

LITHOLOGY, AGE AND STRUCTURE OF EARLY PROTEROZOIC GREENSTONE BELTS, WEST AFRICAN SHIELD; Kodjo Attoh, Geology Department, Hope College, Holland, MI 49423

Distribution, Lithologic characteristics and Stratigraphic relations. Distribution of early Proterozoic volcanic rocks in the West African shield is shown in Fig. 1; an approximate boundary between Archean age terrane, to the west, and the Proterozoic terrane to the east, is partly marked by a major fault. Lithologic and chemical data have been compiled for belts (2-9) in the Proterozoic terrane from BRGM reports [1,2]. Available stratigraphic information from geologic maps of these areas indicate that a typical sequence is comprised of predominately mafic lava flows (basalt-andesite) at the base, which are overlain by felsic volcanic rocks including pyroclastic rocks and lavas. This succession, referred to as Lower Birimian, is overlain by Middle and Upper Birimian sedimentary rocks. Lithostratigraphic data from belt (1), located in northeastern Ghana [3], indicate the volcanic succession is 6-8 km thick. The lowest unit in this succession is represented by 2 km of felsic pyroclastic rocks, flows and fine grained sediments. This is followed by 3-4 km of basaltic lava flows which are locally pillowed, the top of the unit is marked by a distinctive manganese formation (MF) consisting of Mn-Fe rich cherts up to 200 m thick. Dacitic lithic tuffs, welded tuffs and andesitic flows up to 2500 m thick overlie the mafic lava flow unit. The youngest volcanic unit consists of mafic tuffs and breccia with a distinctive fragmental texture. Preliminary data indicate that a similar succession occurs in belt (10). The internal plutonic rocks of belt (1) include: (a) hornblende-bearing granodiorite bodies considered to be subvolcanic plutons (σ -plutons); and (b) post-kinematic mica-bearing granitic plutons (π -plutons). External plutonic rocks include tonalitic and granodioritic rocks which immediately flank the volcanic belt, and paragneisses which occur within the plutonic terrane.

Chemical characteristics and Ages. Of about 100 chemical analyses reported for belts (2-9) calc-alkaline rocks constitute 55% and tholeiites 45%. Quartz-normative basalt constitutes 99% of the rock type in the tholeiitic suite. In the calc-alkaline suite, 9% of the analyses is basalt, 45% andesite and the rest is dacite and rhyodacite. The ratio of tholeiitic to calc-alkaline rocks based on the stratigraphic thicknesses and chemical analyses of samples from belt (1) is between 57% and 43%. Ultramafic volcanic rocks occur in belt (3), indicated from chemical data from belt (6) and (9) and constitute 1% of all samples analysed. Komatiites have not been reported from the West African Shield, thus the rocks analysed may be classified as high-Mg-basalts. The tholeiitic rocks from belt (1) are enriched in Ti, and depleted in Zr relative to modern ocean floor basalts [4], and are depleted in K, Rb, Sr and Ba relative to the calc-alkaline rocks. Within the calc-alkaline suite which include the subvolcanic plutons, the major and trace elements show continuous trends from calc-alkali basalts to rhyolites.

The hornblende-bearing plutons plot in granodiorite and diorite fields of Q-Kf-Pl diagram; whereas the rocks from the pi-plutons have normative and modal mineral compositions of granodiorite, quartz-monzonite and minor quartz synite and monzonite. All the plutonic rocks are strongly HREE depleted [6]. The -plutons (SiO₂=56-66%) show the least depletion with $[La/Yb]_n = 13-43$. The paragneisses of the external plutonic terrane (SiO₂=70-71%) show the steepest REE pattern with $[La/Yb]_n = 33 - 66$; while the post-kinematic plutonic rocks (SiO₂=70-75), and La/Yb = 18 - 58, are somewhere in between. Relative to the subvolcanic plutons with (Th=1.9-5.7, and U=0.9 -1.9) the pi-plutons are enriched in Th and U (Th=7.7-10.9 and U=4.5-25ppm). Age of volcanism in the West African Shield is not known; however, K/Ar and Rb/Sr ages have been reported for the rocks which intrude the volcanic rocks and can be used to place minimum age limits. Rb/Sr analyses of mica pi-pluton samples from belts (2-9) yielded the following ages (my): 1870 ± 157 to 2004 ± 42 for whole rock; and 1940 ± 45 mineral (plagioclase) isochron [5]. K/Ar analyses of amphiboles from belt (1) gave the following ages: (i) an older age of 2223 ± 283 was obtained from hornblende in the youngest volcanic unit; and (ii) a younger age, 2087 ± 138 was obtained from zoned, titaniferous hornblende in a deformed diorite porphyry intruded into the lowest unit in the volcanic succession. The available data lead to the conclusion that the minimum age for the volcanic activity must be between 2200 and 2100 my. It is significant that Archean ages have not been reported from any of the volcanic belts (1-10).

Structure of an early Proterozoic Volcanic belt in northeastern Ghana. Cleavage in the volcanic belt strikes N40E and dips steeply to the NW and SE. Mesoscopic folds, with locally well developed axial surface cleavage parallel to this foliation, plunge steeply NW and SE. Because the orientation of fold axes and cleavage surfaces do not change with respect to the stratigraphic position, it is concluded that the whole volcanic succession was deformed during a pre-2000 my old orogenic event. Evidence for multiple deformation occurs in the form of NW plunging folds and the folded trace of the axial surface of the major folds. The strong NE-SW orientation of the major structures is such that one has to conclude that the second deformation was not as intense as the first. Foliation in the external plutonic terrane is subparallel to the foliation in adjacent volcanic rocks. Unequivocal evidence for pre-greenstone belt structure was not found in the external plutonic terrane; however, NS structures occur in the paragneisses, which are oblique to NNE-NE structures in the volcanic belt. Gravity anomalies associated with the greenstone belt and the internal plutons have been modelled taking the surrounding plutonic terrane as background. The model predicts that the depth to the bottom of the volcanic succession is 3-4 km. Fig 2 is a structural section of belt(1) based on gravity models especially with regard to allowable geometries of the rock units at depth. The overturned limb of the major anticlinal fold is consistent with available facing indicators.

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Attoh, K.

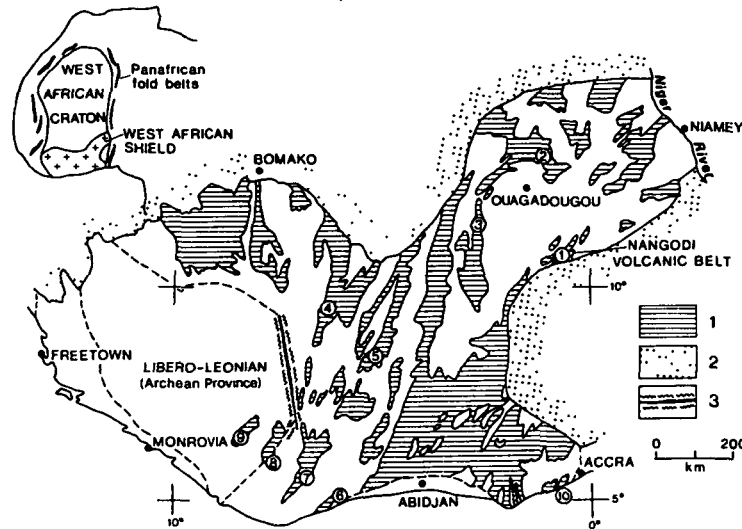


Fig 1. West African Shield showing the distribution of Proterozoic volcanic-sedimentary belts: 1) early Proterozoic volcanic belts, numerical labels referred to in text; 2) late Proterozoic platform sediments; 3) boundary between Archean and Proterozoic shields.

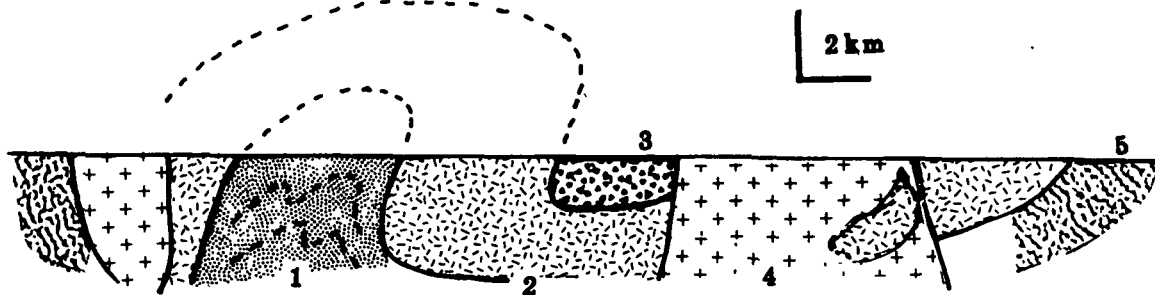


Fig 2. Geologic section across belt (1) in northeastern Ghana: 1) epiclastic sediments and tuffs; 2) mafic lavas (tholeiitic basalts); 3) felsic tuffs and intermediate lavas (calcalkaline); 4) postkinematic granites (pi-granite); 5) granodiorites, tonalites and paragneisses of external plutonic terrane.

References - [1] BRGM: Bureau de Recherches Geologique et Minieres. [2] Alsac, C., (1968, 1969) - BRGM publication G4514; Blanchot, A. et al (1972) Carte Geologique de la partie meridionale de l'Afrique de l'ouest (BRGM map); Doucelier, J., (1963) BRGM mem 10; Papon, A., (1973) BRGM mem 80. [3] Attoh, K., (1980), Geol. Surv. Can. 80-1C; (1982) Prec. Res. 18, 275-290. [4] Pearce, J. A. and Cann, J. R., (1973) - Earth Plan. Sci. Lett., 19, 290-300. [5] Bessoles, G., (1977) BRGM mem 88. [6] REE analyses done by Schultz, K. J.