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Research paper

Major oxide geochemistry of Okeigbo stream sediments in Akungba-Akoko, southwestern Nigeria: implications for chemical classification and provenance

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Abstract

In this paper, major oxide concentrations in Okeigbo stream sediments were used to chemically classify them and to determine their provenance. The study area lies in Akungba-Akoko area of Ondo State, southwestern Nigeria. Seventeen samples were collected and analyzed using Energy Dispersive X-ray Fluorescence Spectrometer. The major oxides analyzed in the samples are SiO_2, Al_2O_3, Fe_2O_3, TiO_2, K_2O, CaO, MnO and P_2O_5. The average concentration values of SiO_2, Al_2O_3 and Fe_2O_3 are 56.50 wt. %, 13.50 wt. % and 10.70 wt. %, respectively. On the other hand, the average concentration values of K_2O and CaO are 6.30 wt. % and 4.99 wt. %, respectively, while TiO_2, MnO and P_2O_5 have values < 1.00 wt. %. Okeigbo stream sediments are classified using the plot of log10(SiO_2/Al_2O_3) versus log10(Fe_2O_3/K_2O) to be 89.0% greywackes, 10.0% litharenites and 10.0% arkose. The average value of 4.28 for SiO_2/Al_2O_3 indicates that the sediments originated from majorly acid igneous source rock, while the average value of 1.73 for Fe_2O_3/K_2O is indicative of mineralogically stable sediments.

Keywords: *Akungba-Akoko; Geochemistry; Major Oxides; Okeigbo; Stream Sediments.*

1. Introduction

Stream sediments have been used in different parts of the world to study the geology, environmental geochemistry, mineral exploration, provenance of the sediments of an area [1-7]. Stream sediments serve as ultimate sinks for elements in aquatic setting. Stream sediments are employed almost exclusively for reconnaissance geochemical studies in drainage basins [8].
The study area is located in Okeigbo area of Akungba-Akoko, which is a town in Ondo State southwestern Nigeria (Fig. 1). The aim of this paper is to present the use of major oxide concentrations in stream sediments to chemically classify and decipher their provenance. The study area is situated within the tropical rainforest of southwestern Nigeria [9].

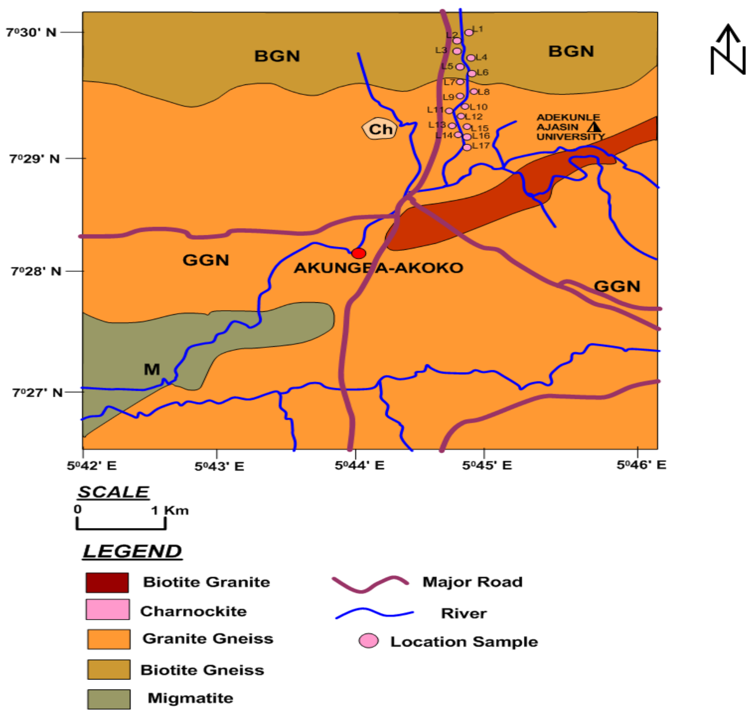

Fig. 1: Geological Map of Akungba-Akoko Showing Samples Locations (After Ogunyele et al. [10]).

1.1. Regional geology

The study area lies within the crystalline Basement Complex rocks of southwestern Nigeria [10-13]. The Nigerian Basement Complex is subdivided into six groups, namely: (1) migmatite gneiss quartzite complex, (2) meta-sedimentary schist belts, (3) older granite, (4) charnockitic or charnoclastic gabbroic and dioritic rocks, (5) metamorphosed and unmetamorphosed calc-alkaline volcanic and hyperbyssal rocks and lastly, (6) metamorphosed dolerite dykes, syenite dykes [11].
The migmatite gneiss quartzite complex occupy vast portion in Nigeria [11]. The constituent rocks of this complex are heterogeneous and made up mainly of migmatites, granitic gneisses, basic schists, gneisses and relict meta-sedimentary calcareous quartzitic and granulitic rocks. The rocks of this complex were further classed into three main groups [14] such as (a) migmatitic unit consisting largely of paleosomatic, banded para-gneisses, banded ironstones, ferruginous quartzite that have been mixed with quartzites, granites and aplites; (b) gneissic unit made of hornblende granites and augen gneisses, and (c) mafic unit made up of calcareous and biotite-plagioclase schists.
The second group, meta-sedimentary schist belts have lithologic similarities to schist belts from other parts of the world and they are host rocks to very importance economic mineral deposits [11].
On the other hand, the older granites, which are Pan-African in age [10-13], constitute around 40-50% of the Nigerian Basement Complex and >20% in southwestern Nigeria. Older granites refer to rocks such as tonalites, true granites, granodiorites and syenites [11].

2. Materials and methods

Seventeen samples were taken from Okeigbo stream sediments around Akungba-Akoko covering latitudes N07° 29' 10" and N07° 29' 39" and longitudes E05° 44' 13" and E05° 44’ 42" at mean elevation of 416m above the sea level. The samples were packed into labeled Kraft envelopes covered with polythene bags and transported to the laboratory for treatment and 60 µm size grains of the samples were analyzed for major oxide elements using X-ray fluorescence (XRF) spectrometer at NASENI EDMI Center of Excellence in Nanotechnology Laboratory in Akure, Nigeria.
Each sample was pulverized and then dried in an oven at 110°C for 24 hours to remove its moisture content and thereafter converted to beads for major elemental analysis expressed in oxide weight percent. Furthermore, 5 grams of each dried sample was weighed in the silica crucible and ignited in the furnace at 1,000°C for 2 to 3 hours to calcinate the impurities in each sample powder. Thereafter, each sample was taken out from the furnace and cooled to room temperature using desiccators. The ignited sample powders were weighed again to determine the weight of calcinated impurities such as H_2O^-, H_2O^+ and CO_2. Into 1 gram of each of the stored ignited sample powder was added 5 times of flux (x-ray flux-type) 66%:34% (66% lithium tetraborate: 34% lithium metaborate) to lower the vitrification temperature. The mixture was weighed and properly mixed in a Platinum dish and then placed in pre-set furnace (Eggon-2 automatic fuse bead maker) at 1,500^{0}C for 10 minutes to convert into a glass bead. Each glass bead produced was labeled and placed into the computerized XRF (Epsilon-5 pAnalytical model) to analyze the concentrations of the major oxides of elements in weight percentages. The X-ray fluorescence (XRF) spectrometer analysis was carried out in line with published standard procedure [15].

3. Result

The major oxide geochemical result is given in Table 1 and the bivariate plot of $Log_{10}(Fe_2O_3/ K_2O)$ on y-axis against $Log_{10}(Si_2O/Al_2O_3)$ on x-axis is shown on Fig. 2.

4. Discussion

In Table 1 the major oxides concentrations are as follows: SiO_2 (50.75 wt. % - 68.12 wt. %, average 57.26 wt. %), Al_2O_3 (10.36 wt. % - 15.96 wt. %, average 13.50 wt. %), Fe_2O_3 (3.96 wt. % - 14.20 wt. %, average 10.70 wt. %), TiO_2 (0 - 0.7 wt. %, average 0.26 wt. %), K_2O (4.45 wt. % - 8.85 wt. %, average 6.30 wt. %), CaO (1.08 wt. % - 8.70 wt. %, average 4.99 wt. %), MgO (0 wt. %), MnO (0.03 wt. % - 0.11 wt. %, average 0.07 wt. %), P_2O_5 (0.54 wt. % - 0.93 wt. %, average 0.73 wt. %). The calculated values of $Log_{10}(Fe_2O_3/K_2O)$ are -0.18 to 0.39, average 0.22, while $Log_{10}(Si_2O/Al_2O_3)$ values are 0.52 to 0.82, average 0.63. The plot of $log_{10}(SiO_2/Al_2O_3)$ versus $log_{10}(Fe_2O_3/K_2O)$ indicated that the sediments from the study area are 89.0% greywackes, 10.0% litharenites and 10.0% arkose. According to Amiewalan and Lucas [18],

SiO_2/Al_2O_3 ratio ~3.0 represents basic igneous rock;
SiO_2/Al_2O_3 ratio: ~5.0 represents acid igneous rock;
SiO_2/Al_2O_3 ratio: >5.0 means the sediments progressively matured.

In Table 1 and Fig. 2, SiO_2/Al_2O_3 ratios range from 3.31 to 6.54 with average of 4.33 and that indicated that the stream sediments came from mixed sources of basic to acid igneous rocks. Lastly, Fe_2O_3/K_2O ratios range from 0.66 to 2.43 with average of 1.73 indicative that the sediments are mineralogically stable.

5. Conclusion

The oldest basement rocks in the study area are the Precambrian migmatites, biotite gneisses, granite gneisses and the Pan-African charnockites and biotite granites. The average compositions of major oxides are as follows: SiO_2 (57.26 wt. %), Al_2O_3 (13.50 wt. %), Fe_2O_3 (10.70 wt. %), TiO_2 (0.26 wt. %), K_2O (6.30 wt. %), CaO (4.99 wt. %), MgO (0 wt. %), MnO (0.07 wt. %), P_2O_5 (0.73 wt. %). The average values of SiO_2 suggest the provenance of the stream sediments to be from basic igneous or metamorphic rocks. The plot of $Log_{10}(Fe_2O_3/K_2O)$ versus $Log_{10}(Si_2O/Al_2O_3)$ indicates that the sediments from the study area are 89.0% greywackes, 10.0% litharenites and 10.0% arkose. Moreover, SiO_2/Al_2O_3 ratios range of 3.31 to 6.54 with average of 4.33 indicates that the stream sediments came from mixed sources of basic to acid igneous rocks. The stream sediments indicated progressive maturity, although majority of the sediments are not matured. Lastly, the average value of Fe_2O_3/K_2O (1.73) indicates that the sediments are mineralogically stable.

Table 1: Major Oxide Geochemical Result (Values in Wt.%)

Oxide	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8	SL9	SL10	SL11	SL12	SL13	SL14	SL15	SL16	SL17	MIN.	MAX	MEAN
SiO_2	60.36	67.76	61.92	68.12	57.83	60.85	56.37	59.86	53.62	56.79	51.13	55.47	53.91	50.75	52.84	51.08	54.78	50.75	68.12	57.26
Al_2O_3	12.09	10.36	14.9	11.96	12.67	11.07	12.53	15.47	13	15.09	13.89	13.28	15.83	14.96	15.96	12.52	13.98	10.36	15.96	13.50
Fe_2O_3	11.94	6.75	9.15	3.96	8.43	7.74	12.05	14.2	9.71	11.35	13.35	12.35	11.55	12.17	12.1	13.73	11.39	3.96	14.2	10.70
TiO_2	0.28	0	0.06	0	0.34	0.7	0.19	0.35	0	0.19	0.27	0.41	0.18	0.45	0.32	0.63	0	0	0.7	0.26
K_2O	5.98	4.45	5.15	5.96	7.48	7.03	6.98	6.29	7.55	4.67	6.65	5.73	6.31	6.53	8.85	5.82	5.74	4.45	8.85	6.30
CaO	1.22	1.08	2.95	3.34	5.72	4.79	2.71	6.42	7.75	5.74	5.29	5.86	5.46	6.27	5.02	8.7	6.46	1.08	8.7	4.99
MgO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
MnO	0.05	0.05	0.05	0.03	0.05	0.03	0.06	0.09	0.07	0.08	0.09	0.08	0.07	0.06	0.09	0.11	0.09	0.03	0.11	0.07
P_2O_5	0.75	0.85	0.54	0.62	0.73	0.79	0.93	0.69	0.85	0.59	0.8	0.6	0.66	0.8	0.77	0.76	0.72	0.54	0.93	0.73
Fe_2O_3/K_2O	2.00	1.52	1.78	0.66	1.13	1.10	1.73	2.26	1.29	2.43	2.01	2.16	1.83	1.86	1.37	2.36	1.98	0.66	2.43	1.73
Si_2O/Al_2O_3	4.99	6.54	4.16	5.70	4.56	5.50	4.50	3.87	4.12	3.76	3.68	4.18	3.41	3.39	3.31	4.08	3.92	3.31	6.54	4.33
$Log_{10}(Fe_2O_3/K_2O)$	0.30	0.18	0.25	-0.18	0.05	0.04	0.24	0.35	0.11	0.39	0.30	0.33	0.26	0.27	0.14	0.37	0.30	-0.18	0.39	0.22
$Log_{10}(Si_2O/Al_2O_3)$	0.70	0.82	0.62	0.76	0.66	0.74	0.65	0.59	0.62	0.58	0.57	0.62	0.53	0.53	0.52	0.61	0.59	0.52	0.82	0.63

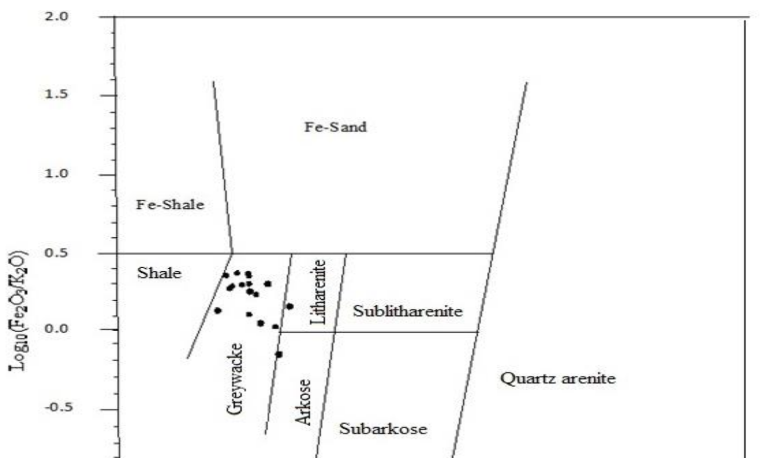

Fig. 2: Plot of log (SiO_2/Al_2O_3) Versus Log (Fe_2O_3/K_2O) (After [16-17]).

6. Conflicts of interest

The authors declare that there is no any conflict of interest in the execution of the research and its publication.

References

[1] E. Sababa, C.O. Mbesse, W. Mouko, C. Nelly, A.Z. Ekoa Bessa, P. Ndjigui, Geochemistry of stream sediments from Eséka area (SW Cameroon): implication for surface process assessment and precious metals (Au, Pd and Pt) exploration, Journal of Sedimentary Environments 7(1) (2022) 43-66. https://doi.org/10.1007/s43217-021-00082-3.

[2] F. Yang, M. Kong, S. Xie, L. Nie, Y. Song, C. Wang, E.J.M. Carranza, Q. Wang, Z. Guo, The relationship between particle size and element distribution in stream sediments from Donyuan W-Mo deposit, Eastern China, Mineral 12(431) (2022) 1-20. https://doi.org/10.3390/min12040431.

[3] D.J. Lapworth, K.V. Knights, R.M. Key, C.C. Johnson, E. Ayoade, M.A. Adekanmi, T,M. Arisekola, O.A. Okunola, B. Backman, M. Eklund, P.A. Everett, R.T. Lister, J. Ridgway, M.J. Watts, S.J. Kemp, P.E.J. Pitfield, Geochemical mapping using stream sediments in west-central Nigeria: implications for environmental studies and mineral exploration in West Africa, Applied Geochemistry – Elsevier 27 (2012) 1035-1052. https://doi.org/10.1016/j.apgeochem.2012.02.023..

[4] Y. Li, Q. Hou, Y. Xiao, Geochemical compositions and detrital minerals of stream sediments around the Zijinshan Copper-Gold orefield and their implications, Mineral 12(32) (2022) 1-19. https://doi.org/10.3390/min12010032..

[5] N.M. Waziri, Environmental geochemistry of soils and stream sediments from the Birnin-Gwarri artisanal gold mining area, northwestern Nigeria, Universal Journal of Geoscience 2(1) (2014) 18-27. https://doi.org/10.13189/ujg.2014.020103.

[6] S.O. Obaje, A.O. Pirisola, Geochemical characterization of Egbetua stream sediments, southwestern Nigeria: implication for provenance and depositional conditions, British Journal of Earth Sciences Research 11(1) (2023) 17-30. https://doi.org/10.37745/bjesr.2013/vol11n11730..

[7] S.O. Obaje, A.A. Adefemisoye, Geochemical characterization of Lokoja-Basange Sandstone at Imiegba and Okpekpe areas, Benin flank of Anambra basin, Nigeria: implications for provenance, tectonic setting and source-rock weathering, International Journal of Advanced Geosciences 12(1) (2024) 1-6. https://doi.org/10.14419/gcmec839..

[8] H.E. Hawkes, The downstream dilution of stream sediment anomalies: exploration, Journal of Geochemical Exploration 6 (1976) 345-358. https://doi.org/10.1016/0375-6742(76)90023-6.

[9] A.D. Olabode, Awareness of climatic variation through indigenous knowledge in Akungba-Akoko, Ondo State, Nigeria, Journal of Earth Sciences and Climate Change, S11 (2014) 004. https://doi.org/10.4172/2157-7617.S11-004..

[10] A.C. Ogunyele, O.A. Oluwajana, I.Q. Ehinola, B.E. Ameh, T.A. Salaudeen, Petrochemistry and Petrogenesis of the Precambrian Basement Complex rocks around Akungba-Akoko, southwestern Nigeria, Mat Geoenv. 66(3) (2019) 173-184. https://doi.org/10.2478/rmzmag-2019-0036..

[11] M.A. Rahaman, Review of the basement geology of southwestern Nigeria, In: C.A. Kogbe (ed.) Geology of Nigeria. Elizabethan Publishers, Lagos 1976; 41-58.

[12] C.A. Ogunyele, S.O. Obaje, A.S. Akingboye, A.O. Adeola, A.O. Babalola, A.T. Olufunmilayo, Petrography and geochemistry of Neoproterozoic charnockite-granite association and metasedimentary rocks around Okpella, southwestern Nigeria, Arabian Journal of Geosciences 13(16) (2020) 1-22. https://doi.org/10.1007/s12517-020-05785-x.

[13] A.C. Ogunyele, S.O. Obaje, A.S. Akingboye, Lithostructural relationships and petrogenetic affinities of the Basement Complex rocks around Okpella, southwestern Nigeria, Earth Science Malaysia 2(1) (2018) 29-36. https://doi.org/10.26480/esmy.01.2018.29.36.

[14] I.A. Odeyemi, Review of the orogenic events in the Precambrian basement of Nigeria, West Africa, Geologische Rundschau 70 (1982) 897-909. https://doi.org/10.1007/BF01820170.

[15] R. Fonda, B. Collins, The cathode ray tube in x-ray spectroscopy and quantitative analysis, Journal of the American Chemical Society 53(1) (1931) 113-125. https://doi.org/10.1021/ja01352a017.

[16] M.M. Herron, Geochemical classification of terrigenous sand and shales from core or log data, Journal of Sedimentary Petrology 58(5) (1998) 820-829.

[17] D.A. Lindsey, An evaluation of alternative chemical classification of sandstones, United State Geological Survey Open File Report 1999; 99-346. https://doi.org/10.3133/ofr99346.

[18] F.O. Amiewalan, F.A. Lucas, Geochemical characterization of FE-1 well, Onshore Western Niger Delta Basin Nigeria. Journal of Applied Science and Environmental Management 24(2) (2020) 381-391. https://doi.org/10.4314/jasem.v24i2.26.