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GEOCHEMISTRY OF SLATES AND SEMI-PELITIC SCHISTS FROM KORIGA AREA, N. W. NIGERIA AND JEBBA AREA, S. W. NIGERIA

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ABSTRACT

In the Koriga area, of northwestern Nigeria and in Jebba area of southwestern Nigeria, slates and semi-pelitic schists, are intercalated with other basement rocks. Geochemical analyses of these slates and schists suggest their protoliths were derived from source rocks of granitic composition and that they are compositionally similar to the average Post-Archaean shale but differ from the Archaean mudstone in several respects.

Several geochemical indices of sediment maturity indicate that the Koriga slates were derived from the most intensely weathered source rocks compared to the less "mature" Jebba semi-pelitic schists derived from less weathered source rocks. The "mature" Koriga slates are characteristic of stable cratonic environments unlike the generally "immature" Jebba schists which were probably associated with tectonically active setting.

KEYWORDS: geochemistry, slates, semi-pelitic schists, sediment maturity, provenance.

INTRODUCTION

The geochemistry of fine-grained clastic semi-pelitic rocks from parts of the Nigerian basement complex in terms of sediment maturity (source rock weathering), source rock types and tectonic environment.

Sedimentary rocks (slates and mudstones) is determined mainly by source rocks and degree of chemical weathering (sediment maturity) which are also dependent on the tectonic setting of the sedimentary basin (Bhatia and Taylor, 1981; Cox and Lowe, 1995; McLennan *et al.,* 1995). Other factors may include sorting of the weathered detritus and any post-depositional alteration during diagenesis and metamorphism of their metamorphic equivalents.

Geochemistry is the best index of compositional differences between pelitic rocks because clay minerals recrystallise very readily during diagenesis and metamorphism. These processes are largely isochemical except for the loss of volatiles (Shaw,1954; Holland and Winchester, 1993). The aim of this paper is to investigate the chemical compositions of pelitic and semi- pelitic rocks form parts of the Nigerian basement complex in terms of sediment maturity (source rock weathering), source rock types and tectonic environment.

GEOLOGY OF THE STUDY AREAS

Koriga Area, northwestern Nigeria

Koriga area forms part of the Kushaka Schist belt located, in northwestern Nigeria (Figs. 1 and 2). The Kushaka Schist Formation (Truswell and Cope, 1963) comprises slates, phyllites, mica schists, amphibolites and iron-rich rocks. The iron-rich rocks have been assigned to the Koriga Iron Formation consisting mainly of biotite, plagioclase and quartz with little or no muscovite. Accessory minerals include magnetite, (Okonkwo, 1991) or to the silicate facies member of the Birnin Gwari Iron Formation (Adekoya,1993). The schists are intercalated with gneisses and migmatites which all together have been intruded by Pan-African granitic rocks dated ca. 600 Ma (Truswell and Cope, 1963; Grant, 1978; Turner, 1983). Grant (1978) has recognised four generations of ductile

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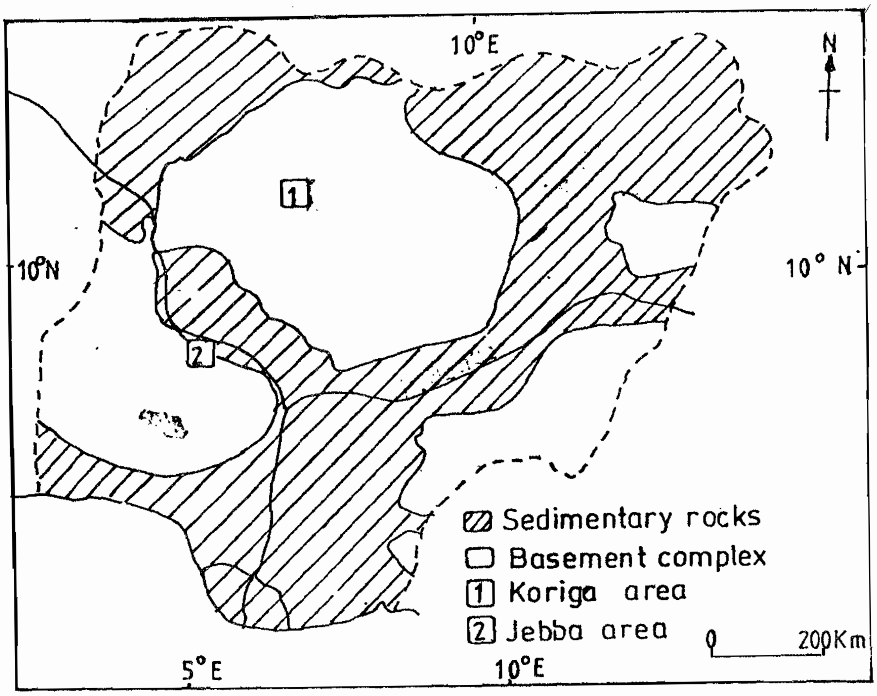

Fig. 1. Simplified geological map of Nigeria showing the Koriga and Jebba areas.

structures followed by late transcurrent faulting of the rocks of the area. Petrographically, the slates of Koriga area are fine-grained, silvery grey rocks consisting of sericitic mica, quartz and chlorite with accessory graphite. The modal compositions of the rocks are presented in Table1.

Jebba area, southwestern Nigeria

Jebba area forms part of the northern margin of the southwestern sector of the Nigerian basement complex (Figs. 1 and 3). The area comprises metasedimentary and metaigneous rocks which have been subjected to polyphase deformation and intruded by late-tectonic granitic rocks of probable Pan-African age (Okonkwo, 1992). In the eastern part of the area, locally migmatitic gneisses crop out which are intercalated with bands of quartzite 20 to 50m thick. These gneisses are bound in the west by a sequence of metagreywackes which locally display relict grading with quartzo-feldspathic bottoms and biotite-rich tops. Concordant to slightly discordant amphibolite bands occur within the metagreywackes.

A thick, locally micaceous quartzite sequence forms a series of north-south trending ridges west of Jebba (Fig. 3) and is bounded in the west by quartz-biotite-muscovite schists east of Oke Awon. A small body of granitic gneiss is intercalated between the metagreywackes and the migmatitic gneiss.

The semi-pelitic schists associated with the metagreywackes and the gneiss of Jebba area are medium-grained rocks sphene, apatite, chlorite and zircon. The schists of Oke Awon contain muscovite, biotite and quartz with minor garnet and plagioclase. Accessory minerals include chlorite, sericite and magnetite. Modal compositions of these rocks are given in Table 1.

GEOCHEMISTRY

Seven samples comprising two slates from Koriga area, two schists from Oke Awon area and three schists from Jebba area were analysed for major and trace elements at Keele University, England using an ARL 8420 X-ray spectrometer calibrated against both international and internal Keele standards of appropriate compositions.

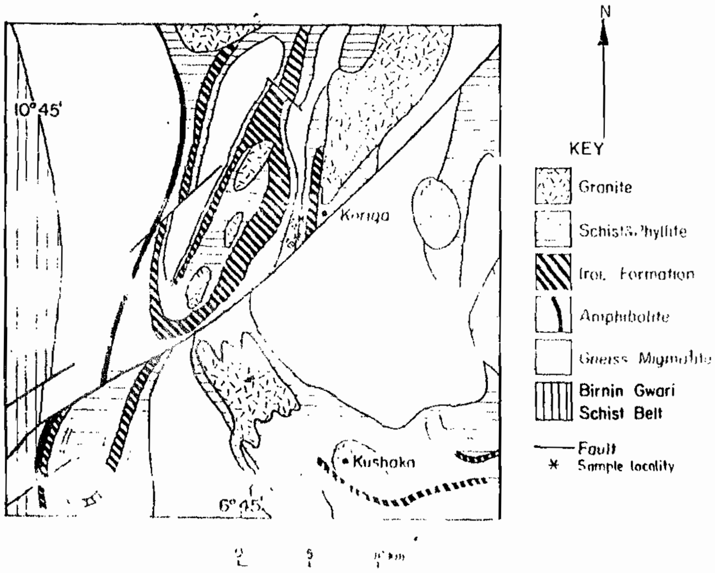

Fig. 2. Geological map of Koriga area (after Turner, 1983). x- sample locations

Major Elements

The major element compositions of the various pelitic and semi-pelitic rocks are given in Table 2. The relatively high Fe_2O_3 contents of the biotite schists associated with the gneisses and metagreywackes is a reflection of their dominant biotite content, also sample 923 contains a significant amount of magnetite. This rock is also characterised by a relatively high content of MgO suggesting some contribution from basic rocks. They are also marked by very low values of MgO and CaO along with the biotite-muscovite schists of Oke Awon area which are also typified by very low Na_2O contents. These low values of CaO and Na_2O indicate low plagioclase content of these rocks. The relatively high SiO_2 contents of the schists from Jebba area are a reflection of their high quartz contents (Table 1).

Trace Elements

The trace element concentrations of the various rocks are given in Table 2. The rocks are characterised by low values of compatible trace elements (Cr, Ni, Cu) and average to relatively high values of incompatible trace elements (Rb, Th, Zr, Ba and La). Exceptionally low Sr, V and high Ba contents mark the biotite muscovite schists of Oke Awon area. The very low Sr corresponds with the CaO contents of these rocks. Also their low V correlates with their low MgO contents. (Table 2).

Provenance

Immobile trace elements are important for provenance determination in pelitic rocks (Cullers *et al.*, 1975; Taylor and McLennan, 1985) because immobile trace element concentrations often reflect those of the source rocks. Such elements include the rare-earth elements, and the high field strength elements including

Table 1. Modal analyses of the slates and semi-pelitic schists

	892	923	TP1	AW1	AW2	1A	1B
Quartz	26	25	32	35	34	25	24
Plagioclase	28	26	25	6	7	5	5
Biotite	45	45	22	24	25	-	-
Muscovite	tr	-	20	30	29	-	-
Garnet	-	-	-	5	4	-	-
Sericite	tr	tr	tr	tr	tr	44	45
Chlorite	tr	tr	tr	tr	tr	25	25
Apatite	0.5	tr	tr	tr	tr	tr	tr
Magnetite	0.5	3	tr	tr	tr	tr	tr
Sphene	tr	1	tr	tr	tr	-	-
Zircon	tr	tr	tr	tr	tr	tr	tr
Epidote	tr	tr	tr	tr	tr	-	-
Graphite	-	-	-	-	-	1	1

1A, 1B - Koriga slates; 892, 923, TP1 - Jebba schists; Aw1, AW2 - Oke Awon schists; tr - trace.

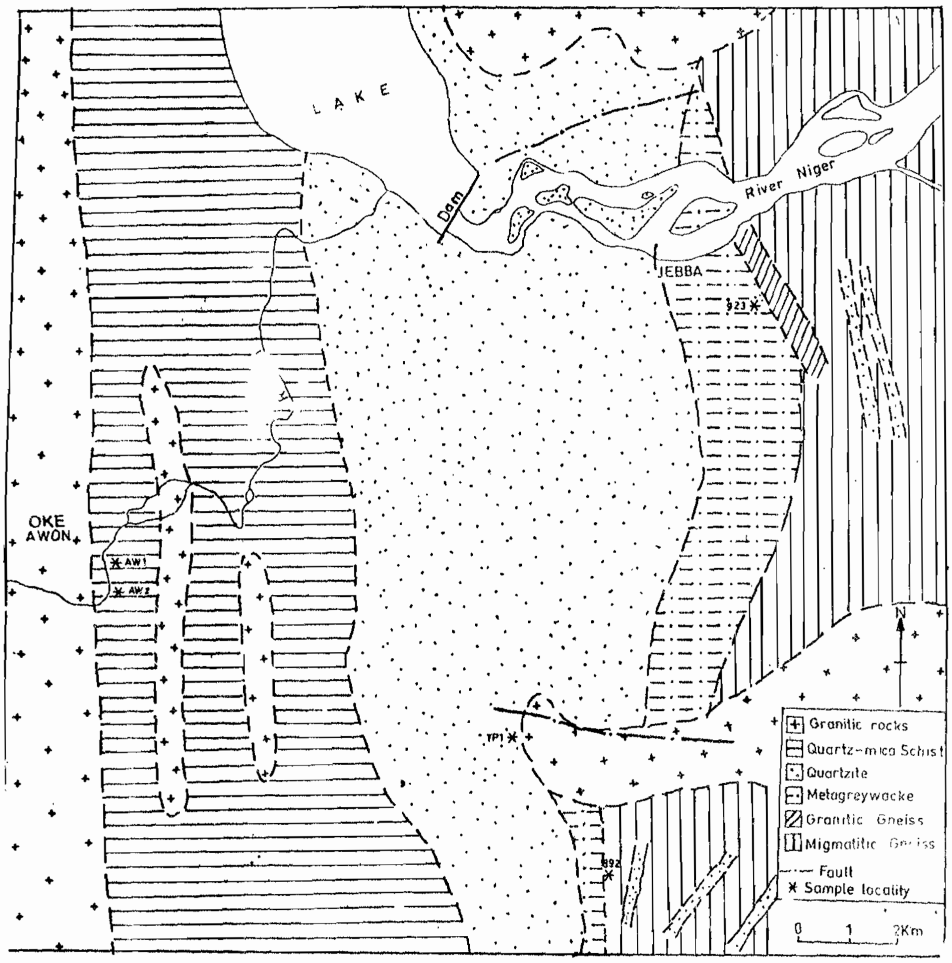

Fig. 3. Geological map of Jebba area. x - sample locations

Th. The relatively high contents of Th and La in the biotite schists of Jebba area and in the slates of Koriga area suggest their derivation from source rocks of granitic composition.

Compared with the average Archaean mudstone (Table 2) the schists of Jebba area and the slates of Koriga area posses lower values of MgO, Cr, Cu and Ni, and higher values of K_2O, Nb, Rb, Th, Y, Zr and Ba. On the other hand, these rocks are compositionally similar to the average Post-Archaen shale (Table2) except for their low contents of Cr and Ni.

Source Rock Weathering and Sediment Maturity

Since upper crustal rocks consists predominantly of plagioclase, K-feldspar and quartz (Nesbitt and Young, 1982), the effect of chemical weathering is the breakdown of the feldspars to clay minerals coupled with the removal of Ca, Na and K in solution. Nesbitt and Young (1982) proposed a Chemical Index of Alteration (CIA) defined as:

CIA = $Al_2O_3 / (Al_2O_3 + CaO + Na_2O + K_2O)$ x 100 (using molecular proportions and CaO residing in the silicate minerals only). This index thus allows the degree of chemical weathering of source rocks to be compared.

The results obtained from the analyses of the rocks (Table 2) show that the source rocks of the slates of Koriga area were most intensely weathered and therefore they were the most "mature" with CIA values of 76.74 and 77.05, followed by the schists of Oke Awon area with 68.00 and 69.00 and then the other schists of Jebba area with values ranging from 47.19 to 54.55 (Table 2).

Different proportions of alumina

Table 2. Chemical composition of the slates and semi -pelitic schists and average Post-Archaean shale and Archaean mudstone

	892	923	TP1	AW1	AW2	1A	1B	**PAS	**AM
SiO_2	60.01	54.18	76.90	76.87	76.87	60.86	63.94	62.8	60.4
TiO_2	1.33	1.91	0.39	0.26	0.27	0.87	0.72	1.0	0.8
$A1_2O_3$	15.98	14.56	11.05	12.11	12.00	24.05	22.62	18.9	17.1
Fe_2O_3*	9.53	13.20	2.60	4.23	4.69	4.08	3.28	6.5	9.5
MnO	0.15	0.13	0.01	0.02	0.05	0.02	0.01	0.1	0.1
MgO	2.84	4.16	2.10	0.34	0.37	0.41	0.35	2.2	4.3
CaO	2.56	3.58	0.54	0.21	0.21	0.20	0.20	1.3	3.2
NaO	3.92	3.03	3.42	0.06	0.05	1.84	1.67	1.2	2.1
K_2O	3.34	4.41	2.49	4.76	4.49	3.38	3.42	3.7	2.3
P_2O_5	0.35	0.79	0.17	0.20	0.20	0.02	0.01	0.2	-
LOI	0.50	0.29	0.50	1.28	1.23	4.28	3.78	-	-
Total	100.49	100.24	100.17	100.36	100.43	100.01	100.00	99.90	99.80
Cr	3	0	55	11	9	88	69	110	205
Cu	18	14	2	3	3	8	6	50	150
Ga	25	23	12	19	18	22	22	20	15
Nb	34	18	10	21	20	15	13	19	9
Ni	11	21	11	2	1	9	44	55	100
Pb	18	19	7	15	14	25	18	20	20
Rb	174	148	103	182	176	141	141	160	60
Sr	195	239	109	23	28	127	107	200	180
Th	51	7	9	17	17	14	14	15	6
V	92	225	49	17	20	125	115	150	135
Y	67	50	22	66	69	15	11	27	18
Zn	139	101	16	30	27	30	30	85	-
Ba	781	1184	504	1172	1298	547	593	650	575
Zr	336	292	274	182	179	164	151	210	120
La	393	56	14	30	23	n. d.	n. d.	n. d.	20
CIA	52.16	47.19	54.55	68.00	69.01	77.05	76.74	-	-
ICV	1.48	2.09	1.05	0.82	0.84	0.45	0.43	-	-

* - Total iron as Fe_2O_3; LOI - Loss on ignition.
* - Composition on volatile-free basis
CIA - Chemical index of alteration
ICV - Index of compositional variability.
1A, 1B - Koriga slates; 892, 923, TPI - Jebba Schists; AW1, AW2 - Oke Awon schists; PAS - Post-Archaean shale; AM - Archaean mudstone (both from Taylor and McLennan, 1985)

characterise clay minerals and non-sillicate minerals, and Cox *et al.*(1995) have defined an Index of Compositional Variability, (ICV) = $(Fe_2O_3 + K_2O + Na_2O + CaO + MgO + MnO + TiO_2)/A1_2O_3$ (wt%). This index measures the abundance of alumina relative to other major constituents of the rock except SiO_2. Compositionally immature pelitic rocks that contain a high proportion of non-clay silicate minerals or those that have high contents of such clay minerals as montmorillonite and sericite will have high ICV values whereas compositionally mature pelitic rocks with very little non-silicates or rich in kaolinite group clay minerals will possess low ICV values.

Results (Table 2) show that the slates of Koriga area have the lowest ICV values (mean = 0.44) followed by the schists of Oke Awon (mean = 0.83) and then the other schists of Jebba area with values ranging from 1.04 to 2.09. These results are in agreement with the CIA values and also indicate that the slates

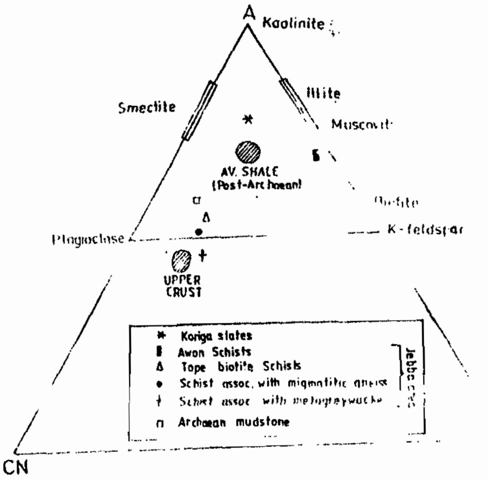

Fig. 4. Ternary plot of molecular proportions Al_2O_3(A) - $CaO+Na_2O$(CN) - K_2O(K) for the slates and semi-pelitic schists (after McLennan *et al.*, 1995). Upper crust composition and average Post-Archaean shale from Taylor and McLennan (1985)

of Koriga area were compositionally mature mudrocks composed dominantly of kaolinite-type clay minerals (Cox *et al.*, 1995). Increasing weathering tends to produce cation-poor kaolinite clays (Barshad, 1966; Weaver, 1989) at the expense of non-clay detrital minerals as well as clays with complex chemical composition such as smectites, chlorites and mixed-layer clays. This is also consistent with the low cation contents of the Koriga slates.

On a ternary plot of molecular proportions ($A1_2O_3$ (A) -$CaO+Na_2O$ (CN) - K_2O (K) for the various rocks (Fig.4), the Koriga slates plot on a trend half-way between average Post-Archaen shale and kaolinite indicating an intense weathering history for the source rocks, Oke Awon schists plot close to the ideal muscovite due to their relatively high K contents as well as the strong weathering history of their source rocks while the other schists of Jebba area plot generally close to the upper crust due to the limited weathering of their source rocks.

DISCUSSION AND CONCLUSIONS

Immature pelitic rocks are generally associated with tectonically active settings and are likely to be first-cycle deposits (Van de Kamp and Leake, 1985). On the other hand, mature pelitic rocks are characteristic of stable, cratonic environments (Weaver, 1989) which are marked by sediment recycling but they may also be produced by very intense chemical weathering of first-cycle material (Barshad, 1966).

Recent studies (Okonkwo and Winchester, 1996) show that the amphibolites intercalated with the metasedimentary rocks of Jebba area were emplaced during a period of crustal extension associated with an intracratonic basin in which immature greywackes derived from rapidly uplifted basement blocks of granitic or quartzo-feldspathic composition were deposited. On the other hand, the very mature slates of Koriga area were probably mudrocks derived from very intense/chemical weathering of granitic rocks in a stable, cratonic environment.

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