DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

REPUBLIC OF LIBERIA
MINISTRY OF LANDS AND MINES
LIBERIAN GEOLOGICAL SURVEY

FOLIO OF THE GBANKA QUADRANGLE, LIBERIA
MAP I-776-D

Base compiled by photo-planimetric methods from aerial photographs taken 1968-69. Controlled from 1953 1:40,000-scale photomosaics by Aero Service Corporation

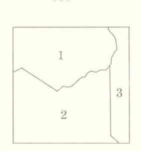
Hotines Rectified Skew Orthomorphic projection and rectangular coordinates

Shaded relief geographic map available as map I-776-A

INTERNATIONAL BOUNDARY SHOWN ON THIS MAP IS NOT NECESSARILY AUTHORITATIVE

SCALE 1:250,000

1970 MAGNETIC DECLINATION VARIES FROM 13°30′ WESTERLY FOR THE CENTER OF THE WEST EDGE TO 13°00′ WESTERLY FOR THE CENTER OF THE EAST EDGE. MEAN ANNUAL CHANGE IS 0°06′ EASTERLY



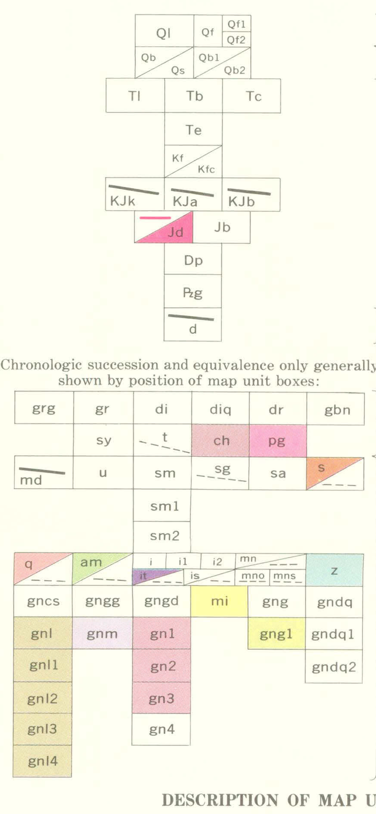
ADMINISTRATIVE BOUNDARIES
1—Bong County
2—Grand Bassa County
3—Nimba County

Interior—Geological Survey, Reston, Va.—1977—G75237

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.

Jd DIABASE—Dark-gray dike rock chiefly diabasic but locally gabbroic in texture; consists primarily of calcic plagioclase and clinopyroxene, with minor amounts of magnetite and ilmenite

pg PEGMATITE—Simple pegmatites usually with graphic granite, muscovite, and tourmaline

ch CHARNOCKITE—Massive gray coarse-grained hypersthene granite with perthitic potash feldspar phenocrysts

z COMPOSITE UNIT—Predominantly mafic schists, including actinolite rock, actinolite-chlorite schist, grunerite-garnet rock, and hornblende-garnet-quartz amphibolite. All are commonly associated with quartzite (either pure or as garnet, mica, or magnetite quartzite), quartz-mica schist, and iron-formation (mostly itabirite)

it IRON-FORMATION, OXIDE FACIES (ITABIRITE)—Finely laminated magnetite-quartz rock

am AMPHIBOLITE—Hornblende-plagioclase gneiss, locally with minor garnet and quartz, usually well-foliated or lineated

q QUARTZITE—Hematite-garnet quartzite with subordinate iron-formation and amphibolite

s SCHIST—Quartz-mica schist, locally garnetiferous, with associated iron-formation and amphibolite

mi MIGMATITE—Gneisses with segregation or injection bands over 10 cm thick of felsic rock in biotite-rich rock

gn1 COMPOSITE GNEISS—Granitic gneiss with subordinate amphibolite and itabirite

gn2 COMPOSITE GNEISS—Assemblage of hornblende-plagioclase amphibolite and leucocratic gneiss

gn3 COMPOSITE GNEISS—Leucocratic gneiss with subordinate magnetite, itabirite, quartzite, hornblende-plagioclase amphibolite, and quartz-mica schist

gnm MELANOCRATIC GNEISS—Amphibolite and dark pyroxene-plagioclase gneiss

gnl LEUCOCRATIC GNEISS—Typically well-foliated medium-grained biotite gneiss, includes numerous small bodies of amphibolite

gnl1 LEUCOCRATIC GNEISS—Differs from gnl in that composition is mostly quartz dioritic to granodioritic

gnl2 LEUCOCRATIC GNEISS—Kyanite- and muscovite-gneiss

gnl3 LEUCOCRATIC GNEISS—Differs from undivided leucocratic gneiss in magnetic signature

gnl4 LEUCOCRATIC GNEISS—Hornblende-bearing gneiss associated with amphibolite

gng1 GRANITIC GNEISS—Mostly coarse-grained or porphyroblastic, relatively massive, biotite gneiss with potash feldspar

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 intersecting foliation; 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 (ky)

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	GP, 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

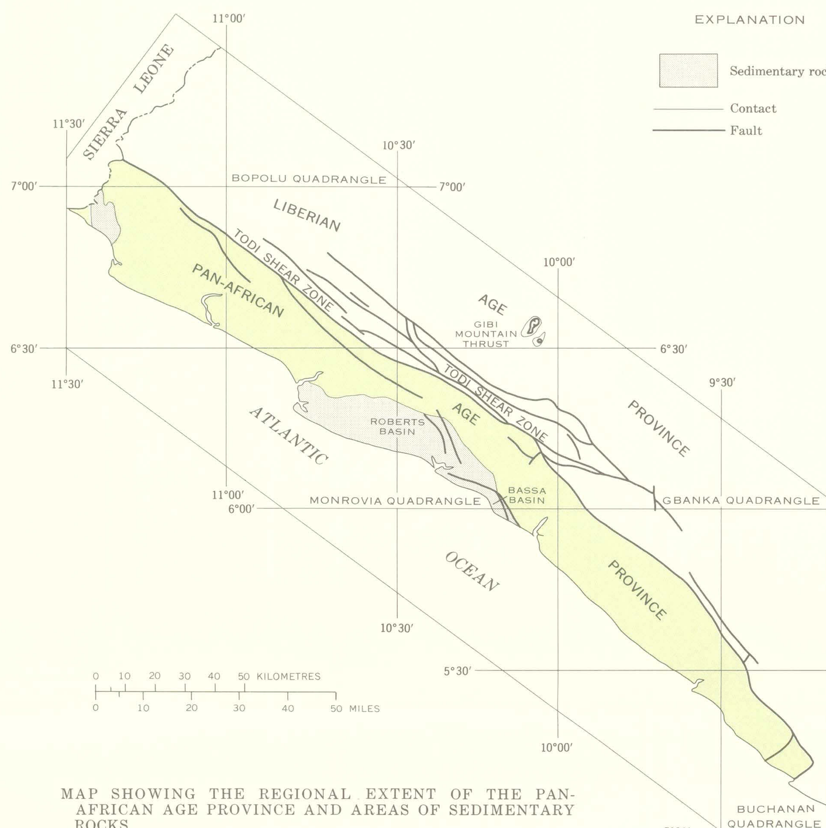
Mine or quarry—S, building stone or road metal; C, clay; I, iron

Prospect pit—B, barite; K, kyanite

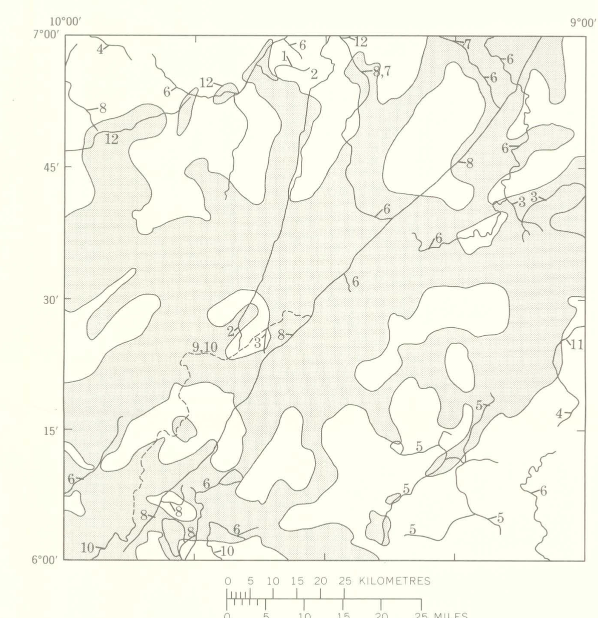
Drill site for offshore well, abandoned

Fossil locality
Invertebrate
Plant

Radiometric age in millions of years—K, potassium-argon; R, rubidium-strontium; F, fission track. Reset age given in parentheses where applicable



MAP SHOWING THE REGIONAL EXTENT OF THE PAN-AFRICAN AGE PROVINCE AND AREAS OF SEDIMENTARY ROCKS



SOURCES OF FIELD DATA

EXPLANATION

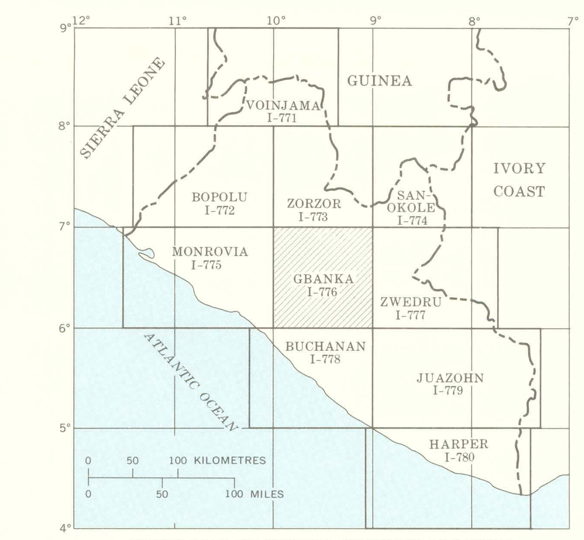
Surface traverse route

Helicopter traverse route

Area covered by Offerberg and Tremaine (1961)

1. M. W. G. Baker (LGS)
2. H. Bergmann (UNMS)
3. G. O. Bachmann (USGS)
4. B. R. Cooper (LGS)
5. J. D. N. Dunbar (LGS)
6. E. R. Force (USGS)
7. C. Johnson (LGS)
8. S. Rosenblum (USGS)
9. J. F. Seitz (USGS)
10. R. G. Tysdal (USGS)
11. C. S. Wotorson (LGS)
12. R. W. White (USGS)

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



INDEX MAP OF LIBERIA SHOWING LOCATION OF QUADRANGLES IN THIS SERIES

INTRODUCTION

Liberia was mapped by geologic and geophysical methods during the period 1965 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).

Systematic synthesis of the geology of the Gbanka quadrangle was begun in 1970 and included field data as shown in the source diagram. Outcrop information but not interpretation from Offerberg and Tremaine (1961) was used and is the most abundant source of data. Photogeologic mapping and interpretation of airborne magnetic and radiometric maps (Behrendt and Wotorson, 1974a, b) are integral to the interpretations shown here.

Altitude in the Gbanka quadrangle ranges from about 50 m to about 500 m. The St. John River drains most of the quadrangle and separates forest to the southeast from areas mostly under cultivation in small upland farms to the northwest. Numerous discrete hills and ranges remain forested.

Approximately 40 towns have populations over 200. The main road to the interior passes through the larger towns of Gbanka and Totota. Dry-season roads extend along a railroad by which iron ore is hauled from the Nimba mine toward the port of Buchanan. The total length of all roads is about 400 km.

ROCKS

The Gbanka quadrangle, like most of Liberia, is underlain by crystalline rocks forming part of the Guinean Shield. Various types of leucocratic gneiss underlie more than 90 percent of the area. White and Leo (1969-1970) and Hurley and others (1971) show an age province boundary through the southwest corner of the quadrangle that separates the Liberian age province (about 2700 m.y.) to the northeast from the Pan-African province (about 550 m.y.) to the southwest.

Swarms of diabase dikes cross the quadrangle from northwest to southeast.

The following discussion of metamorphic rock types implies no stratigraphic relationships. Units that are appropriately characterized by the same symbol but which differ distinctively in some aspects are distinguished by numbers. Surficial and residual deposits, which commonly obscure bedrock, are not mapped separately.

METAMORPHIC ROCKS

In the overall Liberian geologic mapping program, igneous nomenclature was used for classification of gneisses where appropriate. The terms leucocratic and melanocratic gneiss are a separate terminology based on gross color index, used for rocks in which variability is high or for which our knowledge is poor. Offerberg and Tremaine (1961) attempted to use a textural classification of gneiss with mixed success; lack of correlation between their units classified by texture and those based on mineralogy was a major factor in our widespread mapping of undivided units.

Granitic gneiss

A large area of low relief surrounding a range of hills, possibly block faulted, is underlain by massive granitic gneiss (gng1). Exposure is poor, except along the St. John River. Magnetic relief is very low, and the contrast with the higher magnetic relief of surrounding gneisses was used as one criterion for mapping the boundary between them. Surprisingly, the radiometric pattern is not distinctive, considering the high potassium feldspar content of the fresh rock. A smaller area of gng1 to the north is identified and delineated mainly on magnetic and photogeologic extrapolation of control in the Monrovia quadrangle (Thorman, 1977). The granitic gneiss probably was formed by slight metamorphism of a granitic intrusive rock.

Leucocratic gneiss

Most of the bedrock in the quadrangle is mapped as leucocratic gneiss. In addition to undivided leucocratic gneiss, four varieties are mapped.

Undivided leucocratic gneiss (gnl) is shown where gneisses are dominantly quartzo-feldspathic but otherwise variable, or in areas where our knowledge of the mineralogy is too poor to subdivide the unit. The undivided leucocratic gneiss contains rocks shown by Offerberg and Tremaine (1961) as "injection," "augen," and "slur" gneiss. Small bodies of amphibolite are very common within the unit, and other rock types are locally present. Leucocratic gneiss underlies large areas of low relief, as it is one of the least resistant rocks within the quadrangle. Exposures are few except along rivers, and because of differential weathering tend to underrepresent the proportion of leucocratic gneiss present. Magnetic patterns of leucocratic gneiss are variable, in accordance with the variable nature of the unit, but many small linear anomalies are probably due to associated amphibolite. The unit probably includes metasedimentary rocks, as well as metamorphosed and (or) sheared igneous rocks.

Unit gnl1, limited to the southwestern part of the quadrangle, is restricted predominantly to gneiss of quartz dioritic to granodioritic composition and includes some amphibolite and other rock types. Kyanite and muscovite gneisses (gnl2) also occur in the southwestern part of the quadrangle. Kyanite is present mostly in the western part of the north-trending map unit. The pattern shown is based mostly on outcrops and trends observed in the adjacent Monrovia quadrangle traced photogeologically into Gbanka quadrangle. The aluminous composition of the unit makes a metasedimentary origin likely. Unit gnl3 is distinguished from undivided leucocratic gneiss primarily on the basis of more subdued magnetic anomalies and a characteristic radiometric pattern (Thorman, 1977). Hornblende gneiss (gnl4) is mapped in several elongate belts. Subordinate rock types within this unit are amphibolite and locally hornblende granite. Topography over the unit is distinctive, having a ribbed appearance on aerial photographs that is due to the higher resistance of amphibolites within the gneiss. Magnetic anomalies are similar to those associated with amphibolites.

Melanocratic gneiss

Offerberg and Tremaine (1961) report amphibolite and hypersthene-plagioclase gneiss (gnm) forming Guo Mountain (Miatro).

Composite gneiss units

Three map units consist of assemblages of rock types in which gneisses predominate. In unit gn1, granitic gneiss contains small bodies of itabirite and amphibolite unmappable at scale 1:250,000; most are in adjacent quadrangles. Unit gn2 consists of hornblende-plagioclase amphibolite and leucocratic gneiss; the amphibolite is common and may locally be more abundant than leucocratic gneiss. The unit stands out as a ridge and has high magnetic relief. Unit gn3 consists mostly of leucocratic gneiss but also includes small bodies of itabirite, quartzite, schist, and amphibolite, individual bands of which are too thin to map separately and are normally too discontinuous to show as marker beds. The unit can be distinguished on aerial photographs from other gneiss units by resistant "ribs" parallel to foliation, and on magnetic maps by its relatively high-gradient magnetic pattern. The contact relations of the known metasedimentary rocks and their internal structure are not known, but the thickness of individual bands is at most a hundred metres. The metasedimentary layers are probably refractory remnants left undigested by anatexis, and if so, imply a metasedimentary origin of the whole map unit.

Migmatite

As isolated outcrops, migmatite is common in leucocratic gneiss terrane but is mapped as a separate unit (mi) only in an area south of the St. John River, based largely on observations of Offerberg and Tremaine (1961). Topographic relief over the migmatite is greater than over leucocratic gneiss; inspection of aerial photographs suggests the presence of numerous small folds. Magnetic and radiometric patterns were not useful in delineating the unit. The migmatite probably represents leucocratic gneiss which has undergone partial anatexis, and if so, has no stratigraphic significance.

Schist

A unit of schist (s) is shown in the southeastern part of the quadrangle. The boundaries of the unit are drawn roughly along a prominent east-west magnetic anomaly (see Behrendt and Wotorson, 1974a); within the unit quartz-mica schist, locally garnetiferous, appears to be predominant; amphibolitic schist and itabirite are associated. Topographic relief is low, except for small hills elongate east-west, probably formed of itabirite. Contacts with gneiss are concordant and gradational, the muscovite content decreasing from schist into gneiss. The unit clearly is of metasedimentary-metavolcanic origin, and adjacent muscovite gneisses are probably part of the same depositional sequence.

Quartzite

Quartzite (q) is common in other map units, particularly associated with amphibolitic schist, but is mapped separately only along the southern edge of a topographic high in the southeastern part of the quadrangle, where it appears to be protecting gneiss to the north from erosion by south-flowing streams. Quartzite is concordant to foliation of adjacent gneiss. Magnetic anomalies, high over the quartzite, are probably due to the associated iron-formation. The unit is metasedimentary.

Amphibolite

Offerberg and Tremaine's (1961) single "amphibolite" unit contains two distinct types of assemblages. One is hornblende-plagioclase amphibolite in gneiss terrane and is the unit here mapped as amphibolite (am). The other assemblage is included in composite unit "z" (see below).

Amphibolite (am) as small bodies is common in all the gneiss map units; where amphibolite is mapped separately, subordinate leucocratic gneiss is common within the unit. Normally, quartzite, schist, and itabirite are not present. Amphibolite stands up above surrounding, less resistant leucocratic gneiss as small hills; the bases of these hills were taken as the boundaries of amphibolite in photogeologic interpretation. Of the few field observations of amphibolite-leucocratic gneiss contacts, most are of small unmapped amphibolite bodies along rivers. Here, the contacts are sharp and concordant. Magnetic anomalies of as much as 1,000 gammas are typical of amphibolites.

The hornblende-plagioclase amphibolites are probably metamorphosed mafic intrusive and volcanic material. Offerberg and Tremaine (1961) refer to several amphibolites in the south-central part of the quadrangle which have relict igneous textures. Amphibolites that contain minor garnet and quartz may be impure pyroclastic deposits.

Iron-formation, oxide facies

Itabirite (it) forms a central spine in many of the ranges of hills, but is mappable in only a few. Magnetic anomalies are quite large (see Behrendt and Wotorson, 1974a). The itabirite is of metasedimentary origin.

Composite unit

The composite unit (z) is an assemblage of interlayered amphibolite (types distinct from those in the amphibolite map unit), quartzite, schist, and iron-formation in which amphibolite is apparently predominant, and may be actinolite schist, or hornblende-plagioclase-garnet-quartz rock. The unit forms the slopes of most of the higher ridges and ranges of hills. Hillside exposure is usually good but locally obscured by lateritic cappings. Contacts with gneiss were observed at several places but were sheared; generally, the rocks are concordant with adjacent gneisses. Magnetic anomalies up to a thousand gammas are typical of the unit, and radiometric values are low. The assemblage is metasedimentary-metavolcanic.

IGNEOUS ROCKS

Charnockite

In the southwest part of the quadrangle, a charnockite (ch) stock is mapped. Besides the predominant coarse massive hypersthene granite, the unit includes biotite granite along the eastern edge and some biotite augen gneisses which are believed to be sheared. Offerberg and Tremaine (1961) mapped the charnockite roughly as shown here.

Contacts with gneiss, into which the charnockite is believed to be intrusive, were observed on the north edge of the unit in a railroad cut. In zones outward from charnockite, the rocks are first a more foliated finer-grained hypersthene-bearing phase and next a garnetiferous amphibolite extending for about 500 m. The contact zones are more resistant to erosion than rocks on either side, standing up as rows of knobby hills; the contacts were delineated on aerial photographs by the presence of these hills. Charnockite weathers as large rounded boulders. Magnetic patterns over charnockite are not distinctive. Whole-rock rubidium-strontium dating gives an age of 2750 m.y. for the charnockite. (C. E. Hedge and Z. E. Peterman, written commun., 1973).

Pegmatite

Along the St. John River, thin pegmatite bodies (pg) occur in and adjacent to schists and iron-formation. In the northeastern Kpoh Range, the pegmatites are bounded by faults and are themselves sheared or are folded concordantly with other rock types. In the southwestern St. John Range near Petabli, granular veins associated with the pegmatite contain cassiterite. The close spatial relationship with migmatite suggests that the downstream pegmatites may be related to anatexis of migmatite.

Hypabyssal igneous rocks

Diabase (Jd) forms northwest-trending dikes which are as much as 30 m thick. Dikes thicker than 10 m have central zones approaching gabbroic texture. Where observed, chill zones are very thin and contacts are sharp. The dikes form long narrow ridges easily traceable on aerial photographs; associated negative magnetic anomalies are accurate predictors of dike location. (Where photogeologic and magnetic data indicate the existence and location of diabase dikes, they are mapped as though observed.) In two localities, diabase plugs are mapped on the basis of photogeology only.

Diabase is much more resistant than gneiss wallrock and weathers into spheroidal boulders. The diabase is considered Jurassic in age on the basis of K-Ar dating and paleomagnetic studies, although the radiometric ages are not wholly in accord with one another (Grommé and Dalrymple, 1972).

AGE RELATIONS

No stratigraphic relation among the metamorphic rocks can even be tentatively suggested. There is no compelling evidence that schists are younger than gneisses, as contacts observed were either sheared or gradational, and metamorphic grades and deformational history are similar. Photointerpretation of the Zeeia Range area suggests a north-plunging synclinal structure at the south end of the range, but this may not indicate relative age, especially as minor structures in adjacent gneiss also plunge north at the north end of the range.

STRUCTURE

Our knowledge of folding is limited. Lithologic units and foliation in gneiss are folded, commonly isoclinally. In most of the quadrangle, axial planes of flexures of the gneissic foliation trend northwest. It is possible that these flexures are genetically related to foliation that also trends northwest in the more recently metamorphosed Pan-African province to the southwest.

The course of the St. John River follows the St. John fault system. In places, branches of the system separate schist and iron-formation from gneiss. In the St. John Range, pegmatite and cassiterite-bearing veins are associated with the faults. Faults generally parallel the strike of foliation in gneiss but locally transect it. Along the west margin of the St. John Range, leucocratic gneiss has strong subhorizontal lineation within less than 1 km of the fault system. Another major set of faults truncates the St. John fault system on the south and separates the Pan-African province (not labeled on map) in the southwestern corner of the quadrangle from the Liberian province in the remainder of it. Foliation southwest of this fault set in the Pan-African province is locally oriented almost north-south, whereas that in the Liberian province is northeast-southwest. An intermediate zone of mixed foliations is bounded on both sides by northwest-trending shear zones. The southern shear zone, just south of Mt. Finley, is locally intruded by diabase and includes southwest-dipping mylonites. The intrusive charnockite straddles some of these mylonites and may itself have been locally sheared, producing coarse augen gneiss. The northern shear zone, as interpreted from aerial photographs, separates the zone of irregular foliation trends from more orderly northeast trends of the Liberian province. Yet other northwest-trending shear zones farther to the north truncate rock bodies, and in one place form the northern boundary of melanocratic pyroxene gneiss at Mt. Guo (Miatro). Such granulite facies rocks are elsewhere characteristic of the Pan-African province.

The long, straight course of Zo Creek is controlled by a fracture which is believed to be part of a joint set rather than a fault. Closely spaced joints were observed by H. Bergmann (United Nations Mineral Survey) all along the creek. Neither field traverses nor magnetic data give evidence of offset. What appear in aerial photographs to be offsets of diabase dikes along the Zo Creek trend may instead be the effect of the joint set on the pattern of later intrusion.

Fractures parallel to diabase dikes are common. In some areas, these appear to form geologic boundaries. Mylonite was observed on the trend which forms the Pan-African boundary. A fault with protomylonite trends into a diabase dike in the southeastern part of the quadrangle. Along the St. John Range, the pattern of diabase dikes and faults parallel to them has contributed to the anomalous course of the St. John River which cuts back and forth through the range.

Another set of fractures, based mostly on photogeology, trends north in the south-central part of the quadrangle.

METAMORPHISM

Metamorphism of the amphibolite facies is predominant in the Gbanka quadrangle. In two areas, rocks of the granulite facies have been found; one is in hypersthene-plagioclase gneiss at Mt. Guo (Miatro) in the southwestern part of the quadrangle, and the other is in hypersthene-bearing quartz-garnet amphibolite near Zienzu in the northwestern part.

MINERAL RESOURCES

No mining is known to have been conducted in the quadrangle. At Green Hill typical gneiss has been quarried for railroad-bed material.

Cassiterite-bearing granular veins occur with pegmatites along shear zones and in composite unit z in the southern part of the St. John Range. The pegmatite zone, the faults, and the host rocks extend far beyond the known cassiterite-bearing areas. Offerberg and Tremaine (1961) show geochemical anomalies of tin in stream sediments near the northern part of the St. John Range.

REFERENCES

Behrendt, J. C., and Wotorson, C. S., 1974a, Aeromagnetic map of the Gbanka quadrangle, Liberia: U.S. Geol. Survey Misc. Inv. Ser. Map I-776-B.

———1974b, Total-count gamma radiation map of the Gbanka quadrangle, Liberia: U.S. Geol. Survey Misc. Inv. Ser. Map I-776-C.

Grommé, C. S., and Dalrymple, G. B., 1972, K-Ar ages and paleomagnetism of dikes in Liberia [abs.]: Am. Geophys. Union Trans., v. 53, no. 11, p. 1130.

Hurley, P. M., Leo, G. W., White, R. W., and Fairbairn, H. W., 1971, Liberian age province (about 2700 m.y.) and adjacent provinces in Liberia and Sierra Leone: Geol. Soc. America Bull., v. 82, no. 12, p. 3483-3490.

Offerberg, J. O., and Tremaine, J. W., 1961, Report on LAMCO Joint Ventures geological investigations in Liberia between Nimba and Lower Buchanan along the Railroad Concession Area: Stockholm, W-Reklar/Caslon Press Botr. AB, 74 p.

Thorman, C. H., 1977, Geology of the Monrovia quadrangle, Liberia: U.S. Geol. Survey Misc. Inv. Ser. Map I-775-D.

White, R. W., and Leo, G. W., 1970, Geologic summary of age provinces in Liberia: Geol. Mining Metall. Soc. Liberia Bull., v. 4, p. 96-106.

GEOLOGIC MAP OF THE GBANKA QUADRANGLE, LIBERIA

By
E. R. Force, U.S. Geological Survey, and J. D. N. Dunbar, Liberian Geological Survey

1977

For sale by Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202