Multivariate Statistical Evaluation of Geochemical Data from Quartz Vein-Associated Gold Mineralisation at the Badukrom Prospect within the Tarkwaian Base*

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Abstract

The Kawere conglomerate at the base of the Tarkwaian Group in the Iduapriem Mine appears to show good prospect for hydrothermal gold mineralisation evidenced by major structures mapped from magnetic and Airborne Electromagnetic (AEM) geophysical data. Detailed geological mapping and sampling at Badukrom target which lies within the Kawere rocks confirm the presence of multiple structures as well as quartz veins indicative of potential hydrothermal gold mineralisation. Follow up soil sampling conducted within the area revealed a strong anomalous trend from the southern portion. Two diamond drilled (DD) holes pushed to delineate the extent of the anomalous zones returned narrow veins of significant gold intersections. Twenty-five (25) samples of the Badukrom hydrothermal Au mineralisation intersects were sent for analysis to ascertain the optimum pathfinder element suite for the hydrothermal targets within the Iduapriem concession. A total of fifty-nine elements were analysed via ICP-MS and ICP-OES. Multivariate statistical evaluation was carried out on the results to understand the geochemical associations of Au and the other elements to aid future exploration programmes planned for the hydrothermal targets. Multivariate analysis of the geochemical data using Pearson product-moment of correlation suggests a stronger positive correlation of gold with Iron, Antimony, Sulphur, Chromium, Vanadium respectively. However, the Spearman Rank correlation data indicates that, the optimum pathfinder elements for hydrothermal Au are: As, Sb and Te.

Keywords: Tarkwaian Base, Statistical Evaluation, Hydrothermal Mineralisation, Geochemical Data

1 Introduction

Two major gold mineralisation styles are known to occur in Ghana: (1) the hydrothermal mesothermal quartz vein gold mineralisation associated with shear zones and faults within the Birimian belts and (2) the paleoplacer deposits associated with the Tarkwaian Group (Kesse, 1985; Ridley, 2013). Economic gold mineralisation at Iduapriem has been known to occur within the conglomerates of the Banket Series of the Tarkwaian Group (Griffis *et. al*., 2002). Currently, exploitation of gold takes place in the Banket Series rocks which consist of individual beds of quartz pebbles and breccia conglomerates separated by quartzites. All gold mineralisation occurs within four specific zones namely, the A, B, C and D reefs with the highest grades, tonnage and geological continuity found in the B and C reefs.

However, evidenced by major structures mapped from magnetic and Airborne Electromagnetic (AEM) geophysical data, the Badukrum prospect shows good prospect for hydrothermal gold mineralisation within the Kawere conglomerate and at the contact between the Kawere and the Sefwi lithologies. Further works, which encompasses detailed geological mapping and sampling at the Badukrom prospect, confirmed the presence of multiple structures and quartz veins indicative of potential hydrothermal gold mineralisation. Two conceptual

diamond holes drilled to delineate the extent of the anomalous zones returned narrow veins significant gold intersections (between 0.08 and 29.1 ppm). To ascertain the best likely pathfinder element suite for other hydrothermal targets within the Iduapriem lease, twenty-five samples were analysed via Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES).

Usually in statistics, four major types of correlations could be employed to measure relationships between two variables. This includes *Kendal*, *Pearson*, *Biserial* and *Spearman* correlations. In this paper however, two of such multivariate statistical methods, *Pearson* and *Spearman* rank correlations coefficients were used. The most significant correlation coefficient using the geochemical data set was used to predict the best pathfinder element suite within the hydrothermal prospect at Badubrom prospect at Iduapriem Mine, and for prospecting similar concessions within the deposit.

This could guide exploration geologists with elemental analysis in addition to the selection of suitable pathfinder of gold for future mineral exploration programmes planned for the hydrothermal targets. Furthermore, this will provide information on the nature and mineral association of gold in similar prospects within the Tarkwaian.

1.1 Pearson and Spearman's Rank Correlation Coefficients

The Spearman's rank correlation coefficient is a monotonic function or nonparametric measure which seeks to assess how well the relationship between two variables can be established. The major significance of Spearman correlation is that it shows direction of association between the independent variable (X) and the dependent variable (Y). Under a given circumstance, if Y tends to increase as X also increases, then the correlation coefficient is said to be positive. The assumptions are that data must be at least ordinal and the score on one variable must be monotonically related to the variable in such that (+1), zero and (-1) magnitudes indicate *perfect*, *nil* and *negative* associations respectively. The correlation function is given as:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

where:
ρ= Spearman's rank correlation coeffient
d$_i$=difference between the two ranks of each observation
n= number of observations

Pearson's product moment correlation coefficient is a measure of strength of a linear association between two variables. Correlation assumes that variables are normally distributed. The correlation function is given as:

$$r = \frac{\sum(x_1 - \bar{x})(y_1 - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

where
r = Pearson correlation coefficient
x$_i$=Values of the x-variable
x̄=mean of the values of the x variable
y$_{1=}$ value of the y-variable
ȳ= Values of the y-variable

If the magnitude of correlation coefficient falls between 0.5 and 0.7, it indicates *Moderate* correlation while if value falls between 0.3 and 0.5 it indicates *low* correlation It is worth noting that the Pearson product-moment coefficient of linear correlation assumes that variables are normally distributed and have linear relationships. However, the Spearman rank correlation does not require normal distribution of variables. It rather assumes random variables thereby making it more efficient for analysing major or trace element data.

1.2 The Geology of Iduapriem Concession

The Iduapriem concession is located within the Tarkwaian Group of rocks that form part of the West Africa Craton, which is covered to a large extent by metavolcanics and metasediments of the Birimian Supergroup (Fig. 1) (Griffis *et. al*., 2002).

The entire Tarkwaian Group has been folded into a broad syncline which is locally referred to as the Tarkwa Syncline (Fig. 3) (Anon, 2005).
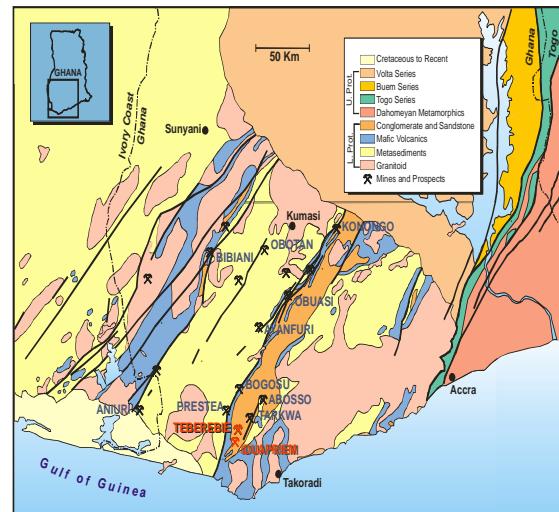
Fig. 1 Geology Map of South-West Ghana
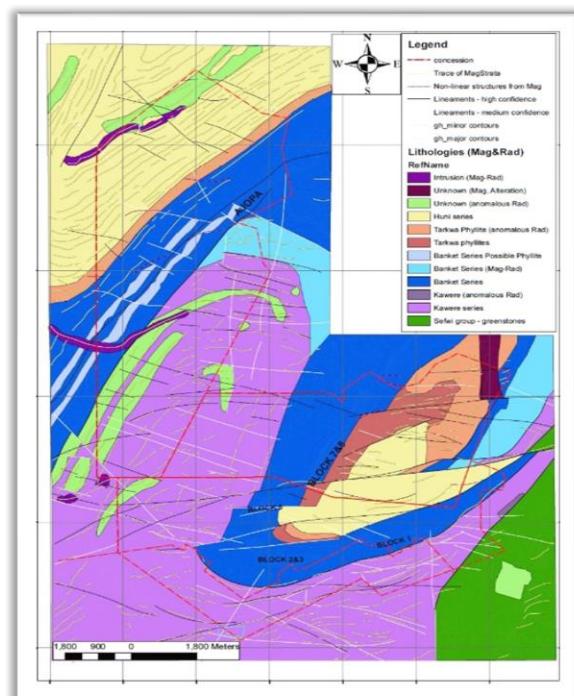
Fig. 2 Geological Map of the Iduapriem

The Iduapriem concession is located along the south-western margin of the Tarkwa syncline (Fig. 3) The main lithologies in Iduapriem block include the Huni Series (phyllites, conglomerates, sandstones), Tarkwa Phyllites, Banket Series (conglomerates, sandstones), Kawere Series (sandstones, conglomerates) and basal Sefwi Group (volcaniclastics and granitoids) (Fig. 3).

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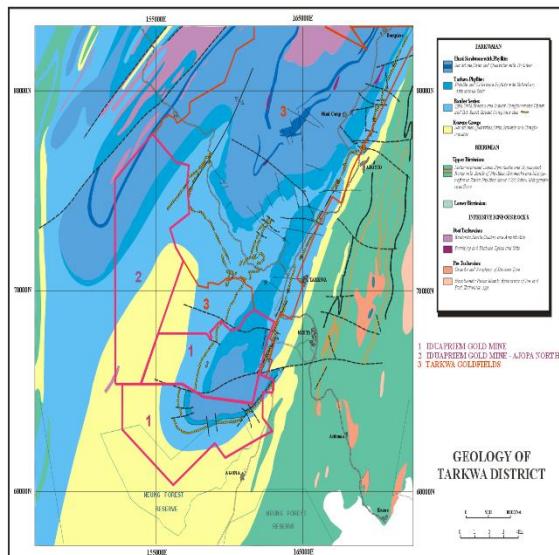
Fig. 3 Geological Map of the Tarkwa Basin

Gold mineralisation is confined to the Banket Reef Zone (BRZ), which comprises a sequence of individual beds of quartz pebble conglomerate, breccia conglomerate, quartzite and grit. The outcropping Banket Series in the mine lease area forms prominent curved ridges that extend southwards from Tarkwa, westwards through Iduapriem and northwards towards Teberebie. The deposit consists of eight blocks (i.e. Blocks 1-8) (Anon., 2005).

At Blocks 7 & 8 (Teberebie deposit), the western limb of the syncline extends over 4 kilometres on the property, with the eastern limb reaching the surface (outcropping) just beyond the eastern boundary of the concession. The western and the eastern limbs outcrop about 4 kilometres apart with the mineralised horizons buried some 400 metres below the surface at the centre of the syncline (Anon., 2005),

The Ajopa deposit (Block 6), comprise of a series of north-east south-west (NE-SW) trending ridges with dips generally between 50 to 60 ° W. The gold is fine-grained, particulate and free milling (i.e. not locked up with quartz or iron oxides). Mineralogical studies indicate that the grain size of native gold particles ranges between 2μm and 500μm and averages 130μm. Sulphide mineralisation is present only at trace levels and is not associated with the gold. Haematite mineralisation is often extremely well developed on cross bed fore sets. The conglomerates often show strong haematite mineralisation in the matrix with rare visible gold grains.

1.3 The Badukrom Project

The hydrothermal target at Badukrom, a locality within the Iduapriem concession. sits within the

Kawere conglomerates at the base of the Tarkwaian Group (Fig. 4). Mineralisation is associated with pyrite+carbonate+tourmaline with primary magnetite seemingly stable (Fig 5). Geochemical soil anomaly at the Badukrom prospect occur parallel to the regional scale anticline with strong sulphidation in country rock sandstone.
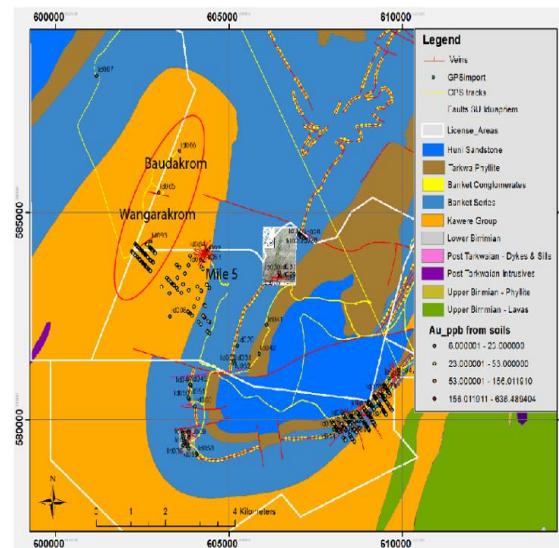
Fig. 4 Map of the Iduapriem Block Showing the Badukrom Prospect

Fig. 5 Badukrom Quartz Vein-Related Mineralisation

2 Resources and Methods Used

2.1 Data Description

The samples utilised in this study were selected from two conceptual DD holes (BD001 and BD002) drilled at the Badukrom prospect to delineate the extent of the quartz vein mineralisation. Twenty-five (25) samples of hydrothermal quartz veining were selected for multi-element analysis. The multi-elements were analysed at SGS South Africa Pty Ltd in Johannesburg by four-acid digestion and analysis

via ICP-OES (Al, Ba, Ca, Cr, Cu, Fe, K, Li, Mg, Mn, Na, P, S, Sr, Ti, V, Zn and Zr) and ICP-MS (Ag, As, Be, Bi, Cd, Ce, Co, Cs, Dy, Er, Eu, Ga, Gd, Ge, Hf, Ho, In, La, Lu,Mo, Nb, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Te, Th, Tl, Tm, U, W, Y and Yb). Gold was assayed by SGS in Tarkwa.

The four-acid digestion has a very effective dissolution procedure for a large number of mineral species and is best for this work. The analytical technique involved the use of a combination of HNO$_3$ (nitric acid), HF (hydrofluoric acid), HClO$_4$ (perchloric acid) and HCl (hydrochloric acid) to attain a near-total digestion. ICP-OES and ICP-MS finish were utilised because this geoanalytical instrumentation techniques yield many elements concurrently and are universally recognised in the mineral exploration industry as a faster and efficient means for trace element analysis (Hu, 2014 and Finch *et al.,* 2018).

2.2 Data Processing and Analysis

Multivariate statistical analysis which involves two or more variables considered simultaneously was used to analyse the geochemical data. In addition, graphical analysis involving scatter plots between gold and other elements were generated to measure the degree of interrelation between the variables. The correlation coefficient (*r*) which measures the degree of interrelations between gold and other elements was computed and displayed as a matrix via both Pearson product-moment coefficient of linear correlation and the Spearman rank correlation.

3 Results and Discussion

3.1 Descriptive Statistics for Au

The descriptive statistic for Au is shown in Table 1 The result displays quite an interesting recovery from the least expected Badukrom prospect. Using the sample size of 25, it implies according to Hair *et al.,* (2013) that since R^2 is approximated above 39, it is deemed statistically significant for the simple linear regression analysis used in this study. The mean Au value for the sample is 2.82ppm with grades varying from 0.08-29.1 ppm. Most of the samples recorded more than 1.0 ppm rising up to 29.02 ppm, although significant proportion fell below cut-off grade of 0.5 ppm.

3.2 Statistical Analysis

The correlation coefficients for both the Pearson product-moment and Spearman rank were computed to determine the degree of association of gold with each of the 59 elements. Results of the Pearson correlation matrix revealed a stronger positive correlation between Gold and Iron, Antimony,

Sulphur, Chromium, Vanadium, Copper, Silver, Selenium and Cobalt (see Tables 2 & 3). The other elements showed moderate to poor association with Au mineralisation. The scatter plots for elements with strong association to gold are illustrated below:

Table 1 Au Descriptive Statistics

Au (PPM)	
Mean	2.82
Standard Error	1.15
Median	0.86
Mode	0.64
Standard Deviation	5.77
Sample Variance	33.31
Kurtosis	19.65
Skewness	4.27
Range	29.02
Minimum	0.08
Maximum	29.1
Sum	70.52
Count	25
Largest(1)	29.1
Smallest(1)	0.08
Confidence Level (95.0%)	2.38
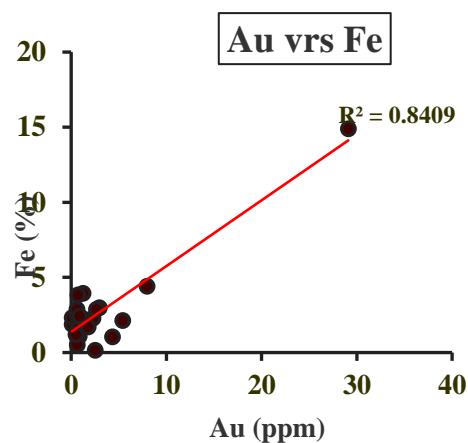
Fig. 6 Plot of Au versus Fe
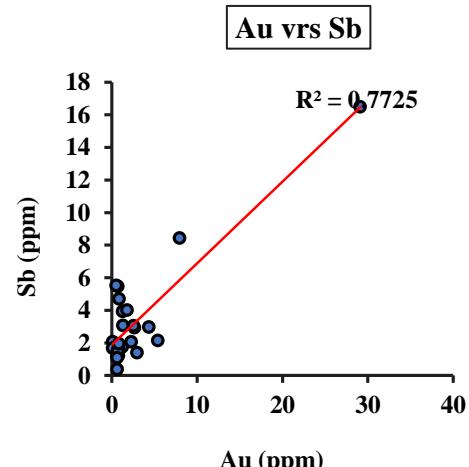
Fig. 7 Plot of Au versus Sb

Au vrs S

R² = 0.7666
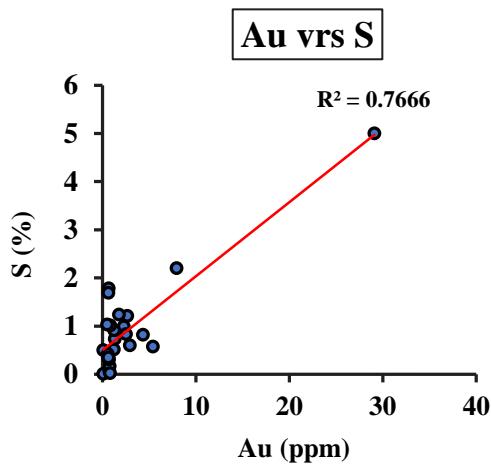
Fig. 8 Plot of Au versus S

Au vrs Cr

R² = 0.7068
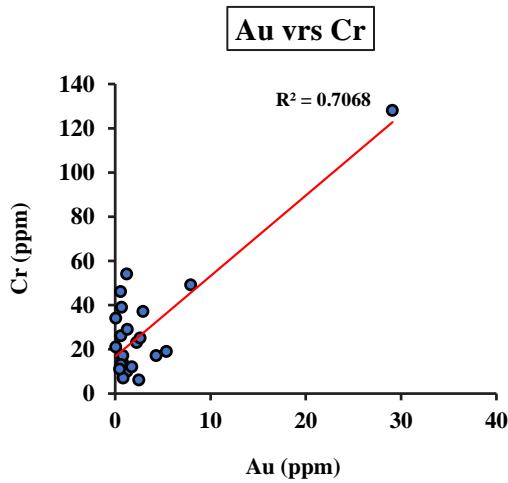
Fig. 9 Plot of Au versus Cr

As shown on the above scatter plots, Fe has the strongest association with Au with a coefficient (R) of 0.92 (Fig. 6). Sb and S show a correlation coefficient (R) of 0.88 (Figs, 7 & 8) whilst Cr gives an R of 0.84 with Au (Fig. 9).

On the other hand, Spearman Rank correlation coefficients (see Tables 2 &4) indicated that Au present moderate correlation with Ag (R=0.558), As (R=0.504), Sb (R=0.474); (Fig. 10) Te (r=0.453), and weak correlation with S (r=0.395), Se (r=0.391) and U (r=0.336).

3.2 Discussions

A comparison of the results of the Pearson product-moment coefficient and the Spearman Rank Correlation coefficients shows significant differences in the degree of interrelations between Au and the other elements. The data shows that the minimum R^2 is considered statistically significant considering the powers obtained (Table 2). Gold shows a stronger correlation with Iron, Antimony,

Sulphur, Chromium, Vanadium based on the data analysis with the Pearson correlation matrix (Table 3), whilst it shows moderate correlation with Silver, Arsenic, Antimony and Tellurium and weak correlation with Sulphur. The strength of correlation ranges from strong to moderate for the Pearson whilst that of the Spearman Rank ranges from moderate to weak for the likely pathfinder elements (Table 2). Despite, seemingly strong to moderate Pearson correlation which suggest linear relationship between the variables, the erratic signature of Au within the deposit does not fully support the theoretical assumption.
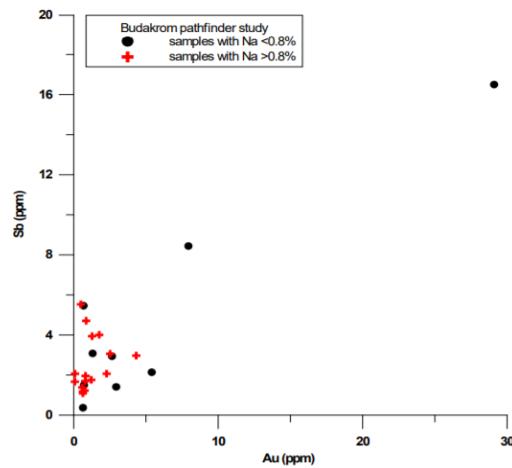
Fig. 10 Spearman Rank Correlation Plot of Au versus Sb

Table 2 Pearson and Spearman Rank Correlation Coefficients for likely Pathfinder Elements at Badukrom

	Pearson	Spearman Rank
Element	Au (PPM)	Au (PPM)
Au (PPM)	1	1.00
Fe %	0.92	0.23
Sb (PPM)	0.88	0.47
S %	0.88	0.40
Cr (PPM)	0.84	0.23
V (PPM)	0.84	0.31
Cu (PPM)	0.77	-0.20
Ag (PPM)	0.73	0.56
Se (PPM)	0.73	0.39
Co (PPM)	0.72	0.29
Ni (PPM)	0.64	0.30
Ti %	0.61	-0.12
As (PPM)	0.30	0.50
Te (PPM)	0.26	0.45

Hence, based on the Spearman rank data (Table 2), the most useful elements including as (up to >1%), Sb (0.37-16.5 ppm) and Te (0.19-32 ppm), and Ag assays which fell below 1 ppm present much probabilistic elemental pathfinder tracing. The

ranges for other potential pathfinder elements are somewhat inconsistent: (Se <2-7; S 0.01->5; and U 0-14-0.27).

Arsenic is also relatively strongly correlated with S (r=0.735), Sb (r=0.823), Se (r=0.771) and Te (r=0.84) (see Table 4).

The Zr vs. Ti diagram (Fig. 11) tries to interpret the possible hydrothermal setting of the felsic mineralogy and melting proportions according to Hanson (1980),

There appears to be two group of samples: those with Na <0.8% and with elevated K, and those with Na >0.8% and lower concentrations of K. This does not appear to be related to difference in rock type but may reflect differences in mineralogy of the hydrothermal alteration. A positive correlation of the minerals on a plot of Zr vs. Ti, therefore, indicates a simultaneous role of assimilation and fractional crystallization.

It depicts the possibility that the range in chemical composition within the deposit might be a result of varying degrees of partial melting of a parent material or fractional crystallization of a differentiated magma as has been suggested by work of Lightfoot *et al*. (1987) in other deposits of similar tectonics. This however, could be properly could be resolved by spectral analysis, XRD or petrography.
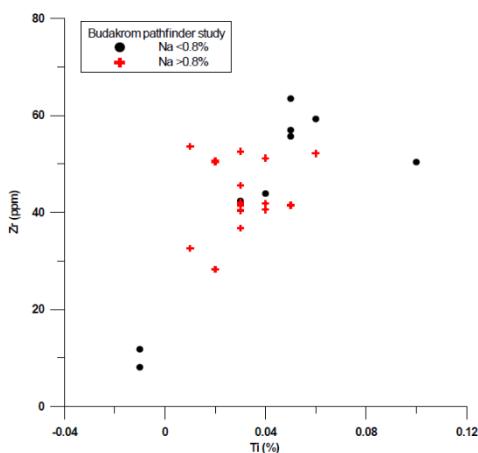
Fig. 11 Plot of Ti versus Zr

4   Conclusions and Recommendations

4.1 Conclusion

Analysis of the geochemical data using Pearson product-moment reveals that Au has a stronger positive linear relationship with Iron, Antimony, Sulphur, Chromium, Vanadium, Copper, Silver, Selenium and Cobalt. It shows a stronger correlation with Iron and Sulphur, which suggests that it occurs

either as inclusions or substitutions within pyrite. However, this practically does not support seemingly erratic hydrothermal deposit at Badukrom. On the other hand, Spearman's ranking which is monotonically related and showing moderate to poor correlation with Au mineralization, appears more realistic.

Spearman rank assumes random variables and appears more efficient for trace element analysis and hence best technique for indicator tracing for deposit of this nature

The Zr vs. Ti diagram depicts the strong possibility of hydrothermal setting of felsic to mafic mineralogy and varying melting proportions.
Therefore, the optimum pathfinder elements for hydrothermal Au tracing within the Badukrom prospect include: As, Sb and Te.

4.2 Recommendation

It is recommended that more detailed drilling programme is carried out to further probe the deposit.

Acknowledgement

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Table 3 Pearson Rank Correlation Matrix

	Au (PPM)	Al %	Ba (PPM)	Ca %	Cr (PPM)	Cu (PPM)	Fe %	K %	Li (PPM)	Mg %	Mn (PPM)	Na %	P (PPM)	S %	Sr (PPM)	Ti %	V (PPM)	Zn (PPM)	Zr (PPM)	Ag (PPM)	As (PPM)	Be (PPM)	Bi (PPM)	Cd (PPM)	Ce (PPM)	Co (PPM)	Cs (PPM)	Dy (PPM)	Er (PPM)	Eu (PPM)	Ga (PPM)	Gd (PPM)	Ge (PPM)	Hf (PPM)	Ho (PPM)	In (PPM)	La (PPM))	Lu (PPM)	Mo (PPM)	Nb (PPM)	Nd (PPM)	Ni (PPM)	Pb (PPM)	Pr (PPM)	Rb (PPM)	Sb (PPM)	Sc (PPM)	Se (PPM)	Sm (PPM)	Sn (PPM)	Ta (PPM)	Tb (PPM)	Te (PPM)	Th (PPM)	Tl (PPM)	Tm (PPM)	U (PPM)	W (PPM)	Y (PPM)	Yb (PPM)
Au (PPM)	1.00
Al %	-0.03	1.00
Ba (PPM)	-0.19	0.80	1.00
Ca %	-0.39	0.30	0.22	1.00
Cr (PPM)	0.84	0.21	0.06	-0.35	1.00
Cu (PPM)	0.77	-0.11	-0.23	-0.37	0.79	1.00
Fe %	0.92	0.19	-0.02	-0.23	0.95	0.83	1.00
K %	0.03	0.87	0.89	0.09	0.29	0.01	0.20	1.00
Li (PPM)	0.46	-0.29	-0.05	-0.07	0.37	0.54	0.44	-0.19	1.00
Mg %	0.03	0.30	0.27	0.80	0.10	0.09	0.24	0.14	0.34	1.00
Mn (PPM)	0.14	0.49	0.34	0.59	0.39	0.29	0.39	0.48	0.09	0.69	1.00
Na %	-0.26	-0.47	-0.60	0.22	-0.46	-0.30	-0.36	-0.74	0.04	0.05	-0.26	1.00
P (PPM)	-0.04	-0.23	-0.32	0.22	-0.12	-0.18	-0.11	-0.27	-0.13	-0.02	0.13	0.46	1.00
S %	0.88	-0.06	-0.24	-0.30	0.76	0.68	0.86	-0.07	0.41	0.10	0.06	-0.13	0.05	1.00
Sr (PPM)	-0.29	0.81	0.69	0.63	-0.13	-0.37	-0.07	0.58	-0.24	0.57	0.36	-0.15	-0.18	-0.17	1.00
Ti %	0.61	0.29	0.26	-0.06	0.77	0.65	0.75	0.44	0.42	0.26	0.56	-0.45	-0.08	0.56	-0.01	1.00
V (PPM)	0.84	0.09	0.09	-0.16	0.85	0.74	0.91	0.17	0.65	0.36	0.32	-0.33	-0.14	0.83	-0.02	0.74	1.00
Zn (PPM)	0.16	-0.41	-0.60	-0.17	0.01	0.06	0.04	-0.50	-0.11	-0.20	-0.21	0.41	0.09	0.26	-0.37	-0.20	-0.10	1.00
Zr (PPM)	0.12	0.07	0.14	0.30	0.18	0.07	0.19	0.15	0.24	0.30	0.40	0.17	0.51	0.27	0.05	0.54	0.30	-0.02	1.00
Ag (PPM)	0.73	-0.28	-0.48	-0.52	0.48	0.42	0.53	-0.25	0.08	-0.29	-0.22	0.06	0.15	0.69	-0.43	0.16	0.39	0.53	-0.04	1.00
As (PPM)	0.30	-0.10	-0.07	0.09	0.07	-0.02	0.20	-0.12	0.18	0.18	-0.14	0.17	0.33	0.53	0.13	0.09	0.37	0.08	0.36	0.31	1.00
Be (PPM)	-0.11	0.73	0.91	0.25	0.05	-0.24	0.03	0.76	0.07	0.35	0.24	-0.41	-0.19	-0.04	0.73	0.24	0.21	-0.52	0.24	-0.36	0.28	1.00
Bi (PPM)	0.03	0.03	-0.17	-0.17	0.01	0.01	0.02	-0.07	-0.16	-0.19	-0.04	0.26	0.11	-0.02	-0.07	0.17	-0.09	0.09	0.07	0.28	-0.10	-0.18	1.00
Cd (PPM)	-0.10	0.11	0.01	-0.04	-0.06	-0.02	-0.07	0.06	-0.08	-0.07	0.08	0.18	-0.03	-0.18	0.02	0.23	-0.11	0.00	0.13	0.02	-0.25	-0.06	0.93	1.00
Ce (PPM)	0.21	0.59	0.37	-0.01	0.43	0.13	0.39	0.48	-0.06	0.13	0.29	-0.06	0.19	0.41	0.43	0.37	0.34	0.02	0.46	0.10	0.29	0.52	0.10	0.06	1.00
Co (PPM)	0.72	-0.22	-0.23	-0.03	0.55	0.67	0.70	-0.22	0.73	0.42	0.16	0.08	-0.01	0.78	-0.13	0.47	0.85	0.05	0.31	0.37	0.49	-0.02	-0.10	-0.14	0.16	1.00
Cs (PPM)	-0.05	0.71	0.89	0.10	0.21	0.00	0.11	0.84	0.07	0.22	0.45	-0.62	-0.32	-0.22	0.44	0.39	0.14	-0.56	0.13	-0.43	-0.30	0.72	-0.16	0.05	0.30	-0.20	1.00
Dy (PPM)	-0.09	0.06	-0.13	0.39	-0.15	-0.23	-0.07	-0.14	-0.09	0.23	0.12	0.57	0.75	0.19	0.26	-0.09	-0.03	0.11	0.59	0.04	0.51	0.13	0.03	-0.08	0.56	0.16	-0.26	1.00
Er (PPM)	-0.17	0.16	0.01	0.51	-0.22	-0.27	-0.11	-0.05	0.01	0.36	0.18	0.54	0.61	0.11	0.39	-0.03	-0.04	0.05	0.63	-0.13	0.49	0.28	0.03	0.00	0.56	0.16	-0.12	0.95	1.00
Eu (PPM)	-0.05	0.54	0.36	0.26	0.12	-0.14	0.10	0.38	-0.13	0.23	0.30	0.19	0.45	0.16	0.51	0.19	0.10	-0.10	0.60	-0.09	0.31	0.53	0.08	0.04	0.89	0.03	0.26	0.79	0.80	1.00
Ga (PPM)	0.04	0.55	0.63	0.32	0.05	-0.14	0.12	0.45	0.31	0.45	0.21	0.03	0.05	0.11	0.65	0.24	0.31	-0.45	0.44	-0.23	0.43	0.83	-0.06	0.01	0.58	0.26	0.48	0.45	0.59	0.69	1.00
Gd (PPM)	0.02	0.51	0.27	0.17	0.18	-0.07	0.16	0.36	-0.19	0.12	0.24	0.14	0.46	0.26	0.45	0.18	0.12	-0.03	0.54	0.01	0.36	0.75	0.12	-0.03	0.92	0.04	0.15	0.79	0.77	0.97	0.58	1.00
Ge (PPM)	0.47	0.24	0.31	-0.02	0.47	0.35	0.55	0.32	0.43	0.30	0.21	-0.27	0.12	0.62	0.21	0.58	0.66	-0.28	0.40	0.20	0.66	0.55	-0.07	-0.15	0.48	0.52	0.22	0.26	0.31	0.40	0.59	0.40	1.00
Hf (PPM)	0.10	0.58	0.42	0.22	0.17	-0.03	0.22	0.45	0.01	0.25	0.25	0.06	0.24	0.30	0.55	0.27	0.24	-0.09	0.57	-0.05	0.40	0.61	-0.07	-0.07	0.87	0.19	0.31	0.70	0.77	0.91	0.77	0.90	0.50	1.00
Ho (PPM)	-0.10	0.03	-0.13	0.35	-0.17	-0.25	-0.09	-0.15	-0.05	0.18	0.05	0.57	0.73	0.19	0.22	-0.06	-0.05	0.12	0.64	0.04	0.55	0.14	0.07	-0.04	0.56	0.15	-0.27	0.98	0.95	0.78	0.47	0.79	0.29	0.71	1.00
In (PPM)	0.01	0.08	0.02	-0.10	0.05	0.12	0.06	0.09	0.04	0.00	0.12	0.07	-0.11	-0.07	-0.02	0.32	0.02	-0.01	0.09	0.12	-0.26	-0.04	0.90	0.95	0.04	-0.04	0.09	-0.16	-0.08	-0.02	-0.01	-0.09	-0.02	-0.11	-0.13	1.00
La (PPM))	0.27	0.57	0.33	-0.07	0.49	0.19	0.44	0.47	-0.08	0.08	0.27	-0.10	0.18	0.46	0.38	0.40	0.37	0.04	0.44	0.16	0.29	0.47	0.10	0.04	0.99	0.17	0.28	0.53	0.51	0.86	0.52	0.90	0.48	0.85	0.53	0.02	1.00
Lu (PPM)	-0.20	0.52	0.40	0.40	-0.08	-0.22	-0.06	0.40	-0.12	0.26	0.31	0.19	0.36	0.00	0.54	0.19	-0.03	-0.16	0.65	-0.29	0.24	0.53	0.02	0.07	0.73	-0.03	0.30	0.75	0.84	0.90	0.70	0.85	0.19	0.76	0.85	-0.02	0.69	1.00
Mo (PPM)	0.00	0.09	-0.09	-0.29	0.03	0.02	-0.01	0.01	-0.11	-0.27	-0.12	0.21	-0.12	-0.02	-0.01	0.12	-0.08	0.15	-0.07	0.15	-0.13	-0.06	0.82	0.79	0.20	-0.08	-0.09	-0.03	0.04	0.09	0.01	0.08	-0.05	0.06	0.08	0.76	0.20	0.11	1.00
Nb (PPM)	0.10	0.65	0.55	-0.11	0.33	0.19	0.26	0.65	0.01	0.08	0.35	-0.37	-0.35	-0.03	0.34	0.49	0.16	-0.31	0.04	-0.12	-0.31	0.43	0.48	0.58	0.44	0.15	0.37	0.24	0.22	0.19	0.33	-0.16	0.61	0.42	0.30	0.58	0.49	0.47	0.34	1.00
Nd (PPM)	0.09	0.64	0.40	0.04	0.30	0.01	0.26	0.51	-0.20	0.06	0.25	-0.04	0.23	0.28	0.48	0.27	0.19	-0.02	0.44	0.03	0.25	0.53	0.07	0.03	0.97	0.01	0.31	0.60	0.60	0.93	0.59	0.90	0.59	0.93	0.95	-0.01	0.97	0.80	0.18	0.40	1.00
Ni (PPM)	0.64	-0.03	-0.02	0.05	0.60	0.53	0.70	-0.05	0.71	0.50	0.25	0.05	0.09	0.76	0.05	0.55	0.88	-0.04	0.48	0.30	0.56	0.22	-0.06	-0.10	0.41	0.91	-0.04	0.31	0.33	0.29	0.48	0.29	0.65	0.39	0.32	-0.01	0.40	0.18	-0.08	0.01	0.25	1.00
Pb (PPM)	-0.08	0.09	-0.01	-0.04	0.03	-0.01	-0.05	0.06	0.20	-0.02	-0.14	0.05	0.22	-0.09	0.04	0.13	0.05	-0.20	-0.06	0.94	0.99	0.06	-0.10	-0.02	0.11	-0.07	-0.02	0.96	0.06	0.80	0.55	0.03	-0.07	0.02	0.69	0.20	0.39	0.30	0.58	1.00
Pr (PPM)	0.14	0.60	0.35	0.01	0.34	0.05	0.30	0.47	-0.18	0.07	0.24	-0.01	0.23	0.35	0.45	0.29	0.23	0.03	0.45	0.09	0.28	0.49	0.10	0.05	0.98	0.07	0.26	0.61	0.60	0.92	0.56	0.95	0.42	0.90	0.60	0.00	0.98	0.72	0.41	0.15	0.37	0.30	0.05	1.00
Rb (PPM)	-0.05	0.79	0.96	0.16	0.19	-0.07	0.11	0.94	-0.04	0.23	0.43	-0.70	-0.25	-0.12	0.58	0.42	0.18	-0.57	0.22	-0.38	-0.05	0.86	-0.19	-0.01	0.41	-0.18	0.92	-0.12	0.00	0.37	0.57	0.30	0.39	0.45	-0.12	0.02	0.39	0.41	-0.13	0.57	0.44	0.01	-0.04	0.39	1.00
Sb (PPM)	0.88	-0.07	-0.17	-0.21	0.75	0.67	0.86	-0.06	0.55	0.21	0.14	-0.13	0.07	0.92	-0.17	0.64	0.88	0.04	0.32	0.59	0.54	0.01	0.04	-0.08	0.29	0.84	-0.12	0.14	0.07	0.09	0.20	0.63	0.21	0.15	0.01	0.34	-0.05	-0.06	0.02	0.15	0.85	-0.05	0.21	-0.06	-0.06	1.00
Sc (PPM)	-0.10	-0.09	0.21	0.44	-0.12	-0.03	-0.04	-0.08	0.62	0.67	0.16	0.23	-0.06	0.03	0.28	0.10	0.33	-0.27	0.36	-0.34	0.37	0.38	-0.19	-0.05	0.04	0.52	0.08	0.23	0.38	0.15	0.57	0.03	0.33	0.22	0.25	0.01	-0.04	-0.13	-0.06	-0.05	0.61	-0.02	-0.05	0.10	0.19	1.00
Se (PPM)	0.73	-0.24	-0.38	-0.05	0.47	0.42	0.64	-0.33	0.45	0.20	-0.01	0.19	0.24	0.86	-0.16	0.34	0.66	0.39	0.31	0.64	0.67	-0.11	-0.01	-0.16	0.22	0.76	-0.42	0.34	0.27	0.11	0.14	0.17	0.52	0.20	0.34	-0.11	0.25	-0.04	-0.10	-0.31	0.11	0.73	-0.11	0.17	-0.32	0.85	0.16	1.00
Sm (PPM)	0.03	0.61	0.36	0.11	0.23	-0.05	0.19	0.46	-0.22	0.09	0.27	0.06	0.33	0.23	0.49	0.21	0.12	-0.05	0.48	-0.01	0.25	0.49	0.09	0.03	0.95	-0.01	0.27	0.69	0.68	0.96	0.59	0.98	0.37	0.90	0.67	-0.03	0.94	0.84	0.15	0.35	0.99	0.23	0.03	0.98	0.11	-0.03	0.09	1.00
Sn (PPM)	0.00	0.24	0.16	-0.08	0.10	0.10	0.08	0.22	-0.01	0.01	0.19	0.02	-0.15	-0.11	0.08	0.39	0.03	-0.14	0.13	0.00	-0.26	0.07	0.88	0.95	0.14	-0.08	0.23	-0.17	-0.07	0.07	0.11	-0.01	0.02	-0.01	-0.13	0.95	0.11	0.10	0.80	0.73	-0.03	0.94	0.10	0.15	-0.01	-0.01	-0.19	0.07	1.00
Ta (PPM)	-0.04	0.73	0.74	-0.01	0.19	-0.02	0.11	0.73	-0.08	0.12	0.33	-0.38	-0.33	-0.17	0.48	0.36	0.06	-0.35	0.04	-0.27	-0.26	0.61	0.23	0.36	0.45	-0.24	0.79	-0.17	-0.02	0.36	0.49	0.27	0.22	0.41	-0.15	0.37	0.41	0.38	0.89	0.45	-0.08	0.35	0.42	0.72	-0.14	0.00	-0.40	0.41	0.54	1.00
Tb (PPM)	0.01	0.29	0.05	0.24	0.05	-0.13	0.09	0.11	-0.15	0.14	0.17	0.37	0.66	0.26	0.34	0.05	0.05	0.06	0.57	0.10	0.44	0.27	0.10	-0.02	0.79	0.10	-0.07	0.93	0.87	0.92	0.52	0.95	0.36	0.82	0.92	-0.09	0.77	0.80	0.05	0.03	0.82	0.31	-0.01	0.83	0.07	0.18	0.08	0.28	0.88	-0.07	0.06	1.00
Te (PPM)	0.26	-0.09	-0.17	-0.02	0.04	-0.14	0.16	-0.20	-0.04	0.04	-0.33	0.19	0.30	0.52	0.14	-0.13	0.23	0.19	0.12	0.52	0.82	0.15	0.04	-0.20	0.26	0.34	-0.44	0.48	0.37	0.25	0.24	0.33	0.43	0.27	0.49	-0.19	0.27	0.08	-0.08	-0.35	0.22	0.43	-0.14	0.26	-0.19	0.49	0.14	0.65	0.23	-0.27	-0.36	0.44	1.00
Th (PPM)	0.41	0.39	0.22	-0.12	0.63	0.47	0.60	0.37	0.15	0.15	0.29	-0.20	0.06	0.63	0.21	0.58	0.57	0.00	0.50	0.20	0.33	0.35	0.07	0.08	0.84	0.40	0.21	0.39	0.39	0.67	0.44	0.73	0.56	0.70	0.42	0.06	0.89	0.52	0.11	0.38	0.78	0.58	0.03	0.81	0.31	0.55	0.08	0.78	0.54	0.25	0.60	0.27	1.00
Tl (PPM)	-0.09	0.63	0.79	0.01	0.05	-0.21	-0.04	0.78	-0.17	-0.02	0.15	-0.59	-0.08	-0.11	0.48	0.11	-0.01	-0.34	0.07	-0.16	0.02	0.76	-0.28	-0.20	0.40	-0.31	0.69	-0.07	0.07	0.38	0.47	0.36	0.29	0.47	0.11	-0.17	0.38	0.33	-0.19	0.35	0.45	-0.14	-0.22	0.41	0.84	-0.16	-0.08	-0.26	0.42	-0.12	0.52	0.19	0.02	0.23	1.00
Tm (PPM)	-0.21	0.18	0.01	0.43	-0.19	-0.22	-0.12	0.05	-0.09	0.21	0.21	0.40	0.63	0.06	0.30	0.07	-0.11	-0.03	0.66	-0.13	0.31	0.20	0.08	0.03	0.53	0.01	-0.10	0.89	0.91	0.76	0.45	0.76	0.28	0.72	0.91	-0.02	0.49	0.84	0.04	-0.02	0.59	0.17	0.04	0.58	0.05	-0.01	0.20	0.13	0.67	-0.02	-0.01	0.84	0.23	0.40	0.13	1.00
U (PPM)	0.41	0.44	0.34	-0.01	0.57	0.38	0.58	0.43	0.23	0.27	0.31	-0.18	0.00	0.63	0.04	0.56	0.57	0.14	0.46	0.60	0.78	0.04	0.10	0.08	0.50	0.10	0.08	0.48	0.50	0.64	0.48	0.58	0.50	0.44	0.53	0.08	0.45	0.42	0.54	0.25	0.49	0.79	0.00	0.29	0.65	0.30	0.94	0.35	0.46	1.00
W (PPM)	-0.06	0.28	0.18	0.33	-0.07	-0.13	-0.04	0.36	-0.17	0.07	0.38	-0.22	0.12	-0.12	0.18	0.17	-0.06	-0.13	0.21	-0.16	0.05	0.14	-0.09	-0.03	0.00	-0.15	0.10	0.08	0.10	0.08	0.01	0.11	0.09	0.07	0.07	-0.06	0.00	0.15	-0.13	-0.09	0.08	-0.13	-0.05	0.06	0.24	-0.10	-0.09	0.00	0.09	-0.05	-0.06	-0.07	-0.10	-0.08	0.11	0.25	-0.04	1.00
Y (PPM)	-0.13	0.08	-0.08	0.47	-0.19	-0.25	-0.10	-0.10	0.00	0.27	0.19	0.56	0.74	0.11	0.26	-0.02	-0.05	0.08	0.67	-0.06	0.46	0.17	0.04	-0.01	0.51	0.14	-0.19	0.97	0.97	0.76	0.50	0.75	0.25	0.70	0.97	-0.10	0.47	0.79	0.00	-0.15	0.55	0.31	0.01	0.55	-0.07	0.10	0.29	0.31	0.64	-0.10	-0.12	0.88	0.37	0.34	0.03	0.92	0.43	0.17	1.00
Yb (PPM)	-0.20	0.45	0.32	0.37	-0.13	-0.30	-0.10	0.28	-0.15	0.21	0.16	0.30	0.38	0.04	0.54	0.05	-0.06	-0.03	0.62	-0.20	0.35	0.50	-0.02	-0.01	0.74	-0.02	0.16	0.81	0.87	0.92	0.69	0.88	0.25	0.91	0.82	-0.12	0.70	0.95	0.03	0.12	0.82	0.19	-0.01	0.80	0.31	-0.04	0.23	0.07	0.86	-0.03	0.25	0.85	0.24	0.52	0.36	0.82	0.65	0.11	0.82	1.00

Table 4 Spearman Rank Correlation Coefficients

Spearman Rank Correlation

Iduapriem

	Au	Al	Ba	Ca	Cr	Cu	Fe	K	Li	Mg	Mn	Na	P	S	Sr	Ti	V	Zn	Zr	Ag	As	Be	Bi	Cd	Ce	Co	Cs	Dy	Er	Eu	Ga	Gd	Ge	Ho	Hf	In	La	Lu	Mo	Nb	Nd	Ni	Pb	Pr	Rb	Sb	Sc	Se	Sm	Sn	Ta	Tb	Te	Th	Tl	Tm	U	W	Y	Yb
Au	1																																																												
Al	0.03	1																																																										
Ba	0.162	0.787	1																																																									
Ca	-0.358	0.243	0.113	1																																																								
Cr	0.155	0.561	0.544	-0.141	1																																																							
Cu	-0.196	-0.185	-0.272	-0.146	0.15	1																																																						
Fe	0.227	0.616	0.466	0.152	0.757	0.195	1																																																					
K	0.131	0.866	0.917	0.096	0.612	-0.128	0.587	1																																																				
Li	0.02	-0.068	0.126	0.001	0.118	0.437	0.272	0.017	1																																																		
Mg	-0.156	0.32	0.207	0.71	0.208	0.233	0.593	0.24	0.475	1																																																
Mn	-0.119	0.426	0.289	0.65	0.391	0.244	0.569	0.413	0.265	0.778	1																																														
Na	-0.241	-0.458	-0.615	0.177	-0.617	-0.152	-0.53	-0.733	-0.044	-0.132	-0.303	1																																													
P	0.177	-0.331	-0.239	0.161	-0.169	-0.228	-0.216	-0.259	0.057	-0.025	0.104	0.304	1																																											
S	0.395	-0.153	-0.064	-0.12	0.027	-0.324	0.285	-0.083	-0.023	0.036	-0.255	0.058	0.286	1																																										
Sr	-0.027	0.784	0.578	0.592	0.204	-0.291	0.559	0.597	-0.035	0.55	0.416	-0.169	-0.284	0.081	1																																									
Ti	-0.123	0.452	0.439	0.131	0.64	0.199	0.562	0.571	0.432	0.378	0.609	-0.436	0.094	-0.131	0.235	1																																						
V	0.312	0.194	0.353	0.034	0.4	0.159	0.653	0.306	0.643	0.495	0.319	-0.319	0.046	0.466	0.304	0.482	1																																				
Zn	0.027	-0.647	-0.71	-0.081	-0.228	0.362	-0.172	-0.695	0.127	0.089	-0.022	0.442	0.386	0.126	-0.528	-0.283	-0.107	1																																	
Zr	0.114	0.13	0.173	0.137	0.125	-0.255	0.2	0.224	0.201	0.086	0.262	-0.027	0.585	0.4	0.092	0.564	0.388	-0.153	1																															
Ag	0.558	-0.229	-0.255	-0.591	0.02	-0.192	-0.054	-0.186	-0.228	-0.399	-0.345	0.03	0.267	0.454	-0.376	-0.2	-0.056	0.403	0.151	1																													
As	0.504	-0.243	-0.077	-0.124	-0.171	-0.453	0.001	-0.12	0.071	-0.061	-0.199	0.036	0.362	0.735	-0.018	-0.023	0.393	-0.048	0.468	0.398	1																											
Be	0.161	0.608	0.866	0.208	0.363	-0.389	0.469	0.753	0.274	0.332	0.266	-0.465	-0.091	0.28	0.6	0.437	0.533	-0.628	0.402	-0.208	0.292	1																									
Bi	0.155	-0.067	-0.307	-0.417	0.184	-0.078	0.075	-0.194	-0.3	-0.289	-0.238	0.129	0.11	0.365	-0.187	-0.021	-0.088	0.303	0.121	0.736	0.261	-0.258	1																							
Cd	-0.048	-0.433	-0.563	0.027	-0.274	0.016	-0.2	-0.501	-0.103	0.032	-0.011	0.432	0.523	0.29	-0.291	-0.148	-0.124	0.723	0.155	0.506	0.231	-0.365	0.615	1																					
Ce	0.217	0.485	0.352	-0.058	0.652	-0.126	0.592	0.425	-0.142	0.113	0.178	-0.308	0.051	0.456	0.276	0.316	0.308	-0.198	0.373	0.214	0.177	0.336	0.386	-0.009	1																				
Co	0.289	-0.244	-0.198	-0.001	-0.039	0.264	0.381	-0.196	0.482	0.347	0.069	0.059	0.198	0.655	0.03	0.036	0.705	0.304	0.266	0.123	0.432	0.092	0.019	0.172	0.18	1																			
Cs	0.076	0.67	0.848	0.047	0.502	-0.038	0.345	0.771	0.211	0.163	0.305	-0.479	-0.379	-0.363	0.37	0.403	0.152	-0.588	-0.019	-0.34	-0.338	0.619	-0.443	-0.637	0.619	0.115	1																		
Dy	0.11	0.002	-0.063	0.344	-0.207	-0.452	0.004	-0.068	-0.148	0.1	0.028	0.266	0.494	0.647	0.258	-0.009	0.193	-0.094	0.635	0.093	0.57	0.236	0.113	0.287	0.38	0.289	-0.303	1																	
Er	0.023	0.033	-0.046	0.411	-0.271	-0.426	0.012	-0.073	-0.038	0.171	0.049	0.308	0.419	0.583	0.3	-0.003	0.18	-0.122	0.612	-0.035	0.532	0.269	0.079	0.272	0.318	0.281	-0.27	0.942	1																
Eu	0.075	0.557	0.45	0.202	0.465	-0.324	0.46	0.465	-0.23	0.133	0.207	-0.16	0.081	0.425	0.462	0.28	0.211	-0.361	0.496	0.032	0.153	0.484	0.238	-0.042	0.892	0.036	0.283	0.579	0.542	1															
Ga	0.271	0.252	0.383	0.12	-0.112	-0.431	0.146	0.185	0.403	0.206	-0.07	0.112	0.043	0.394	0.417	0.057	0.433	-0.322	0.421	0.045	0.508	0.66	-0.01	-0.083	0.178	0.331	0.197	0.416	0.523	0.335	1													
Gd	0.152	0.501	0.362	0.114	0.43	-0.336	0.427	0.416	0.068	0.12	-0.202	0.125	0.494	0.396	0.25	0.202	-0.374	0.509	0.097	0.265	0.426	0.272	-0.045	0.884	0.072	0.155	0.668	0.605	0.953	0.309	1												
Ge	0.231	0.167	0.361	0.025	0.301	-0.172	0.444	0.358	0.386	0.35	0.227	-0.38	0.101	0.519	0.21	0.486	0.591	-0.248	0.508	0.097	0.652	0.631	0.131	-0.008	0.453	0.377	0.157	0.291	0.348	0.395	0.544	0.412	1											
Ho	0.044	-0.04	-0.083	0.252	-0.235	-0.461	-0.061	-0.096	-0.076	0.015	-0.083	0.314	0.521	0.672	0.185	0.037	0.18	-0.118	0.705	0.095	0.612	0.241	0.159	0.286	0.341	0.285	-0.333	0.964	0.945	0.532	0.479	0.625	0.342	1										
Hf	0.285	0.49	0.384	0.054	0.316	-0.348	0.404	0.444	-0.149	0.076	0.072	-0.223	0.072	0.532	0.406	0.213	0.223	-0.385	0.535	0.198	0.335	0.472	0.229	-0.076	0.781	0.136	0.199	0.678	0.655	0.849	0.462	0.918	0.461	0.652	1									
In	-0.065	-0.022	-0.026	-0.185	0.106	0.2	0.293	0.044	0.311	0.236	0.094	-0.087	-0.012	0.257	-0.011	0.274	0.371	0.315	0.177	0.329	0.115	0.13	0.406	0.526	0.144	0.293	-0.08	-0.019	0.043	0.058	0.132	0	0.396	-0.001	0.038	1								
La	0.263	0.468	0.321	-0.104	0.695	-0.087	0.622	0.414	-0.12	0.097	0.199	-0.344	0.044	0.448	0.242	0.37	0.322	-0.185	0.38	0.239	0.206	0.311	0.419	-0.004	0.988	0.177	0.203	0.36	0.293	0.856	0.144	0.869	0.467	0.319	0.767	0.147	1							
Lu	-0.126	0.433	0.266	0.343	0.13	-0.174	0.326	-0.194	0.11	0.17	0.054	0.109	0.277	0.418	0.291	-0.008	-0.44	0.582	-0.143	0.168	0.359	0.092	-0.064	0.566	-0.12	0.175	0.703	0.738	0.793	0.357	0.815	0.32	0.717	0.828	-0.084	0.542		1						
Mo	-0.001	-0.048	-0.25	-0.416	0.184	0.054	-0.031	-0.179	-0.224	-0.337	-0.266	0.148	0.023	0.04	-0.227	-0.077	-0.221	0.223	-0.181	0.483	-0.08	-0.333	0.747	0.42	0.272	-0.023	-0.269	-0.081	-0.096	0.086	-0.138	0.13	-0.093	-0.055	0.1	0.233	0.293	-0.039	1					
Nb	-0.031	0.718	0.615	-0.026	0.665	0.165	0.585	0.706	0.233	0.293	0.367	-0.491	-0.401	-0.237	0.384	0.567	0.192	-0.437	-0.02	-0.2	-0.281	0.451	-0.018	-0.329	0.418	-0.158	0.728	-0.305	-0.232	0.304	0.117	0.243	0.28	-0.282	0.281	0.164	0.432	0.211	0.156	1				
Nd	0.219	0.56	0.419	-0.008	0.572	-0.265	0.515	0.48	-0.256	0.043	0.142	-0.282	0.039	0.398	0.354	0.266	0.202	-0.313	0.399	0.169	0.166	0.401	0.324	-0.071	0.961	0.055	0.267	0.461	0.402	0.946	0.228	0.951	0.4	0.412	0.853	0.064	0.947	0.68	0.21	0.367	1			
Ni	0.295	-0.026	0.042	0.101	0.23	0.107	0.547	-0.028	0.625	0.501	0.247	-0.008	0.279	0.637	0.182	0.303	0.843	0.179	0.461	0.133	0.493	0.346	0.134	0.179	0.346	0.818	-0.145	0.359	0.359	0.256	0.545	0.254	0.591	0.361	0.263	0.375	0.354	0.046	-0.043	0.008	0.219	1		
Pb	0.056	-0.214	-0.362	-0.064	-0.168	-0.167	-0.089	-0.297	-0.166	-0.004	-0.17	0.275	0.308	0.375	-0.064	0.514	0.074	0.567	0.306	-0.208	0.662	0.775	0.112	0.232	-0.556	0.191	0.195	0.002	0.087	0.017	0.125	0.232	0.067	0.432	0.101	-0.067	0.518	-0.169	0.038	0.164			1	
Pr	0.238	0.515	0.336	-0.062	0.583	-0.209	0.539	0.426	-0.229	0.042	0.131	-0.256	0.067	0.431	0.307	0.281	0.22	-0.228	0.404	0.249	0.193	0.324	0.415	0.017	0.983	0.112	0.202	0.444	0.387	0.914	0.197	0.921	0.408	0.407	0.835	0.131	0.975	0.639	0.283	0.393	0.983	0.265	0.136	1
Rb	0.146	0.778	0.959	0.094	0.553	-0.19	0.48	0.943	0.133	0.203	0.354	-0.679	-0.261	-0.07	0.534	0.533	0.323	-0.739	0.263	-0.243	-0.053	0.844	-0.307	-0.569	0.38	-0.212	0.859	-0.006	0.473	0.338	0.161	0.357	0.295	0.8	0.452	0.321	0.726	0.258	0.668	0.447	0.008	-0.405	0.375
Sb	0.474	-0.15	-0.038	-0.058	0.06	-0.194	0.245	-0.08	0.357	0.155	0.028	0.006	0.366	0.627	0.01	0.22	0.617	0.016	0.511	0.275	0.823	0.285	0.183	0.167	0.217	0.582	-0.2	0.373	0.329	0.116	0.497	0.162	0.615	0.425	0.179	0.145	0.251	0.018	-0.149	-0.051	0.111	0.733	0.2	0.178
Sc	-0.031	0.165	0.284	0.319	0.098	0.2	0.422	0.176	0.689	0.609	0.31	0.068	0.072	0.334	0.413	0.333	0.767	-0.268	0.179	0.504	-0.169	0.035	0.085	0.569	0.145	0.263	0.327	0.175	0.553	0.093	0.389	0.28	0.135	0.348	0.052	0.134	-0.228	0.16	0.014	0.74	-0.041	0.017	0.237	0.391
Se	0.391	-0.362	-0.321	-0.08	-0.189	-0.362	0.002	-0.347	0.1	0.031	-0.168	0.152	0.506	0.726	-0.12	-0.083	0.299	0.354	0.408	0.495	0.771	0.039	0.292	0.441	0.092	0.493	-0.583	0.53	0.466	0.018	0.331	0.161	0.39	0.547	0.219	0.194	0.128	-0.006	-0.011	-0.467	0.073	0.517	0.528	0.115
Sm	0.134	0.57	0.412	0.074	0.512	-0.286	0.47	0.474	-0.295	0.046	0.145	-0.212	0.061	0.41	0.392	0.253	0.142	-0.345	0.43	0.101	0.12	0.395	0.276	-0.077	0.932	0.005	0.271	0.513	0.458	0.973	0.223	0.965	0.342	0.469	0.859	0.019	0.906	0.756	0.156	0.344	0.986	0.174	-0.007	0.963
Sn	0.078	0.586	0.505	-0.107	0.611	0.215	0.679	0.618	0.264	0.338	0.39	-0.457	-0.463	-0.074	0.374	0.583	0.428	-0.278	0.049	0.025	-0.112	0.417	0.183	-0.145	0.375	0.023	0.575	-0.297	0.909	0.524	0.199	-0.295	0.909	0.524	0.529	0.935	0.548	-0.019	-0.308	0.2	0.553	0.397	0.096	0.121
Ta	-0.16	0.714	0.689	0.115	0.556	-0.008	0.421	0.685	0.151	0.303	0.326	-0.314	-0.424	-0.27	0.452	0.461	0.137	-0.476	-0.074	-0.282	-0.314	0.51	-0.08	-0.344	0.382	-0.262	0.792	-0.266	-0.196	0.367	0.193	0.237	0.253	-0.253	0.249	0.119	0.35	0.275	0.109	0.893	0.358	-0.077	-0.145	0.349
Tb	0.189	0.346	0.232	0.122	0.271	-0.319	0.33	0.285	-0.207	0.053	0.093	-0.081	0.292	0.593	0.324	0.207	0.262	-0.241	0.625	0.184	0.376	0.357	0.295	0.114	0.825	0.213	0.002	0.804	0.731	0.907	0.345	0.955	0.47	0.762	0.907	0.072	0.877	0.348	0.138	0.866	0.291	0.255	0.178	0.297
Te	0.453	-0.141	-0.106	-0.084	-0.074	-0.476	0.146	-0.103	-0.125	0.015	-0.197	0.029	0.344	0.862	0.103	-0.144	0.318	0.122	0.356	0.594	0.84	0.221	0.49	0.402	0.275	0.442	-0.478	0.545	0.467	0.225	0.413	0.324	0.498	0.558	0.378	0.198	0.277	0.112	0.113	-0.309	0.244	0.509	0.554	0.286
Th	0.265	0.433	0.277	-0.125	0.69	0.031	0.718	0.371	0.047	0.166	0.231	-0.297	0.05	0.519	0.251	0.414	0.476	-0.109	0.44	0.261	0.19	0.314	0.417	0.024	0.939	0.363	0.161	0.357	0.295	0.8	0.452	0.321	0.726	0.258	0.953	0.47	0.294	0.414	0.871	0.533	0.086	0.913	0.325	0.318
Tl	0.142	0.774	0.93	0.084	0.568	-0.282	0.392	0.872	-0.01	0.102	0.229	-0.589	-0.258	-0.083	0.513	0.393	0.156	-0.721	0.156	-0.21	-0.125	0.758	-0.227	-0.546	0.433	-0.364	0.846	0.021	0.027	0.541	0.308	0.483	0.279	-0.006	0.526	-0.147	0.414	0.436	-0.155	0.65	0.512	-0.098	-0.371	0.437
Tm	-0.144	0.2	0.048	0.391	-0.073	-0.272	0.073	0.102	-0.031	0.102	0.068	0.31	0.334	0.581	0.273	0.07	-0.188	0.742	-0.084	0.267	0.261	0.198	0.395	0.085	0.843	0.285	0.868	0.714	0.031	0.38	0.881	-0.06	-0.028	0.494	0.227	0.061	0.047	0.155	0.138	0.251	0.25	0.57	-0.128	-0.037
U	0.336	0.379	0.34	-0.091	0.591	-0.011	0.686	0.396	0.141	0.218	0.22	-0.342	0.038	0.619	0.292	0.4	0.625	-0.176	0.495	0.22	0.332	0.44	0.279	-0.05	0.865	0.469	0.165	0.486	0.419	0.773	0.317	0.802	0.561	0.432	0.794	0.267	0.877	0.508	0.15	0.294	0.823	0.605	0.034	0.838
W	0.186	0.477	0.58	-0.106	0.484	-0.205	0.395	0.622	0.215	0.031	0.307	-0.468	0.087	-0.033	0.199	0.714	0.383	-0.505	0.541	-0.031	0.22	0.596	-0.021	-0.211	0.361	-0.097	0.533	0.084	0.096	0.374	0.247	0.36	0.547	0.111	0.327	0.308	0.408	0.298	-0.098	0.518	0.403	0.17	-0.262	0.385
Y	-0.055	-0.094	0.089	0.398	-0.254	-0.402	-0.106	-0.131	0.017	0.108	0.053	0.336	0.611	0.449	0.169	0.093	0.123	-0.051	0.708	-0.036	0.429	0.19	0.038	0.315	0.225	0.199	-0.295	0.909	0.524	0.529	0.935	0.548	-0.019	0.205	0.675	-0.103	-0.279	0.304	0.329	0.195	0.29	-0.043	0.317	0.278
Yb	0.041	0.365	0.213	0.241	0.031	-0.455	0.134	0.217	-0.225	-0.004	-0.013	0.143	0.169	0.479	0.429	0.092	0.079	-0.384	0.585	-0.005	0.311	0.355	0.126	-0.032	0.579	0.035	0.039	0.837	0.832	0.802	0.467	0.833	0.866	-0.123	0.55	0.916	-0.043	0.011	0.701	0.163	0.004	0.663	0.282	0.13

(continued columns)

	Rb	Sb	Sc	Se	Sm	Sn	Ta	Tb	Te	Th	Tl	Tm	U	W	Y	Yb
Rb	1															
Sb	-0.034	1														
Sc	0.533	0.086	1													
Se	0.25	0.18	0.391	1												
Sm	0.444	0.067	0.036	0.013	1											
Sn	0.786	0.303	0.2	-0.061	0.343	1										
Ta	0.684	-0.158	0.217	-0.561	0.354	0.739	1									
Tb	0.896	0.054	0.073					1								
Te	-0.132	0.665	0.162	0.804	0.204	-0.123	-0.341	0.42	1							
Th	0.234	0.158	0.833	0.448	0.291	0.769	0.295			1						
Tl	0.948	-0.14	0.129	-0.364	0.521	0.437	0.695	0.338	-0.146	0.329	1					
Tm	0.764	0.218	0.38	0.173								1				
U	0.4	0.355	0.361	0.261	0.777	0.4	0.22	0.813	0.372	0.932	0.368	0.44	1			
W	0.636	0.306	0.115	-0.016	0.374	0.573	0.416	0.297	-0.034	0.392	0.51	0.24	0.391	1		
Y	0.485	0.37	-0.377	-0.267	0.667	0.369	0.215	-0.005	0.902	0.304	0.118				1	
Yb	0.169	0.208	0.766	-0.074	0.069	0.881	0.301	0.515	0.359	0.862	0.586	0.192	0.76			1

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