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Stream Sediments Geochemistry of the Nyambaka Drainage System Northern Cameroon (Central Africa): A Target for Mining Exploration

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Abstract: Mining exploration in the Nyambaka area Northern Cameroon still at reconnaissance stage. In this study, ten active stream sediments samples were collected for geochemical survey. These stream sediments were analyzed by inductively coupled Plasma/ Mass Spectometry (ICP/MS), the data set obtained was transformed into a standard formation an excel database, and was subject to statistical treatment using IBM SPSS statistics 21 for 33 chemical elements to highlight the relationship between the stream sediments geochemistry, the region lithology, the geological processes and eventual primary mineralization. The data were analyzed using multivariate statistics. R-mode analysis produced a five-factor model behind multi-elements associations which account for 93.40% of the total variance in the data with the following metals associations: Sc-Mo-V-In-Ga-Cu-Cr, Ba-Sr-Ag-Cr-Cu-Co-Be-Ni-Y-Zn-V, Ga-Hf-Zr, Sn-Au, As-Cd. Sn-Au association indicates that Au mineralization is link to Sn mineralization. As-Cd, Cu Ga, In, Mo suggested that the paragenesis represent others sulphidation events that is barren with respect to Au. The spatial distribution of Sn-Au and As-Cd factors show that these factors are mores express in the centre part of the study area; they can be link to granitic rocks, defining a primary gold target. A detail mining investigation have to me carry out in that area to highlight the primary mineralizations.

Keywords: Stream Sediments, Nyambaka Area, Northern Cameroon

1. Introduction

Geochemical mapping surveys have been conducted in different parts of the word at various scales to booster geochemical prospecting [1]. Acceptance of sediments composition is representative of the geochemistry of the catchment basin upstream [2]. The spatial display of stream sediment geochemical data, and statistical treatment of the data can unravel element associations relevant to primary exploration in a region [3], and high mining potential area. these associations are useful in speculating on the source region lithology, geological processes and the nature of the primary (rock-hosted) mineralization, if any is present [4, 5, 1].

The study area is a part of the Adamawa-Yadé domain, and was subject to geochemical, petrological, and geochronological studies of the basement rocks [6-9]. A few is known about mining index in the Adamawa- Yadé; and the study area is not yet subject to a geochemical exploration of stream sediments. The aim of this study is to do the mapping of the distribution of chemical elements in the study area watershed, to identify area of high mining potential for the boosting of mining exploration.

2. Geographical and Geological Setting

The study area is located in the Adamawa region, and lies between longitudes 10°0'E and 14°09'E, and latitudes 6°60'N and 6°52'N respectively. It's hydrographic system belong to two main hydrographic basins known in Cameroon the Tchad Basin and the Sanaga Basin (Olivry, 1986) (figure 1A); and to the Mayo Mambaka Wathersheed (figure 1B).

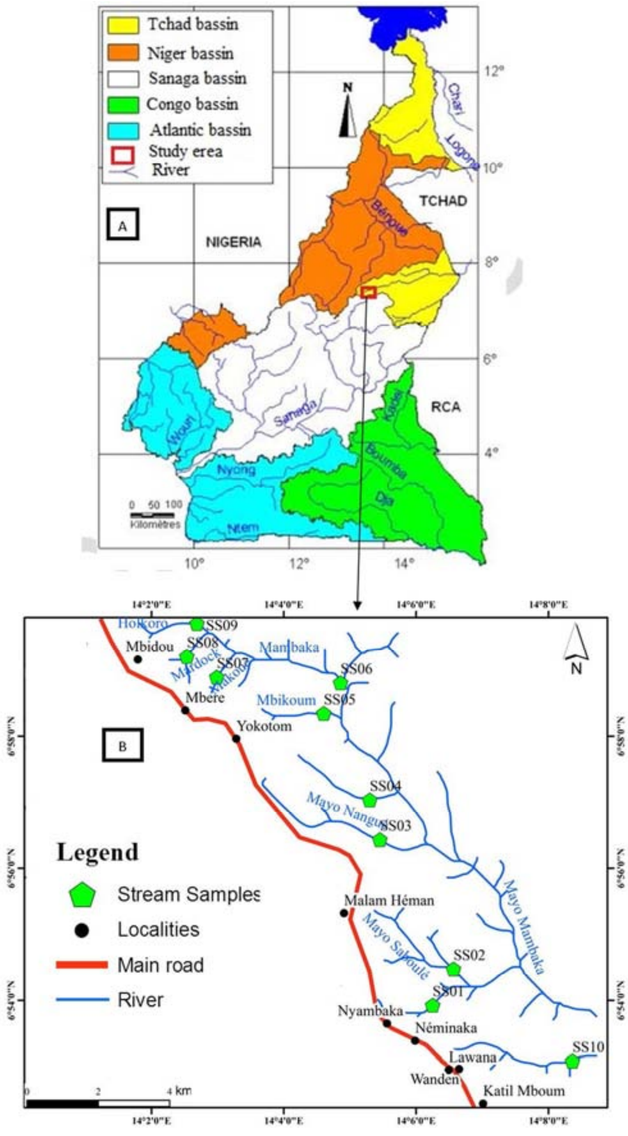


Figure 1. *Maps: A- Hydrographic bassins of Cameroon (Olivry, 1986); B- The Mayo Mambaka Wathersheed and Stream sediment sampling.*

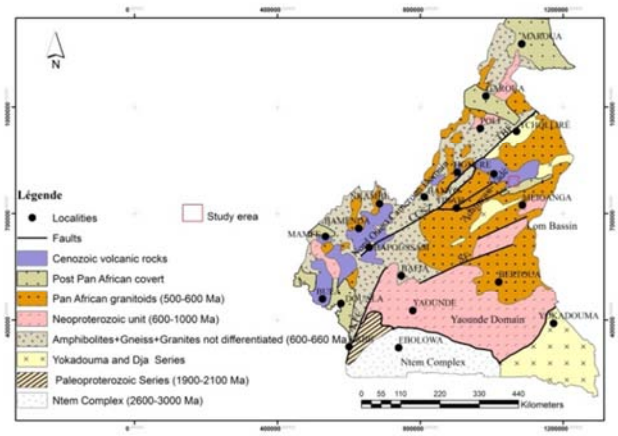


Figure 2. *Geological map of the Central African Orogenic Belt (CAOB) in Cameroon.*

Geologically, the study area belongs to the Adamawa-Yadé domain, which is a part of the Central Africa, Orogenic Belt (CAOB) [10]. In Cameroon, the Central African Orogenic Belt (CAOB) is subdivided into three geological domains, from the North to the South (figure 2): the Northern domain, the Adamawa-Yadé Domain, the Southern nappes (figure 2). The Adamawa-Yadé domain is made up of various low-to high-grade metamorphic rocks and abundant pan-african granites, bearing Archaean to palaeoproterozoïc isotopic signatures [11, 12]. Reference [13] suggest that the Adamaoua-Yadé domain represents an Archaean/palaeoproterozoîc microcontinent, which was detached from the northern margin of the Congo Craton in the early Neoproterozoïc, but became reaccreted together with the Mayo Kebbi magmatic arc during the Pan-African orogeny.

3. Material and Methods

Ten active stream sediments samples were collected within the drainage system (figure 1B). First and second tributaries rivers were sampled. These samples were weighed with an electronic balance (Sartorius et Kitchen scale SF-400), and air dry in the ''Laboratory of Mineral Treatment''; after drying, samples were crushed using a ''Fritsch Pulverizer'', and 30g of 180µm fraction was retained for further geochemical analysis.

In the laboratory, a 0.2g of each sample was analyzed for 65 chemical elements by inductively coupled Plasma/ Mass Spectometry (ICP/MS) at ''Bureau Veritas Laboratories Canada''. Replicates samples chosen from the sample batch were randomly place in each analysis to test for analytical precision.

The data set obtained was transformed into a standard formation an excel database, and was subject to statistical treatment using IBM SPSS statistics 21 for 33 chemical elements (table 6). Statistical parameters like minimum, median, mean, maximum were measured to have central tendency; while standard deviation, variance, give statistical dispersion. The asymmetry is given by Skewness and

Kurtosis index. Correlation matrix, factor analysis were performed to obtain trends and relationship between variables, and deduce the factors influencing the stream sediment geochemistry.

Colored geochemical maps of the data were draw using ArcGis 10.2 software. Symbol plots of factor scores of the elements associations obtained after factor analysis, were produced to analyze their relationship with the geological catchment of the area. These factor scores were projected on a map along the watershed system to present sectors of high mining potentials.

4. Results and Discussion

Ten samples were analyzed for a whole suite of elements; only 33 elements with concentrations above the detection limit are reported (table 1). The descriptive statistics are presented in table 2. Twenty elements present positive skewed distribution.

Table 1. *Detections limits of 33 elements concentrations.*

Elements	Unit	DL	Elements	Unit	DL	Elements	Unit	DL
Mo	ppm	0.01	Cd	ppm	0.01	Cs	Ppm	0.02
Cu	ppm	0.01	Sb	ppm	0.02	Hf	Ppm	0.02
Pb	ppm	0.01	Bi	ppm	0.02	Nb	Ppm	0.02
Zn	ppm	0.1	V	ppm	1	Rb	Ppm	0.1
Ag	ppb	2	Ca	%	0.01	Sn	Ppm	0.1
Ni	ppm	0.1	Cr	ppm	0.5	Zr	Ppm	0.1
Co	ppm	0.1	Ba	ppm	0.5	Y	Ppm	0.01
As	ppm	0.1	Sc	ppm	0.1	In	Ppm	0.02
U	ppm	0.1	Tl	ppm	0.02	Be	Ppm	0.1
Au	ppb	0.2	Hg	ppb	5	Sr	Ppm	0.5
Th	ppm	0.1	Se	ppm	0.1	Ga	Ppm	0.1

Table 2. *The descriptive statistics (N=10).*

	Minimum	Maximum	Mean	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Erreur std	Statistic	Erreur std
Mo	1.42	2.06	1.77	0.042	-0.51	0.68	-0.692	1.33
Cu	22.54	54.21	41.12	143.43	-0.67	0.68	-1.19	1.33
Pb	5.81	13.31	8.24	6.98	1.24	0.68	0.47	1.33
Zn	29.20	89.60	62.23	385.62	-0.20	0.68	-0.98	1.33
Ag	15.00	24.00	20.5	9.61	-0.89	0.68	-0.55	1.33
Ni	36.40	231.10	134.29	3615.35	-0.00	0.68	-0.74	1.33
Co	12.90	65.70	38.19	314.64	0.32	0.68	-0.89	1.33
As	1.20	2.60	1.47	0.17	2.70	0.68	7.92	1.33
U	2.20	4.00	2.69	0.42	1.43	0.68	0.82	1.33
Au	0.40	1.00	0.79	0.04	-0.63	0.68	-0.34	1.33
Th	9.80	25.60	15.19	21.31	1.47	0.68	2.11	1.33
Sr	7.10	105.00	32.36	764.96	2.32	0.68	6.27	1.33
Cd	0.01	0.06	0.03	0.00	0.19	0.68	-0.14	1.33
Sb	0.00	0.06	0.02	0.00	0.03	0.68	-1.22	1.33
Bi	0.00	0.08	0.04	0.00	-0.69	0.68	-0.29	1.33
V	142.00	312.00	247.70	3380.90	-0.89	0.68	-0.45	1.33
Ca	0.00	0.25	0.07	0.00	1.78	0.68	3.49	1.33
Cr	202.70	763.00	443.20	32084.82	0.23	0.68	-0.51	1.33
Ba	43.20	325.20	134.45	5997.41	1.74	0.68	4.26	1.33
Sc	15.20	34.50	28.23	39.44	-1.28	0.68	0.74	1.33
Tl	0.05	0.22	0.09	0.00	1.69	0.68	1.25	1.33
Hg	17.00	54.00	26.40	121.15	1.95	0.68	4.61	1.33
Se	0.00	0.20	0.08	0.00	0.13	0.68	0.17	1.33
Ga	20.40	34.60	27.50	17.93	0.05	0.68	-0.36	1.33
Cs	0.44	1.12	0.73	0.06	0.44	0.68	-1.36	1.33
Hf	0.34	0.89	0.60	0.03	0.00	0.68	-1.61	1.33
Nb	0.91	4.04	1.92	0.89	1.29	0.68	1.76	1.33
Rb	2.30	18.1	5.94	38.12	1.75	0.68	1.37	1.33
Sn	2.80	3.80	3.08	0.08	1.75	0.68	3.98	1.33
Zr	27.00	61.50	42.86	158.32	0.16	0.68	-1.41	1.33
Y	12.20	27.88	23.15	24.69	-1.21	0.68	1.43	1.33
In	0.08	0.15	0.12	0.00	-0.78	0.68	0.39	1.33
Be	0.60	2.60	1.86	0.32	-1.29	0.68	1.90	1.33

Elements relationship was investigate using a Pearson's correlation matrix (table 3) the correlation values (r) display a wide range from -0.4 between Au and Se, to 0.9 between Au and U, and between Au and Zn. other elements pairs with a high positive r values (≥ 0.9) include V-Cr, Mo-Ni, Ni-Zn, U-Th, Sc-V (table 3).

Table 3. *(a, b, c). Pearson's correlation matrix (N=10).*

a)	**Mo**	**Cu**	**Pb**	**Zn**	**Ag**	**Ni**	**Co**	**As**	**U**	**Au**
Mo	1.00									
Cu	0.28	1.00								
Pb	-0.63	-0.77	1.00							
Zn	-0.00	0.88	-0.59	1.00						
Ag	0.23	0.68	-0.48	0.59	1.00					
Ni	0.04	0.92	-0.65	0.97	0.61	1.00				
Co	-0.21	0.71	-0.45	0.83	0.68	0.84	1.00			
As	0.35	0.01	-0.00	-0.09	0.10	-0.17	-0.34	1.00		
U	-0.76	-0.63	0.96	-0.44	-0.36	-0.50	-0.27	-0.03	1.00	
Au	0.27	0.23	-0.05	-0.01	0.07	-0.03	-0.10	0.38	-0.00	1.00
Th	-0.74	-0.48	0.89	-0.29	-0.34	-0.33	-0.16	-0.22	0.94	0.02
Sr	-0.35	0.53	-0.34	0.63	0.34	0.58	0.80	-0.24	-0.15	0.18
Cd	0.10	0.32	-0.26	0.425	0.15	0.27	0.21	0.62	-0.23	0.36
Sb	0.48	-0.53	0.24	-0.71	-0.42	-0.72	-0.83	0.54	0.04	0.30
Bi	0.15	-0.67	0.55	-0.88	-0.43	-0.87	-0.84	0.32	0.42	0.40
V	0.57	0.88	-0.81	0.68	0.54	0.75	0.414	0.14	-0.77	0.22
Cr	0.27	0.87	-0.75	0.77	0.49	0.86	0.57	-0.17	-0.67	-0.09
Ba	-0.49	0.44	-0.16	0.62	0.29	0.55	0.79	-0.27	0.02	0.14
Sc	0.61	0.82	-0.83	0.52	0.54	0.61	0.36	0.06	-0.79	0.37
Tl	-0.76	-0.68	0.93	-0.41	-0.29	-0.49	-0.19	-0.10	0.95	-0.23
Hg	0.40	-0.41	-0.19	-0.47	-0.27	-0.51	-0.42	0.27	-0.32	-0.14
Se	0.50	-0.24	-0.24	-0.18	-0.05	-0.23	-0.34	0.27	-0.43	-0.45
Ga	0.78	0.24	-0.39	-0.16	0.20	-0.07	-0.31	0.36	-0.48	0.49
Cs	-0.49	-0.82	0.90	-0.77	-0.42	-0.81	-0.52	0.12	0.86	0.07
Hf	0.51	0.25	-0.07	0.13	0.26	0.16	-0.11	0.23	-0.18	0.29
Nb	0.29	-0.66	0.16	-0.58	-0.37	-0.66	-0.58	0.34	-0.04	-0.24
Rb	-0.83	-0.64	0.92	-0.35	-0.34	-0.44	-0.15	-0.15	0.95	-0.19
Sn	0.32	0.07	0.05	-0.31	0.01	-0.18	-0.32	0.04	0.05	0.61
Zr	0.6	0.41	-0.26	0.27	0.39	0.31	0.02	0.16	-0.35	0.28
Y	-0.20	0.70	-0.27	0.82	0.74	0.78	0.85	-0.23	-0.09	0.08
In	0.70	0.68	-0.69	0.32	0.56	0.41	0.15	0.14	-0.67	0.44
Be	-0.20	0.63	-0.17	0.80	0.482	0.74	0.55	0.23	-0.03	-0.06
Ca	-0.55	0.26	-0.00	0.42	0.25	0.34	0.67	-0.23	0.17	0.21

b)	**Th**	**Sr**	**Cd**	**Sb**	**Bi**	**V**	**Cr**	**Ba**	**Sc**	**Tl**
Th	1.00									
Sr	-0.10	1.00								
Cd	-0.33	0.47	1.00							
Sb	-0.10	-0.69	0.03	1.00						
Bi	0.29	-0.62	-0.24	0.83	1.00					
V	-0.65	0.17	0.25	-0.15	-0.44	1.00				
Cr	-0.52	0.28	0.05	-0.45	-0.67	0.90	1.00			
Ba	0.08	0.97	0.45	-0.72	-0.61	0.05	0.19	1.00		
Sc	-0.70	0.24	0.16	-0.09	-0.28	0.93	0.80	0.07	1.00	
Tl	0.87	-0.14	-0.23	-0.03	0.29	-0.85	-0.70	0.04	-0.89	1.00
Hg	-0.52	-0.19	0.18	0.47	0.27	-0.26	-0.39	-0.30	-0.13	-0.20
Se	-0.59	-0.46	0.13	0.42	0.04	0.03	-0.04	-0.50	-0.01	-0.25
Ga	-0.49	-0.39	-0.04	0.60	0.44	0.57	0.28	-0.53	0.69	-0.62
Cs	0.71	-0.32	-0.23	0.42	0.73	-0.82	-0.84	-0.21	-0.74	0.82
Hf	-0.07	-0.45	-0.05	0.38	0.18	0.53	0.32	-0.42	0.42	-0.26
Nb	-0.25	-0.47	0.15	0.66	0.42	-0.42	-0.56	-0.47	-0.40	0.11
Rb	0.89	-0.04	-0.18	-0.10	0.24	-0.84	-0.68	0.14	-0.88	0.98
Sn	0.14	-0.33	-0.42	0.37	0.57	0.22	0.04	-0.39	0.37	-0.18
Zr	-0.20	-0.36	-0.06	0.23	0.03	0.63	0.44	-0.36	0.53	-0.40
Y	0.05	0.63	0.18	-0.78	-0.68	0.37	0.47	0.68	0.31	-0.05
In	-0.60	-0.00	0.02	0.07	-0.03	0.82	0.64	-0.15	0.93	-0.78
Be	0.06	0.32	0.39	-0.56	-0.65	0.43	0.50	0.38	0.17	-0.02
Ca	0.17	0.92	0.42	-0.62	-0.42	-0.13	-0.02	0.96	-0.04	0.18

c)	**Hg**	**Se**	**Ga**	**Cs**	**Hf**	**Nb**	**Rb**	**Sn**	**Zr**	**Y**	**In**	**Be**	**Ca**
Hg	1.00												
Se	0.69	1.00											
Ga	0.11	0.18	1.00										
Cs	0.06	-0.19	-0.18	1.00									
Hf	-0.40	0.08	0.64	-0.18	1.00								

c)	Hg	Se	Ga	Cs	Hf	Nb	Rb	Sn	Zr	Y	In	Be	Ca
Nb	0.82	0.81	0.05	0.29	-0.09	1.00							
Rb	-0.23	-0.31	-0.68	0.78	-0.32	0.05	1.00						
Sn	-0.29	-0.44	0.70	0.16	0.49	-0.36	-0.21	1.00					
Zr	-0.39	0.09	0.63	-0.38	0.96	-0.17	-0.46	0.46	1.00				
Y	-0.63	-0.41	-0.26	-0.44	0.09	-0.67	-0.01	-0.15	0.23	1.00			
In	-0.12	0.03	0.82	-0.58	0.55	-0.32	-0.80	0.54	0.65	0.24	1.00		
Be	-0.59	-0.23	-0.28	-0.41	0.17	-0.53	-0.00	-0.27	0.24	0.69	0.07	1.00	
Ca	-0.21	-0.51	-0.52	-0.00	-0.50	-0.36	0.28	-0.35	-0.47	0.59	-0.22	0.23	1.00

Factor analysis was applied on the log-transformed geochemical data to infer the controlling factors behind multi-elements associations in relation to catchment geology and mineralizations. The factor analysis using the varimax normalization Kaiser Method produced a five-factor model accounting for 93.40% (table 4) of the total data variance. The spatial distribution of these factors whiting the drainage system is presented in figure 3. These factors are presented as follows (table 4):

Table 4. *Factor analysis with varimax rotation for 33 trace metals in stream sediments (N=10).*

Variables	Factors				
	1	2	3	4	5
Mo	0.79	-0.29	0.39	-0.00	0.19
Cu	0.60	0.75	0.06	0.20	0.07
Pb	-0.93	-0.30	0.11	0.08	-0.02
Zn	0.32	0.92	-0.02	-0.08	0.12
Ag	0.33	0.60	0.18	0.07	0.14
Ni	0.40	0.90	0.01	-0.02	-0.03
Co	0.17	0.87	-0.28	-0.00	-0.07
As	0.06	-0.19	0.28	0.02	0.86
U	-0.97	-0.11	0.00	0.18	-0.03
Au	0.14	-0.06	0.04	0.84	0.44
Th	-0.93	0.04	0.07	0.25	-0.19
Sr	0.10	0.62	-0.70	0.22	0.12
Cd	0.16	0.24	-0.25	-0.04	0.89
Sb	0.06	-0.82	0.38	0.08	0.33
Bi	-0.25	-0.83	0.25	0.39	0.11
V	0.77	0.46	0.34	0.13	0.07
Cr	0.63	0.63	0.21	-0.01	-0.21
Ba	-0.09	0.68	-0.64	0.18	0.13
Sc	0.85	0.30	0.18	0.33	0.00
Tl	-0.97	-0.09	-0.04	-0.07	-0.04
Hg	0.33	-0.69	-0.38	-0.39	0.25
Se	0.36	-0.41	0.16	-0.75	0.20
Ga	0.63	-0.34	0.51	0.41	0.10
Cs	-0.77	-0.52	-0.03	0.20	0.06
Hf	0.19	0.08	0.89	0.18	0.10
Nb	0.00	-0.72	-0.03	-0.54	0.33
Rb	-0.98	-0.04	-0.13	-0.04	-0.04
Sn	0.13	-0.26	0.44	0.79	-0.23
Zr	0.34	0.18	0.85	0.15	0.04
Y	0.00	0.91	-0.01	0.13	0.00
In	0.77	0.14	0.38	0.39	0.00
Be	0.09	0.85	0.23	-0.13	0.29
Ca	-0.18	0.40	-0.84	0.17	0.13

Factor 1: account for 39.20% of the total variability, and show high positive loadings for (tab.) Sc-Mo-V-In-Ga-Cu-Cr. these elements association can be interpreted to reflect an hydrothermal alteration leading to the development of Ga Cu In and Mo. but gold is not in this paragenesis, suggesting that the paragenesis represent another sulphidation event that is barren with respect to Au. The presence of V can be explained by its normal occurrence in small amount in magnetite [14]. The presence of Cr in this factor can be link by the presence of chromite in parent rocks. Scandium can be associated to organic matter. Its small size and high charge favor the formation of stable organic complexes in soils or absorption on clay minerals derived from the chemical weathering of granitic rocks [15]. The factor 1 spatial distribution (figure 3) show high levels in the SE of the study area on the Mayo Saboulé river and in the NW on the Makoué river.

Factor 2: account for 26.90% of the total variability and is made up of the associations of Ba-Sr-Ag-Cr-Cu-Co-Be-Ni-Y-Zn-V. These associations can be interpreted to reflect a lithological control. It can be attributed to the catchment weathering, and disseminated sulfides such as chalcopyrite, pyrite, and sphalerite. Reference 16 showed that Fe can be substituted for by Co, Ni in magnetite reflecting the receptivity of the octahedral and tetrahedral sites in spinel lattices; V can be explained by its normal occurrence in small amounts in magnetite [14].

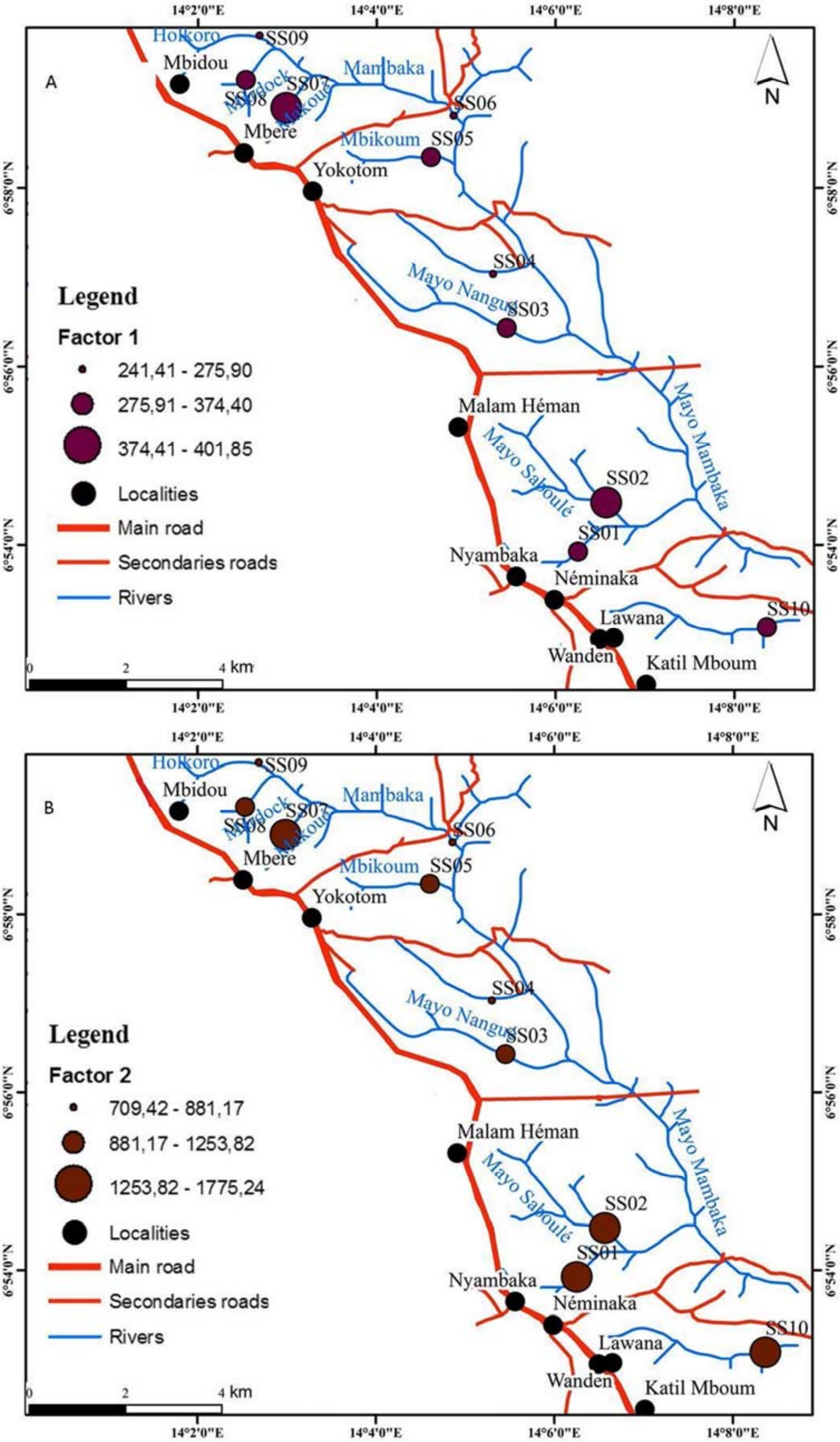
Factor 3: comprise Ga-Hf-Zr and explains 13.04% of the total variance. Reference [17] proposed that the enrichment of any stream sediment in high field strength elements (HFSE) such as Hf-Zr is a strong indication of granitic source. This factor indicate a granitic origin, and present a high leadings in the SE of the study area on the Lawana river (figure 3).

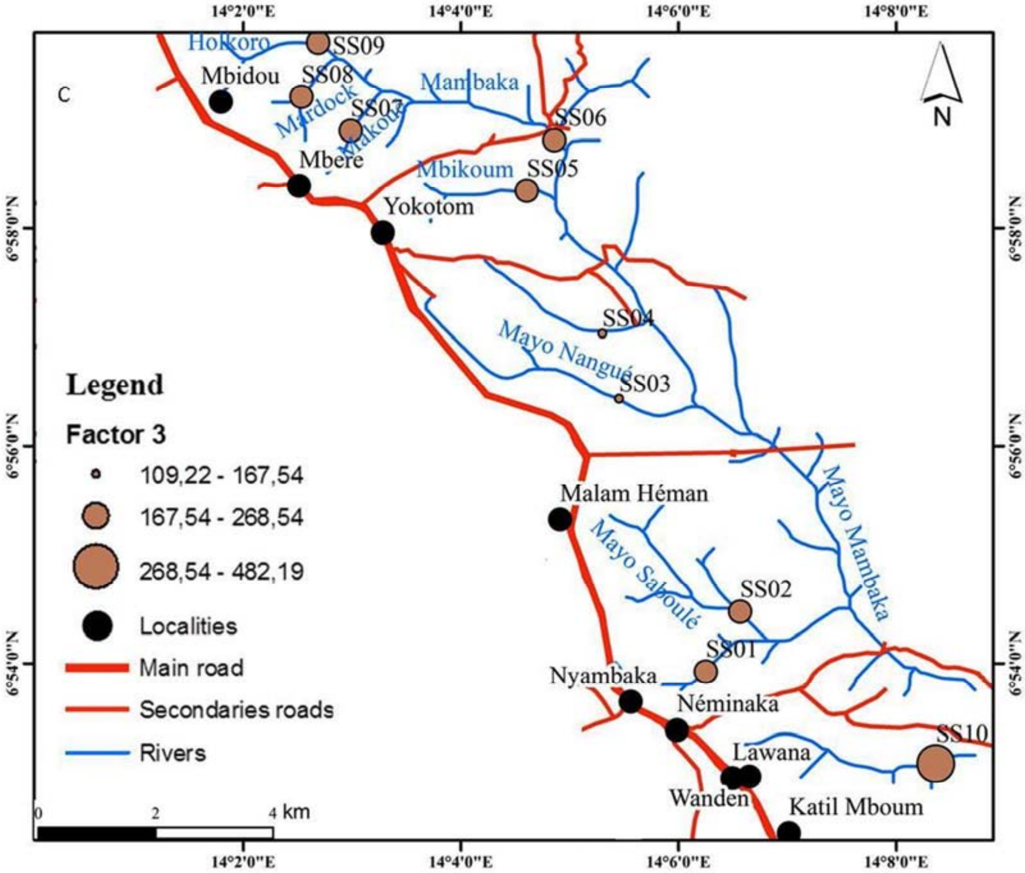
Table 5. *Percentage of variance and cumulative variance of factors.*

Component	Initial values		
	Total	% of variance	% of cumulative
1	12.93	39.20	39.20
2	8.87	26.90	66.11
3	4.30	13.04	79.15
4	2.56	7.76	86.92
5	2.13	6.47	93.40

Factor 4: Sn-Au; this factor explains 7.7% of the total variance. This is a mineralization factor. Cassiterite deposit is known in the Adamawa region in granitic rocks context and associated veins. This factor shows that cassiterite deposit and gold mineralizations are contemporaneous. This factor present a high leadings in the center part of the study area (sample S504), and medium leadings on mayo Nangue, Mbikoum, Makoué, Mardock rivers (figure 3).

Factor 5: As-Cd explains about 6.47% of the total variability (table 5). It is also a mineralization factor which represents another sulphidation event that is barren with respect to Au. This factor is more express in the central part of the study area, on the Mayo Nangue river (figure 3).




C
14°2'0"E
14°4'0"E
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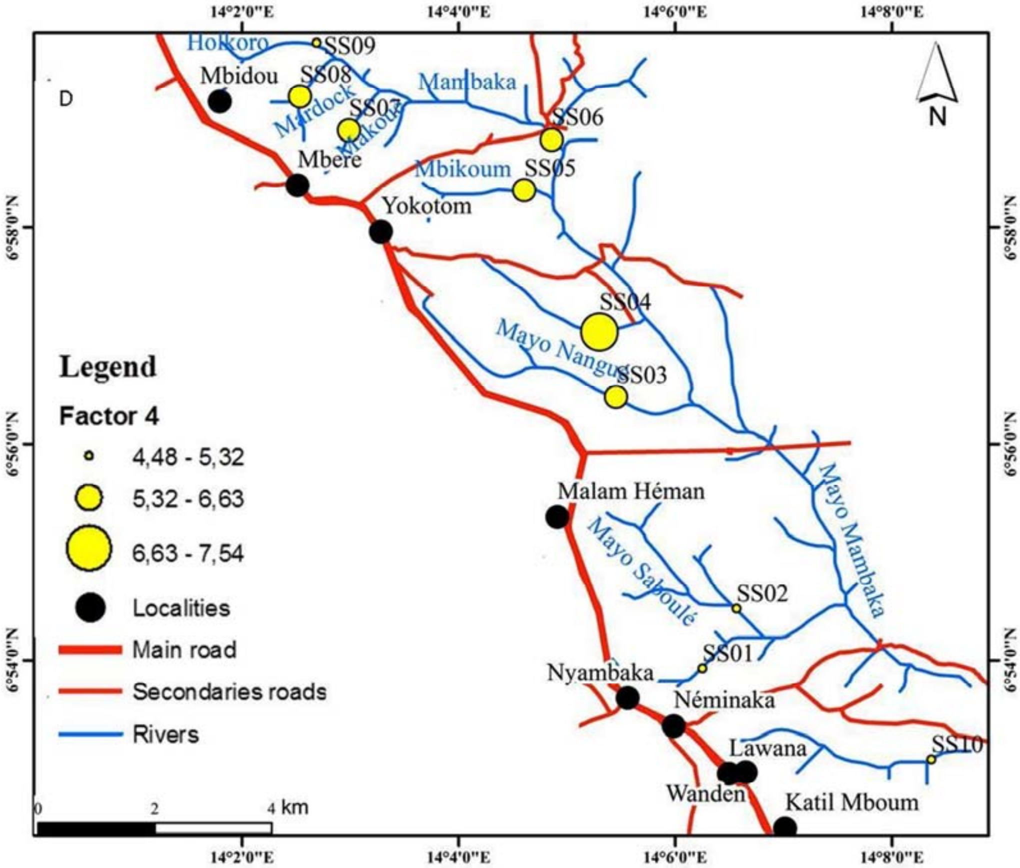
14°8'0"E
6°58'0"N
6°56'0"N
6°54'0"N
N
Holkoro
SS09
Mbidou
SS08
Mambaka
Mardock
SS07
Makoua
SS06
Mbere
Mbikoum
SS05
Yokotom
SS04
Mayo Nangué
SS03
Malam Héman
Mayo Saboulé
Mayo Mambaka
SS02
SS01
Nyambaka
Néminaka
SS10
Lawana
Wanden
Katil Mboum
Legend
Factor 3
109,22 - 167,54
167,54 - 268,54
268,54 - 482,19
Localities
Main road
Secondaries roads
Rivers
0 2 4 km


D
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Holkoro
SS09
Mbidou
SS08
Mambaka
Mardock
SS07
Makoua
SS06
Mbere
Mbikoum
SS05
Yokotom
SS04
Mayo Nangué
SS03
Malam Héman
Mayo Saboulé
Mayo Mambaka
SS02
SS01
Nyambaka
Néminaka
Lawana
SS10
Wanden
Katil Mboum
Legend
Factor 4
4,48 - 5,32
5,32 - 6,63
6,63 - 7,54
Localities
Main road
Secondaries roads
Rivers
0 2 4 km

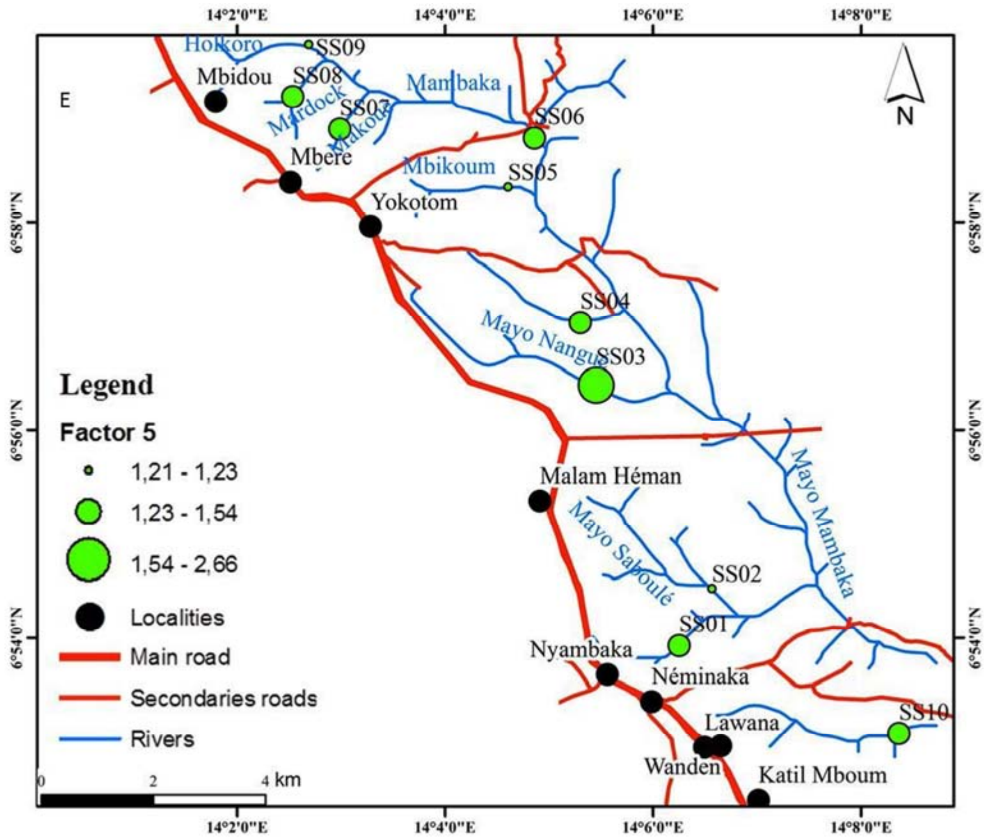

Figure 3. *Spatial distribution of the factors over the watershed of the studied area.*

5. Conclusion

As conclusion, we can say that:

Statistical and spatial analysis was carried out to relate the concentration and the distribution of chemical elements in stream sediments to lithology and mineralizations.

The factor analysis applied to the data defines five factors that explained about 93.2% of the total variance. Factor 1 accommodate elements Sc-Mo-V-In-Ga-Cu-Cr. this association reflect an hydrothermal alteration leading to the development of Ga; Cu, In and Mo. this suggest that the paragenesis represent another sulphidation event that is barren with respect to Au.

Factor 2 (Ba-Sr-Ag-Cr-Cu-Co-Be-Ni-Y-Zn-V) These associations can be attributed to the catchment weathering, and disseminated sulfides such as chalcopyrite, pyrite, and sphalerite.

Factor 3 (Ga-Hf-Zr) explains 13.04% of the total variance. This factor indicates a granitic origin.

Factor 4 (Sn-Au) explains 7.7% of the total variance and indicate that gold and cassiterite mineralizations are contemporaneous and link to granitic rocks context and associated veins.

Factor 5 (As-Cd) explains about 6.47%, and also indicates another sulphidation event that is barren with respect to Au.

These results highlight the fact that gold mineralization is link to granitic rocks.

Table 6. *Geochemical data of the concentration of elements in stream sediments from Nyambaka area.*

Elements	Unit	DL	SS01	SS02	SS03	SS04	SS05	SS06	SS07	SS08	SS09	SS10
Mo	PPM	0.01	1.81	1.71	1.93	1.95	1.86	1.50	1.86	2.06	1.42	1.62
Cu	PPM	0.01	50.86	53.45	42.86	22.54	42.70	27.57	46.42	46.35	24.30	54.21
Pb	PPM	0.01	5.81	6.00	8.27	7.56	8.52	12.49	7.77	6.75	13.31	5.96
Zn	PPM	0.1	73.70	89.60	57.10	29.20	44.70	52.90	72.10	73.30	44.30	85.40
Ag	PPB	2.00	24.00	23.00	21.00	16.00	22.00	22.00	18.00	23.00	15.00	21.00
Ni	PPM	0.1	170.70	231.10	110.50	36.40	108.40	86.20	160.90	162.50	78.20	198.00
Co	PPM	0.1	45.20	63.80	21.70	12.90	34.60	41.10	26.40	47.10	23.40	65.70
As	PPM	0.1	1.40	1.20	2.60	1.40	1.20	1.50	1.40	1.50	1.20	1.30
U	PPM	0.1	2.30	2.20	2.70	2.20	2.80	3.70	2.40	2.20	4.00	2.40
Au	PPB	0.2	0.70	0.40	1.00	0.60	1.00	0.70	0.90	0.90	0.70	1.00
Th	PPM	0.1	12.30	12.50	13.10	9.80	16.70	20.30	14.60	13.60	25.60	13.40
Sr	PPM	0.5	38.20	39.10	14.50	7.10	20.10	34.40	16.90	28.80	19.50	105.00
Cd	PPM	0.01	0.03	0.03	0.06	0.03	0.01	0.04	0.04	0.04	0.02	0.06
Sb	PPM	0.02	0.00	0.00	0.06	0.06	0.04	0.03	0.04	0.03	0.02	0.00
Bi	PPM	0.02	0.03	0.00	0.07	0.07	0.08	0.06	0.05	0.04	0.06	0.02

Elements	Unit	DL	SS01	SS02	SS03	SS04	SS05	SS06	SS07	SS08	SS09	SS10
V	PPM	1	266.00	312.00	277.00	197.00	271.00	168.00	308.00	269.00	142.00	267.00
Ca	%	0.01	0.08	0.05	0.02	0.00	0.04	0.14	0.02	0.06	0.07	0.25
Cr	PPM	0.5	548.10	763.00	393.80	273.30	487.00	221.90	614.70	412.80	202.70	514.70
Ba	PPM	0.5	137.70	151.50	73.40	43.20	83.40	171.90	100.60	131.80	125.80	325.20
Sc	PPM	0.1	31.70	31.20	29.70	24.90	34.50	20.00	33.40	29.50	15.20	32.20
Tl	PPM	0.02	0.07	0.07	0.08	0.07	0.08	0.22	0.05	0.07	0.22	0.06
Hg	PPB	5.00	29.00	18.00	32.00	54.00	18.00	24.00	17.00	27.00	19.00	26.00
Se	PPM	0.1	0.10	0.10	0.10	0.20	0.00	0.10	0.10	0.10	0.00	0.00
Ga	PPM	0.1	26.60	25.40	31.90	28.80	34.60	23.80	30.70	28.40	20.40	24.40
Cs	PPM	0.02	0.51	0.44	0.84	0.81	0.89	1.12	0.53	0.53	1.08	0.58
Hf	PPM	0.02	0.44	0.66	0.72	0.42	0.78	0.6	0.89	0.82	0.42	0.34
Nb	PPM	0.02	1.41	1.28	2.43	4.04	0.91	2.67	1.69	2.21	1.52	1.05
Rb	PPM	0.1	3.50	2.60	3.30	2.70	3.30	17.10	2.40	2.30	18.10	4.10
Sn	PPM	0.1	3.00	2.80	3.20	2.90	3.80	2.80	3.20	3.10	3.10	2.90
Zr	PPM	0.1	38.10	47.20	47.00	29.70	52.90	37.70	59.00	61.50	28.50	27.00
Y	PPM	0.01	27.88	26.37	19.22	12.2	22.1	25.52	22.75	27.36	20.37	27.82
In	PPM	0.02	0.14	0.12	0.13	0.11	0.15	0.10	0.14	0.13	0.08	0.12
Be	PPM	0.1	2.20	2.60	2.30	0.60	1.20	1.80	2.00	2.00	1.90	2.00

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