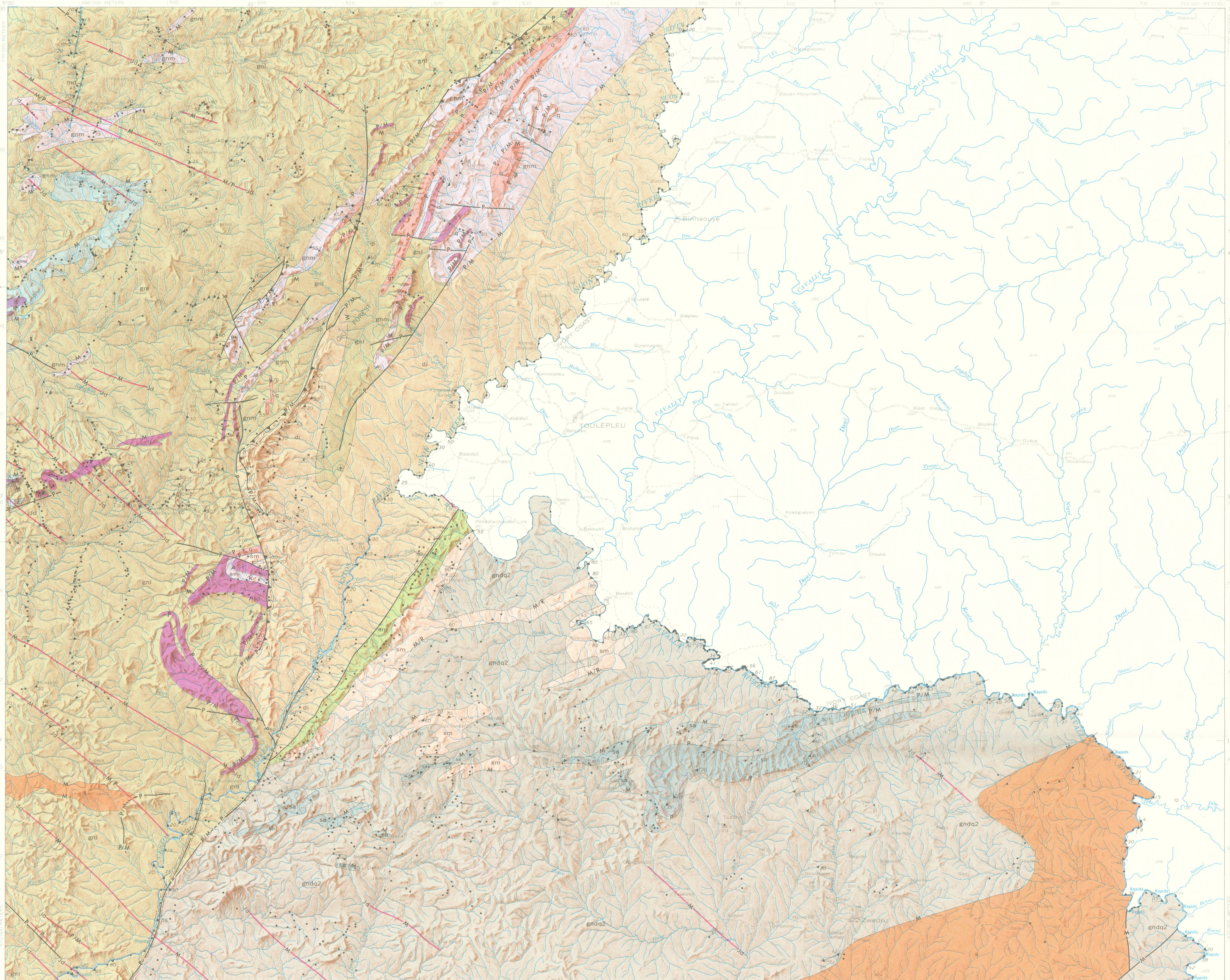


Base compiled by photo-planimetric methods from aerial photographs taken 1946, 1952-53, and 1968-69. Controlled from 1953 1:40,000-scale photo-mosaics by Aero Service Corporation

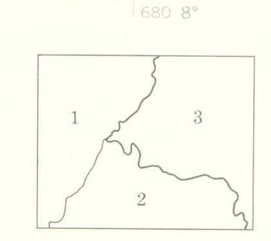
Hotines Rectified Skew Orthomorphic projection and rectangular coordinates

Shaded relief geographic map available as map I-777-A

INTERNATIONAL BOUNDARY SHOWN ON THIS MAP IS NOT NECESSARILY AUTHORITATIVE

SCALE 1:250,000

1971 MAGNETIC DECLINATION VARIES FROM 13°00′ WESTERLY FOR THE CENTER OF THE WEST EDGE TO 12°30′ WESTERLY FOR THE CENTER OF THE EAST EDGE. MEAN ANNUAL CHANGE IS 0°06′ EASTERLY

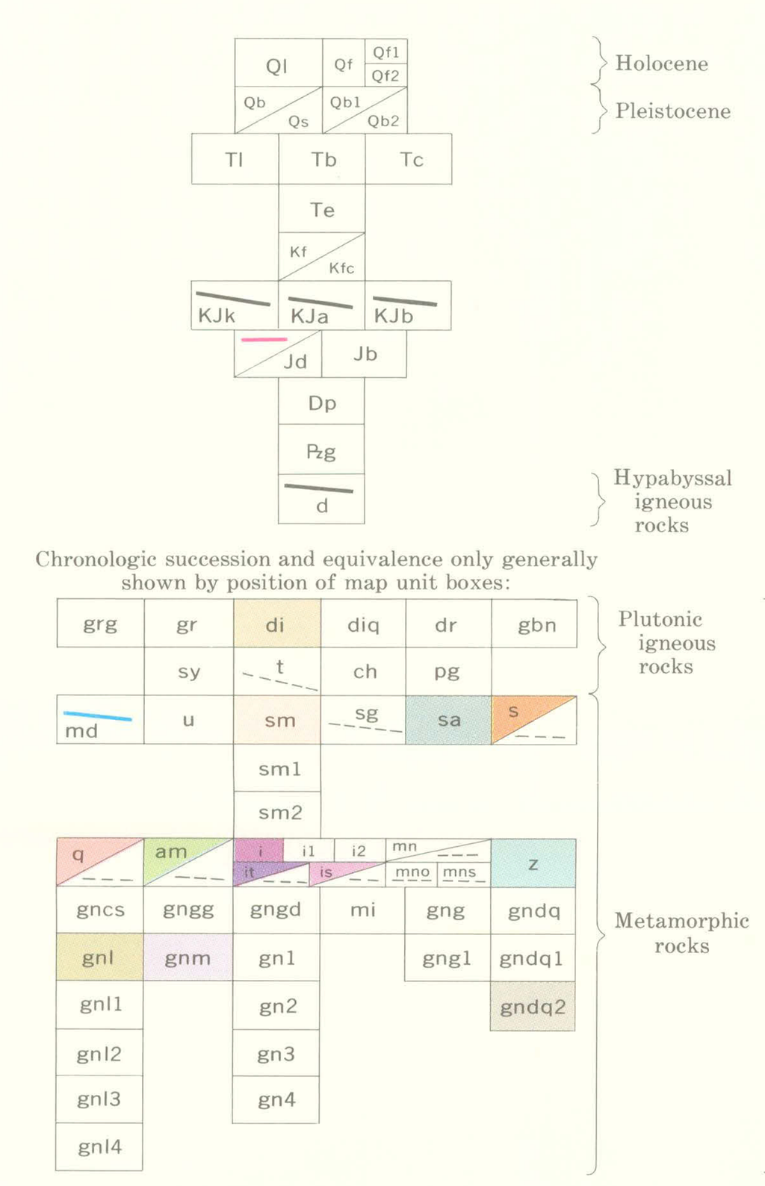


ADMINISTRATIVE BOUNDARIES
1—Nimba County, Liberia
2—Grand Jide County, Liberia
3—Ivory Coast

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



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 diabasic dike rock, consisting primarily of pyroxene and plagioclase
- **di** DIORITE—Massive to slightly foliated hornblende diorite, locally with quartz, partly altered to static biotite, actinolite, epidote, and chlorite. Mylonitic on western boundary
- **md** METADIABASE—Dark-colored, massive to slightly foliated diabase dikes containing secondary amphibolite. In northwest corner of quadrangle
- **z** COMPOSITE UNIT—A unit comprising predominantly amphibolite but with some schist, quartzite, and iron-formation
- **i** IRON-FORMATION, UNDIVIDED—Mainly coarse-grained magnetic and hematitic itabirite, with associated magnetic quartzite. Near Saaly, partly orthopyroxene-garnet iron silicate
- **is** IRON-FORMATION, SILICATE FACIES—Massive amphibole-pyroxene-garnet-quartz rock
- **it** IRON-FORMATION, OXIDE FACIES (ITABIRITE)—Massive coarse-grained magnetite-quartz rock
- **am** AMPHIBOLITE—Actinolite-epidote-banded greenstone near Tobli, mineralogy and texture elsewhere unknown
- **q** QUARTZITE—Massive garnetiferous quartzite, magnetic quartzite, and mica quartzite associated with some iron-formation. Kyanite-garnet quartzite in Gbi Range
- **s** SCHIST—Mostly quartz-mica schist, locally garnetiferous, with some quartzite, iron-formation, and amphibolitic schist
- **sa** AMPHIBOLITIC SCHIST—Foliated actinolite and hornblende schist, locally garnetiferous
- **sm** MICA SCHIST—Garnet-muscovite schist near Tobli, fine-grained feldspathic muscovite schist elsewhere
- **gnm** MELANOCRATIC GNEISS—Amphibolite and slightly foliated pyroxene-hornblende-plagioclase gneiss
- **gnl** LEUCOCRATIC GNEISS—Typically well-foliated medium-grained biotite gneiss; includes numerous bodies of melanocratic gneiss not mappable at this scale
- **gndq2** QUARTZ DIORITE GNEISS—Mostly well-foliated leucocratic biotite gneiss poor in 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.

- 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 — 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)

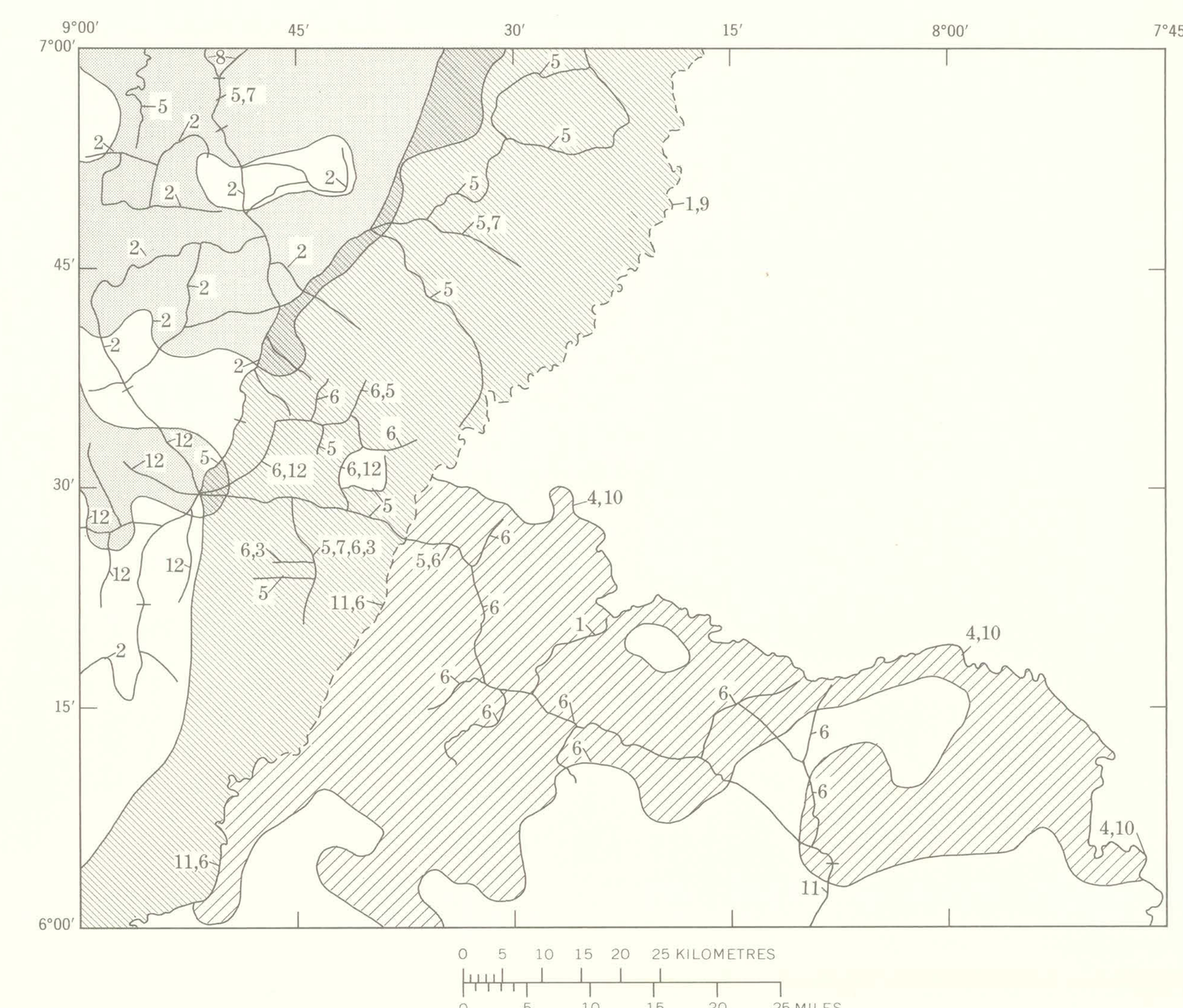
HY Index minerals:

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

- Surface traverse route
- Helicopter traverse route
- Area compiled by Force; the remainder compiled by Beikman
- Area covered by Offerberg and Tremaine (1961)
- Area covered by the Muller Company

1. G. O. Bachman (USGS)
2. B. R. Cooper (LGS)
3. J. D. N. Dunbar (LGS)
4. R. L. Earhart (USGS)
5. E. R. Force (USGS)
6. J. M. Hoare (USGS)
7. E. Phillips (LGS)
8. S. Rosenblum (USGS)
9. J. F. Seitz (USGS)
10. G. C. Simmons (USGS)
11. R. G. Tysdal (USGS)
12. C. S. Wotorson (LGS)

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LIBERIAN GEOLOGICAL SURVEY
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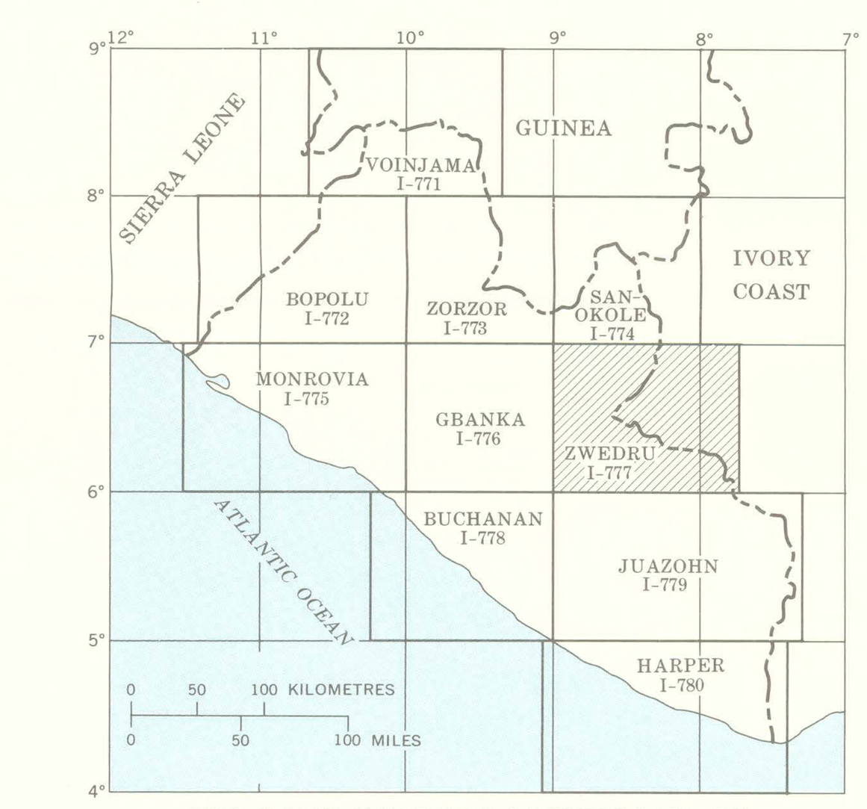
U.S. DEPARTMENT OF STATE



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 covering one quadrangle (see index map). Systematic map synthesis of the Zwedru quadrangle began in 1971 and included field data as shown in the source diagram. Observations but not interpretations made by geologists from private exploration surveys (Offerberg and Tremaine, 1961; van Griethuysen, 1970; Muller Co. unpub. reports) and from the Ivory Coast (Lemarchand, 1966; Contri, 1966) were incorporated in the mapping. Photogeologic mapping and interpretation of airborne magnetic and radiometric surveys (Behrendt and Wotorson, 1974a, b) are integral to the interpretation as presented.

Altitudes in the Zwedru quadrangle range from about 150 to 450 m. The most prominent topographic feature is Gbi Range at the southern end of a set of ranges which extend 80 km from Sanokole quadrangle through the Gio Forest. The Nuon (Cestos) and Cavalla Rivers form the boundary with Ivory Coast. Except for areas around Zwedru, around and north of Tapeta, and along the Nuon River, the land is forested.

Approximately 50 towns have a population of more than 200. Laterite-surfaced all-weather roads connect the larger towns of Tapeta, Zwedru, and Sagleipie. The total length of all roads is about 600 km; many of these are haulage ways for logging trucks.

ROCKS

Zwedru quadrangle, like the rest of Liberia, is crystalline terrane forming part of the Guinean Shield. Various types of leucocratic gneiss underlie most of the area. A metasedimentary-metavolcanic assemblage of quartzite, iron-formation, and amphibolitic schist forms long outcrop belts through much of the quadrangle. Hurley and others (1971) have shown the quadrangle to be within the Liberian age province (about 2700 m.y.).

The order of discussion below is organized by rock type and carries no stratigraphic implication. Surficial deposits are not mapped.

METAMORPHIC ROCKS

Gneissic rocks in the Zwedru quadrangle are subdivided mostly by color index, owing to the lack of information about gneiss compositions over wide areas.

Quartz diorite gneiss

The quartz-diorite-gneiss unit (gndq2) occupies most of the eastern part of the quadrangle. The designation is based on correlation with rocks in the Juazohn quadrangle (Tysdal, 1974). The gneiss is poorly exposed except along rivers, and forms large areas of low relief. Magnetic relief over this unit is quite variable.

Leucocratic gneiss

The most widespread unit in the west part of the mapped area is designated leucocratic gneiss (gnl). Other rock types are locally present within the unit. Leucocratic gneiss underlies large areas of low relief, as it is not resistant. Outcrop is poor except along rivers and because of differential weathering tends to underrepresent the proportions of leucocratic gneiss present. Magnetic patterns are variable, in accordance with the variable nature of the unit, but many small linear anomalies are probably due to associated amphibolite. Leucocratic gneiss probably includes metasedimentary rocks, as well as metamorphosed and (or) sheared igneous rocks.

Melanocratic gneiss

The melanocratic gneiss unit (gnm) includes both amphibolite and pyroxene-hornblende-plagioclase gneiss. In many places, as at Sagleipie, melanocratic gneiss forms small bodies unmappable at 1:250,000 scale in leucocratic gneiss. In turn, unmapped leucocratic gneiss can be found within the melanocratic gneiss; for example, in the large body of garnetiferous melanocratic gneiss in the Leputa area. Most of the long discontinuous belt of melanocratic gneiss between Leputa and Gloie is pyroxene bearing. Along the southern segment of this belt, some of the melanocratic gneisses are blastomylonitic hypersthene-blue quartz rocks. The melanocratic gneiss tends to weather spheroidally; topographic expression is extremely variable. Magnetic patterns are also variable, as pyroxenic varieties contain ilmenite rather than magnetite. Foliation in small bodies of melanocratic gneiss is roughly concordant to that in the surrounding leucocratic gneiss, but discordances and sheared contact zones along the western margin of the long belt mapped suggest a fault contact. Melanocratic gneiss is believed to represent metamorphosed mafic intrusive and volcanic rocks.

Mica schist

In several areas of low relief, mica schist (sm) can be mapped separately. The schist produces a distinct magnetic anomaly in one area along the Cavalla River; elsewhere, magnetic patterns over the schist are not distinctive. Near Tobli, compositional layering, which is parallel to banding in mafic schists nearby, is cut by the foliation of micaceous minerals. Contacts with gneiss were not observed, but foliation is concordant where contacts are believed to be unfaulted. The mica schist is of metasedimentary origin.

Amphibolite schist

Several linear belts of high relief are underlain by amphibolitic schist (sa), locally associated with iron-formation and quartzite. Outcrops are generally good, though in places obscured by lateritic cappings. Magnetic anomalies of a few hundred gammas are common, and radiometric values are low. No unsheared contacts with gneiss were observed. The amphibolitic schist probably represents metamorphosed volcanic and impure pyroclastic material.

Schist

Undivided schist (s) is mapped in two areas. That in the southwest part of the quadrangle is based on extrapolation along a prominent east-trending magnetic anomaly of schist from field traverses in the Gbanka quadrangle (Force and Dunbar, 1977). There the unit is mostly quartz-mica schist and is concordant and gradational with the adjacent gneiss. In the southeast part of the quadrangle, a large area of schist is mapped on the basis of exposures in the Cavalla River but is poorly exposed elsewhere. Low magnetic relief was used as the criterion for mapping its boundary.

Quartzite

Quartzite (q) forms many of the long, narrow, broad-topped ridges in the Saale area and is associated with minor iron-formation of both oxide and silicate facies. Magnetic anomalies are variable but commonly small. Outcrop is poor, but float boulders are abundant. Contacts were not observed.

Amphibolite

In the area of Tobli, east of the Cestos River, amphibolite (am) forms a long narrow range of hills; it has no magnetic expression. Contacts were not observed but the nearest rock exposed on either side is mica schist. Probably the unit is metavolcanic.

Iron-formation

Iron-formation (i) is found in several narrow ridges in gneiss terrane or associated with quartzite and amphibolitic schist in the northwestern part of the quadrangle. It holds up high ridges but forms few outcrops, being represented instead by float boulders. As a coarse-grained, low-grade itabirite with subordinate iron silicate, ferruginous quartzite, and kyanite-garnet quartzite, it forms a large area in the Gbi Range south of Tapeta. The great areal extent is due to generally low dip and probable repetition by folding. The largest associated magnetic anomaly is 3000 gammas. Some areas underlain by itabirite have no magnetic expression, probably because much of the itabirite and quartzite is hematitic, and because the iron-formation forms a thin, nearly-horizontal layer. Radiometric values over the iron-formation are low. It is not known whether there is a significant zone of surficial enrichment of iron minerals over the iron-formation. Contacts, except with interbedded quartzite, were not observed.

The silicate facies of iron-formation (is) is mapped separately only in a ridge near Saale, but similar rocks commonly occur within other units of quartzite and iron-formation. Itabirite (it) forms central spines of ridges whose slopes consist of amphibolitic schist in the western part of the quadrangle.

Composite unit

A composite unit (z), which includes several types of metasedimentary and metavolcanic rocks, is mapped where information is too poor to allow subdivision in the northwestern part of the quadrangle. Relief is mostly low and outcrop poor. A chain of magnetic anomalies was helpful in drawing the boundaries of the unit.

IGNEOUS ROCKS

Metadiabase

Metadiabase (md) that is partly amphibolitized but is apparently not folded is found in a fracture zone oriented north-northeast along Ya Creek in the northwestern corner of the quadrangle.

Diorite

A large area along the Nuon (Cestos) River is underlain by diorite (di). The unit is unresistant to weathering and erosion and crops out mostly in the river bed. Magnetic and radiometric patterns are not distinctive. Late-formed low-temperature metamorphic minerals indicate either retrograde metamorphism or deuteric alteration. Along the western edge of the body, adjacent to a major thrust fault, the diorite grades into mylonitic augen gneiss several hundred metres thick. The mylonite is resistant to erosion. The diorite is believed to be an igneous intrusive, but faults are so widespread along its margins that it may not have been intrusive into rocks now adjacent to it.

Hypabyssal igneous rocks

In the Zwedru quadrangle, diabase (Jd) typically forms northwest-trending dikes. It is considered Jurassic in age on the basis of K-Ar determinations and paleomagnetic studies for similar rocks elsewhere in Liberia, although the radiometric ages are not wholly in accord with one another (Grommé and Dalrymple, 1972).

STRATIGRAPHY AND STRUCTURE

The only determinable age relationship among the metamorphic rocks in the Zwedru quadrangle is that metamorphosed diabase dikes are younger than the gneisses which they intrude. In numerous places, gneiss occupies both the core and the flanks of folds in metasedimentary units, thus not all gneiss can be older than the metasedimentary rocks.

There is a fundamental difference between the quartzite-iron-formation assemblages in the Gbi Range and Gio Forest, and the amphibolitic schist-iron-formation assemblage on either side. The metasedimentary-metavolcanic sequences in these belts may be of different ages.

Probably the diorite found along the Nuon (Cestos) River is younger than surrounding metamorphic rocks. However, in the absence of radiometric dates or unfaulted contacts, this can only be inferred.

The contact in the extreme eastern part of the mapped area, between schist to the east and quartz diorite gneiss to the west, is almost in line with an age-province boundary shown in Ivory Coast by Tagini (1965). The younger province is shown toward the east. An age of 2130 m.y. is reported by Hurley and others (1971) for a gneiss collected in the contact zone; thus, the significance of this date is not known. Hurley and others (1971) use it in support of separating rocks of Eburnean age to the east from those of Liberian age to the west. They also report an age of 2300 m.y. for a leucocratic gneiss toward the west, near Zle, which they mapped as part of the Liberian age province.

FOLDS

In the Gbi Range and in the Gio Forest, folds are marked by iron-formation and quartzite. Most of these appear to be isoclinal, but in the northern part of the Gbi Range, nearly horizontal iron-formation may be gently warped. East of the Cestos (Nuon) River near Zai, a northeast-trending isoclinal fold in amphibolitic schist and gneiss appears to have been refolded about a northwest-trending axis.

Photogeologic study has disclosed a probable ring structure in the southern part of the quadrangle. Traverses by the Muller Co. indicate that most of the rocks in the area are "migmatite."

FAULTS

Two known thrust faults trend northeast and have appreciable thickness of mylonite in the upper plate. Probably the more important fault thrusts massive diorite westward over gneiss, quartzite, and iron-formation. Mylonitized diorite several hundred metres thick dips 30°-60° east and locally forms resistant ridges. The mylonite consists of perthitic augen in a matrix of tabular quartz, hornblende, garnet, and diopside. On the Tapeta-Zwedru road, a kaolinized gouge zone is exposed at the base of the mylonite; this zone can be traced on photographs for 20 km to the north. The gouge probably represents postmylonitization faulting on the same trend, at a shallow crustal level.

The other fault thrusts pyroxene-bearing melanocratic gneiss on the east westward over leucocratic gneiss. Mylonitized melanocratic gneiss dipping east is found in the Gloie area; it contains rutilated hypersthene augen in a matrix of rutilated quartz and biotite. In the Leputa area, the thrust is interpreted from the strong discordance in structure in rocks of the upper and lower plates.

Another zone of faulting, probably more strike-slip than dip-slip in nature, follows roughly the course of the Cestos (Nuon) River and branches northward. The southern end of the eastern set of thrust faults is truncated against the Cestos River shear zone or is a branch of it. Mylonites have been observed along the Cestos River shear zone along the river in the southern part of the quadrangle; they vary in character from ultramylonite to blastomylonite (Tysdal, 1977). On the Tapeta-Zwedru road, the fault forms the western margin of a schist-greenstone sequence and is marked by a laminated micaceous gouge zone.

METAMORPHISM

West of the Cestos River, amphibolite facies metamorphism is believed to be widespread, as hornblende amphibolites are common. Kyanite is present in quartzite in the Gbi Range. Between Leputa and Gloie in the northern part of the quadrangle, melanocratic gneiss containing hypersthene is common and represents lower granulite facies metamorphism. As these rocks are found on the upper plates of east dipping faults, they have probably been brought from depth by thrust faulting. In the hills just east of the Cestos River, actinolite, epidote, and kyanite are found. If they represent a single metamorphic assemblage, it must be in the lower amphibolite facies.

MINERAL RESOURCES

Based on the wide distribution of itabirite and magnetic quartzite in Gbi Range, and the large associated magnetic anomaly, the iron-formation here is a possible resource. Quartzite containing much coarse-grained kyanite is apparently interlayered with iron-formation.

The only current mining activity in the quadrangle is minor panning of diamonds from alluvium along Zina Creek near Leputa.

REFERENCES

Behrendt, J. C., and Wotorson, C. S., 1974a, Aeromagnetic map of Zwedru quadrangle, Liberia: U.S. Geol. Survey Misc. Inv. Ser. Map I-777-B.

———1974b, Total-count gamma radiation map of the Zwedru quadrangle, Liberia: U.S. Geol. Survey Misc. Inv. Ser. Map I-777-C.

Contri, J. P., 1966, Rapport de Fin de Leve Couperes Toulepleu 4c-4d Guiglo 3c-3d: Societé pour le development minier de la Cote D'Iviore Rapport 175 (1).

Force, E. R., and Dunbar, J. D. N., 1977, Geology of Gbanka quadrangle: U.S. Geol. Survey Misc. Inv. Ser. Map I-776-D.

Grommé, C. S., and Dalrymple, C. B., 1972, K-Ar ages and paleomagnetism of dikes in Liberia [abs.]: Am. Geophys. Union Trans., v. 43, 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.

Lemarchand, R., 1966, Rapport de Fin de Leve Couperes Toulepleu 1d-2c-2d-3b-4a-4b: Societé pour le development minier de la Cote D'Ivoire Rapport 181.

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

Tagini, B., 1965, Carte Geotectonique de la Cote D'Ivoire 1:1,000,000: Societé pour le development minier de la Cote D'Ivoire.

Tysdal, R. G., 1977, Geologic map of the Juazohn quadrangle, Liberia: U.S. Geol. Survey Misc. Inv. Ser. Map I-779-D.

van Griethuysen, H. W., 1970, Mineral exploration of Wm. H. Muller and Co. in Eastern Liberia: Geol. Mining Metall. Soc. Liberia Bull., v. 4, 1969–1970, p. 88–95.

GEOLOGIC MAP OF THE ZWEDRU QUADRANGLE, LIBERIA

By
E. R. Force and H. M. Beikman
1977

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