A geological information system for paleoseismological data retreiving and analysis.

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INTRODUCTION

In recent years, Geographical Information Systems (GIS) have given a significant impulse to the use of computers for digitization, archiving and statistical analysis of geological data.
Using GIS technologies makes it possible to manage within a single file a whole set of data such as raster images, vectorial drawings, alphanumeric databases, samples and even animations. These data being always correctly referenced both geometrically and geographically.
The very large dataset obtained in paleoseismology during both trench description and laboratory tests have to be organised in such a way that crosscorrelation studies can be performed on the data. For such a purpose, ArcView GIS v.3.1. used in this study appeared to be the right tool.

MATERIALS AND METHODS

The procedure adopted for the study of trench walls can be divided into two main parts : the first one consists in image acquisition, treatment and further importation within a GIS software; the second refers to the correct organisation of both graphical and alphanumerical data, to their correct superposition with the image and to their final analysis.

ACQUISITION

Images of the trenches excavated in 1999 in Neer (Netherlands) and Jülich (Germany) were acquired using a classical color slide photographic camera (35mm focal). Within each scene a colorimetric reference chart (Kodak Color Separation Guide) was used to facilitate the calibration and colour rendering corrections required in the image processing step. Particular attention was given to the presence within each frame of an entire square (1m x 1m) of the reference thread grid used by the geologists in the trench. This precaution was fundamental to permit later geometrical correction of each individual image with reference to the field grid and to the associated landmarks (nails).
The films were digitized through the Kodak Photo-CD process (3072*2048). However, for sake of mosaïcking and faster redisplay of the whole set of trench images, a compromise had to be found between the image resolution and memory occupation. A classical 768*512 pixels format giving 2mm of spatial resolution on the outcrop was selected to keep the image file size to 1,1 Mb. Considering a 1 m^2 cover per image, this leads to more than 130 Mb for a single trench of say 60 m (width) * 2 m (height).

PROCESSING

Each photography was corrected for colour rendering on the basis of the RGB values obtained for each colour tile of the colorimetric chart. The reason for this was to compensate for changes in illumination during image capture. These can be due either to modification of the light spectrum (temporary clouds) or to the relative displacement of the light source.
The next step in image processing was geometric warping caused by imperfect horizontality of the camera or due to default of parallelism between the film plane and the trench wall. Linear corrections were performed under Adobe Photoshop, whereas non-linear warping such as compensation for the "barrel deformation" of the 35 mm optics required an additional package Panorama Tools.
After geometric correction the thread grid must appear perfectly quadrangular as it will serve for systematic mosaïcking of neighbouring images. This mode of operation is of fundamental importance since it is the basis of any further analysis of structural information in the image.

GEOREFERENTIATION

Georeferencing is a fundamental step for correctly localizing data within a reference space. In the present case, georeferentiation is performed through the creation of a text file (with extension *.tifw) in which geographic coordinates, dimension of a single pixel in metric units and the rotation factor to be applied to the image are stored. This file when associated to a TIF image becomes a TIFFWORLD document.
The same kind of operation is applied to vectorial data when exporting data from a graphical software such as Adobe Illustrator towards a georeferenced vectorial data file such as ArcView's shapefile format. This can be done with a specific plug-in called MapPublisher.
A typical "shapefile" contains vectorial information gathered in the field, such as stratigraphic level, lithology, pedology, fault,... These data are treated either as punctual, lineal or superficial objects to which all geological characteristics are associated in the form of a small spreadsheet.
Both the vectorial shapefile and the referenced raster image are imported in the GIS environment giving as a

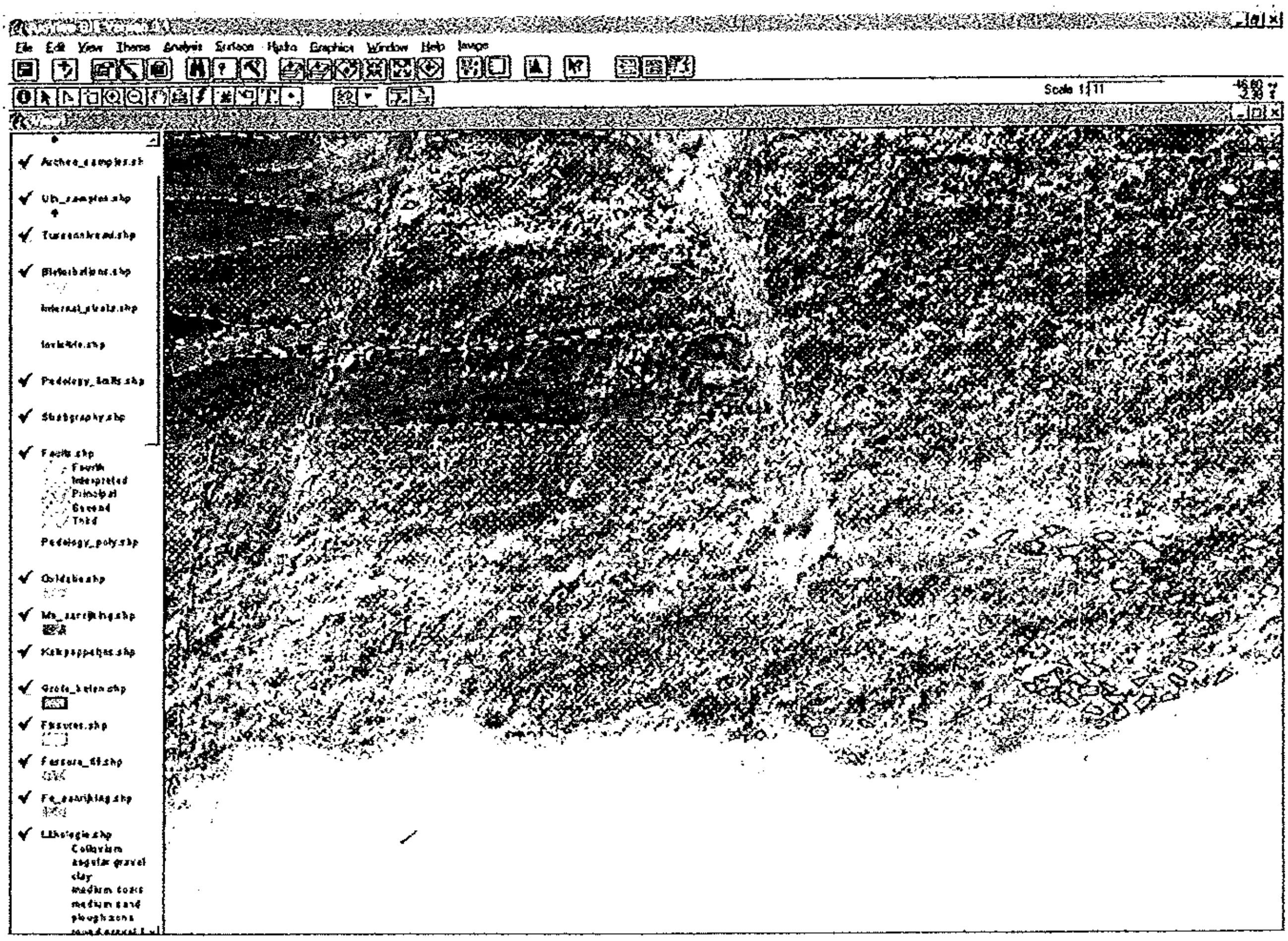

FIGURE 1 - *Superposition of raster and vector data (Hambach trench - PALEOSIS project 1999).*

final result the full image of the trench wall having as overlay the interpreted geological structures and their associated properties.

RESULTS

The superposition of raster and vector data (Fig.1) allows for more detailed analysis of the sedimentary and tectonic structures observed in the trench.
This gives way to occasional correction of field errors or even to detection of features that are overlooked during field work.
The accuracy with which geological structures can be analyzed allows for precise measurement and positioning of the limits of a fault, the thickness of a sedimentary level, the orientation of clasts, etc.

Interactive retreival, selection and analysis of all variables present in the database is a major feature of a GIS software. A better term in this case would be Geological Information System.

The faculty of consulting images of the outcrop in a rigourous geometrical context after the trench has been filled in opens the way to a more thorough analysis of the details visible in the structure.

At this stage of the project automatic image analysis has not been performed. One must keep in mind however that quantitative analysis of colour or texture of defined geological bodies could help assessing correlations between several units.

DISCUSSION

It is obvious that such kind of meso scale applications of GIS will be given more and more attention in the future.

The experience gained in this study points out that more importance has to be given to the methodology of systematic observation in the field and above all to the correct positioning of structures.

The most common errors are revealed by incorrect superposition of images and vectorial mappings.

The hand drawings are traditionnaly performed in the field on millimetric paper.

The subjectivity or inexperience of the drawer as well as a poor measurement of the distance to the grid are a frequent cause for mispositionning of the analysed data.

As a consequence it is not uncommon to observe a bias of several centimeters between the drawing and the position of the corresponding feature in the image.
Correction of these errors afterwards is a long and tedious work.

A logical extension of this kind of GIS recording that can be implemented from now on would be the creation of a database available on-line via the internet.

A freeware such as ArcExplorer allows for interactive retreiving and importation of any structural data associated to the trench.

It is clear from that a GIS management of paleosismological data, such as the one presented here, largely improves data analysis through traditional methods by filling the gap between visual information and analytical results.

References:

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ArcView GIS – http://www.esri.com
MapPublisher – http://www.avenza.com
Panorama Tools - http://www.fh-furtwangen.de/~dersh