U. S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

REPUBLIC OF LIBERIA
BUREAU OF NATURAL RESOURCES AND SURVEYS
LIBERIAN GEOLOGICAL SURVEY

USGS OPEN FILE REPORT (IR) LI-47
LGS MEMORANDUM REPORT MR-54

70-23

HIGH-AMPLITUDE RADIOACTIVITY ANOMALIES IN LIBERIA

by
John C. Behrendt, U. S. Geological Survey and Cletus S. Wotorson, Liberian Geological Survey
1970

U. S. Geological Survey
OPEN FILE REPORT
This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.

HIGH-AMPLITUDE RADIOACTIVITY ANOMALIES IN LIBERIA

INTRODUCTION

During the 1967-68 dry season, a total-count gamma-radiation survey was flown over Liberia in conjuction with an aeromagnetic survey (Behrendt and Wotorson, 1969, 1970). The north-south survey lines, spaced 0.8 km at 150 m altitude above terrain, cover the entire country. The data were automatically corrected for altitude variations and have been adjusted to a level of 220 m. East-west control lines allowed reduction to a common datum. Cosmic radiation background was subtracted by extending the flight lines over the Atlantic Ocean and assuming zero radiation level over the water. Continous photography and Doppler navigation provided horizontal control. The airborne scintillometer consisted of three thallium-activated sodium iodide crystals, 12 cm in diameter and 5 cm thick. The contour intervals of the original data at 1:40,000 scale are 25 and 50 counts per second (cps); 180 cps equals 1 ur/hr. Composite map sheets at 1:250,000 scale are being prepared for publication.

DISCUSSION

The radioactivity and magnetic surveys were made to provide data for a program of regional geologic mapping, and they have proved useful in contributing fundamental tectonic and lithologic information. A secondary objective was the location of potential targets for mineral exploration. This map shows all the radioactivity anomalies above 500 cps and some potentially economically significant anomalies of lower amplitudes. Approximate regional-background contours have been sketched in to give some idea of the amplitude of specific anomalies.

The general relationships between rock type and average K, Th, and U content (Clark and others, 1966) are reflected in the background levels over much of the area. Generally, the higher the level of background radiation, the more felsic is the terrain. Comparison of radioactivity maps with available geologic map data (White and Leo, in press) indicates that mafic granulite-facies metamorphic rocks, metasedimentary, and unmetamorphosed sedimentary rocks generally display radiation levels <100 cps in the coastal area. Granite and granitic gneiss, the bulk of the mapped bedrock in the country, have a high and quite variable radioactivity background.

Although chemical analyses indicating the relative abundances of K, Th, and U in specific rocks are lacking at present, we do have some analyses of K_2O from bedrock samples which show a significant correlation (inset, fig. 1) with total count gamma radiation below 500 cps. Consideration of figure 1 suggests that the high-amplitude anomalies indicated on this map could only have been caused by anomalously high concentration of Th and U in the bedrock, as commonly high K_2O concentration would be required to explain the anomalies on this basis alone. Of course, many more analyses of K, Th, and U in samples collected for this purpose are necessary to fully utilize the radioactivity data.

It is encouraging to realize that this survey, flown over thick forest and deeply weathered terrain having very few outcrops, reflects the felsic character of the bedrock geology. This is not surprising, however, as many of the radioactive minerals such as monazite and zircon are relatively resistant to weathering and may even be concentrated on the surface as a residual deposit.

The central area of the country generally displays the highest background radiation level, and it is in this area that most of the high-amplitude anomalies are observed. The southeast one-third of the country generally is low in background radiation. The boundary separating this area from the northwestern two-thirds coincides with a boundary based on aeromagnetic data (Behrendt and Wotorson, 1969, 1970) which correlates with the break between the Eburnean lithologic age (1800-2000 m.y.) province in the southeast part of the country and the Liberian age (2700-3400 m.y.) province (Hurley and others, 1969). The boundary between the Pan-African age (500-600 m.y.) and Liberian age province (Hurley and others, 1967) as shown is inferred from the aeromagnetic data.

One of the interesting anomalies shown on this map is the linear east-west feature extending for about 80 km just south of 7° N. between 10° 15' and 11°15' W. Sam Rosenblum (written commun., 1970) has identified monazite and zircon in laterite samples collected from this region. The 250-375 cps anomalies along the beaches are associated with "black sand" concentrations that contain a few percent of zircon and monazite (Sam Rosenblum, written commun, 1970). These and other radioactive minerals transported by rivers from source areas of higher background radiation in the interior are probably the cause of these anomalies and may be economically significant.

ACKNOWLEDGMENTS

This survey was made as part of a mineral resources exploration program undertaken cooperatively by the Liberian Geological Survey and the U. S. Geological Survey, under the auspices of the Government of Liberia and the Agency for International Development, U. S. Department of State.

REFERENCES

Behrendt, J. C., and Wotorson, C. S., 1969, Aeromagnetic and gravity investigations of the sedimentary basins on the continental shelf and coastal area of Liberia, West Africa: U. S. Geological Survey open-file report; Liberian Geol. Survey Memo Rept. 50.

Behrendt, J. C., and Wotorson, C. S., 1970, Total-intensity aeromagnetic map of Liberia including the continental shelf [map with text, 1:400,000 scale]: U. S. Geological Survey open-file report.

Clark, S. P., Jr., Peterman, Z. E., and Heier, A. S., 1966, Abundance of uranium, thorium, and potassium, in Handbook of Physical Constants, revised edition, S. P. Clark, Jr., ed: Geol. Soc. America, Mem. 97, p. 522-541.

Hurley, P. M., de Almeida, F. F. M., Melcher, G. C., Cordani, U. G., Rand, J. R., Kawashita, K., Vandoros, P., Pinsen, W. H., Jr., and Fairbairn, H. W., 1967, Test of continental drift by comparison of radiometric ages: Science, v. 157, p. 495-500.

Hurley, P. M., White, R. W., and Leo, G. W., 1969, The location of the boundary between the Eburnean and Liberian orogenic provinces in eastern Liberia, in Variations in Isotopic Abundances of Strontium Calcium and Argon and Related Rocks: Massachusetts Inst. Technol. - 1381-17, 17th Ann. Progress Rpt., 1969, Dept. Geology and Geophysics, Mass. Inst. Technology, Cambridge, p. 25-26.

White, R. W., and Leo, G. W., in press, Geological reconnaissance in western Liberia: Liberian Geol. Survey Spec. Paper 1.

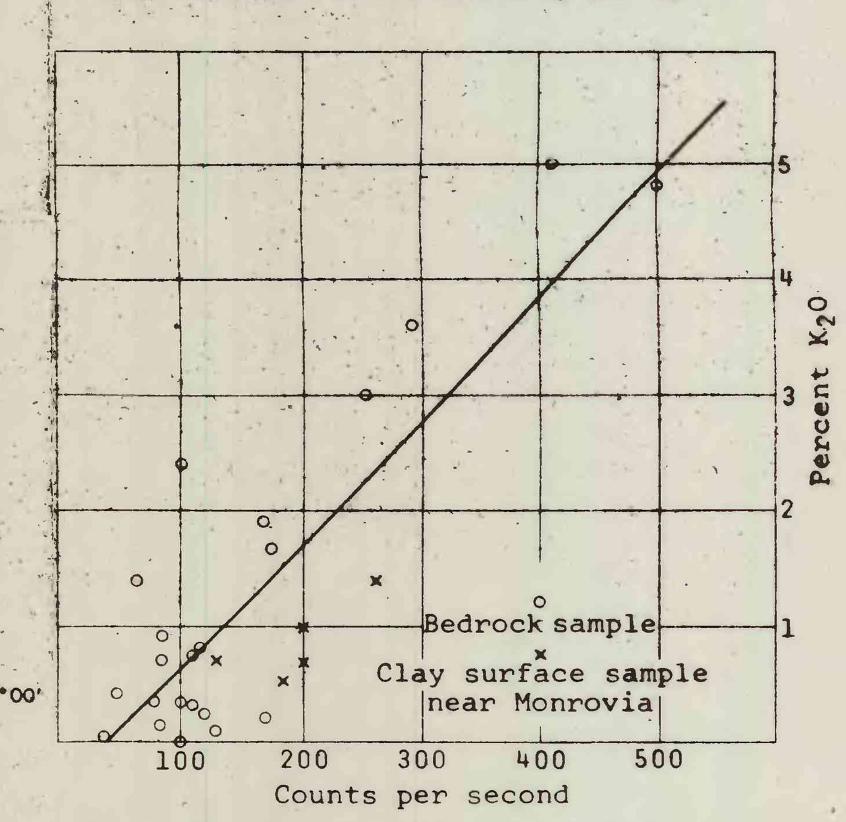

Figure 1.—Percent K_2O from rock (or clay) sample compared to total gamma count observed. The least-squares straight line fitted to the data is $\%K_2O = -.44 + .0108R$, where R is total gamma count. Standard deviation = $\pm .80\% K_2O$. Correlation coefficient, $r = .81$, is greater than .47 required for significance at the 1 percent level.