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LATERİT JEOKİMYASI KULLANARAK WA-LAWRA BÖLGESİNDE OROJENİK ALTIN YATAKLARININ ARAŞTIRILMASI, ÖRNEK BİR UYGULAMA, KUNCHE, NW GANA

Emmanuel Daanoba SUNKARI (ORCID: 0000-0002-0898-2286) [1*]
Michael APPIAH-TWUM (ORCID: 0000-0002-6300-5429) [2]
Abdurrahman LERMI (ORCID: 0000-0003-4117-689X) [1]

[1]Niğde Ömer Halisdemir Universitesi, Mühendislik Fakültesi, Jeoloji Mühendisliği Bölümü, 51240, Niğde, Turkiye
[2]University of Electronic Science and Technology of China, School of Resource and Environment, 611731, Chengdu, Sichuan, China

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ÖZ

Bu çalışmada, Wa-Lawra kuşağı içinde yer alan Kunche (KB Gana) bölgesindeki lateritlerin mekânsal dağılımı, eser element dağılımları ve jeokimyasal birliktelikleri incelenmiştir. Kunche bölgesinde yaygın olan laterit örnekleri XRF ve ICP-MS yöntemleri kullanılarak analiz edilmiş, çok değişkenli jeoistatistik analizler kullanılarak bu veriler değerlendirilmiştir. Lateritler, lateritik duricrust (kalıntı lateritler) ve ferruginous duricrust (taşınmış lateritler) olarak sınıflandırılabilirler. Çok değişkenli istatistik sonuçları, bu kayaçlarda üç farklı element birlikteliği olduğunu (Fe, S, Pb, Co-Grup-1; Cu, Cr, As, Au, Ag-Grup-2; Mn, Ca, Ti, Ni, Rb, Sr, Zr, Y, Zn-Grup-3) göstermiştir. Bu element grupları, taban kayaçları olan metavolkanitler ve içindeki altın yataklarının yoğun ayrışması sonucu iz bulucu elementlerin ikincil dağılımı ile doğrudan ilişkili olduğunu göstermektedir. Medyan mutlak sapma metodu kullanılarak hesaplanan eşik değerler S (>% 0,41), Pb (> 48 ppm), Cu (46 ppm), As (134.2 ppm) ve Ag (> 0.42 ppm) olarak tespit edilmiştir. Diğer yandan, çok elementli haritalama tekniği, Pb+Cu+As+Ag elementlerinin bu yatakların araştırılmasında en iyi iz element birlikteliği olduğunu göstermiştir. Bu ilişki, özellikle kalıntı lateritler içinde aynı yöntemle hazırlanan Au dağılım haritasına oldukça benzer elipsoidal anomali verdiği tespit edilmiştir.

Anahtar kelimeler: iz element jeokimyası, laterit, laterit jeokimyası, regolit, orojenik altın yatakları

USING LATERITE GEOCHEMISTRY FOR EXPLORATION OF OROGENIC GOLD DEPOSITS IN THE WA-LAWRA BELT, NW GHANA: KUNCHE IN PERSPECTIVE

ABSTRACT

In this study, the spatial distribution of laterites in Kunche within the Wa-Lawra belt of NW Ghana, their trace element distributions, and geochemical associations were investigated. XRF and ICP-MS techniques were employed to generate the geochemical data and interpreted using multivariate geostatistical analysis. The laterites are classified as lateritic duricrust (residual laterites) and ferruginous duricrust (transported laterites). Three element associations (Fe, S, Pb-Group 1; Mn, Cu, Co, Cr, Ni, Ti, As, Au, Ag-Group 2; Ca, Rb, Sr, Zr, Y, Zn-Group 3) are observed from the multivariate geostatistical analysis implying that the element association in the area is directly related to secondary dispersion of the gold-bearing underlying meta-volcanic host rocks and laterization. Threshold values from medium absolute deviation method indicate anomalous concentrations in the laterites for S (>0.41%), Pb (>48 ppm), Cu (46 ppm), As (134.2 ppm), and Ag (>0.42 ppm), implying that these elements are the important pathfinder elements of gold identified in the laterites. However, multi-element mapping indicates that Pb + Cu + As + Ag is the best element association in the exploration of gold deposits. This association

*Corresponding author / Sorumlu yazar. Tel.: +905414086813; e-mail: emmanueldaanoba.sunkari@mail.ohu.edu.tr

shows ellipsoidal anomalies in a contour map restricted to the environment of the residual laterites and similar to the gold distribution map.

Keywords: trace element geochemistry, laterites, laterite geochemistry, regolith, orogenic gold deposits

1. INTRODUCTION

Kunche located in NW Ghana within the Wa-Lawra greenstone belt is predominantly composed of metavolcanics, undifferentiated pyroclastic rocks, volcanoclastics, and metasediments (Fig. 1). The area is reported to have potential for gold mineralization but several attempts in harnessing and exploring for this valuable resource have been abortive over the years. It is covered with laterites of varying origin. Gold exploration in such complex terranes is better enhanced using laterites as the sampling medium.

The use of laterite trace element geochemistry in mineral exploration was initiated by Mazzucchelli and James [1] in Western Australia and has since become a useful tool for successful gold exploration in the world [2]. By determining the behavior of trace elements in laterites within complex regolith environments, it is possible to completely understand secondary geochemical dispersion mechanisms useful for geochemical exploration programs. This study is aimed at using the trace element geochemistry of laterites in Kunche to determine areas of unusual element enrichment, the primary geological environment, and of the possible existence of base and precious metals mineralization, as there are few outcrops of primary rocks in the area.

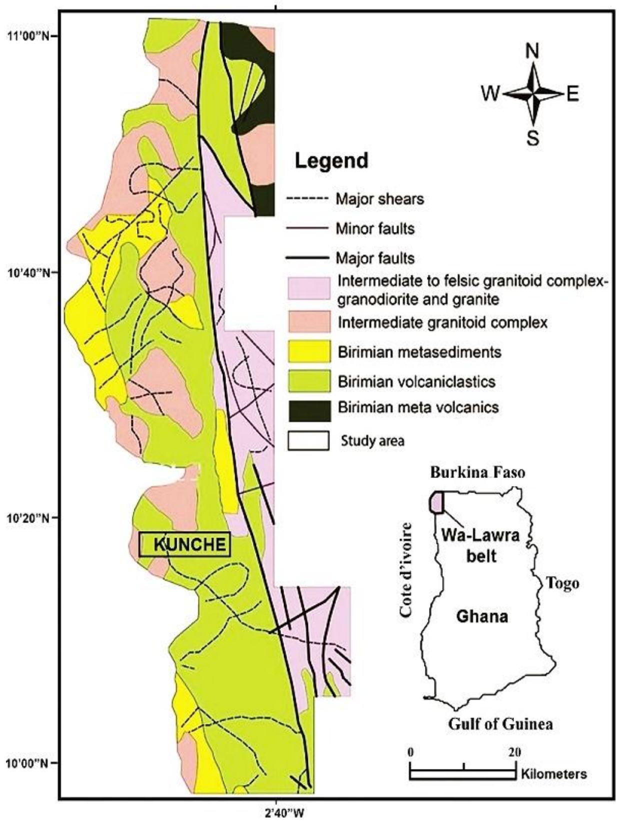

Figure 1. Geological map of the Wa-Lawra belt showing the dominance of Birimian volcaniclastics in Kunche, after [3]

2. MATERIAL AND METHOD

A total of 67 laterite samples were collected from in-situ materials on the surface of the landscape, old pits, and from 30 cm diameter-holes dug in the plateaus and hills by means of a digging hoe. At each of the 67 sample points, about 2 kg weight samples were collected and sent to the geochemical laboratory of Azumah Resources

Limited, Ghana. The geochemical analysis involved XRF (Fe, S, Mn, Ca, Ti, Cr, Mo, Ni, Co, Cu, Th, Rb, Sr, Zr, Y, Pb, Zn, and Sb) and ICP-MS (Au, As, and Ag) following the standard procedures. The geochemical data was interpreted using multivariate geostatistical analysis mainly Principal Component Anlysis (PCA). Threshold values for delineating gold anomalies in the study area were calculated using the median absolute deviation method as detailed in Tukey [4].

3. RESULTS AND DISCUSSION

3.1. Laterite types and formation

The information gathered from the laterite mapping in the field shows that the study area is largely composed of transported (ferruginous) duricrusts and residual (lateritic) duricrusts (Fig. 2). The pisoliths and quartz pebbles associated with these type of laterites are interpreted as transported detritus overlying the regolith whilst the clay units are interpreted as members of the saprolite. The residual laterites formed as a result of residual accumulation and cementation of Fe-oxides and clay mineral concentrates through ferruginization.

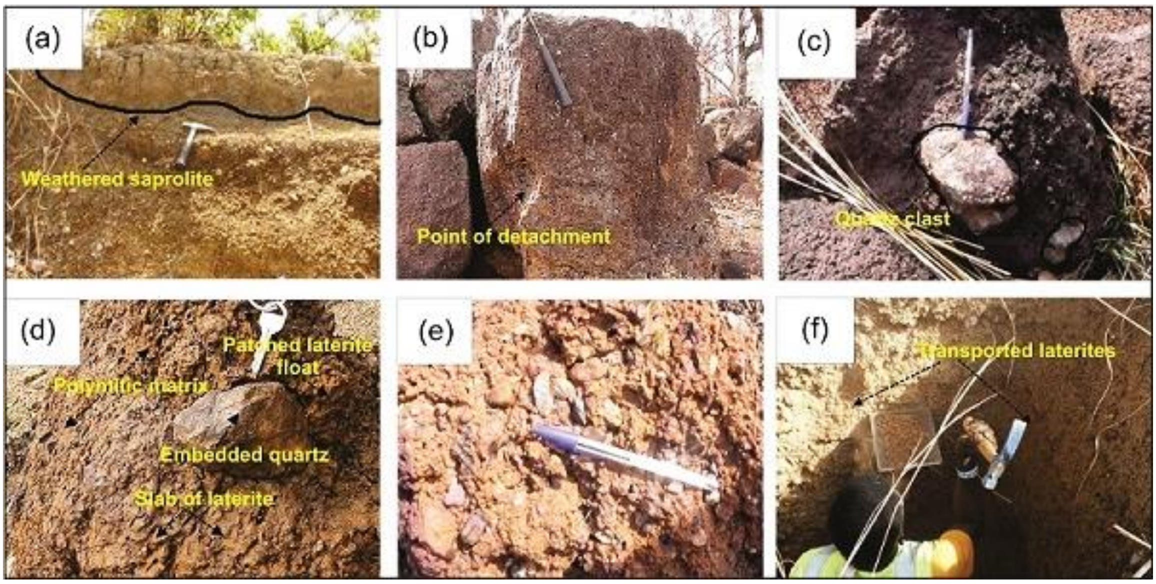

Figure 2. (a) Laterite profile exposing the weathered saprolite and residual laterites in Kunche (b) Lateritic duricrust showing point of detachment during weathering, (c) Lateritic duricrust with quartz clasts, (d) Ferruginous duricrust formed from different jumbled materials, (e) Eroded ferruginous fragments with pisoliths and quartz pebbles and (f) Transported laterites exposed in an old pit

3.2. Geochemistry, anomaly models and exploration implications

Summary statistics of the analysed trace elements are presented in Table 1. The concentrations of Fe (0.60 - 59.70%), S (0.15 - 0.66%), Mn (137.00 – 4560.00), Ti (567.00 – 3420.00), Cu (8.00 – 411.00), Ni (29.00 – 167.00), Pb (3.90 - 100), As (4.20 – 213.00), Au (8.00 – 196.00 ppb), and Ag (0.01 – 0.98) are higher in the lateritic duricrust than the ferruginous duricrust. The concentrations of Pb and As are also higher in the residual laterites than the transported laterites. The relatively high As content may represent a dispersion halo around gold mineralization in Kunche. The high Au concentrations may be as a result of complex geochemical processes including residual accumulation, colluvial transport, surficial wash of Au grains in the course of surface reduction activities, and mobility of Au in colloids. This resulted in lateral dispersion of Au from the sap rocks towards the top of the profile restricted to the lateritic duricrusts and the mottled zones.

From the PCA, three element associations (Fe, S, Pb-Group 1; Mn, Cu, Co, Cr, Ni, Ti, As, Au, Ag-Group 2; Ca, Rb, Sr, Zr, Y, Zn-Group 3) were observed (Fig. 3). By using median absolute deviation (MAD) method for selected elements, threshold values indicate anomalous concentrations in the laterites for S (>0.41%), Pb (>48 ppm), Cu (46 ppm), As (134.2 ppm), and Ag (>0.42 ppm) (Table 1). A contour diagram defined by the threshold values for Au using the MAD method reveal ellipsoidal anomalies that denote dispersion and accumulation of the pathfinder elements around the northeastern, central, and southeastern parts of Kunche in close proximity to the gold prospect in the area (Fig. 4a).

Multi-element mapping involving Pb+Cu+As+Ag (Fig. 4b) also resulted in ellipsoidal anomalies in the contour map similar to the Au anomaly distribution map. The multi-element contour map (Fig. 4b) appears to overlap with the Au anomaly distribution map (Fig. 4a). To confirm the anomalies and to understand whether the anomalies are significantly impacted by the lithology of the mafic host rocks, a multi-element ratio (Pb+As+Cu+Ag)/Zr contour diagram (Fig. 4c) was prepared using their raw concentrations. It is observed in this diagram that the anomalies are mainly restricted to the residual laterites with trace elemental ratios ranging from 1.2 to 2.6 hosted in meta-basaltic rocks (Fig. 4c). We therefore recommend that exploration programs for orogenic gold should be focused in the environment of the residual laterites than that of the transported laterites.

Table 1. Summary statistics of trace element concentrations of the lateritic samples (A.CC* – Average continental crust, Th: Threshold values)

Element	Fe*	S*	Mn	Ca	Ti	Rb	Sr	Zr	Y	Cr	Ni	Co	Cu	Pb	Zn	As	Au*	Ag
Detection limits	0.01	0	5	5	5	1	1	5	1	10	5	10	1	2	5	0.01	5	0
No. of samples	67	67	66	67	67	67	67	67	48	67	15	28	64	66	17	66	67	67
Mean	29.2	0.3	624.56	851.31	1846.4	18.5	16.81	160	5.4	479.8	72.3	919.25	50.3	37.8	45.4	75.1	63.2	0.3
Minimum	0.6	0.2	137	243	567	1.7	2.8	5.5	1	74	29	243	8	3.9	6	4.2	8	0
Maximum	59.7	0.7	4560	2749	3420	48.8	72	344	13	1704	167	2399	411	100	129	213	196	1
Median	28	0.3	399.5	781	1809	18.3	12.8	156	4.6	420	65	724.5	31	33	36	63.5	44	0.1
Standard Deviation	13.4	0.1	765.9	441.18	543.96	8.2	13.91	71.94	2.6	238	39.9	571.09	58.7	22.7	33.5	52.3	50.8	0.3
Sample Variance	180	0	586608	194637	295894	67	193.4	5174	6.7	56641	1595	326147	3450	514	1123	2735	2583	0.1
Skewness	0.25	0.4	4.29	2.05	0.39	1.02	2.3	0.22	1	2.46	1.55	1.04	4.19	0.65	1.17	0.65	1	1
Confidence (95.0%)	3.27	0	188.28	107.61	132.68	2	3.39	17.55	0.8	58.05	22.1	221.45	14.7	5.58	17.2	12.9	12.4	0.1
MAD	7.62	0.1											15	15		37.6	19.2	0.2
Th (median+2MAD)	43.2	0.4											46	48		134	82.5	0.4
A.CC**	4.32	0.1	716	38500	4010	78	333	203	24	126	56	24	25	14.8	65	1.7	2.5	7

*Fe, S are % and Au is ppm; Average Continental Crust** [5]

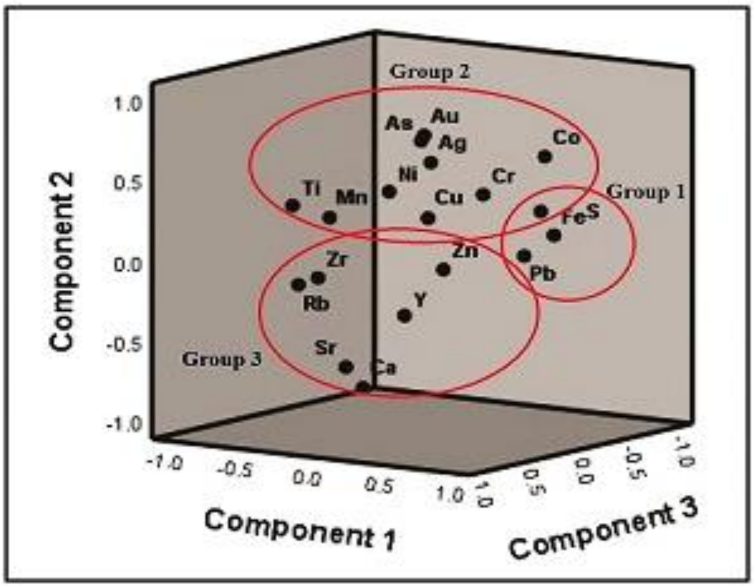

Figure 3. Dendrogram using average linkage (within groups) indicating three groups of clusters for the trace elements

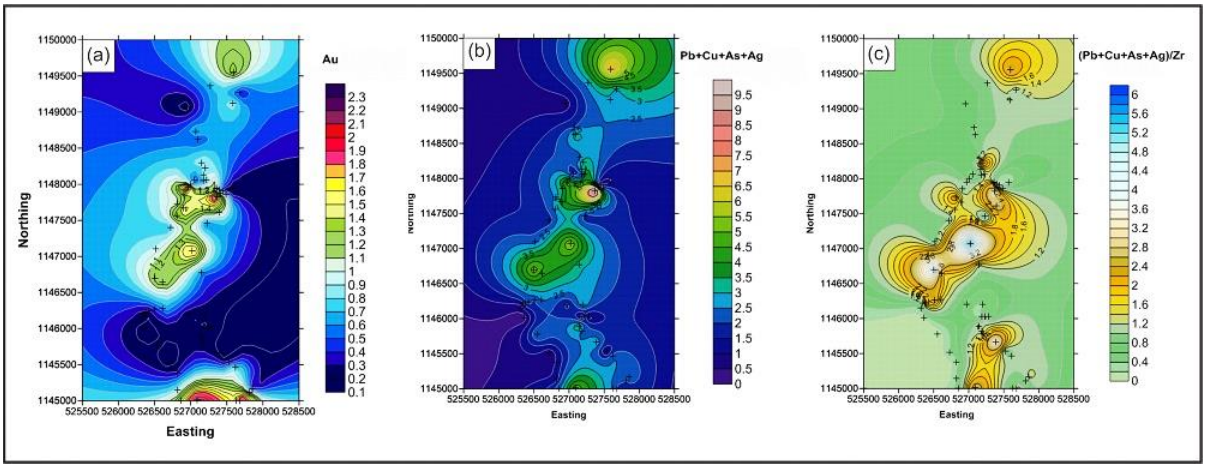

Figure 4. Prospective gold areas defined by single and multi-element mapping using the MAD method (a) Au anomaly distribution, (b) Pb+Cu+As+Ag, and (c) (Pb+Cu+As+Ag)/Zr. The ellipsoidal anomalies indicated with bold lines are the target areas proposed for exploration programs in Kunche

4. CONCLUSIONS

The studied laterites range from transported laterites (ferruginous duricrust) to residual laterites (lateritic duricrust). Geostatistical analysis indicate three element associations (Fe, S, Pb-Group 1; Mn, Cu, Co, Cr, Ni, Ti, As, Au, Ag-Group 2; Ca, Rb, Sr, Zr, Y, Zn-Group 3), which may be due to three factors; mainly the underlying volcanoclastic host rocks and sulphide-bearing deposits, mixed sources, and from wall rocks. The element associations imply that the occurrence of sulfide-bearing deposits such as gold in Kunche is directly associated with secondary dispersion of the underlying host rocks and laterization. The important pathfinder elements of gold identified in the laterites are Pb, Cu, As, and Ag since they correlate positively with Au but careful consideration should be given to S during exploration programs due to its high content in the laterites and positive correlation with Au. Geochemical anomalies are mainly restricted to areas dominated by the residual laterites (northeastern and central parts) on hills and plateaus, hence we recommend gold prospecting in those areas which are increasingly enriched in the pathfinder elements to minimize waste of resources.

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