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Geochemistry and Tectonic Setting of Gadani-Phuari Segment of Bela Ophiolites, Balochistan, Pakistan

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ABSTRACT. The volcanic rocks exposed at Gadani-Phuari area, District Lasbela, Balochistan, mark part of the southernmost, onshore remnant of the Bela Ophiolites. In Lasbela region, there are two prominent groups of Cretaceous igneous rocks. The first are Bela ophiolitic rocks which are allochthonous in nature and are unrelated to the second group, *i.e.* the Porali Intrusion which is equivalent to Deccan Trap and represent younger within-plate basalts (WPB).

The southern most exposure of Bela Ophiolites are present in small and scattered outcrops in Gadani-Phuari area west of Karachi. Major and trace element analyses of 20 selected samples have been used for evaluating these rocks. The variation of total alkali with silica (TAS) of the volcanic rocks suggests that they are mostly alkaline basalts and trachy-basalts. Whereas the trends of the other major and trace elements indicate that they are low K tholeiites derived from a source similar to that of E-Type Mid Oceanic Ridge Basalt (MORB). These ophiolitic rocks were emplaced onto the western margin of the Indian plate during Maastrichtian to Lower Eocene time.

Introduction

The Bela ophiolitic Belt is the last remnant of the 5000 km long Peri-Indian Suture zone (Himalayan Ophiolite Belt) before it disappears into the Arabian Sea. The Murray and Owen Ridges mark the offshore oceanic continuity of the zone. In Lasbela region, there are two prominent groups of igneous rocks emplaced during Cretaceous time. The first group consists of ophiolitic rocks (Bela Ophiolites) which are allochthonous and comprises large thrust sheets that overlie melange units (Sarwar and DeJong, 1984). The second group of rocks (Porali Intrusion, equivalent to Deccan Trap) is continental and autochthonous and consists of mafic intrusive and volcanic rocks associated with the sub-ophiolitic autochthonous sequence (Sarwar, 1992). The area under study represents a portion of southern Bela Ophiolitic Belt, which is intermittently exposed below Quaternary marine terraces in a narrow strip between Gadani Hill in the north and the mouth of the Hub River in the south (Gansser, 1979 & 1980).

Gadani village is situated 50 km NW of Karachi in the Lasbela District of Balochistan Province. The area is easily accessible from Karachi through RCD Highway via Hub Chouki (Fig. 1). The area has very low relief. Gadani Hill is a prominent feature in the area and has 87 m elevation. The second higher hill located near Qasim village is 64 m in elevation (Fig. 1).

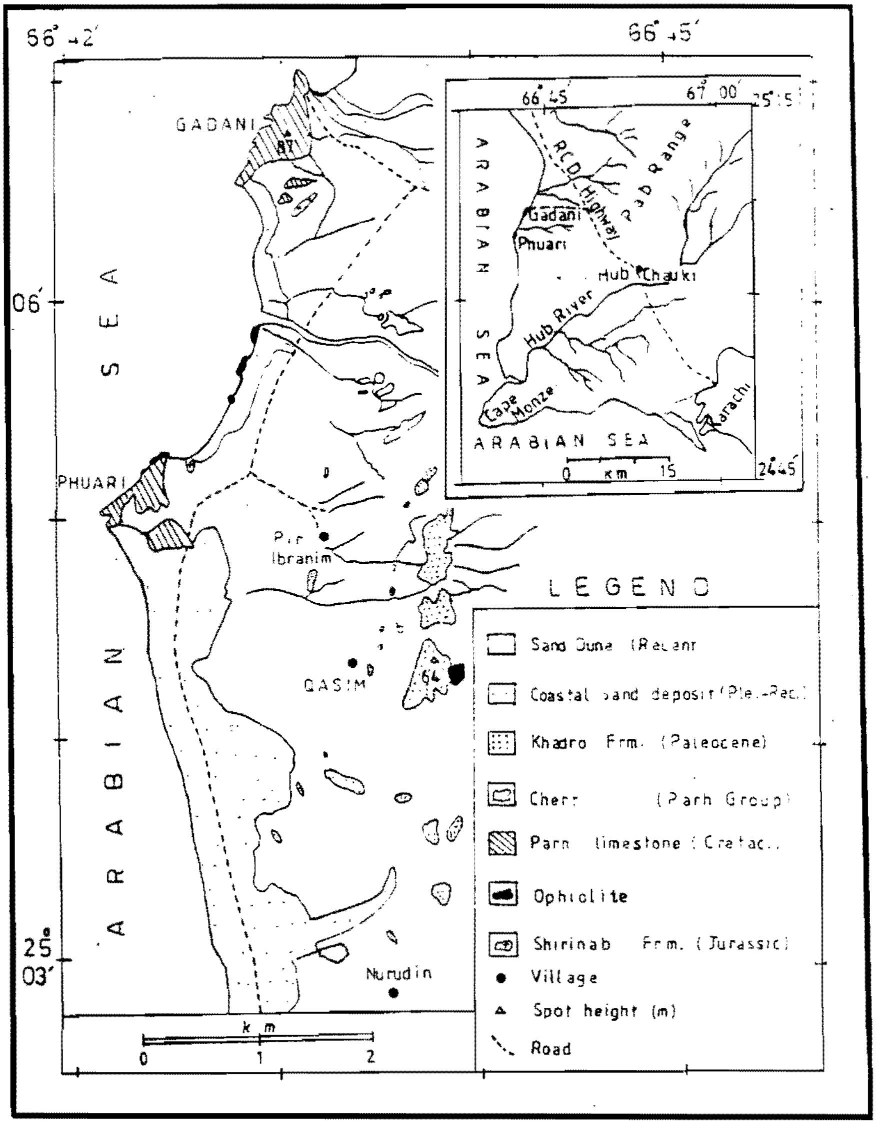

FIG. 1. Geological map of the Gadani-Phuari area (Modified after Khan, 1973).

The ophiolites of the study area are exposed along the coast of the Arabian Sea from Gadani Hill to south of Phuari Hill and are associated with Parh Limestone of Late Cretaceous age (Fig. 1). Field relationship of rocks and the position of samples are shown in plate (1A, 1B, and 1C). The present study is concerned with the geochemistry of major and selected trace elements of these ophiolitic rocks. Major and trace elements of the 20 selected samples from Gadani-Phuari area were analyzed by atomic absorption spectrophotometer (Hitachi, Z-8000) at the laboratories of the Pakistan Council of Scientific and Industrial Research (PCSIR), Karachi. Silica was estimated gravimetrically using hydrofluric acid.

Stratigraphy

The sedimentary succession exposed in the area range in the age from Jurassic to Paleocene.

Shirinab Formation (Jurassic)

The Shirinab Fm. consists of few isolated and small outcrops of dark gray, hard and fractured limestone. It is thick to medium bedded, massive and has a brecciated appearance. It shows no normal stratigraphic relationship with the younger rocks (Khan, 1973).

Parh Limestone (Cretaceous)

The Parh includes limestone, marl and shale, with minor amount of sandstone. The limestone is porcellaneous and has variable shades of colour. Chert and jasper are also associated with the marl and limestone. The outcrops at Gadani and Phuari Hills and a small exposure northeast of Qasim village are of Parh limestone. Most of the volcanic rocks are associated with this limestone (Khan, 1973 and Gansser, 1979).

Khadro Formation (Paleocene)

The Khadro consists of shale with thin interbedded sandstone and subordinate limestone. The shale is soft, fissile and olive green to brown. Thin beds of sandstone present within the shale are grey to brown, medium grained and hard. The limestone is generally thick bedded and grey to light brown. Some beds are rich in Forams.

Dune, Stream and Coastal Deposits (Pleistocene to Recent)

Surficial deposits consists of semi-consolidated to unconsolidated Recent wind blown sand deposits. The coastal strip consists of sand, gravel, stream bed deposits, tidal mud and lagoonal deposits of Pleistocene to Recent age (Khan, 1973).

Bela Ophiolites

The Bela Ophiolites form the continuation of the southern branch of the main Himalayan Ophiolitic Belt in southern Balochistan and continues into the Arabian Sea near Gadani where it joins the Murray Ridge and the Owen Fracture Zone (Gansser, 1980). They represent oceanic crust-mantle segment obducted into the western margin of the Indian continental plate (Fig. 1). Nearly all segments of a typical ophiolite are present

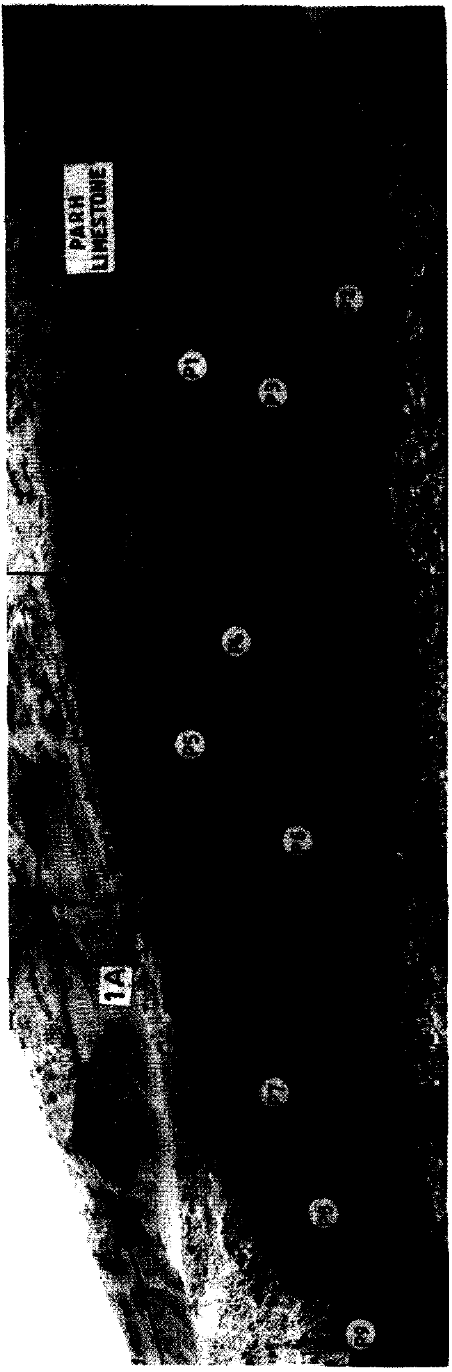

PLATE 1A. Phuari area.

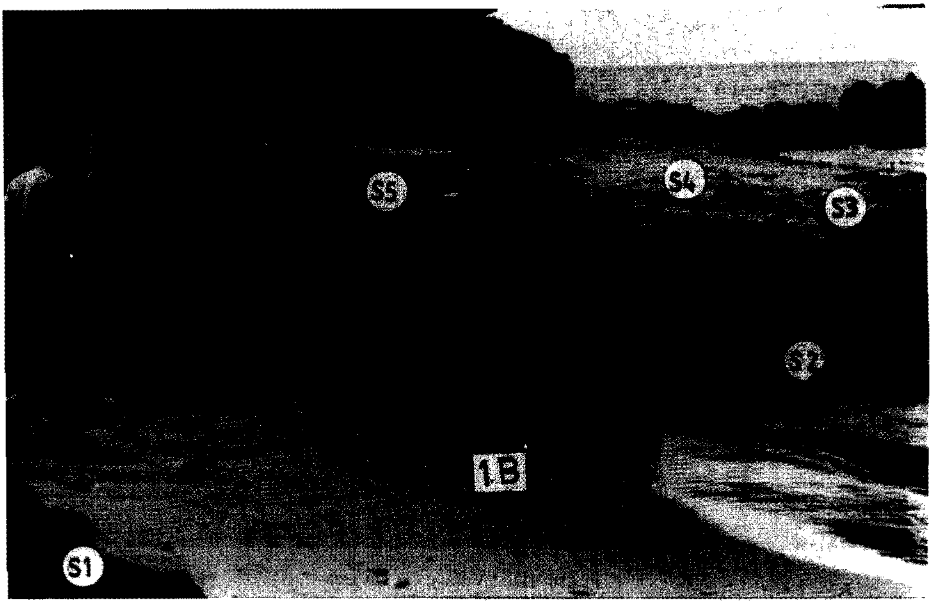

PLATE 1B. South of Phuari.

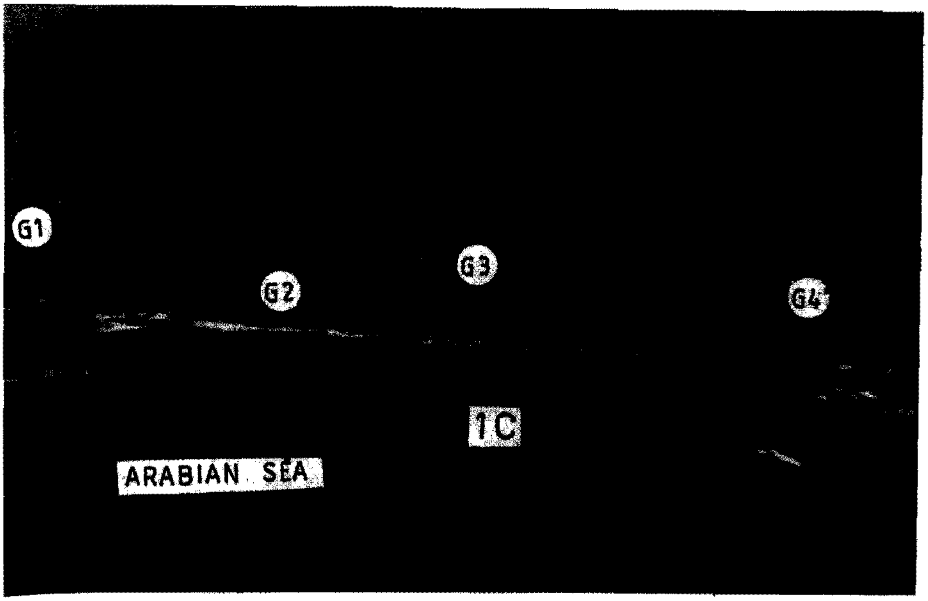

PLATE 1C. South of Gadani Hill.

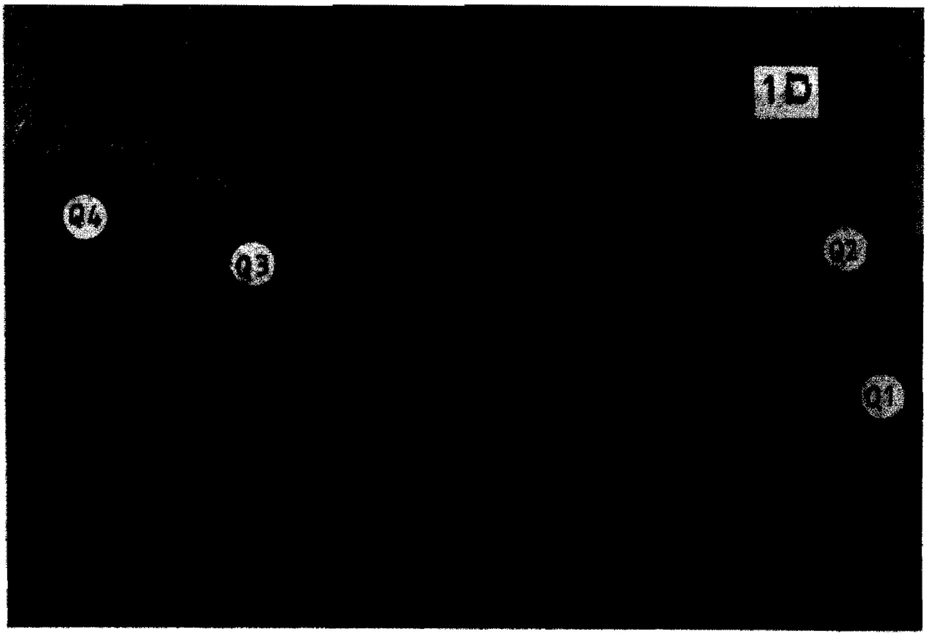

PLATE 1D. Village Qasim area.

in different parts of the Bela Ophiolites but the crustal sequence is better represented than the mantle sequence (Ahmed, 1992). The pelagic sediments found in association with the pillow lavas contain gabbroic and doleritic sills suggesting the former presence of volcanic seamounts formed on the oceanic floor at some distance from the spreading centre (DeJong and Subhani, 1979). The volcanic rocks of the Bela Ophiolites are of submarine origin and are older than Deccan Trap of the Indian Peninsula. The ophiolites appear to be more than one rock suite. Basalts of ophiolitic sequence are either pillowed or occur as flows.

Stockin (1977) has assigned a Santonian-Campanian to Paleocene age to the Bela Ophiolites, whereas Sarwar (1992), on the basis of a paleontological study suggests that the Bela Ophiolites were formed during Aptian-Maastrichtian time and emplaced during Maastrichtian to Lower Eocene (Allemann, 1979) or in the Paleocene (Dejong and Subhani, 1979).

The ophiolitic rocks present in the Gadani-Phuari area are according to Gansser (1979), the tail end of the Bela Ophiolitic Belt. Zaigham and Mallick (1994), on the basis of gravity studies, concluded that these rocks are the subsurface extension of the Bela Ophiolites. The aeromagnetic anomaly map of the area (Fig. 2) also shows the presence of rocks with aeromagnetic values of 140-175 nanotesla, which is of values for the main body of the Bela Ophiolites in the north. Magnetic data endorse the conclusions drawn from the gravity studies that these rocks are the southern-most part of Bela Ophiolites and are tholeiitic in nature. Ophiolitic rocks of the area consist of diabase, gabbro, basalt, pillow basalt and chert.

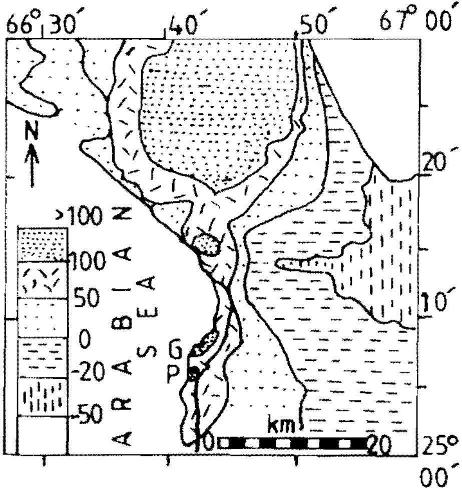

FIG. 2. Magnetic anomaly map of Gadani-Phuari and adjoining areas, Units are in Gamma = (nanotesla), G and P mark Gadani and Phuari Hills. (Redrawn from ASAL, 1981).

The rocks of the study area were previously described by Gansser (1979) as basalts and doleritic diabase. In the field, these rocks can only be classified into two groups as melanocratic and mesocratic rocks. The melanocratic rocks of Phuari area are aphanitic in texture, black in colour and form irregular discordant bodies within Parh Limestone. In the field, these rocks can only be identified as basalts. The ophiolitic bodies mark a clear contact with the underlying Parh Limestone (Plate 1A). The mesocratic rocks are medium to fine grained. The fresh rocks are greenish grey while the weathered rocks are pinkish. In these rocks, small laths of feldspars are clearly visible. The laths are fine, 2-3 mm in length and are irregularly distributed among the fine grained greenish black ferromagnesian minerals. Other mesocratic rocks are exosed south of Gadani. These are relatively large irregular bodies on the shore (Plate 1C) but their relation with Parh Limestone is not clear. Apparently, these rocks resemble fine grained-gabbro/ diabase with nearly a uniform character. Few small size volcanic bodies are exposed near Qasim village. These small bodies are slightly weathered and are surrounded by fragments of Parh Limestone, Khadro and Shirinab Formations (Plate 1D). The igneous and sedimentary rocks, exposed in the area, appear to be part of a tectonic melange.

Chemical Classification

The total alkali-silica (TAS) diagram, proposed by the IUGS for the chemical classification of volcanic rocks (Le Bas *et al.,* 1986 and Le Maitre, 1989) is used here for the classification of the volcanic rocks of the Gadani-Phuari area (Fig. 3). The raw chemical data (Table 1) indicate that the rocks of study area have undergone alteration, suffering various degrees of silicification, enrichment, depletion and redistribution of various elements. To avoid the effect of alteration, raw data are recalculated on anhydrous basis. It is also useful to recalculate the raw data to equivalent to 50% SiO_2

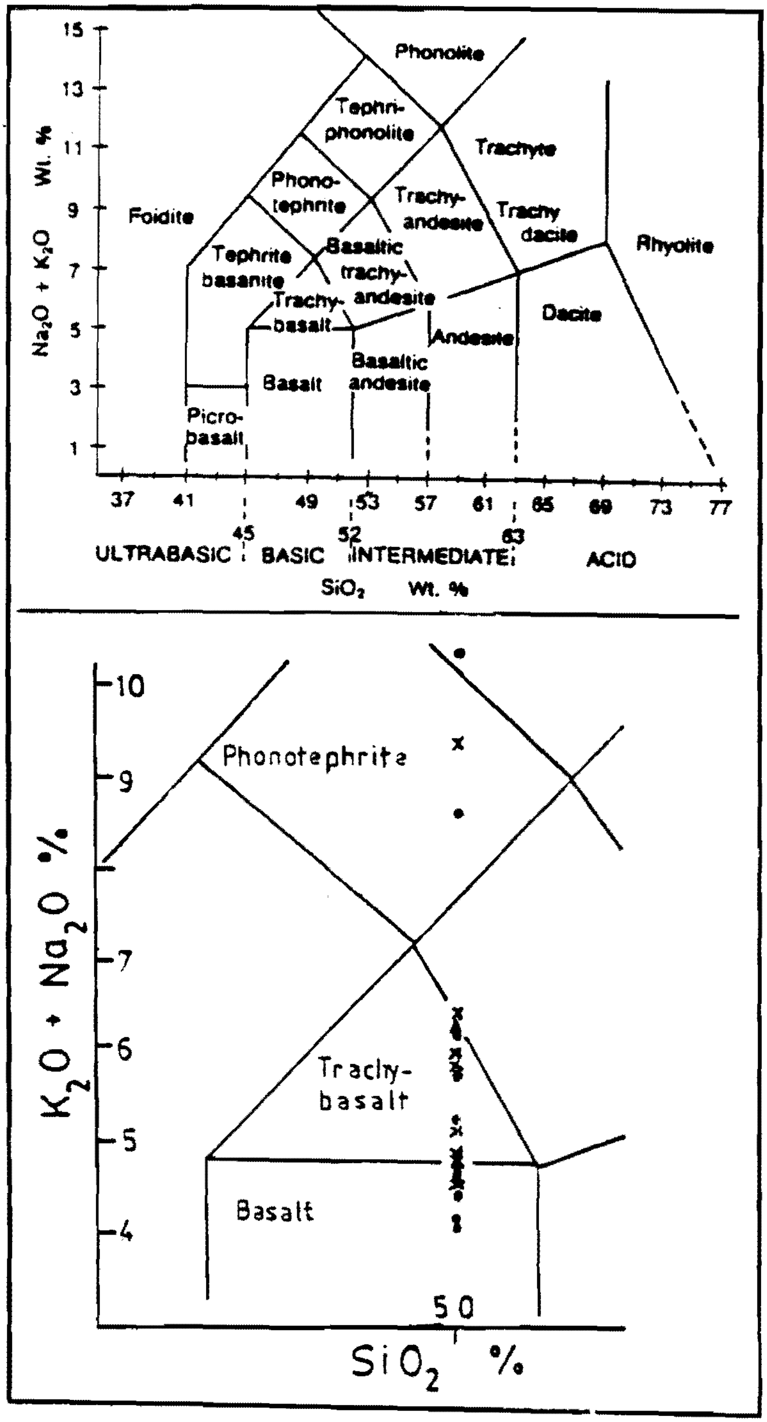

FIG. 3. TAS diagram of the studied rocks (after Le Maitre, 1989).
Solid circles = unaltered samples; hollow circles with dots = MgO depleted samples; cross = CaO depleted samples; and solid triangle = FeO depleted sample.

TABLE 1. Raw chemical analysis of Gadani-Phuari Ophiolites (wt. %).

Sample	SiO_2	TiO_2	Al_2O_3	Fe_2O_3*	MgO	CaO	Na_2O	K_2O	L.O.I.**
P 1	56.69	3.34	17.48	7.40	3.48	1.62	1.35	2.25	5.12
P 2	63.25	2.58	14.98	5.84	3.91	1.93	3.15	0.25	3.91
P 3	64.14	2.56	11.88	5.50	2.06	1.93	3.55	0.05	3.43
P 4	55.66	3.16	18.69	7.20	2.84	1.73	1.30	2.30	5.17
P 5	72.40	1.95	09.82	3.85	2.35	0.88	1.45	1.15	3.42
P 6	54.97	3.84	18.07	6.95	2.80	3.16	1.70	1.85	6.59
P 7	50.40	4.52	15.03	7.01	3.27	7.01	4.80	0.20	5.97
P 8	57.80	4.51	17.14	7.12	3.02	1.05	1.70	2.70	3.26
P 9	79.82	3.14	07.65	3.43	2.52	0.70	1.50	0.35	1.01
S 1	44.70	8.21	12.71	7.73	5.54	9.81	3.95	0.10	7.34
S 2	49.60	5.85	15.33	5.65	5.54	5.58	5.50	0.05	5.86
S 3	83.02	3.43	07.08	0.53	0.25	2.11	3.65	0.02	0.89
S 4	80.52	3.28	06.97	1.64	1.51	1.05	3.35	0.05	1.73
S 5	43.64	5.95	13.51	0.26	4.78	8.36	4.70	0.10	9.94
G 1	51.16	4.26	12.76	6.72	5.15	7.28	3.95	0.30	6.71
G 2	52.97	3.67	12.91	5.81	5.22	8.95	3.45	0.25	5.87
G 3	54.16	5.19	11.99	7.92	6.30	8.26	3.35	0.25	2.49
G 4	42.68	4.81	14.19	6.30	3.80	7.28	7.50	0.35	2.18
Q 1	46.06	5.35	12.19	6.72	7.40	9.93	3.85	0.50	7.74
Q 2	50.56	4.49	12.34	4.49	7.80	7.22	3.65	0.10	9.09

* Total iron

** Loss on ignition.

values assuming that the rocks have been diluted by an amount of $XSiO_2 = (2\ SiO_2$ anhydrous-100) and dividing each element in the analysis by the factor $(100 \times SiO_2) / 100$. Rock samples exhibiting very low values of $CaO + Na_2O < 12$, $MgO < 5$ and $FeO < 5$ are not taken into consideration. The recalculated data exhibit four categories with respect to alteration, *i.e.* unaltered, CaO depleted, MgO depleted and FeO depleted rock samples (Table 2). The plot of unaltered samples show that initially they are mainly basalts, while the recalculated data plots of altered and depleted rock samples indicate basalt, trachybasalt, and few phonotephrite rocks. The majority of the samples are alkaline; however, few samples show ultra-alkaline field (Fig. 3).

Geochemical Evidence for Tectonic Setting

The plots and diagrams of important elements reflect the composition, geochemistry, and tectonic affiliation of the igneous rocks of the area under study. Important element groups, such as immobile, incompatible, elements of high ionic potential, large ion lithophile elements, and high field strength elements, are widely used to classify and discriminate among various ophiolitic rocks emplaced in different tectonic settings.

Yagi *et al.* (1976), Wu and Wanming (1980), Gibson (1990) and Wanming (1992) have used SiO_2, vs., total alkalies ($Na_2O + K_2O$) relationship to demonstrate the composition of basaltic rocks into three main types, *i.e.* tholeiite, high-Al basalt, and alkali basalt. The plots of the rocks of the area under study show that they belong to the alkali basalts.

TABLE 2. Recalculated geochemical data for SiO_2 as 50% and on anhydrous basis.,(Major elements in wt.% and trace elements in ppm).

Sample	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	Cr	Ni
Unaltered samples										
S 1	50	8.54	13.22	8.04	5.76	10.20	4.11	0.10	120	85
S 2	50	6.72	17.62	6.49	6.36	6.41	6.32	0.05	145	75
G 1	50	5.26	15.78	8.31	6.37	9.00	4.88	0.37	100	25
G 2	50	4.55	16.03	7.21	6.48	11.11	4.28	0.31	130	50
G 3	50	5.99	13.85	9.15	7.28	9.54	3.87	0.28	40	30
Q 1	50	5.82	13.26	7.31	8.05	10.80	4.19	0.54	135	50
Q 2	50	5.59	15.39	5.59	9.72	9.00	4.55	0.12	365	85
CaO depleted samples										
P 1	50	4.52	23.67	10.02	4.71	2.19	1.82	3.04	225	170
P 2	50	3.95	22.94	8.94	5.98	2.95	4.82	0.38	265	165
P 3	50	4.64	21.57	9.98	3.74	3.50	6.44	0.09	300	190
P 4	50	4.24	25.10	9.67	3.81	2.32	1.74	3.08	135	60
P 5	50	4.52	23.67	10.02	4.71	2.19	1.82	3.04	225	170
P 6	50	5.00	23.54	9.05	3.64	4.11	2.21	2.41	120	65
P 8	50	6.05	23.01	9.55	4.05	1.40	2.28	3.62	120	85
P 9	50	8.13	19.82	8.89	6.53	1.81	3.88	0.90	360	285
S 4	50	9.18	19.52	4.59	4.22	2.94	9.38	0.14	165	140
MgO depleted samples										
S 3	50	10.04	20.73	1.55	0.73	6.18	10.69	0.05	235	75
G 4	50	5.43	16.04	7.12	4.29	8.22	8.47	0.39	175	85
P 7	50	5.40	17.96	8.37	3.90	8.37	5.73	0.23	25	75
FeO depleted sample										
S 5	50	7.89	17.93	0.34	6.34	11.09	6.24	0.13	55	45

K and other large-ion lithophile elements (LILE) are used to understand the petrologic evolution of convergent plate boundaries (Peccerillo and Taylor, 1976). Wanming (1992) has used K_2O, vs., SiO_2 relationship to elaborate volcanic rock association. Using this criteria also, the obtained data once again confirm the tholeiitic composition of these ophiolitic rocks. Generally, these rocks have low K_2O content which is indicative of oceanic tholeiite. Continental tholeiitic basalt contains K_2O (0.75-1%) (Radain *et al.*, 1988). Li-Zhaolin *et al.* (1994) show that the Na/K ratio of the alkali basalt in south China Seamounts between 4.4 to 3.1 is representing a composition close to continental tholeiite. Oceanic tholeiite has generally high Na/K ratio. The average Na/K ratio of the rocks under study is about 35 suggesting oceanic tholeiitic composition. Pillow lavas from Hokkaido, Japan are also rich in Na and poor in K (Yagi *et al.*, 1976) and show similar rock suite. The low K content tholeiite rocks of the area under study show relation with Bela Ophiolites which is E-type MORB (Sarwar, 1992). The Deccan and Porali basalts are within-plate basalts (WPB) and have no relation with the Gadani-Phuari volcanic rocks.

Low ionic potential elements (LIPE) are also used to discriminate among tholeiites from island-arc and ocean floor. Ocean floor tholeiites have generally less concentration of LIPE than island-arc tholeiites of similar silica content. High enrichment of LIPE is the characteristic of calc-alkaline subduction related basalts from intra-oceanic areas (Wood *et al.*, 1979 and Hole, 1988). Here, the low concentrations of K is used for depicting tectonic setting of the volcanic rocks of Gadani-Phuari area, which once again represent ocean floor tholeiites.

Immobile elements (Ti, Cr, V, Zr & Y) are least affected by weathering, alteration, and tectonic emplacement, and do not infrequently become mobile during above conditions. These elements also show higher degree of inter-element correlation, and, hence, their mutual plots can be of great importance in discriminating environments of ophiolite generation. However, the meta-volcanic rocks of the Arabian Shield show high mobility for Nb and Y, whereas, Zr and Ti show relatively moderate mobility during metamorphism (Al-Shanti *et al.*, 1989). It is important to note that the TiO_2 concentration in the unaltered samples is high (4.55 to 8.54%). The other analyzed samples also contain similar range of concentration. The possible reasons for such high enrichment is probably due to its low mobility. Possibly, these ophiolite rocks are generated by oceanic plume volcanic island derived sequence. Ti enriched in these rocks is probably due to melting of the mantle under anhydrous conditions. The idea of enrichment is also supported by the occurrence of Kop Ophiolites of the Eastern Pontian, Turkey, which are high Ti bearing alkaline-tholeiitic back-arc basin basalts (Bektas, 1987).

Pearce (1975) and Pearce and Wanming (1988) have used Ti-Cr discrimination diagram for the tectonic setting of the ophiolitic rocks. All the samples plot in the field of ocean floor tholeiite (Fig. 4). The unaltered samples show a wide range of Cr concentration for nearly close concentration of Ti. Ca depleted samples show enrichment of Cr due to differential leaching of these rocks. Ti and Cr show high compatibility with MORB. Ti/Cr vs. Ni discrimination diagram (Fig. 5) show a good demarcation between ocean floor and island-arc tholeiites. Wood *et al.* (1979) suggested that the ridge segments with positive residual gravity, depth, and heat flow anomalies (E type MORB)

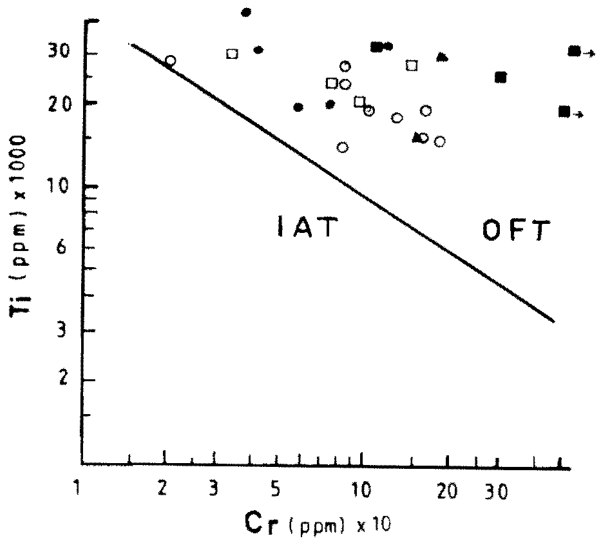

FIG. 4. Ti/Cr plot for the Gadani-Phuari ophiolites. Diagram from Pearce (1975). Symbols as Fig. 3.

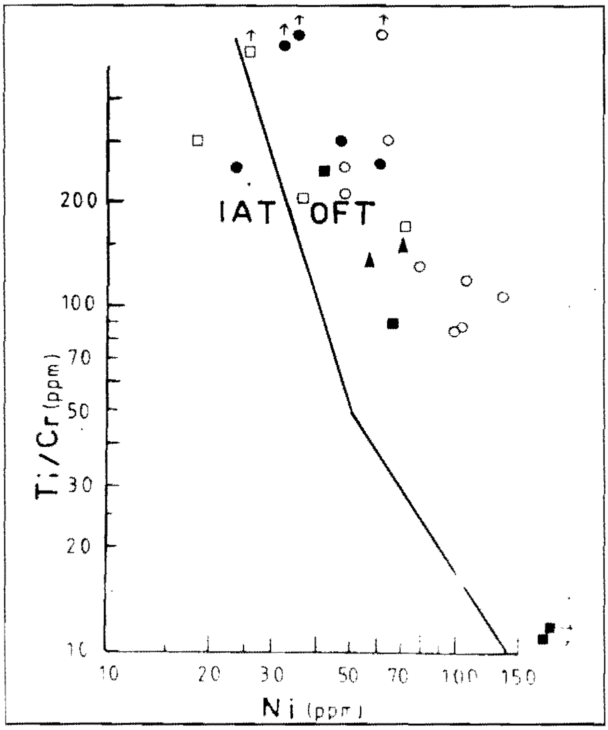

FIG. 5. Ti/Cr, vs., Ni plot for the Gadani-Phuari ophiolites. Diagram after Beccaluva *et al.*, 1979. Symbols as Fig. 3.

are enriched in hygromagmatophile element (HYG). The plot of Ti/Cr, vs., Ni of the rocks of Gadani-Phuari area also show a clear cut evidence of affiliation of these rocks with ocean floor tholeiite. Beccaluva *et al.* (1980) used the above plot for comparison with other Tethyan ophiolites. Sarwar (1992) has shown similar conclusion from the analysis of the volcanic rocks of Lasbela area by plotting Ti, vs., Cr and Ti/Cr, vs., Ni plots. From the two diagrams, *i.e.* Fig. 4 and 5, it appears that Ti, Cr and Ni are enriched in samples because of depletion of elements like Ca, Mg and Fe during leaching. The poor mobility of these elements may be another possible cause for their high concentration.

Triangular variation diagram between major elements like Fe + Ti, Al and Mg is also used to differentiate various tectonic environment in which the rocks are formed (Malapas and Langdon, 1984; Myers and Breitkopf, 1989). The plots of samples show tholeiitic field of ophiolite generation except sample No. S5 which is depleted in Fe and therefore it is plotted near the boundary of CAF (Fig. 6). In contrast to unaltered samples, the altered samples are depleted in Mg and slightly enriched in Al.

Geochemical Evolution of the Ophiolitic Rocks

MgO can be used as an index of differentiation when it is plotted against Cr and Ni

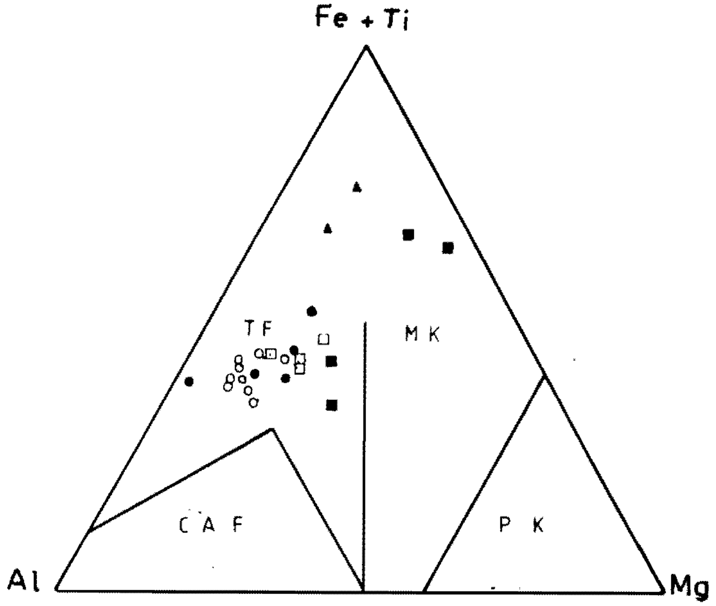

FIG. 6. Fe + Ti, Al and Mg variation diagram for the Gadani-Phuari ophiolites. Diagram after Malapas and Langdon, 1984. Symbols as Fig. 3.

(Fig. 7). The trends of these plots depict a precise petrographic modal and fractionation index of the ophiolitic rocks (Gibson, 1990). MgO, vs., Cr and Ni (Fig. 7) shows nearly similar trends of variation. Generally, tholeiitic rocks show incorporation of Cr and Ni during the crystallization of olivines and pyroxenes. It appears from the graph that all unaltered samples have relatively high percent of MgO (> 6%). The compatibility of Mg with Cr and Ni in the ophiolitic rocks probably indicates freezing of these rocks from direct mantle melts and simultaneously suggests their generation from magnesian precursor minerals. The altered samples show depletion of Mg and enrichment of Ni and Cr in the ophiolitic rocks. The plots of altered samples graphs show a linear relationship between MgO, vs., Cr and Ni. The Ca depleted samples show a wide variation whereas the Mg depleted samples have Cr or Ni concentration < 100 ppm.

Emplacement Model

The southern Tethyan ophiolites originated within the Arabian passive margin during Late Cretaceous. Continental lithosphere becomes thinner in an irregular way as the continent-ocean crust boundary is approached and crustal extension is assumed to occur by listric faulting.

A transform fault or fracture zone in the southern Tethys originated during Late Cretaceous, probably due to plate-bending stress caused by subduction of the Indian plate. This fracture zone was destroyed as transform movement progressively gave way to oblique convergence which culminated in ophiolite emplacement during Paleocene-

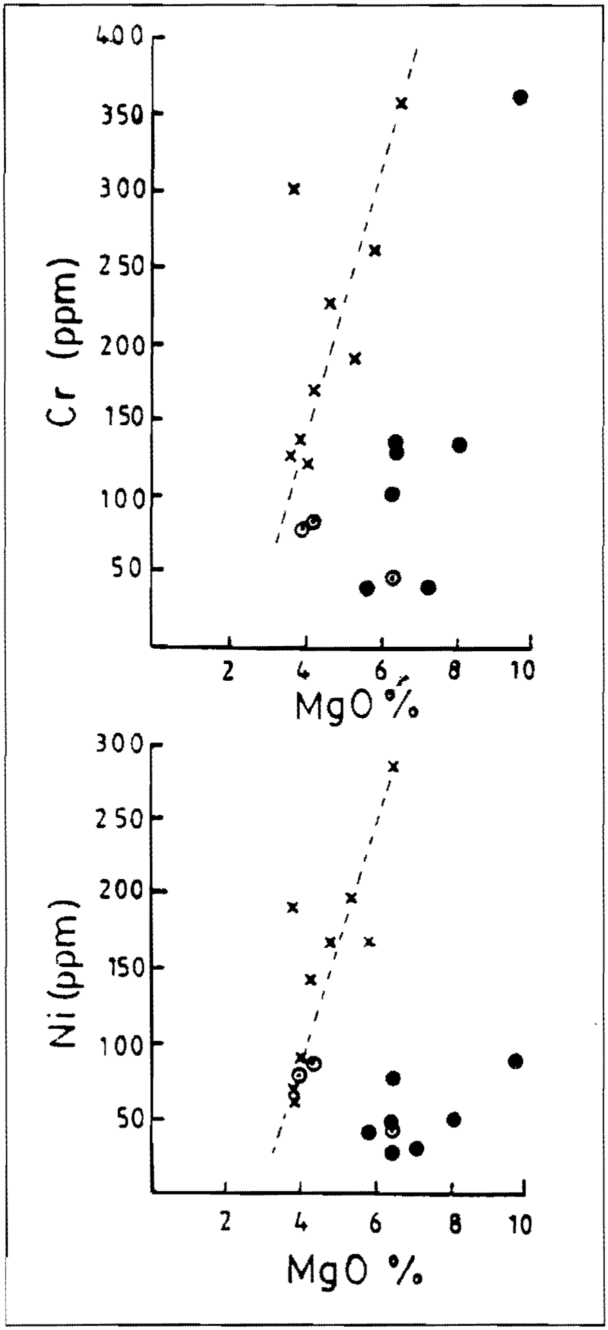

FIG. 7. Cr and Ni plotted against MgO as a fractionation index. Symbols as Fig. 3.

Early Eocene time (Sarwar, 1992).

Bela Ophiolites were emplaced on the continental margin of Indian plate just after their formation. The platform onto which these ophiolites were weakly deformed and composed of thick sequence of carbonate, *i.e.* Parh Limestone of Late Cretaceous. The overlying sediments of Khadro Formation are either contemporaneous or post emplacement (Fig. 8). Woodcock and Robertson (1984) have discussed the structural varieties in Tethyan ophiolites. The characteristics of the different units of ophiolites and their structural styles suggest "dip-slip emplacement model" for the Bela Ophiolites.

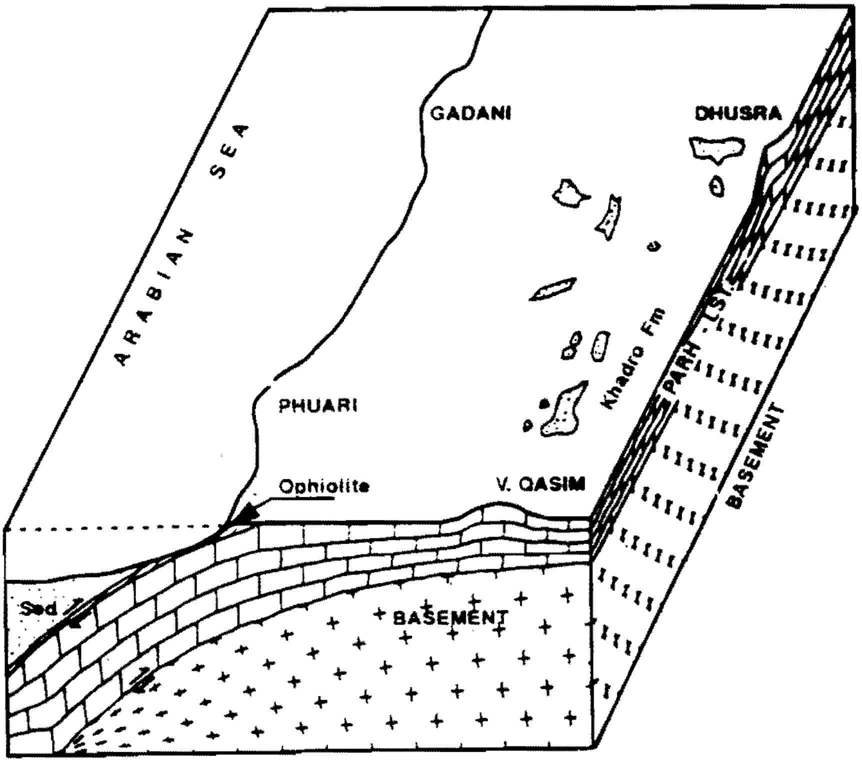

FIG. 8. Sketch model for the emplacement of Gadani-Phuari ophiolites.

Conclusion

1. Chemical classification of igneous rocks (TAS diagram) of Gadani-Phuari area suggests alkaline field. Most of the unaltered samples are basalts, and trachybasalts. The other altered samples also show nearly similar composition with depletion of Ca, Mg and Fe. It appears that initially they were basalts, but due to alteration and depletion they show variation in composition. Recalculation of the geochemical data

made it possible to reach a justifiable conclusion.

2. The low K and high Na/K ratio indicates oceanic tholeiites; low concentration of other large ion lithophile elements also suggests similar composition.

3. Immobile elements and their ratio plot such as Ti-Cr and Ti/Cr-Ni discrimination diagrams (Fig. 4 & 5) also correspond to ocean floor tholeiites.

4. The discrimination diagrams further suggest that the ophiolitic rocks of Gadani-Phuari area are related with ridge system and they are close to E-Type MORB or back-arc-basin (BAB) derived ophiolites. This emphasizes that these ophiolites have no relations neither with Deccan trap nor Porali Intrusion. Both of them are within-plate basalt (WPB), and are younger in age. Also, the lateral extension of Deccan trap does not reach upto the area under study.

5. A "dip-slip emplacement" of the ophiolites of Gadani-Phuari is presented in Fig. 8. The obduction took place in Neo-Tethys along the transform boundary onto the carbonate (Parh Limestone) continental margin sometime between Maastrichtian to Lower Eocene. This obduction/emplacement resulted due to oblique convergence of Indian Plate below oceanic crust.

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جيوكيمياء والوضع التكتوني لقطاع جاداني - فعاري لأوفيوليت بيلا ، بالوجيستان - باكستان

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المستخلص . تمثل الصخور البركانية الموجودة في منطقة جاداني - فعاري ، لاسبيلا - بالوجستان جزءًا في أقصى الجنوب لبقايا أوفيوليت بيلا . وتوجد في منطقة لاسبيلا مجموعتان من الصخور النارية من العصر الكريتاوي :

المجموعة الأولى هي صخور أفيوليت بيلا ذات طبيعة منقولة ولا ترتبط بالمجموعة الثانية ، أي إن متداخل بورالي الذي يكافئ مصيدة الدكان (Deccan Trap) يمثل بازلتًا بين الألواح الحديثة .

يوجد الجزء الجنوبي لمظاهر صخور أوفيوليت بيلا متناثرًا في منطقة جاداني - فعاري غرب كراتشي . وقد تم استخدام تحليل العناصر الأساسية والشحيحة لعشرين عينة مختارة لتقييم هذه الصخور . إن التغير في العناصر القلوية مع السليكا في الصخور البركانية يدل على أن معظم هذه الصخور من البازلت القلوي والتراكي ، في حين يشير اتجاه تغير بعض العناصر الأساسية والشحيحة الأخرى إلى أنها من نوع الثولييت المنخفض البوتاسيوم ، والذي اشتق من مصدر مشابه لبازلت حيود وسط المحيط من نوع هـ (E-Type) وقد وضعت صخور الأفيوليت هذه على الحافة الغربية للوح الهندي أثناء وقت المستريخي إلى الأيوسين الأسفل .