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The lithology and structure of a Mesozoic sedimentary-igneous assemblage beneath the Muslim Bagh Ophiolite, northern Balochistan, Pakistan

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MENGAL Jan Mohammad, KIMURA Katsumi, SIDDIQUI Muhammed Rehanul Haq, KOJIMA Satoru, NAKA Takahito, BAKHT Malik Sikander and KAMADA Kotaro (1994) The lithology and structure of a Mesozoic sedimentary-igneous assemblage beneath the Muslim Bagh Ophiolite, northern Balochistan, Pakistan. *Bull. Geol. Surv. Japan*, vol. 45(2), p. 51–61, 7figs., 1table.

Abstract: A Mesozoic sedimentary-igneous assemblage named the Bagh Complex beneath the Muslim Bagh Ophiolite is widely distributed in the Muslim Bagh area, western Pakistan.

On the basis of lithology and age, the Bagh Complex is divisible into seven lithologic units: 1) serpentinite melange, 2) mudstone melange, 3) basalt-chert unit (Upper Jurassic to Cretaceous), 4) hyaloclastite-mudstone unit (Cretaceous), 5) ultramafic-mafic rock unit, 6) upper sedimentary rock unit (Jurassic) and 7) lower sedimentary rock unit (Triassic). These units are bounded by layer-parallel thrust faults and stacked against each other. With this assemblage, the Bagh Complex can be distinguished from the sedimentary cover sequence on the Indian subcontinent. The lithologic features suggest that the Bagh Complex consists of rock assemblages which were initially deposited in the extensive area which ranges from the continental margin of the Indian subcontinent to the Neo-Tethys ocean.

1. Introduction

The Himalayan orogenic belt is the largest convergent zone, which have resulted from collision between the Eurasia and Indian continental plates about 50 Ma (Powell, 1979). In the western Pakistan, oblique collision of the Indian subcontinent with the Afghan block resulted in the development of the Sulaiman and Kirthar fold-thrust belt (Yeats and Lawrence, 1984). The western margin of the fold-thrust belt is marked by the discontinuous occurrence of several huge ophiolite bodies in Bela, Muslim Bagh, Zhob, and Waziristan (Fig. 1) (Asrarullah *et al.* 1979; DeJong and Subhani, 1979; Ahmad and Abbas, 1979). These ophiolite bodies occur as thrust sheets overlying the sedimentary cover of the Indian subcontinent (Ahmad and Abbas, 1979; DeJong and Subhani, 1979). The emplacement of the ophiolites occurred in the Paleocene or earliest Eocene time (Allemenn, 1979). These ophiolite and associated sedimentary-igneous

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Keywords: Triassic, Jurassic, Cretaceous, ophiolite, melange, chert, basalt, Bagh complex, Neo-Tethys, Muslim Bagh, Pakistan

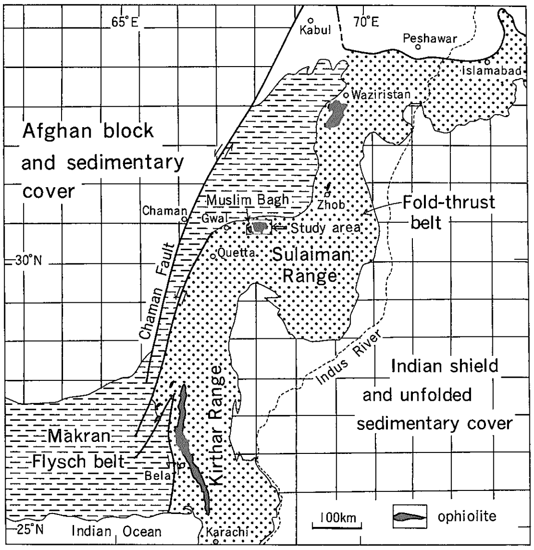

Fig. 1 Schematic tectonic map of western Pakistan. (modified from Kazmi and Rana, 1982; DeJong, 1982)

assemblage offer significant evidence to reconstruct the paleoenvironments of a passive margin of the Indian subcontinent and the Neo-Tethys ocean. There are, however, a few geologic studies. Among these ophiolites, the Muslim Bagh Ophiolite is one of the best studied ophiolites (Ahmad and Abbas, 1979), and it is underlain by the sedimentary-igneous assemblage regarded as an large remnant of an emplaced Neo-Tethyan sedimentary sequence (Otsuki *et al.*, 1989; Kimura *et al.*, 1992).

In this paper, we call the sedimentary-igneous assemblage beneath the Muslim Bagh Ophiolite the Bagh Complex after Bagh village located south of the Saplai Tor Ghar (Fig. 2).

This work is the result of cooperative field research in 1991 by members of Geological Survey of Pakistan and the Japanese party. This project was financially supported by Japan International Cooperation Agency (JICA). Detailed radiolarian fossil ages of the Bagh Complex is reported in the same volume by Kojima *et al.* (1993). Radiometric ages and geochemistry of igneous rocks of the Bagh Complex and Muslim Bagh Ophiolite have been preliminarily reported by Sawada *et al.* (1992), and their details will be published later. The purpose of this paper is to describe the lithologic divisions and their lithofacies of the Bagh Complex based on detailed field survey in the Muslim Bagh area, and to discuss the environment of deposition of the com-

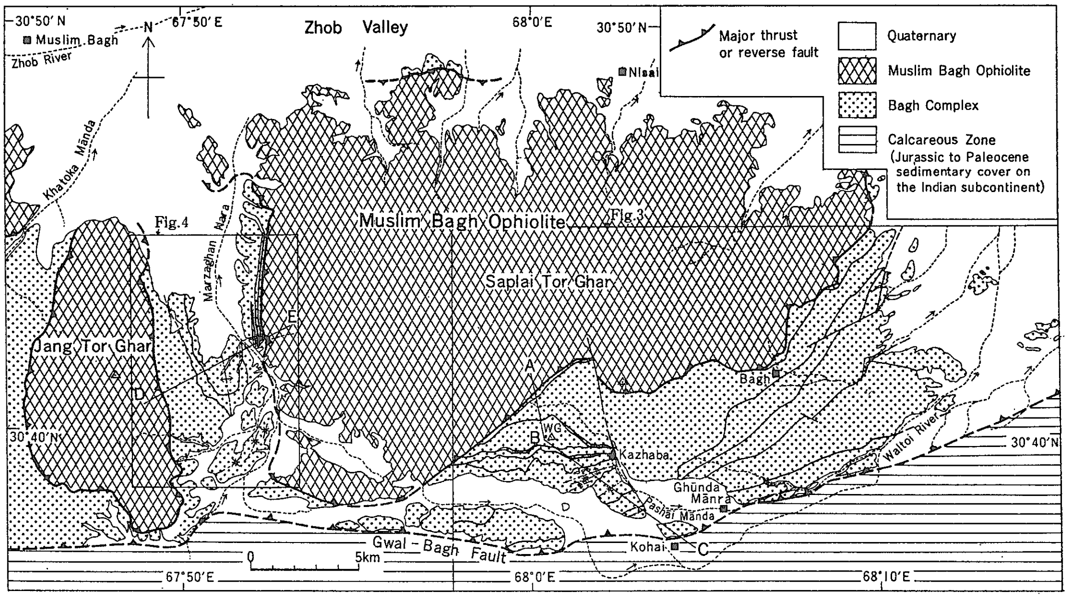

Fig. 2 Geologic map of the Muslim Bagh area (after from Hunting Survey Corporation, 1961; Ahmad and Abbas, 1979; Otsuki *et al.*, 1989 and this study).

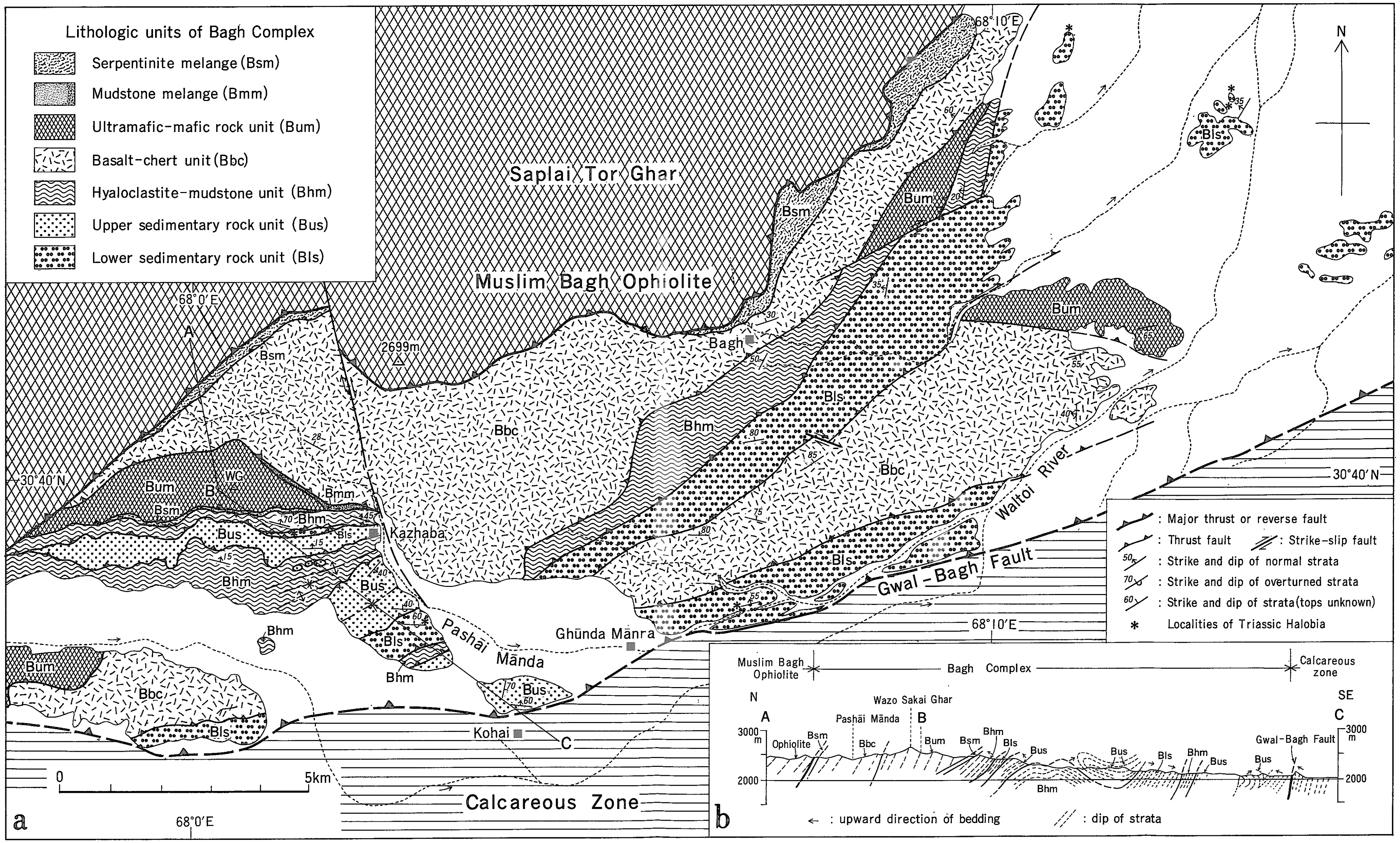

Fig. 3 Geologic map of the Bagh Complex in the eastern part of the Muslim Bagh area. WG: Wazo Sakai Ghar

plex. Our study area is located in the Muslim Bagh area, northwestern Balochistan, western Pakistan (Figs. 1 and 2).

2. Previous study

Hunting Survey Corporation (1961) published a series of geologic maps on a scale of 1:253,440 including the Muslim Bagh area under the Colombo Plan Project and first clarified outline of the geology of the Muslim Bagh area. Detailed studies on the Muslim Bagh Ophiolite and the associated "melange" have been reported recently. Ahmad and Abbas (1979) and Gansser (1979) pointed out that the "melange" zone beneath the Muslim Bagh Ophiolite includes slivers of metamorphic rocks and ophiolite rocks, and considered that it was formed by shear in association with obduction of the ophiolite. Otsuki *et al.* (1989) presented that the "melange" zone includes not only melange unit, but also a coherent sedimentary-igneous unit consisting of Triassic sedimentary rocks and igneous rocks, and considered that these rocks were deposited in the trough basin resulting from the breakup of the northern margin of the Indian subcontinent. These ages were determined only based on megafossils including Halobia of Triassic time. However, the occurrence of the Upper Jurassic to Lower Cretaceous radiolarians in the "melange" zone are noted in the appendix section of the volume edited by Japanese-Pakistani Research Group (1989). These radiolarian ages are not consistent with the stratigraphic division offered by Otsuki *et al.* (1989). Kimura *et al.* (1992) preliminary divided the "Melange" zone into seven lithologic units based on lithologies and ages, and indicated that the "Melange" zone is characterized by a variety of Mesozoic sedimentary-igneous rock successions. This paper follows the lithologic division presented by Kimura *et al.* (1992).

3. General geology

The study area around Muslim Bagh is located in the northern margin of the E–W trending Sulaiman Range, and is occupied by the Muslim Bagh Ophiolite, the Bagh Complex, and the Jurassic to Paleocene sedimentary cover of the Indian subcontinent (called Calcareous Zone hereafter) (Fig. 2). These rocks comprise a fold-thrust belt consisting mainly of Permian to Eocene platform deposits on the Indian subcontinent (*e.g.*, Kazmi and Rana, 1982; Humayon *et al.*, 1991). The Muslim Bagh Ophiolite thrusted over the Bagh Complex, which is in fault contact with the sedimentary cover to the south. The boundary fault between the Bagh Complex and the sedimentary cover can be clearly traced in the Muslim Bagh area (Fig. 2) and is assumed to be extended toward west near Gwal based on the topographic features (Fig. 1; Otsuki *et al.*, 1989). The fault is named the Gwal-Bagh Fault after Gwal town and Bagh village in this paper.

The Muslim Bagh Ophiolite is made up of ultramafic tectonites, ultramafic and mafic cumulates and a sheeted dike 33 complex (Ahmad and Abbas, 1979). The Bagh Complex is a sedimentary-igneous assemblage consisting of Triassic to Jurassic sedimentary rocks, and Jurassic to Cretaceous basic igneous rocks with Cretaceous pelagic to hemipelagic sediments and small amounts of melange.

To the north of the Zhob valley, Eocene to Miocene flysch-like coarse sedimentary rocks are widely distributed and extend to the Makran range in southwest Pakistan (Fig. 1). Eocene transgressive marine beds of the flysch belt unconformably overlie in part the ophiolite bodies including the Muslim Bagh Ophiolite and Mesozoic sedimentary rocks (Hunting Survey Corporation, 1961; Allemann, 1979). The strata of the flysch belt are interpreted to have been deposited in the narrow zones between the Indian subcontinent and the Afghan blocks after the emplacement of the ophiolites on the Indian subcontinent (De-Jong, 1982).

4. Bagh Complex

4.1 Outline

In the Muslim Bagh area, the Muslim Bagh Ophiolite occupies mainly two mountain areas such as the Saplai Tor Ghar and the Jang Tor Ghar. The Bagh Complex is distributed around these mountains, and is in fault contact with the overlying Muslim Bagh Ophiolite (Fig. 2). The fault boundary is commonly outlined by serpentinite melange (Figs. 3 and 4), rarely by slivers of

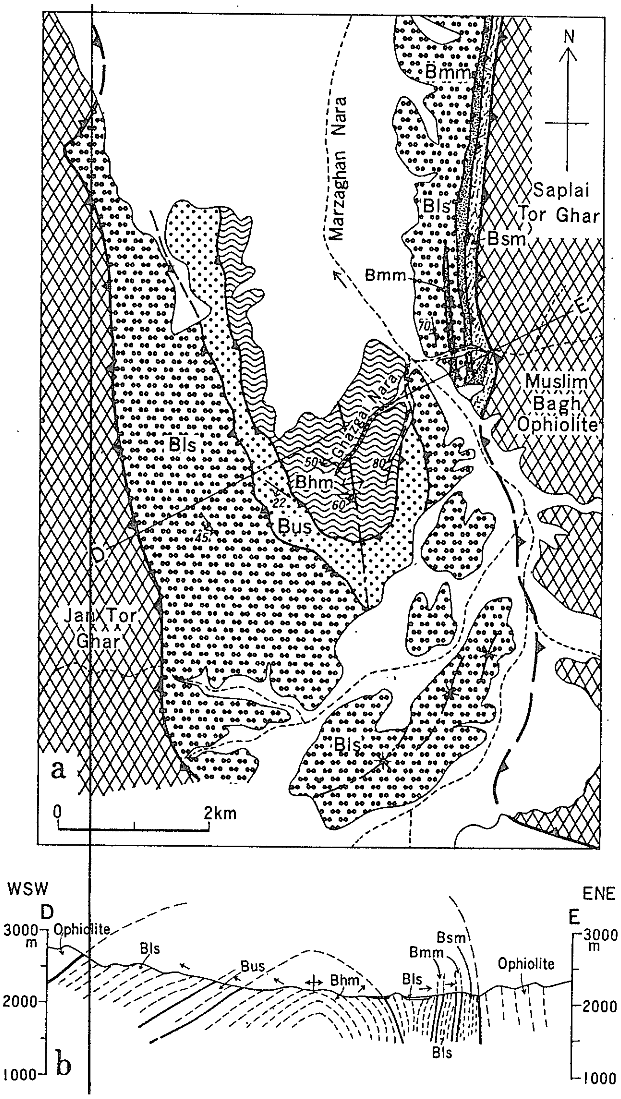

Fig. 4 Geologic map of the Bagh Complex in the western part of the Muslim Bagh area. Legends are the same with those of Fig. 3.

metamorphic rocks at the northwest side of the Jang Tor Ghar (Gansser, 1979; Otsuki *et al.*, 1989). We have researched the Bagh Complex in the areas around the Marzaghan Nara (Western part) and around Bagh-Kazhaba (Eastern part) (Fig. 2) within the Muslim Bagh area and the geologic maps of the two areas are shown in Figs. 4 and 3, respectively.

The Bagh complex is divisible into seven lithologic units based on lithologic assemblage, structure, and ages: 1) serpentinite melange (Bsm), 2) mudstone melange (Bmm), 3) basalt-chert unit (Bbc), 4) hyaloclastite-mudstone unit (Bhm), 5) ultramafic-mafic rock unit (Bum), 6) lower sedimentary rock unit (Bls) and 7) upper sedimentary rock unit (Bus) (Table 1). Each unit is bounded by layer-parallel thrust faults.

4.2 Lithology

1) Serpentinite melange (Bsm) occurs at the bottom of the Muslim Bagh Ophiolite, and also along the margin of ultramafic rock slices in the Bagh Complex. Serpentinite melange includes various types of blocks in scaly serpentinite matrix (Fig. 5). Blocks consist mainly of ultramafic-mafic rocks and metamorphic rocks such as amphibolite, garnet-hornblende schist, and greenschist, intercalating basalt, chert, limestone, and shale. Judging from the lithologies, it is estimated that ultramafic-mafic rocks were derived from the Muslim Bagh Ophiolite, basalt and sedimentary rocks from the basalt-chert unit.

2) Mudstone melange (Bmm) occurs near the fault boundary between the ophiolite and Bagh complex east of Ghazgai Nara, and also along faults bounding the ultramafic unit at Kazhaba (Fig. 3). The mudstone melange includes various types of blocks surrounded by scaly mudstone (Fig. 5). These blocks consist of basalt, radiolarian chert, foliated limestone, interbedded limestone and shale, and massive limestone. Basalt, chert and limestone are correlative to those of the basalt-chert unit, and interbedded limestone and shale is similar in lithology to Triassic sedimentary rocks in the Bagh Complex.

3) Ultramafic-mafic rock unit (Bum) consists of ultramafic cumulate and mafic cumulate, and conspicuously forms higher ridges than other units in the Bagh Complex. Typical tectonic slices, consisting mainly of ultramafic cumulate, occur discontinuously along the boundary fault between the Bbc and Bhm, extending from Kazhaba to east of Bagh. The margin of this slice is commonly remarked by melange units (Fig. 3). The lithology and occurrence of this unit suggest that this unit is a tectonic slice derived from the Muslim Bagh Ophiolite. There are no age data from the Bum.

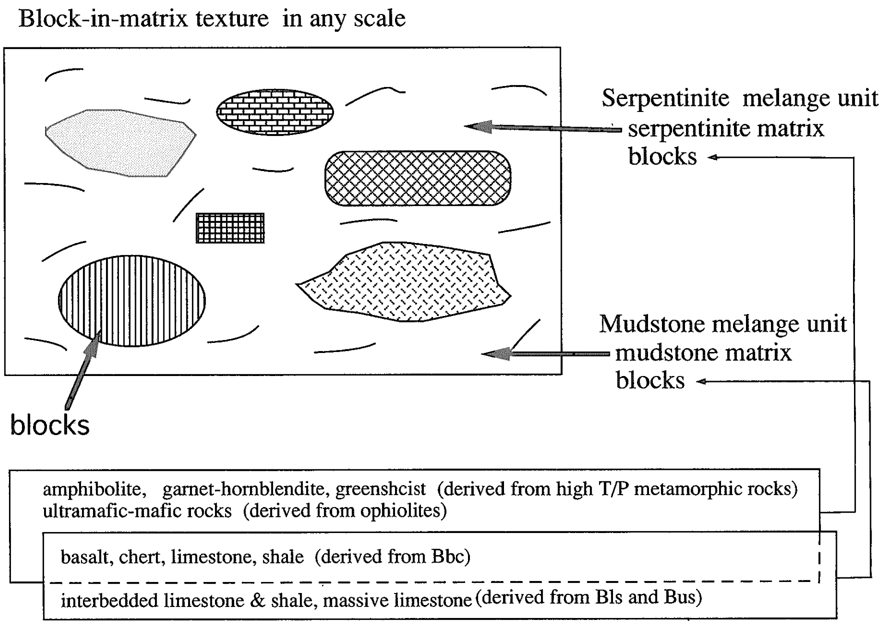

Fig. 5 Schematic descriptions of melange units in the Bagh Complex.

4) Basalt-chert unit (Bbc) is characterized by thick basalt rocks with bedded chert, micritic limestone and hemipelagic mudstone. The basalt rocks are tholeiitic (Sawada *et al.*, 1992), and occur as pillow lava with minor amounts of massive lava and volcanic breccia. The pillow lava consists mostly of closed-packed pillows, ranging in diameter from 10 cm to 1 m, with some intercalations of limestone. The bedded chert is reddish brown in color and rich in radiolarian fossils, forming alternating beds of 2 to 15 cm-thick chert layer and fine mudstone layer of up to 10 cm thick. This unit is so severely sheared and faulted that the original sedimentary sequence is almost broken. Some outcrops, however, show that the pillow lava is conformably covered by 30 to 50 m-thick limestone-chert sequence. In contrast, there is no evidence that the pelagic sediments are conformably covered by the basaltic rocks. In addition, the basalt-chert unit is marked by thrust-related repetition of the vertical sequence of basalt, limestone and chert in ascending order. Accordingly, the original stratigraphic succession of the basaltic-chert unit can be reconstructed as the basaltic rocks in the lower part, and the limestone-chert in the upper part as shown in Fig. 6. Siliceous shale, 2 to 10 m thick, crops out close to bedded chert. Although the stratigraphic relationship of these rocks is not clear, bedded chert is likely to be conformably covered by siliceous shale as shown in Fig. 6. The chert-limestone interval ranges in age from Early Cretaceous to Turonian on the basis of radiolarian fossil ages from chert (Kojima *et al.*, 1994).

5) Hyaloclastite-mudstone unit (Bhm) consists of thick basalt volcanic rocks interbedded with siliceous mudstone and micritic limestone. This unit is less sheared compared to the basalt-chert unit so that the sedimentary sequence can be safely reconstructed as shown in Fig. 6. The lower subunit consists of siliceous mudstone and limestone, which are frequenctly intruded by basalt and dolerite. These intrusions are similar in lithology with volcanic rocks of the middle subunit. The middle subunit consists of volcanic rocks, intercalating small amounts of limestone and siliceous shale. The volcanic rocks consist of basanite, alkali basalt, and trachy basalt (Sawada *et al.*, 1992) and occur as hyaloclastite and reworked volcanic breccia with minor amounts of pillow lava and lava sheets (Fig. 6). They are

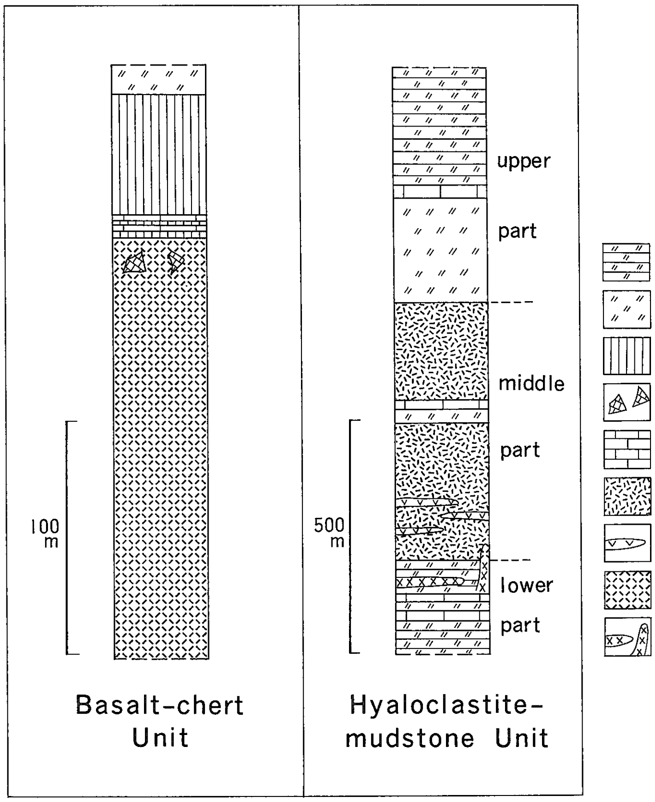

Fig. 6 Schematic reconstructed stratigraphy of the basalt-chert unit and the hyaloclastite-mudstone unit in the Bagh Complex. 1: bedded siliceous shale, 2: siliceous shale, 3: bedded chert, 4: interpillow limestone, 5: limestone, 6: hyaloclastite, 7: lava sheet, 8: pillow lava, 9: sill and dike, 6–9: basic rocks.

characterized by the development of vesicles and the existence of phenocryst of pyroxene of several mm to 2 cm in diameter. The upper subunit is composed of siliceous shale with limestone. Early Cretaceous radiolarian assemblages were collected from siliceous mudstone of the lower subunit (Kojima *et al.*, 1994). K–Ar ages of amphibole and biotite collected from volcanic rocks range from 68 to 81 Ma (Sawada *et al.*, 1992). Hence, the approximate age of this unit can be Cretaceous.

6) The Lower sedimentary rock unit (Bls) consists of interbedded limestone and shale in the upper part, and fissile greenish gray shale in the lower part (Fig. 7). The thickness is some 500 m. A limestone bed of interbedded limestone and shale is characterized by sedimentary structures such as parallel and cross laminations, grading and current marks including groove and flute marks. The interbedded limestone and shale yield Triassic *Halobia* fossils from many localities (Otsuki *et al.*, 1989 and this study). Figure 3 indicates localities of *Halobia* which were newly found in this study. The fissile shale yields Late Triassic Ammonite and Triassic radiolarian assemblage (Kojima *et al.*, 1994). These fossil data show that this unit is approximately of Triassic age.

7) The Upper sedimentary rock unit (Bus) consists of siliceous shale, bedded micritic limestone, fissile shale and calcareous sandstone with conglomerate. The thickness is some 500 m (Fig. 7). The siliceous shale collected from two localities at north of Kohai yields Early Jurassic and Late Jurassic radiolarian assemblage fossils (Kojima *et al.*, 1994). An ammonite showing

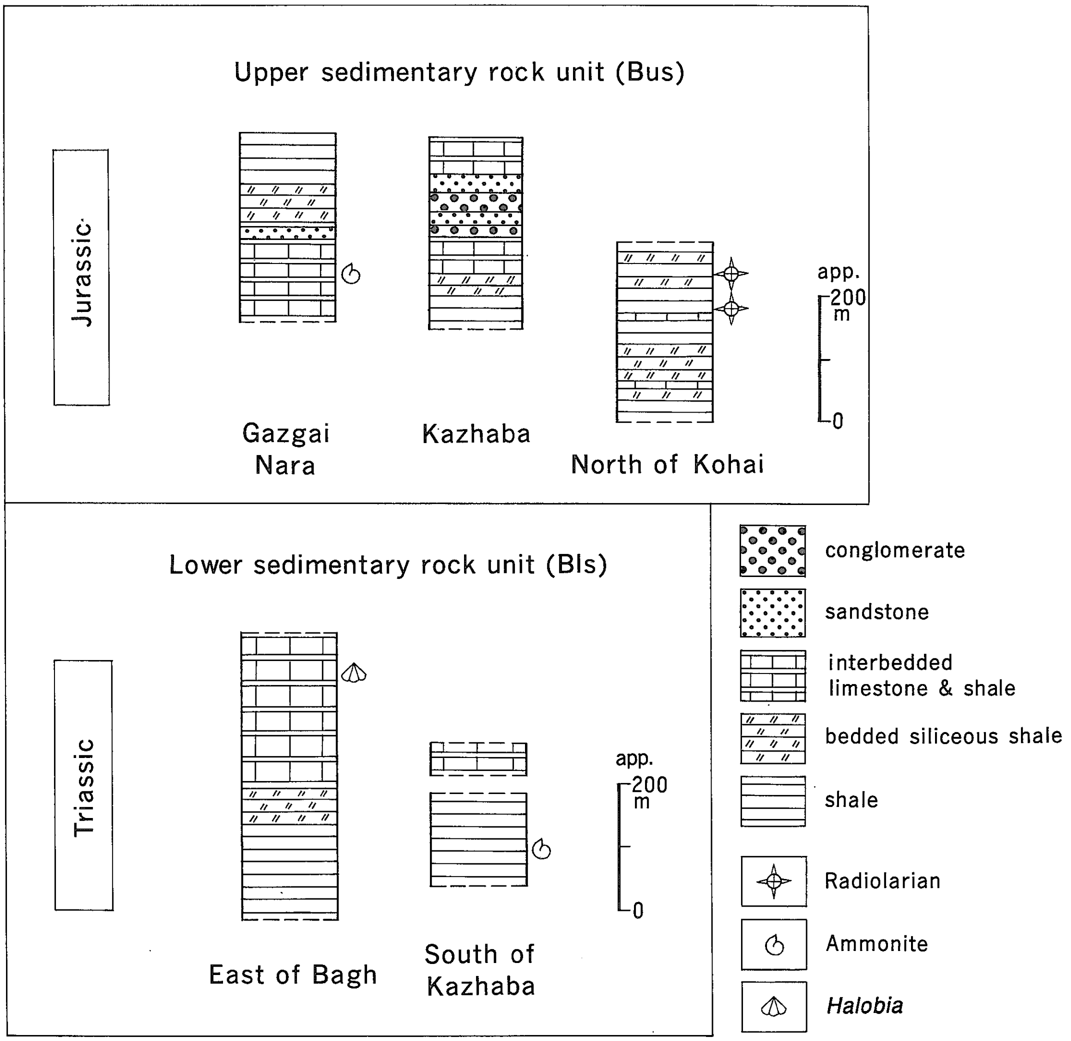

Fig. 7 Geologic column of the sedimentary rock units in the Bagh Complex.

Jurassic age was collected around the Gazgai Nara, although it was a dropped stone. These fossil data show that Bus is almost of Jurassic age.

4.3 Geologic structure

The Bagh Complex is clearly separated from Jurassic to Paleocene calcareous rocks to the south by the Gwal-Bagh Fault (Fig. 2). This fault, with a 50 to 200 m-thick shear zone in the hanging wall, generally strikes ENE and dips steeply to the north in the Muslim Bagh area. The Bagh Complex is also in fault contact with the overlying Muslim Bagh Ophiolite (Figs. 3 and 4). The boundary fault between the Bagh Complex and the ophiolite have approximately the same attitude as the underlying Bagh Complex.

Each lithologic unit of the Bagh Complex is separated by layer-parallel faults. These fault zones sometimes contain serpentinite melange or mudstone melange. Bedding within each unit is commonly right-way-up, although there are few recumbent folds. In the Eastern area (Fig. 3), the Bagh Complex generally strikes ENE-WSW to E–W and dips to the north, and however in the area from Kazhaba to Kohai, strata are folded to form ENE–WSW trending upright folds with a

Table 1 Lithologic units of the Bagh Complex in the Muslim Bagh area and these remarks. Absolute ages are from the time scale published by Harland *et al.* (1989). Radiolarian ages and K–Ar radiometric ages are based on Kojima *et al.* (1994) and Sawada *et al.* (1992), respectively.

LITHOLOGIC UNITS	Abb.	LITHOFACIES	AGE
SERPENTINITE MELANGE	Bsm	blocks in scaly serpentinite matrix	chert blocks: early Cretaceous to Turonian (Rd)
MODSTONE MELANGE	Bmm	blocks in scaly mudstone matrix	chert blocks: Berriasian to Turonian (Rd)
ULTRAMAFIC-MAFIC UNIT	Bum	ultramafic cumulate and mafic cumulate	
BASALT-CHERT UNIT	Bbc	tholeiitic basalt rocks overlain by limestone, bedded chert and siliceous shale	chert: Berriansian to Turonian (Rd)
HYALOCLASTINE-MUDSTONE UNIT	Bhm	alkaline volcanic rocks interbedded with siliceous shale and limestone	alkaline rocks: 68 to 81 Ma (K–Ar) shale of the lower part: Early Cretaceous (Rd)
UPPER SEDIMENTARY ROCK UNIT	Bus	siliceous shale, micritic limestone with sandstone and conglomerate	Jurassic to Cretaceous (?) (Rd)
LOWER SEDIMENTARY ROCK UNIT	Bls	interbedded limestone and shale and siliceous shale	Triassic (Rd, MF)

Abb.: Abbreviation, Rd: radiolarian age, K–Ar: radiometric age of K–Ar
MF: mega fossils including *Halobia* and Ammonite.

wavelength of 500 to 1500 m. A largescale tight recumbent fold, which are refolded by upright folds, is found south of Kazhaba (Fig. 3). In the Western area (Fig. 4), strata form a N–S trending upright anticlinal fold, plunging southward. The boundary fault between the ophiolite to the east and the serpentinite melange to the west strikes N–S and dips steeply, being consistent with the attitude of the Bagh Complex as shown in a ENE–WSW profile section (Fig. 4). According to Otsuki *et al.* (1989) and Gansser (1979), at the northwestern side of the Jan Tor Ghar, both the boundary fault and the Bagh Complex are folded to form an antiformal structure.

As pointed out by Ahmad and Abbas (1979) and Otsuki *et al.* (1989), the attitude of the boundary fault close to bedding in the Bagh Complex suggests that the boundary fault was originally nearly horizontal and was later folded during the deformation event also responsible for folding of the Bagh Complex. The internal structure of the ophiolite is, however, crosscut by the boundary fault (Ahamd and Abbas, 1979).

5. Tectonic significance of the Bagh Complex

The Bagh Complex contains various types of lithologic units as described in the previous section (Table 1). Each lithologic unit forms an individual thrust sheet. We will describe their depositional environments based on the lithofacies and age. Serpentinite melange and mudstone melange are characterized by various types of blocks in scaly matrix. As mentioned before, the characteristic features of lithologies indicate that these blocks, except for metamorphic rocks such as garnet-hornblende schist and greenschist, were possibly derived from the surrounding rock units such as the Muslim Bagh Ophiolite and the coherent lithologic units of the Bagh Complex based on these lithofacies. The origin of metamorphic rocks is not clear. Melanges occur only along the margin of the Muslim Bagh Ophiolite and the ultramafic slices possibly derived from the ophiolite. The above mentioned occurrence and the development of scaly fabric of the melanges suggest that they were formed by shear in association with the emplacement of the Muslim Bagh Ophiolite.

The previous studies such as Ahmad and Abbas (1979) and Otsuki *et al.* (1989) regarded the basalt-chert unit as an upper member of the Muslim Bagh Ophiolite. The reconstructed stratigraphy of the basalt-chert unit in this study shows that basalt rocks are overlain by Early Cretaceous to Turonian pelagic radiolarian bedded chert, followed by the deposition of younger hemipelagic mudstone. In contrast, the K–Ar ages from the Muslim Bagh Ophiolite are of 67 to 82 Ma (Sawada *et al.*, 1992). The age difference clearly indicates that the basalt-chert unit is not a member of the Muslim Bagh Ophiolite.

The hyaloclastite-mudstone unit is of Cretaceous age based on radiolarian fossils (Kojima *et al.*, 1994) and K–Ar ages (Sawada *et al.*, 1992). It consists of alkaline rocks interbedded with radiolarian siliceous shale and micritic limestone. This association of sediments and alkaline igneous rocks shows that alkaline rocks were erupted in the hemipelagic environment.

As for sedimentary rocks in the sedimentary units of the Bagh Complex, these are characterized by more abundant hemipelagic sediments and much less shallow-marine sediment than the calcareous sediment on the Indian subcontinent to the south. These features show that sedimentary rock units of the Bagh Complex were deposited in the more distal part of the Indian subcontinent.

The above mentioned characteristic lithofacies of the Bagh Complex clearly distinguish the Bagh Complex from the Calcareous Zone to the south. We think that these rock assemblages of the Bagh Complex were possibly initiated during Triassic to Cretaceous time in the area which extends from the continental margin of the Indian subcontinent over the Neo-Tethys ocean, and then were thrust-stacked during obduction of the Muslim Bagh Ophiolite over the Indian subcontinent.

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パキスタン西部，モスリムバーグオフィオライトの下位の中生代堆積岩・火成岩コンプレックスの岩相・構造およびその重要性

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要　旨

インド–ユーラシア大陸の衝突境界にそって，オフィオライトがインド大陸上に衝上している．それらのうち，西縁境界に相当するオフィオライト岩体の一つがパキスタン西部，モスリムバーグ地域に分布する．このモスリムバーグオフィオライト(MBO)の直下に断層を境にして，中生界の堆積岩・火成岩コンプレックス(バーグコンプレックス)が分布する．バーグコンプレックスの南側にはインド大陸上に堆積した浅海成中生界(石灰岩地帯)が広く分布し，褶曲・スラスト帯を構成する．バーグコンプレックスと石灰岩地帯とは層相が異なり，両者は東西走行のグワール–バー断層で境されている．本研究はパキスタン地質調査所との共同プロジェクトであり，論文ではバーグコンプレックスの地質を記載し，ネオテーチスの古地理復元におけるその重要性を指摘する．堆積岩の地質年代及び火成岩の年代・化学組成はそれぞれ小嶋ほか(本号)，沢田ほか(1992)に基づく．バーグコンプレックスは7つの岩相ユニットに区分される．①蛇紋岩メランジュ(Bsm)：オフィオライト・変成岩，及びBbcから由来したブロックと蛇紋岩基質からなる．②泥岩メランジュ(Bmm)：おもにBbcとBls由来のブロックと泥岩基質からなる．③玄武岩–チャートユニット(Bbc)：ソレアイト質の枕状玄武岩とそれに重なる白亜紀前期からTuronianにかけての層状チャート，そして半遠洋性泥岩からなる復元層序を有す．④ハイアロクラスタイト–泥岩ユニット(Bhm)：半遠洋性泥岩(下部は白亜紀前期を示す）とアルカリ火山岩(68–81 Ma)からなる．⑤堆積岩ユニット：石灰質泥岩・砂岩ないし珪質泥岩からなる三畳系(Bls)とジュラ系(Bus)からなる．⑥超塩基性–塩基性岩ユニット(Bum)：オフィオライト由来の岩石からなる．

Bsm及びBmmのメランジュはオフィオライトの直下，ないしBumの境界にそって産出すること，剪断構造が発達していることから，オフィオライトのオブダクトに関連して形成された構造性メランジュと考えられる．BbcはMBOとは年代が異なり，MBOの一員ではない．堆積岩ユニットのBls・Busは，断層で境されているが，堆積岩の岩相の類似性は，三畳紀からジュラ紀にいたる一連の堆積体をなしていたことを示唆する．これらは浅海成相の石灰岩地帯の同時代の地層と異なり，層厚が約1000 mと薄く，かつ珪質堆積物に富む半遠洋性層の発達を特徴としており，インド大陸の縁辺にあったと推定される．

バーグコンプレックスについての以上の層相の特徴と石灰岩地帯の地層との比較に基づくと，バーグコンプレックスを構成する主要な堆積岩と火山岩は，インドとユーラシア大陸の衝突にともなって消失したネオテーチスからインド大陸縁辺で形成されたと考えられる．

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