimentary Environments: Sindh Univ. Res. Jour. (Sci. Ser.) Vol.42 (2) 15-34.

Siddiqui, R. H., Khan, I. H. and Aziz, A., 1994. Petrogenetic study of hotspot related magmatism on the northwestern margin of Indian Continent and its stratigraphic significance: Proc. Geosci. Colloq. Geosci. Lab, GSP, 8, p. 1

Siddiqui, R.H., Khan, I.H. and Aziz, A. 1996. Geology and petrogenesis of hotspot-related magmatism on the northwestern margin of the Indian continent. Proceedings of Geoscience Colloquium, Geoscience Laboratory, GSP, 16, 115-148.

Williams, M. D., 1959. Stratigraphy of the lower Indus basin, West Pakistan: Proc. 5th World Petroleum Congress, Sec. I, 19, 337-391, New York.