Integrated database and GIS techniques to convert geologic field information into geological and thematic maps: the CARG Project

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About two decades ago the National Geological Survey (SGN) of Italy started to carry out the new geological and tematic cartography to a scale of 1:50.000 with the aim to map all the italian national territory (CARG Project). Together with the traditional field analysis and mapping, the project aimed at the building of a related data base to a scale of 1:25.000, which represented the most innovative experience in this field at that moment.
With this purpose the SGN offered suitable tools and some guide lines, as references both for the surveying and mapping phases and for the data base building, in order to obtain an omogenous product within the whole territory.
Ten years after the beginning of the project, the informatic phase took place, through an agreement among SGN, CNR (National Council of Research) and DSTN (Dept. of National Technical Services) which choose 15 sample Geological Sheets, distributed throughout the whole national territory, for carrying out a geological data base.
On the basis of the standard methodologies provided by SGN and of some previous experiences (Sheet n. 197 – Bobbio; Sheet n. 153 – Bardonecchia) the CNR developed a procedure which allows an effective and reliable digital acquisition and the storage and the management of the geological data which are georeferenced and topologically correct.
At the moment the procedure has been applied on three Geological Sheet (n. 506 - Sant'Arcangelo; n. 625 – Acireale n. 284 – Rosignano Marittimo).
The phase of informatization of the above mentioned three geological sheets has followed a traditional approach that entalis the existence of a paper manuscripts yielding all the available data. These are inserted within the data base system by an operator, under the control of the field geologists in the conclusive phase.
The goals of the present paper are:
1. to describe the adopted procedure;
2. to describe some possible applications of the database.
The work carried out from 1998 till today aimed at the elaboration of a procedure for the creation of the database, whose loading could be the most indipendent possible from the operator in order to guarantee a correct insertion of the information and to facilitate the control operations through a suitable documentation in relation to the single phases of the entire process.
The structure of the proposed database needs a logical model in which two main categories are detectable:
- objects characterized from geometric properties and descriptive properties.
- objects characterized exclusively by descriptive properties.
Both are organized in different informative layers: one for points, one for lines or polygons, one for descriptive tables.
The relation between the geometric elements and the descriptive ones is managed by direct connections of the type one-to-one, one-to-many (or many-to-one) and many-to-many.

In the proposed physical model, the mentioned geometric properties comprise not only the primitive forms (points, lines and polygons) but also relations between

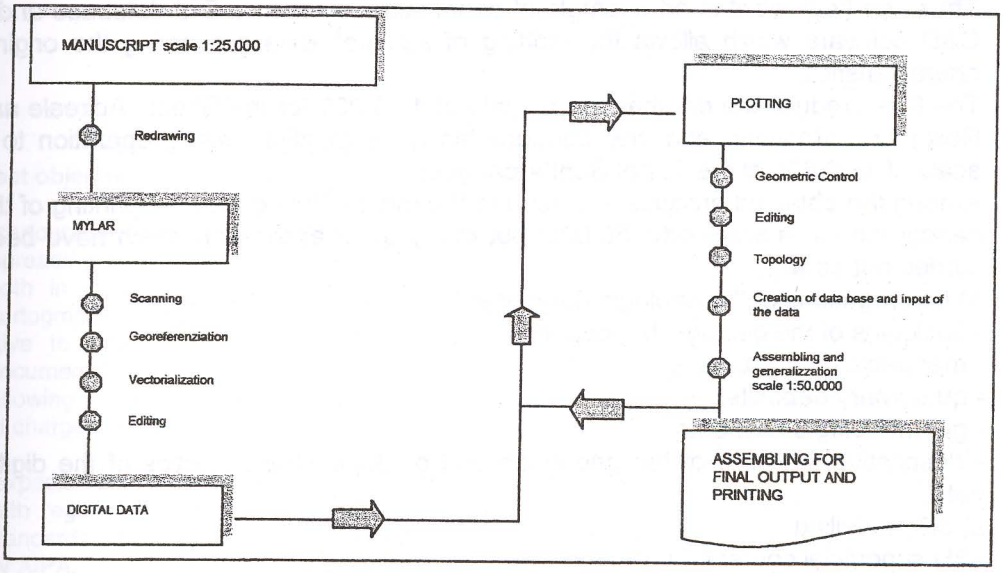

Fig. 1 - Flow diagram

these last (relations of inclusion, of adjacency, etc).
The following step is the building of the suitable topology for the three geometric entities: lines, ponts and polygons.
In particular it must be defined:
- the relations of inclusion;
- the relations of adjacency and sharing;
- the relation of belonging.

Once acquired the digital data, the physical structure of the database has been created with an automatic procedure which translate into ArcInfo® the model proposed by the SGN; this model subdivides the geological data into different fields with peculiar characteristics and tables to infill the descriptive data.
Once the phase of loading of all the available data is finished, it follows the gathering of all the collected material into only one sheet, mixing the polygons and lines between adjacent entities.
The final step is the phase of generalization in order to obtain a sheet to a scale of 1:50.000, which needs the partecipation of the field geologist.
The preparation of the field paper and the frame elements for the final plotting has followed the standard proposals of the SGN (Guide to the Cartographic Rapresentation).
To obtain this goal we choose a suitable software, able to manage:
1. the preparation for printing as previewed by SGN;
2. the connection among the database, the field paper and the elements to frame;
3. the CARG symbols-set yielded in SGN Guidebook 2;
4. an inner program language.

The choice has fallen back on Auto CAD® implemented with a version of the LISP® language, which allowed us to realize the applicative ruotines in order to resolve the problems linked to the realization of the database.

The transition from a topologic GIS system, sucg as ArcInfo®, to a non-topologic CAD system, has occurred without any loss of information using the ArcView® transitional system.
Thus, the final result is an example of connection between a GIS database and a CAD software which allows the plotting of ArcInfo® data preserving the original characteristics.
The final product is a database to a scale of 1:25.000 for the Sheets Acireale and Rosignano Marittimo and one cartographic generalization, with preparation to a scale of 1:50.000 of the Sheet Sant'Arcangelo.
Among the obtained producs the first and the most visible one is the printing of the cartography to a scale od 1:50.000; but many other application which have been carried out as well:
1) interrogations of the geologic database:
- tipologies of the geologic boundaries;
- mappable geologic units;
- quaternary deposits;
- geomorfologic elements;
- descriptive statistics of the geometric and geologic characteristics of the digital data.
2) 3D modelling.
- 3D superficial courses;
- 3D of stratigrafic and structural boundairs;
- geometric reconstructions of the geologic bodies;
- realization of geologic sections;
- reconstructions of the volumetries of the geologic bodies.
The creation of the SGN database to a scale of 1:25.000 for the three available sheets has pointed out the possibility to realize an uniform standard product for a geolgically diversified territory as the Italian one. The proposed model is in fact an open and easy model even if still partially lacunose as far as the vulcanic and metamorfic aspects concearn.
It's possible to extract information from the inserted data and to elaborate them with a simple spread-sheet, or to obtain more sofisticated operation with specific softwares. The generalization and the preparation for a cartography to a scale of 1:50.000 directly comes out from the database, thus the rapresentation of different geological tematism is rapid and agile.