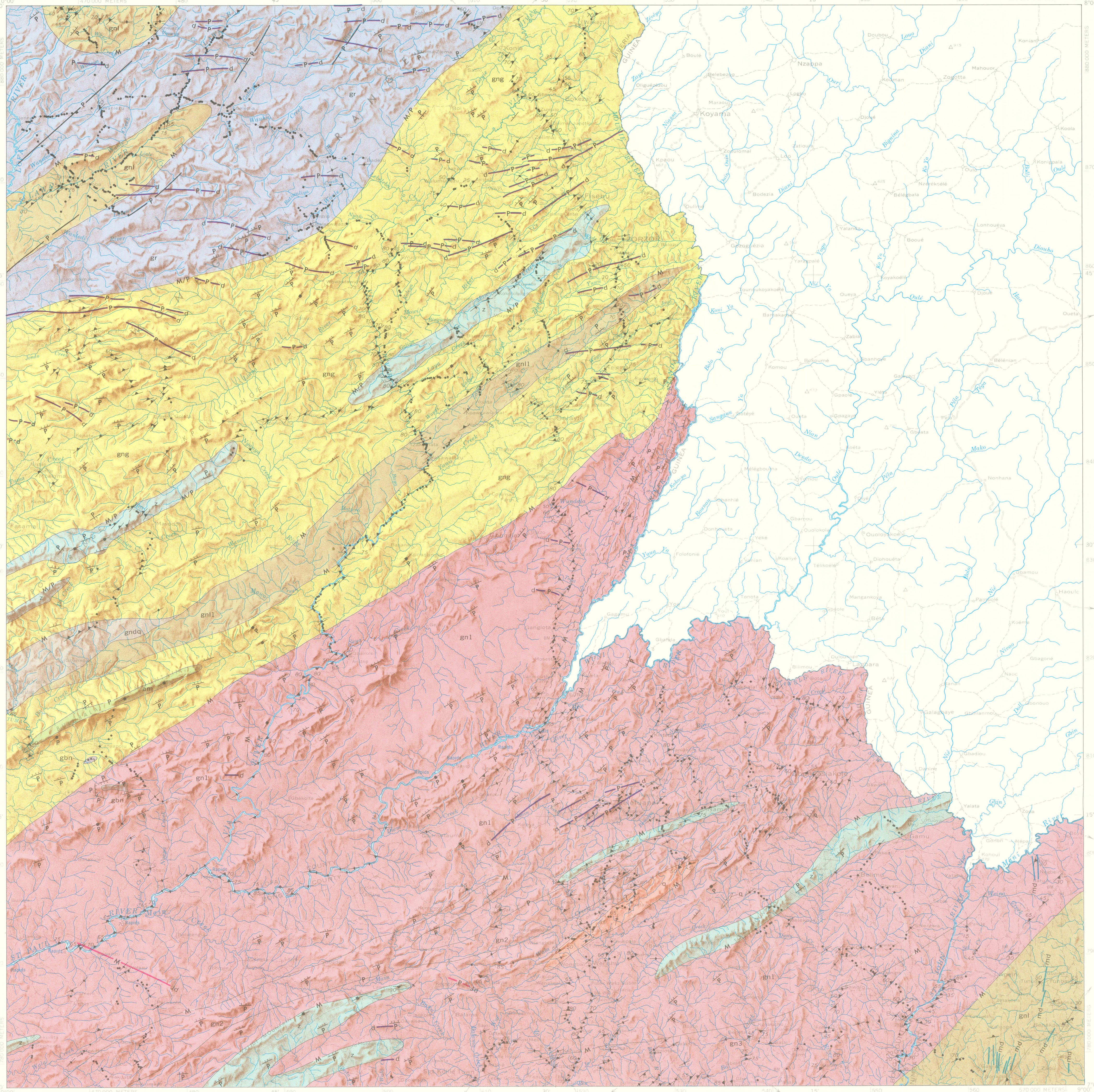
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

REPUBLIC OF LIBERIA
MINISTRY OF LANDS AND MINES
LIBERIAN GEOLOGICAL SURVEY

FOLIO OF THE ZORZOR QUADRANGLE, LIBERIA
MAP I-773-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
Hotinee Rectified Skew Orthomorphic projection and rectangular coordinates
Shaded relief geographic map available as map I-773-A
INTERNATIONAL BOUNDARY SHOWN ON THIS MAP IS NOT NECESSARILY AUTHORITATIVE

SCALE 1:250,000

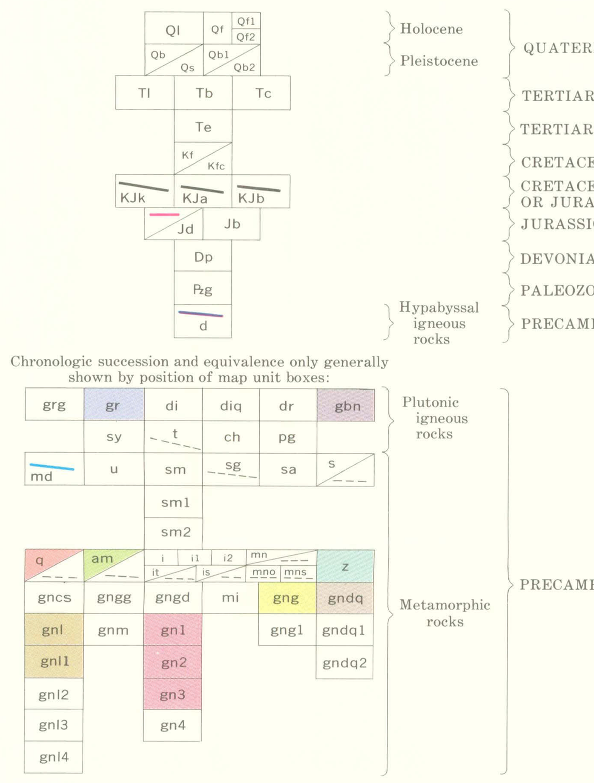
ADMINISTRATIVE BOUNDARIES
1—Lofa County, Liberia
2—Bong County, Liberia
3—Nimba County, Liberia
4—Guinea

Interior—Geological Survey, Reston, Va.—1977—G75234

E X P L A N A T I O N

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



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 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, occurring in dikes and composed of clinopyroxene and calcic plagioclase with appreciable olivine. Forms east-trending, narrow ridges. Altered in places to metadiabase

gbn NORITE—Dark-gray medium-grained rock, occurring in small stocks. Composed of calcic plagioclase, hypersthene, and augite

gr GRANITIC ROCKS—Predominantly massive medium- to coarse-grained rock, mostly granite and granodiorite, but ranging to quartz diorite in composition. Locally has gneissic structure

md METADIABASE—Dark-gray rock, occurring in dikes and composed in part of foliated amphibolite derived from diabase. Forms north-trending, narrow ridges

z COMPOSITE UNIT—Comprises rock units characteristically associated with itabirite and iron-formation that are too small to map separately. Includes schist, quartzite, iron-formation, and amphibolite with minor amounts of gneiss

am AMPHIBOLITE—Foliated rock composed of approximately equal amounts of plagioclase and hornblende. Forms a steep-sided sinuous ridge

q QUARTZITE—Composed predominantly of quartzite with substantial amounts of schist and gneiss and minor amount of iron silicate rock

gn1 COMPOSITE GNEISS—An extensive composite unit of gneissic rock that includes granodiorite, syenite, quartz diorite, quartz mica schist, quartzite, and abundant amphibolite

gn2 COMPOSITE GNEISS—Medium-grained granitic gneiss characterized by large proportion of widely distributed amphibolite

gn3 COMPOSITE GNEISS—Medium-grained granitic with substantial amount of amphibolite and quartzite

gnl LEUCOCRATIC GNEISS—Light-colored medium-grained rock with granitic composition and gneissic structure. In northwest area, includes some migmatite, amphibolite, and massive granitic rock. In extreme southeast area, includes substantial amounts of amphibolite and quartzite

gnl1 LEUCOCRATIC GNEISS—Light-colored medium-grained rock with granitic composition and gneissic structure. Includes appreciable amounts of schist, amphibolite, and quartzite

gndq QUARTZ DIORITE GNEISS—Medium- to coarse-grained gneiss of predominantly quartz diorite composition with biotite and hornblende composing the mafic mineral component

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

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.

M/P — Contact—Showing direction of dip where known

U/D P/R — 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

M — Antiform—Showing trace of crestal plane and direction of plunge; degrees of dip and plunge given where known

Overturned antiform

P — 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
- 30 Inclined
- Vertical

Strike and dip of beds
- 60 Inclined
- Vertical
- Horizontal

Strike and dip of foliation—Open symbol indicates foliation transecting earlier foliation or bedding; solid symbol indicates relation to bedding unknown
- 60 60 Inclined, degree of dip given where known
- Vertical
- Horizontal

Strike and dip of parallel layering or bedding and foliation
- 60 Inclined
- Vertical
- Horizontal

Strike of foliation, no dip determined

Strike and dip of joints
- 70 Inclined
- Vertical
- Horizontal

M P M P — 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

10 — 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

---M--- Structural trend based on aeromagnetic data

Observed outcrop

---q--- Marker bed distinguished by rock symbol (q) or index mineral (AD)

HY 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	

G — Sand, gravel, clay, or placer pit—B, barite; D, diamond; G, gold

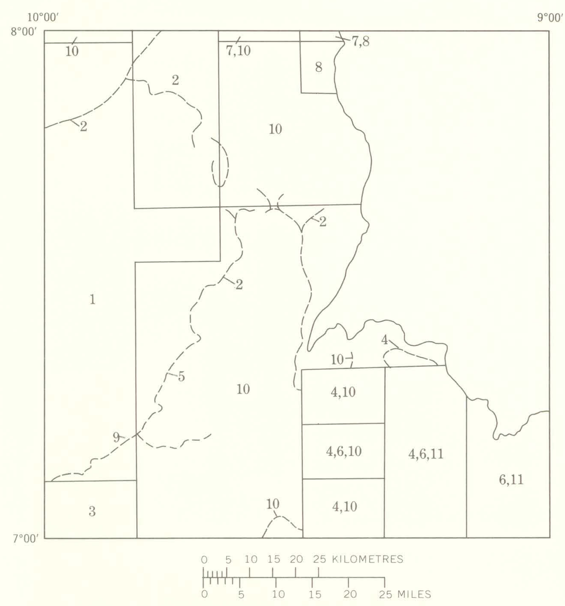
S — Mine or quarry—S, building stone or road metal; C, clay; I, iron

K — 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

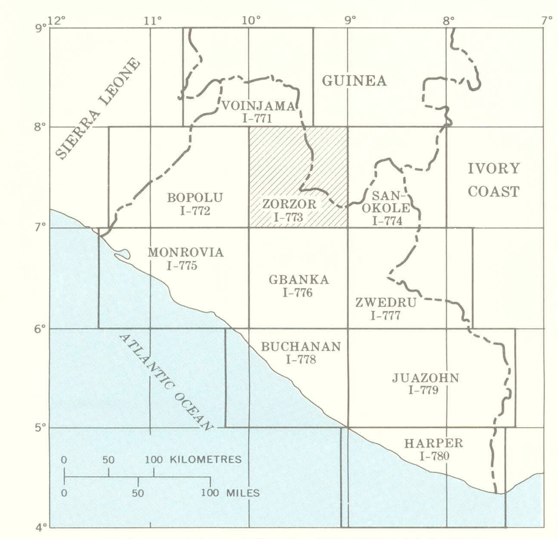


SOURCES OF FIELD DATA

EXPLANATION

---4--- Traverse route

1. M. W. G. Baker (LGS)
2. L. V. Blade (USGS)
3. B. R. Cooper (LGS)
4. J. C. Johnson (LGS)
5. A. M. Mezzetti (United Nations)
6. Sam Rosenblum (USGS)
7. S. P. Srivastava (LGS)
8. W. A. Stewart (LGS)
9. J. F. Seitz (USGS)
10. R. W. White (USGS)
11. J. Offerberg and J. Tremaine (1961)



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

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 10 folios, each folio covering one quadrangle (see index map). Responsibility for field mapping the Zorzor quadrangle is shared by many geologists who worked in different areas at various times (see sources of field data map). Compilation of field data and interpretation of geophysical data and aerial photographs were done by J. F. Seitz. Field data from mineral exploration and geologic mapping provided by private companies and other members of the LGS-USGS project were used in map compilation, and are hereby acknowledged. Total-intensity aeromagnetic and total-count gamma radiation surveys (Behrendt and Wotorson, 1974a, c) were also used in the compilation in discriminating map units, locating contacts, extrapolating field data, and determining structural attitudes.

The topography of the region is characterized by a series of parallel ridges separated by broad-floored valleys 6 to 12 km wide. The ridges generally rise about 200 m above the valley floors and trend northeast parallel to the bedrock structure. Hill slopes are predominantly gentle and relief is subdued. The few sharp ridges owe their configuration mainly to the presence of resistant beds of iron-formation, and these ridges rise as much as 400 m above adjacent lowlands. Rivers follow the regional trend, the St. Paul River providing the principal drainage to the southwest. In the northwest part of the quadrangle, 30 to 40 bare granitic domes, or inselbergs, rise 100 to 200 m above the surrounding terrain. The inselbergs are characterized by steep slopes and rounded tops; they are generally bare of vegetation, but grass grows where a thin veneer of soil has accumulated.

Except for areas cleared for cultivation, the entire quadrangle is covered by thick forest. The human population is fairly dense in the eastern and southern parts and consists largely of members of the Loma, Kpelle, Bande, and Belle tribes. Cultivation is accomplished by cutting and burning of the forest to clear the land and fertilize the fields.

A main motor road extends from south to north across the quadrangle, connecting Gbanka to the south to Voinjama, 61 km (38 miles) north of the quadrangle border. Another main road extends eastward from Gbanka through Gahnpa and provides connections to the Liberian American Mining Company (LAMCO) Mt. Nimba iron mine to the northeast and Harper to the southeast. A few spur roads provide access to areas adjacent to these main roads. The eastern part of the quadrangle is accessible only by trail, river, or by small aircraft, where airstrips exist.

ROCKS

The Zorzor quadrangle is within the Guinean Shield of West Africa and is part of the Liberian age province described by Hurley and others (1971) and White and Leo (1970). Most of the bedrock in the area consists of leucocratic granitic rocks that range from granite to quartz diorite in composition and massive to gneissic in texture. Amphibolite, schist, quartzite, and iron-formation form lenses and elongate zones within and between gneissic units. Diabase dikes transect all other types of bedrock in several areas in the quadrangle.

Where two or more map units are composed of essentially the same rock but differ in some distinctive characteristic, they are distinguished by numbers added to the symbol. The order of discussion is organized by rock type and implies no stratigraphic sequence.

METAMORPHIC ROCKS

Metamorphic rocks underlie most of the area. Gneiss predominates, but schist, amphibolite, iron-formation, quartzite, and metadiabase constitute several mappable units and are also widely distributed in small unmapped units within the gneiss.

For purposes of mapping, the gneiss has been subdivided into seven units. The distinguishing criteria are based in part on the mineral composition and color index of the gneiss, and in part on the characteristic assemblage of other types of rocks that are incorporated within the gneiss. Locally, the included nongneissic rocks make up the greater part of the bedrock, and therefore isolated outcrops may not be representative of the rock unit.

Granitic gneiss

Granitic gneiss (gng) forms a broad northeast-trending belt in the northern part of the quadrangle. The belt is characterized by the predominance of granitic rocks and by the scarcity of other types of rock, but in the northeastern part of the belt the composition of the gneiss increases, and quartz diorite is abundant. Though field data are scanty, this variation appears to mark a broad facies change. A second, narrower band of granitic gneiss lies south of the main belt, from which it differs slightly in that it contains more schist, amphibolite, and itabirite. It also has a lower level of radioactivity; a scintillometer traverse along the highway indicated average levels of 40 to 60 cps for this southern band and 60 to 160 cps for the larger northern belt.

Quartz diorite gneiss

Quartz diorite gneiss (gndq) is common throughout the region and in places forms a sizable component of the granitic, leucocratic, and composite gneiss units. The area mapped as quartz diorite gneiss in the west-central part of the quadrangle is an extension of a larger mass to the west in the Bopolu quadrangle (Wallace, 1977) where sufficient field data were available to provide the basis for mapping it separately from the granitic gneiss. When more detailed mapping has been completed in the Zorzor quadrangle, quartz diorite gneiss may prove to be widely distributed.

Leucocratic gneiss

Leucocratic gneiss (gnl) includes those rocks ranging in composition from granite to diorite, which cannot be readily subdivided into more specific units, owing either to the complex assemblage of rock types or to the lack of detailed information. Leucocratic gneiss forms a large unit in the northwestern part of the quadrangle and extends westward into the Bopolu quadrangle. In the Zorzor quadrangle, it consists mostly of granite and granodiorite with some migmatite and amphibolite and could be termed a granitic gneiss; in the Bopolu quadrangle (Wallace, 1977), it contains a greater range of rock types, and thus the more general term "leucocratic gneiss" is assigned. The leucocratic gneiss in the southeast part of the quadrangle is characterized by an abundance of amphibolite and quartzite.

Extending diagonally northeast across the central part of the quadrangle is a leucocratic gneiss (gnl1) unit containing appreciable amounts of schist, amphibolite, and quartzite.

Composite gneiss

Gneiss units of heterogeneous composition (gn1) occupy a third of the Zorzor quadrangle. Granitic gneiss is the dominant rock, but the range of composition includes granite, syenite, granodiorite, quartz diorite, diorite, melanocratic gneiss, amphibolite, quartzite, quartz-muscovite schist, and migmatite. Outcrops along the St. Paul River show a particularly wide range of compositions where gneiss of granite, granodiorite, syenite, and quartz diorite composition, and melanocratic gneiss were observed within a zone 3 km wide. Along the Via River, a considerable amount of mylonitic gneiss is exposed. Gamma radiation measured with a hand-held scintillation counter in a traverse along the highway registered within the relatively narrow range of 40 to 100 cps, indicating the similarity in composition of the component rocks in the unit.

Gneissic foliation is defined mostly by differential layering of biotite or hornblende or by orientation of individual minerals such as feldspar augen and phenocrysts in coarse-grained gneiss. In some outcrops, the gneiss is highly layered; biotite is concentrated in layers 1 to 3 mm thick separated by felsic bands 5 to 10 mm thick, and generally coarse grained. In other localities, the felsic layers contain feldspar augen, commonly about 1 cm thick by 2 cm long, with preferred orientation parallel to the layering. In places, the mafic and felsic components form interfingering lenses ranging from 5 to 10 cm thick and from 30 cm to several metres long.

A second composite unit (gn2) forms a narrow tongue extending into the area from the southwest corner of the quadrangle and is characterized by a large proportion of amphibolite. Field observations suggest that amphibolite constitutes more than half the rock in the unit. Its presence and distribution are further confirmed by a distinct negative magnetic anomaly pattern.

A third unit (gn3) consists largely of medium-grained granitic gneiss and substantial amounts of amphibolite and quartzite. It is distinguished from the leucocratic gneiss (gnl) unit to the east by a proportionately greater amount of quartzite and lesser amount of amphibolite, and from the gn1 unit to the west in that it lacks the schist and the wide range of granitic compositions of that unit. Its delineation in part is an extension of the magnetic pattern of the unit in the Gbanka quadrangle (Force and Dunbar, 1977) on the south.

Quartzite

Quartzite (q) is distributed throughout much of the gneiss in the south part of the quadrangle and in places is associated with schist. In other areas it is associated with amphibolite. As it is derived from sedimentary rock, its association with gneissic rock suggests that much of the gneiss may also be of metasedimentary origin. In one area several kilometres long, quartzite forms a distinctive and significantly large part of the bedrock and is shown as a unit on the map, although it also contains appreciable intermixed schist, iron-formation, and gneiss.

Amphibolite

Amphibolite (am), composed essentially of hornblende and plagioclase, is widely distributed, especially within areas of gneissic rock, where it locally forms an appreciable part of the bedrock. It commonly exists as lenses and layers as much as several metres thick within the gneissic rock. Much of the amphibolite may be of metasedimentary or metavolcanic origin, but in some places, discrete tabular bodies of it have apparently been derived by metamorphism of diabase dikes (White and Leo, 1969, p. 9). Amphibolite makes up one body large enough to be mapped as an individual unit in the west part of the quadrangle where it forms a sharp sinuous ridge.

Composite unit

This unit (z) is composed of iron-formation associated with schist, quartzite, and amphibolite and minor amounts of gneiss. The magnetic anomalies, characteristic of the unit are due to the large proportion of iron-formation, which forms prominent ridges.

IGNEOUS ROCKS

Igneous rocks comprise diabase dikes, small bodies of norite, and one large body of granite. The dikes are of at least two different ages; some of the older ones have been metamorphosed to amphibolite.

Granitic rocks

Massive granitic rock (gr) underlies a large area in the northwest part of the quadrangle adjacent to an extensive area of the same unit in the Voinjama quadrangle (Seitz, 1977) to the north. This rock forms most of the inselbergs. In the Zorzor quadrangle, the rock observed is mostly granite, but in the Voinjama quadrangle, observed compositions range from granite to quartz diorite. Where large expanses of bare rock are exposed, such as on inselbergs, gneissic rock will typically be found within the massive rock. Contacts between the two are gradational, and the composition is nearly the same. The relationship between the massive granitic rock and the granitic gneiss is apparently close; probably the granitic rock was in large part derived from the same rock as the gneiss, representing a further stage in metamorphism in which the gneissic fabric was obliterated. In the Voinjama quadrangle to the north, these rocks have been dated by the rubidium-strontium method, and an age of approximately 2700 m.y. has been determined for both (White and Leo, 1970; and Hurley and others, 1971).

Norite

Norite (gbn) is exposed in the southwestern part of the quadrangle. The size of the norite bodies is not known, but they are probably small. The norite is composed principally of bytownite, hypersthene, and augite and has a hypidiomorphic-granular texture with an average grain size of 0.5 mm to 1.5 mm. Although only two norite bodies have been observed in the area, more probably will be found when further mapping has been completed.

DIABASE DIKES

Metadiabase and diabase

Diabase dikes in the Zorzor area have been described by White (1970) as being metamorphosed to amphibolite. These east-trending dikes (d) are part of the system of dikes that have been dated as 2.8 b.y. old in the Voinjama quadrangle (Seitz, 1977). Some of the north-trending dikes in the southeast part of the quadrangle have also been altered to metadiabase (md).

Diabase dikes (d, Jd) are found throughout the region, and they intrude all other rocks. The dikes generally are vertical, as much as 50 m thick, and are oriented in different patterns in different areas. In the southwest section, the dikes trend northwest in accord with the pattern of the ubiquitous diabase dike swarms that characterize a 130-km wide zone bordering the coast of Liberia. These dikes (Jd) have been determined by radiometric methods as having an age of 173 to 192 m.y. (Grommé and Dalrymple, 1972). The diabase dikes (d) in the northern third of the quadrangle trend east, following the pattern of the dikes in the Voinjama quadrangle (Seitz, 1977). A few dikes in the east-central area trend northeast, paralleling the regional structural orientation of the gneissic bedrock.

The Jurassic dikes are revealed on aeromagnetic maps as linear elements with strong negative magnetic anomalies. The east-trending dikes and the metamorphosed dikes do not produce a magnetic anomaly discernible on the geophysical maps.

STRUCTURE

Structural trends within the quadrangle are remarkably uniform, having a persistent northeast strike throughout the area. Locally, the foliation attitude deviates from this direction, as in the extreme southeast part of the quadrangle, but elsewhere the attitudes mapped in the field are almost totally conformable with the regional trend. The aeromagnetic map (Behrendt and Wotorson, 1974a) reflects the same trend throughout. Small-scale folds are common in the gneiss. The outcrops along the St. Paul River show extensive folds, largely isoclinal, and having amplitudes as much as 8 m and axes plunging at angles ranging from 35° to vertical. Drag folds are common; ptygmatic folds were observed at one place. Broad undulatory folds present in places have amplitudes of several hundred metres with crest distances of 10 m.

Faults generally follow the regional structural trend. In places major faults are marked by river courses. In some areas, including the Via River valley, gneiss has been extensively mylonitized. In the southwest corner of the quadrangle, the St. Paul River flows in a channel that is a shear zone several hundred metres wide. The shear zone trends N. 70° E., and extends eastward from the west border of the quadrangle for 6 km. In the central part of the quadrangle, a fault zone trending N. 20° E. has been inferred from aeromagnetic data (Behrendt and Wotorson, 1974a) and topography. The course of the St. Paul (Niandu) River is in this zone from lat 7°20' N. to 7°48' N. Before no fieldwork in the area had been undertaken to verify the presence of this fault zone.

The diabase dikes present somewhat of a puzzle as they probably are controlled by fractures related to faulting, but in four separate areas they follow four different orientation patterns, as previously described. One of these is parallel to the regional northeast trend. The time of fracturing and emplacement of the dikes may be different for each group that shares a common orientation.

METAMORPHISM

Nearly all the rocks in the quadrangle have been subjected to regional metamorphism. In much of the area this was accompanied by moderate to intense deformation, as reflected by the abundant isoclinal folds in much of the schist and gneiss.

Much of the metamorphic rock, including the schist, iron-formation, quartzite, and some of the amphibolite, is of sedimentary origin. The extent to which the gneiss is of sedimentary origin has not been determined, but where the gneiss is part of a metasedimentary sequence, it probably was derived from pelite and psammite. Possibly the massive granitic rocks were also derived from similar sediments, but the evidence now is obliterated by the degree of mobilization or anatectic state attained.

MINERAL RESOURCES

Gold has been mined from alluvial deposits along tributaries of Zaya and Mawi Creeks in the Kiliwu-Zolowo area 10 to 20 km southwest of Zorzor (Thayer, Lill, and Coonrad, in press). Although nuggets weighing as much as three-fourths ounce (24 grams) have been found, production from the area has been on a small scale. Gold has been found in many other parts of the quadrangle, but to date, not in deposits that warrant extensive development.

Diamonds have been mined on a small scale in the region near Zorzor.

Itabirite and iron-formation occur in the quadrangle, but quantity and grade are not sufficient for commercial exploitation.

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GEOLOGIC MAP OF THE ZORZOR QUADRANGLE, LIBERIA

By
J. F. Seitz
1977

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