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GEOLOGY OF THE ZWEDRU QUADRANGLE, LIBERIA

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by

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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, Liberia was mapped by geologic and geophysical methods during the period 1965 to 1972. 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, in press, a, 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 ($gndq_2$) 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 tend 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.

Amphibolitic schist

Several linear belts of high relief are underlain by amphibolitic schist (sa), locally associated with iron-formation and quartzite. Outcrop is generally good, though often 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, 1974). 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 meters 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 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 the 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 thicknesses 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 meters 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 post-mylonitization 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, 1974). 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.

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