The GARS Kibaran Project in Africa

by Gottfried Gabert

One of the programs that IUGS runs jointly with Unesco is entitled "Geological Applications of Remote Sensing." Initiated in 1984, GARS aims to further international cooperation by developing new methods and techniques in remote sensing. This article reviews one of the first activities under this program, the GARS Kibaran Project, which assisted geological mapping and interpretation in the Kibaran and Ubendian fold belts of eastern Africa. (Ed.)

Introduction

The GARS Kibaran Project was run from 1985 to 1988 to apply remote sensing methods and techniques to geological work in the Proterozoic Kibaran and Ubendian fold belts, to improve this interpretation of their lithology, structure and mineralization, and to train African geoscientists. It was linked to Unesco's own program "Geology for Economic Development" and to the "Multisatellite Thematic Mapping Project" of CODATA, the Committee on Data for Science and Technology (Bardinet et al., 1987; Bardinet et al., 1988; Gabert, 1987; Unesco, 1986).

The following European institutions were involved in the project: Musée Royal de l'Afrique Centrale (MRAC) in Tervuren, Belgium; Université de Nice; the Ecole Nationale Supérieure/Ecole des Mines in Sophia Antipolis; BRGM in Orléans; Université VI de Paris; and BGR in Hannover. The geological departments of the universities of Dar es Salaam, Tanzania, and Bujumbura, Burundi, and the geological surveys of these two countries also participated in the field work. The Project was funded by IUGS and Unesco and coordinated by BGR. The European institutions provided personnel for field work, data processing and interpretation as well as laboratory and computing facilities, and training facilities for African geoscientists.

Multisensor data of Landsat MSS, Landsat TM and SPOT were directed to the following problems:

- discrimination of lithological units within meta-sedimentary complexes and recognition of different types of intrusive rocks,
- influence of tropical weathering on characteristic mineral assemblages of rocks and soils,
- recognition of alteration zones,
- differentiation of Precambrian and overprinted Cenozoic structures,
- recognition of structural control of mineralization, and
- determination of the spectral properties of geo-objects by radiometer measurements.

Three different test sites were selected and evaluated both by remote sensing techniques and field investigations. Two of these sites were situated in the Kibaran fold belt of central and northwestern Burundi, and in the Ubendian fold belt of western Tanzania (Fig. 1). Here, spectro-radiometric measurements and geological, petrographical, tectonic and geomorphological studies were carried out.

Western Tanzania

In the latter area research was directed to

- radiometric surveys and discrimination of geological objects,
- geological interpretation of Landsat TM imagery and air photographs,
- structural and spatial analysis of Landsat TM data with emphasis on pattern recognition and lithological classification,
- development of digital terrain models based on stereo imagery of SPOT data,
- investigation of the structural relations of Precambrian and Cenozoic tectonics, and
- regional metallogenic analysis.

This investigation assisted in recognizing and evaluating the extent of the different lithological units of the Ubendian fold belt, their tectonic behaviour and the nature of the contact zones, and in improving the existing geological map (1:125,000). A digital map of the test area formed the geological database.

Figure 1: Sketch map showing GARS test sites in eastern Africa. 1) Karema area, western Tanzania (Ubendian). 2) central Burundi (Kibaran). 3) northwestern Burundi (Kibaran). Area 4 (in the Usagaran of southern Tanzania) was the subject of the CODATA project (see Bardinet et al., 1987, 1988).

Spectral measurements were carried out on the different rock and soil types, with a 3-channel, SPOT-calibrated radiometer corresponding approximately to channels 2, 3 and 4 of Landsat TM. These measurements formed the basis for the evaluation of the satellite data of Landsat 5 TM and Landsat 3 MSS.

The combination of different Landsat MSS and TM channels enabled workers to discriminate between the main lithological units of the Ubendian and to recognize the main tectonic elements. Structural analysis of the test area involved automated procedures for spatial and statistical evaluation, and the studies also included pattern recognition, textural analysis and atmospheric corrections of the satellite data.

Burundi Test Sites

The test area in central Burundi comprised, in addition to Kibaran metasediments and felsic intrusives, part of the ultramafic belt with associated Ni-mineralization. Here the relief is relatively low and the vegetation cover light. The test area in northwestern Burundi is composed of Sn-, W- and Au-bearing Kibaran metasediments and metavolcanics and granite intrusions, covered by lateritic soils and dense vegetation. The relief is high.

In these test areas, field work (Fig. 2) concentrated on lithologic discrimination between the Kibaran metasediments and granitic, mafic and ultramafic intrusions, and on structural analysis for the recognition of the structural control of the mineralization. In addition, alteration phenomena of mineralized zones were investigated. Extensive field work with a high-resolution spectro-radiometer revealed the spectral properties of rocks, soils and vegetation. A large number of rocks and soils were sampled for the construction of a spectral database. Laboratory work comprised stereo modeling of SPOT data, photogeological interpretation, sophisticated image analysis as well as structural and statistical studies.

Results

The overall conclusion of the GARS Kibaran program is positive, although not all the objectives have been reached (see Lavreau and Bardinnet, 1988). Under favourable geological

Figure 2: Adjusting reference and soil samples for measurements with the BGR high-resolution spectroradiometer in Burundi.

conditions, the feasibility of lithologic discrimination and structural analysis in tropical regions with their variable soil and vegetation cover has been demonstrated. Geological units of rather contrasting lithological characteristics have been differentiated from surficial rocks. Through structural analysis, tectonic domains have been identified according to their mechanical, lithology-related behaviour. Distinct structural features were recognized that control Sn, W and Au mineralization, some of which must be considered as metallotects of particular importance for future gold exploration. The methods are appropriate for the study of large surface areas and provide an aid for geological mapping of Proterozoic fold belts. The first GARS results have already contributed to an improvement of the existing geological map 1:500,000 of Burundi and of our understanding of the tectonic processes and associated mineralization.

Future Work

IUGS and Unesco are also funding the second phase of the GARS Program, which focusses on the recognition of geological hazards, particularly landslides and erosion in South America. For this project, which will be carried out from 1989 till 1992, a test area in central Colombia has been selected. The research work will comprise geological field studies, analyses of Landsat TM and SPOT imageries, construction of digital terrain models and geoinformation systems. Several international remote sensing institutions and South American geoscientists are expected to participate in this project.

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