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GEOCHEMISTRY OF SEMIPELITIC SCHIST OF ISANLU AREA, SOUTH WEST NIGERIA: IMPLICATION FOR THE GEODYNAMIC EVOLUTION OF THE EGBE-ISANLU SCHIST BELT

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ABSTRACT

Field and geochemical studies carried out on the semipelitic quartz-mica schist of Isanlu area, SW Nigeria have been used to speculate on the geodynamic activity prevalent in the Egbe-Isanlu palaeobasin at the time its sediment was deposited.

Basement rock exposures in the Egbe-Isanlu schist belt are dominated by metasedimentary rocks, chiefly, quartz-mica schist with small occurrences of quartzite, marble and silicate facies iron-formation. These metasedimentary rocks are interbanded with metaigneous rocks such as talc schist and amphibolite, all of which are intruded in places by granitoids.

Chemical data on major and trace elements of the sheared and unsheared varieties of quartz – mica schist from the Isanlu area, reveal a composition comparable to that of semipelitic metasediment. However, the sheared variety shows elevated values of Na_2O, MnO and Nb, and depleted mean values of FeO and MgO relative to the composition of normal metasediments. This enrichment – depletion signature is probably a consequence of the movement of metamorphic remobilised fluids along these shear zones during the Pan-African or earlier events. A further geochemical characterisation of the rock indicates that its protolith was an immature sub-greywacke to greywacke-type sediment derived from a predominantly granitic provenance. This immature nature of the protolith sediment suggests rapid subsidence of the basin during its genesis, and/or tectonic instability in the surrounding environment from which the sediment was derived. Nonetheless, field observations indicate the absence of typical deep-water sediments and a lack of regional proximal-distal facies variation suggesting a limited depth and width for the basin The presence of shallow, stable shelf-type sediments such as carbonates and iron-formation (some of which contain carbonaceous material) suggests a change in tectonic regime at some point in the evolution of the basin from a rapidly sinking, to a stable shallow basin.

KEY WORDS: Geochemical studies, Semipelitic schist, Geodynamic activities, Rapidly sinking basin

INTRODUCTION

In terrains of polyphase deformation and metamorphism, the study of the structural relationships and styles as well as rock compositions involving their major, trace and rare earth elements have been used as aids in interpreting ancient tectonic environments (Chikhaouri et al., 1980). In the Nigerian basement complex such integrated studies are not widespread, consequently, views diverge considerably on the evolution of the Nigerian basement complex.

Metasedimentary schist belts constitute prominent geologic features in the Nigerian basement complex (Ajibade et al., 1987). These belts make important hosts to metallic and industrial mineralisation and their geology has

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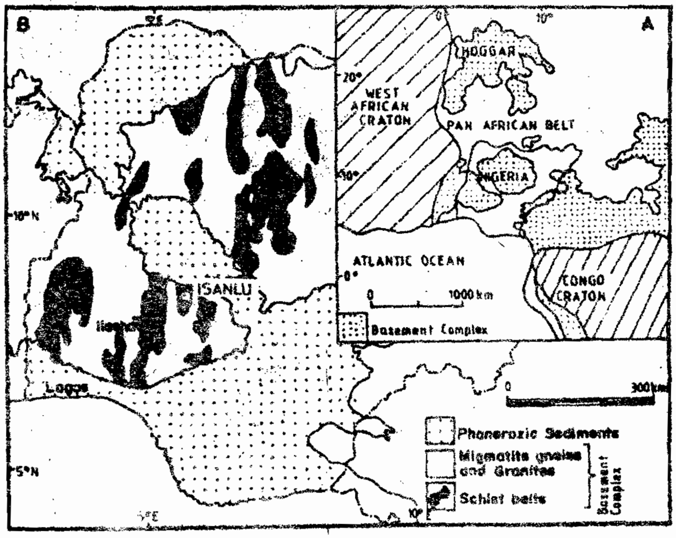

Fig 1: Map of Nigeria showing the location of Isanlu in the Egbe-Isanlu schist belt. Inset: Map showing the location of the Nigerian basement within a Pan-African mobile belt (after Annor et al., 1996)

been compared to that of classical Archaean greenstone belts (Wright and McCurry, 1970; Hubbard, 1975). In most cases the direct parental sources of the dominant metasediment is not readily detectable hence issues such as the geotectonic evolution of the basins and the prevailing conditions under which its sediments were laid down can only be gleaned by indirect fingerprinting. Since a good knowledge of the evolution of the schist belts is crucial to a proper understanding of the evolution of the Nigerian basement complex, several workers have used the chemical composition of the constituent metabasites to define the tectonic environments of the belts (Olade and Elueze, 1979; Rahaman et al., 1988; Utke, 1987; Bafor, 1988; Holt, 1982; Oyinloye and Odeyemi, 2001). Although the chemistry of basaltic and granitic rocks have been widely advocated as discriminant tools for tectonic environments (e.g. Pearce and Cann, 1973; Pearce et al., 1977; Wood, 1980; Mullen, 1983; Meschede, 1986), they often fail to give conclusive results and their applications have been shown to imply incorrect tectonic setting in several provinces (Holm, 1982; Duncan, 1987). In an environment of multiple deformation and metamorphism such as the Nigerian basement complex, extensive rock-fluid interaction during metamorphism and/or crust-magma interaction during magma ascent can lead to significant alteration in element ratios and hence a distortion in inferences that could be made from such studies. On the other hand, sediments if carefully studied provide clues to the environment in which they form and it is often possible to relate the types of sediment in a sedimentary basin to adjacent orogenic activities (Spencer, 1977). Therefore, definitive conclusions and models regarding the tectonic evolution of the Nigerian schist belts must use the sedimentological and/or geochemical nature of the associated sediments as important constraints.

In this paper, the petrographic and chemical characteristics of metasedimentary quartz mica schist that constitutes the dominant lithology of the Egbe-Isanlu schist belt is presented. These with the observed field characteristics are used to speculate the nature of geodynamic activity prevalent during the genesis of the basin and the deposition of its sediment.

REGIONAL GEOLOGICAL SETTING

The Egbe-Isanlu schist belt is one of the many schist belts of the Nigerian basement complex (Fig. 1). The basement complex itself consists of a floor of migmatites and gneisses (Russ, 1957; Odeyemi, 1988) into which is infolded N-S trending metasedimentary belts, consisting of a sequence of interlayered metaigneous and metasedimentary units (McCurry, 1976; Rahaman, 1976). Both basement and supracrustals have suffered polyphase deformation and are intruded in places by Pan-African granitoids (Holt et al,. 1978).

The schist belts predominantly occupy the western part of the Nigerian basement. They consist of metaclastics, which vary from pelite to semipelites to greywacke and quartzites, metacarbonates, plus mafic-ultramafic and granitic bodies (Elueze, 1992). Metamorphic grade within the belts varies from greenschist to amphibolite facies (Ajibade et al., 1987). Although the stratigraphy of the belts is broadly similar, there are differences in fine details. Consequently, some workers have proposed that the belts represent several disconnected basins (Rahaman 1976; Grant, 1978), which probably evolved at two different periods of geologic history (Grant, 1978). Others have argued that the metasediments represent relicts of a single supracrustal cover infolded into the gneiss and now disjointed by erosion (McCurry, 1976; Oyawoye, 1972). It has also been proposed that lithological differences between the belts probably reflect lateral volcanic and facies changes within a complex volcano-sedimentary basin (Fitches et al. 1985). Subsequent field investigations reveal the presence of relict schists in inter-belt rocks. This indicates that the present belt margins do not represent the original basin margins (Ajibade et al., 1987) even if the belts were deposited in different basins.

Most of the postulated models have recognised that the belts formed in response to plate-tectonic activity at the margins of the West-African craton and the Togo-Nigerian-Benin Shield in the Neoproterozoic. Holt (1982) and Turner (1983) considered that the schist belts might have been developed after the onset of subduction at the cratonic margin of the West African craton and the Togo-Nigerian shield. The possibility that the schist belts may represent additional microcontinents has been suggested (McCurry and Wright, 1977; Turner, 1983) although no typical Wilson cycle signatures have been identified in any of these belts (Ajibade et al., 1987). An alternative view has suggested an ensialic model for the genesis of the basins during the Pan-African event (Olade and Elueze, 1979) or that the belts were formed in pre-Pan-African times and reactivated during the Pan-African orogeny (Olobaniyi, 1997).

FIELD OCCURRENCE

Rock exposures of the Egbe-Isanlu schist belt (Fig. 2) are dominated by quartz-mica schist with minor occurrences of quartzite, metacarbonate and silicate facies iron formation. This metasedimentary sequence is interbanded

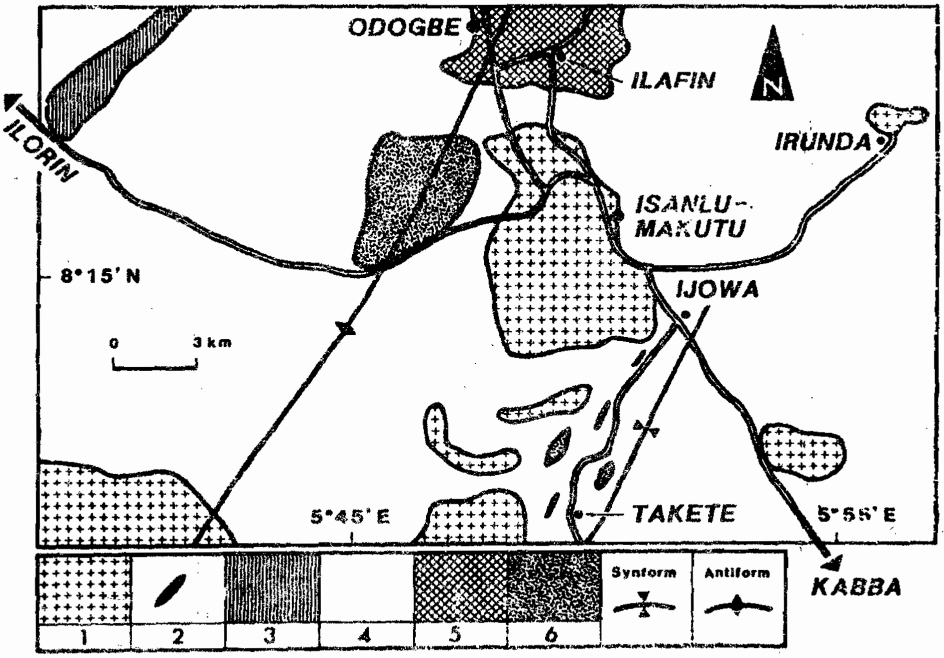

Figure 2. Geological map of the southern portion of Isanlu area. 1: granite; 2: iron-formation; 3: amphibolite; 4: quartz-mica schist; 5: talc schist; 6: quartzite

with metaigneous rocks such as talc schists and amphibolites, all of which are intruded in places by Pan-African granitoids. Both metasediment and metaigneous rocks are metamorphosed in the upper greenschist - amphibolite facies conditions, and they also share a common planar fabric although minor contact discordances sometimes occur. This suggests that the metaigneous members are probably contemporaneous sills and dykes within the original sediments of the area.

Although quartz-mica schist is the most extensive rock type in the area, it is the least exposed due to its high susceptibility to weathering. It generally occurs as low-lying outcrops or small isolated hills in the extensive peneplain of the area. Occasionally however, it forms extensive high-rising ridges. The rock is broadly homogeneous in composition with only local gradation to graphite-bearing quartzite and phyllitic schist. Locally, the rock becomes gneissic partly due to feldspathisation but more apparently due to increase in metamorphic grade in areas that have experienced intense strain. Quartz-mica schist contacts with other rocks are usually sharp and well defined. However, at the contacts with the main granite bodies, large-scale feldspathisation leads to a marginal granitisation (migmatisation) of the schist thus obscuring the cross-cutting contact with the intrusive granite.

Apart from the local occurrences of quartzite and phyllite mentioned above, no major textural or proximal-distal variations were recorded within the metasediment. Conglomerates and typical deep-water sediments have not been found in the study area

PETROGRAPHY

Quartz-mica schist is medium to fine grained and has a slaty to dark grey colour. The rock is made of quartz (5-65 vol.%) and biotite (10-65 vol.%) mainly. Other minerals that may occur in the rock include muscovite (0-3 vol.%), plagioclase (1-10 vol.%), microcline (2-5 vol.%) and almandine garnet (0-3 vol.%). Accessory minerals like epidote, zircon and sericite are common.

The groundmass is a matrix of interlocking grains of quartz and plagioclase mainly, with subordinate amounts of microcline. Biotite and muscovite exhibit preferred orientation clearly marking foliation planes in the rock. In the migmatised variety porphyroblasts of garnet around which biotite laths anastomise are common.

Quartz is characteristically clear and colourless with low relief. Two generations of quartz are usually evident. The first is stumpy with anhedral shapes but are usually elongated parallel to the fabric and exhibits wavy extinction. In the sheared variety of this rock it is multigrained, lenticular and ribbon-like. The younger and finer grained variety occurs as localised granoblastic aggregates and shows regular extinction. This variety is of secondary origin probably formed as a product of the breakdown of other minerals. Biotite is brown to light green in colour and occurs as slender or prismatic with occasional stumpy laths. Plagioclase is of Oligoclase–andesine composition (Table 1). It is colourless and where twinning is absent it is often distinguished from quartz by the alteration to saussurite. Garnet is predominantly almandine with subordinate amounts of spessartine, grossularite, Pyrope and andradite (Table 1). In plane polarised light it is usually dark brown in colour. The grains are megacrysts with subhedral outlines. Poikiloblastic texture characterised by inclusions of fine crystals of quartz, opaques and mica is common.

GEOCHEMISTRY

Thirteen representative samples of quartz-mica schist were collected from different localities around Isanlu and analysed for their bulk chemical compositions. Major constituent minerals in the rock were also analysed using the electron microprobe analyser to determine their compositions. Chemical analyses were undertaken at the Geochemistry institute of Georg August University, Gottingen, Germany. While the compositions of microprobed minerals are shown in Table 1, results of whole-rock bulk analyses of major and

Table 1: **Electron Microprobe analyses of selected minerals from Isanlu quart-mica schist**

	Plagioclase			**Biotite**			**Garnet**	
	105B	106B		104B	107B		95B	98B
SiO_2	60.35	60.16	FeO	22.25	22.51	FeO	33.44	33.54
Al_2O_3	24.82	25.21	TiO_2	1.27	1.33	FeO calc	33.25	33.54
FeO	0.02	0.13	K_2O	8.32	8.55	Fe_2O_3 calc	0.21	0.03
CaO	6.14	6.39	Al_2O_3	20.32	19.92	MnO	5.16	5.01
Na_2O	8.03	7.74	CaO	0.00	0.00	MgO	1.58	1.58
K_2O	0.08	0.08	Na_2O	0.31	0.24	CaO	1.65	1.60
	99.44	**99.71**	MnO	0.09	0.09	Al_2O_3	20.73	20.91
			SiO_2	34.23	33.88	SiO_2	37.46	37.67
Ca	0.294	0.306	MgO	7.73	7.76		**100.04**	**100.32**
Na	0.696	0.670	H_2O calc	3.82	3.80			
K	0.005	0.005		**98.34**	**98.08**	Fe^{2+}	2.262	2.273
	0.995	*0.981*				Mn	0.355	0.344
			K	0.832	0.809	Ca	0.144	0.139
Si	2.697	2.687	Na	0.047	0.036	Mg	0.197	0.191
Al	1.307	1.327		*0.879*	*0.895*		*2.953*	*2.946*
Fe	0.001	0.005						
	4.005	*4.019*	Mg	0.903	0.912	Al	1.987	1.998
			Mn	0.006	0.006	Fe^{3+}	0.013	0.002
O	**8.000**	**8.000**	F_2^{2+}	1.458	1.483		*2.000*	*2.000*
Component			Al^{vi}	0.558	0.520			
Mole %			Ti	0.075	0.079	Si	3.047	3.054
An %	29.55	31.19		*3.000*	*3.000*			
Ab %	69.95	68.39				O	12.000	12.000
Or %	0.50	0.51	Si	2.682	2.670	Component		
			Al^{iv}	1.318	1.330	mole %		
				4.000	*4.000*	Almandine	77.00	77.52
						Spessartine	11.82	11.46
			O	**10.000**	**10.000**	Andradite	0.65	0.10
						Grosularite	4.13	4.53
			OH	**2.000**	**2.000**	Pyrope	6.40	6.39

Oxides in wt. % and cations in mol. %. Total iron is determined as FeO. Calculations are based on the numbers of cations in the respective formulae: for plagioclase, 5 cations for 8 oxygens; for biotite 8 cations for 10 oxygens and for garnet 8 cations for 12 oxygens. The amount of H_2O in biotite was calculated on the basis of 2 (OH) in the formula and was added as H_2O calc. to the sum. In Garnet FeO calc. and Fe_2O_3 calc. were calculated from the measured FeO on the basis of the electroneutrality of the formula. FeO calc. and Fe_2O_3 calc. were added to the sum instead of FeO.]

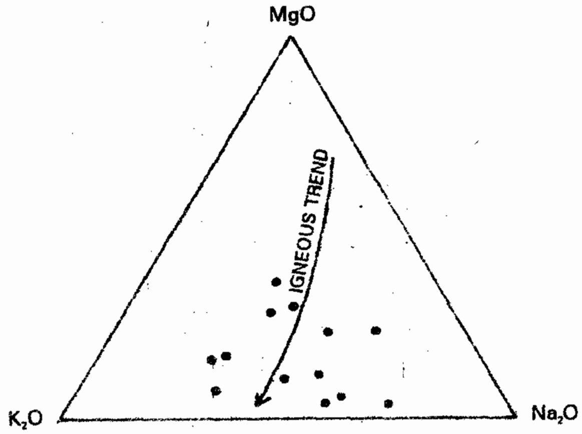

Fig 3: Plot for distinction of sedimentary versus igneous protolith for the Isanlu quartz-mica schist (after De LaRoche, 1974). The samples plot as scattered points relative to the trend defined for igneous rocks.

trace elements are presented in Table 2. The average geochemical value of the rock is also compared in Table 3 with that of greywacke of Pettijohn et al., (1972) and metasedimentary rocks from Nigeria and other parts of the world.

Analytical techniques

The major and trace element composition of the rock samples were measured by XRF using a Phillips PW 1480 automated sequential spectrometer. Data processing was controlled by the Phillips X40 software package. Discs for both major and trace element determination were prepared at 1100^{0}C by using Spektroflux 100 containing Lithium tetraborate. For the determination of Fe^{2+}, a titration method was used.

Microprobe analyses were carried out with ARL-SEMQ-II electron microprobe analyser, which was equipped with six spectrometers and four different crystals (LiF, PET, ADP and TAP). It was operated at 15Kv accelerating voltage with a 20nA sample current on brass. The reference materials for standardisation were ilmenite and kaersutite. Matrix correction for the intensity of measurement was made using the Bence and Albee (1968) correction programme.

Major Elements

Both sheared and unsheared varieties of the quartz-mica schist were analysed for their element abundances and presented in Table 2. The rock is enriched in SiO_2 (> 56 wt. %) and show moderate Al_2O_3 (< 18 wt. %) values. The ratio SiO_2/Al_2O_3 ranges between 3.42 and 6.42. K_2O (> 1.22 wt. %) values as similar in both sheared and unsheared varieties of the rock. On the contrary, Na_2O is relatively more enriched in the sheared rock (mean value 7.12 wt. %) compared to the unsheared variety (mean value 3.09 wt. %). Both Na_2O and K_2O show poor correlation with SiO_2. This phenomenon may be due to their redistribution during past tectono-metamorphic events. TiO_2 concentration (0.18 – 1.06 wt. %) is similar in both sheared and unsheared varieties of the rock. MnO shows a notably high concentration in the sheared quartz-mica schist (> 5 wt. %) compared to the unsheared variety (< 0.40 wt. %). On the contrary, FeO (mean value 0.70 wt. %) and MgO (mean value 0.35 wt. %) reveal depleted values in the sheared rock relative to the unsheared variety (mean values 3.73 wt. % and 1.30 wt. % respectively).

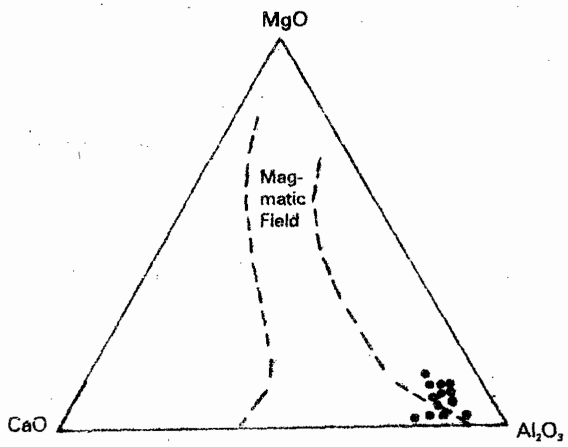

Fig 4: MgO-CaO-Al_2O_3 diagram for the discrimination of Metasedimentary and metaigneous rocks (after Leyreloup et al., 1977). All samples except the mylonitised ones plot outside the magmatic field.

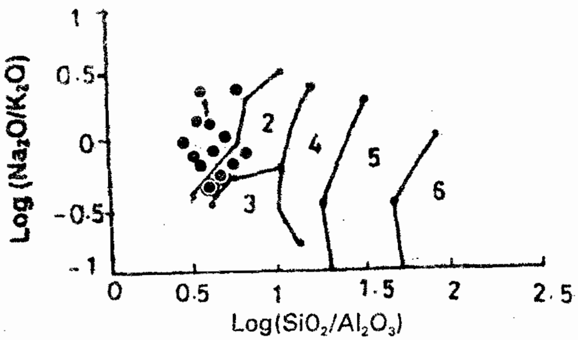

Fig 5: The compositional classification of quartz-mica schist from Isanlu after Pettijohn et al. (1972) modified by Herron (1988). The metasediment plots in the field of greywacke and litharenite. Fields are 1. Greywacke 2. Litharenite 3. Arkose 4. Subarkose 5. Sublitharenite 6. Quartz arenite.

Generally, TiO_2, Al_2O_3, FeO, MgO and P_2O_5 show a decrease in concentration with increasing SiO_2 content. This probably denotes an increase in quartz content with a decrease in the chemically unstable grains (lithic components) (Bhata and Crook, 1986). Except for the elevated values of Na_2O and MnO and depleted value of FeO in the sheared variety of the rock, the major element composition of the Isanlu quartz-mica schist is comparable to that of metasediments from Ife-Ilesha schist belt (Elueze, 1981), Iseyin and Obudu areas (Rahaman, 1978; Ekwueme, 1991), and the semipelitic metasedimentary rocks of North-west Scotland (Okeke et al., 1983). It is also similar to the composition of the average crust (Harris, 1972).

Trace Elements

The behaviour of trace elements during sedimentary processes is complex due to varying factors such as weathering, physical sorting, provenance and diagenesis (Garrels and McKenzie 1971; Nesbitt et al., 1980). However the relative abundance of some trace elements can be a pointer to the nature of the protolith of a metasediment.

Ni, Cr and V abundance in the rock are in the ranges 19 – 169 ppm, 20 – 135 ppm and 24 –

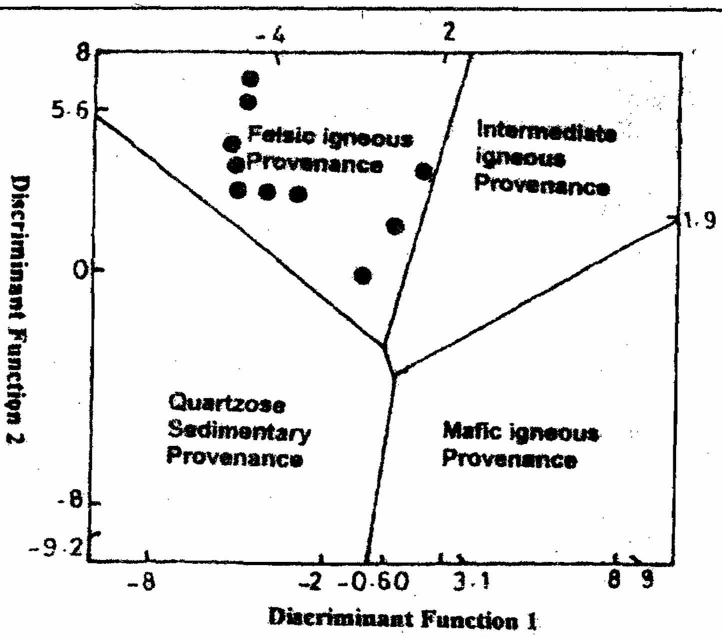

Fig 6: Discrimination function diagram for the provenance signatures of sandstone - mudstone suite using major elements (after Roser and Korsch, 1988). Quartz-mica schist from Isanlu plots in the field of dominant felsic igneous provenance. Mylonitised samples plot outside the fields defined in the diagram because of their significant enrichment in some elements. Discriminant functions are:

Discrimination function 1 = $-1.773TiO_2 + 0.06Al_2O_3 + 0.76Fe_{(total)} - 1.5MgO + 0.616CaO + 0.509Na_2O - 1.224K_2O - 9.09$

Discrimination function 2 = $0.445TiO_2 + 0.07Al_2O_3 + 0.25Fe_{(total)} - 1.142MgO + 0.438CaO + 1.47Na_2O - 1.426K_2O - 6.861$

136 ppm respectively (Table 2). Zr, Sr and Rb concentration are enhanced in the metasediment and similar in values to those of granitic rocks in the area (Olobaniyi, 1997). Zn and Co show mean concentration values of 50.80 ppm and 14.46 ppm respectively in the rock similar to values obtained in metasediments from Northern Obudu area (Ejimofor et al., 1996). Ba has higher values in the sheared rock (> 1200 ppm) than the unsheared variety (< 750 ppm), but generally within the range of values for metasediments (Elueze , 1981). Nb also shows slightly elevated values in the sheared rock (> 90 ppm) relative to the unsheared variety (< 30 ppm).

The elevated values of Na_2O, MnO and Nb, and the depletion of FeO and MgO encountered in the sheared variety of quartz-mica schist relative to the unsheared variety may be related to the movement of metamorphic remobilised fluids during the Pan-African or earlier events which could have imparted the enrichment – depletion signature. In the Isanlu area, some of the shear zones host auriferous quartz veins that are presumed to be formed by metamorphic dewatering of the country rocks during the Pan-African event. This supposedly led to element remobilisation in the rocks and deposition in the shear zones (Akande et al., 1988).

Characterisation of protolith

To understand the pre-metamorphic parent material of the quartz mica schist of Isanlu, some sensitive discriminant diagrams have been employed.

Table 2: **Whole rock bulk chemical analyses of quart-mica schist of Isanlu .**

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
	IR1	IR5	IR9	Q16	3-(2)	OK18	IR2	IR3	Sb4a	Sb4b	MY3	MY4	MY5
SiO_2	60.50	74.90	62.70	71.50	75.70	69.63	70.70	72.66	67.44	70.40	62.36	57.54	56.16
TiO_2	1.03	0.48	1.06	0.55	0.28	0.57	0.38	0.18	0.30	0.43	0.33	0.33	0.38
Al_2O_3	17.70	11.80	16.70	13.10	12.40	14.55	13.28	11.32	15.23	12.35	15.28	16.28	17.28
FeO_{tot}	6.28	4.61	7.00	3.74	2.03	4.54	2.77	0.89	3.63	1.80	1.08	0.88	0.15
MnO	0.10	0.21	0.17	0.07	0.04	0.37	0.13	0.03	0.03	0.04	5.23	6.05	7.41
MgO	2.94	1.05	1.96	0.96	0.40	1.13	1.42	0.96	1.40	0.74	0.43	0.29	0.32
CaO	2.64	1.66	2.54	1.49	1.19	1.72	2.12	1.98	2.09	1.99	2.12	4.22	3.52
Na_2O	2.60	3.08	2.80	2.27	2.04	2.12	2.92	5.92	2.92	4.18	6.92	7.31	8.28
K_2O	3.27	1.22	2.82	3.93	5.17	4.32	5.21	5.11	6.23	5.02	5.21	5.11	3.18
P_2O_5	0.15	0.04	0.07	0.13	0.08	0.12	0.01	0.01	0.00	0.01	0.41	0.43	0.61
LOI	1.21	0.36	0.80	0.69	0.41	0.40	0.53	0.44	0.33	1.62	0.22	0.74	0.90
Total	**98.42**	**99.41**	**98.62**	**98.43**	**99.74**	**99.47**	**99.17**	**99.50**	**99.60**	**98.58**	**100.17**	**99.58**	**98.16**
Sc	18	12	18	7	5	-	-	-	-	-	-	-	-
V	118	49	109	43	24	63	-	-	-	-	136	101	97
Cr	127	46	88	46	20	35	-	-	-	-	100	119	134
Co	21	12	23	14	9	16	6	19	10	16	16	16	10
Ni	102	169	120	153	109	19	-	-	-	-	24	24	38
Zn	95	58	81	59	24	54	45	24	14	43	45	53	66
Rb	157	85	153	152	234	153	-	-	-	-	-	-	-
Ga	22	14	23	13	12	18	-	-	-	-	-	-	-
Sr	247	194	256	133	85	179	148	114	140	124	148	114	572
Y	26	35	29	39	43	46	56	60	54	45	40	56	44
Zr	236	167	242	195	138	214	302	193	312	351	302	302	305
Nb	22	14	20	14	11	-	-	-	-	-	98	108	127
Ba	557	134	738	734	502	745	242	209	222	245	1220	1242	1209
Pb	24	37	23	35	28	37	-	-	-	-	-	-	-
SiO_2/Al_2O_3	3.42	6.38	3.75	5.46	6.10	4.78	5.30	6.42	4.43	5.0	4.08	3.53	3.20
Chemical index of alternation (CIA)	67.53	66.44	67.17	63.01	59.61	64.06	56.08	46.52	57.54	52.46	51.74	48.80	53.56

Oxides in wt. %, trace elements in ppm. FeO_{tot} is the total amount of Fe expressed as FeO. -: not analysed. S and C were not analysed. Chemical index of alteration (CIA) = 100 [Al_2O_3/ (Al_2O_3 + CaO + Na_2O + K_2O)]

Index to Table 2

I – X = Quart-mica (± garnet) schist

XI – XIII = Mylonitised quartz-mica schist

On the compositional igneous-sedimentary discrimination diagram of De LaRoche (1974), plots of the Isanlu quartz-mica schist fail to reveal any charasteristic igneous trend. Rather they plot as scattered points relative to the trend of igneous rocks (Fig.3). Also on the MgO-CaO-Al_2O_3 diagram of Leyreloup et al., (1977), the samples, except the mylonitised ones that are presumed to have been enriched in certain elements, plot outside the field of magmatic rocks defined by the magmatic funnel (Fig.4). This implies a sedimentary protolith for the schist. An indication of the nature of the parent sedimentary rock to the quartz-mica schist is obtained with the plot of the samples on the chemical maturity diagram of Pettijohn et al., (1972). On this diagram the samples plot in the compositional fields of greywacke and litharenite (sub-greywacke) (Fig. 5). This is corroborated by the close comparison of the chemical composition of the quartz-mica schist with the average chemical composition of greywacke (Pettijohn et al., 1972) (Table 3).

Following the work of Nesbitt and Young (1982) and its application to sand-size clastic rocks by Maynard et al., (1991) and Archean sedimentary rocks (Wronkiewicz and Condie, 1989), the calculated values of the chemical index of alteration (CIA) (which is a measure of the degree of chemical weathering of the protolith) of the metasediment samples range from 46.52 to 67.53. These values show moderate chemical alteration and imply that the protolith of the metasediment did not suffer deep weathering before its removal, transportation and subsequent deposition.

PROVENANCE

Roser and Korsch (1988) have evolved discriminant functions involving the use of major elements to distinguish between sediments derived from felsic, intermediate and mafic igneous and quartzose sedimentary provenance. A plot of the chemical compositions of the Isanlu quartz-mica schist samples on this diagram (Fig. 6), show that they were derived predominantly from felsic igneous sources. This deduction is supported by the high concentration of Ba, Sr, Rb and Zr, which are higher than their concentrations in mafic and ultramafic rocks but similar to what obtains in felsic granitoids (Olobaniyi, 1997). Some of the samples reveal a high concentration of Ni, Cr, V and Co suggesting an input from some mafic sources. Thus, it could be inferred that the metasediment was derived from the basement complex rocks of predominant granitic and minor basic and ultrabasic rocks that are typical of Southwest and Northwest Nigeria.

GEODYNAMIC IMPLICATIONS

Although there is no direct evidence for the nature of the bedrock to the metasediment of Egbe-Isanlu schist belt, previous works such as Olobaniyi (1997) have suggested that the Egbe-Isanlu schist belt evolved as an ensialic basin in an environment of thin (attenuated) crust. The occurrence of relatively immature sedimentary assemblages (now metamorphosed) of the sub-greywacke to greywacke-type suggests that the depocentre was a rapidly subsiding basin and/or a considerable difference in topographic elevation between the sediment source and depocentre existed. Nonetheless the absence of typical deep-water sediments and regional proximal-distal facies variation suggests that only a moderate depth and width was attained in the basin, a fully mature ocean was not developed. The rapid subsidence of the basin was probably contemporaneous with tectonic instability in the surrounding environment from where sediment was derived. This might have aided in the rapid removal of the sediments before deep weathering and mineralogical maturity was achieved in such areas. The rapid removal of sediments from the source and its dumping in the basin probably account for the limited depth achieved in the basin.

Olobaniyi (1997) has reported the presence of shallow, stable shelf-type sediments such as carbonate and iron-formation in the Isanlu area. Furthermore, the BIF and quartzite contain carbonaceous materials suggesting a

Table 3: **Comparison between the chemical composition of the quartz-mica schist of Isanlu area with similar rocks from elsewhere in the world**

	1	2	3	4	5	6	7	8	9
SiO_2 wt.%	60.50 – 75.70	69.60	58.69	69.10	60.30	67.69	65.69	61.90	66.70
Al_2O_3	11.32 – 17.70	13.84	16.28	12.57	14.90	15.35	17.28	15.60	13.50
FeO_{tot}	0.89 – 7.00	3.73	0.70	4.64	5.25	3.85	5.50	6.50	3.54
CaO	1.19 – 2.64	1.94	3.29	3.55	4.74	3.29	2.18	5.70	2.50
MgO	0.40 – 2.94	1.30	0.35	3.98	4.34	1.84	2.57	3.10	2.10
Na_2O	2.04 – 5.92	3.09	7.29	1.11	3.06	3.40	2.49	3.10	2.90
K_2O	1.22 – 6.23	4.23	4.50	2.62	3.45	2.52	2.03	2.09	2.00
TiO_2	0.18 – 1.06	0.53	0.34	0.77	0.74	0.50	0.90	0.80	0.60
P_2O_5	0.00 – 0.15	0.06	0.48	0.37	-	-	0.19	-	0.20
MnO	0.03 – 0.37	0.11	6.23	0.36	0.09	0.07	0.00	0.10	0.10
Nb ppm	11 – 22	16.20	111	-					
Zr	138 – 351	235.00	303	210					
Y	26 – 60	43.30	46.66	-					
Sr	85 – 247	162.00	278	205					
Rb	85 – 234	155.67	-	145					
Pb	23 – 37	30.67	-	-					
Ga	12 – 23	17.00	-	-					
Zn	14 – 95	49.70	54.66	5					
Ni	19 – 169	67.20	28.66	98					
Co	6 – 23	14.60	14.00	11					
Cr	20 – 127	60.33	117.66	100					
V	24 – 118	67.67	111.33	100					
Ba	134 – 745	432.80	1224	2270					
Sc	5 – 18	12.00	-	-					

Oxides in wt. %. trace elements in ppm. 1. Range of elemental composition of 10 analyses of unsheared quartz mica-schists from Isanlu. 2. Average of the 10 analyses of unsheared quartz-mica schist 3. Average of 3 analysis of Isanlu sheared quartz-mica schist 4. Average of 8 analyses of quartz-plagioclase-biotite schist from Ife-Ilesha schist belt (Elueze, 1981) 5. Average composition of paragneiss, Iseyin Southwest Nigeria (Rahaman, 1978) 6. Average composition of semipelitic metasedimentary rocks. Northwest Scotland (Okeke et al., 1983) 7. Average composition of migmatitic schist, Obudu Southeast Nigeria (Ekwueme, 1991) 8. Average crust (Harris, 1972) 9. Average of greywacke compositions of Pettijohn et al. (1972).

change in tectonic regime from a rapidly sinking basin to a stable shallow basin where relative quietness and limited terrigenous influx from the hinterland was favoured. In this environment, occasional stagnation and/or sub-aerial exposure probably encouraged the production of carbonaceous material in the sediments.

DISCUSSION

The evolution of the Nigerian schist belts has been explained in terms of an initial continental extensional stage culminating in rift openings, sedimentation with contemporaneous magmatism in the basins formed, followed by closure which led to the deformation and metamorphism of the sediments (Ajibade et al., 1987, among others). These sediments vary in maturity from pelite to semipelite and greywackes from one belt to another (Holt et al., 1978; Elueze, 1981;Ekwueme, 1991) probably reflecting the disparities in fault patterns, dimensions and subsidence rates among the original sedimentary basins (Elueze, 1992).

As a result of multiple deformation and metamorphism of these sediments, primary sedimentary textures and structures are often obliterated and sedimentary facies are usually difficult to define precisely. Nonetheless, a careful examination of these metasediments can still give clues to the depositional histories of their protoliths. These with their compositions and gross stratigraphic relations with other lithofacies can be of immense help in constraining and/or testing tectonic models advanced for the belts. Such will permit a more reliable regional correlation of the schist belts and shed a brighter light on the geotectonic evolution of the Nigerian basement complex in general. Consequently, questions relating to whether the metasediments represent a single supracrustal cover now disjointed by erosion or whether the belts are broadly contemporaneous but evolved more or less independently of each other or whether at least some are of different ages and belong to different geotectonic cycles (Ajibade, 1980) could be addressed more convincingly.

In the Ife-Ilesha schist belt metasediment comprises predominantly of quartzite and quartz-mica schist of sub-greywacke to greywacke compositions. This suite of rocks, because of its composition, has been interpreted as deposited in a rift environment of rapid subsidence (Elueze, 1981). The neighbouring Egbe-Isanlu schist belt hosts metasediments with similar compositions. By implication therefore, the two belts might have experienced a generally similar geodynamic evolution even if they were formed as two distinct basins. Although in both belts, the metasediments are associated with metaultramafic rocks of komatiitic affinity (Elueze, 1982; Ige and Asubiojo, 1991; Olobaniyi, 1997), and silicate facies iron-formation of volcano-sedimentary affinity (Olobaniyi, 1997; Elueze, 2000). These lithofacies are regarded as stratigraphic markers for the early Precambrian (Nesbitt, 1980; James, 1992), it yet remains to be established whether or not these two belts are time-stratigraphic equivalents.

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