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STREAM SEDIMENT GEOCHEMICAL SURVEY OF AN AREA AROUND DASS, N.E. NIGERIA

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ABSTRACT

Stream sediment geochemical survey was carried out in Dass area to determine possible dispersion train for Pb, Cu, Co, Ni and Zn. A total of 114 active stream sediment samples were collected over an area of 60km^2. The samples were treated with hot HNO_3 and analysed for Pb, Cu, Co, Ni, Zn, Mn, Mg, Ca, and Fe.The results indicated high concentration of Zn (81.3µg/g), Cu (10.8µg/g), Pb (50.0µg/g), Ni (20.0µg/g) and Co (51.6µg/g) in the area. Descriptive statistical method together with element distribution maps, employed in the presentation of the result, point to a dispersion train for anomalous Pb, Zn, Cu, Co, and Zn in the western flank of the study area. The underlying geology probably played a major role in the distribution of the anomalies.

KEYWORDS: Dass, Dispersion train, Stream sediment.

INTRODUCTION

Attention in exploration is increasingly being directed to the poorly out cropping regions of the world. In such regions, ore deposits are concealed beneath thick lateritic cover, which are products of intense weathering processes. This type of setting renders geological methods ineffective for mineral exploration.

Though rocks of the Dass area are well exposed at the far northern and southeastern parts of the area, they are unfortunately covered by thick laterites in the other parts. Consequently, prospecting for mineral deposits in a large part of the area is made difficult and is only confined to the far isolated hills of the northern part which are not easily accessible.

Specifically, the area extends from around river Bagel through Kagadama broad plains to Dott-Bagel-Lir area. It consists of steep-sided, round top hills that stretch from south to north in the western part. Isolated flat-topped hills are scattered in the far eastern part of the area. The northern part is a region of dissected uplands. The central section comprising Kagadama may be said to consist of a relatively elevated broad plains that form the watershed between Bagel and Dott river systems. These river system and their numerous tributaries made stream sediment geochemical survey the most convenient tool for mineral prospecting in the area.

Geological Setting

The study area (Fig 1) forms part of the Nigerian Basement Complex, which is underlain by gneisses, migmatites and metasediments of Pre-Cambrian age. The lithology varies considerably. The major rock units of the area include granite gneiss, migmatite gneisses, charnockitic gneisses and charnockites.

Others include pegmatites and dolerites. Migmatite gneiss occur in the northcentral and northeastern parts of the area. Texturally, they are medium to coarse grained, dark to light coloured and occur as low-lying outcrops. Granite gneiss covers almost the whole of the eastern and southern parts and extends through Kagadama westward to Lir and Bajar to the far north at Layi. The gneisses are generally medium to coarse grained and strongly foliated. The charnockitic gneiss occupies the area south of Jahun extending for about one kilometer southwards to around Dajim where it grades into the banded gneisses. It also occurs as discrete individual hills in the granite gneiss complex west of the study area.

Pegmatites ranging from a few meters to tens of meters in length and oriented SW-NE are concentrated in the western part of the area. They are mostly tourmaline- and amethyst-bearing. Charnockites are restricted to the western part where they occur as coarse grained bouldery rocks that form parts of the Bajar and Lir hills in the granite gneiss terrane.

Sampling Method and Analysis

Stream sediment samples were collected at the mouths of tributaries discharging into major streams in the area (Fig 2). At each sample point, active stream sediments weighing about 50g was collected bearing in mind the factors that could affect elemental distribution such as dilution effect and factors that could cause contamination such as collapsed bank materials. The samples were prepared using the method described by Smith et al (1976). This involved sun drying, disaggregating in a porcelain mortar and sieving to minus 80 mesh fraction. The samples were then decomposed using hot HNO_3 and the concentrations of Copper, Lead, Zinc, Nickel, Cobalt, Cadmium, Magnesium, Manganese and iron in the various samples determined using atomic absorption spectrophotometer. Routine rechecking of the standard working range of the machine was conducted at regular intervals to minimise errors.

The large numbers of analytical results were condensed into tables (Table 1) by grouping the values into

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adequate number of classes and calculating their cumulative frequency distributions. To ease determination of the characteristic parameters of the distributions and comparison between various population types, the cumulative frequency of occurrence in each class was plotted as ordinate on a probability graph paper against the class midpoint to give a cumulative frequency curve represented by more or less straight lines.

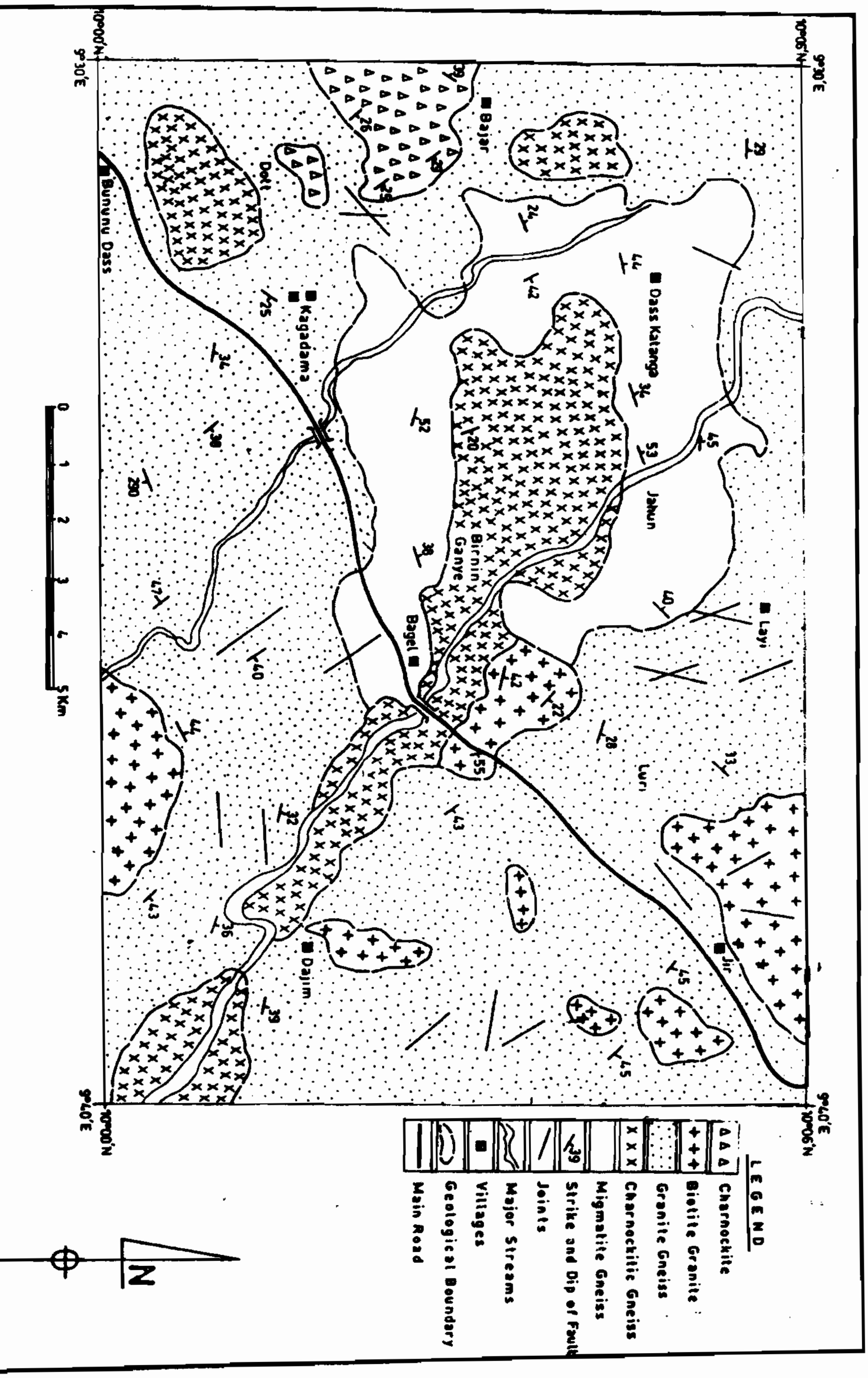

FIG. 1 : GEOLOGICAL MAP OF THE STUDY AREA

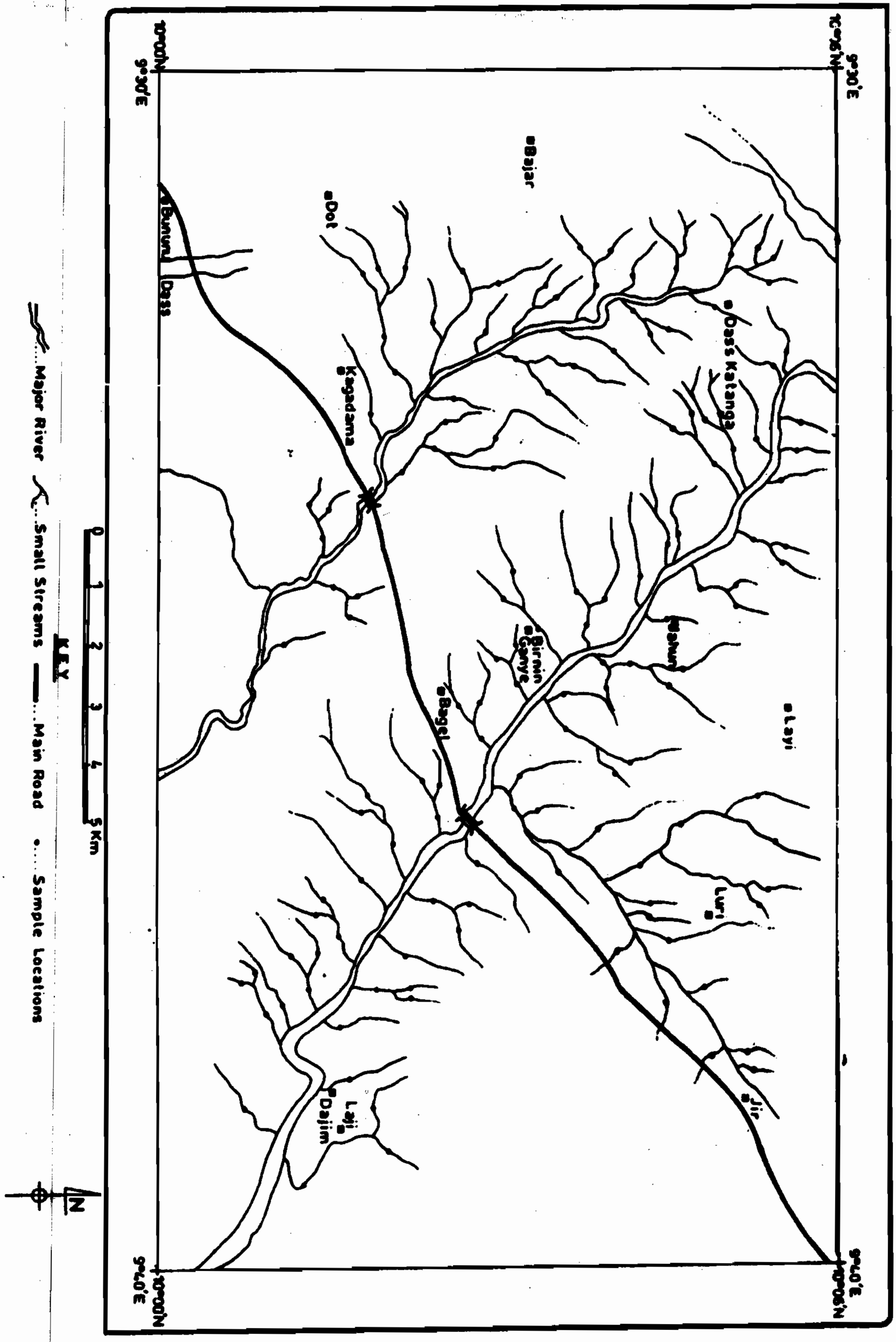

Fig. 2 : Geochemical Sample Locations of the Study Area.

Table 1. Some statistical parameters of extractable metal content from stream sediment

Interval of element concentration (µg/g)					Internal mid point					Frequency					Relative frequency (%)					Relative Cumulative frequency (%)				
Zn	Cu	Pb	Co	Ni	Zn	Cu	Pb	Co	Ni	Zn	Cu	Pb	Co	Ni	Zn	Cu	Pb	Co	Ni	Zn	Cu	Pb	Co	Ni
20 – 25	3-4	3-7	8-12	6-8	22.5	3.5	5	10	7	6	9	4	5	9	10.53	15.79	7.02	8.77	15.79	99.99	99.99	99.99	100.00	100.00
25 – 30	4-5	7-11	12-16	8-10	27.5	4.5	9	14	9	9	9	6	7	15	15.79	15.79	10.53	12.28	26.32	89.46	84.2	92.96	91.23	84.21
30 – 35	5-6	11-15	16-20	10-12	32.5	5.5	13	18	11	5	11	7	5	5	8.77	19.30	12.28	8.77	8.77	73.67	68.41	82.43	78.95	57.89
35 – 40	6-7	15-19	20-24	12-14	37.5	6.5	17	22	13	10	12	10	2	13	17.54	21.05	17.54	3.51	22.81	64.9	49.11	70.15	70.18	49.12
40 – 45	7-8	19-23	24-28	14-16	42.5	7.5	21	26	15	4	5	3	8	7	7.02	8.77	5.26	14.04	12.28	47.36	28.06	52.61	66.67	26.31
45 – 50	8-9	23-27	28-32	16-18	47.5	8.5	25	30	17	6	3	9	5	3	10.53	5.26	15.79	8.77	5.26	40.34	19.29	47.35	52.63	14.03
50 – 55	9-10	27-31	32-36	18-20	52.5	9.5	29	34	19	9	6	7	11	5	15.79	10.53	12.28	19.30	8.77	29.81	14.03	31.56	43.86	8.77
55 – 60	10-11	31-35	36-40		57.7	10.5	33	38		3	1	7	8		5.26	1.75	12.28	14.04		14.02	3.5	19.28	26.56	
60 – 65	11-12	35-39	40-44		62.5	11.5	37	42		1	1	1	2		1.75	1.75	1.75	3.51		8.76	1.75	7.00	10.52	
65 – 70		39-43	44-48		67.5		41	46		1		1	1		1.75		1.75	1.75		7.01		5.25	7.01	
70 – 75		43-47	48-52		72.5		45	50		1		1	3		1.75		1.75	5.26		5.26		3.5	5.26	
75 – 80		47-51			77.5		49			0		1			0		1.75			3.51		1.75		
80 – 85					82.5					2					3.51					3.51				

Interval of element concentration (µg/g)				Internal mid point				Frequency				Relative frequency (%)				Relative Cumulative frequency (%)			
Mg	Ca	Fe	Mn	Mg	Ca	Fe	Mn	Mg	Ca	Fe	Mn	Mg	Ca	Fe	Mn	Mg	Ca	Fe	Mn
200-300	00-200	000-1000	15-20	250	100	500	17.5	24	19	1	1	42.12	33.33	1.75	1.75	99.99	99.97	100.00	99.92
300-400	200-400	1000-2000	20-25	350	300	1500	22.5	17	26	3	1	29.82	45.61	5.26	1.75	57.87	66.64	98.25	98.17
400-500	400-600	2000-3000	25-30	450	500	2500	27.5	7	3	12	1	12.28	5.26	21.05	1.75	28.05	21.03	92.99	96.42
500-600	600-800	3000-4000	30-35	550	700	3500	32.5	3	3	5	3	5.26	5.26	8.77	5.26	15.77	15.77	71.94	94.67
600-700	800-1000	4000-5000	35-40	650	900	4500	37.5	1	1	3	4	1.75	1.75	5.26	7.02	10.51	10.51	63.17	89.41
700-800	1000-1200	5000-6000	40-45	750	1100	5500	42.5	1	2	8	14	1.75	3.51	14.04	24.56	8.76	8.76	57.91	82.39
800-900	1200-1400	6000-7000	45-50	850	1300	6500	47.5	0	1	8	14	0	1.75	14.04	24.56	7.01	5.25	43.87	57.83
900-1000	1400-1600	7000-8000	50-55	950	1500	7500	52.5	2	1	2	16	3.51	1.75	3.51	28.02	7.01	3.5	29.83	33.27
1000 – 1100	1600-1800	8000-9000	55-60	1050	1700	8500	57.5	1	1	6	1	1.75	1.75	10.53	1.75	3.5	1.75	26.32	5.25
1100 – 1200		9000-10000	60-65	1150		9500	62.5	1		9	1	1.75		15.79	1.75	1.75		15.79	3.5

The various central tendency parameters (Table 2) were estimated following the method described by Lepelter (1969)

Table 2: Estimates of statistical parameters from the graphs

Element	Range(µg/g)	Mean(µg/g)	Threshold(µg/g)
Zn	23.1 - 81.3	41.2	45.0
Cu	3.0 - 10.8	6.3	6.5
Co	8.4 - 51.6	31.0	24.0
Ni	6.0 - 20.0	12.0	17.0
Pb	3.3 - 50.0	23.0	23.0
Mg	270 – 1116	380	800
Mn	15.0 - 73.5	49.0	43
Fe	870 – 9960	6200	4500
Ca	48 – 1700	380	500

• N.D = not detectable

The pH of sediments determined in a 1:5 sediment distilled water slurry by means of standardized pH meter gave a rang? of 5.8 – 6.3 for the western flank and 6.1 – 6.8 for areas around river Bagel

RESULTS

Result of analysis of the stream sediments as condensed in Table 1 are presented in Fig. 2. The forms of cumulative frequency curves shown by almost all elements of economic importance (Pb, Zn, Ni, Cu, Co) are characteristic of two populations (Fig. 3). In other words, the curves show two breaks suggesting bimodal density distribution. Individually however, the elements behave differently. For Copper, the positively broken line is an expression of an excess of low values in bimodal population distribution. An estimate of their proportions is given at 48 percentile. This indicates the presence of 48% higher population and 52% of lower population. The threshold taken at the abscissa of this breaking point corresponds to 6.5µg/g.

In the probability plot for Zn distribution, a smooth curve through the data points has the form of a bimodal density distribution with an inflection point at the 44 cumulative percentile. The positive branch towards lower values corresponds to the normal population while the negative branch corresponds to a population of higher concentrations. The central branch corresponds to a mixture of the two populations. Threshold taken at the middle of this branch corresponds to 45.0:g/g. The probability of finding values higher than 72.5:g/g in the area is 0.05%.

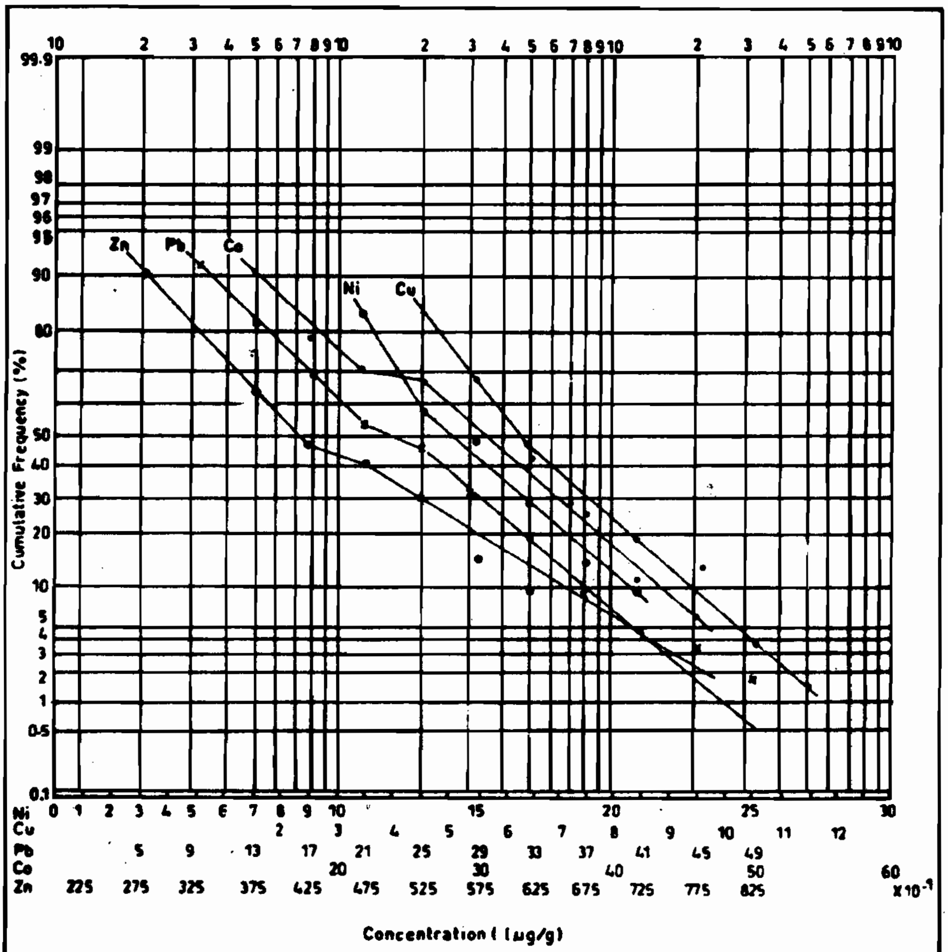

Fig 3 Cumulative Frequency distribution for Pb, Zn, Cu, Co, and Ni

The cumulative distribution curve for Ni shows positive skewness. A histogram would give a frequency curve skewed to the right in the direction of high values. Break of the distribution line occurs at 58% level. The abscissa of the breaking point indicates the limit above which there is departure from normal distribution. This breaking point occurs above the normal threshold level of 2.5%. Threshold taken at the abscissa of this breaking point corresponds to 13.0µg/g.

The form of cumulative distribution curve for Co is similar to that of Pb but with inflection points at 68 cumulative percentile indicating, the presence of 68% higher populations and only 32% lower population. Abscissa of the midpoint of the central segment indicates a threshold of 24.0µg/g.

The form of curve shown by Pb is characteristic of two populations with the central segment indicating considerable overlap of the two. The inflection point at 50% cumulative percentile indicates the presence of equal proportions of high and low populations. Abscissa of the midpoint indicates a threshold of 23.0µg/g.

In summary, a greater percentage of the data falls within the background and threshold values whereas the anomalous values are few and scattered.

Summary of their range, mean, ratio and thresholds is presented in Table 2.

DISCUSSION

Copper - Zinc

In general terms, most of the anomalous values of the elements lie in the western flank of the study area (Fig 4) and conforms with the chain of uplifted basement that run from south to north.

Relatively high values are scattered in the northwestern part of the area under consideration. The low values of Cu are related to the bedrock lithology and suggest the near absence of basic and ultrabasic rocks in the entire study area. Cu is one of the chalcophile elements concentrated in pyroxenes and amphiboles, as well as, magnetite and biotite in intrusive rocks (Krauskopf, 1979). In basic and ultrabasic rocks, pyroxenes, amphiboles and to a lesser extent, olivines are strongly indicated by Cu among other elements (Beus and Grigorian, 1977). The bulk of the Cu in the basement is therefore incorporated in silicate minerals, the most important of which being pyroxenes. As a result of oxidation and weathering, Cu is liberated from the Cu-bearing minerals in the country rocks as a soluble sulphate under acid to near neutral conditions. Its divalent ion is then adsorbed and co-precipitated with, or adsorbed to sediment particles (Boyle et al 1996). Alternatively, Cu may be adsorbed by organic matter and co-precpitated with Fe-Mn oxides, but is less readily scavenged by Fe-Mn oxides than other base metals, such as Co, Zn and Ni.

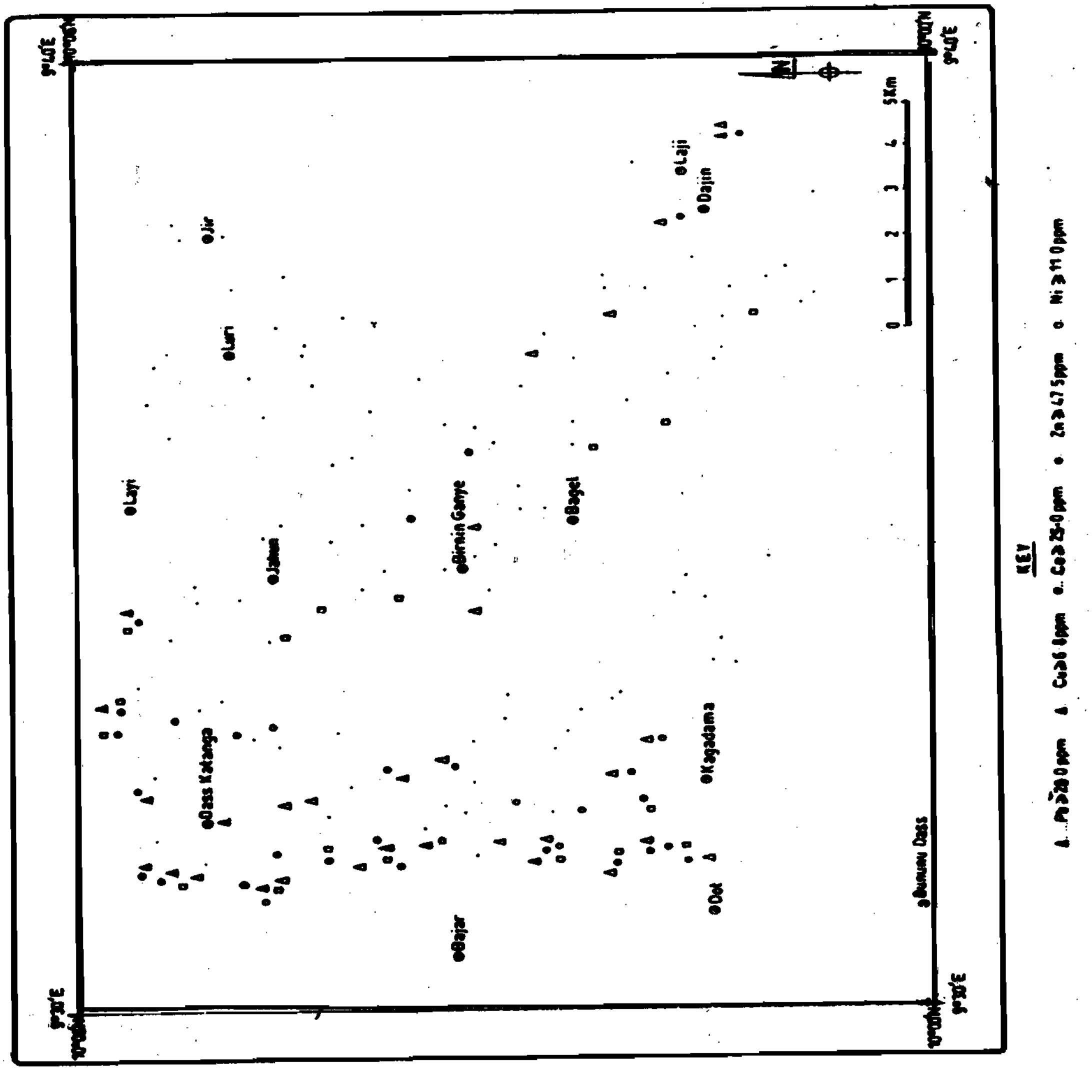

Fig. 4 : Geochemical Anomalies of Dass Area

Zn has a close affinity with Pb in its distribution in the stream sediments. Like Pb, the anomalous values (80µg/g) of Zn lie on the western flank of the area with low values (≤ 50µg/g) recorded along river Bagel and its tributaries in the east.

The distribution of Zn is controlled by lithology. Zn is one of the chalcophile elements that substitutes for the major cations of Mg and Fe in silicate structures (Krauskopf, 1979). However, for the most part, the metals are left to accumulate in the residual solutions that eventually form sulfide ores. The traces of chalcophile metals commonly reported in ordinary igneous rocks may be present in large part as tiny sulfide grains rather than as substitute for major elements. The concentration of high values of Zn in the western flank coincides with the distribution of charnockites, charnockitic gneiss and granite gneiss.

The Zn-bearing minerals in these rocks weather, releasing Zn, which pass through underground water into streams, where it is co-precipitated in the sediments. Average background content of Zn in stream sediments range between 10-200µg/g and values greater than 200µg/g may indicate mineralization (Reedman, 1980).

Low values of Zn (mostly <60µg/g) are recorded along River Bagel and its tributaries in the east. These low values may not be unrelated to the dilution effects and chemical characteristics of Zn. Although Zn has high mobility, it is often absorbed by organic matter.

Nickel – Cobalt - Lead

Fairly high values of Ni are sparsely distributed in the western, northwestern and southeastern part of the study area while background values are recorded north of Bagel Bridge. This distribution can be interpreted in terms of the bedrock lithology underlying the sampled areas. Ni has intermediate radii and is abundant in the earlier members of differentiation sequence as a result of ready substitution for Fe and Mg, with some strongly enriched with magnesium in ultramafic rocks (Krauskopf,1979). Ni is concentrated in magnesium pyroxenes and olivines (in ultrabasic and basic rocks), and biotite in intermediate and acid rocks (Beus and Grigorian, 1977). The fairly high (about 20µg/g) and sparsely distributed values in the west, northwest and southeast can be attributed to contributions from the biotite granites and the granite gneisses. In granites, such as those present in the study area, almost all the Ni is contained in the biotite, and in such environment, which practically, has no ultrabasic rocks economic Ni minerlization is rare.

The low values (6-20µg/g) of nickel content in the stream sediments is probably due to the paucity of basic and ultrabasic rocks in the area, its relatively high mobility not withstanding. The average background content of nickel in stream sediments is between (5-50µg/g). The low values of between 6-20µg/g are well within this range.

Cobalt content in the area ranges between 8.4-51.6µg/g with minimum anomalous value graphically estimated at 24.0µg/g. Most of the anomalous values are scattered in the western, northwestern and southeastern parts of the area, with background values distributed in an area north of the Bagel river bridge.

The source of the Co is attributed to crystalline rocks in the west and northwestern part of the area. Co is one of the elements occurring in the transition group, and like Ni, has intermediate radii and substitute readily for Fe and Mg, hence it is abundant in the earlier members of the differentiation sequence. Co is therefore concentrated in magnesian pyroxenes and olivine and in biotite in intermediate and acid rocks such as found in the area under consideration. However, economic Co deposits in the area can not be expected.

Average background content of Co in stream sediments normally range between 5-50 µg/g with anomalous concentrations over mineralization always more than 100-500µg/g (Reedman, 1980). The low values of Co can therefore be explained in terms of the paucity of basic and utrabasic rocks, and its chemical behavior during transportation. Co has relatively high mobility but readily scavenged and held by Fe-Mn oxides (Reedman, 1980).

Most of the high values of Pb lie on the western flank of the study area, while low or background values are recorded along river Bagel and its tributaries in the east. The underlying geology plays a major role in the distribution of Pb anomalies. Pb is one of the elements belonging to "large-ion lithophile" group (LIL). It has cations with large radii and low electric charge, which tend to substitute for K; hence it is concentrated in felsic rather than mafic rocks (Krauskopf, 1979). Abundance of Pb in a rock series is a good indication of the extent to which differentiation has sorted out constituents of the original igneous material. Pb is concentrated in orthoclase, which is the mineral indicator of the geochemical characteristic of acid and intermediate rocks. Maximum concentrations are found in zircon and in some other accessory minerals (Beus and Grigorian, 1977). The concentration of high values of Pb in the western flank is therefore not surprising, but serves to confirm the presence of plutonic acidic rocks such as charnockite and charnockitic gneisses, which consist of mineral such as biotite, hornblende, zircon and microcline.

As a result of weathering, Pb is released from the various Pb- bearing minerals in the charnockites and charnockitic gneisses. It then passes into the soil where it co-precipitates with or gets absorbed by clay minerals and organic matter. Subsequently, it passes directly through underground water into streams where it is co-precipitated in the sediments. The values range between 5-50µg/g. The low values (<30µg/g) for Pb recorded along river Bagel and its tributaries in the east are probably due to its low mobility and the dilution effects.

Manganese – Iron – Calcium - Magnesium

Although the association of Fe – Ca – Mg has been used as a lithological index reflecting the geology of the underlying rocks (Ojo, 1988), these elements are often used by most authors to aid interpretation of minor and trace elements. Hydrous oxides of these elements can be sorbents i.e. carriers of trace elements in surface and ground waters. For example, Fe is said to be very effective trap for trace metals such as Cu, Pb, Zn (Lecomte and Sondag 1980). The precipitation of a trace element along the paths of its aqueous migration sequence does not depend on its solubility product or on its activity in the solution rather it is controlled by the precipitation of a sorbent, which is capable of being a carrier of this trace element. For majority of trace elements whose concentrations in waters in the supergene zone is very low, and which almost reaches values necessary to ensure precipitation from the solution, the sorption precipitation (co-precipitation) together with the sorbent – carrier is the principal mode of precipitation.

Mn does not occur in significant amounts in the area. The low content of Mn is attributed to the acid bedrock lithology of the area. Mn, like Co, Ni and Cr falls in the group of elements with intermediate radii; it is therefore abundant in the earlier members of the differentiation sequence as a result of its substitution for Fe and Mg. It has its maximum abundance in gabbros and basalts. Its low mobility is probably one of the limiting factors to its distribution.

CONCLUSION

Interpretation of trace element composition of the stream sediment has pointed to a dispersion train for anomalous Cu, Zn, Pb, Co and Ni, in the western flank of the area. Pb, Co and Ni are indicator element for Cu-Zn minaralisation while Pb, Zn, Cu may be suggestive of hydrothermal uranium deposits. The western flank of the area is criss-crossed by pegmatite and aplite veins along the flank of Dott, Lir and Bajar hills. The veins might have acted as traps for ore-bearing fluids migrating from the subajacent charnockites and charnockitic gneisses.In fact, amethyst, tourmaline and beryl have been visually identified from heavy mineral sampling in this area. Detail geochemical survey is therefore recommended in the western flank of the study area.

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