DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

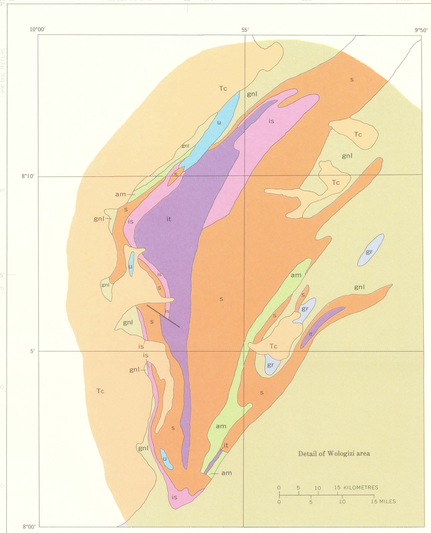
REPUBLIC OF LIBERIA
MINISTRY OF LANDS AND MINES
LIBERIAN GEOLOGICAL SURVEY

FOLIO OF THE VOINJAMA QUADRANGLE, LIBERIA
MAP I-771-D

GEOLOGIC MAP OF THE VOINJAMA QUADRANGLE, LIBERIA

By
J. F. Seitz

1977



Base compiled by photo-planimetric methods from aerial photographs taken 1962–63 and 1966. Controlled from 1963 1:40,000-scale photomosaics by Aero Service Corporation
Hotines Rectified Skew Orthomorphic projection and rectangular coordinates

Shaded relief geographic map available as map I-771-A

INTERNATIONAL BOUNDARIES SHOWN ON THE MAP ARE NOT NECESSARILY AUTHORITATIVE

Interior—Geological Survey, Reston, Va.—1977—G75232

INTRODUCTION

Liberia was mapped by geologic and geophysical methods during the period 1963 to 1972 as part of a program undertaken cooperatively by the Liberian Geological Survey (LGS) and the U.S. Geological Survey (USGS), under the sponsorship of the Government of Liberia and the Agency for International Development, U.S. Department of State. The resulting geologic and geophysical maps are published in ten folios, each folio covering one quadrangle (see index map). The Voinjama quadrangle was mapped by ten geologists who worked in different areas at various times (see sources of field data map). Compilation of field data, interpretation of geophysical data, interpretation of aerial photographs, and field checks by helicopter and motor vehicle traverse were the responsibility of J. F. Seitz.

Field data gathered by project geologists were supplemented by data provided by private companies from their mineral exploration surveys and geologic mapping programs. Aerial photography, airborne magnetic and radiometric surveys of the entire country (Behrendt and Wotorson, 1974a, b, c), and limited gravity data were utilized extensively in defining map units, determining location of contacts, extrapolating field data, and determining structural attitudes.

Topography in the region ranges from rolling to rugged. Bare granite domes, or inselbergs, that rise with steep sides and rounded tops to as much as 300 m above the surrounding terrain form a distinctive feature in the western and northern parts of the area. Most of the inselbergs are round in outline, but in the far western part, a few are elongate and oriented northeast. In the central part of the quadrangle, the Wologizi Range rises 1,000 m above the surrounding terrain; the summit of Mt. Wuteve, the highest point, has an altitude of nearly 1,400 m above sea level. These mountains trend northward in the southern part and northeastward in the northern part. The range is approximately 22 km long with spurs extending as much as 5 km on either side of the ridge. Slopes on the ridges are exceedingly steep and in places form sheer cliffs as much as 100 m high. East of the Wologizi Range the drainage tends to flow southwest, the major streams following relatively straight courses parallel to foliation, joint, and fault trends. West of the mountains the drainage pattern is dendritic, reflecting the presence of massive granite which predominates in that area. With the exception of the areas cleared for farms, the several small savannas, and the bare inselbergs, the region is covered by dense forest. Intense weathering has formed a saprolitic soil as much as 7 m thick in places; fresh bedrock outcrops are scarce and limited mostly to road cuts, stream channels, and inselbergs.

In comparison with other parts of Liberia, the Voinjama quadrangle area is well populated; most of the people are concentrated in the western part. The people, principally of the Loma, Kissi, and Bande tribes, live in small villages and practice slash and burn cultivation.

A main motor road provides access from the south to the town of Voinjama, administrative seat of government for Lofa County, and westward to the Sierra Leone border. Spur roads form a limited net in the east, north, and west parts of the quadrangle, but much of the area is accessible only by trail or river. Airstrips in some of the small villages and missions provide access to otherwise remote areas.

ROCKS

The Voinjama quadrangle lies within the Precambrian Guinean shield in the Liberian age province of White and Leo (1970), Hurley and others (1971), and Hedge and others (1975). Most of the area is underlain by granitic gneiss and massive granitic rock. Extensive bodies of schist, iron-formation, and amphibolite, as well as associated small bodies of ultramafic rock, are enclosed within the granitic rocks. Diabase dikes are widespread throughout the area. Canga covers some piedmont slopes in the vicinity of iron-formation, and local accumulations of bauxite nodules are found in the northwestern part of the area.

The order of discussion below is organized by rock type and implies no stratigraphic sequence.

METAMORPHIC ROCKS

Gneiss of granitic to dioritic composition covers about half of the area. Other metamorphic rocks in the area are confined to the Wologizi Range area and represent sedimentary and volcanic rocks that were metamorphosed and folded in a complex north- to north-east-trending structure. Included in the sequence is iron-formation consisting of interbedded iron silicate and iron oxide, quartz-muscovite and quartz-biotite schists, phyllite, quartzite, amphibolite, and serpentinite.

The metamorphic rocks of the Wologizi Range were mapped and studied by R. W. White, and the descriptions given here of the schist, iron-formation, amphibolite, and ultramafic rocks are from his reports (1970 and 1973).

Leucocratic gneiss

Leucocratic gneiss (gnl) underlies approximately half the area. Composition of the gneiss ranges from granite to quartz diorite, but because of lack of exposure and complexity of the geology, no attempt was made to map compositional differences within the gneiss.

Gneissic foliation follows a general northeast trend throughout the region; it is defined mostly by differential layering of biotite or hornblende or by the orientation of individual minerals such as feldspar augen and phenocrysts in coarse-grained gneiss. In small isolated outcrops such as those encountered along trails, the gneiss appears to be a relatively uniform rock with the same texture and composition throughout, but in the large expanses of bedrock exposed on the inselbergs, the heterogeneous character of the gneiss is revealed. Textures range from medium grained to very coarse grained, and individual feldspar crystals in places exceed 10 cm in length. Such variations in texture and structure can be noted within distances of a few metres across the strike. A radiometric age for the gneiss of about 2700 million years (m. y.) was determined by Hurley and other (1971). Samples were collected from three localities (described by White and Leo, 1970, p. 103): one south of Popolahun yielded an age of 2580 m. y.; one near Voinjama, 2680 m. y.; and one at the highway crossing of the Lofa River, 2730 m. y. Comparable and slightly older ages of gneiss and schist in other Liberian age province localities were also determined in the subsequent work of Hedge and others (1975).

Granitic gneiss

Granitic gneiss (gng) underlies a small area in the extreme southeast part of the quadrangle; it is characterized by the predominance of granitic rocks and the scarcity of other rock types. This unit underlies an extensive area in the Zorzor quadrangle (Seitz, 1977) to the south where quartz diorite makes up a considerable part of the mass adjacent to the Voinjama quadrangle. The rock is medium to coarse grained, contains a minor amount of amphibolite, and is predominantly foliated, though locally it grades to massive granitic rock.

Schist

Most of the schist (s) in the Voinjama quadrangle is confined to the Wologizi Range, where it forms the bulk of the range. It includes quartz-biotite-garnet schist, quartz-muscovite schist, chlorite-muscovite-biotite-quartz schist, biotite-quartz-plagioclase-chlorite schist, phyllite, and micaceous quartzites, derived from shale, sandstone, graywacke, conglomerate, and chert. The schist weathers readily; as a result it is poorly exposed except on steep slopes, in stream beds, or where excavated in road construction.

"Biotite and quartz are widespread in the schists, in association with a variety of the common aluminum-bearing silicates. The present mineral assemblages in most of the schists are those of the amphibolite facies of regional metamorphism. Locally, higher or lower grade metamorphic assemblages have been recognized. * * * Some low-grade schists are fine grained and have the well-developed rock cleavage and micaceous sheen of phyllite; they are especially prevalent in contact with itabirite in the higher regions of some of the larger mountain ranges such as Nimba and Wologizi. Some phyllites consist largely of quartz and iron silicates and are interbedded with and grade into itabirite; such rocks represent the siliceate facies of iron-formation. * * * Others have argillaceous compositions and represent clay-rich sediments, some of which are graphitic." (White, 1970, p. 15)

Iron-formation

"The iron-formations in the Wologizi group consist of the metamorphosed equivalents of both the oxide and the siliceate sedimentary facies, as well as all gradations between them. * * * Quartz and magnetite are present throughout both facies. The metamorphosed oxide facies corresponds closely to itabirite as defined by Dorr and Barbosa (1963, p. 18), and the term itabirite is used * * * as a synonym for oxide-facies iron-formation. Itabirite [it] in the Wologizi group is a thin-bedded rock made up of alternating quartz-rich, magnetite-rich, or quartz-magnetite (-iron silicate) laminae. * * * The quartz in itabirite is finely crystalline and granoblastic, and representation and cuts at a low angle across the contact between metasedimentary rocks and the bounding granitic gneiss. * * * Serpentinization is more or less complete near the margins of the largest ultramafic body and throughout most of the smaller bodies; a talc-rich border zone is locally developed. Some of the smaller bodies consist wholly of talc-rich schists with serpentine, chlorite, or carbonate. Sparse thin veinlets of fibrous chrysotile were found in a few blocks of float near the south end of the larges ultramafic body." (White, 1973, p. 24–25)

Massive granitic rocks

Massive granitic rocks (gr) ranging in composition from granite to quartz diorite and trondjemite underlie large areas in the region. Textures range from equigranular to porphyritic, medium to coarse grained. Most of the rock is gray but in some areas the potassium feldspar is pink and results in a pink-colored granite. As no consistent distinction between the pink and the gray granite was made by the geologists in the field, no distinction is shown on the map. With more detailed mapping the pink and gray granites probably could be mapped as separate units. Biotite is the most abundant mafic mineral and hornblende is second.

The massive granitic rocks appear to have a close genetic relation to the gneisses. Both include the same range of mineral compositions, with the exception of pink feldspar, which is largely confined to the massive granite. Sharp, intrusive contacts were not observed, and where both types of granitic rocks are exposed, as on the inselbergs, the contacts are gradational. Ages of massive granitic rock determined by radiometric methods were 2670 m.y. and 2770 m.y. in the vicinity of Kolahun (Hurley and others, 1971), and 2950 m.y. (1969 m.y. on reset biotite) in the southeastern part of the quadrangle (Hedge and others, 1975). These ages, approximately the same as the gneiss, indicate that the final development of both was related to the same thermotectonic event. A scintillometer traverse along the highway that crosses the quadrangle yielded remarkably uniform emission levels over the entire distance and indicated no difference between gneiss and massive granite. In other parts of Liberia, massive granites have emission levels from 4 to 40 times as high as the level in this region. These observations suggest that the massive granitic rock may be of anatectic origin, derived from the same source as the gneiss.

HYPABYSSAL IGNEOUS ROCKS

Diabase dikes (d) are found throughout the region where they have intruded all other crystalline rocks. The dikes are vertical, range to 50 m thick, and most are oriented east-west. They form long narrow ridges, rising as much as 15 m above the adjacent terrain; the ridges can be readily observed on aerial photographs and some can be traced continuously for as much as 25 km. Only a few of the dikes are associated with magnetic anomalies; where anomalies exist they are positive. As the diabase dikes in other areas of Liberia have strong negative anomalies, these dikes appear unrelated to the others. A preliminary dating of a mafic dike southeast of Foya Kamara at 2850 m.y. (Hedge and others, 1975, sample 1) indicates that dikes of this area are much older than dikes dated in other areas of Liberia.

In the southwest part of the quadrangle, several northwest-trending dikes (Jd) may belong to the system of abundant northwest-trending dikes that form a broad zone parallel to the coast. In other parts of Liberia such dikes generally produce negative magnetic anomalies and have been dated by radioactivity methods as being approximately 185 m.y. old (Grommé and Dalrymple, 1972).

An outcrop of basalt (Jb) is exposed on the highway 7 km southwest of Voinjama. Columnar jointing in the basalt, with prominent vertical columns of cross sectional dimension of about 30 cm, is clearly exposed on the face of the outcrop. The basalt is in contact with granite on the east side of the outcrop, and it extends northward where it is exposed in places over an area approximately 400 by 800 m. The columnar structure and the fine-grained texture indicate that the basalt formed as a flow or thin near-surface sheet. Petrographic examination reveals that the rock has fine-grained intergranular texture and is composed of plagioclase and pyroxene with clusters of coarser-grained plagioclase and olivine interspersed throughout. The age of this basalt has been determined (Hedge and others, 1975) as 428 m.y. by K/Ar methods, but the structural and stratigraphic relationships of the outcrop suggest comparison with similar outcrops of diabase in the Monrovia area that have been determined as Jurassic. The greater age determined here may be due to argon contamination from the gneissic country rock at the time of extrusion, as some of the diabase dikes in metamorphic terrane of interior Liberia yielded a range of dates, of which the older ages were attributed to such contamination.

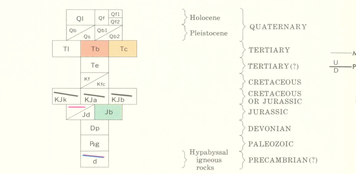
COLLUVIAL AND ELUVIAL DEPOSITS

Bauxite nodules and cobbles form small cappings on saprolite in the northwest part of the area. Canga forms fans and small piedmont plains on the flanks of the Wologizi Range, where it is conspicuous because of the open savannas that have developed on much of its surface. Alluvial sand and gravel form terraces and plains, too small to depict on the map, along the bank of the Makona River.

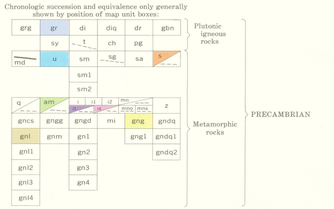
EXPLANATION

Rock symbols in the correlation diagram are standard for all of Liberia. Only rock units present in this quadrangle are shown in color in the correlation diagram.

CORRELATION OF MAP UNITS



Chronologic succession and equivalence only generally shown by position of map unit boxes:



DESCRIPTION OF MAP UNITS

The names of igneous and metamorphic rocks are based on composition as follows:

Igneous rock	*Metamorphic rock*	*Percent potassium feldspar of total feldspar*	*Percent quartz in rock*
Granitic rocks, undivided	*Granite gneiss*	*>10*	*>10*
Granite	*Granite gneiss*	*>50*	*>10*
Granodiorite	*Granodiorite gneiss*	*>10 and <50*	*>10*
Dioritic rocks, undivided	*Diorite gneiss*	*<10*	
Quartz diorite	*Quartz diorite gneiss*	*<10*	*>10*
Diorite	*Diorite gneiss*	*<10*	*<10*

Metamorphic rocks classified according to this scheme are not necessarily igneous in origin. Leucocratic (light colored) and melanocratic (dark colored) are used for gneiss units of variable or complex composition for which mineralogic classification is not applicable.

Tc CANGA—Conglomeritic deposit consisting predominantly of clasts of iron-formation cemented by iron oxides. Forms plains and fans

Tb BAUXITE—Deposit composed of scattered bauxite nodules forming thin layer in soil at surface

Jb BASALT—A fine-grained dark-gray rock with columnar jointing. Composed of plagioclase, pyroxene, and olivine

Jd DIABASE—Dark-gray rock occurring in dikes and composed principally of augite and calcic plagioclase. Forms northwest-trending narrow ridges and produces a characteristic strong negative magnetic anomaly

d DIABASE—Dark-gray rock, diabasic to basaltic in texture, occurring in dikes and composed of clinopyroxene and calcic plagioclase with appreciable olivine. Forms east-trending narrow ridges

gr GRANITIC ROCK—Predominantly massive medium- to coarse-grained rock, mostly granite and granodiorite but ranging to quartz in composition. Locally has gneissic structure. Boundaries with gneiss are generally gradational

u ULTRAMAFIC ROCK—Includes lenses of serpentinite, partly serpentinized dunite, and talc or amphibolite-rich metaperidotite

am AMPHIBOLITE—Foliated rock composed of approximately equal amounts of hornblende and plagioclase with minor quartz, epidote, and diopside. Generally forms elongated bodies

is IRON-FORMATION, SILICATE FACIES—Metamorphosed silicate facies of iron-formation. Composed of grunerite, quartz, magnetite or pyrite, and garnet or chlorite

it IRON-FORMATION, OXIDE FACIES (ITABIRITE)—Dark-gray finely laminated rock composed of magnetite and/or hematite, quartz, and accessory minerals

s SCHIST—Quartz-muscovite schist, micaceous quartzite, peltic-phyllite. Locally includes amphibolite and silicate iron-formation where too poorly exposed to be delineated separately

gng GRANITIC GNEISS—Medium- to coarse-grained rock ranging in composition from granite to quartz diorite. Includes minor amount of amphibolite. Predominantly foliated, commonly banded. Locally grades to massive granitic rock.

gnl LEUCOCRATIC GNEISS—Medium- to coarse-grained rock ranging in composition from granite to quartz diorite. Includes minor amount of amphibolite. Predominantly foliated, commonly banded. Locally grades to massive granitic rock.

Map symbols are standard for the geologic quadrangle maps of Liberia (I-771-D to I-780-D). Not all symbols are used on any one map.

Letter symbol within contact, fault, or other structural symbol indicates source of information used in locating contact: **M**, aeromagnetic data; **P**, photointerpretation; **R**, near-surface radiometric data; **G**, gravity data; and **P/M**, combination source (predominant source given first). Segments without letter symbol were located by surface traverses. Break in line indicates change in source of information.

Where rock units are present only as marker beds within other formations, they are shown in black (see below) with the appropriate unit symbol.

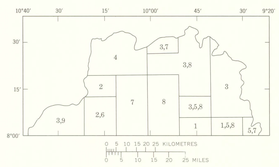
- Contact—Showing direction of dip where known
- Fault—*U*, upthrown side; *D*, downthrown side; dip where known
- Thrust fault—Sawteeth on upper plate
- Fault zone or shear zone
- Fault intruded by dike
- Antiform—Showing trace of crestal plane and direction of plunge; degrees of dip and plunge given where known
- Overturned antiform
- Synform—Showing trace of trough plane and direction of plunge; degrees of dip and plunge given where known
- Overturned synform
- Strike and dip of axial plane of minor fold: Inclined; Vertical
- Strike and dip of beds: Inclined; Vertical; Horizontal
- Strike and dip of foliation—Open symbol indicates foliation transecting earlier foliation or bedding; solid symbol indicates relation to bedding unknown: Inclined, degree of dip given where known; Vertical; Horizontal
- Strike and dip of parallel layering or bedding and foliation: Inclined; Vertical; Horizontal
- Strike of foliation, no dip determined
- Strike and dip of joints: Inclined; Vertical; Horizontal
- Strike and dip of planar features determined from photointerpretation (**P**) or aeromagnetic data (**M**)—One, two, three, or four ticks indicate gentle, medium, steep, or vertical dip
- Bearing and plunge of lineation formed by minor fold. Barbed arrow indicates crinkle axis or intersecting foliation; solid arrow indicates bearing and plunge of mineral lineation
- Structural trend or lineation based on photointerpretation
- Structural trend based on aeromagnetic data
- Observed outcrop
- Marker bed distinguished by rock symbol (Q) or index mineral (AD)

Index minerals:

AD, andalusite	EN, enstatite	K, kyanite
AN, anthophyllite	EP, epidote	M, muscovite
AU, augite	EU, eulite	PY, pyrite
B, biotite	GA, garnet	PX, pyroxene
CL, chlorite	GR, graphite	S, sillimanite
CG, cummingtonite-grunerite	H, hornblende	ST, staurolite
D, diopside	HY, hypersthene	TA, tremolite-actinolite
IL, ilmenite		

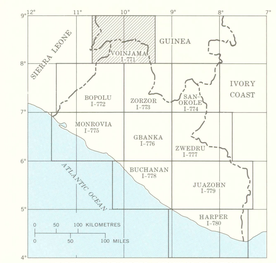
- Sand, gravel, clay, or placer pit—**B**, barite; **D**, diamond; **G**, gold
- Mine or quarry—**S**, building stone or road metal; **C**, clay; **I**, iron
- Prospect pit—**B**, barite; **K**, kyanite
- Drill site for offshore well, abandoned
- Fossil locality: Invertebrate; Plant
- K2600 Radiometric age in millions of years—K, potassium-argon; R, rubidium-strontium; F, fission track. Reset age given in parentheses where applicable

NOTE: The Voinjama quadrangle lies entirely within the Liberian age providence



SOURCES OF FIELD DATA

1. L. Blake (USGS)
2. R. R. Cooper (LGS)
3. A. E. Nyema Jones (LGS)
4. J. Ponserne (USGS)
5. S. P. Srivastava (LGS)
6. S. A. Stanin (USGS)
7. W. E. Stewart (LGS)
8. R. W. White (USGS)
9. C. S. Wotorson (LGS)



INDEX MAP OF LIBERIA SHOWING LOCATION OF QUADRANGLES IN THIS SERIES

Prepared by the
U.S. GEOLOGICAL SURVEY
and the
LIBERIAN GEOLOGICAL SURVEY
Under the joint sponsorship of the
GOVERNMENT OF LIBERIA
and the
AGENCY FOR INTERNATIONAL DEVELOPMENT
U.S. DEPARTMENT OF STATE

Bauxite

Bauxite (Tb) was mapped by J. B. Pomerene in the northwest part of the quadrangle. The largest deposit found is about 6 km northwest of Kolahun. Pomerene (written commun., 1966) described this deposit as covering approximately 21 hectares; it consists of nodules and cobbles of aluminous hydroxide minerals mixed with laterite soil extending to a depth of 1½ m. Analyses of the nodules found in the pit, but tone is as large.

Pomerene suggested that the bauxite material was residual eluvium from a former peneplain surface. Other deposits of bauxite were found in the region, but none is as large.

Canga

Conglomerate rich in fragments of iron-formation forms piedmont plains and fans bordering the Wologizi Range. Cobbles and pebbles derived from iron-formation outcropping on the ridges were deposited on the flanks of the ridges; subsequently, this material was cemented by hematite into a hard crustal layer. This crust, called canga (Tc), has been enriched in iron through leaching of the silica, but at present it does not constitute an economic source of iron. As the crust inhibits the growth of trees, much of it is covered by grassy vegetation that forms savannas. Test pits driven by the Liberian Iron and Steel Company indicate that the canga is as much as 15 m thick.

STRUCTURE

The foliation of the gneiss and the trend of the major faults in the area strike predominantly northeast. Except for a few small areas in scattered localities where other trends are found, the only major exception to this is in the south part of the Wologizi Range where foliation and fold axes trend north.

Beds of metamorphosed sediments in the Wologizi Range have been folded into a series of isoclinal synclines and anticlines. Detailed exploration by the Liberian Iron and Steel Company indicates that structures within the range are complex; information provided by more mapping, drilling, and study in the furture will no doubt require modification and revision of present concepts regarding the structures and the relationships between beds.

Diabase dikes in the quadrangle strike east along a trend divergent from the structural trend of the bedrock. The fractures controlling the emplacement of the dikes appear to be more recent than the major faults.

METAMORPHISM

A thermotectonic event occuring about 2.7 b.y. B.P. resulted in regional metamorphism that affected most of the rocks in the region. The schist and foliated rocks of the Wologizi area and the gneisses in the rest of the quadrangle were all metamorphosed by this event. The massive granite also was affected by the same event, and it may have been derived from the same source rock as the gneiss, differing in that anatectic mobilization obliterated the foliation. The gradational nature of the contacts between the gneiss and granite, the intimate interfingering of the two, are commonly porphyroblastic, the plagioclase porphyroblasts ranging to 12 centimetres in length.

A study of the bedded rocks of the Wologizi Range (White, 1973) shows that the metamorphic grade present there is lower than the amphibolite facies represented by the gneisses in the region.

MINERAL RESOURCES

The iron-ore deposit in the Wologizi Range constitutes the major known mineral resource of the region. At the present time, preliminary development studies have been completed and reserves of low-grade iron ore are estimated to exceed 40 million tons; however, development of this deposit will entail a major investment in mining, processing, and transportation faeilities.

Bauxite in the form of nodules in surface cappings exists in scattered areas, but the total amount known is small.

Diamonds have been found at some localities, but to date production has been small.

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