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INTERACTIVE PROCESSING OF LANDSAT IMAGE FOR MORPHOPEDOLOGICAL STUDIES

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I/ INTRODUCTION

With the increasing amount of data made available from Landsat there is a clear need for an integrated method of soil mapping in which these data can be exploited to provide valuable information for the various stages of conventional soil mapping:

- preliminary study
- detail mapping
- verification of the results of photo-interpretation
- updating of soil map by temporal study

A joint research study was initiated between the Scientific Center of IBM France and IRAT, the Tropical Agriculture Research Institute to investigate these possible contributions.

II/ BACKGROUND and OBJECTIVES

In developing their soil map, IRAT adopts a working method consisting of a study of the overall pedogenesis and morphology of the region followed by an

in-situ soil survey and profile sampling. The soil is then classified into morphopedological units according both to the nature of the soil and the final usage of the map.

In the present study following morphopedological units (fig. 1) were studied to determine the possible land use and the danger of erosion:

- 1/ Sandstone hill
- 2/ Ferrite hardpan
- 3/ Low glacis
- 4/ Cultivated area

A method of analysing the Landsat image was then sought:

to characterise the radiometric signatures of these morphopedological units

- to study the variation of these signatures in space and in time.

- and finally to obtain a working method of image processing and a number of keys for interpreting Landsat images.

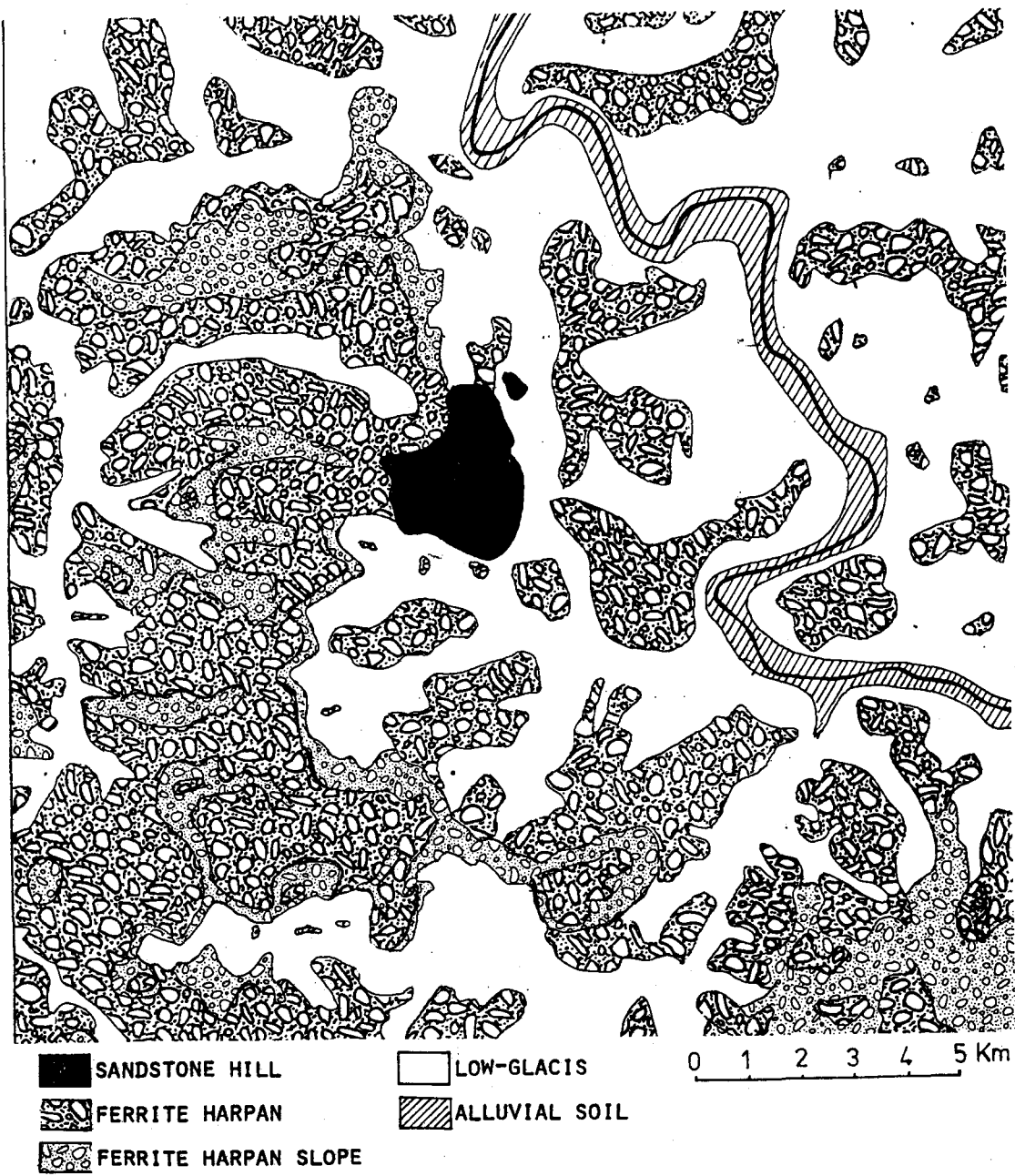


Figure 2 : Morphopedological Map

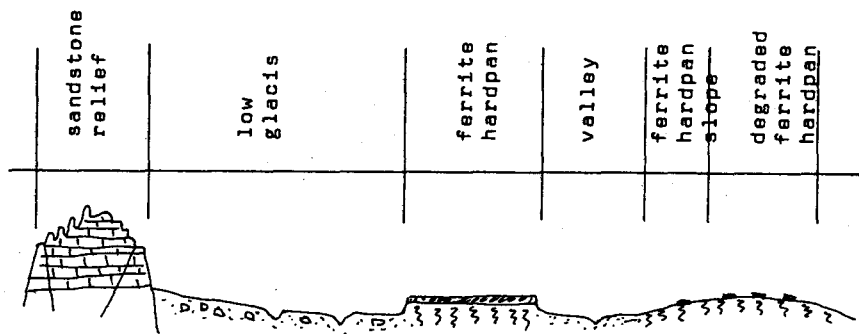


Figure 1 : Principal landscape-units of the Mandingue plateau in Mali.

III/ METHODOLOGY

The study was carried out by using ERMAN II (Earth Resource Management System) and a new interactive image processing system developed at the Scientific Center, IBM France. These two systems and their interface provided the necessary tools for displaying, manipulating, and processing of the image.

The area chosen for the study was in Gale on the Mandingue plateau in Mali. This area had been studied previously by IRAT (Raunet, 1975 and Brouwers, 1976) and a morpho pedological map was produced (fig. 2). Images from 1972, 1973 and 1976 for this area were used.

Training fields belonging to the different morphopedological units were determined from a series of 4 aerial photographs covering the central part of the studied zone (fig. 3). A model of transformation between corresponding co-ordinates on photograph and image was then calculated from a set of landmarks. The co-ordinates of the subimages were obtained by applying the model of transformation to the

co-ordinates on photographs. The image to UTM (Universal Transverse Mercator projection) registration normally used was avoided intentionally for two important reasons. Firstly to avoid errors from the interpolation required in image re-sampling, and secondly to reduce the errors due to the use of a global model of deformation for the whole image. In our study, separate models of deformation were calculated for smaller areas corresponding to each aerial photograph.

The first operation was then the principal component analysis of the original Landsat channels (fig. 4a-b). Since most of the information was contained in the first two channels (95 percent of the total variance), they were used instead of the original channels. These facts, mentioned also by other researcher (Lowitz, 1976) and are illustrated clearly in fig 4c.

The representation on color TV screen of the first component (CF1) as brightness and the second (CF2) as color also gave a better visualisation for the pedologists to identify the different morphopedological units than the normal false color visualisation of the original channels (Chaume, 1977).

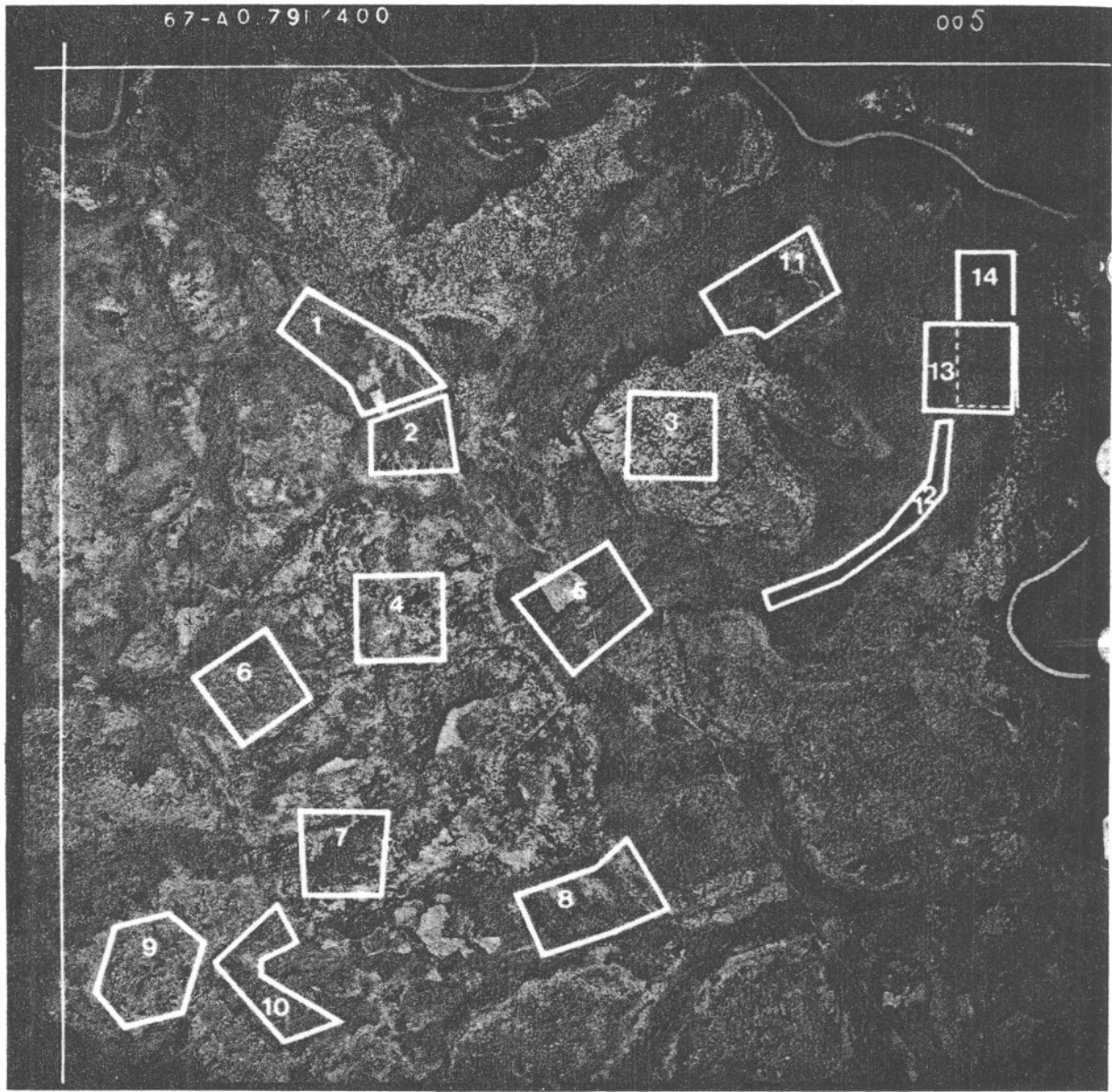
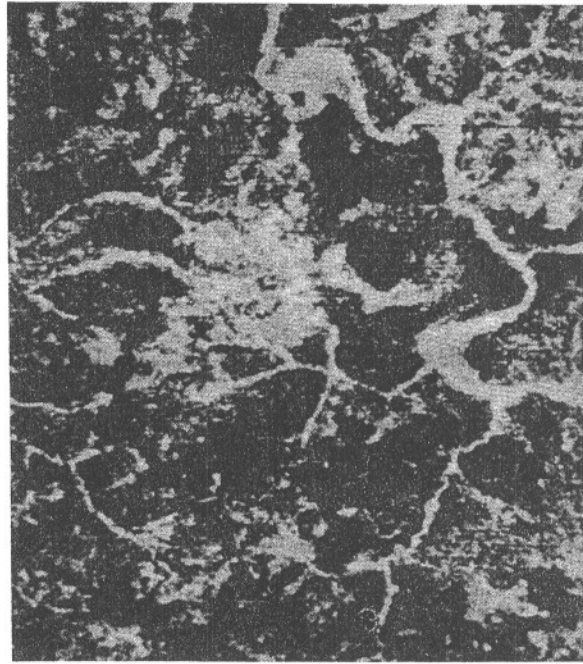


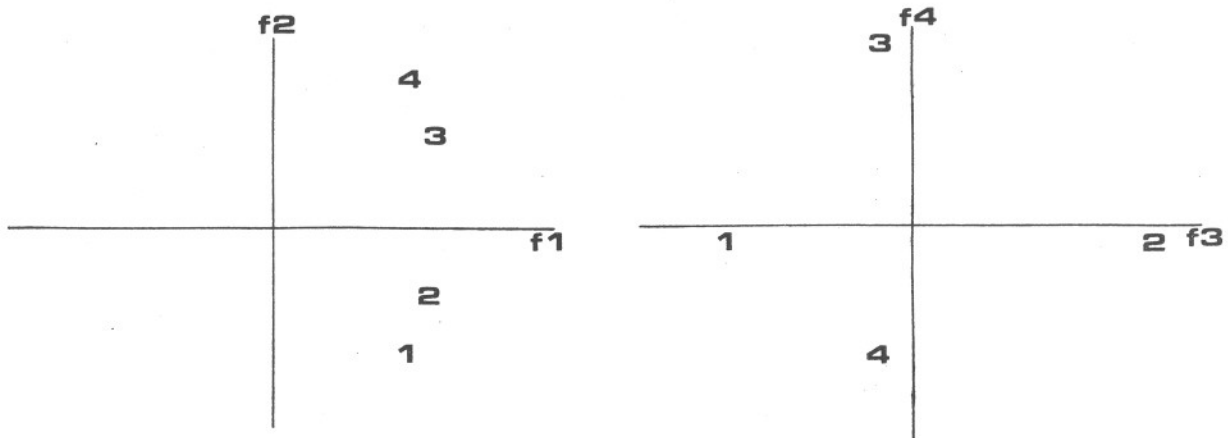
Figure 3 : Examples of training fields drawn on an aerial photograph.



a) first component



b) Second component



c) Distribution of the original bands in plans F1/F2 and F3/F4.

Figure 4 : Principal component analysis

The distribution domains of the morphopedological units were then determined in the two-dimensional histogram of the two components CF1 and CF2 (fig 5). Each pixel in the study area was then classified according to their respective position in the distribution domains

The classified image was then deskewed and re-sampled at the same scale as the morphopedological map of IRAT. The classified image was then compared with the groundtruth map and the aerial photographs. The subimages corresponding to the training fields were re-adjusted, the distribution domains re-calculated and the classified image re-produced accordingly. The process was repeated interactively until a good fit was obtained between classified image and groundtruth map for the study area

The final distribution domains as obtained were then used to extrapolate the result into a larger area around the study area. The final classified image produced at the same scale as the morpho-pedological map and the photographs was then viewed on the color or TV screen (fig. 6) or produced as gray level map by the IBM 3800 printer.

IV/ RESULTS AND DISCUSSIONS.

The results obtained proved that it was possible to localise the distribution domains of different morphopedological units due to:

- The separation of the distribution domains in the two-dimensional histogram

- The consistent location of these distribution domains in areas surrounding the study area

These are valuable assets for the spatial extrapolation of the results. An attempt was made to study the same area using images

available at different dates but there existed two main difficulties: the poor quality of the Landsat-I images taken on 31 OCT 1972 and 29 APR 1973, the presence of haze in the rainy season also had an unacceptable influence on the orientation of the principal component axes.

The image used (02 FEB 1976) corresponds to the dry season in Mali, and a small percentage of the area studied (40x30 km) was covered with bush fire. These bush fires were however clearly identified. The morphopedological units classified most accurately was the ferrite hardpan, particularly where sharp cliff exist. On the contrary, the ferrite hardpan slope were in some areas classified as low-glacis, the limit between the hardpan and the low-glacis are difficult to locate accurately. The low-glacis extending from the riverside up to the hardpan slope are in general well classified. Cultivated areas were detected by the presence of bare soil (characterized by their extreme values in the first and second principal components), these areas also revealed the human activities in nearby villages. The sandstone hills were very similar in their spectral signature with the river but their presence was detected by their massive grouping.

Low-glacis with erosion was the most difficult unit to characterise because of their small dimensions (1 to 3 pixels wide). It was difficult to locate these fields and to obtain a reasonable population to represent the unit accurately. Another approach in which their textural properties are analysed was necessary to study these small. Works in this direction are being followed at the IBM Scientific Center at Paris.

V/ CONCLUSIONS

With the encouraging results, the present study has now passed on to the second phase where

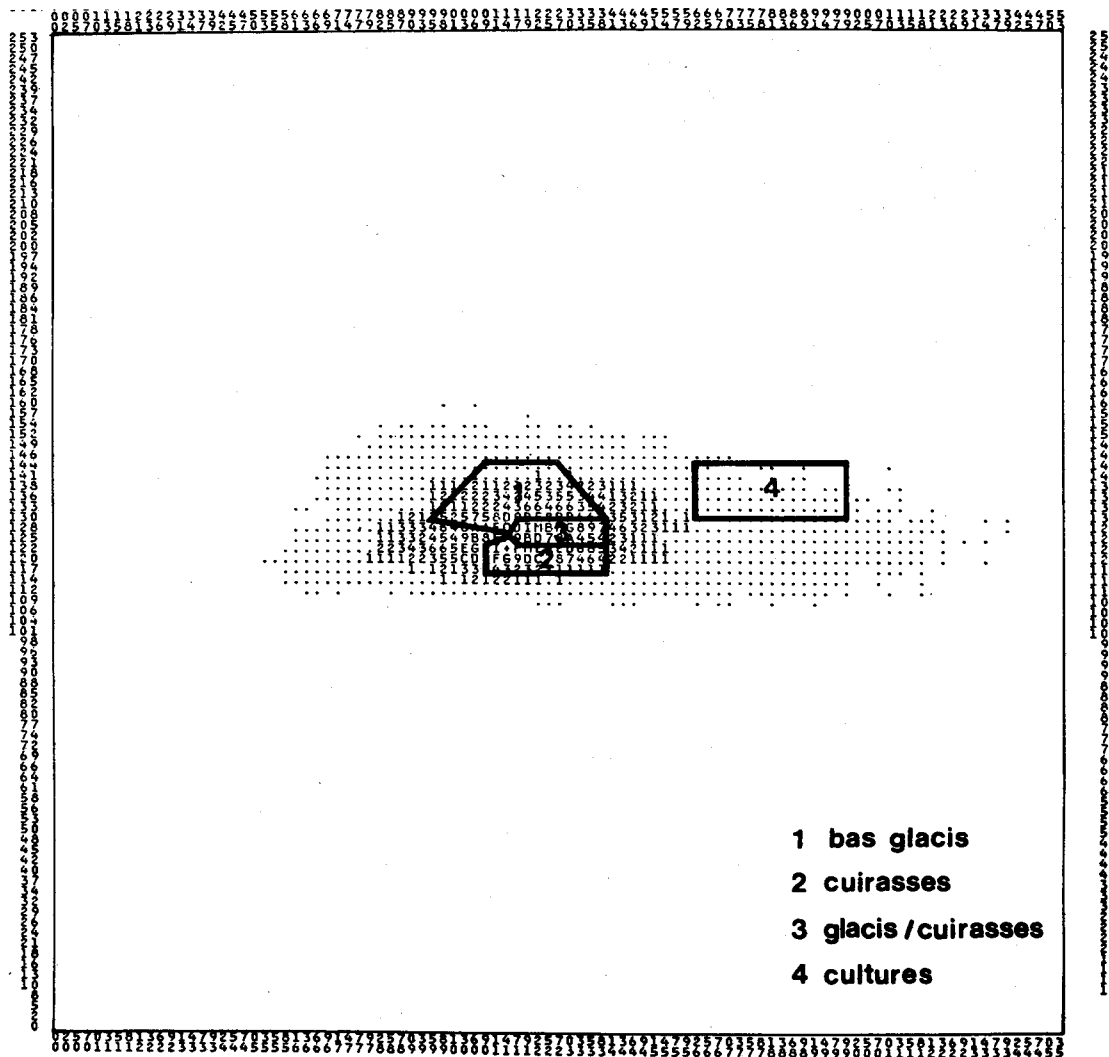


Figure 5 : Two-dimensionnal histogram with landscape unit distribution domains. (1: low-glacis, 2: ferrite hardpan, 3: transition area, 4: cultivated area)

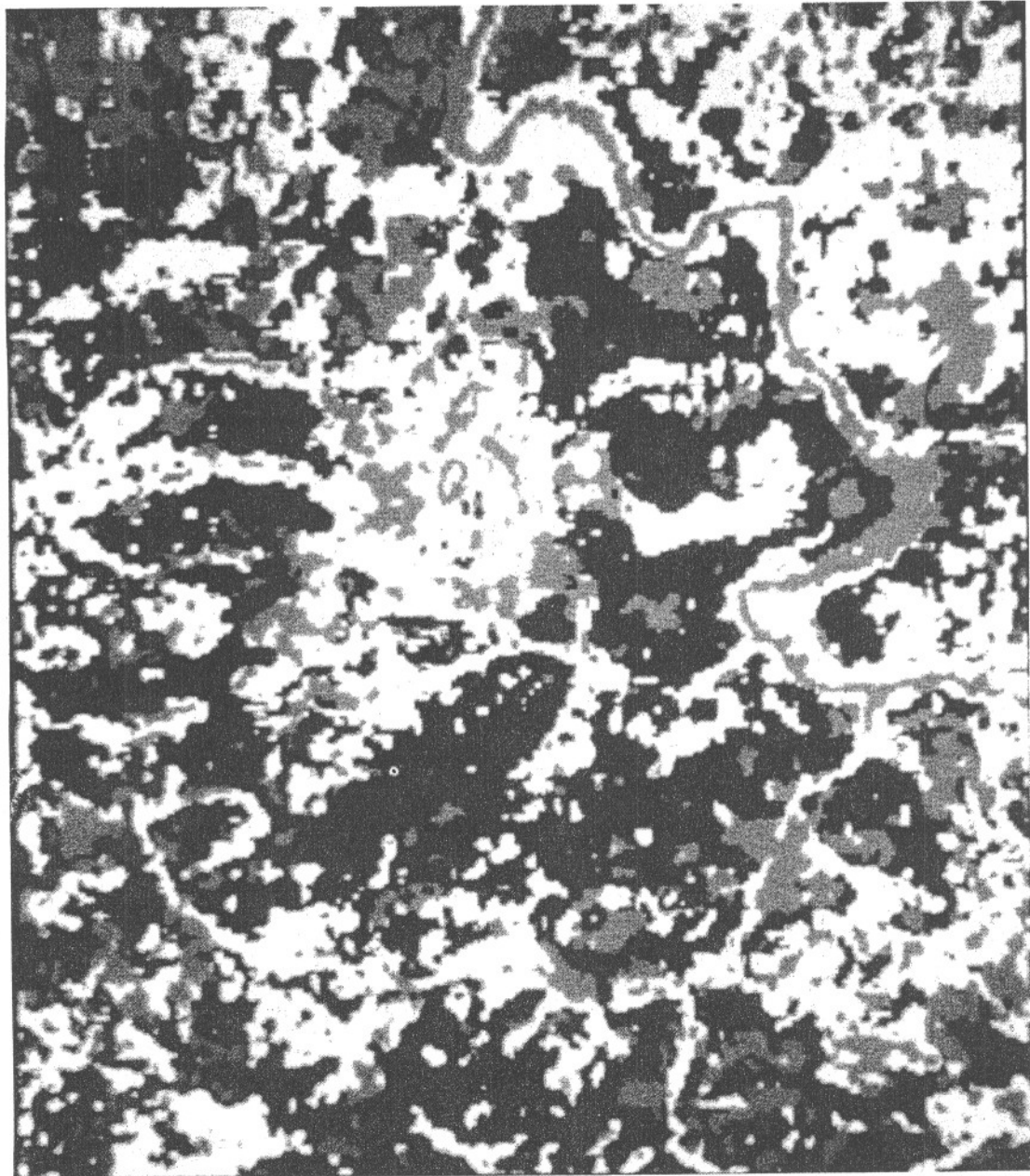


Figure 6 : Classified image as window TV screen (blank: low-glacis, dark grey: ferrite hardpan, black: cultivated area, light grey: unclassified).

the established procedures will be applied to another region of Africa - Upper Volta. In this study the area to be studied will cover a more extensive area including an area where detail soils map is not available.

It remains to improve the accuracy and the generality of the method and two parallel approaches are required.

Firstly to exploit fully the satellite image the choice of the morphopedological units proved to be vital. These units should be orientated to the properties of the soil surface such as the vegetation, soil moisture, human activities, erosion or other factors which can be revealed by their different reflectances.

On the other hand, a further study of the distribution domains of typical morphopedological units should be followed and a method of transforming these distribution domains according to the variation of the principal component axes should be derived to make these keys of interpretation applicable both for spatial and temporal extrapolation. Some encouraging results obtained in this direction are presented in another paper (Oudin M.F, 1980).

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