STREAM SEDIMENT SURVEY OF ERUKU AND ITS ENVIRONS, CENTRAL NIGERIA: IMPLICATION FOR EXPLORATION

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ABSTRACT
Eruku and its environs lie within two belts of different lithologies (Osi migmatite – gneiss complex to the west and Egbe schist belt to the east) which have been well studied. This area has remained relatively uninvestigated in terms of mineralization and hence its mineralization potential is unknown. This work therefore aims at identifying the mineralization types and also to delineate the mineralized zones in this area.
In order to achieve these objectives, stream sediments sampling in Eruku and its environs was carried out. The stream sediments were collected at the confluence points of two or more rivers mostly at a depth of 20 – 25cm. The stream sediment samples were analyzed for trace and rare-earth elemental concentration using ICP-MS analytical method. The result of the geochemical analysis was thereafter subjected to multivariate statistical analysis and isograde plotting.
The multivariate analysis shows a total of five factor groups. Four of the five factor groups are related to mineralization. From the dendogram, a total of six cluster groups were distinct, three of these groups are related to mineralization while the other three are considered to be product of weathering and erosion of both mineralized and barren rocks in the study area. The correlation analysis of some selected elements from the result of the geochemical analysis shows Cs, Nb, Sn, Ta, Cu, Mo, Ni, V, Zn, Co among others to be strongly correlated while Ba is negatively or not correlated with most of the elements. The isograde plots show that almost all the elements have their peaks in the south-eastern part of the study area.
The conclusion drawn from the integration of the geochemical analysis, multivariate analysis and isograde plotting in this study is that the study area is mineralized with tantallite-cassiterite-columbite. These mineralizations are hosted by pegmatites that intrude the country rocks in the southeastern part of the study area. Also, these mineralisations are similar to the mineralization type in Egbe that lies to the east of the study area in terms of their host rocks and mineralization type.

Keywords: *Stream sediments, Multivariate analysis, Dendogram, Isograde map, Geochemical relief, Eruku, Nigeria.*

1. INTRODUCTION

Stream sediments are employed almost exclusively for reconnaissance studies in drainage basins (Hawkes, 1976[17]) and if samples are properly collected, the samples represent the best composite of materials from the catchment areas upstream from the sampling site with potential of recognizing geochemical or mineralogical anomalies within the catchment areas for follow-up works (Adekeye, 1999[1]; Lepeltier, 1971[22]; Webb, 1971[32]). This work is aimed at identifying the mineralized zones in the in the study area (Eruku and its environs) using stream sediments survey. The study will also attempt to compare the mineralization present in the study area with those present in Egbe that lies to the east of the study area.
Eruku area lies approximately 8km west of Egbe (Fig. 1) and is bounded by Long. $5^0 23^1$E and $5^0 30^1$E; Lat. $8^0 05^1$N and $8^0 13^1$N (Fig. 3). This area is located within two belts of different lithologies i.e. Osi migmatite-gneiss complex to the west and Egbe schist belt to the east. The geology of these belts have been well studied relative to the geology of Eruku and its environs (Bafor, 1981[8],1988[9]; Jacques, 1947[20]). Egbe schist belt has been proved to be mineralized with tantalite, iron (BIF), gold, beryl, marcasite etc (Adekoya, 1993[2]; Akande et al, 1988[3]; Garba, 1988[14]; Mucke and Annor, 1993[27] and Olobaniyi, 1997[28]) while Osi migmatite- gneiss complex to the west is relatively unmineralized (Jacobson and Webb, 1946[19]).

2. LOCAL GEOLOGY

Eruku and its environs which lie between Egbe schist belt in the east and Osi migmatite-gneiss complex in the west fall within the Precambrian Basement Complex of Nigeria. The geology of Nigeria has been described to consist of older and younger metasediments, Older and Younger Granites and volcanic intrusives which are overlain unconformably by younger sedimentary basins of Lullumeden, Niger-Delta, Bida, Benue and Dahomey (Fig. 1) (Grant, 1970[16]; McCurry and Wright, 1971[26]; Cooray, 1972[12]; Oyawoye, 1972[30] and Rahaman, 1976[31]). The rocks that dominate the study area can be grossly divided into gneiss, granite, gabbro, migmatite, amphibolite and pegmatite (Fig. 2)

Granite occurs essentially in the extreme eastern part and in the western part of the mapped area. The granite bodies are biotite granite, porphyritic granite and fine grained granite. These granites have very sharp contact with the gneisses and are intruded by pegmatites that trend essentially in north-northeastern direction. They also have faults trending predominantly in the northeastern direction. These fault zones are filled by pegmatites of different dimensions. The granite bodies are conically shaped in the western part while they form ridges traceable over 4km lengths in the northeastern part of the study area (Fig. 2). Gneisses predominate in this area covering approximate 80% of the total area studied. The gneisses trend mainly in the northeastern direction and have sharp contacts with the granitic rocks. The gneisses like the granites have been faulted with the fault planes occupied by pegmatitic intrusions which are differently oriented.

The migmatites occur essentially as pockets of rocks within the gneisses and are associated with gabbro in the south-western part. The migmatites are fine to medium grained with joints trending mainly in northeastern and northwestern directions. Gabbro occurs as boulders and cobbles arranged in southwestern and northwestern directions occupying an area of approximately 0.2km^2 in the eastern part of the study area. Other gabbros occur as xenoliths within the gneisses and migmatitic rocks within the gneisses at the south- western part of the study area. Pegmatites present in the study area can be grossly divided into complex and simple pegmatites. The complex pegmatites are traceable over a distance of 0.25 – 0.5 km and have widths that range between 10 and 20m (Fig. 2). The simple pegmatites generally fall short of this dimension and are not represented on the map.

3. METHODOLOGY

The methods and procedure applied in this work are fieldwork and laboratory work exercises. The fieldwork is essentially geological field mapping. During the fieldwork exercise, thirty stream sediment (Fig. 3) samples were taken. The sediment samples were taken at a depth of 20 – 25cm at the confluence points of two or more rivers and at the centre of some drainage systems. The sediments were sun-dried and thereafter pulverized using agate mortal and pestle in the Department of Geology and Mineral Sciences, University of Ilorin, Ilorin, Nigeria. The agate mortal and pestle were rinsed initially with ethanol before and after each pulverization to prevent contamination of the samples that were being pulverized. 20g each of the pulverized samples were weighed out and sent for analysis at ACME Analytical Laboratory, Vancoover, Canada through Petroc Analytical Laboratory, 7, Alfonso road, Shasha, Ibadan, Nigeria. In the Laboratory, 0.5g each of the samples were fused with lithium-borate metaborate and then leached with 30% dilutes nitric acid. The resulting solution was then analysed using ELAN 6000 ICP-MS machine. The result of the geochemical analysis was then subjected to multivariate and correlation analysis and isograde plotting.

4. RESULT

The result of the geochemical analysis of 38 trace and rare-earth elements determined in the stream sediment samples analyzed is shown in Table 1. From the Table, Ag has a constant value of <1ppm in all the samples analyzed. Co, Cr, Cs, Cu, Mo, Nb, V and Zn have their highest concentration values in JB 23 while Sr has its lowest concentration in this sample. Like JB 23, JB 25 has the highest concentration value of Y, Dy, Er, Eu, Ho, Lu, Yb and Tm. The result of the geochemical analysis was subjected to multivariate analysis using SPSS software programme. The components of the analysis correspond to the elements detected in the samples analysed with the exception of Ag which has a constant value, hence it cannot be clustered. Table 2 shows the result of the multivariate analysis. From the Table, five component factors are distinct and these are: Factor 1 with Y, Ho, Tm, Er, Dy, Yb, Lu, Tb, Gd, La, Sm, Nd, Pr and Eu while Factor 2 has Co, Cu, Ni, Cs, V, Mo, Cr, Zr and Nb. Factor 3 has Zr, Hf, Th, U and Ce. Factor 4 has W, Rb, Pb, Ba, Ga and Sr while Factor 5 has Ti, Sn and Ta.

Dendogram is the hierarchic classification represented by a two-dimensional diagram. This illustrates the fusions or divisions made at each successive stage of the analysis (Brian, 1993[11]). The dendogram of the cluster analysis is shown in Fig.4. From the dendogram (Fig. 4), 3 cluster groups are distinct at the first cluster stage. These are Lu, Tm, Ho,Tb, Ti, Eu, Mo, Gd, Sm, Er, Yb, Dy, U, Pr, Cs, Ta, W, Nb, Sn, Co, Cu, Ni, Hf, Ga, Nd, La, Th, Y, Zn, Pb, V, Ce, Rb, Sr and Cr while the second group has Zr and the third group has Ba. At the second cluster stage, 2 groups are distinct. These groups are Ba which forms a distinct group while other elements form the second cluster group. At the third cluster stage, a group comprising the entire elements is distinct.

The result of the correlation analysis of some selected elements (Table 3) shows that Cs, Nb, Sn, Ta, Cu, Mo, Ni, V, Zn and Co has high positive correlation coefficients. Other groups of elements with very high correlation coefficients are Pb, Nb, Sr, Rb, Cu and Ni; U, Nb, Zr, Rb, Cu, Ni and Pb; V, Pb and U; Zn, Zr, Rb, Pb, U and V; Co, Pb, U, V and Zn; Ba, Sr, Rb and Pb. Negative correlation coefficient is recorded between W and Cs, Nb, Sr, Ta, Zr, Rb, Cu, Ni, Pb, U, V, Zn, Co and Ba. There is also negative correlation coefficient between Sr and Cs, Zr, Cu, Mo, U and Co; Zr, Mo and Ba while Ba has negative coefficient of correlation with Cu, Ni, U, V and Co.

5. INTERPRETATION

It is a general observation in geochemical mapping using stream sediments that element distribution patterns are often very stable despite the fact that the chemical composition of individual samples are much influenced by local geologic condition. This particularly influences the image displayed by multivariate data though the choice of method greatly influences the resulting image(s), (Allan et al., 2008[6]). The rotated component matrix (varimax with Kaiser Normalisation) in Table 2 shows the factor groups from the cluster analysis based on their loading. Factor 1 with Y, Ho, Tm, Er, Dy, Yb, Lu, Tb, Gd, La, Sm, Nd, Pr, and Eu is an association produced from weathering of rocks within the mapped area. Hence, it is influenced by lithology and is not related to mineralization (Imeokparia, 1981[18]; Levinson, 1981[23]). Factor 2 which comprises of Co, Cu, Ni, Cs, V, Mo, Cr, Zn and Nb is mostly related to hydrothermal sulphide ore with abundance of Co, Cu, Ni, V, Mo and Zn (Levinson, 1981[23]). Cu and Zn in Factor 2 also indicate the presence of gold (Ako, 1980[5]; Onuogu and Ferrantes, 1965[29]) while Cu is an indicator of Nickel. Co, Cr, Cu and Ni that is present in Factor 2 are also basic rock indicator elements (Ako, 1980[5]). Factor 3 with Zr, Hf, Th, U, Ce and W is related to pegmatitic intrusions found within the study area. Factors 2 and 3 associations were enhanced by albitization process in this area hence are related to mineralization. Factor 4 with Rb, Pb, Ba, Ga and Sr is related to base metal deposit bearing outcrops while Factor 5 with Ti, Sn and Ta is an association generated from weathering of rocks with granitic composition that have been intruded by tantalite-columbite-cassiterite bearing pegmatite or placer deposits. Factors 4 and 5 are therefore influenced by mineralization or weathering of mineralized rocks within Eruku and its environs.

At the first cluster stage of the dendogram, the first group consists of elements which are related to mineralization and is influenced by weathering of both mineralized and barren/unmineralized rocks that are present in the study area (Bottrill, 2008[10]; Makanjuola, 1980[24]; McClenagham et al., 1982[25]). The second group at the first cluster stage is related to minerals which are rich in Zr. The third cluster group at the first stage might have been produced by Ba^- rich minerals e.g. barite in this area. The first cluster group at the second stage of clustering is obviously related to both mineralization and rock weathering processes while the second cluster group at the second stage (Ba) is significant in indicating the presence of barite and other minerals that are rich in Ba. The group at the third stage of clustering shows the agglomeration of the entire elements produced from the weathering of both minerals and rocks whose materials were drained or washed into the drainage basin. Hence, it is insignificant in mineral exploratory work.

The isograde plot links together areas with equal concentration of elements. Isograde plots were done for the analyzed elements. Regional and local threshold concentration values of the analyzed elements were identified and are summarized in Table 4. These values were used to produce the isograde maps (Figs 5 - 8). Areas of anomalous concentration of elements are highlighted on these maps. Of particular interest are the maps for Nb, Sn, Ta and W which are rare metal elements for columbite, cassiterite, tantallite and wolframite respectively. The maps show very similar shapes and they occur in the same quadrant of the study area.

6. DISCUSSION

Ba with very high concentration in all the analysed samples share similar distribution patterns with Sr. It has negative and low correlation coefficients with all the correlated elements with the exception of Sr, Rb and Pb. The correlation coefficient recorded between Ba and Pb, Ba and Rb may imply their relative low mobility in oxidizing environmental conditions (Andrew-Jones, 1968[7]) which prevail in the drainage basin from which the samples were taken. This low relative mobility of Ba and Pb and their high correlation coefficients confirms their similar chemical properties that are identical with period (vi) elements of the periodic table to which they belong. However, they are classified as lithophile and chalcophile element respectively (Goldschmidth, 1937[15]). Similarly, the high correlation coefficient between Ba and Sr implies their position in the group II of the periodic table and their classification as lithophile elements under Goldschmidth's geochemical classification of elements.

Ce like other lanthanide group elements (Dy, Er, Gd, Ho, La, Lu, Pr, Tb, Yb and Sm) has its anomalous zone within the same latitude and longitude in the southern part of the study area. This area is also similarly related to negative anomaly. Though not correlated, their similar positions of some positive and negative anomaly might have been due to and supported by their similar position in the periodic table. These elements are also grouped together as lithophile elements in the Goldschmidth's geochemical classifications of elements. From the periodic table, Goldschmidth's geochemical classification of elements, dendogram and multivariate analysis (with the exception of Ce), these elements are found together and can be said to have also moved together from the same source or concentrated by their similar chemical behaviour.

Cs has high correlation coefficient with Nb, Sn, Ta, Cu, Mo, Ni, V, Zn, and Co. Sn and Ta have similar but not identical distribution pattern. Unlike Ta, Nb, Sn and Mo, Cs does not have distribution pattern similar or related to Ni, V, Zn, Co and Cu. The high correlation coefficient between Cs and Ni, Mo, Zn, Co, Cu and Nb can then be explained by their position in the same factor group of the multivariate analysis and dendogram even though, they are not related in the periodic table. Its strong correlation coefficient with Sn and Ta may be traced to mineralization.

Zr found in the Factor 3 of the multivariate analysis and second group at the first stage of clustering in the dendogram has low to negative correlation coefficient with all the correlated elements with the exception of U and Zn. The little or no correlation of Zr with most of the elements might have accounted for its presence alone in the second cluster group of the dendogram. Its presence only in the second cluster group of the dendogram may also imply its very low mobility to immobility in the oxidizing conditions that prevail in the sampling environment. Its presence in Factor 3 of the multivariate analysis with other elements like Hf, Th, U and Ce might have been made possible by their similar chemical affinities that group them as lithophile in the Goldschmidth's geochemical classification of elements.

W in the Factor 4 of the multivariate analysis shares a distribution pattern similar to the distribution pattern of Cu and almost identical with the distribution pattern of V. This similarity in the distribution patterns of W, Cu, and V are shown to be negatively correlated (Table 3). These negative correlations may imply their supply or enrichment from different sources and their different or unrelated positions in the periodic table.

Unlike other elements in Factor 4 of the multivariate analysis, Ga, a chalcophile element, is grouped together with lithophile elements in this factor group. The relationship between other elements in this group may be explained by their chemical behaviour and affinities for silicates and their concentration in the earth's crust. The presence of Ga probably implies the effect of weathering and erosion which has enriched the stream sediments sampled to the extent that it now shares similar statistical characteristics with W, Rb, Pb, Ba and Sr in the Factor 4 of the multivariate analysis.

Ti, Sn and Ta found in the Factor 5 of the multivariate analysis are related to mineralization. This relationship can be traced to their zone of highest concentration. Unlike Ti, Ta and Sn have almost identical distribution pattern though with other element like Nb. The relationship in this factor group is partly due to similar chemical properties and partly to mineralization. Those due to chemical properties can be traced to Ti and Ta regarded as lithophile elements while those due to mineralization involve the elements Ti, Ta and Sn. The high correlation of Ta and Sn (0.996) also strongly supports their relationship. Hence, their position in the same group by the multivariate analysis is justified. All these elements in Factor 5 have their mobility in oxidizing environments range from very low to immobile.

7. IMPLICATION FOR EXPLORATION

Nb and Ta are the ore elements found together in the theoretical end-members of a solid solution series called columbite-tantallite. Sn and W may be present in the structure in small amounts. However, when present in high enough concentration, cassiterite and wolframite minerals are formed leading to coexistence of columbite, tantalite, cassiterite and wolframite in the same environment. These minerals generally occur in pegmatites and placer deposits.

From the isograde plots (Figs 5 - 8), the peaks of these rare metal elements occur in the southeastern quadrant of the study area. These elements usually indicate the presence of highly differentiated granites and / or rare-metal pegmatites. They also represent strongly fractionated residual melts rich in silica, alumina water and rare metals (Akintola and Adekeye, 2008[4]). For example, tantalum is known to be enriched in extremely fractionated magmas (Evensen and London, 2002[13]).

Since the end-member minerals containing these elements are rapidly reduced to fines by weathering and erosion coupled with their low mobility, the similar positioning of their peaks suggests the metallogenetic potentials of the pegmatites and / or granites in the southeastern quadrant of the study area. Hence the southeastern quadrant of the study area is a good target for columbite-tantallite-cassiterite exploration.

8. CONCLUSION

It is concluded from the integration of geochemical result, statistical analysis and isograde plotting that this area have enhancement of tantallite-niobium-columbite mineralization or is mineralized with tantallite-niobium-columbite, probably gold and refractory minerals like sphene, epidote, ilmenite etc and probably brannerite (an uranium titanium oxide). These enhancements or mineralizations are concentrated in the southeastern part of the study area within Long. 5.43° – 5.50°E and Lat. 8.08° – 8.15°N essentially. The enhancements or mineralizations present in the southeastern part of the area are similar to the mineralization type found in Egbe east of the study area in terms of their host rock (pegmatite) and type of mineralization (tantallite-niobium-columbite and gold). Furthermore, it is concluded that the mineralizing fluids or processes that enriched Egbe east of the study area have influenced the southeastern part of the study area and possibly stopped or were impeded towards the centre of the study area.

9. ACKNOWLEDGEMENT

The authors are grateful to Dr. O. O. Oshin, the Managing Director, Petroc Analytical Laboratory for his assistance in the analysis of the samples. The assistance of Dr. G. Oyeyemi of Statistics Department, University of Ilorin, Ilorin, Nigeria in the statistical analysis of the geochemical data is also gratefully acknowledged.

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TABLE 1: GEOCHEMICAL DATA SHOWING CONCENTRATION (PPM) OF TRACE AND RARE EARTH ELEMENTS IN STREAM SEDIMENTS FROM ERUKU AND ITS ENVIRONS

Sample No.	Elements / Lab. No.	Ag	Ba	Ce	Co	Cr	Cs	Cu	Hf	Mo	Nb	Nd	Ni	Pb	Rb	Sn
6	JB1	<1	1015	20.3	2.7	60	0.6	<5	4.8	<2	5.5	7.7	6	32	118	1
21	JB2	<1	470	27.3	3.9	140	0.66	<5	2.7	<2	1.3	6.1	6	21	45.7	<1
23	JB3	<1	632	16.8	2.9	90	0.75	<5	3.3	<2	1.8	6.3	6	22	57.3	<1
28	JB4	<1	615	81.9	16.8	170	1.18	19	11.8	<2	5.5	13.6	18	52	122.5	1
37	JB5	<1	664	108.5	6.2	80	3.12	6	9.9	<2	7.2	29.1	6	48	183	2
43	JB6	<1	485	14.7	2.4	100	0.78	<5	2.5	<2	1.4	4.9	5	19	53.9	1
51	JB7	<1	364	92.7	1.5	120	0.43	<5	17.9	<2	2	36.7	<5	16	30.5	<1
53	JB8	<1	342	10.4	2.4	160	0.43	<5	2	<2	0.9	3.3	<5	13	30.9	<1
54	JB9	<1	534	15.4	2.6	120	0.6	<5	3	<2	1.2	4.9	<5	16	44.9	<1
69	JB10	<1	498	26.1	1.9	100	1.96	<5	5.2	<2	4.8	8.2	<5	31	150.5	1
73	JB11	<1	613	16.8	3.2	110	0.89	<5	2.5	<2	2.1	4.3	<5	27	108.5	1
74	JB12	<1	573	21.3	4.6	150	0.71	5	2.5	<2	2.6	4.9	7	24	74.6	1
75	JB13	<1	985	12.9	2.3	100	0.54	<5	2.3	<2	2.5	4.1	<5	27	118	1
78	JB14	<1	963	14	2	160	0.56	<5	2.1	<2	2.5	4.6	<5	31	127.5	<1
87	JB15	<1	930	40.5	2.6	120	1.59	<5	5.6	<2	3.3	5.8	<5	36	118.5	1
99	JB16	<1	420	22.3	2.8	140	1.82	<5	3.4	<2	3.4	8.8	5	26	127	1
100	JB17	<1	466	21.2	2.8	170	0.49	5	7	<2	2	8.5	7	16	33.6	1
103	JB18	<1	459	21.2	10	150	0.57	8	1.9	<2	3.2	5.6	11	20	54.5	1
109	JB19	<1	482	54.2	1.7	140	0.42	<5	4.7	<2	1.8	21.3	<5	15	44.2	<1
114	JB20	<1	509	25.2	1.8	130	0.39	7	3.5	<2	1.6	10.8	<5	16	53.4	1
119	JB21	<1	923	20	3.1	120	0.96	<5	3.5	<2	4.4	6.5	7	32	141.5	1
120	JB22	<1	830	13.9	2.3	130	0.84	<5	2.8	<2	2.3	4.9	5	37	127	1
132	JB23	<1	536	72.7	22.7	220	14.3	23	9.3	3	19	11.6	25	28	118	19
133	JB24	<1	365	32	3.2	150	1.35	<5	2.5	<2	2.8	8.1	<5	22	76.4	1
134	JB25	<1	454	41.8	2.6	140	1.19	<5	3.6	<2	3	17.1	6	27	58.1	<1
135	JB26	<1	722	67.3	13.3	190	1.85	13	5.4	<2	22	23.7	19	33	111	37
139	JB27	<1	472	17.2	3.2	140	0.88	<5	2.8	<2	2.7	5.8	5	19	62	<1
146	JB28	<1	436	15.3	2.6	100	0.75	<5	2.3	<2	1.4	5.1	<5	17	51.5	<1
148	JB29	<1	845	62.8	9.4	150	0.58	8	2.7	2	2.7	7.5	6	29	60.2	1
151	JB30	<1	913	17.2	1.5	110	0.5	<5	2.3	<2	2.9	4.9	<5	25	122.5	<1

Table1(i) Cont'd

Sample No.	Elements / Lab. No.	Sr	Ta	Th	Ti	U	V	W	Y	Zn	Zr	Ga	Dy	Er	Eu	Gd
6	JB1	203	0.4	5.23	<0.5	1.15	12	1	4.4	16	167	8.8	0.95	0.53	0.48	1.27
21	JB2	79.2	0.1	3.31	<0.5	1.29	17	1	3.7	11	96	4	0.8	0.44	0.31	1.14
23	JB3	120	0.2	2.82	<0.5	0.87	14	1	4.2	12	120	5.2	0.83	0.5	0.38	1.08
28	JB4	103	0.6	8.28	<0.5	7.81	86	1	7.3	19	421	9.6	1.62	0.99	0.43	2.55
37	JB5	135.5	0.8	28.6	0.6	6.84	34	1	22.6	26	329	14.2	3.79	2.26	0.57	4.94
43	JB6	83.2	0.2	2.77	<0.5	0.91	10	2	5.7	9	85	3.9	0.89	0.6	0.24	0.87
51	JB7	56.5	0.3	30.1	<0.5	4.19	20	1	31.6	16	622	3	5.13	3.24	0.42	5.86
53	JB8	54.7	0.1	2.46	<0.5	0.94	20	4	3.4	6	73	3	0.62	0.39	0.19	0.67
54	JB9	94.4	0.1	2.49	<0.5	0.79	12	3	4	6	114	3.9	0.73	0.46	0.24	0.91
69	JB10	60.6	0.6	4.41	<0.5	1.66	11	1	8.3	11	200	9.3	1.59	0.87	0.39	1.67
73	JB11	98.8	0.3	4.14	<0.5	1.48	26	1	4	12	84	6.5	0.72	0.46	0.28	0.83
74	JB12	105	0.6	3.56	<0.5	1.2	23	3	4.8	9	90	6.1	0.84	0.57	0.32	0.98
75	JB13	181.5	0.2	3.41	<0.5	0.75	11	5	3.1	10	73	7.3	0.6	0.34	0.37	0.68
78	JB14	158	0.2	3.44	<0.5	0.73	7	3	3.3	11	73	6.9	0.6	0.37	0.36	0.7
87	JB15	142.5	0.4	5.94	<0.5	2.22	15	2	6.2	12	190	6.9	0.93	0.71	0.28	1.07
99	JB16	41.1	0.4	5.37	<0.5	1.92	9	2	15	13	111	7.1	2.54	1.48	0.31	1.91
100	JB17	79.5	0.2	5.11	<0.5	1.56	37	3	7.8	12	244	3.9	1.26	0.89	0.33	1.46
103	JB18	113	0.3	6.53	<0.5	1.3	68	4	4.3	18	62	6	0.81	0.49	0.31	1
109	JB19	81.2	0.2	18.7	<0.5	2.01	16	5	10.3	9	160	3.5	1.92	1.07	0.34	3.2
114	JB20	97.9	0.1	7.35	<0.5	1.15	11	2	6	10	113	4.4	1.11	0.62	0.33	1.62
119	JB21	200	0.5	9.71	<0.5	1.69	18	2	6.3	20	112	10.3	1.07	0.67	0.45	1.12
120	JB22	139.5	0.2	6.21	<0.5	1.56	18	4	4.7	18	91	7.7	0.79	0.47	0.35	0.87
132	JB23	14.3	8.6	5.55	0.5	3.43	94	4	11.7	37	164	12	2.23	1.33	0.46	2.45
133	JB24	52.2	0.5	8.58	<0.5	1.69	29	2	7.7	6	81	5	1.39	0.76	0.25	1.64
134	JB25	125.5	0.3	7.93	<0.5	3.2	15	4	36.3	8	130	6	5.45	3.65	0.66	4.14
135	JB26	193.5	14.1	11.3	0.7	3.09	68	3	11.4	25	168	11	2.4	1.27	0.53	4.34
139	JB27	92.3	0.3	4.44	<0.5	1.46	15	9	8.3	6	97	4.8	1.27	0.95	0.27	1.17
146	JB28	78.6	0.2	2.61	<0.5	0.9	10	15	4.5	<5	83	4.1	0.79	0.47	0.25	0.97
148	JB29	186	0.3	5.5	<0.5	1.92	89	3	5.5	11	98	9.2	1.18	0.72	0.44	1.52
151	JB30	153.5	0.3	3.6	<0.5	0.81	7	5	2.5	7	88	7.3	0.51	0.3	0.38	0.84

Table 1(ii) Cont'd

Sample No.	Elements / Lab. No.	Ho	La	Lu	Pr	Sm	Tb	Yb	Tm
6	JB1	0.17	9.6	0.08	2.08	1.37	0.17	0.51	0.07
21	JB2	0.14	7.3	0.07	1.71	1.15	0.15	0.48	0.06
23	JB3	0.16	7.6	0.07	1.77	1.09	0.15	0.48	0.07
28	JB4	0.3	16.1	0.19	3.71	2.46	0.3	1.16	0.15
37	JB5	0.73	36.7	0.44	8.36	5.56	0.73	2.77	0.37
43	JB6	0.18	6	0.1	1.38	0.9	0.15	0.63	0.09
51	JB7	1.01	42.7	0.55	10.35	6.48	0.89	3.67	0.52
53	JB8	0.13	3.8	0.06	0.9	0.63	0.11	0.41	0.06
54	JB9	0.15	6.3	0.07	1.39	0.84	0.13	0.45	0.07
69	JB10	0.31	10.3	0.14	2.27	1.68	0.27	0.97	0.15
73	JB11	0.16	5.9	0.09	1.25	0.81	0.12	0.55	0.07
74	JB12	0.18	6.3	0.1	1.37	0.9	0.15	0.62	0.09
75	JB13	0.11	5.4	0.05	1.21	0.79	0.1	0.37	0.04
78	JB14	0.12	6.1	0.05	1.33	0.77	0.11	0.36	0.05
87	JB15	0.2	7.3	0.16	1.67	1.08	0.16	0.97	0.12
99	JB16	0.49	9.3	0.24	2.36	1.85	0.4	1.67	0.23
100	JB17	0.27	9.7	0.16	2.32	1.59	0.22	1.01	0.13
103	JB18	0.15	6.6	0.07	1.56	1.02	0.15	0.5	0.06
109	JB19	0.36	24.8	0.16	5.96	3.92	0.42	1.08	0.15
114	JB20	0.22	11.6	0.08	2.89	1.92	0.22	0.6	0.08
119	JB21	0.21	8.3	0.11	1.83	1.16	0.18	0.71	0.09
120	JB22	0.16	6.8	0.08	1.45	0.86	0.14	0.53	0.07
132	JB23	0.42	12.2	0.26	3.12	2.44	0.4	1.69	0.21
133	JB24	0.28	10.4	0.15	2.3	1.53	0.23	0.9	0.13
134	JB25	1.21	20.9	0.62	4.77	3.33	0.81	3.96	0.62
135	JB26	0.43	27.8	0.2	6.6	5.03	0.53	1.17	0.18
139	JB27	0.31	8.3	0.17	1.67	1.12	0.2	1.05	0.15
146	JB28	0.16	6.4	0.08	1.44	0.88	0.13	0.52	0.07
148	JB29	0.25	8.7	0.11	2.13	1.53	0.21	0.74	0.11
151	JB30	0.1	7.3	0.05	1.51	0.83	0.1	0.29	0.04

TABLE 2: Rotated Components Matrix (Varimax with Kaiser Normalization)

	Component				
	1	2	3	4	5
Y	.992				
Ho	.990				
Tm	.987				
Er	.986				
Dy	.979				
Yb	.978				
Lu	.974				
Tb	.938		.269		
Gd	.834		.427		.321
La	.750		.548		.341
Sm	.749		.507		.399
Nd	.746		.551		.343
Pr	.746		.552		.343
Eu	.648	.224		.583	.201
Co		.933			
Cu		.921	.230		
Ni		.855			.263
Cs		.850			
V		.820	.270		
Mo		.810			
Cr		.710		-.335	.202
Zn		.691	.291	.397	.246
Nb		.687		.254	.624
Zr	.509		.783		
Hf	.521	.264	.732		
Th	.639		.641		
U	.492	.378	.633	.267	
Ce	.567	.390	.624		
W			-.400	-.299	
Rb		.265		.855	
Pb			.302	.832	
Ba	-.298	.474		.823	
Ga		-.274		.800	
Sr				.734	.317
Ti				.253	.866
Sn	.206	.526			.820
Ta		.588			.772

Table 3: Correlation Coefficient of Some Selected Elements From the Result of Geochemical Analysis of Some Stream Sediment Samples From Eruku and Its Environs

	Cs	Nb	Sn	Sr	Ta	W	Zr	Rb	Cu	Mo	Ni	Pb	U	V	Zn	Co	Ba
Cs	1																
Nb	.682	1															
Sn	.475	.929	1														
Sr	-.351	.103	.120	1													
Ta	.547	.954	.996	.087	1												
W	-.006	-.076	.005	-.080	-.004	1											
Zr	.073	.141	.040	-.160	.055	-.315	1										
Rb	.292	.395	.170	.368	.203	-.252	.054	1									
Cu	.657	.711	.576	-.097	.619	-.096	.265	.168	1								
Mo	.796	.484	.334	-.155	.393	.035	-.029	.050	.628	1							
Ni	.643	.786	.665	.002	.704	-.111	.167	.194	.875	.536	1						
Pb	.193	.376	.161	.432	.187	-.330	.281	.822	.385	.071	.398	1					
U	.289	.379	.195	-.062	.224	-.269	.742	.349	.575	.130	.488	.667	1				
V	.500	.596	.492	.003	.526	-.109	.219	.060	.883	.664	.796	.350	.516	1			
Zn	.717	.784	.590	.080	.634	-.296	.354	.502	.719	.517	.784	.540	.562	.628	1		
Co	.711	.754	.610	-.080	.657	-.063	.187	.203	.955	.684	.916	.412	.542	.914	.748	1	
Ba	-.072	.131	.054	.854	.051	-.131	-.156	.589	-.039	.051	-.004	.533	-.090	-.028	.191	-.015	1

Table 4: Regional and Local Threshold Values with the Geochemical Relief of the Analyzed Elements

Elements	Ba	Ce	Co	Cr	Cs	Cu	Hf	Mo	Nb	Nd	Ni	Pb	Rb	Sn	Sr	Ta	Th	Ti	U
Regional Threshold	650	55	5	140	2	6	5	2	4	10	7	26	88	1	111	0.3	7	0.6	2
Local Threshold	950	95	19	190	10	8	10	2	6	24	19	37	142	2	160	1	11	0.7	4
Geochemical Relief	650	95	20	140	13	17	13	1	15	27	18	26	140	36	180	14	23	0.3	6

***Table 4** Cont'd*

Elements	V	W	Y	Zn	Zr	Ga	Dy	Er	Eu	Gd	Ho	La	Lu	Pr	Sm	Tb	Yb	Tm
Regional Threshold	27	3	9	13	151	7	2	1	0.4	2	0.3	12	0.15	3	0.3	0.3	0.8	0.1
Local Threshold	68	5	23	26	329	10	4	2	0.6	5	0.7	28	0.5	8	4	0.7	3	0.4
Geochemical Relief	67	14	28	24	571	41	4	3	0.4	4	1	31	0.6	8	6	0.7	3.4	0.4

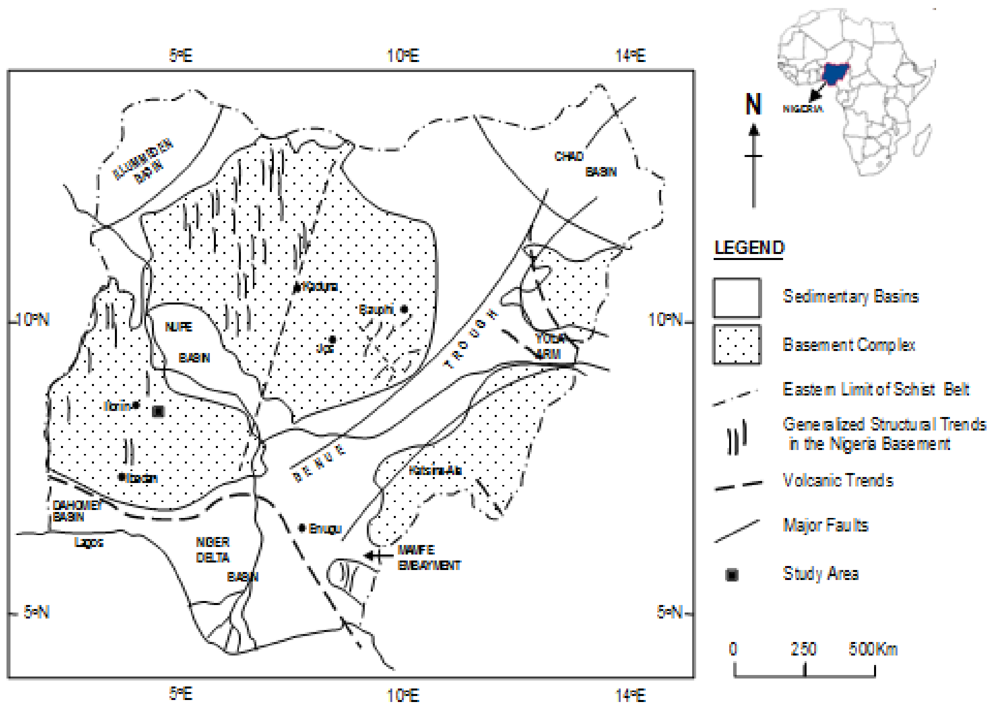

Figure 1: Geological map of Nigeria showing the study area (After Kogbe, 1976[21])

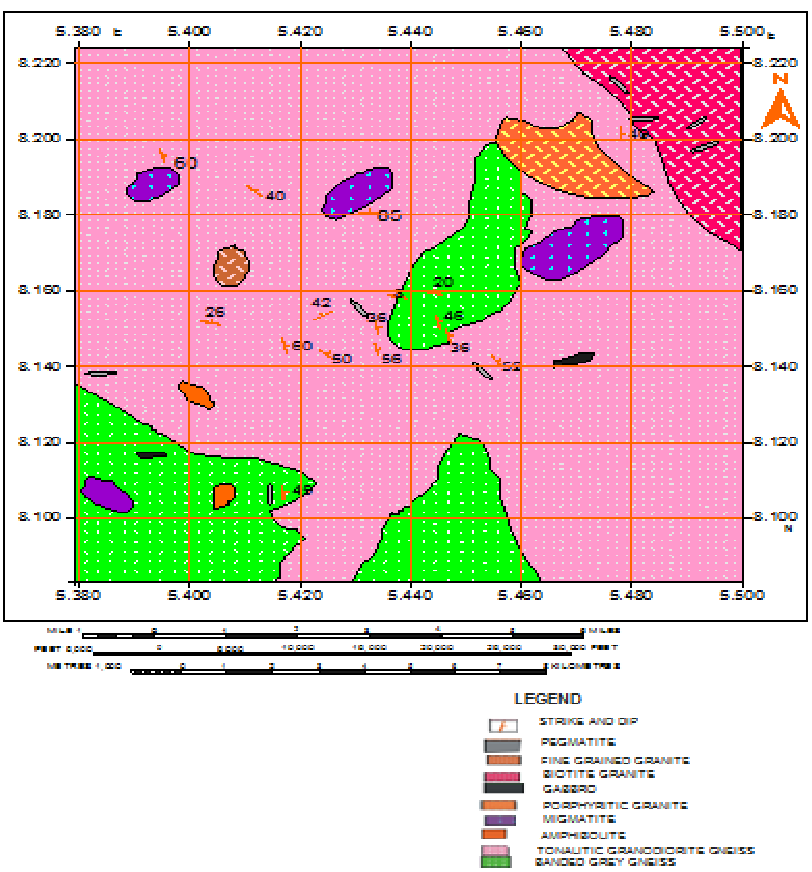

Figure. 2: Geological Map of the Study Area

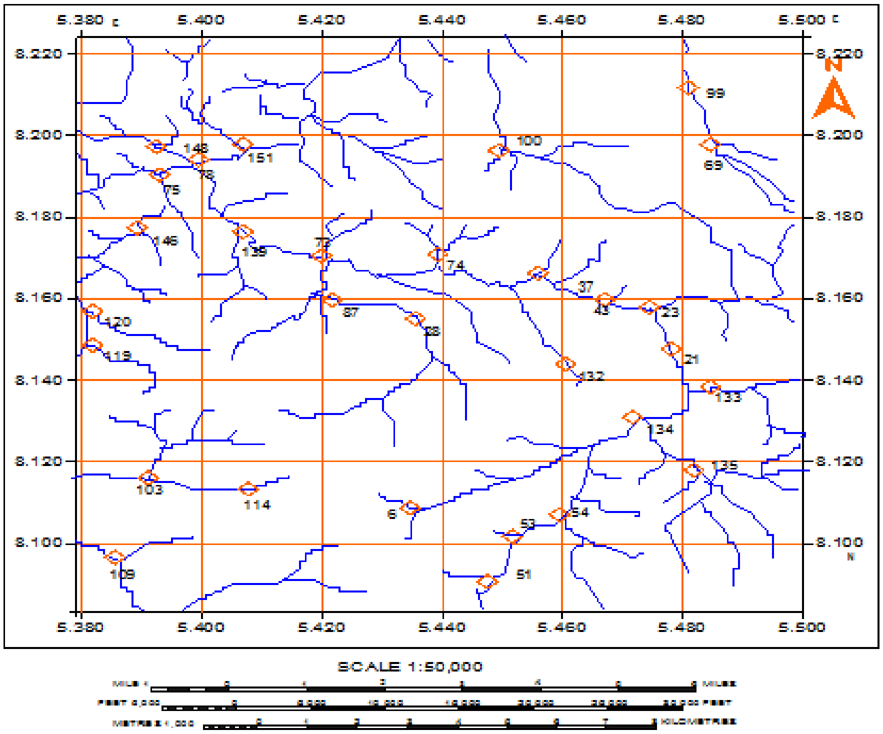

Figure. 3 Samples Analysed and Their Relationship with the Drainage Systems in the Study Area

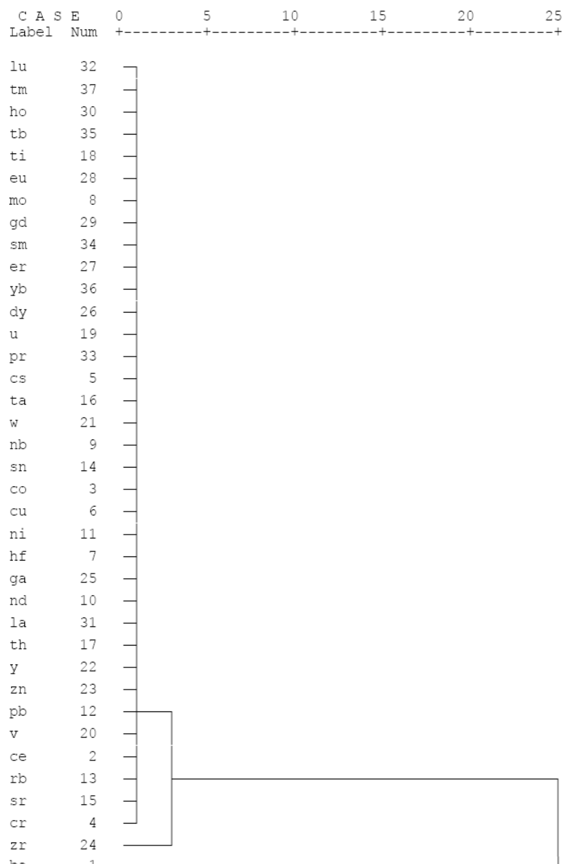

Figure 4: Average Linkage (Between Groups)

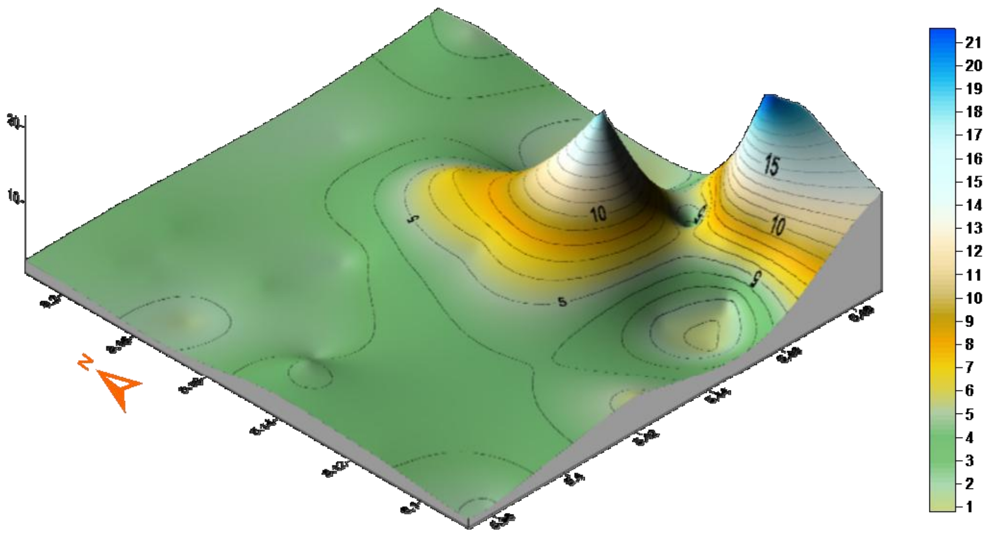

Figure 5: 3D Isograde Map Showing Nb Distribution

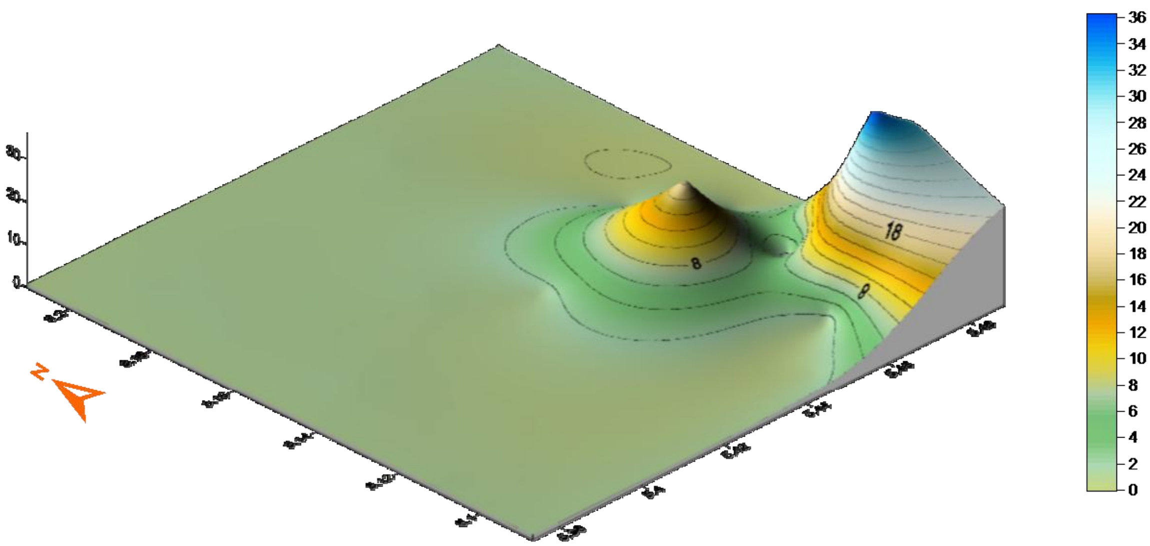

Figure 6: 3D Isograde Map Showing Sn Distribution

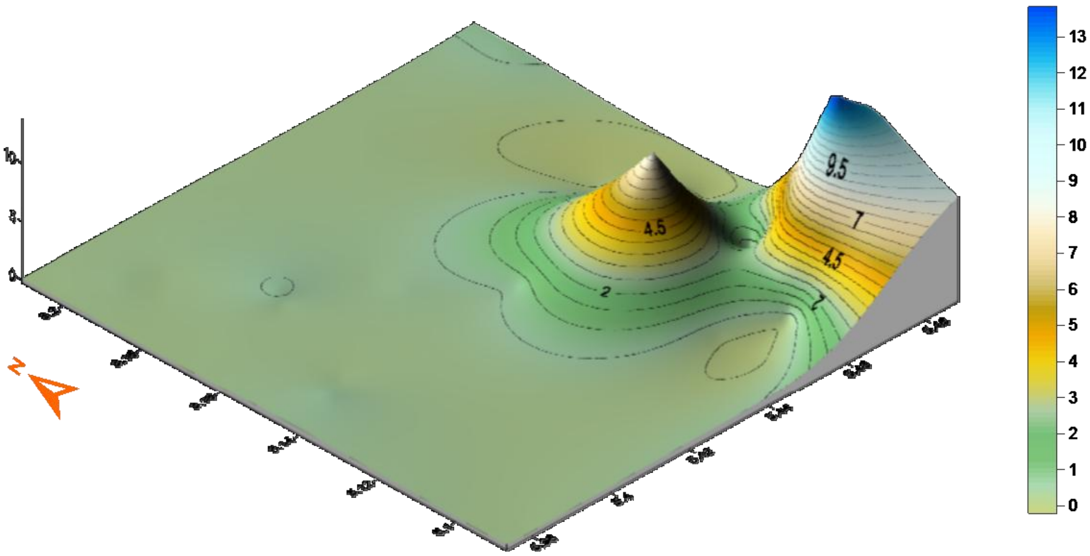

Figure 7: 3D Isograde Map Showing Ta Distribution

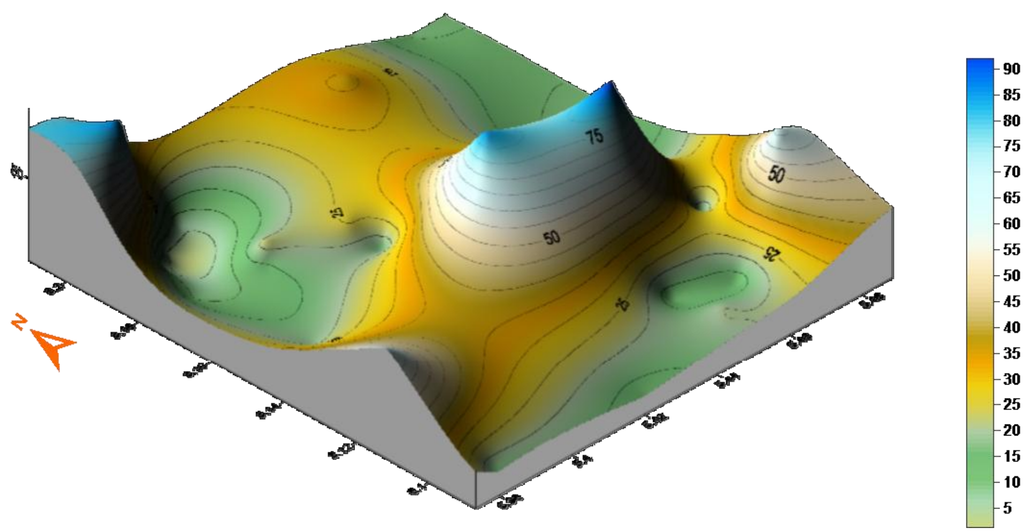

Figure 8: 3D Isograde Map Showing W Distribution