Ghana J. Sci. **29-30,** 13-23

ON THE QUESTION OF THE LATERAL EQUIVALENCE BETWEEN THE VOLTAIAN SEDIMENTS ON THE WEST AFRICAN CRATON AND THE BUEM AND TOGO SEDIMENTS WITHIN THE PAN-AFRICAN DAHOMEYIDE DEFORMED BELT

P. K. BLAY

Department of Geology, Faculty of Science, Garyounis University, Benghazi, Libya

Summary

The threefold classification of the Voltaian sediments into Lower Voltaian, Middle Voltaian and Upper Voltaian is upheld. Detailed examination of the field relations across the stratigraphic boundaries of the Voltaian, the Buem and the Togo sediments have been undertaken by tracing distructive rock units or associations over extensive areas. Results of the field exercise suggest that i. the Basal Sandstone Series of the Voltaian, the Kpandu Hill Series and the Iron-rich sediments of the Buem Formation, and the Togo Series are laterally equivalent and have been classified into the Lower Voltaian; ii. the Conglomerate Series and the Afram Shales Unit (i.e. the Oti Series) of the Middle Voltaian are correlatable with the Dayi Valley Series and the Buem Conglomerate (= Junner's Group B + Group D) of the Buem Formation and are stratigraphically assigned to the lower part of the Middle Voltaian; iii. Sediments of the upper part of the Middle Voltaian (Obosum Beds) and the Upper Voltaian have no lateral equivalents within the Buem and the Togo Series.

Introduction

The separation of the Voltaian System, the Buem formation and the Togo Series (Akwapimian) into three distinct stratigraphic units was proposed by Junner (1940) and for well over two decades up to the late 1960s field geologists following Junner's ideas, mapped the three units separately. However, before Junner's classification considerable differences of opinion existed regarding the age of the Buem formation and the relative stratigraphic positions of the Togo Series, the Buem Formation and the Oti Series.

According to Koert (1910) the Buem Formation is younger than the Togo Series but it is older than the Oti Series, which was classified into the lower part of the Middle Voltaian by Junner & Hirst (1946) because pebbles of Buem rocks occur in the conglomerate horizon of the Oti Series. Koert (1910) suggested a Permo-Carboniferous age for the Buem Formation presumably because of a tillite horizon within it. Koert further correlated the Buem Formation with the Kundelungu Formation in South and Central Africa and suggested that the tillite may be equivalent in time to the tillite at the base of the Kundelungu Formation and probably, therefore, Pre-Cambrian in age.

Both Koert (1910) and Junner (1940) unmistakenly recognized numerous pebbles of Buem and Togo rocks within the conglomerate horizon of the Oti Series (i.e. the Akroso Conglomerate) and the Sang Conglomerate of the Upper Middle Voltaian Obosum Beds (Junner & Hirst, 1946; Bozhko *et al.*, 1964). The author has observed pebbles of quartz-schists and quartzites of the Togo Series and pink jaspers of the Buem Formation in the Akroso Conglomerate of the Oti Series in the Kete-Krachi area, implying that this conglomerate is younger than the Buem Formation and the Togo Series.

The criteria for the separation of the Voltaian System, the Buem Formation and the Togo Series into three distinct units were based on (i) lithology, (ii) structural style and tectonic evidence, (iii) metamorphism, and (iv) field rela-

tions (Anan-Yorke & Cudjoe, 1971). It has been argued elsewhere that lithologic differences, the structural style and metamorphism are not valid parameters for differentiating the three lithostratigraphic units (Crook, 1963, 1970; Blay, 1976).

Recent detailed field mapping and critical review of published and unpublished data attempt to suggest that the Voltaian System, the Buem Formation and the Togo Series are in part synchronous. Prior to the recent field work, Malavoy (1931`) had argued on grounds of similarity in lithology, the gradual increase in the intensity of folding and the degree of metamorphism that the rocks of the Voltaian System and the rocks of the Akwapim Range (Togo Series) are laterally equivalent. Malavoy's ideas are supported by Crook (1963, 1970), Bozhko *et al.* (1964), Grant (1969) and Saunders (1970).

The Voltaian System, the Buem Formation and the Togo Series according to the new concept, comprise a single sedimentary unit which, in the east, has been involved in the Pan-African orogeny resulting in the development of the Pan-African Dahomeyide deformed belt along the south-eastern border of the West African craton. It is argued, for example, that the shallow marine lower Middle Voltaian Oti Series is in part the lateral equivalent of the geosynclinal Buem Formation, whereas the upper Middle Voltaian Obosum Beds and the Upper Voltaian Sandstones constitute a molasse to the Pan-African orogeny (Grant, 1969).

Crook (1970) proposed the following classification for the rocks of south-east Ghana:

Upper Voltaian:	Afram Shales; Dayi Valley Series; Buem Volcanic Group
Lower Voltaian:	Kpandu Hill Series; Iron-Ore Group; Togo Series quartzites; schist and con glomerate
Dahomeyan:	Orthogneises and paragneiss, showing a major post-Birimian metamorphism and possibly developed from Birimian rocks.

Ahmed, Blay, Castor & Coakley (1977) challenged the basis for the above classification by Crook and instead led evidence in support of the fourfold classification of Dahomeyan-Togo Series (Buemian-Voltaian) initially proposed by Junner & Hirst (1946). This author has done extensive field work in areas of Buem and Togo rocks in the Volta Region of Ghana and in areas of the Kwahu Scarp along the southern rim of the Volta Basin from the Kwahu-Tafo area to west of Aburi where the Voltaian rocks are in direct contact with the Togo rocks.

Following the work of Bozhko *et al.* (1964) and Anan-Yorke (1980), the stratigraphic sequence of the Voltaian basin has been established (Table 1). The stratigraphic units of the Buem Formation and the Togo Series are also well established. In this paper, rock units which, by their field relations, belong to two or more series are outlined. The important role the Afram Shales of the Oti Series play directly or otherwise in support of the concept of lateral equivalence is examined in some detail and recommendations for future work are proposed.

Lithostratigraphic Correlations

In this section rock units which are widespread in their occurence and are common to two or more series are discussed.

The Iron-Ore Group

According to Crook (1957, 1970) the most easily recognizable rock type to transgress boundaries of the series in a systematic manner is the iron-ore rich sediments which outcrop in the Shiene area of the Northern Region of Ghana. These rocks have also been mapped in the Santrokofi Hills area of the Volta Region (Bell, 1962). The present author has observed identical rocks, along the regional strike, between the Shiene and Santrokofi areas. In Field Sheet 184 (Fig.1) and along the western parts of Field Sheets 185 and 187, the author mapped haematite-rich,

TABLE I

Classification proposed for the Voltaian sediments

Subdivision	*Bozhko* et al. *(1964) (sub-surface data)*	*Anan-Yorke (1980) (sub-surface data)*	*Blay (1983) (surface & sub-surface data)*
Upper Voltaian	Massive sandstone series (PZ_1 $Vt^2/_1$)	Massive sandstone	Massive sandstone with white spots of Kaolin
	Thin-bedded sandstone ($PZ_1Vt\ ^1/_3$)	Thin-bedded sandstone	Thin bedded micaceous sandstone
		Tamale Red Beds	
Middle Voltaian	Tamale Red Series (PZ_1 $Vt^1/_2$)	? ? ? ? ? ?	Tamale Red Beds
	Upper greenish-grey series ($PZ_1Vt^3/_2$)	Upper Green Beds	Glay gall sandstone
	Variegated series PZ_1 $Vt^2/_2$	Afram Shales	Afram Shales = Dayi Valley Series of Crook (1963) Buem
	Conglomerate-sandstone series PZ_1 Vt½	Akroso Conglomerate	Akroso conglomerate-sandstone series, conglomerate-like tillite
		Lower Green Beds	
Lower Voltaian	PZ_1Vt_1 Basal Sandstone (West of V. Basin) Lower Greenish-grey series (East of V. Basin = Buem)	Basal sandstone	Basal sandstone

poorly sorted sandstones in the hills west of Borada, on the Dayi Plateau, the hill areas south of Worawora and West of Guaman.

The haematite-rich sandstones form the northern extension of the iron-ore group of the Santrokofi Hills of Field Sheet 182. These sandstones underlie the Konsu Valley Shales which are correlated with the Afram Shales (Blay, 1983). South of the Santrokofi Hills, Bell (1962) mapped iron-rich sediments in the Agome Hills, the Peki area and the area west of Frankadua. In all cases, evidence of a metasomatic origin of the rocks was not apparent, and without doubt, these iron-rich rocks represent a related group of sediments as samples from one locality can be closely matched with samples from any other locality except that south of Agome there is a marked increase in quartz-veining. From Agome as far north as the Shiene area, the iron-rich sediments exhibit the regional northern strike of the Buem Formation within which they occur. South of Agome, the iron-rich rocks show the north-north east strike characteristic of the Togo Series and fall within the Togo sediments as indicated on the Geological Map of Ghana (Bates, 1955). Again, at Agome, according to Crook (1963) these sediments represent the most westerly outcrops of the Togo Series and are actually grouped with the Togo.

The Sedimentary Breccias and Arkoses

The rocks that outcrop on the Kpandu Hill and the Dayi Plateau belong to the Group C classification of the Buem (Junner, 1936). Detail mapping south of Kpandu indicates a total gradation from a sedimentary breccia at the base to a fine-

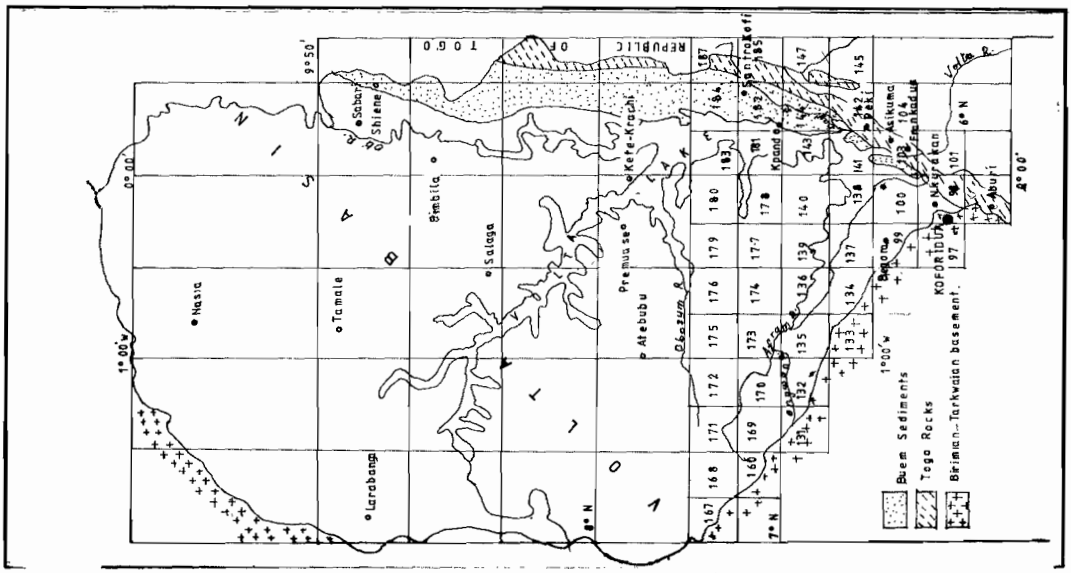

Fig. 1. Map of Eastern Ghana showing locations of field sheets

grained arkosic sandstone at the top. In the very coarse horizons the rock consists of large fragments of feldspar and angular fragments of gneiss, vein quartz, quartzite and some schist in a matrix of large crystals of calcite and limonitic fragments. The most southerly occurence of the sedimentary breccias and arkoses is in the area just north-east of the Dayi River-Volta River confluence where they occur in the Buem Formation with the typical regional strike of north-south. To the south of the Dayi River, similar rocks occur in Field Sheets 103 and 101 in the Jakiti and Boso areas where they show the north-north east strike of the Togo Series with which they are grouped. Identical breccias occur at the base of the quartzites of the Togo Series and it is well exposed along the western part of the Bame Pass near Kpeve. It has been traced by the author along strike from the Bame Pass northwards to Have-Odumasi, some 10 km away.

The Afram Shales and the Dayi Valley Series

The stratigraphic position of the Afram Shales has in the past been quite controversial. Some authors placed it at the level of the Upper Voltaian (Saunders, 1970; Grant, 1969; Crook, 1970). Others regarded it as Lower Voltaian (Mason, 1963; Mitchell, 1960). However, it has now been authentically placed at the level of the Middle Voltaian (Bozhko *et al.*, 1964; Anan-Yorke, 1980.)

The Afram Shales have been geographically correlated with the Dayi Valley Series which form part of Group D of the Buem Formation (Crook, 1970) and (Blay, 1983). In the Peki-Tsibu-Todome area of Field Sheet 142 a group of unmetamorphosed shales occur in an embayment within an area of typical Togo Series rocks and these shales have been correlated with the Afram Shales and the Dayi Valley Series (Crook, 1970; Blay 1983), and subsequently placed within the Buem Formation.

The Shales and Mudstones at Shiene

In the Bimbilla and Sabari areas of the Oti Valley flat-bedded unfolded shales, greywackes and mudstones occur and have been assigned to the Oti Series of the Middle Voltaian. Eastwards of this area, folded and overturned mudstones and greywackes occur at the foot of the hill formed by iron-rich sediments. Traverses along streams and systematic mapping and pitting in-

dicated that there is no break between the undeformed, flat-bedded shales, mudstones and greywackes of Voltaian age and their deformed counterparts which are mapped as Buemian (Crook, 1957). The traverses and the pitting also clearly showed a gradual increase in the severity of the folding from west to east and this was attributed to thrusting within the iron-rich ore bodies (Crook, 1957). Thus, it is apparent that the shales, greywackes and mudstones of the Oti Valley which belong to the lower part of the Middle Voltaian are traceable eastwards into the area of the iron-rich sediments which are grouped with the Buem Formation.

Limestones of the Afram Valley

Mitchell (1960) described the occurence of some limestones in the Voltaian Basin and assigned them to the Middle Voltaian. Limestones in the Afram Valley are associated with the Afram Shales which have been correlated with the Dayi Valley Series of Buem age. Mitchell (1955) noted that at no stage is there a marked change within these outcrops and that the only significant change is the increasing folding and faulting within the limestone and associated sediments as the Volta and the Dayi Valleys are approached from the Afram Valley in the west. There is thus the suggestion that the limestone-shale-sandstone association mapped as Middle Voltaian in the Afram Valley west of the Volta River continue into the Dayi Valley east of the Volta River where they merge with the shale-limestone-greywacke-sandstone series and then become Buem in age.

Crook's Volta Gorge Series

In the hill area east of the Volta Dam, Crook (1963) described weakly deformed shales and sandstones which are traceable along their strike northwards to south of Asikuma. These sediments grade into chlorite-schists, quartschists and phyllites of the Togo Series in the Asikuma area of Field Sheet 142. In these sediments the original fold trends are north-north east which is typical of the Togo structures. The rocks here constitute the Volta Gorge Series (Crook, 1963). According to Tevendale (1957) they are Buem; Bates (1955) regarded them as Togo, but Crook (1963) mapped them as Lower Voltaian. This author correlates them with the Kpandu Hill Series which were originally mapped as Buem but which the author has found to be correlatable to the Lower Voltaian Basal Sandstone Series and the Togo Series.

Afram Shales of the Oti Series

The stratigraphic position of the Afram Shales is now placed at the lower part of the Middle Voltaian and included in the Oti Series (Table 1). The position of the Afram Shale is unique in that it is about the only rock unit which is traceable over a wide area and whose field relations to other rock units make it most useful to illustrate the concept of lateral equivalence between parts of the Voltaian, the Buem Formation and the Togo Series. In the Ongwan River valley of Field Sheet 132 (Fig.1) the Afram Shales underlie the massive Dente Clay Gall Sandstone Formation (Mason, 1963).

In the area of Field Sheet 132, all the sandstones stratigraphically above the Afram Shales, namely, the Dente Gall Sandstone Formation and the Chirimfa Pink Arkosic Sandstone Formation form part of the Kwahu Sandstone Formation (Saunders, 1970). This relationship holds between Agogo and Nkurakan, that is, along the entire length of the Kwahu Scarp. The Dente Clay Gall Sandstone has been correlated with the Upper Greenish-Grey Series whereas the Chirimfa Arkosic Sandstone Formation has also been equated to the Tamale Red Bed Series.

Across the Volta River into the Dayi Valley, the Afram Shales, as indicated above, become the Dayi Valley Series which belong to Group D of the Buem. The Ataulo Valley shales west of the Kpandu Hill Range has been traced into the Dayi Valley and correlated with the Dayi Valley Series east of the Kpandu Hill range (Blay, 1983). structurally, the Kpandu Hill is an overturned anticline with the sedimentary breccias and

arkoses of the Kpandu Hill Series occurring within the core of the anticline. Thus, the Afram Shales overlie the Kpandu Hill Series. It will be shown later that because of this stratigraphic relationship, the Kpandu Hill Series underlies the Conglomerate Series of the Lower Middle Voltaian and its precise position is at the level of the Lower Voltaian Basal Sandstone Series.

In the Tsibu-Todome-Peki area of Field Sheet 142, the Afram Shales or the Dayi Valley Series occur in an embayment within an area of typical Togo Series rocks that contain well developed chlorite schists. From this relationship Crook (1970) deduced that the Afram Shales and Dayi Valley Series overlie the Togo Series. Hence, from what has been discussed above, the Kpandu Hill Series must be laterally equivalent to the Togo Series since both the Togo Series and the Kpandu Hill Series directly underlie the Afram Shales.

Saunders (1970) suggested that the sandstones of the Kwahu Scarp be classified into the Lower Voltaian. Saunders sub-divided the sandstones into two groups, namely, the Kwahu Sandstones (Upper Greenish-Grey Series) at the base and the pink Anyaboni Sandstone Formation (Tamale Red Bed Series) above it, and attempted to show that the Kwahu Sandstones correlated with the Togo Series whereas the Anyaboni Sandstones Formation and the Afram Shales unit correlate with the Upper Voltaian. From the position of the Afram Shales based on borehole evidence and from the field relations discussed above (Blay, 1983) Saunders' suggestions that the Kwahu Sandstones are Lower Voltaian and that they are the correlatives of the Togo Series are unacceptable. Saunders' correlation was based on the position of the Afram Shales which he misplaced at the level of the Upper Voltaian, that is, above the Kwahu Sandstone wrongly regarded as Lower Voltaian.

Based on the position of the Afram Shales in the Kwahu Scarp Zone which is at the base of the Kwahu Scarp Sandstone, in the Kpandu Hill-Dayi Valley axis, and in the Tsibu-Todome-Peki area the correlation suggested by the author is valid (Table 2). Table 2 is based on borehole data from parts of the Volta Basin, and Table 3 is deduced from the relationships in Table 2. The anticlinorium mentioned in Table 2 is described by Bozhko *et al.* (1964) and Anan-Yorke & Cudjoe (1971). If this correlation is acceptable, then, it should be appreciated that the Afram Shales play a significant role in establishing lat-

TABLE 2

Correlation of some rock units from borehole data deduced from Bozhko et al. *(1964)*

	Western margin of Volta Basin	*Central part of Volta Basin*	*Eastern part of Volta Basin*		
Middle Voltaian	Afram Shales	Afram Shales	Afram Shales		
		Conglomerate sandstone series with tillite horizon	Conglomerate-sandstone series with tillite	core of anticlinorium	Buem Series Conglomerate-like tillite, siltstones shales, mudstones, sandstones
	Unconfirmed	Unconfirmed		Lower Greenish Grey series	
Lower Voltaian					Effusive rocks, mudstones, shales, siltstones, sandstones, conglomerates with tillite & quartzite
	Basal sandstone	Basal sandstone	Basal sandstone = Kpandu Hill Series = Togo Series		

eral equivalence between certain portions of the Voltaian System, the Buem Formation and the Togo Series.

Earlier workers held the view that the Buem rocks underlie the Voltaian rocks (Junner, 1940; Junner & Hirst, 1946). According to Bozhko *et al.* (1964) rocks of the Buem Formation are synchronous with, and stratigraphically equivalent to the Middle and Upper Voltaian rocks. This view is tenable at least in part when the position of the Afram Shales unit is taken into consideration. The Afram Shales have been correlated with the Buem Formation in some sections above. It is appropriate at this stage to subdivide the Buem Formation into its units in order to place the Afram Shales at their correct stratigraphic level within the Buem Formation.

Suggested Classification for the Buem

Junner (1940) sub-divided the Buem Formation into the following units:

Group A: Volcanic Group
Group B: Calcareous and ferruginous shales, limestones and tillite
Group C: White bleached feldspathic sandstones, grits, quartzites and conglomerates and arkoses
Group D: Shales and mudstones with thin beds of arkose, greywacke and limestone

The field evidence indicates that the structure of the Dayi Plateau (Bell, 1962 in Field sheet 182; Blay, 1971 in Field Sheet 184) and the Kpandu Hill area (Crook, 1963 in Field Sheet 144) are essentially overturned anticlines with the Dayi Plateau sandstones and the Kpandu Hill Series which are lithologically the same as Junner's group C above, outcropping in the core of the anticlines. With this structural interpretation, Group B and Group D of Junner's classification form the same unit of the Buem and constitute the Dayi Valley Series whose stratigraphic position is directly above Junner's Group C. Hence, the following sub-division is suggested for the Buem, from top to bottom:

B_3: Volcanic Group = Junner's Group A
B_2: Shales, mudstones, limestones with thin beds of greywacke and some tillite = Junner's Group B + Group D = Dayi Valey Series = Afram Shales
B_3: White bleached feldspathic sandstones, grits, quartzites and conglomerates = Junner's group C = Kpandu Hill Series = Iron-Ore Group = Togo Series.

The Buem Conglomerate is not well exposed. The author has mapped it as boulders (Blay, 1971) in Field Sheets 184 and 182. In the hand specimen, it is lithologically similar to the Akroso Conglomerate which the author has studied in the Kete Krachi area. The only difference lies in the texture. The pebbles and other rock fragments in the Buem Conglomerate are smaller. It appears, therefore, that the Buem Conglomerate is a facies of the Akroso Conglomerate and both are in fact regarded as being synchronous by the author (Fig. 2).

In the Abutor area of Field Sheet 184, siltstone, thin-bedded sandstone and limestone occur interbedded with basalts and andesites of the Volcanic Group. This association is also found west of Nkonya (Field Sheet 182) and West of Kpandu (Field Sheet 142).

Discussion

The undeformed shales and mudstones of the Oti Valley in the Sabari and Bimbilla areas have been correlated with the folded and overturned shales, mudstones and greywackes associated with the Shiene iron-ore rich rocks east of the Oti Valley. The Afram Shales and its associated siltstones are generally either undeformed or weakly so, west of the Volta River; but as they are traced eastwards from the Afram Valley across the Volta River into the Dayi Valley they become progressively buckled into fairly tight isoclinal structures and are actually traced into the Dayi Valley where they have been mapped as the Dayi Valley Series (Crook, 1963; Blay, 1983).

The shales and mudstones of the Oti Valley

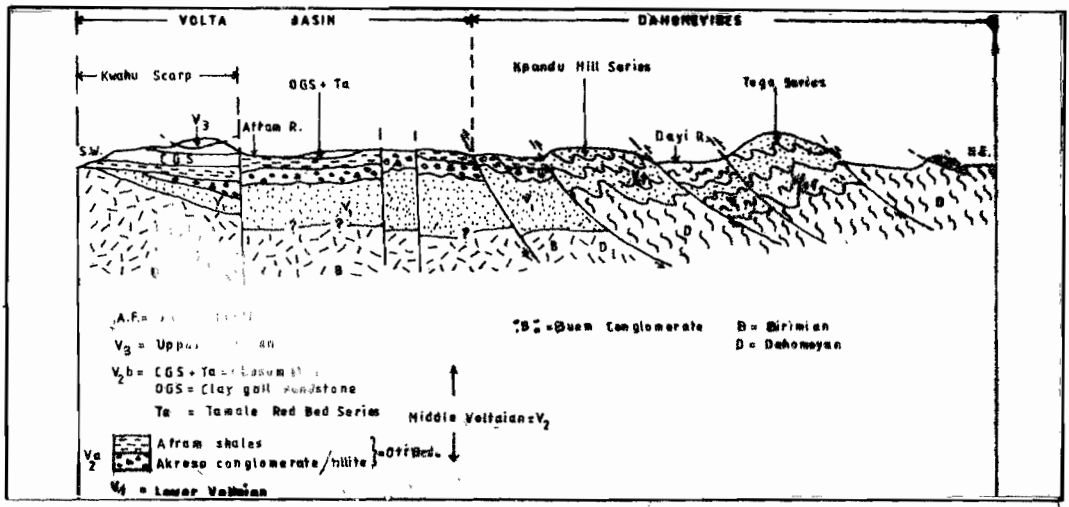

Fig. 2. A section showing the structure of the Volta Basin and the Dahomeyides

and the Afram Shales are correlatable and both belong to the Oti Series which have been stratigraphically assigned to the Middle Voltaian (Junner & Hirst, 1946; Anan-Yorke, 1980) whereas the Dayi Valley Series and the Iron-ore Group of sediments in the Shiene area have been mapped as Buem (Junner, 1940; Junner & Hirst 1946). This relationship is suggestive of synchroneity between the Oti Series and parts of the Buem Formation. If the stratigraphic position of the Afram Shales is accepted, then, it must be concluded that all sediments of the West African Craton and in the Buem Togo mobile belt which directly underlie the Afram Shales are correlatable; similar reasoning holds for the sedimentary breccias and arkosic group of the Kpandu Hill Series which belong to the Buem Formation and which are correlated with the quartzites of the Togo Series. In the area west of the Volta River, notably the Kwahu Scarp zone, evidence as to which rock units underlie the Afram Shales is provided by projecting the stratigraphic data obtained from borehole cuttings along the western and northern margins of the Volta Basin into the Kwahu Scarp zone.

In these areas the argillaceous Carbonate Series to which the Afram Shales belong appear to overlap the Conglomerate-Sandstone Series and directly overlies the Basal Sandstone of the Lower Voltaian. It follows that the Basal Sandstone at the western and northern margins of the Volta Basin may be correlated in time to the Kpandu Hill Series and the quartzites of the Togo Series. This interpretation further explains the absence of the Basal Sandstone along the southern and eastern margins of the Volta Basin. The correlation of the Kwahu Scarp Sandstones with the quartzites of the Togo Series by Saunders (1970) is thus untenable.

The stratigraphic relationships illustrated in Table 2 are based on field observation and borehole data in parts of the Volta Basin. In the eastern part of the Volta Basin the drilling by Bozhko *et al.* (1964) suggested the occurence of an anticlinorium in this area. The data in Table 2 further suggests that the Conglomerate Series on the western limb of the anticlinorium is laterally equivalent to the Buem Formation in the trough of the synclinal structure along the eastern flank of the same anticlinorium. The Lower Greenish-Grey Series is placed below the Buem Series and the Conglomerate Series as it structurally occurs within the core of the anticlinorium. Hence, the stratigraphic correlation of Table 3, modified after Bozhko *et al.* (1964) should be acceptable. Table 4 gives precise correlation of

TABLE 3

Stratigraphic correlation deduced from Table 2

Lower part of the Middle Voltaian	West of Volta Basin Afram Shales Conglomerate-Sandstone series	East of Volta Basin Buem Series Conglomerate-like tillite, mudstone siltstone, sandstone, quartzites and effusive rocks, greywacke, shales (Afram Shales in part)
Lower Voltaian	Basal Sandstone Series	Lower greenish-grey series polymictic sandstones, mudstones, and siltstones

The Dayi Valley Series (= Afram Shales) of Field Sheets 142 and 144 are traceable northwards through Field Sheet 182 to Field Sheet 184 where they have been mapped as Konsu Valley Shales (Blay, 1971). These shales overlie the arkosic sandstones and sedimentary breccias of the Kpandu Hill Series. In places within the outcrop area of the Kpandu Hill Series in Field Sheet 184, greenish-grey, pebbly, conglomerate-like rock occurs as boulders. This rock has been identified as the Buem Conglomerate. This so-called Buem Conglomerate is not widespread but it appears to occur at the top of the Kpandu Hill Series. Eastward from the axis of the Kpandu Hills the Afram Shales/Dayi Valley Series completely overlaps the Conglomerate Series as it is not

TABLE 4

Correlation of units of the Voltaian system with Buem Formation and Togo Series

	Voltaian area		*Buem area (F.S. 184, 182 & 144*	*Togo Series area (F.S. 142, 101, 103, 98, 62, 59 & 33*
Middle Voltaian	OTI SERIES OBOSUM BEDS	Tamale Red Beds	Not represented	Not represented
		Upper Greenish-Grey series - Kwahu Scarp Sandstones	Effusive rocks	Not represented
		Afram Shales	Dayi Valley series = Afram Shales = mudstones, siltstones, limestone and shales	Shales in the Tsibe-area of F.S. 142 = Afram Shales
		Conglomerate - series	Buem Conglomerate	Bame pass tectonised conglomerate
Lower Voltaian		Quartz-sandstone of Basal sandstone series	Arkosic sandstone, sedimentary breccias of the Kpandu Hill series and iron-ore groups of Santrokofi and Shiene areas	Togo quartzitic sandstones cataclastic quartzite, quartz-schists.
		Mudstone, siltstone of Basal Sandstone Series	Lower greenish-grey series i.e. mudstones, siltstones and polymictic sandstones	Togo phyllites, phyllonites, chlorite schists

some units of the Volta Basin sediments with units of the Buem Formation and the Togo Series.

found at all even as boulders. The stratigraphic correlation shown in Table 4 is based on the author's detail field mapping of Field Sheet 184 and

from his observations in key areas of Field Sheets 182 and 144, all in typical Buem rocks terrain.

Above the Afram Shales, the Upper Greenish-Grey Series and the Tamale Red Beds which are classified into the Obosum Beds(Junner & Hirst, 1946) do not find their lateral equivalents in the Buem and Togo areas east of the Volta Basin. It has been suggested (Grant, 1969) that the facies variation between the Voltaian System, the Buem Formation and the Togo Series are due to structural style and the grade of metamorphism.

The Geological Survey of Ghana (Annual Report, 1964-65, p. 73-4) and others, for example, Anan-Yorke & Cudjoe (1971), used metamorphism and structural style amongst other criteria, to distinguish between them. The Buem Formation and the Togo Series are complexly folded and faulted. On the other hand, the Voltaian is only folded along the eastern margin of the basin as indicated by the shales and mudstones of the Oti Series in the Sabari, Bimbilla and Shieni area, and also by the Afram Shales and limestones in the lower parts of the Afram and Pawnpawn river valleys.

The Buem and Togo rocks are units of the Pan-African Dahomeyide deformed belt, and as has been shown above, the Afram Shales and the Oti Valley Series are playing the dual role of belonging to the units of the mobile belt and units of the stable foreland.

Conclusion

From the above discussion, it is quite clear that based on the field relations, the Afram Shales unit of the Middle Voltaian Oti Series establishes lateral quivalence between the Lower Voltaian, parts of the Buem Formation and the Togo Series. The Afram Shales is a facies of the Dayi Valley Series of Buem Age. The following stratigraphic correlations have also been made:

(i) The quartz-sandstone unit of the Lower Voltaian Sandstone Series are synchronous with, and stratigraphically equivalent to, the Kpandu Hill Series, the Iron-ore Group of sediments in the Shieni and Santrokofi areas which belong to the Buem Formation, and the quartzites of the Togo Series.

(ii) The occurence of siltstone, thin-bedded sandstone and limestone interbedded with pillow lavas, andesites and basalts in the Abutor area west of Kwamekrom (Field Sheet 184) and west of Nkonya and Kpandu (Field Sheets 144 & 182) suggests that the Buem Volcanism is contemporaneous with the deposition of the limestone-siltstone-sandstone association which is correlatable with the Dayi Valley Series and the Afram Shales and, hence, the Buem Volcanism is probably synchronous with the deposition of the Afram Shales and the Dayi Valley Series and so partly Middle Voltaian.

(iii) Absolute age determination of the Voltaian, Buem and the Togo sediments is lacking, although some work has been started (Bozhko *et al.*, 1971; Anan-Yorke, 1980). To aid the stratigraphic correlation efforts so far based on field relations and borehole data, it is recommended that a sys tematic geochronologic programme to cover at least some units of the Voltaian System, the Buem Formation and the Togo Series be planned and carried out.

(iv) On the basis of the above stratigraphic correlations across the Voltaian, Buem and Togo stratigraphic boundaries the four-fold classification below is suggested:

Upper Voltaian:	Massive Sandstone Series
Middle Voltaian:	Buem Volcanics, the Obosum Beds (Tamale Red Beds = Anyaboni Formation; Upper Greenish-Grey Series = Kwahu Sandstone); Oti Beds (Afram Shales; Conglomerate-tillite Series and the Dayi Valley Series)
Lower Voltaian:	Basal sandstone series; Kpandu Hill Series, Iron-ore Group, the Togo

quartzites and the Lower Greenish-Grey Series.

Basement Rocks: Birimian and the re-activated Birimian (= Dahomeyan); Tarkwaian

Acknowledgment

The manuscript was read through by Dr Roland Anan-Yorke of the Geological Survey of Ghana and Dr Pascal Affaton of Laboratoire de Geologie Dynamique, Faculte des Sciences et Technique de Saint-Jerome. The useful suggestions and criticisms they offered are gratefully appreciated. The author is also grateful to Mr G. O. Kesse, Director of the Geological Survey of Ghana for permission to use unpublished material of the department.

References

AHMED, S. H., BLAY, P. K., CASTOR, S. B. & COAKLEY, G. J. (1977) The geology of field sheets 62, 61, 59 and 33. *Ghana Geological Survey Bull.* No.32.

ANAN-YORKE, R & CUDJOE, J. E. (1971) Geology of the Voltaian Basin. *Special Bull. for Oil Exploration.* Ghana Geological Survey.

ANAN-YORKE, R. (1980) A new classification proposal for the Voltaian Basin sediments. *Ghana Geological Survey Ann. Rep.*

BATES, D. A. (1955) *Geological map of Ghana.* Scale 1:1,000.000. Re-printed by the Survey Dept. 1966.

BELL, S. V. (1962) *Ghana Geological Survey Ann. Rep.* April 1961 - March 1962.

BLAY, P. K. (1968) *The geology of field sheets 62.* Ghana Geological Survey. (unpublished).

BLAY, P. K. (1976) Preliminary notes on the fold trends of south-east Ghana. In *Contribution to the geology of Ghana Vol.* 1.

BLAY, P. K. (1978) *The geology of field sheets 184, 185, 187. Ghana Geological Survey Bull.* No.45 (in press).

BLAY, P. K. & BRANTUOH, E. K. (1978) *The geology of field sheet 98.* Ghana Geological Survey. (unpublished).

BLAY, P. K. & KETE, K. S. (1978) The geology of field sheet 99. Ghana Geological Survey. (unpublished).

BLAY, P. K. (1983) The stratigraphic correlation of the Afram Shales of Ghana, West Africa. *J. Afr. Earth Sci.* **1** (1).

BOZHKO, N. A. *et al.* (1964) In Anan-Yorke R. and Cudjoe J. E., 1971.

BOZHKO, N. A., KAZAKOV, G. A., TROFIMOV, D. M., KNORRE, K. G. & GATINSKY, Y. A. (1971) *A new absolute dating of West African glauconites.* Acad. Nauk. SSR, Doklady, Earth Science Section, 198-139 (AGI translations).

CROOK, J. P. (1957) *Ann. Rept. of the Director, Geological Survey of Ghana* 1956-1957.

CROOK, J. P. (1963) *The geology of field sheets 142, 144 and 147.* Ghana Geological Survey. (unpublished).

CROOK, J. P. (1970) Some preliminary notes on the classification of rocks of S. E. Ghana. *Ghana Geological Survey Bull.* No. 38.

GRANT, N. K. (1969) The late precambrian to early paleozoic orogeny in Ghana, Togo, Dahomey and Nigeria. *Geol. Soc. Bull.* Vol. **80**.

JUNNER, N. R. (1936) *Ann. Report. of the Director, Ghana Geological Survey* 1935-36.

JUNNER, N. R. (1940) Geology of the Gold Coast and Western Togoland. *Gold Coast Geological Survey Bull.* No.11.

JUNNER, N. R. & HIRST, T. (1946) *The geology and hydrology of the Volta Basin.* Gold Coast Geological Survey . (Memoir 8).

KOERT, W. (1910) Notes accompanying geological map of Togo. *Hans Meyer's Das deutsche Kolonialrich, Vol. Leipsig and Vienna* (in German).

MALAVOY, J. (1932) Sur le Voltaian et L'Atacora (Gold Coast et Togo et Dahomey). *Acad. Sci. Competes Rendus T.*195, pp. 713-714.

MASON, D. (1963) The geology of field sheets 132, Bompata N. E. Ghana. *Geological Survey Bull.* No.33.

MITCHELL, J. (1955) *Ann. Report of the Director of Ghana Geological Survey* 1953-54.

MITCHELL, J. (1960) Limestones of Ghana. *Ghana Geological Survey Bull.* No. 23.

SAUNDERS, R. S. (1970) Early paleozoic orogeny in Ghana; Foreland Stratigraphy and structure. *Geol. Soc. Am. Bull.* **81**, 233-240.

TEVENDALE, R. (1957) The Geology of the Volta Dam Project. *Ghana Geo. Sur. Bull.* No.18.

Received 15 May 86; revised 13 April 89.