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U-Th enrichment in Arıklı ignimbirites: A multivariate statistical analysis

Cihan Yalçın *1, **Önder Belgin** 2

[1]Ministry of Industry and Technology, World Bank Project Implementation Unit, Ankara, Türkiye, cihan.yalcin@sanayi.gov.tr
[2]Ministry of Industry and Technology, General Directorate of Strategic Research and Productivity. Ankara, Türkiye onder.belgin@sanayi.gov.tr

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Abstract

There are various geological issues that can be resolved using multivariate statistical analysis techniques. Based on the findings of geochemical research, mineralization zones have particularly recently been examined. In this study, enriched U-Th anomalies in Arıklı ignimbrites' fault zones were statistically assessed. In the area with the highest radioactive enrichment, descriptive data of the major oxide and trace element concentrations were found. As a result, it was determined that MnO had the lowest average abundance and that Ba had the highest average abundance among the elements Then a factor analysis was carried out. The research produced 7 factors that were identified. Many of the chemical concentrations (SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, K_2O, TiO_2, MnO, LOI, As, Cu, Ga, Rb, and Zr) elements are classified under factor 1. P_2O_5, Nb, Sr, Th, and Y are classed under factor 2 along with U-Th elements. As a result, other majo oxide and trace element contents worked in concert to enrich radioactive material.

Introduction

In geological research, as well as in many other professional disciplines, multivariate statistical methods are used to detect important clues [1]. Many researchers have attempted to identify analytical and statistical explanations for properly implementing the geochemical analysis results [2]. These explanations employ a variety of mathematical techniques, including both traditional [3-4] and modern (such as fractal/multifractal analysis) [5-6]. To highlight geological relationships, studies based on statistical parameters, mineralization, correlation, and anomalies are presented [7-8].

High natural radiation values were also reached in the fault zones around Örencik and Feyzullah Tepe, northwest of Arıklı. Magnesite breccias located in the northwest of Arıklı are formed by the effect of hydrothermal waters and there are U up to 700 ppm and Th greater than 1000 ppm in this fault zone [9]. In and around Arıklı, bayleite and ningyoite have a U enrichment in chemical composition, according to Günaydın's [9] explanation.

Öztürk et al., [10] examined microthermometric measurements from magnesite observed in these fault zones and determined that (Th, °C) was between 282-348 °C and % NaCl salinity equivalents were between 4.2-8.0. They also set forth that the solution system of liquid inclusions is in the form of H_2O-$MgCl_2$-$CaCl_2$ and the density of liquids is between 0.58-0.74 g/cm^3. Yalçın et al. [11] used GIS applications and thematic maps to show the geochemical distribution of U and Th enrichment in this region.

This paper was using a multivariate statistical analysis of the geochemical contents of 30 samples taken in the northwest of Arıklı, where Öztürk et al. [10] found the greatest radioactive results.

Material and Method

The results of the previous geochemical analysis were used in this investigation to determine the descriptive statistics. Finally, factor analysis was used to calculate factor loads. In Microsoft Excel, these computations and analyses were conducted.

Multivariate Statistical Analysis

In the study, multivariate statistical analysis techniques were used to investigate the chemical composition of 30 samples. Table 1 provides descriptive statistics for chemical data. As a result, it was determined that MnO had the lowest average abundance and that Ba had the highest average abundance among the elements.

Table 1. Descriptive statistics of geochemical data

Variant	min	mean	max	sd	skewness	kurtosis
SiO_2	2.00	46.69	95.70	25.77	-0.56	2.12
Al_2O_3	0.11	10.50	19.96	6.20	-0.52	1.88
Fe_2O_3	0.22	3.38	11.27	2.59	0.74	3.42
MgO	0.00	10.21	40.10	13.78	1.17	2.79
CaO	0.00	5.13	30.57	7.24	2.35	8.37
Na_2O	0.00	0.48	3.91	0.76	2.91	12.95
K_2O	0.00	5.25	15.40	4.55	0.55	2.39
TiO_2	0.01	0.45	1.28	0.34	0.33	2.16
P_2O_5	0.00	0.18	0.93	0.22	2.29	7.93
MnO	0.01	0.07	0.18	0.05	0.80	2.83
Cr_2O_3	0.00	0.08	0.45	0.13	1.69	4.52
SO_3	0.00	0.11	0.60	0.17	1.72	4.62
LOI	0.00	17.20	49.02	18.60	0.82	1.87
As	0.00	184.25	727.00	170.02	1.62	5.74
Ba	0.00	643.44	5039.00	837.44	4.11	22.40
Ce	0.00	94.72	1491.00	269.25	4.14	21.40
Cl	0.00	187.94	2874.00	474.27	5.26	30.26
Co	0.00	4.28	68.00	12.43	4.15	20.86
Cu	0.00	31.94	91.00	17.86	0.55	5.03
Ga	0.00	8.03	40.00	12.50	1.24	3.27
Nb	0.00	6.22	62.00	11.34	3.45	17.37
Ni	0.00	93.72	409.00	106.01	1.14	3.38
Pb	0.00	11.81	75.00	23.22	1.56	3.74
Rb	0.00	125.11	395.00	104.78	0.59	2.65
Sr	19.00	364.11	2977.00	544.29	3.38	16.05
Th	0.00	376.39	11813.00	1962.99	5.72	33.86
U	0.00	47.64	1640.00	273.19	5.73	33.92
V	0.00	22.61	458.00	82.30	4.48	23.35
Y	0.00	25.67	864.00	143.80	5.74	33.95
Zn	0.00	17.64	88.00	25.68	1.27	3.44
Zr	0.00	151.92	523.00	119.74	0.78	3.81

The variations between the samples were discovered using factor analysis. Following this investigation, 7 factors were identified. Table 2 displays the variance explanation ratios together with the determined eigenvalues of the factors. Table 3 lists the factor loading values for the elements connected to the determined factors. The elements' inclusion in the factors is shown by the values in bold.

SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, K_2O, TiO_2, MnO, LOI, As, Cu, Ga, Rb, and Zr elements are classified under factor 1; P_2O_5, Nb, Sr, Th, U, and Y elements are classified under factor 2; Na_2O, Pb, and V elements are classified under factor 3; SO_3, Ba, and Ce elements are classified under factor 4; Co element is classified under factor 5. Ni and Zn elements are the last to be included under factor 6; factor 7 also includes Cr_2O_3 and Cl elements.

Conclusion

In this study, statistical techniques were also used to explain the geochemical behavior of the geochemically prospected U-Th enrichment with other major oxides and trace elements.

Table 2. Eigenvalues of the Factors obtained

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	10.079	4.809	0.328	0.328
Factor 2	5.269	1.842	0.172	0.500
Factor 3	3.428	1.294	0.112	0.611
Factor 4	2.134	0.195	0.070	0.681
Factor 5	1.939	0.232	0.063	0.744
Factor 6	1.707	0.378	0.056	0.800
Factor 7	1.329	0.378	0.043	0.843

Table 3. Factor load values

Variant	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
SiO_2	**0.7973**	-0.064	-0.078	-0.1065	-0.5452	-0.0558	-0.0865
Al_2O_3	**0.8952**	0.0285	-0.0643	0.1049	-0.1049	0.0478	-0.161
Fe_2O_3	**0.8023**	0.2191	0.4695	0.092	0.1077	-0.0863	0.0132
MgO	**-0.8327**	-0.2273	0.055	0.0241	0.3759	0.0771	0.1187
CaO	**-0.6118**	0.4963	0.083	0.1631	0.2257	-0.1084	-0.0387
Na_2O	0.4242	0.1166	**0.7402**	0.2023	0.1919	0.3059	-0.0888
K_2O	**0.8316**	0.1592	-0.3625	-0.2295	0.0696	-0.022	0.0364
TiO_2	**0.85**	0.2139	0.3096	0.0424	0.1139	-0.1339	0.0551
P_2O_5	0.1846	**0.7755**	0.419	-0.1987	0.0464	0.021	0.2323
MnO	**0.5672**	0.2724	0.2737	-0.015	0.2968	-0.3685	0.1336
Cr_2O_3	0.2613	-0.0428	-0.2266	0.3566	-0.3436	0.0695	**0.6752**
SO_3	0.4136	0.1232	-0.0875	**0.752**	0.0628	0.117	-0.1894
LOI	**-0.9019**	-0.0519	0.0422	0.0562	0.3829	0.0517	0.087
As	**0.559**	0.306	-0.3948	-0.3787	0.4203	0.0672	0.0442
Ba	0.3929	0.2145	0.0745	**0.5817**	0.0859	-0.0242	-0.3412
Ce	0.3941	0.1616	-0.4148	**-0.45**	0.3784	-0.1187	0.1348
Cl	0.1594	0.0117	-0.3897	0.3344	-0.0098	0.4423	**0.4664**
Co	-0.165	0.2727	0.0355	-0.3189	**-0.6059**	-0.0591	-0.1297
Cu	**0.6962**	0.038	0.4286	0.0541	0.0423	0.1394	0.2289
Ga	**0.4571**	0.1195	-0.2868	0.0799	0.2938	-0.3812	-0.2936
Nb	-0.0545	**0.905**	-0.2036	0.0937	-0.169	0.0555	0.0294
Ni	0.4793	0.11	0.2352	0.0055	-0.1074	**-0.6309**	0.2811
Pb	0.2694	0.4514	**-0.5777**	-0.1204	0.2525	0.3768	-0.0193
Rb	**0.8187**	0.2221	-0.3469	-0.0777	0.0276	0.1028	-0.0555
Sr	-0.6516	**0.6768**	0.0886	0.1532	0.1105	-0.0094	0.0029
Th	-0.4371	**0.8717**	-0.0168	-0.0145	-0.1441	0.0122	-0.0354
U	-0.4234	**0.8742**	-0.0136	-0.0126	-0.1549	0.004	-0.036
V	0.3029	0.1325	**0.7324**	-0.2403	0.1541	0.3257	0.1445
Y	-0.406	**0.8834**	-0.0112	0.0017	-0.161	-0.0006	-0.0363
Zn	0.2345	-0.071	0.3727	-0.4316	-0.1364	**0.5551**	-0.2605
Zr	**0.6908**	0.1154	-0.3371	0.2021	0.0353	0.2368	-0.1066

References

1. Sunkari, E. D., Appiah-Twum, M., & Lermi, A. (2019). Spatial distribution and trace element geochemistry of laterites in Kunche area: Implication for gold exploration targets in NW, Ghana. *Journal of African Earth Sciences*, *158*, 103519. https://doi.org/10.1016/j.jafrearsci.2019.103519
2. Cheng, Q., Agterberg, F. P., & Ballantyne, S. B. (1994). The separation of geochemical anomalies from background by fractal methods. *Journal of Geochemical exploration*, *51*(2), 109-130.
3. Hawkes, H. E., & Webb, J. S. (1963). Geochemistry in mineral exploration. *Soil Science*, *95*(4), 283.
4. Tukey, J. W. (1977). *Exploratory data analysis* (Vol. 2, pp. 131-160).
5. Cheng, Q., & Agterberg, F. P. (1995). Multifractal modeling and spatial point processes. *Mathematical Geology*, *27*(7), 831-845.
6. Cheng, Q., & Agterberg, F. P. (1996). Multifractal modeling and spatial statistics. *Mathematical Geology*, *28*(1), 1-16.
7. Agterberg, F. P. (1994). Fractals, multifractals, and change of support. *Geostatistics for the next century*, 223-234.
8. Cheng, Q., Bonham-Carter, G. F., Hall, G. E. M., & Bajc, A. (1997). Statistical study of trace elements in the soluble organic and amorphous Fe-Mn phases of surficial sediments, Sudbury Basin. 1. Multivariate and spatial analysis. *Journal of Geochemical Exploration*, *59*(1), 27-46.
9. Günaydin, A. (2017). Geology and geochemistry of nodular-phosphate and fault-controlled hydrothermal-phosphate mineralizations in Arikli and Nusratli Villages (Ayvacik-Çanakkale, Nw Turkey). *Bulletin of the Mineral Research and Exploration*, *155*(155), 131-146. https://doi.org/10.19111/bulletinofmre.314197.
10. Öztürk, S., Yalçin, C., & Kumral, M. (2021). Microthermometric characteristics of vein type U-Th enrichment observed in the Fault Zones in Northwest of Arıklı (Çanakkale-Turkey). *Gümüşhane Üniversitesi Fen Bilimleri Dergisi*, *11*(3), 729-743.
11. Yalçın, C., Öztürk, S., & Kumral, M. (2022). Evaluation of U-Th enrichments in QGIS platform; Example of Arıklı (Çanakkale, Turkey) district. *Intercontinental Geoinformation Days*, *4*, 225-228.