

VOLTAIAN BASIN WORKSHOP: MARCH 2008

FIELD EXCURSION GUIDE AND NOTES



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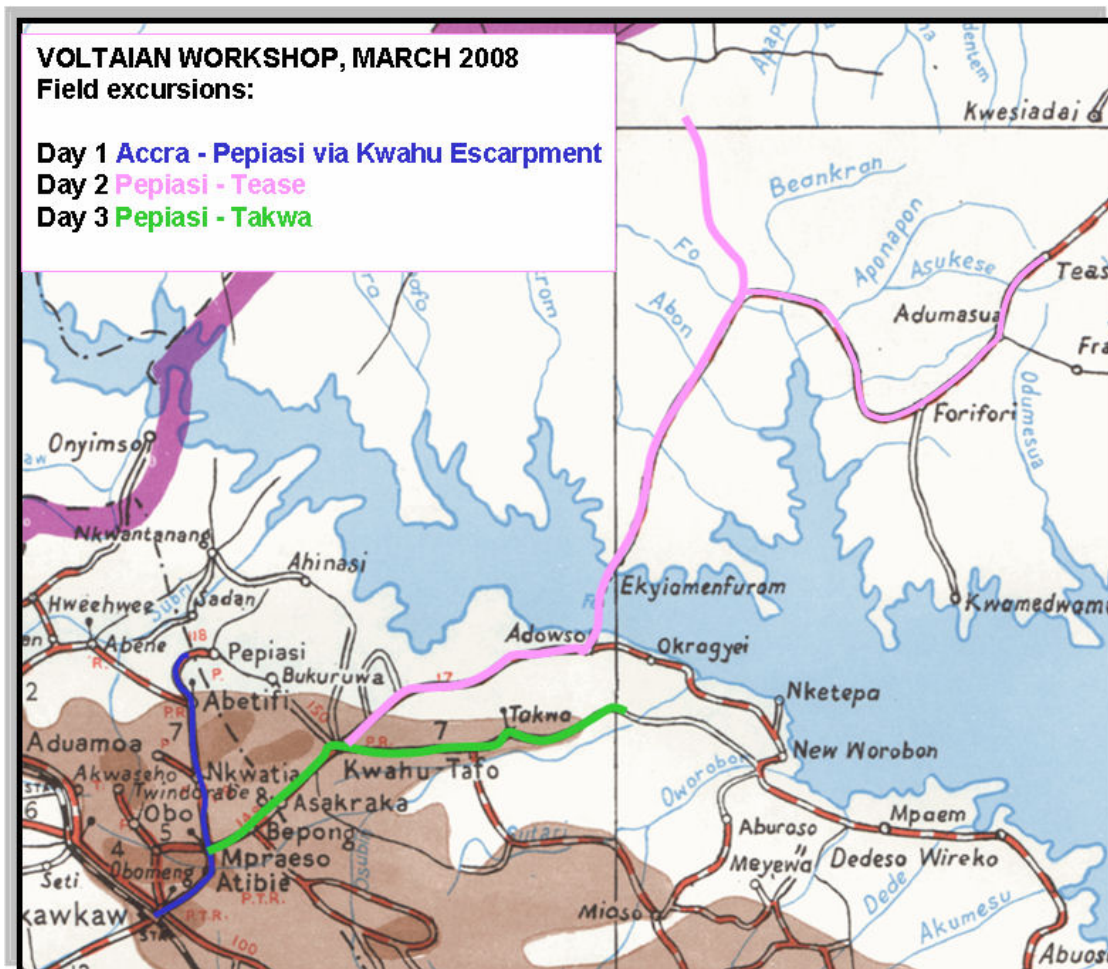
**British
Geological Survey**
NATURAL ENVIRONMENT RESEARCH COUNCIL

Provisional Itinerary

Day 1 Travel from Accra to Pepiasi. View Kwahu escarpment, basal Voltaian unconformity and (if there is time) sandstones of the Mpraeso and Abetifi formations.

Day 2 Pepiasi to Tease, via Adowso Ferry. Obosum Group sandstones and Tease Sandstone. Views of Afram Escarpment, Abetifi Sandstone and channel bodies in Anyaboni Sandstone.

Day 3 Pepiasi to Takwa. Exposures in Abetifi and Anyaboni sandstones; discussion on methodologies for remote mapping of these units.



Note: This excursion summarises only some of the findings of a FUGRO/BGS project aimed at establishing the mineral potential and stratigraphy of the Volta and Keta basins. A table listing all of the stratigraphical units that will appear on the final GIS and 1:250 000 scale maps is provided at the back of this Guide.

Remote mapping Methodologies used on the Project

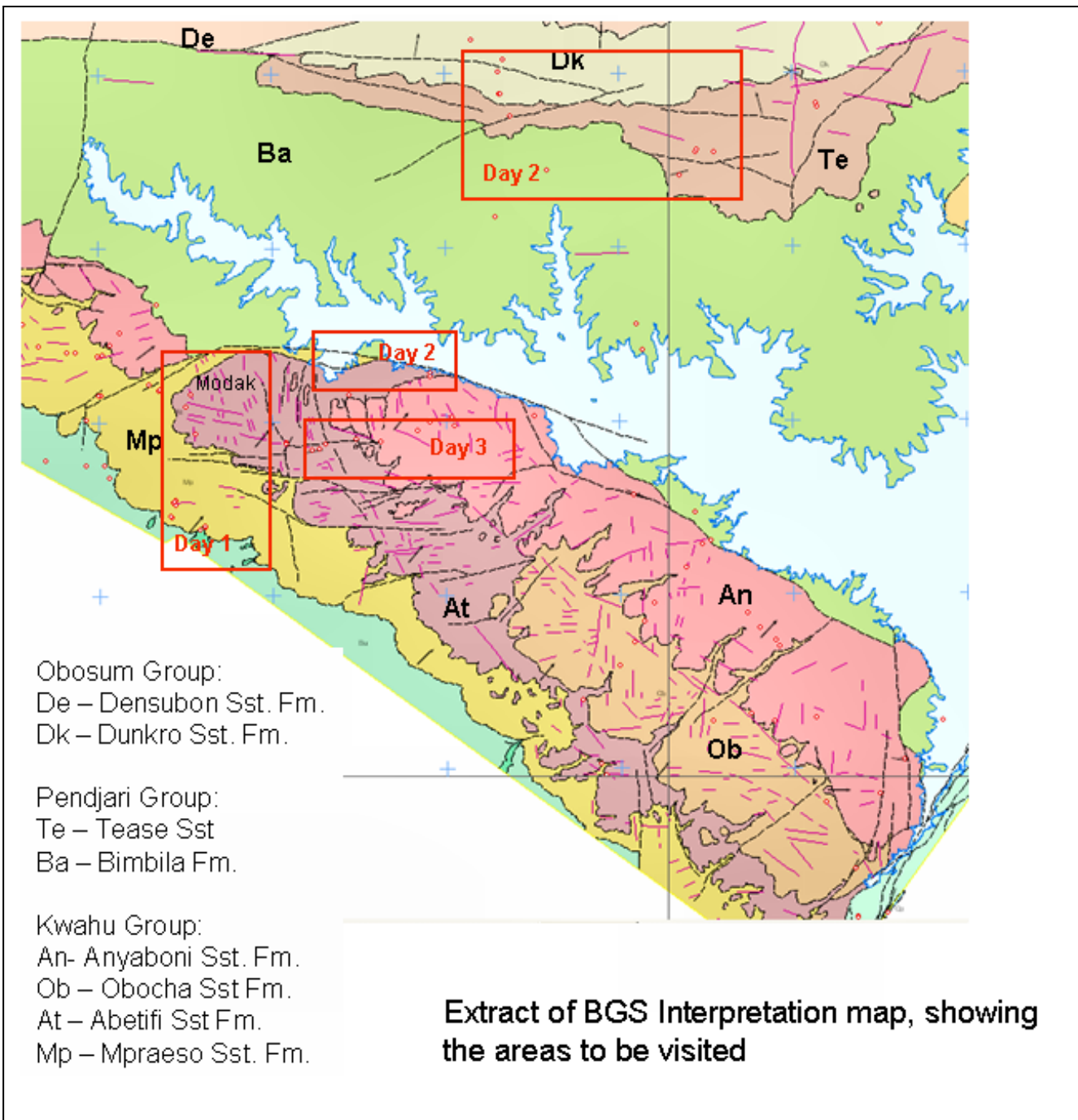
The gently tilted Neoproterozoic sedimentary rocks of the Kwahu Group give rise to bold features that can be viewed on a desk-top workstation and used to construct a preliminary geological map. In order to do this, a digital terrain model (DTM) of the topography is manipulated to enhance those geomorphological features that correspond to the boundaries of rock outcrops, as shown on the image below. The preliminary interpretation map (see extract on next page) will form the basis for subsequent field-based geological surveys.

The principal structural elements recognisable on the remote sensing imagery include: Bedding – traces and planes; Lithological units – marker beds and stratigraphic successions; Lithological boundaries and unconformities; Fractures – faults, shear zones and joints.

An understanding of the bedding is essential for a remote sensing interpretation of the geological structure, and hence the stratigraphy; although in areas where no bedding can be seen due to deep weathering or cover by superficial deposits then detailed fieldwork, possibly including shallow drilling, is a prerequisite. Bedding manifests itself in various ways on the remote sensing imagery, the clearest being the ‘bedding trace’, which is the line separating the dip slope from the relatively steeper scarp slope (see map below, and discussion on p.18).



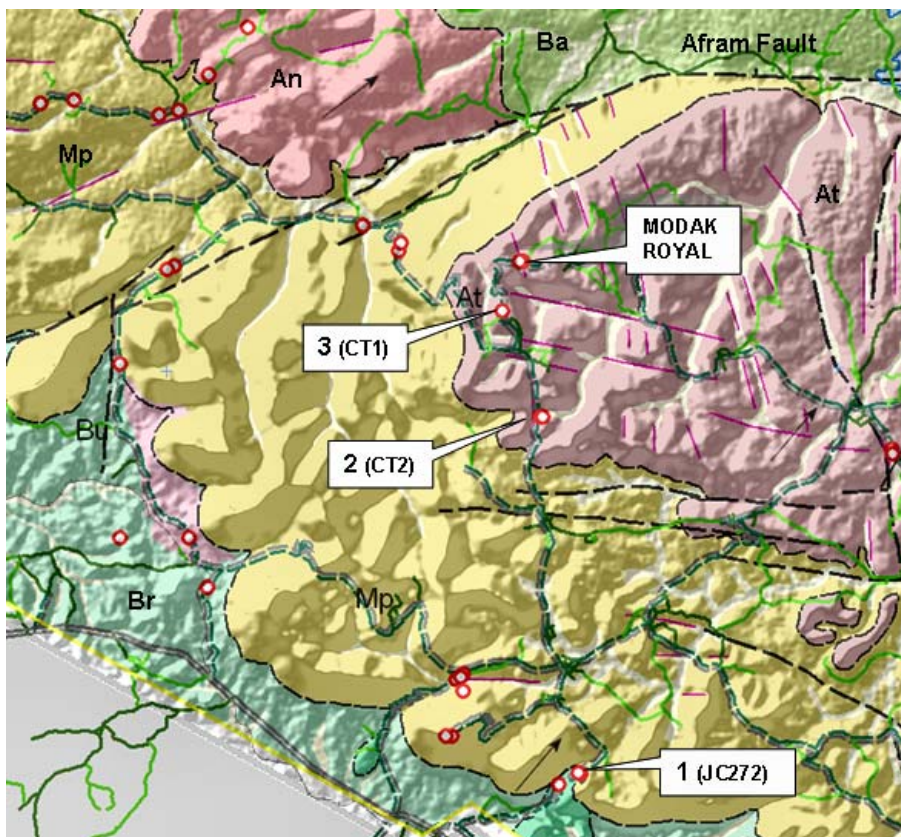
Oblique view of the Kwahu area, looking NW and showing the main geological units draped over the DTM. The geological interpretation map for this area is shown on the next page.



Day 1 – Accra to Pepiasi

The excursion commences with excellent exposures showing the basal unconformity of the Mpraeso Sandstone Formation on Birimian granitoid (Locality 1). If time allows, other exposures of the Mpraeso Sandstone will be viewed along the escarpment and on the dissected dip slope to the north. Localities 2 and 3 show facies variations within the next-highest unit, the Abetifi Sandstone Formation.

The map below shows that the Afram Fault has exerted an important control on sedimentation during deposition of the Kwahu Group. Westwards across the fault, the Abetifi Sandstone disappears and only two units are represented: the Mpraeso Sandstone Formation and overlying it, the Anyaboni Sandstone Formation (see map on preceding page).



DAY 1: GEOLOGY & LOCATIONS

Pendjari Gp:
Ba-Bimbila Formation

Kwahu Gp:
An-Anyaboni Sandstone Fm.
At-Abetifi Sandstone Fm.
Mp-Mpraeso Sandstone Fm.

Pre-Voltaian:
Br-Birimian

↗ Structural dip
(Generalised, from remote imagery)

Day 1: Locality 1 (JC 272), the basal Kwahu Group unconformity

UTM 30 Grid Reference: 750917 726379. Roadside section on Kwahu Escarpment

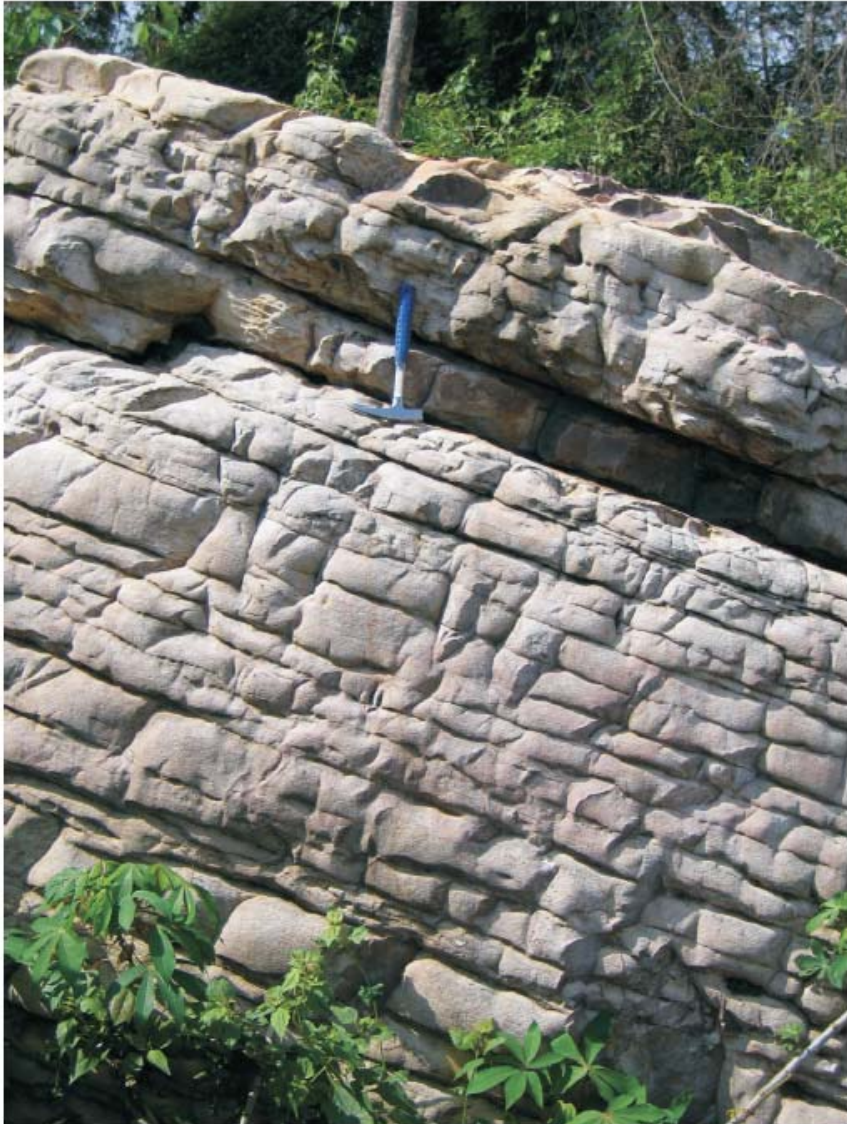


Description: Core stones of Birimian granitoid are mantled by mudstones and siltstones, which form the local base to the Mpraeso Sandstone (Kwahu Group). Certain of the basal mudstone and siltstone beds show flexuring and load structures, which were possibly induced by compaction against an irregular Birimian surface (photo at lower right). Beds of fine-grained, micaceous sandstone increase in proportion, and become progressively thicker, up the section. Higher up, the Kwahu Escarpment is composed of a thick sequence of white, highly mature quartzitic sandstones forming the middle and top of this spectacular feature (front cover picture of this Guide).

Interpretation: The core stones indicate that weathering during this part of the Neoproterozoic occurred within a humid to semi-arid climatic regime.

The depositional environment of these basal beds of the Mpraeso Formation is uncertain: they may represent early lacustrine or deltaic (marginal marine) conditions, which were superseded by fluvial channel environments (quartz-rich sandstones higher up the escarpment) as sea levels fell. Samples from the basal mudstone are currently being investigated for acritarchs, which if present would confirm a marine environment.

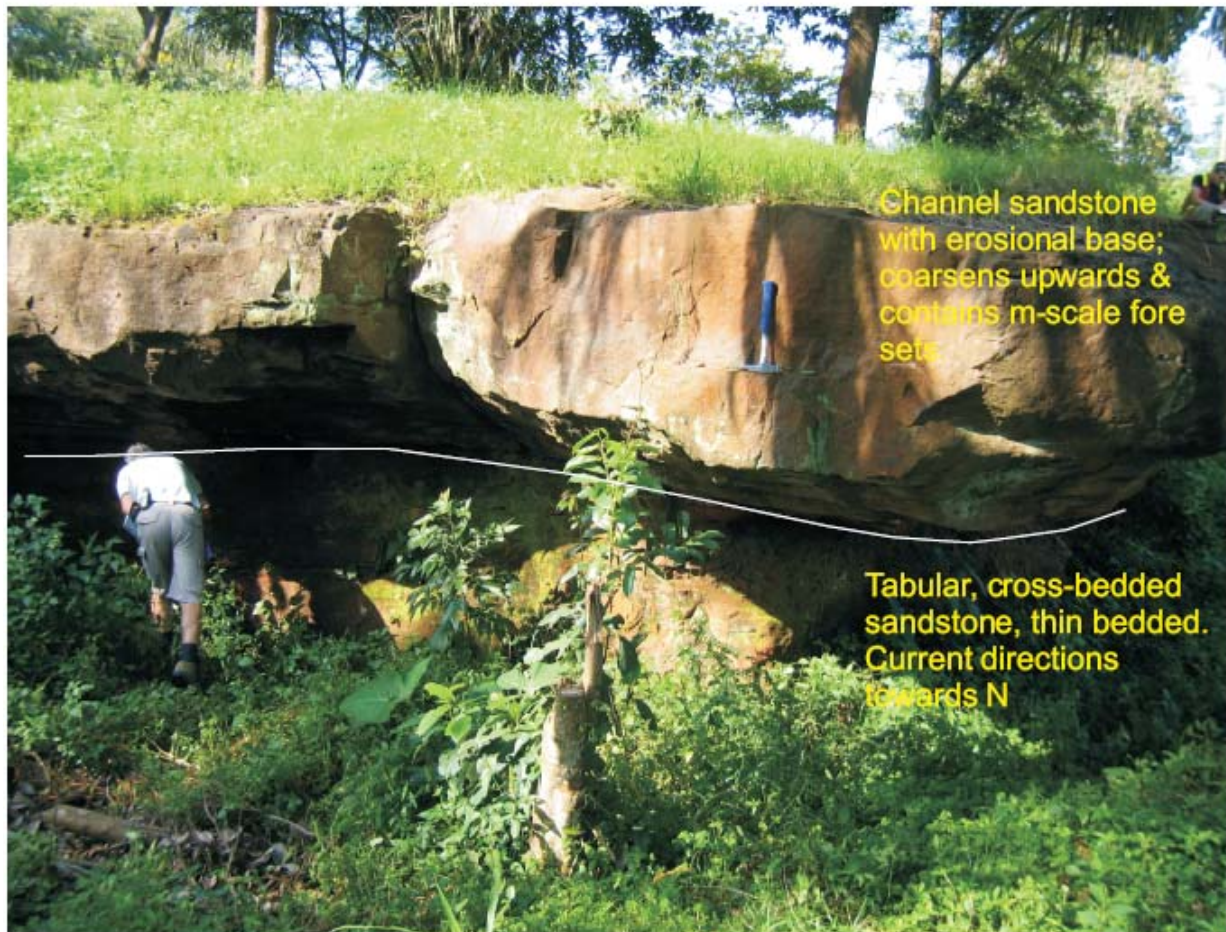
Day 1, Locality 2 (CT2): Abetifi Sandstone Formation
UTM 30 Grid Reference: 750917 726379



Description: Thin to medium bedded quartzite with well-developed 'saw-tooth' profile to beds, suggesting that they are graded and fine upwards. Tabular beds are laterally very extensive. Bed tops are scoured locally and some are weakly rippled and undulatory. In some places there is very faint, low-angled cross stratification (current towards the E).

Interpretation: The saw-tooth profile and laterally extensive tabular character are typical of graded turbidites. The mature, very quartz-rich sandstone is interpreted to have been deposited by turbidity currents from a beach or delta system into deeper waters near to a shoreline, possibly due to storm activity. Very weak (?storm-induced) reworking is suggested by the gentle undulations seen along certain bed-tops.

Day 1, Locality 3 (CT1): Abetifi Sandstone Formation
UTM 30 Grid Reference: 748771 739094. Near Presbyterian Church



Channel sandstone with erosional base; coarsens upwards & contains m-scale foresets

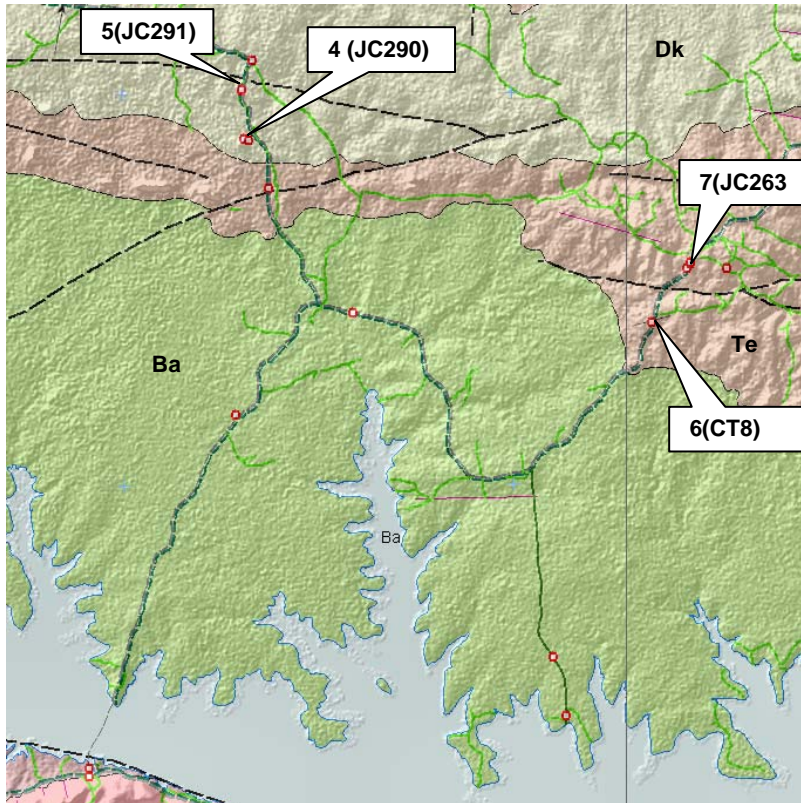
Tabular, cross-bedded sandstone, thin bedded. Current directions towards N

Description: Sandstone, quartz-rich, medium- to coarse-grained and medium to very thick bedded in the upper unit. Foresets in the lower beds indicate transport directions towards the N. Those in the upper unit vary more widely, from SW to N. Well-rounded quartz-rich granule lags are present in some channel bases.

Interpretation: Fluvial sandstone, the upper unit being deposited in a channel with an erosive base.

Day 2 – Pepiasi to Tease via Lake Volta (Adowso Ferry)

This part of the Excursion falls into 2 stages. In the **morning** the priority is to catch the Ferry at Adowso, and then proceed to localities 4-7 in the Obosum and upper Pendjari groups ('North' map). On returning to the southern shore in the **afternoon**, there may be sufficient time to visit localities 8 & 9 ('South' map)

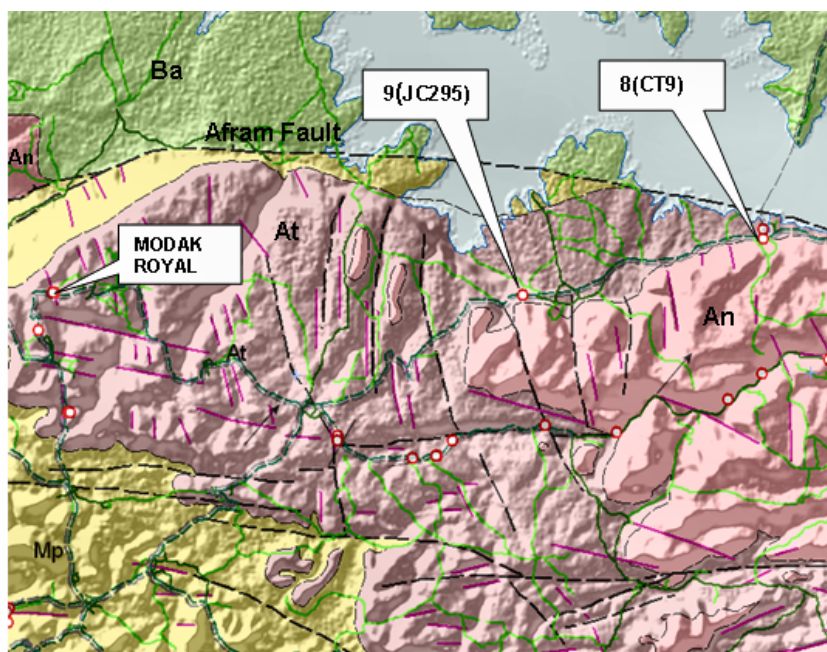


DAY 2: GEOLOGY & LOCATIONS (North)

Obosum Gp:
Dk-Dunkro Sandstone Fm.

Pendjari Gp:
Te-Tease Sandstone Fm.
Ba-Bimbila Formation

↗ Structural dip
(Generalised, from remote imagery)



DAY 2: GEOLOGY & LOCATIONS (South)

Pendjari Gp:
Ba-Bimbila Formation

Kwahu Gp:
An-Anyaboni Sandstone Fm.
At-Abetifi Sandstone Fm.
Mp-Mpraeso Sandstone Fm.

↗ Structural dip
(Generalised, from remote imagery)

Day 2, Locality 4 (JC290): Dunkro Sandstone Formation (Obosum Group)
UTM 30 Grid Reference: 7482218 772307. Large koppies to west of road.



Description: Sandstone, weathering red-brown, medium to coarse-grained and very thickly bedded to locally massive. Some thinner intervals show cross-bedding, which is locally oversteepened. Compositionally, these sandstones are rich in feldspars and lithic grains, and thus are highly immature. The bedding is locally chaotic, with slumps and lenses of bouldery, matrix-rich conglomerate. Palaeocurrents are towards the SW and W.

Interpretation: Very rapidly deposited and poorly sorted, little reworked fluvial sandstone, probably deposited by flash floods and/or debris flows in or adjacent to wadis. The whole association has been interpreted as a terrestrial molasse to the Pan African orogen

Day 2, Locality 5 (JC291): Dunkro Sandstone Formation (Obosum Group)
UTM 30 Grid Reference: 781931 774671. Pavements by roadside.



Description: Red-purple sandstone; highly immature composition indicated by abundant feldspar and lithic grains. Medium- to coarse-grained, with sporadic 'floating' pebbles and pebble lags. Pebbles include pink porphyritic ?microgranite and foliated ?metasedimentary lithologies. Pebble lags seem to be associated with scour troughs. Palaeocurrent to WSW.

Interpretation: As for Locality 4, a very rapidly deposited, poorly sorted and worked fluvial sandstone, probably deposited by flash floods or debris flowage in or adjacent to wadis. Part of the terrestrial molasse, which was deposited during uplifts associated with the Pan-African orogen farther east.

Day 2, Locality 6 (CT 8): Tease Sandstone Formation (Top of Pendjari Group)
UTM 30 Grid Reference: 801269 763747. Exposures in front of school



Description: Sandstone, medium- to coarse-grained, quartz-rich but with some feldspar. Hard and well cemented, with heavy mineral rich laminae in the foresets. Thin trough cross beds in herring-bone form are prominently developed. Palaeocurrents (uncorrected for tectonic dip) towards the N and SW.

Interpretation: Shallow marine (upper shoreface) sandstone deposited under the influence of high energy tidal waters. The relatively high degree of compositional maturity of these sandstones, compared to typical Obosum Group lithologies, is one of the reasons for placing this unit at the top of the Pendjari Group, rather than within the Obosum Group.

Day 2, Locality 7 (JC263): Tease Sandstone Formation (Top of Pendjari Group)
UTM 30 Grid Reference: 803056 766542. Tease Village.

This locality represents a continuation of the sandstones seen at locality 6. The sandstones are white and cross-laminated, and are feldspathic. Most are medium-grained and moderately well sorted, but there are also some very coarse/granule lenses and mudflakes. Some coarse, 'millet seed' grains occur, suggesting a local aeolian influence during deposition. No pictures are available.

Day 2, Locality 8 (CT9): Abetifi Sandstone Formation (Kwahu Group)
UTM 30 Grid Reference: 774729 742383. Roadside cutting.

Description: The sandstone here is a fine- to medium-grained, pale buff coloured quartzite. It is locally cross-bedded (currents towards the NE), but is dominantly plane laminated in medium and mainly thick beds. Possibly some HCS (hummocky cross-stratification) is present, indicated by shallow, swaley lamination. No pictures are available.

The exposure represents the top-surface of the Abetifi Sandstone, which here forms a broad platform, the edge of which lies to the north. The escarpment feature of the Anyaboni Sandstone rises above this locality, not far to the south. Along this escarpment, a major channel feature is developed at the base of the upper package of beds that form the Anyaboni Sandstone succession.

Interpretation: Although this exposure is of limited size, the features present suggest deposition within lower shoreface environments, above storm-wave base.

Day 2, Locality 9 (JC295): Abetifi Sandstone Formation (Kwahu Group)
UTM 30 Grid Reference: 7766104 740391. Pavements on plateau to N of road.

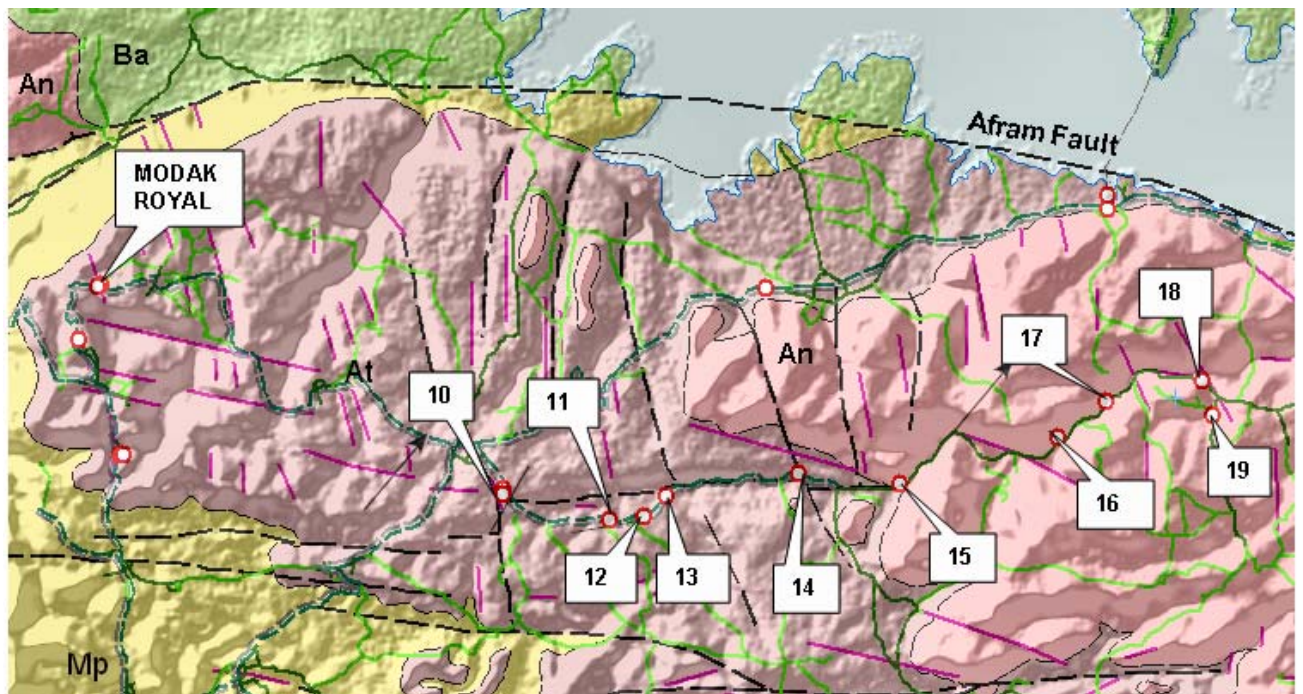
Description: This exposure is probably a continuation of that seen at Locality 8, in that it represents the topmost beds of the Abetifi Sandstone. The exposures are in pale grey to cream, ripple-marked and cross-laminated quartzitic sandstone. Some interference ripple structures are visible, one set of which may have been formed by wind-driven currents. Palaeocurrents are mainly in the SE and SW quadrants. No pictures are available.

Interpretation: The high degree of current-agitation suggests that these sandstones may have been deposited in upper shoreface environments subjected to tidal and wind-driven current activity.

Day 3, Area between Pepiasi and Takwa, upper Kwahu Group

The object of today's excursion is to view the range of sedimentary structures and environments shown by the Abetifi and Anyaboni sandstones. There are also readily accessible exposures showing the basal facies of the Anyaboni Sandstone.

The area offers an opportunity to view and discuss the methodology behind 'remote' geological mapping using features and imagery. With this methodology (see also, inside front cover), geomorphological features seen on the ground and on remote images provide a means for tracing geological boundaries; they include the scarp slopes and dip slopes that define the outcrops of the various sandstone units (see also, p.3).



DAY 3: GEOLOGY & LOCATIONS

Pendjari Group:
Ba-Bimbila Formation

Kwahu Group:
An-Anyaboni Sandstone Fm.
At-Abetifi Sandstone Fm.
Mp-Mpraeso Sandstone Fm.

Day 3, Locality 10 (CT3; JC279): Abetifi Sandstone Formation (Kwahu Group)
UTM 30 Grid Reference: 759496, 735183. Section down side-road ('Be A Man').



Description: Hard, creamy-white, quartz arenite sandstone. Medium to very coarse-grained, with granules; commonly very well-sorted, with well-rounded grains, Compositionally very mature. Beds are thin to medium in thickness, and are plane- to commonly cross-stratified, with herring-bone cross-stratification developed locally. Palaeocurrents here are bipolar, to NE and SW.

Interpretation: High energy, upper shoreface deposits, accumulated under the influence of tidal (ebb and flood) currents possibly within an estuary or bay. This facies appears to form the uppermost part of the Abetifi Sandstone (see also, Locality 9), and may suggest a northward-prograding shoreface environment.

Day 3, Locality 11 (CT4; JC280): Abetifi Sandstone Formation (Kwahu Group)
UTM 30 Grid Reference: 762159 734528. Roadside pavement.



Description: Pale grey, coarse to very coarse-grained, locally granule grade quartzite. Very well rounded grains, some of which have a high sphericity; the sandstone is generally very well sorted. Palaeocurrents are towards SW and NW

Interpretation: Similar to Locality 10, probable upper shoreface beach deposits. The unit is interpreted as part of a northwards prograding shoreface system. Its presence suggests a sea-level highstand, wherein no accommodation space is being created, so that the shoreface sands can migrate laterally into the basin inferred to the north.

Looking northwards from here, the top surface of the Abetifi Sandstone forms a very prominent dip slope feature, with an easterly as well as a northerly dip component (ie overall dip to the NE). The erosional scarp slope of the Anbyaboni Sandstone feature rises above the Abetifi dip slope (see photo above).

Day 3, Locality 12 (CT5; JC281): Abetifi Sandstone Formation (Kwahu Group)

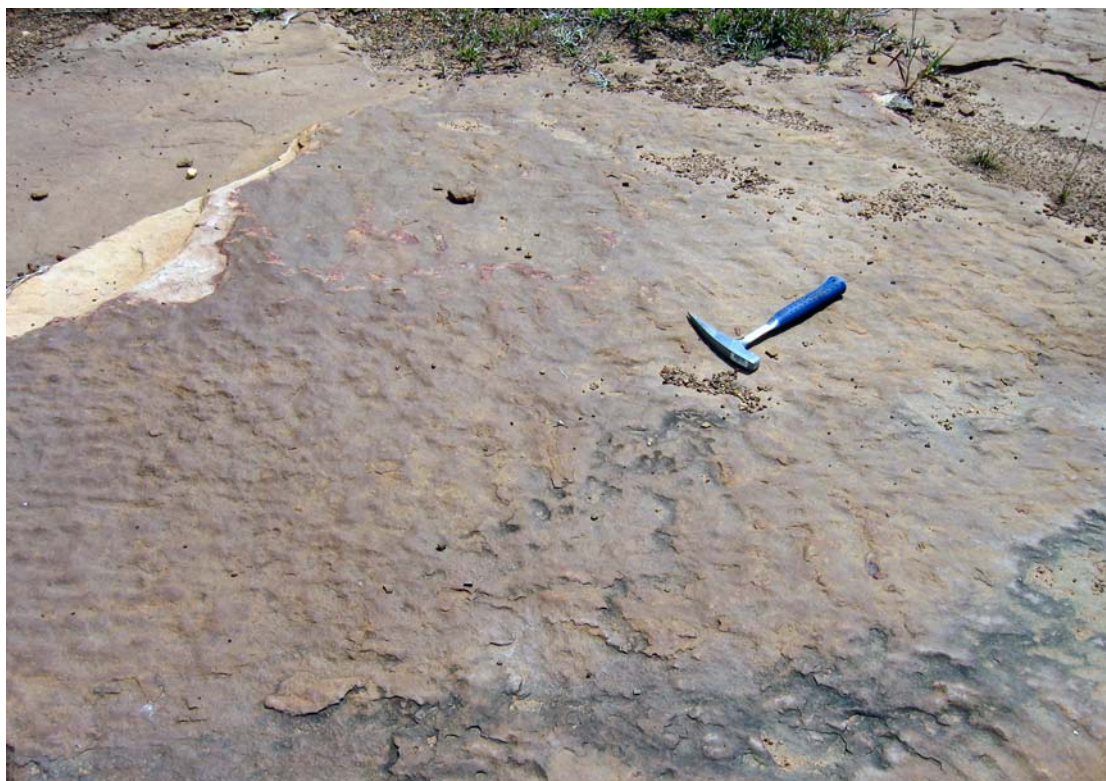
UTM 30 Grid Reference: 763026 734620. Roadside pavement.

Description: Sandstone, medium- to coarse-grained, locally micaceous, planar bedded to small-scale trough cross-bedded. Some wind and current ripples well preserved on bedding surfaces. The troughs indicate palaeocurrents to the NE.

Interpretation: Fluvial to very shallow marine (intertidal/estuarine).

Day 3, Locality 13 (CT6; JC282): Abetifi Sandstone Formation (Kwahu Group)

UTM 30 Grid Reference: 763602 735144. Roadside pavement.



Description: Sandstone, medium- to coarse-grained, locally micaceous, with trough cross-stratification seen in plan view, and very good (?) wind-driven current ripples; the latter locally interfere with former, as shown by the image above. Palaeocurrents are to NE and NW.

Interpretation: Shallow water, marine; possibly shoreface or estuarine.

Day 3, Locality 14 (JC283): Abetifi Sandstone Formation (Kwahu Group)

UTM 30 Grid Reference: 766912 735699. c. 6m roadside sections.

This section is in quartz arenites forming the uppermost part of the formation, and directly underlying the Abetifi dip slope. The topmost bed is in coarse-grained sandstone with ripples and trough x-lamination. One palaeocurrent measured, to the NE. No images are available

Day 3, Locality 15 (JC284): Anyaboni Sandstone Formation (Kwahu Group)

UTM 30 Grid Reference: 769493 735452. Road exposures in basal beds.

Description: These limited exposures indicate that the very base of the Anyaboni Sandstone is composed of purple-grey, very fine-grained, highly micaceous sandstone. Some local fine-scale cross-lamination indicates a palaeocurrent to the SW.

Interpretation: These beds may represent fluvial to estuarine conditions, perhaps due to a fall in sea-level and consequent progradation of the shoreline outwards (i.e. towards the former area of marine deposition), relative to the more mature, current-worked shoreface conditions in the underlying beds forming the top of the Abetifi Sandstone (eg at Locality 13). This trend was continued higher in the Anyaboni Sandstone, where fluvial 'red bed' facies are present.

It is probable that vertical variations in lithology, upwards through the Kwahu Group, have played a major role in forming the geomorphological features (scarp and dip topography, see page 3) that allow the outcrop limits of the sandstone formations to be interpreted from the remote imagery. We have seen both here and at Locality 1 that the features formed by two sandstone units (Mpraeso and Anyaboni formations) commence in basal fine-grained, micaceous, flaggy to very thinly-bedded sedimentary lithologies – with mudstone and siltstone also present at the base of the Mpraeso Sandstone. The other two sandstone units (Abetifi and Obocha formations) commence with the same thinly bedded facies. Basal strata of this composition will be more easily eroded than the hard, cemented, quartzitic or arkosic sandstones that predominate higher up in these cyclical units. Consequently, their removal by weathering agencies (streams and mass-wasting) would enable erosional scarps to be formed, which would then wear back, resulting in the type of topography seen on the Kwahu plateau.

Day 3, Locality 16 (JC288): Anyaboni Sandstone Formation (Kwahu Group)
UTM 30 Grid Reference: 773481 736619. Traverse up gully.



Description: This traverse makes use of a recent erosion gully to examine debris from the middle to upper part of the Anyaboni Sandstone, which is exposed in the crags higher up. The debris shows a wide range of sedimentary rock-types and structures appropriate to fluvial and possibly aeolian environments. The sandstones are red and arkosic, with sporadic green or maroon mudflakes. They are plane-laminated to cross-laminated and are locally cross-bedded in units up to 2 m thick. Some debris show 'pinstripe' lamination, and rounded, millet seed grains are also present.

On the opposite (SE) valley side, very thickly bedded sandstones with large-scale foreset beds are visible.

Interpretation: Fluvial red beds, possibly deposited in a major river channel distributary system (see also, view from Adowso Ferry and road, Locality 8). Aeolian dune fields may have been present within the basin and were reworked by the fluvial systems.

Day 3, Locality 17 (JC285): Anyaboni Sandstone Formation (Kwahu Group)
UTM 30 Grid Reference: 774687 737538. Roadside section in lower/middle beds.



Description: Red, fine-to medium-grained arkosic sandstone, in tabular, locally down-cutting, thin to dominantly medium and thick beds. Note very sharp and planar tops and bases to beds. Beds are poorly structured internally, although faint parallel lamination is observed in places. Low-angle cross lamination indicates a palaeocurrent to the NE.

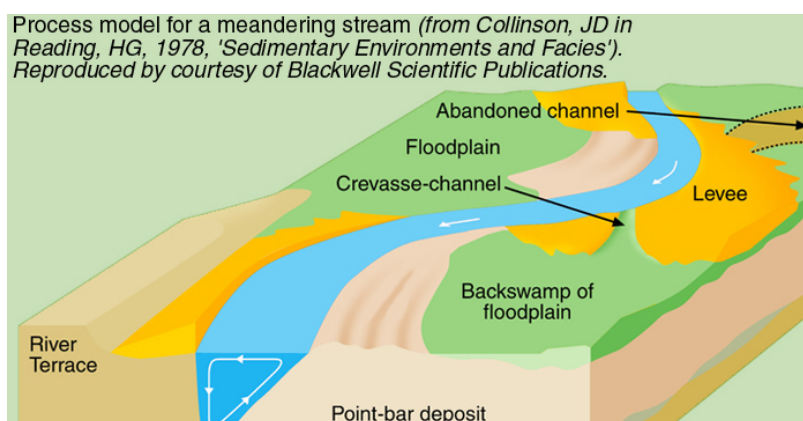
Interpretation: The red colour strongly suggests this sandstone is terrestrial in origin and thus part of a fluvial system. In this case, the relative paucity of well-defined cross-stratification and the sharp bases suggest a sheet flood origin for these beds. Note that, in the Neoproterozoic, the absence of the confining effects of vegetation cover may have aided the deposition of sheet flood sand bodies such as these.

Day 3, Locality 18 (JC287): Anyaboni Sandstone Formation (Kwahu Group)
UTM 30 Grid Reference: 777093 738054. Exposures in Apaiska village.



Description: Very thick-bedded, red, cross-stratified sandstone. The sandstone is medium-grained, immature, feldspathic and locally lithic. Palaeocurrents mainly to NW.

Interpretation: These red beds are interpreted to be part of a major fluvial system. The foresets shown here indicate deposition in a major channel and probably forming part of a point bar, as in the diagram below:



Day 3, Locality 19 (JC286): Anyaboni Sandstone Formation (Kwahu Group)
UTM 30 Grid Reference: 777345 737190. Roadside exposures.



Description: Close to the local top of the Anyaboni Sandstone. Beds are apparently massive and composed of red, medium-grained arkose (c. 20-30% white feldspar grains). A feature of this exposure is a purple to green-grey, all-pervasive lamination.

Interpretation: The environment of deposition was probably fluvial, but is very difficult to ascertain because all original primary sedimentary structures have been obliterated by a secondary lamination. This was probably caused by water table fluctuations during diagenesis.

In the distance to north, the upper beds of the Anyaboni Sandstone are weathered into rounded tors characterised by white weathering colours.

GHANA – FINAL STRATIGRAPHICAL TABLE, BGS/FUGRO Project, Phase 4: UPDATED 2007/08			
AGE	VOLTA BASIN	PAN AFRICAN BELT	KETA BASIN
Quaternary (Holocene)	Alluvium (map-symbols) Alluvial Fan Deposits River Terrace Deposits Quaternary Deposits of uncertain origin		Alluvium (map-symbols) Volta Delta Deposits Tidal Flat Deposits & Salt Pans Shoreface & Beach Deposits Raised Tidal Flat Deposits Raised Beach Deposits River Terrace Deposits
Cenozoic to Pleistocene			Agbakope Sand (Ag) Koluedor Gravel (K)
Cenozoic	Central Volta Surface: Laterite, including gravels and cover silts/sands (as map-symbol)		Laterite & cemented gravel (not mapped)
Neoproterozoic	VOLTA SUPERGROUP Obosum Group: Undivided mudstones, siltstones and sandstones (Os) Tamale Sandstone Formation (Ta) Densubon Sandstone Formation (De) Dunkro Sandstone Formation (Dk) --- UNCONFORMITY --- Pendjari Group: Undivided mudstones, siltstones and sandstones (Pj) Bimbila Formation: Undivided mudstones, siltstones and sandstones (Ba) Bunya Sandstone Member (By) Chereponi Sandstone Member (Cp) Akroso Conglomeratic Member (Ak) Tease Sandstone Formation (Te) Ejura Sandstone Formation (Ej) Afram Formation (Af) Kodjari Formation (Kj): Darebe Tuff Member (Db) Buipe Limestone Member (Bp) -- MAJOR UNCONFORMITY --	Buem Structural Unit: Undivided mudstones, siltstones and sandstones, locally sheared and foliated (Bm) Oterkpolu Limestone Member (Op) Todzi sandstones (Tz) Tokor volcanics (Tk)	
Neoproterozoic	Kwahu Group: Anyaboni Sandstone Fm (An) Obocha Sandstone Fm (Ob) Abetifi Sandstone Fm (At) Mpraeso Sandstone Fm (Mp) Damongo Formation (Dg) Yabraso Sandstone Formation (Yb) Undivided mudstones and siltstones (Kw)	Bombouaka Group (Bk): Panabako Sandstone Fm (Pn) Damongo Formation (Dg) Poubogou Fm (Pg) Tossiegou Fm (Ts)	
Palaeoproterozoic	Birimian Supergroup (Br) Greenstone (grs) Undivided (gn)		Dahomeyan Complex Mesocratic orthogneiss (mgn) Leucocratic orthogneiss (lgn)

