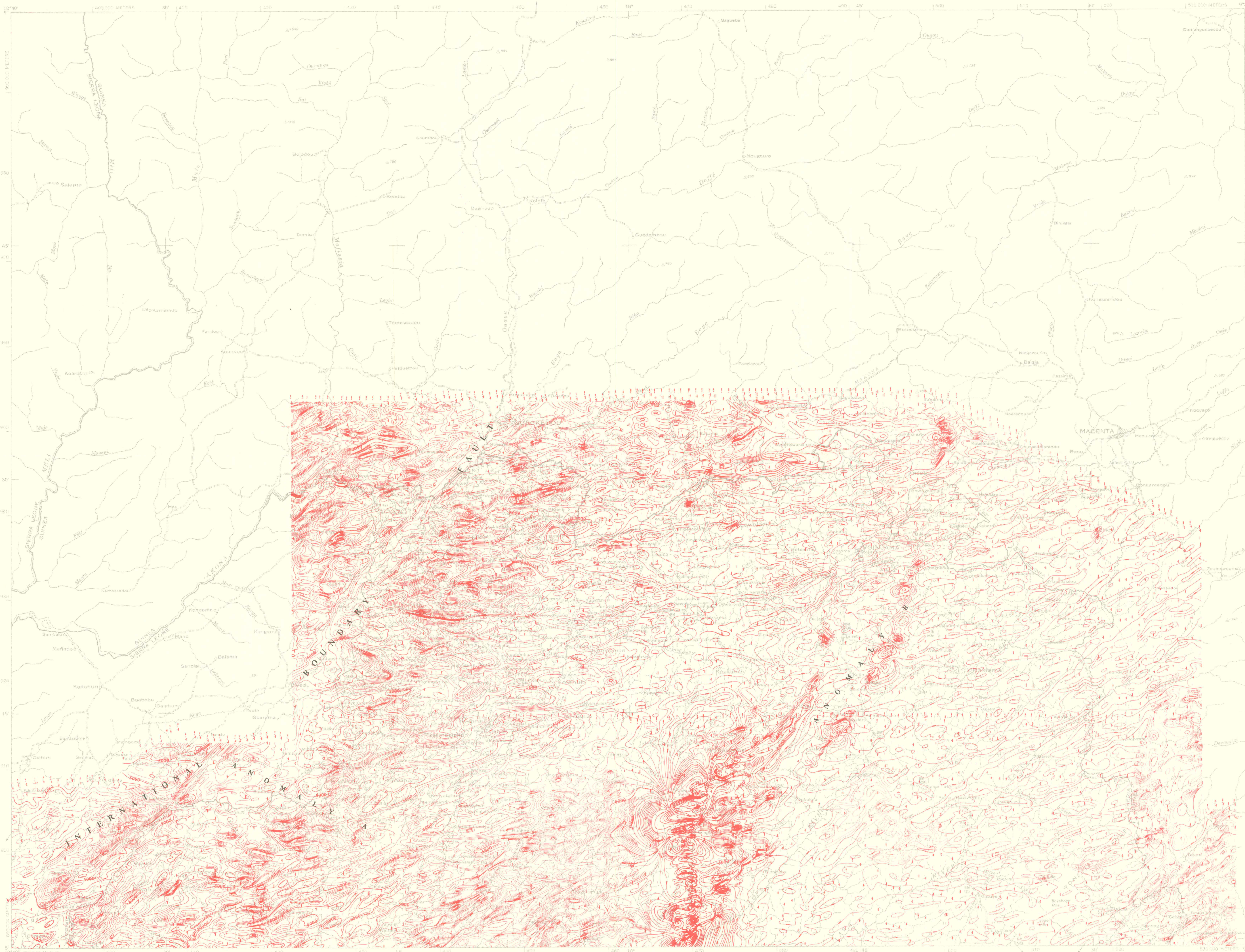
Prepared in cooperation with the
REPUBLIC OF LIBERIA
BUREAU OF NATURAL RESOURCES AND SURVEYS



Coordinates based on Hotines rectified skew orthomorphic projection, U.S. Coast and Geodetic Survey, 1956

NOTE: Country boundaries indefinite

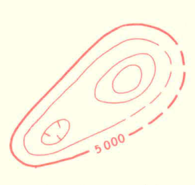
SCALE 1:250,000

5 0 5 10 15 20 25 30 KILOMETERS

5 0 5 10 15 20 MILES

1969 MAGNETIC DECLINATION VARIES FROM 12°40′ WESTERLY FOR THE CENTER OF THE WEST EDGE TO 12°00′ WESTERLY FOR THE CENTER OF THE EAST EDGE. MEAN ANNUAL CHANGE IS 0°06′ EASTERLY

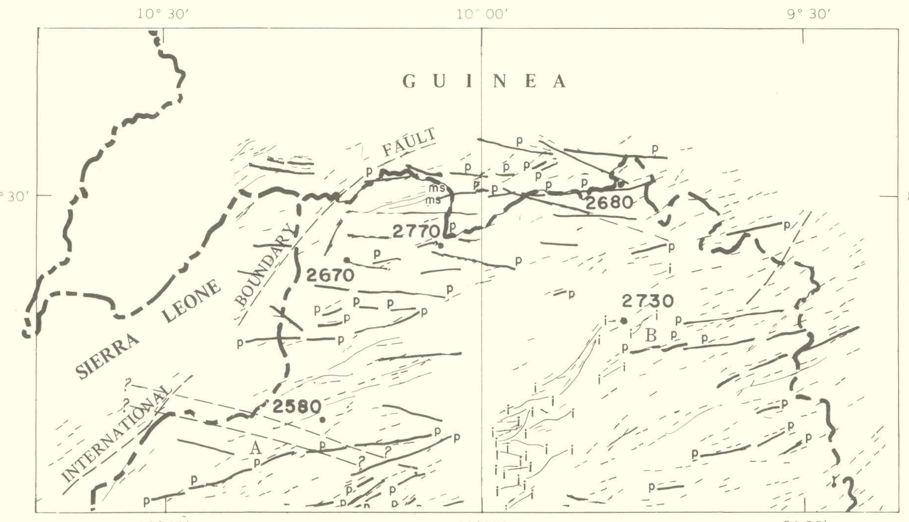
EXPLANATION



MAGNETIC CONTOURS – Showing total intensity magnetic field of the earth in gammas relative to arbitrary datum. Regional magnetic gradient not removed. Hachured to indicate closed areas of lower magnetic intensity. Contour intervals are 10, 50, 250, and 1,000 gammas. Selected contour values shown in larger type

FLIGHT PATH

Aeromagnetic survey flown by Lockwood, Kessler, and Bartlet, Inc. at 150 meters above terrain, 1967–68. Flight-line spacing of 0.8 kilometers over land. Geophysical data reduced from original compilation at 1:40,000-scale by Lockwood, Kessler, and Bartlet, Inc., with minor modifications to improve legibility.



EXPLANATION

TREND DIRECTION OF SHORT WAVELENGTH MAGNETIC ANOMALIES – Assumed to be associated with near-surface geology and interpreted as indicative of rock foliation directions.

LOCATION OF LONG LINEAR MAGNETIC ANOMALIES – Interpreted as being caused by diabase dikes. p, dike inferred from positive anomaly

POSSIBLE FAULT – Suggested by linear change in magnetic or radiomagnetic contour

LINEAR MAGNETIC ANOMALIES – Caused by magnetization contrasts interpreted as geologic structures that may include folds, faults, and contacts

MAGNETICALLY DETERMINED LINEAR STRUCTURE – Inferred to be locally associated with magnetic metasedimentary rocks including schist, quartzite, amphibolites, iron-formation, paragneiss, and migmatite. May include folds, faults, and contacts

MAGNETICALLY DETERMINED LINEAR STRUCTURE WITH ANOMALY GREATER THAN 1,000 GAMMAS – Interpreted as being caused by magnetite iron-formation. May include folds, faults, and contacts

RADIOMETRIC AGE DETERMINATION IN M.Y. – From Hurley and others (1971)

FIGURE 1. – Tectonic map, Voinjama quadrangle. Construction is based primarily on magnetic data.

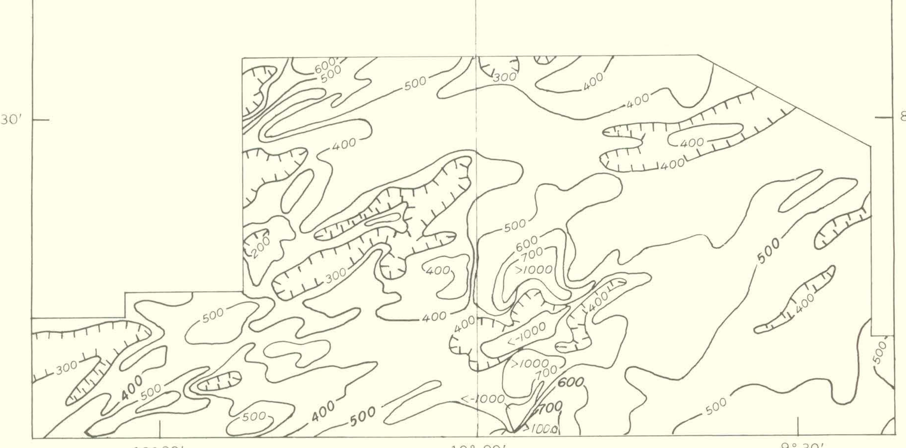


FIGURE 2. – Residual total magnetic intensity map. Compiled by removing the main earth from the map and smoothing to generalized short wave length anomalies. G. Andreasen and P. Zabel assisted in computer processing. Hachures indicate closed areas of lower magnetic intensity. Contour interval 100 gammas, except for areas of extreme anomaly

INTERPRETATION

By John C. Behrendt, U.S. Geological Survey, and
Cletus S. Wotorson, Liberian Geological Survey

INTRODUCTION

Aeromagnetic and total-count gamma radiation surveys were flown simultaneously over Liberia during the 1967-68 dry season. These geophysical surveys were designed to contribute to the geologic mapping program undertaken cooperatively by the Liberian Geological Survey and the U.S. Geological Survey under the auspices of the Liberian Government and the Agency for International Development, U.S. Department of State. The surveys were flown by Lockwood, Kessler, and Bartlett under contract to the Liberian Geological Survey. The geology of the quadrangle has been mapped by Seitz (in press) as part of the cooperative program.

The entire country of Liberia is heavily forested, access is difficult, outcrops are sparse, and thick laterite is widespread. Accordingly, throughout large areas aeromagnetic and aeroradiometric surveys are the only feasible means of gathering virtually continuous data which can be related to near-surface geology, and they are useful in extrapolating geologic observations and in locating potential targets for mineral exploration.

The airborne surveys, which cover the entire country, required approximately 140,000 km of traverse, mostly along north-south lines 0.8 km apart over land and 4 km apart over the continental shelf. Continuous photography and Doppler navigation provided horizontal control; flight altitude was 150 m above mean terrain. Temporal variations in the magnetic field measured with a fluxgate magnetometer were removed by adjustment at crossings of east-west control lines. Varied contour intervals of 10, 50, 250, and 1,000 gammas were used, depending on horizontal gradient.

The geophysical data obtained from these airborne surveys are presented, by quadrangle, in these folios of 1:250,000-scale maps that show on separate sheets geographic, geologic, aeromagnetic, and total-count gamma radiation data for each of 10 quadrangles. The index map shows the locations of these quadrangles and their folio number designations. The total-count gamma radiation map of the Voinjama quadrangle (Behrendt and Wotorson, 1974) should be used in conjunction with this aeromagnetic map.

Figure 1 shows the tectonic interpretation for the area covered by this map. The interpretation is based primarily on aeromagnetic data, but partly on aeroradiometric data and readily available geologic information (White and Leo, 1969; Liberian Geol. Survey, unpub. data).

Figure 2 shows part of the residual total magnetic intensity map of Liberia obtained by digitizing the data from the map area on a 1-minute grid, tying to an absolute survey (Lowrie and Escowitz, 1969) by a constant of $+25{,}980\pm35$ gammas, and removing Cain's "Field G" (Cain and others, 1965).

GEOLOGY

Bedrock in the Voinjama quadrangle consists predominantly of granitic gneiss and a relatively large area of metasedimentary iron-formation in the Wologizi Range (White and Leo, 1969). Diabase dikes in the northwest part of the quadrangle strike east or east-northeast. The predominant trends on the geologic map (White and Leo, 1969) are northeast, which coincides with the general pattern in this part of Liberia. The Voinjama quadrangle is within the Liberian age province (about 2,700 m.y.) described by Hurley, Leo, White, and Fairbairn, 1971. Much of the area mapped as granite by White and Leo (1969) has a linear magnetic grain (fig. 1) that suggests a gneissic texture. The difference is largely one of scale, as a rock may appear to be granite in hand specimen and a gneiss when viewed areally.

AEROMAGNETIC INTERPRETATION

The most striking feature on the aeromagnetic map is the complex anomaly associated with iron-formation in the Wologizi Range where anomaly amplitudes are as great as 12,000 gammas. The high positive values suggest a rather complex structure in the magnetic rock or the presence of remanent magnetization in a direction different from the present field. The northeast-trending contours that bound the range on the north side are inferred on figure 1 as evidence of a steep contact between the granite gneiss and metasedimentary rocks including iron-formation of the Wologizi Range. This is consistent with R. W. White's mapping in the area (written commun., 1969). This structure is parallel to the Lofa River valley, which is probably fault controlled, although there is little magnetic expression owing to the small variation in magnetic properties across this boundary.

Another prominent feature on the magnetic map is the northeasterly linear trend near the west edge of the quadrangle roughly along the Sierra Leone-Liberia boundary. This feature, which we interpret as a fault (fig. 1), is parallel to the drainage pattern in the vicinity and also to the Wologizi Range and Lofa River faults (White and Leo, 1969). The fault, which we name the International Boundary fault, extends at least 90 km to the northeast into Guinea and Sierra Leone; it is directionally correlative with the Moro fault system (White and Leo, 1969) in Sierra Leone.

An east-southeast-trending positive anomaly crosses the International Boundary fault about 20 km north of lat 8° N. This anomaly is 2-4 km in width, about 100-200 gammas in amplitude, and has an observable length of about 40 km. This feature, shown as anomaly A on the map and in figure 1, is possibly a fault zone along which the magnetite has been altered, resulting in a less magnetic rock and, as a consequence, a positive anomaly. This anomaly is lost in the granitic terrane near the center of the area but may continue undetected. This structure is parallel to the diabase dike systems farther south (Behrendt and Wotorson, 1970) and may be of syntectonic origin.

Figure 1 shows a number of diabase dikes as interpreted from the magnetic map. White and Leo (1969) show some of these dikes as observed in the field and on photographs. At least a dozen of the mapped outcrops can be correlated with positive magnetic anomalies, and, on the basis of the magnetic data, probably many more exist than are indicated here. The most interesting thing about these dikes is that the anomalies are positive rather than negative, in contrast to the dike zones to the south. The dikes that produce negative anomalies are dated at about 185 m.y. (White and Leo, 1969) and strike northwest. In this quadrangle the dikes that trend east and have positive anomalies are probably much older and possibly have reversed magnetization.

Amplitudes of anomalies over the dikes indicated in figure 1 range from less than 10 to more than 150 gammas. We examined a number of the observed magnetic profiles and found that outcrops of diabase dikes correlate with low-amplitude anomalies to the data-resolution limit of a few gammas. Some of the dikes observed during geologic mapping do not have magnetic expression, and most of the dikes inferred from the magnetic data have not been mapped on the ground. This is not surprising when one considers the dense forest cover and thick layer of weathered material. The wide range of amplitudes could be the result of varying magnetic properties but more likely is due to structural differences, as thin dikes would produce lower amplitude anomalies than thick ones.

It is possible that most or all of the east-striking magnetic anomalies are the result of the dike zones, as very little east-west lineation is shown on the radiometric map (Behrendt and Wotorson, 1974) of this quadrangle.

A northeast-trending line of roughly circular pairs of positive and negative anomalies northeast of the Wologizi Range (anomaly B on the map) has the same trend as the Wologizi structure, although it is displaced about 5 km to the east. Anomaly amplitudes decrease northeastward from roughly 1,500 to about 300 gammas. Judged from the parallel trend of the iron-formation in the Wologizi Range, these anomalies could probably be caused by iron-formation. The consistent southerly position of the positive anomaly suggests that the magnetized bodies might be dipping to the north but could also be explained by remanent magnetization.

The magnetic character of the areas mapped as granite (White and Leo, 1969) east of the International Boundary fault in the northern part of the quadrangle is different from the granite west of the Wologizi Range. The latter area has the smooth magnetic field more typical of a granite than that in the north, which is characterized by numerous -50 to -300-gammas anomalies. The field changes abruptly about 25 km west of the Wologizi Range, although the area is mapped as granite. Therefore, either there are a number of more mafic intrusive bodies within the granite to the north and west (a likely possibility considering the east-west trends present), or the granite itself contains more magnetite. The radiometric data also suggest that these areas are different.

Examination of the magnetic residual map (fig. 2) reveals a pattern of broad positive and negative anomalies, 20-30 km in width and 100-200 gammas in amplitude, that is part of a regional pattern extending across Liberia into Ivory Coast.

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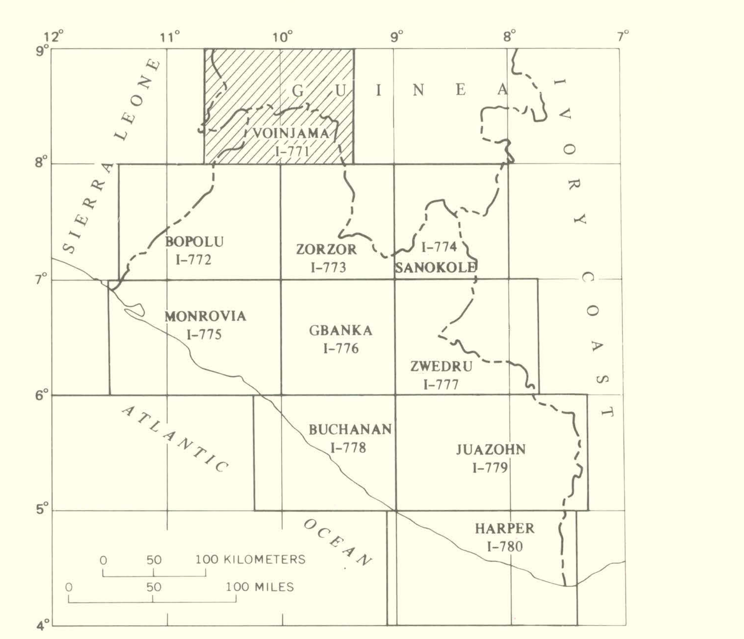

INDEX MAP OF LIBERIA – Showing location of quadrangle and miscellaneous geologic investigations maps published by the U.S. Geological Survey. Area of I-771 shaded.

AEROMAGNETIC MAP OF THE VOINJAMA QUADRANGLE, LIBERIA

By

John C. Behrendt and Cletus S. Wotorson

1974

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