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Geostatistical study of airborne geophysical data of the Tiouit mining area (Eastern Anti-Atlas, Morocco)

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Royaume du Maroc

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Abstract: The main objective of the present work is to use principal component analysis (PCA) on the various airborne geophysical data, including gamma-ray spectrometry (concentrations of radioactive elements ^{40}K and ^{232}Th), magnetism (magnetization contrast due to magnetic susceptibility), and electromagnetism (apparent electrical resistivity) to describe the physicochemical behavior of the mining zones in operation as well as to prospect other zones favorable for exploration. This data's geostatistical study highlights the adequate principal component (PC) to visualize these geophysical variables. We chose PC4 to visualize the zones favorable for mining concentration because it describes the same physical and chemical characteristics represented by the Tiouit alteration zone. The collection and X-ray fluorescence analysis of 32 samples in the field yielded high grades of Arsenic (24 g/t), Copper (5.87%), Iron (19.30 %), Lead (5.70%), and Zinc (8.85%).

Keywords: Geophysics; magnetism; gamma-ray spectrometry; electromagnetism; mining exploration;

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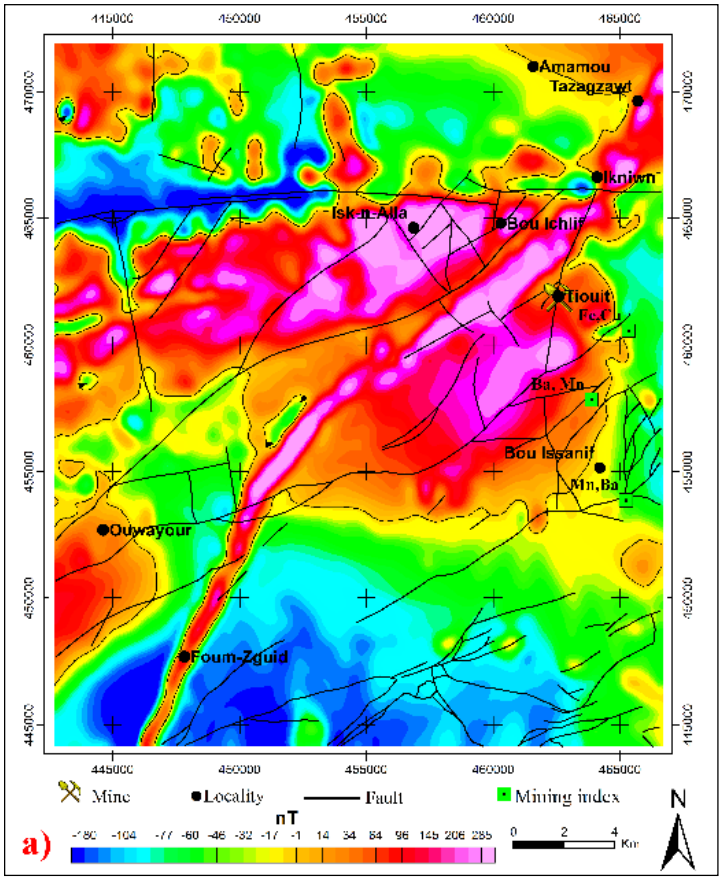
Results and Discussion

Residual magnetic field reduced to the pole

The zone is highly magnetically disturbed, reflecting a heterogeneity linked to magnetized geological objects in the subsoil, varying from -360 to 400 with an average value of about 14.5 nT.

The magnetic anomalies are subcircular and linear in shape with directions generally ENE-WSW, NNW-SSE, W-E, and NW-SE. The map reduced to the pole has allowed identifying the lateral limits of the geological sources.

We found a close relationship between the positive anomalies and the Precambrian age formations. The negative ones are related to relatively recent terrains, ranging from Paleozoic to Quaternary.



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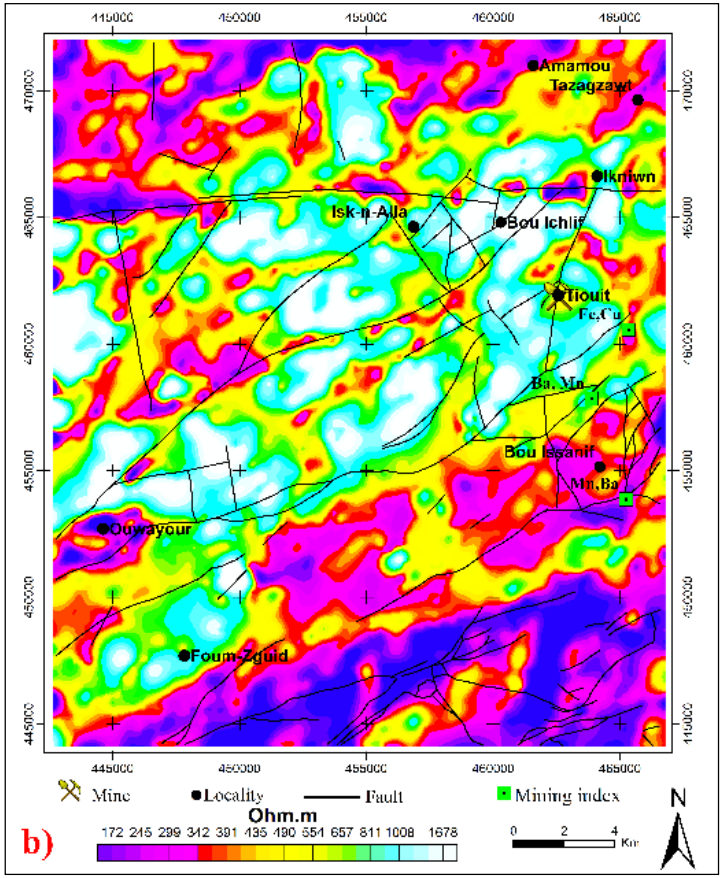
Electromagnetic anomalies of 7200 Hz

The 7200 Hz frequency allows lateral mapping of shallow to shallow water anomalies. From a mining point of view, several electromagnetic anomalies coincide with very important mining showings, namely Au, Zn, Pb, Cu, Fe, Ba and Mn.

The Examination of the 7200 Hz apparent resistivity map shows different types of anomalies with point, elongated, axial, circular to subcircular shapes and with resistive and conductive variants from 19 to 3900 with a mean value of about 625 Ohm.m.

Generally, all of these resistant anomalies are concentrated in the Tiouit zone center with a NE-SW Pan-African direction. They have a punctual aspect and tend to interfere with becoming elongated; this finding can be explained by a deep origin that gave rise to these anomalies.



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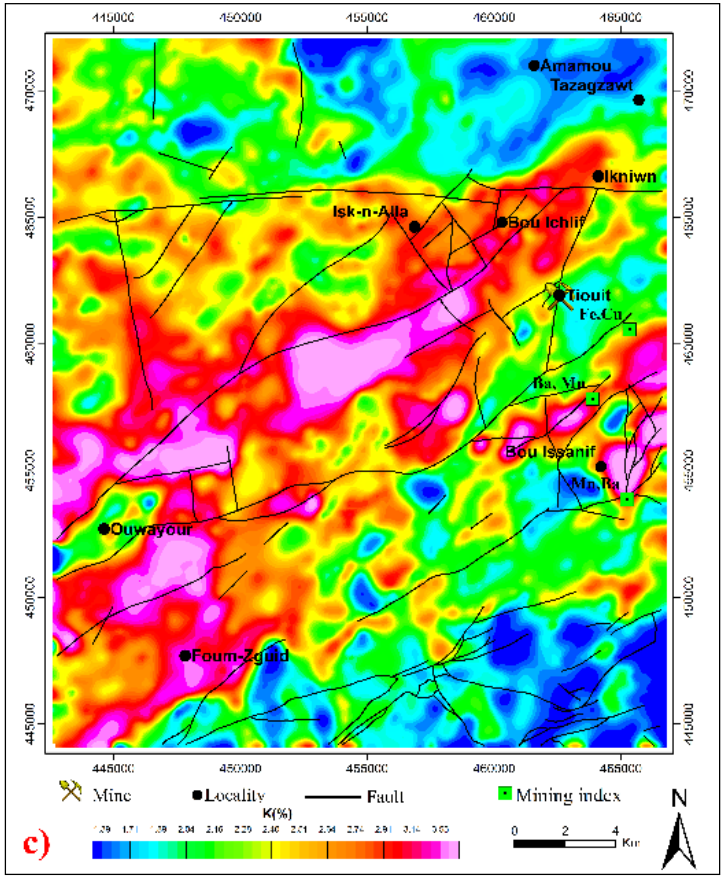
Concentrations in K (%)

The potassium concentration map shows a minimum value of 0.863% of Cambrian sandstone, clay, dolomitic and conglomeratic terrains, and a maximum value of about 4.555% due to Neoproterozoic formations located at the level of microgranites and granite with potassium feldspar.

We also note that the Triassic Foum-Zguid dykes of microgabbro, basalt and dolerite nature represent a relatively high value of 4.205%. The last two formations represent a maximum average value of 2.770%.



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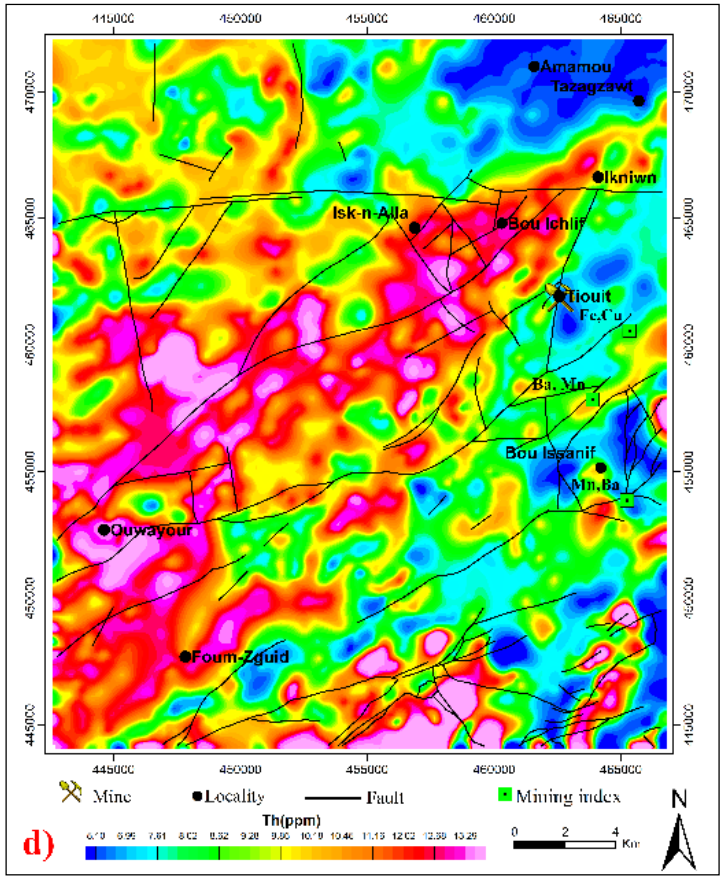
Concentrations in Th (ppm)

The Thorium concentration map shows that the Quaternary formations of alluvial and Cambrian nature of argillite, dolomite, and conglomerate have a minimum value 2.54 ppm.

The Cambrian terrains represent maximum and average maximum values of 14.749 and 10.83 ppm, respectively.

The Neoproterozoic formations belonging to the Ouarzazate Group, rhyolitic, and ignimbritic in nature have a value of 22.90 ppm.



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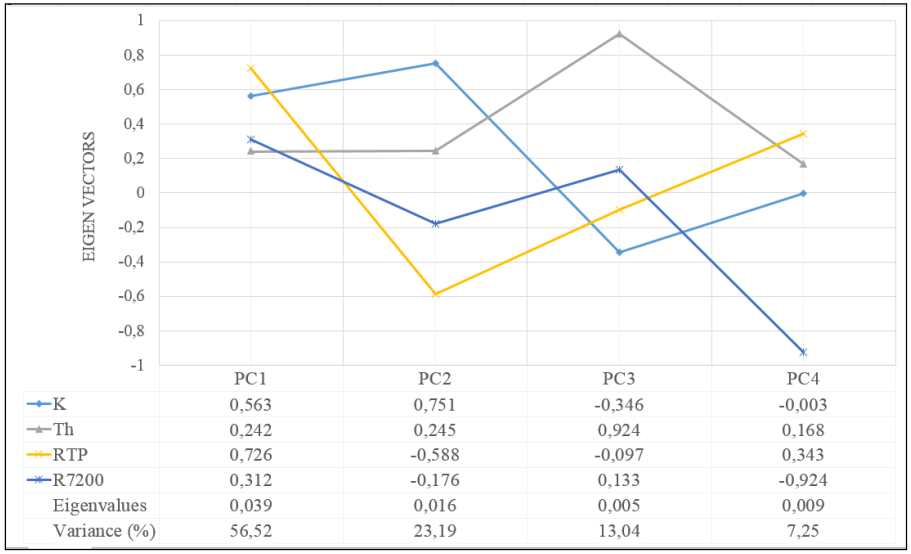
Principal Component Analysis (PCA)

In this work, we have standardized the geophysical data to a range [0, 1]. After applying PCA, the eigenvector matrix is used to select the most suitable PC for the visualization of the desired information.

The examination of the eigenvectors obtained from the application of PCA on geophysical data concludes that the PC4 has eigenvector values of -0.003, 0.168, 0.343, -0.924 for K, Th, RTP, and R7200, respectively.

These values show that component 4 shows an inverse variation in the physical properties of the deposit being searched so that the resulting map will be multiplied by -1. Overlaying it with the mineral occurrences being mined confirms the location and genetic model of the old Tiouit mine proposed by previous studies and other zones likely to contain mineralization.



	PC1	PC2	PC3	PC4
K	0,563	0,751	-0,346	-0,003
Th	0,242	0,245	0,924	0,168
RTP	0,726	-0,588	-0,097	0,343
R7200	0,312	-0,176	0,133	-0,924
Eigenvalues	0,039	0,016	0,005	0,009
Variance (%)	56,52	23,19	13,04	7,25

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Verification of mining zones by geochemical analysis

To validate the method, we conducted a field verification by collecting and analyzing 32 samples located north of the old Tiouit mine.

The results of X-ray Fluorescence analyses clearly show significant metal concentrations at the structural contacts and late andesitic and rhyolitic dykes that cross the metamorphic basement Ikniwn granodiorites, which could indicate a synchronous emplacement of polymetallic mineralization.

N°	Long (°)	Lat (°)	As (ppm)	Cu (%)	Fe (%)	Pb (%)	Zn (%)
1	-5,7985	31,2443	-	0,80	2,01	5,70	8,85
2	-5,7527	31,2285	-	0,04	2,18	0,14	0,26
3	-5,7456	31,1658	-	-	5,08	-	
4	-5,7467	31,1681	2,22	5,87	9,09	-	0,02
5	-5,7467	31,1681	-	0,62	0,65	-	-
6	-5,7467	31,1681	1,43	3,41	3,29	-	-
7	-5,7472	31,1695	1,21	0,48	0,91	-	-
8	-5,7472	31,1695	-	0,22	1,71	0,04	-
9	-5,7587	31,1619	-	-	3,09	-	-
10	-5,7590	31,1625	-	0,02	2,59	-	-
11	-5,7590	31,1625	-	0,06	3,93	-	-
12	-5,7590	31,1625	-	-	8,40	-	-
13	-5,7662	31,1505	1,97	1,11	1,18	0,03	-
14	-5,7665	31,1500	24,00	2,60	16,60	-	0,02
15	-5,7665	31,1500	-	0,07	3,85	-	-
16	-5,7669	31,1515	1,65	0,06	6,72	0,05	0,11
17	-5,7669	31,1515	6,51	0,08	9,10	0,03	0,06
18	-5,7669	31,1515	-	0,03	4,67	0,08	0,03
19	-5,7638	31,1246	-	0,02	10,50	-	-
20	-5,7638	31,1246	4,83	3,90	8,53	-	0,20
21	-5,7638	31,1246	-	-	19,30	-	-
22	-5,8308	31,2243	-	-	5,65	0,03	0,15
23	-5,8308	31,2243	-		5,65	0,03	-
24	-5,8306	31,2244	0,44	0,06	2,47	0,02	0,03
25	-5,8306	31,2244	-	0,02	2,11	-	0,03
26	-5,8306	31,2244	-	0,02	1,60	0,11	0,09
27	-5,8079	31,2238	-	0,03	6,86	-	-
28	-5,8079	31,2238	-	0,09	6,75	-	-
29	-5,8113	31,2516	-	0,01	1,20	0,02	-
30	-5,8113	31,2516	1,01	0,03	2,62	0,15	-
31	-5,8113	31,2516	-	0,03	3,05	0,17	-
32	-5,7928	31,2177	-	0,02	7,92	-	-

Conclusions

The use of Principal Component Analysis in the processing of geophysical data has demonstrated its effectiveness in mining research through its contribution to the identification of new mining zones. The processing of helicopter-borne geophysical data by principal component analysis has enabled these variables' eigenvector matrix to be identified.

The choice of principal component 4 allowed, in a first step, to characterize the copper porphyry type of the Tiouit mine. Secondly, X-ray Fluorescence analyses of samples collected in the northern part of the study area showed significant concentrations of As, Fe, Zn, Pb, and Cu.

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