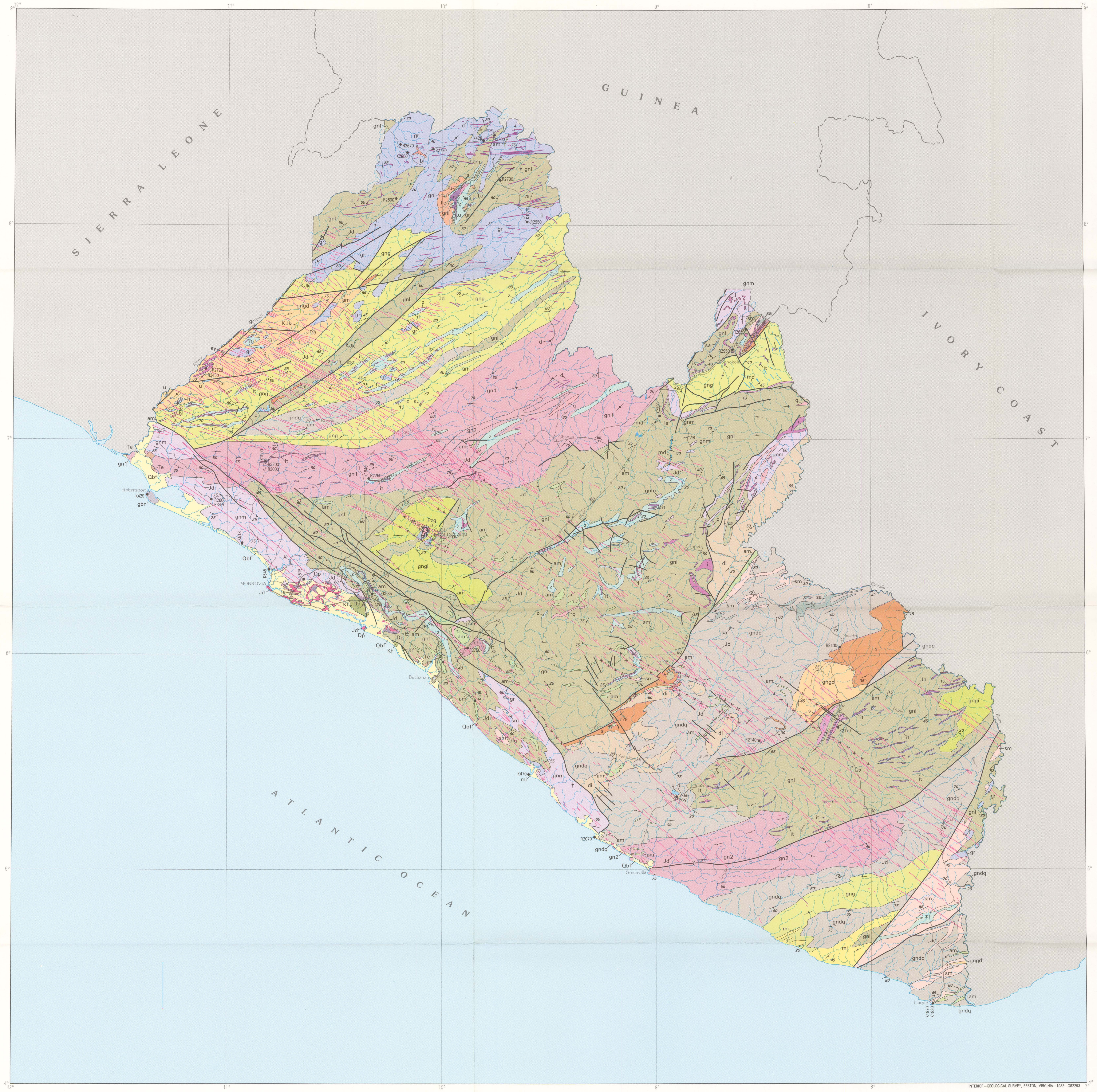
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

REPUBLIC OF LIBERIA
MINISTRY OF LANDS AND MINES
LIBERIAN GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I-1480



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

INTERNATIONAL BOUNDARIES SHOWN ON THIS MAP ARE NOT NECESSARILY AUTHORITATIVE

SCALE 1:1 000 000

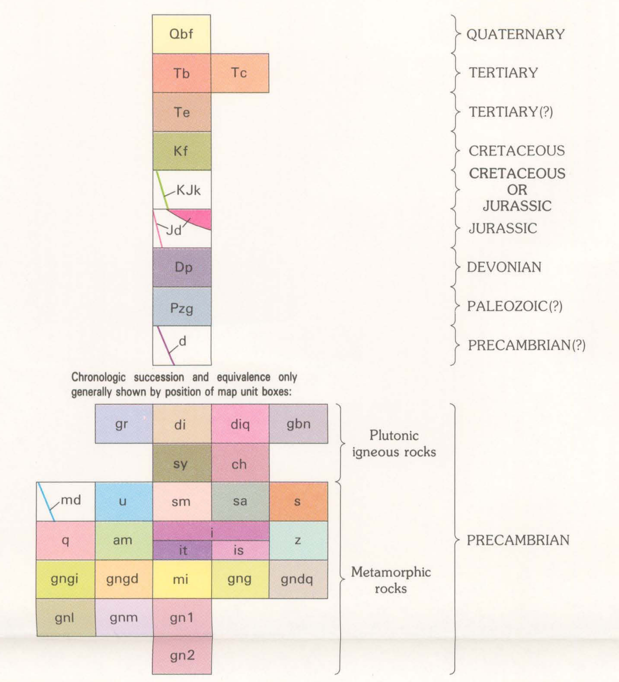
25 0 25 50 75 100 MILES

25 0 25 50 75 100 KILOMETERS

GEOLOGIC MAP OF LIBERIA

By
R. G. Tysdal and C. H. Thorman
1983

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qbf BEACH AND FLUVIAL DEPOSITS (QUATERNARY)—Modern beach deposits including longshore bars; older beach deposits of nearly pure white quartz sand, about 1 m thick, and buff to yellowish-brown silt and sand deposits of probable fluvial and deltaic origin that form large savannahs

Tb BAUXITE (TERTIARY)—Bauxite nodules forming thin layer in soil

Tc CANGA (TERTIARY)—Clasts of iron-formation and associated rocks cemented by iron oxides; clasts form conglomeratic deposit that underlies plains and fans

Te EDINA SANDSTONE (TERTIARY?)—Brownish-yellow, light-brown, white, medium- to coarse-grained gritty to conglomeratic quartz sandstone; commonly well sorted and locally crossbedded; rock cemented by clayey limonitic material; generally less than a few meters thick

Kf FARMINGTON RIVER FORMATION (CRETACEOUS)—Brown to dark-green nearly massive sandstone consisting of poorly to moderately well sorted, subangular to subrounded grains of quartz (25-40 percent), feldspar (10-25 percent), mafic minerals (10-20 percent) and lithic fragments (2-15 percent) in a matrix (5-35 percent) of quartz, mica, clay, chlorite, and calcite. Fragments of gastropod and pelecypod shells and carbonatized plant debris locally present. Conglomerate unit at base contains well-rounded clasts of granitic rock, gneiss, amphibolite, iron-formation, quartz, quartzite, and diabase in sandy matrix. Thickness of formation probably in excess of 1.5 km

KJk KIMBERLITE (CRETACEOUS OR JURASSIC)—Dark-gray rock composed of abundant large ilmenite crystals in fine-grained matrix; contains minor garnet, olivine, mica, and augite. Diamonds locally are associated with the kimberlite. Outcrops are extremely rare, and most of the kimberlite bodies were located by the use of indicator minerals in heavy-concentrates of stream-sediment samples. Kimberlites known only in area about 50 km north-northwest of Bopolu, in westernmost Liberia

Jd DIABASE (JURASSIC)—Dark-gray, fine- to coarse-grained rock, mainly diabasic but locally gabbroic in texture; consists primarily of calcic plagioclase and clinopyroxene, but has minor amounts of magnetite and ilmenite; locally contains orthopyroxene. Occurs chiefly as northwest-trending dikes 5 to 100 m thick, but also forms large sill-like bodies in the coastal area near Monrovia. Rocks produce characteristic strong negative magnetic anomaly

Dp PAYNESVILLE SANDSTONE (DEVONIAN)—Light-colored, fine- to medium-grained, well-rounded and well-sorted, crossbedded quartz sandstone; subordinate crossbedded reddish-brown siltstone and shale along highway near ELWA junction about 20 km east of Monrovia; quartz grains typically frosted. Thickness unknown

Pzg GIBI MOUNTAIN FORMATION (LOWER PALEOZOIC?)—Upper member consists of light-brown shale and mudstone with thin lenses of gritty arkosic wacke; medial sandstone or arkosic wacke consists of light-brown, medium- to coarse-grained, fairly well sorted, subangular to subrounded quartz and feldspar grains in sericite-quartz-chlorite matrix (5-35 percent); basal conglomerate consists of gneiss boulders in light-brown arkosic matrix

d DIABASE (PRECAMBRIAN?)—Gray to dark-gray, medium-grained calcic plagioclase and clinopyroxene dike rock that has a diabasic texture; in northwest Liberia, contains olivine and locally is altered to metadiabase; forms east-trending dikes 5 to 30 m thick

gr GRANITIC ROCKS (PRECAMBRIAN)—Light-gray to light-yellowish-gray, medium- to coarse-grained, predominately massive quartz-two feldspar granitoid rocks containing chiefly muscovite, but locally containing biotite and hornblende. Rocks predominately granitic in composition, but range from granite to quartz diorite. Granitic rocks locally contain megacrysts of potassium feldspar

di DIORITE (PRECAMBRIAN)—Gray-green to dark-gray, medium- to coarse-grained, massive hornblende-feldspar-quartz melanocratic rock. Hornblende content ranges from 20 to 40 percent. At Juazohn, unit includes fine- to medium-grained plagioclase-hornblende-diopside diorite and minor biotite and quartz diorite, trondjhemite, gabbroic diorite, and locally gabbro, all of which are associated with an ultramafic body

diq QUARTZ DIORITE (PRECAMBRIAN)—Medium-gray, medium- to coarse-grained, massive biotite quartz diorite

gbn NORITE (PRECAMBRIAN)—Dark-gray to dark-reddish-gray, medium- to coarse-grained hypersthene-augite-calcic plagioclase rock. At Robertsport, coronas of actinolitic hornblende and garnet commonly rim pyroxenes

sy SYENITE (PRECAMBRIAN)—Brownish-gray to grayish-buff, fine- to coarse-grained rock. Near Mano River, northwest of Bopolu, rock is chiefly perthite, but has minor hornblende and biotite. At Juazohn, rock is composed of orthoclase, aegirine, biotite, and magnetite and is locally pegmatitic

ch CHARNOCKITE (PRECAMBRIAN)—Gray to olive-green, medium- to coarse-grained, massive granite containing hypersthene, hornblende, perthitic potassium feldspar, plagioclase, and quartz

md METADIABASE (PRECAMBRIAN)—Dark-gray, fine- to medium-grained, massive to slightly foliated pyroxene-plagioclase dike rocks; composed in part of foliated amphibolite derived from diabase

u ULTRAMAFIC ROCKS (PRECAMBRIAN)—At Juazohn, consist of dark-green, fine- to medium-grained rocks including serpentinized dunite, serpentinite, and pyroxenite; magnetite composes up to 20 percent of rocks locally. In northwestern Liberia, consist of very dark gray, fine- to medium-grained, massive to schistose talc or amphibole-rich metaperidotite, serpentinite, and partly serpentinized dunite

sm MICA SCHIST (PRECAMBRIAN)—Fine- to medium-grained schist containing muscovite and (or) biotite as major constituent and varying amounts of quartz, feldspar, and garnet; includes sillimanite- and staurolite-bearing schists in southeastern Liberia. Northeast of Sanokole, includes phyllite, schist, and graphitic schist of the Gbahm Ridge and Mt. Alpha Formations of the Nimba Supergroup of Berge (1968; 1974)

sa AMPHIBOLITIC SCHIST (PRECAMBRIAN)—Fine- to medium-grained, banded, in part porphyroblastic schist containing varying amounts of actinolite, tremolite, hornblende, and anthophyllite with local garnet. Northeast of Sanokole, includes the Seka Valley Amphibole Schist of the Nimba Supergroup of Berge (1968; 1974)

s SCHIST, UNDIVIDED (PRECAMBRIAN)—Fine- to coarse-grained, varies widely in composition. Dominant mineral assemblages are biotite-quartz-feldspar, muscovite-quartz-feldspar, biotite-muscovite-quartz-feldspar, quartz-muscovite, and hornblende-biotite-quartz-feldspar; contains staurolite along Cestos River, sillimanite west of Zwedru. Unit locally includes silicate facies iron-formation in vicinity of Sanokole, quartzite and amphibolitic schist along Cestos River and near Sanokole and Zwedru

q QUARTZITE (PRECAMBRIAN)—Fine- to coarse-grained, weakly to strongly schistose, pure to slightly micaceous to feldspathic quartzite; commonly contains varying amounts of garnet, magnetite, hematite, muscovite, and locally pyrite and graphite. North of Buchanan and northeast of Tapeta, unit contains kyanite

am AMPHIBOLITE (PRECAMBRIAN)—Medium- to dark-greenish-gray, fine- to coarse-grained, massive to schistose hornblende-plagioclase rock containing lesser amounts of quartz, clinopyroxene, biotite, sphene, garnet, and epidote

i IRON-FORMATION (PRECAMBRIAN)—Fine- to coarse-grained, in part banded, iron-rich schist containing hematite and magnetite itabirite; locally includes amphibole-bearing iron silicate northeast of Sanokole and orthopyroxene-garnet iron silicate in vicinity of Tapeta

it IRON-FORMATION, OXIDE FACIES (ITABIRITE) (PRECAMBRIAN)—Dark-gray, brown, brick-red, fine- to coarse-grained, finely laminated rock composed of alternating layers of quartz and hematite-magnetite-quartz

is IRON-FORMATION, SILICATE FACIES (PRECAMBRIAN)—Dark-colored, fine- to coarse-grained, massive to schistose rock composed, in varying amounts, of cummingtonite or grunerite or hornblende, quartz, plagioclase, magnetite, garnet, and chlorite. Unit also includes minor amounts of itabirite and garnetiferous quartzite in Sanokole area

z COMPOSITE UNIT (PRECAMBRIAN)—Comprises rock types associated with itabirite (oxide facies iron-formation) that are too limited in distribution to be mapped separately. Unit imparts distinctive linear magnetic anomalies of moderately high amplitude, readily distinguished from lower amplitude signature of encompassing feldspar-quartz gneisses. Rock unit includes a variety of muscovite and biotite schists, amphibolite, quartzite, micaceous quartzite, iron-rich schist, fine-grained micaceous quartz-feldspar gneiss, and locally itabirite. In area between Monrovia and Buchanan, unit includes kyanite-, sillimanite-, and graphite-bearing schists

gngi GRANITIC GNEISS, INTRUSIVE (PRECAMBRIAN)—Medium- to coarse-grained biotite-quartz-plagioclase-potassium feldspar rock that ranges from banded to massive in short distances. Magnetic and aerial photographic trends are irregular and do not follow regional trends. In easternmost Liberia, pegmatites are abundant throughout unit and large outcrops are commonly migmatitic

gngd GRANODIORITE GNEISS (PRECAMBRIAN)—Fine- to coarse-grained, hypidiomorphic, weakly to strongly foliated biotite-quartz-plagioclase-potassium feldspar gneiss of granodiorite composition; contains hornblende in area northwest of Bopolu. Includes local occurrences of schist, amphibolite, quartz diorite gneiss, and granitic intrusive bodies south of Zwedru

mi MIGMATITE (PRECAMBRIAN)—Hybrid rock consisting of mixed, foliated, more mafic country rock (paleosome) and massive to weakly foliated less mafic matrix (neosome). Paleosome is typically fine- to coarse-grained biotite-bearing rock of granodiorite to quartz diorite composition and amphibolite. Neosome is typically fine- to coarse-grained, biotite-bearing granite to granodiorite to quartz diorite and has textures varying from granitic to aplitic to pegmatitic

gng GRANITIC GNEISS (PRECAMBRIAN)—Medium- to coarse-grained, locally fine-grained, weakly to strongly foliated, commonly banded biotite-quartz-plagioclase-potassium feldspar gneiss ranging in composition from granite to granodiorite, locally being quartz dioritic. Locally grades into massive granitic rock. Includes minor amounts of amphibolite. Typified by linear, low amplitude magnetic signature

gndq QUARTZ DIORITE GNEISS (PRECAMBRIAN)—Fine- to coarse-grained, moderately to strongly foliated, commonly banded hornblende- and (or) biotite-quartz-plagioclase-potassium feldspar rock of quartz diorite composition. Typically includes amphibolite and minor amounts of schist

gnl LEUCOCRATIC GNEISS (PRECAMBRIAN)—Light-colored, medium- to coarse-grained, weakly to strongly foliated, commonly banded rock ranging in composition from granite to granodiorite, locally quartz diorite, containing biotite, quartz, plagioclase, and potassium feldspar. Locally includes small bodies of amphibolite, melanocratic gneiss, quartzite, and schist. Unit includes kyanite- and sillimanite-bearing gneiss in region bordered by towns of Buchanan, Monrovia, Gbanka, and Tapeta

gnm MELANOCRATIC GNEISS (PRECAMBRIAN)—Dark-colored, medium-grained, moderately foliated rock typically containing hypersthene, diopside, hornblende, plagioclase, and biotite; includes amphibolite and granitic gneiss with and without pyroxenes. Locally includes sillimanite-hypersthene-garnet-two mica gneiss in western Liberia

gn1 COMPOSITE GNEISS UNIT 1 (PRECAMBRIAN)—Composite unit of gneiss that is typically associated with itabirite (oxide facies iron-formation) and composite unit z rocks that are too small to map separately. Unit includes light-colored, medium-grained, banded, layered biotite-rich granitic gneiss; medium-colored, medium-grained, hornblende-bearing granodiorite to diorite gneiss; and contains more amphibolite than adjacent gneissic units. Near Zorzor, includes rocks of granodiorite, syenite, and quartz diorite composition. Between Monrovia and Buchanan, west of Todi shear zone, unit contains diopside and (or) hypersthene in melanocratic and leucocratic rocks

gn2 COMPOSITE GNEISS UNIT 2 (PRECAMBRIAN)—Composite gneiss unit containing more or less equal amounts of biotite- and (or) muscovite- or hornblende-quartz-feldspar granitic gneiss and amphibolite and quartzite; graphite and garnet occur locally in southeastern Liberia. Clinopyroxene and orthopyroxene occur locally northeast of Greenville

CONTACT

FAULT—Queried where uncertain

THRUST FAULT—Sawteeth on upper plate

FAULT INTRUDED BY DIKE

STRIKE AND DIP OF FOLIATION

70 Inclined—Degree of dip given where known

Vertical

R2770 RADIOMETRIC AGE IN MILLIONS OF YEARS—From Hedge and others (1975), including reevaluation of dates of Hurley and others (1970; 1971). R, rubidium-strontium; K, potassium-argon. Number in horizontal position shows original age of rock; in vertical position, shows age of mineral only

INTRODUCTION

A cooperative program for reconnaissance study of the geology of Liberia was carried out jointly by the Liberian Geological Survey and the U.S. Geological Survey from June 1965 through June 1972. The project was sponsored by the Ministry of Lands and Mines of the Republic of Liberia and the Agency for International Development, U.S. Department of State. Systematic quadrangle mapping began in late 1970 when adequate base maps, prepared during the project, became available, and mapping was completed in 1972. Ten folios of geologic, geographic, and geophysical maps were produced at a scale of 1:250,000 in the course of the study and are given in the list of published folios. The geologic map of Liberia was compiled at a scale of 1:1,000,000 from the ten geologic quadrangle maps of the folios and necessarily shows less detail.

Rock outcrops are sparse in Liberia owing to tropical weathering that has produced a thick laterite and saprolite cover, which supports a dense rain forest. In addition, large areas of the country afford only limited access by road or trail. Hence, a major program was undertaken to traverse the main rivers, where rocks are best exposed and least weathered. To facilitate mapping of rock units, extensive use was made of aeromagnetic and aeroradiometric maps that exist for the entire country. Other major sources of data included unpublished reports by geologists of private companies, photo interpretation, and published reports. The reader is referred to the geologic maps of the folios for references and specific data sources. These maps also show the criteria used to draw boundaries of rock units (for example, ground observation, aeromagnetic data, aerial photo interpretation, etc.), key minerals indicative of metamorphic grade, routes of geologic traverses, descriptive texts, and other data.

Liberia is underlain by the Guinean Shield of West Africa and is composed mainly of Precambrian igneous and metamorphic rocks. Other rocks occur locally and are chiefly Paleozoic sandstone, Jurassic diabase dikes, Cretaceous sandstones, and Quaternary unconsolidated deposits. The classification of igneous and metamorphic rocks used here is, as far as possible, based on igenous 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	<50
Dioritic rocks, undivided	Diorite gneiss	<10	>10
Quartz diorite	Quartz diorite gneiss	<10	>10
Diorite	Diorite gneiss	<10	<10

An igneous origin is not necessarily implied for the metamorphic rocks classified under this scheme.

Rocks that do not fit the above classification are noted by specific compositional names (such as iron-formation, ultramafic rocks) or, where little information is available, by a general name (such as leucocratic gneiss). Composite units are designated for areas containing combinations of specific rock types that cannot be separated appropriately at map scale.

AGE PROVINCES

Three age provinces (see age province map) are recognized in the Precambrian basement rocks of Liberia (Hurley and others, 1970, 1971; Hedge and others, 1975). The Liberian age province was metamorphosed and intruded by plutonic rocks about 2,700 million years (m.y.) ago, but high Sr^{87}/Sr^{86} ratios suggest a crustal history that may be as old as 3,200 m.y. (Hedge and others, 1975). The Eburnean age province was metamorphosed about 2,150 m.y. ago. The boundary between this province and the Liberian province is not well defined, however, owing to limited age dates from east-central Liberia. Rocks of the Pan-African age province were metamorphosed and intruded about 500 m.y. ago, and most of these basement rocks are believed to have been originally part of the Liberian province (Thorman, 1977; Hedge and others, 1975).

Forty potassium-argon and rubidium-strontium dates considered by Hedge and others (1975) to be reliable are shown on the geologic map. Age patterns determined from K-Ar dating suggest that the Pan-African province was uplifted relative to the Liberian province after the 500-m.y.-ago thermal event. Fission-track dates of apatites obtained from rocks on opposite sides of the Todi shear zone indicate that by 120 m.y. ago the Pan-African and Liberian age provinces were in juxtaposition and together were uplifted to within 3 km of the surface (Hedge and others, 1975).

STRUCTURE

The structural grain of the metamorphic rocks in the Liberian and Eburnean age provinces trends mainly northeast, whereas that of the Pan-African age province trends northwest. The metamorphic rocks record several episodes of deformation, including several generations of folding and faulting, metamorphism, and locally inferred unconformities. Isoclinal folds that have steeply dipping limbs and gently to moderately plunging axes are the norm and range from microscopic to several kilometers across. However, a broad region of folds that have gently dipping limbs occurs in the gnl map unit east of the Putu Range of eastern Liberia. Many of the larger folds are easily visible on aerial photographs, because intense tropical weathering has accentuated the contrast in resistance of various rock units to weathering; the itabirite and associated quartz-rich rock units, for example, typically form prominent steep-sided ridges, whereas feldspar-rich gneisses form subdued topography.

The major northeast-trending faults of the eastern half of Liberia are steeply dipping structures that have major vertical, and perhaps lateral, displacement. Generally they are marked by broad zones of mylonite, as well as by differences in rock types and accompanying contrasting aeromagnetic patterns on opposite sides of the faults (Brock and others, 1977; Tysdal, 1977a,b, 1978a,b). These faults are extensions of major structures recognized previously in the Ivory Coast.

In coastal central Liberia, the northeast-trending structural grain is terminated abruptly at the northwest-trending Todi shear zone (Tysdal, 1977a, 1978a; Thorman, 1976), which is the northern limit of the Pan-African age province. Farther west, structural trends bend to the west and intersect the Todi shear zone at about a 45° angle. In westernmost Liberia, rock units can be traced across the Todi shear zone into the Pan-African province (Thorman, 1976, 1977).

The Todi shear zone is defined by a series of faults, marked by wide zones of mylonite that generally dip 50°-70° southwest, except in the eastern extent of the zone where dips are nearly vertical (Thorman, 1976, 1977; Tysdal, 1977a, 1978a). Gravity (Behrendt and Wotorson, 1974a) and field data (Thorman, 1977; Tysdal, 1977a, 1978a) indicate that the shear zone dips southwest beneath the Pan-African age province. Thorman (1976, 1977) postulated that the rocks of Gibi Mountain are a klippe of Pan-African province rocks thrust into its present position during movement along the Todi shear zone.

A system of northwest-trending diabase dikes forms a spectacular linear pattern across the geologic map of Liberia and exhibits negative magnetic anomalies of 50 to 150 gammas that impart a prominent linear grain to the aeromagnetic map (Behrendt and Wotorson, 1971, 1974b). The dikes are of Jurassic age, ranging from 172 to 192 m.y. old (Dalrymple and others, 1975). Most of the dikes were intruded along faults, many of which are marked by shearing and lateral offset of basement rock. These faults are younger than most of the northeast-trending faults and shear zones in the Liberian and Eburnean age provinces, and they are younger than the Todi shear zone. In the Voinjama and Zorzor regions of northwestern Liberia, Seitz (1977a, b) mapped a system of diabase dikes that also transect the basement rocks, but they differ from the Jurassic dikes in that they occupy an east-trending fracture system, lack prominent negative magnetic anomalies, and are older. Hedge and others (1975) obtained a potassium-argon age of 2,850 m.y. from one of them.

Two onshore sedimentary basins are defined by negative gravity anomalies over depocenters of the Cretaceous Farmington River Formation, which overlies a tabular body of Devonian Paynesville Sandstone. The depocenter of the Roberts basin occurs about 50 km east of Monrovia and that of the Bassa basin is about 25 km northwest of Buchanan. Both basins are bordered landward by high-angle faults. A gravity model profile across the Roberts basin shows the Cretaceous strata to be as much as 1.5 km thick and the underlying Devonian strata to be about 1 km thick (Behrendt and Wotorson, 1970, 1972, 1974b; White, 1972).

Holocene uplift of a few meters has permitted preservation of unconsolidated quartz sand both in beach ridges along the coast and beneath savannahs, which are as much as 15 km wide, behind the ridges. Anomalies on the radiometric maps of the coastal area mark the positions of zircon and monazite in heavy-mineral concentrations in lenses of the beach ridges (Rosenblum and Srivastava, 1971).

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FOLIOS

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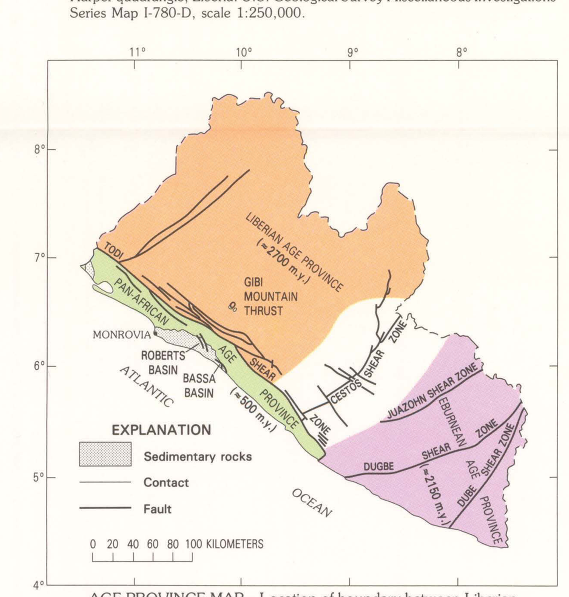
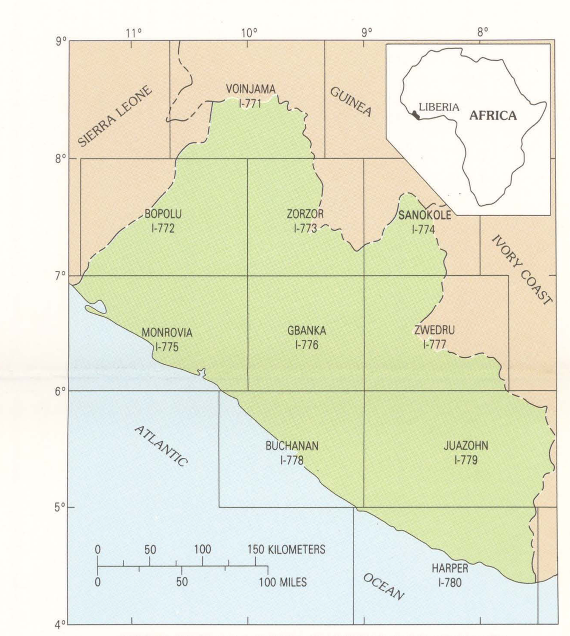


AGE PROVINCE MAP—Location of boundary between Liberian and Eburnean age provinces is uncertain



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