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Lithogeochemical Prospecting Through Stream Sediments in Bela Ophiolite of Lasbela Area

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ABSTRACT. Lithogeochemical investigation of sediments of active streams draining through Bela Ophiolite, from Lasbela area are presented. This area consists mainly of ophiolites associated with sedimentary rocks of Jurassic-Cretaceous age. Quantitative examinations of important immobile elements such as Fe, Mn, Ti & Cr, and semi-mobile to mobile like Zn, Cu, Ni and Co have been carried out. These elements have anomalous concentrations in fine stream sediments in certain regions. An attempt is made to demarcate the areas of possible occurrences of ore mineralization associated with the Bela Ophiolite based on statistical analysis of the geochemical data.

Statistical analysis and plots of data were employed to evaluate the distribution and interrelationship of these elements and coefficient of variation and correlation coefficients were calculated. The suitability of the methods is discussed in relation with the arid climatic conditions of southern Balochistan and the local geology.

Introduction

Methods of prospecting for mineral and ore deposits through stream sediments using lithogeochemical techniques are being successfully employed in different parts of the world. Sampattavanija (1963), Bloomfield *et al.* (1971), Beeson (1984) and Hashimi (1986) have studied and used stream sediments for prospecting. Wahid (1963), Siddiqi (1976) and Bozdar (1982) emphasized the application of geochemical prospecting methods in Pakistan to exploit esoteric mineral deposits.

Stream sediments are derived from the weathering of rocks and are dispersed in stream channels. Commonly, the stream sediments include unaltered primary minerals, altered minerals, precipitated materials and adsorbed elements (Rose *et al.* 1979). The dispersion of immobile and semi-mobile elements such as Ti, Cr, Mn, Fe, Sn, W, Zr, Nb, Ba and Be is best studied from stream sediments.

Stream sediments drainage surveys are by far the most widely used methods in regional reconnaissance, notably in Africa, south-west Pacific, and south-east Asia. In arid climates, stream sediments can provide good results for prospecting mineral and ore deposits, where the development of anomalies in stream sediments are more stable than in water, due to less mobility of certain trace elements.

The area under study consists mainly of ophiolitic rock assemblages of early Cretaceous age associated with sedimentary rocks of Jurassic to Cretaceous age (Sarwar 1992). Nearly all segments of ophiolites are developed and well exposed in the area. Geologically, this area has good potential for the enrichment of metalliferous deposits, but it needs proper prospecting. Fe, Cr, Mn, Cu, Zn, Ni, Pb and Co may form ore concentrations in ophiolite sequences (Kearey and Vine 1990). It is already known that Mesozoic carbonates in the vicinity are hosts for lead, zinc, and barite in the terrain (Ahsan & Mallick 1992), while Ahmed (1975 & 1989), Naseem and Mallick (1992) and Azam *et al.* (1988) reported a few manganese and zinc deposits and showings of copper and chromium in the region.

The present study deals with reconnaissance lithogeochemical survey and prospecting of ore deposits in the southern Bela Ophiolite in Lasbela area, Balochistan. The purpose of present investigation is to establish the importance and application of stream sediments of the area for the search of mineral and ore deposits. Also discussed are the local geology, rock types, drainage system, and climatic conditions of the area.

Geography

The area has a highly rugged topography due to intense deformation, uplift, and erosion of the rocks. The eastern half of the study area contains undulating mountains, hills, and mounds, forming a ridge and valley system striking about north-south. The western half of the area is covered by subrecent to recent material. The topography ranges from 20 metres above sea level in the southern part of the area, to 1448 metres in the north-eastern corner. The drainage is subparallel to dendritic and flows from southwest to south. Small streams are intermittent and seasonal, while the large ones have limited perennial flow. Most of the small streams diminish in flow before reaching the main drainage of the area. The overall climate is extremely arid and characterized by high temperature and very low precipitation. The annual rainfall is less than 10 cm, which is capricious and uncertain.

Geology of the Area

Geologically, the area under study lies within the southern Axial Belt of Pakistan (Fig. 1). The general stratigraphic sequence of the area comprises sedimentary rocks of Jurassic-Cretaceous age in association with the Bela Ophiolite which was

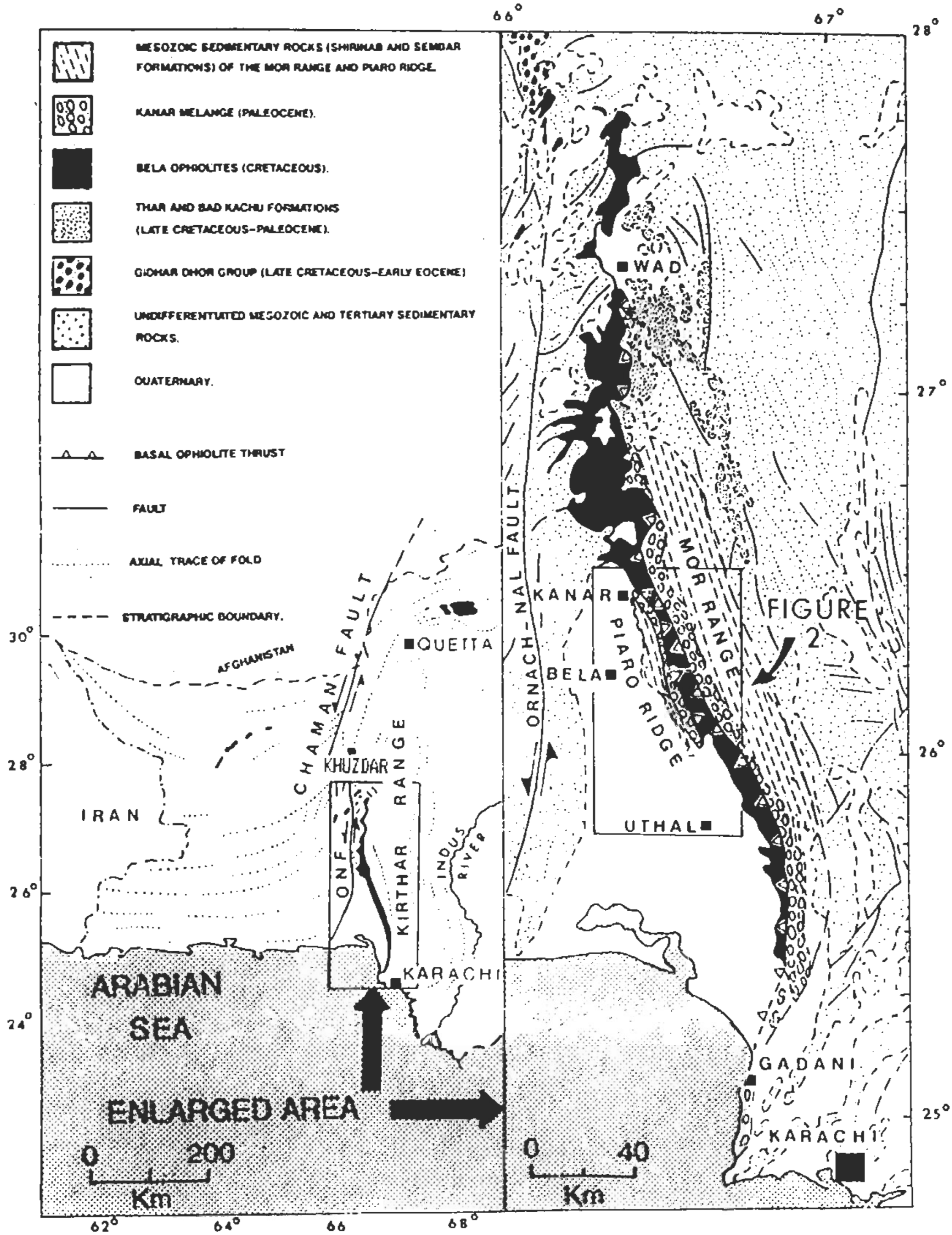


FIG. 1. Geologic map of the Bela ophiolites belt (After Sarwar, 1992).

emplaced in the sedimentary rocks during the Cretaceous (Sarwar 1992). The Bela ophiolite is exposed in a narrow elongated belt striking north-south. The belt is about 380 km long from Uthal to Khuzdar, and 12 km wide. It is bounded in the west by the Ornach-Nal fault system which is the active western tectonic boundary of Indo-Pakistan subcontinent. In the eastern part, the Shirinab and Sembar formations are exposed (Fig. 1). The Bela Ophiolite is the continuation of southern branch of the main Himalayan Ophiolitic Belt in southern Balochistan and continues into the Arabian sea where it reportedly joins the Murray Ridge and the Owen fracture zone (Afridi 1992). The ophiolitic sequence consists of basaltic pillow lavas, and associated sedimentary rocks such as pelagic limestone, argillite, and chert. Debris of serpentinites (up to kilometer-sized blocks), serpentine-carbonate breccia, and less commonly basalt, gabbro, peridotite, and pelagic limestone and their metamorphic equivalents occur throughout the ophiolite sequence (Sarwar 1992). The upper part of ophiolitic sequence is exposed in this area, while the deeper oceanic crust part is exposed in the northern area.

In the study area (eastern part of southern Axial Belt), the Bela Ophiolite is exposed as a sandwiched wedge within the Shirinab formation of Jurassic age (Fig. 2) forming a tectonic contact (Ahsan *et al.* 1988). The Parh and Goru formations of Cretaceous age are missing in the area and only the Sembar formation represents Cretaceous strata. Major stratigraphic units recognized in the Lasbela area are shown in Table 1.

The Shirinab formation consists of carbonates with subordinate amounts of clastics. The rocks exposed in the western part of the area belong to the upper part of the formation comprising interbedded limestone and shale units. They increase in clastic contents upward and grade into olive green shales of the Sembar formation.

The Sembar formation is a monotonous sequence of interbedded shale and mudstone. Its contact with the underlying Shirinab formation is gradational over a few meters and marked by barite-rich nodules. The upper contact of the Sembar formation is with allochthonous clasts generally derived either from the Shirinab formation or the ophiolite.

The rocks of the Lasbela area have been found to be more promising for the concentration of economic minerals. Naseem and Mallick (1992), Abbas (1980), Ahmed (1975) and Ali (1971), reported several manganese mineralized zones associated with pillow basalt and pelagic sediments. Ahsan and Mallick (1992) and Azam *et al.* (1988) have shown the presence of lead, zinc, and barite associated with the Shirinab formation.

The Influence of Local Factors on Concentrations

Several local factors influence the concentration and distribution of different elements in stream sediments. Local geochemical environments also control the application of this prospecting method.

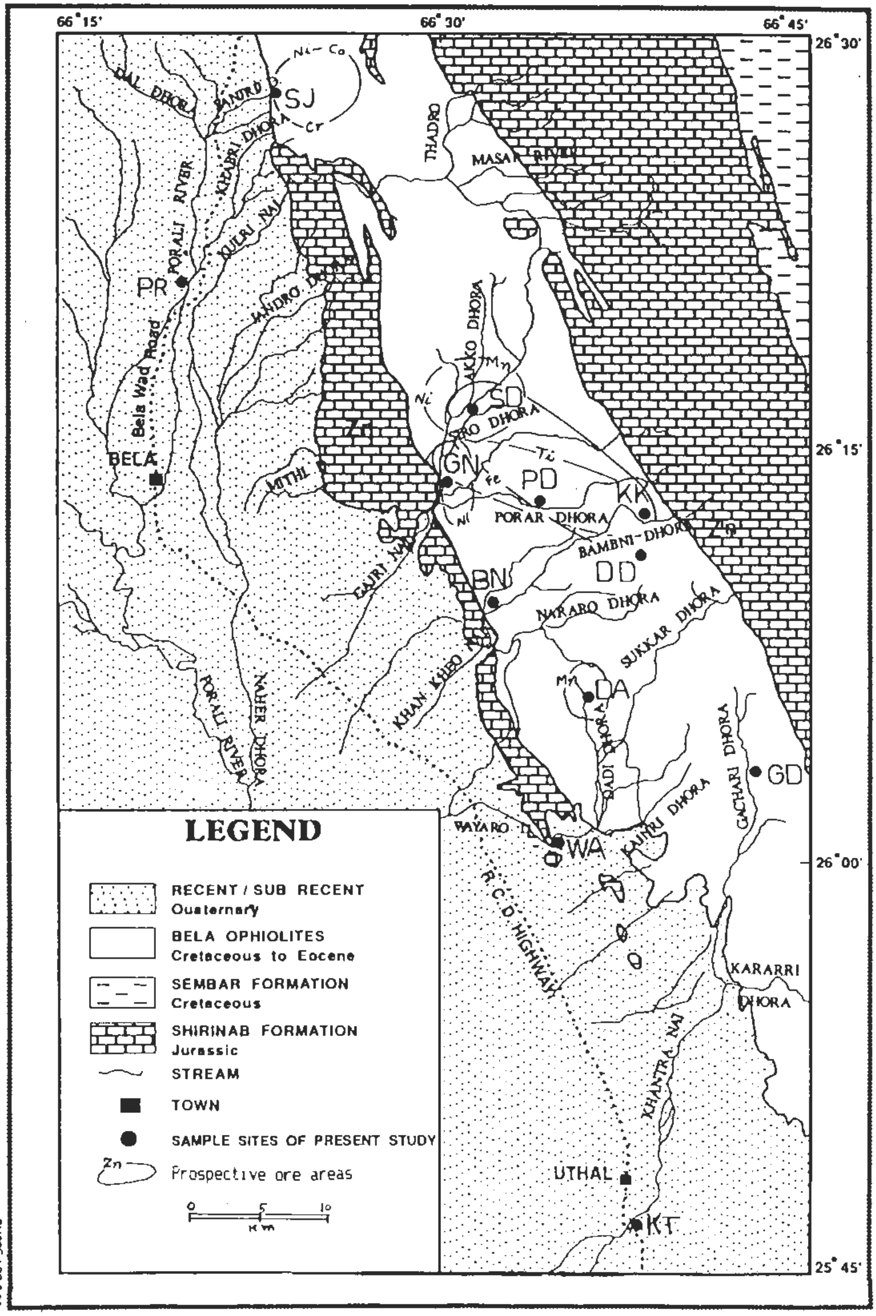


FIG. 2. Geological map of the area under study showing sample locations and prospective areas for different metallic deposits (Modified after H.S.C., 1960).

TABLE 1. Schematic stratigraphic sequence of the formations exposed in the area under study and its vicinity (After Iqbal, and Shah 1980).

ERA	PERIOD	FORMATION	DESCRIPTION
CENOZOIC	QUATERNARY	RECENT / SUB RECENT DEPOSITS	Undifferentiated Piedmont, Subpiedmont, Alluvium, and Stream Deposits
	TERTIARY	HINGLAJ FORMATIONT	Mainly Sandstone With Subordinate Conglomerate, Shale And Argillaceous Limestone
MESOZOIC	CRETACEOUS	BELA OPHIOLITE (Emplacement Age)	Tectonites, Ultramafic Cumulates; Doleritic Dyke Complex; Pillow Basalt Interbedded With Pelagic Sediments; Gabbro at top
		PAB FORMATION	Medium to Coarse Grained Sandstone With Minor Interbedded Shale
		PARH FORMATION	Lithographic Limestone With Minor Intercalation Of Marl
		GORU FORMATION	Limestone Interbedded With Marl And Shale
		SEMBAR FORMATION	Shale And Interbedded Siltstone / Mudstone With Minor Argillaceous Limestone
	JURASSIC	SHIRINAB FORMATION	Thick To Thin Bedded Limestone Subordinately Interbedded With Shale and Sandstone; Hydrothermal Mineralization of Lead and Zinc

In the area under study, lithogeochemical prospecting through stream sediments is advantageous because of the prevalence of small streams. These streams (locally known as dhora) collect weathering products originating very near to the parent ore deposits. In such systems of small streams homogeneity in the lateral sense is not progressively developed, and this favours the well defined and true development of an anomaly (Rose *et al.* 1979). Chemical weathering of rocks is not significant in the area because of the scarcity of rainfall. Hence, limited transportation of weathered material in stream channels only occurs during infrequent rainfalls. Stream sediments are mostly immature and mainly of coarse sand and a finer calcareous matter (up to 30 percent). Fine fractions are less than 5 percent in general.

Location and Collection of Samples

The area is accessible from Karachi by the RCD Highway (Fig. 1). Stream sediment samples were collected along different seasonal streams around Uthal and Bela in Balochistan. The sample collection sites are located on the geological map of the area (Fig. 2). Nearly all sites are accessible by four-wheel drive vehicle. The sample localities were selected keeping in view the nature and type of bedrock and the drainage system of the area. The sampling was done from first (Porali River) and second (locally known as nai) order streams and second and third order streams (locally known as dhora). Therefore, the samples collected represent all the rocks present in the area and can depict any anomalous change in trace element concentration and dispersion up-stream (Hinkle 1988).

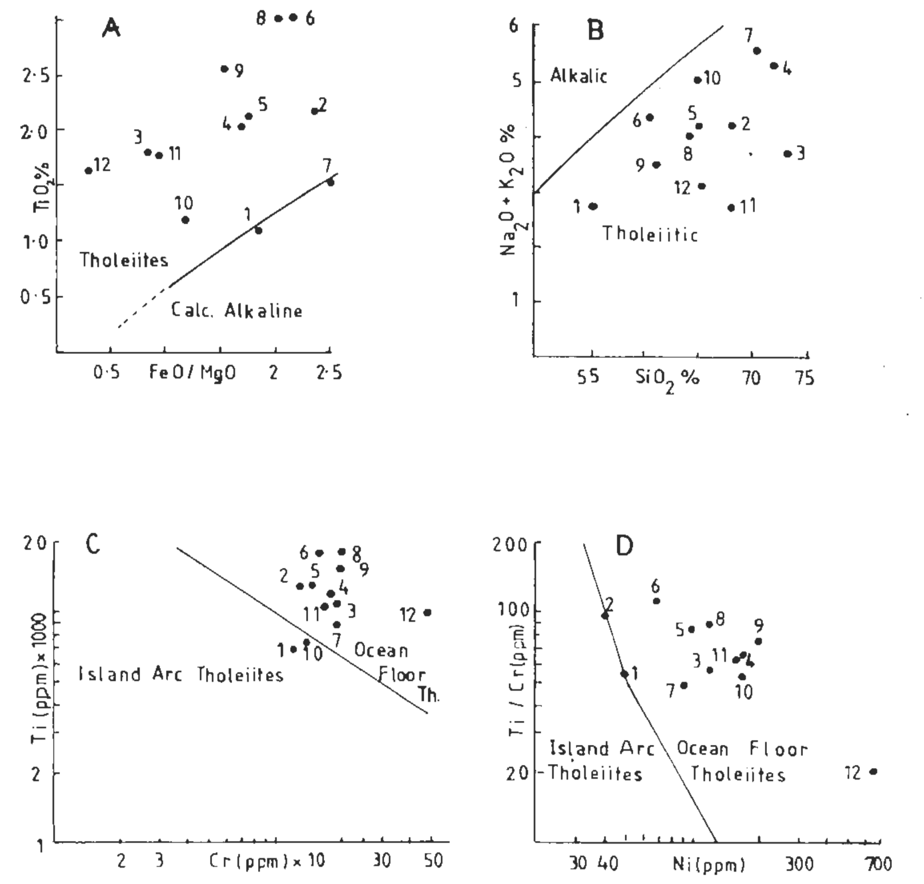
Sample Preparation and Analytical Method

The collected samples were dried in the oven at 105°C and sieved through 80-mesh screen. The minus 80-mesh fraction was selected and pulverized for chemical analyses. A one-half gram portion of the sample was treated with concentrated perchloric and nitric acids, with a ratio of 7:3. After heating to dryness, the residue was leached with 20 ml of 6M HCl by boiling for ten minutes and diluted to 100 ml (Ajayi 1981). Estimation of individual elements was made from this aliquot using an atomic absorption spectrophotometer (Hitachi Model No. Z-8000) as described by Johnson and Maxwell (1981).

Geochemistry of the Rocks

Miyashiro (1975), Pearce (1975), Coleman (1977), Beccaluva (1979), and Rollinson (1993) have used plots and ternary diagrams to categorize different segments of the ophiolite in different parts of the world. Stream sediments are the products of several rocks, through which the stream is running, these represent a rock clan rather than a particular rock type. Though stream sediments are affected from up stream dilution, maturity, depletion of mobile and concentration of immobile elements, their plots are of great significance. In the present study, the plots of major and trace elements of stream sediments reflect the nature and geochemistry of the Bela Ophiolite.

The range of FeO*/MgO is 0.31 to 2.52 with TiO_2 as 1.13 to 3.06 (Fig. 3A). Nearly all show tholeiitic composition. This also shows a slow increase of Si (Fig. 3B) followed by decrease in FéO and TiO_2 with increasing FeO/MgO. This pattern is characteristic of the tholeiitic series (Miyashiro 1975).



LEGEND

Numbers	1	2	3	4	5	6	7	8	9	10	11	12
Localities	KT	GD	WA	DA	BN	KK	DD	PD	GN	SD	PR	SJ

FIG. 3. Plots of major and trace elements from different stream sediments of Lasbela area.

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*Total iron.

The plot of total alkalies versus silica (Fig. 3B) is also helpful in discriminating tholeiitic and alkaline rocks (Coleman 1977). Tholeiitic rocks are poor in total alkalies and the stream sediments show 2.66 to 5.52% total alkalies indicating tholeiitic rock exposure in the study area. The Al_2O_3 content is poor (2.69 to 12.94) and indicative of low alkali feldspar bearing rocks in the area.

Pearce (1975) used Ti versus Cr plot to differentiate ocean floor tholeiite from island arc rocks. The plot of Ti versus Cr of stream sediments of the area also indicates that these rocks belong to ocean floor tholeiites (Fig. 3C). Sarwar (1992) also showed similar conclusion from the analysis of the rocks of the same area by plotting Ti/Cr versus Ni. The same plot of the study area (Fig. 3D) also confirms that these rocks belong to ocean floor tholeiites.

Geochemical Studies and Prospecting of Ore Deposits

The geochemical investigations of stream sediments in various localities in the southern Bela Ophiolite were carried out to explore the influence of the bed rock on compositional variations (Fig. 4). Efforts were made to determine the degree of correspondence and interrelationship among selected immobile and mobile elements, and to present these in a graphical form (Fig. 5 and 6). These plots proved to be of great assistance in the study of possible causes of enrichment and depletion of elements and their distributional patterns in different localities. Prime importance was given to locate possible areas of mineralization, in contrast to background values given by Reedman (1979). The results of the study are discussed in relation to individual and groups of elements of similar geochemical affinity, in the light of bed rock composition, mobility of elements, weathering, drainage, climatic conditions, and their abundance in stream sediments.

Iron, Manganese, Titanium and Chromium

These are lithophile elements and have very low mobility in arid climatic conditions. In stream sediments, the abundance of Fe ranges between 2 to 5 wt %. In the area under study, Fe ranges from 1.64 to 7.81 % (Fig. 4) with a mean of 4.42 (Table 2). Its distributional pattern among the different localities shows a higher concentration in Kokalo (KK), Porar (PD), Siro (SD) and Bhampani Nai (BN) (Fig. 4). In these localities pillow basalt is exposed, which at Siro shows up to 40% Fe. Sanjro Dhora (SJ), Khantra Nai (KT), Wayaro Dhora (WA) and Porali River (PR) localities have relatively low concentrations, probably owing to relatively large streams and excessive weathered material. The interrelationship between Fe and Mn, Ti, Ni & Cr is shown in Figure 5. Cr and Ni exhibit a similar relationship with Fe, both having similar distributions in high and low Fe-bearing localities. Ti forms a roughly linear pattern with Fe, Mn plots as two distinct populations, and some localities (KT, SJ, PR, WA, & DA) have high Ti and low Mn with same background of Fe.

The plots of Fe/Mn, Ti/Mn, and Fe/Ti ratios are given in Figure 6, exhibiting fluctuating patterns in different localities. The plots of Fe/Mn and Fe/Ti show similar dis-

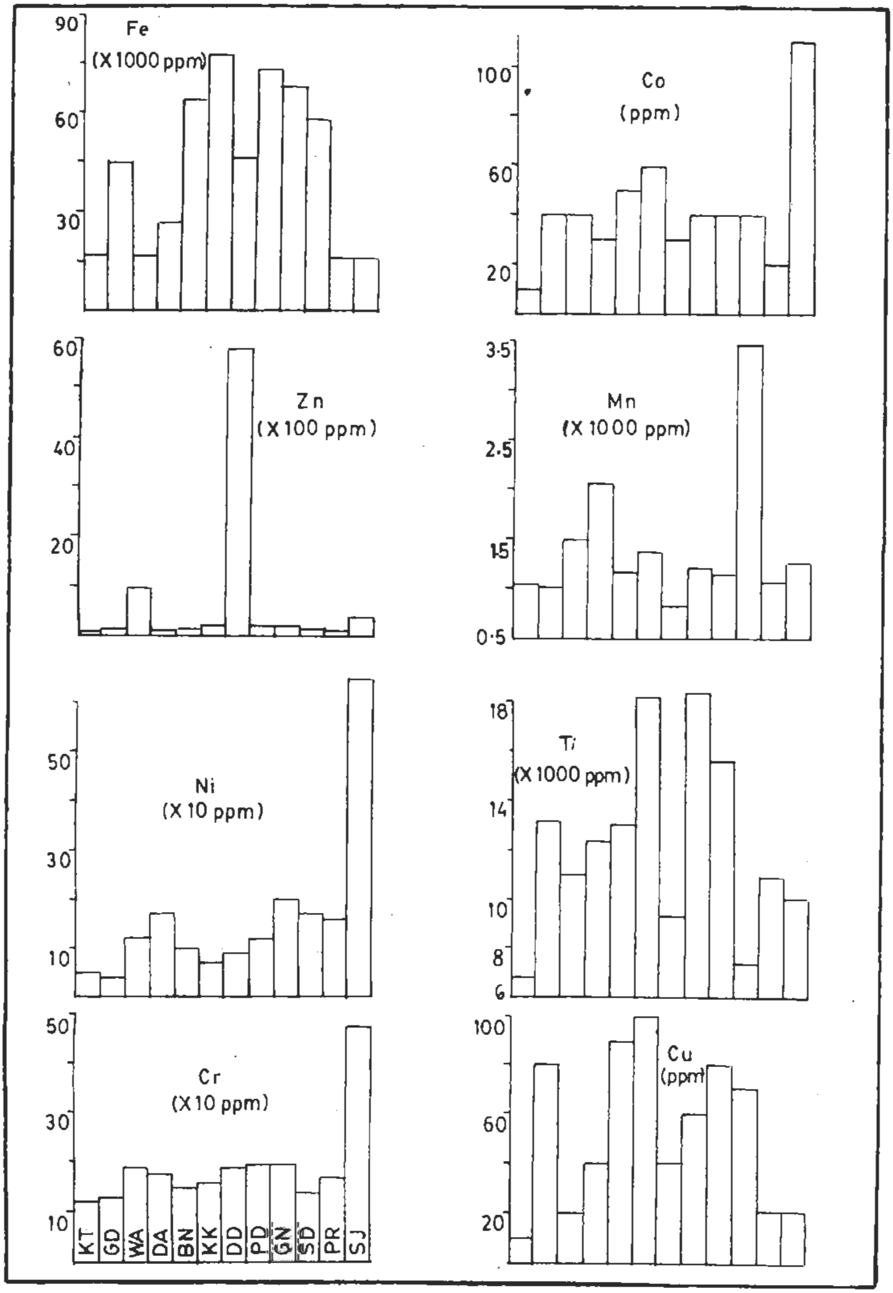

FIG. 4. Showing concentration of various elements in different stream sediments of Lasbela area.

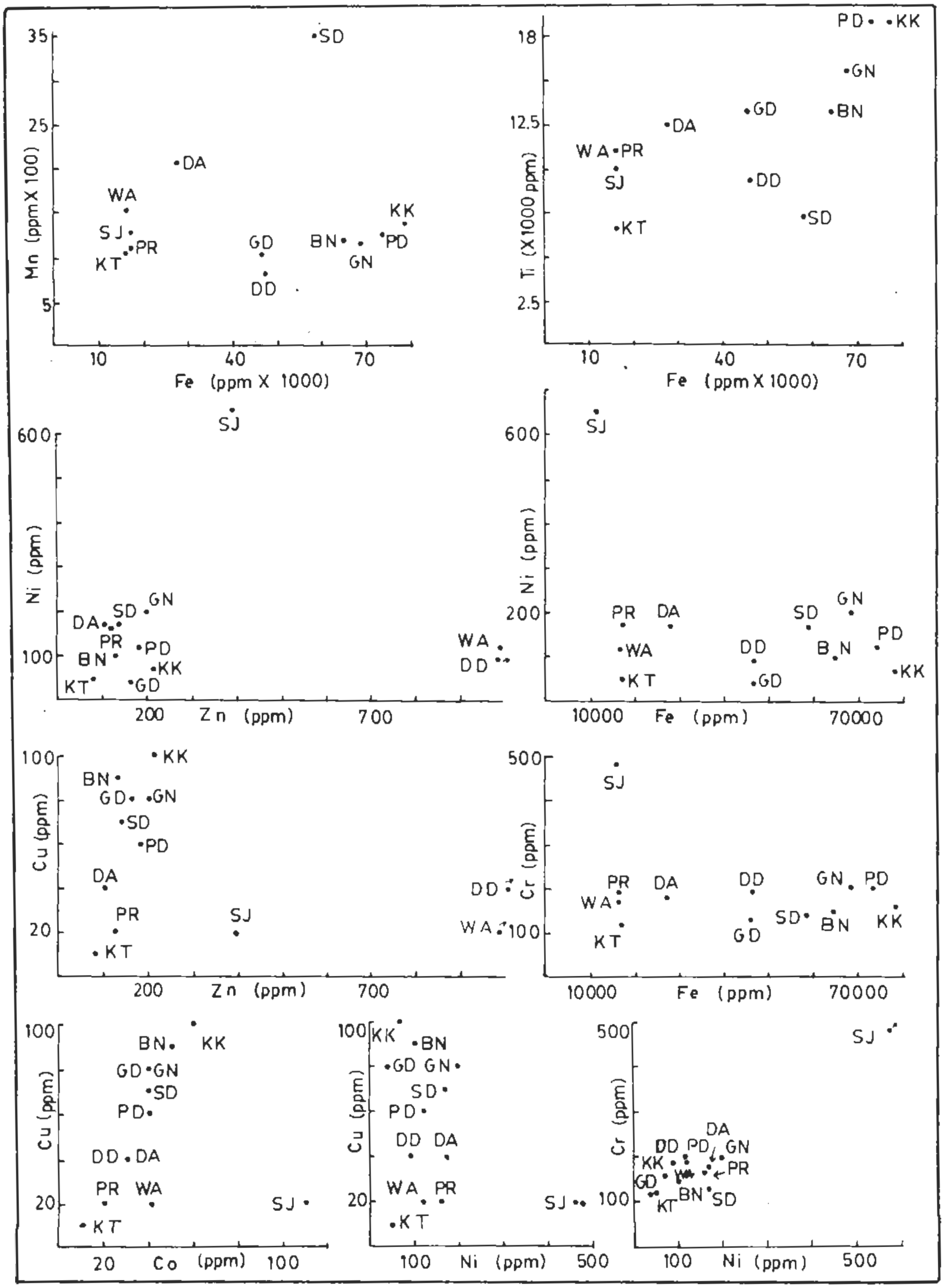

FIG. 5. Showing degree of correspondence among various elements in the stream sediments of Lasbela area.

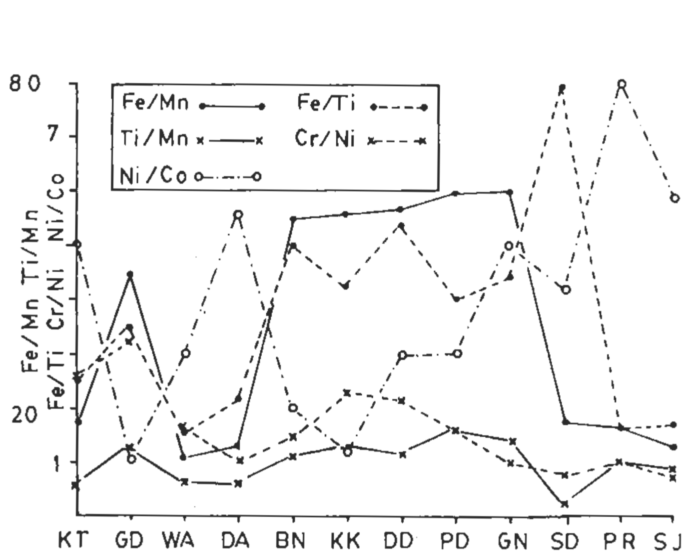

FIG. 6. Showing variation in the ratio of various elements of different stream sediments of Lasbela area.

TABLE 2. Basic statistical data of trace elements in stream sediments of Lasbela area.

Element	Mean (ppm) (X)	Standard deviation (S)	Coeff. of variation (C.V)
Fe	44,225	23,374	0.528
Mn	1,438	690	0.480
Ti	12,217	3,646	0.298
Cr	192	90	0.470
Zn	708	1,553	2.193
Cu	52	30	0.572
Ni	162	155	0.958
Co	42	24	0.561

tribution patterns for various localities. This mostly indicates the presence of basic rocks in the area.

The range of abundance of Mn in stream sediments is 100 to 500 ppm (Reedman 1979). Although the area is famous for manganese mineralization (Nassem and Mallick 1992, Abbas 1980, Ahmed 1975, Ali 1971), the upper limit of 5000 ppm was not reported from any locality. The graph shows anomalous concentration of Mn at Dadi (DA) and Siro Dhora (SD). Other localities show a uniform background of Mn (1170 ppm). This indicates a combination of bed rock, poor chemical weathering, and very low mobility of Mn due to the arid climate of the area. The plot of Mn versus Fe (Fig. 5) shows a uniform distribution of Mn irrespective of Fe concentration, except at Dadi (DA) and Siro (SD).

The range of Ti in stream sediments is between 500 to 10000 ppm. Except Khantra (KT), Draoari (DD) and Siro Dhora (SD), all the samples have over 10000 ppm Ti (Fig. 4). Gajri (GN), Kokalo (KK) and Porar (PD) localities show relatively high Ti concentration and these can be considered as areas of high titaniferous rocks (Fig. 2). The ratio of Ti/Mn shows a smooth pattern for all localities except Gacheri (GD) and Si (SD). The maximum Ti/Mn value was noted in Porar (PD) and the minimum (2.12) in Siro (SD).

Chromium has a 5 to 1000 ppm range in the stream sediments. Reedman (1979) considers more than 1000 ppm Cr as anomalous. Only Sanjro (SJ) has relatively high Cr (480 ppm, Fig. 4), whereas all other localities range between 120 to 200 ppm. These lower values are due to ultramafic rocks which are widely exposed in the area, and are most probably related to the lowermost segment of the ophiolite. The ratio of Cr/Ni shows similar pattern as of Ti/Mn for different localities (Fig. 6).

Zinc, Copper, Nickel and Cobalt

Zinc, copper and cobalt are chalcophile elements while nickel is siderophile. Under normal conditions these elements are mobile but their mobility decreases due to absorption by organic matter or they are scavenged by iron and manganese oxides. The range of abundance of Zn in the stream sediments is 10 to 200 ppm. The Draoari (DD) locality shows an anomalous concentration of Zn (5800 ppm), and also Wayaro (WA) and Sanjro (SJ) are higher than average (Fig. 4). In the area of the present investigation, the Shirinab formation is exposed on either side of Bela Ophiolite and serves as the host rock for Zn. The high concentrations of Zn at Draoari (DD) and Sanjro (SJ) are most probably caused by the eastern exposures of the Shirinab limestone-bearing formation which contains hydrothermal Pb-Zn mineralization (Azam *et al.* 1988). Sample WA (Wayaro) was collected from Wayaro stream running close to the western exposure of the Shirinab formation (Fig. 2), which represents the one truly anomalous zone in Zn in the area under study. Akhter *et al.* (1989) also demarcated many anomalous zones of Pb and Zn in this area.

The plots of Zn against Cu and Ni show narrow spreads (Fig. 5). Except for Draoari (DD), Wayaro (WA) and Sanjro (SJ); all other localities have close values of enrichment of Ni and Cu against Zn. It is to be noted that the distribution patterns of Zn vs. Cu, Cu vs. Co and Cu vs. Ni are very similar, whereas Zn vs. Ni and Ni vs. Cr also show similar but different clustering patterns. These indicate two distinct sets of elements. The first represents a wide scattering distribution of mobile Cu and Zn against less mobile elements. Copper shows differential leaching at different localities, hence its concentration varies between 10 to 100 ppm. The second set, Ni and Co, shows consistent enrichment, except for a few localities, indicating their similar geochemical behaviour and lack of appreciable leaching.

The general range of copper in stream sediments is from 5 to 80 ppm, and over 100 ppm is considered anomalous. In the stream sediments in the study area, Cu ranges from 10 to 100 ppm. Reedman (1979) indicates that the Co/Ni ratio for the locality should be > 1 for Cu mineralization, suggesting a lack of Cu mineralization in the area. The plots of Cu vs. Ni, Co and Zn show similar pattern of distribution except at Sanjro (SJ) and Wayaro (WA) (Fig. 5). This shows that the similar geochemical behaviour of Cu, Ni, Co and Zn is probably due to the unleached parent rock materials.

The concentration of Ni in the stream sediments is 5 to 150 ppm (Reedman 1979). The range of concentration of Ni in various stream sediments in the study area is between 40 to 650 ppm (Fig. 4). Sanjro (SJ) has a significant anomaly and, Dadi (DA), Gajri (GN), Gajri (GN), and Siro (SD) have minor ones. In basic ultramafic rocks, Ni generally has a high background concentration. Such rocks are widely exposed in the area and most probably are the fragments of ophiolites. Cox (1974) employs the Ni/Cr ratio to discriminate Ni mineralization in basic and ultramafic rocks. Ni/Cr ratios > 1 indicates true mineralization. Sanjro (SJ), Siro (SD), and Gajri (GN) localities have Ni/Cr ratios 1.35, 1.21 and 1.00, respectively, and are thus indicative of nickel mineralization (Fig. 2).

Mutual relationships of Ni with Fe, Zn, Cu and Cr are illustrated in Figure 5. Ni shows uniform distribution in various localities (mean 161 ppm, Table 2) against other elements. Most probably this character of Ni may indicate a uniform weathering environment prevailing in the area except at Sanjro (SJ). The Ni/Co ratio plot shows a fluctuating pattern, whereas the Cr/Ni plot is uniform (Fig. 6). The natures of Co and Cr against Ni are different, Co shows variable degree of enrichment while Cr shows a similar geochemical behaviour during weathering.

In stream sediments, Co ranges between 5 to 50 ppm and over 100 ppm is considered anomalous. Only the Sanjro (SJ) locality, at 110 ppm (Fig. 4), is in the anomalous range, and it also has high Ni and Cr. The slightly anomalous concentrations are indicative of basic to ultrabasic rocks.

Statistical Analysis

Quantitative statistical treatment of geochemical data is a useful and widely practiced technique in geochemical interpretation. Selinus (1981), Ayalon *et al.* (1981), Ajayi (1981), Smith *et al.* (1984), Hashmi (1986), and Khan *et al.* (1991) have applied statistical techniques in geochemical prospecting programs in different parts of the world. Basic statistical data for certain trace elements in stream sediments of Lasbela area, such as mean, standard deviation and coefficients of variation are given in Table 2. To test the coherence of the elements, correlation coefficient is computed using raw values (Table 3).

The coefficient of variation is considered as a measure of relative variability which takes into account the mean and the standard deviation. Simply, it is a measure of variability which describes how close the numbers in the data set are to their common measure of centre (Siegel 1988). For instance, as mean increases, variability for most of the observed geochemical distribution tends towards zero. Conversely, for quantities present in very small amounts, variability for the observed data distribution tends towards infinity (Hashmi 1986). Table 2 shows that the mean ranges from 52 to

TABLE 3. Showing correlation coefficient among trace elements of stream sediments of Lasbela area.

	Fe	Mn	Ti	Cr	Zn	Cu	Ni
Mn	0.099						
Ti	0.672	− 0.279					
Cr	− 0.298	− 0.122	− 0.046				
Zn	− 0.019	− 0.272	− 0.078	0.034			
Cu	0.902	0.133	0.188	− 0.331	− 0.174		
Ni	− 0.323	0.083	− 0.045	0.959	− 0.111	− 0.323	
Co	0.067	0.061	0.055	0.843	− 0.117	0.142	0.840

1438 for Mn, Zn, Cu and Ni while the standard deviation ranges from 30 to 1553. The variability calculated from these values of mean and standard deviation for the four elements varies from 0.48 to 2.193. This range of coefficient of variation indicates positive anomalies for these elements which are possibly due to mineralization in the localities already mentioned in the preceding section.

The rest of elements show poor variability (0.47 to 0.298) because their standard deviation is more than twice as compared to their mean (Table 2). This situation indicates that the concentration of these elements is due to country rocks, and more sampling is needed to reach any positive conclusion.

The correlation coefficient among trace elements is presented in Table 3. It shows positive linear relationship among Ni/Cr, Cu/Fe, Cr/Co and Ni/Co (> 0.8). This indicates a strong influence of primary composition of the ophiolite in the stream sediments. This also favours a composite addition of the above elements in the anomalous areas of enrichment. The correlation coefficient between Fe and Ti is, as expected for unaltered stream sediments derived from ophiolite, is roughly linear positive (0.672). The relationship of Fe and Ti among different localities can also be visualized from Figure 5. The rest of the relations between various elements are poor, either positive or negative (Table 3), and does not show any strong sympathetic or antipathetic relationship between these elements. It can be concluded from the above discussion that these sets of elements show no genetic association within the rocks of the area under study.

Conclusion

1. The abundance and distribution of trace elements from different stream sediments of the Lasbela area suggests tholeiitic basalt composition of the Bela Ophiolite.

2. The bedrock chemistry, mobility of elements, nature of weathering, climate and drainage system have played an important role in the enrichment and depletion of these trace elements.

3. Immobile elements show consistency, while mobile to semimobile elements show anomalous fluctuating distributions in stream sediments in some parts of the Lasbela area.

4. The study revealed some possible zones of mineralization of Fe, Mn, Ti, Cr, Ni and Co associated with the Bela Ophiolite in the Lasbela region (Fig. 2).

5. The Shirinab formation is indicated as to be the host rock for Zn mineralization; associate lead and barite mineralization may also be prospected in the Shirinab formation.

6. Possible prospective areas (Fig. 2) can be explored, and the presence of ore mineralization may be indicated with the help of other geochemical and geophysical prospecting techniques.

7. Some statistical relationships were observed from the analytical data. Zn shows high variability due to the hydrothermal mineralization in the Shirinab formation. Inter-elemental correlations between Ni/Cr, Cu/Fe, Cr/Co, Ni/Co and Fe/Ti are positive linear, but are probably a reflection of background concentrations rather than mineralization of these elements in the ophiolite rocks.

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التنقيب الجيوكيمائي لرواسب الأنهار في أوفيوليت بيلا بمنطقة لاسبيلا

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المستخلص . يقدم هذا البحث دراسات جيوكيميائية لرواسب الأنهار في أفيوليت بيلا من منطقة لاسبيلا . تتكون تلك المنطقة من تتابع أوفيوليتي مصحوبا بصخور رسوبية من عصور الجوراسي والطباشيري . تم عمل تحليل كمي للعناصر القابلة للحركة مثل الحديد والمنجنيز والتيتانيوم والكروميوم . كذلك العناصر الشبه قابلة للحركة مثل الزنك والنحاس والنيكل والكوبلت . لهذه العناصر تركيزات شاذة في الرواسب النهرية الدقيقة الحبيبات في بعض المناطق . عُملت محاولة لتحديد المناطق التي يحتمل تواجد تمعدنات للخامات بها مصاحبة لأوفيوليت بيلا بناء على التحليل الإحصائي للمعطيات الجيوكيميائية .

استُخدم التحليل الإحصائي ورسمت المعطيات لتقييم توزيع هذه العناصر والعلاقة فيما بينهم ، كما تم حساب معامل التغير ومعاملات الارتباط . تمت مناقشة مناسبة الطرق وعلاقتها بالمناخ الجاف في جنوب بالوشيستان والجيولوجيا المحلية .