Creation and test of a mobile GIS application to support field data collection and mapping activities on geomorphosites

Marco Giardino, Luigi Perotti, Roberto Carletti, Stefano Russo
GeoSITlab, GIS and Geomatics Laboratory
Department of Earth Sciences
University of Torino
Via Valperga Caluso 35
I - 10125 Torino
E-Mail: marco.giardino@unito.it

1. Introduction

Classical methods for field data collection on geological and geomorphological features are based on the use of relatively simple tools, such as paper notebooks, coloured pencils, base maps, etc., together with the personal skills of researchers. So far, data collected on the field had to be interpreted, summarised and redrawn in order to create base geological and geomorphological maps and/or more elaborated geothematic ones.

In the last 15 years, the use of computers and other electronic devices for collection, analysis and distribution of field data has had a notable development also in the Earth Sciences and their applications to environmental analysis. This triggered effective improvements not only in the field activities, but also in the laboratory ones, in terms of enhancement in both rapidity and precision of data processing, interpretation, and representation. Still, many not-yet-resolved problems concern either the conceptual framework or the practical solutions for field data collection and their transposition onto maps.

As regards geothematic applications in the study of natural heritage, in particular, they need to share, compare and exchange data between researchers and users in unambiguous and accessible ways, possibly following codified standards for map production and user-friendly technologies for communication of the results.

In order to fulfill the above-mentioned requirements, the authors aimed to develop a new application for palm computers to support field data collection and mapping activities on geomorphosites. This paper presents and discusses the results of this research, including some considerations on the essentials in mapping activities, attributes of geological/geomorphological features and characteristics of geomatics tools and methodologies.

2. Mapping and description of geomorphosites

Looking for faster and more suitable procedures for mapping and describing geomorphosites in the field, as a first step, standards of geomorphological techniques have been considered.

Geomorphological studies are devoted to collecting and interpreting information on the Earth’s surface forms, materials, processes and age of formations. Geomorphological maps are synthetic ways of showing the above-mentioned information (Goudie, 2004) and are suitable both for geodiversity studies and geoheritage protection activities. As stated by the Working group on applied geomorphological mapping (AppGeMa) of the International Association of Geomorphologists (IAG), geomorphological maps are, in fact, not only important as end products of scientific studies but also as tools for technical applications by professionals dealing with the landscape and landforms (Pain et al., 2008).
In the case of geoheritage, geomorphological maps can enhance assessment, planning and geomorphosite management projects. Still, standards of mapping procedures and legend systems for different scales have to be followed, in order to provide precise and unequivocal information on distribution of landforms, soils and rocks. Thus, by means of proper geomorphological mapping, a correct identification and interpretation of features created by surface processes can be performed, therefore enhancing the modelling of past and present evolutionary stages of the geomorphosites. This can turn out to be very useful for achieving different objectives: to assess values of natural resources, to disseminate scientific knowledge to the general public and/or to prevent geomorphological hazards in the exploited areas (Embleton, 1988; Panizza, 1999).

Methodologies were tested in Italy for creating maps and descriptions suitable for both scientific and educational purposes (Giardino et al., 2004; Carton et al., 2005; Castaldini et al., 2005). Some case studies evidenced the importance of supporting terrain surveys and mapping products by 3D imagery (combination of DEMs and remote sensing images; Bertacchini et al. 2007). Some others showed the importance of structuring geodatabases and using GIS technologies for better collection, management and presentation of geosite data for geotourism purposes (Avanzini et al. 2005; Gregori & Melelli, 2005; Ghiraldi et al., this volume).

3. Geomatics support for a new methodology

Simplicity, precision and rapidity of field survey techniques are some ingredients for achieving better results in the collection and organisation of data on geomorphosites. In this perspective, a key factor offered by digital techniques is the possibility of organising a complete dataset during field activities, avoiding time-consuming laboratory operations, such as copying data from paper forms and/or repeated drawing of maps.

To develop a digital methodology for mapping and describing of geomorphosites, different studies on computer applications for field-based geological/geomorphological activities were compared, conducted by universities, research centres, and technical institutions (e.g. Haugerud & Thoms, 1999; Walsh et al., 2000; Clarke et al., 2002). Geomatics support to field surveying was also tested for developing skills at an educational level (e.g. International conference: “Supporting fieldwork using information technology”, University of Plymouth). As a common conclusion of the above mentioned works, light, easy-to-handle hardware and user-friendly software have been selected, in order to offer a precise, uniform standard technological path to be followed when collecting and processing data in the field.
The geomatics methodology suggested here consists in the integrated use of digital pictures and maps from different sources (topographic maps, orthorectified aerial photographs, other technical geothematic maps), which become either a base or an output for data collection and representation of geomorphosites, by using dedicated forms for geomorphological descriptions and mapping. The equipment for such activities consists in a pocket PC based on Windows CE, with dedicated GIS software and Bluetooth GPS for ground positioning (Fig. 1). The use of palm/pocket PC is an innovative solution with respect to the use of tablet PC as a field mapping tool proposed by other research teams. Juxtaposition of the two alternatives revealed that palm computers are more convenient tools for supporting field activities, according to several criteria: size, weight, autonomy power of batteries, rapidity and simplicity of use, and overall cost of instrumentation.

Fig. 1  Geomatics supports for digital mapping and description of geomorphosites: palm/pocket PC and digital imagery (topographic maps, orthorectified aerial photographs, other technical geothematic maps).

4. Functioning of SRG$^2$ application

Looking for faster and more suitable procedures of field mapping and data collection on geosites, either for scientific research and technical management, an application called “SRG$^2$” (acronym for the Italian: “Supporto al Rilevamento Geologico/
Geomorfologico”; Support to Geological/Geomorphological Surveys) was created, as an extension for ArcPad (GIS-ESRI for palms) developed in Visual Basic. Into the ArcPad environment, the SRG² application adds a toolbar, vectors and tables made up of several functions for a useful mapping and classification of geological and geomorphological features (Fig. 2). ArcPad software generates vector shapefiles, of large use in GIS projects and of great utility in assessment and management of geomorphosites.

In order to catalogue features relevant to geomorphosites studies (erosional and depositional landforms and related deposits, characteristic processes of different morphogenetic environments, lithological and structural elements, anthropic features and infrastructures, location points for sampling and picture views), the SRG² application was structured into different layers (shape file format) and associated (Fig. 2).

During field activities, as a first step, distinct elements are classified by geometry (points, linear, areal features). Drawing elements in the map can be manually operated, through visual recognition in the field, or automatically, by means of a GPS tracking option.

Then, surveyed features are classified by typology: 1) genetic environments and related processes, either endogenic or exogenic, are interpreted (“glacial”, “fluvial”, “gravity-induced”, “tectonic”, “complex”, etc.) or left unknown; 2) further alphanumeric data (morphometrical, chronological, lithological, etc.) are requested to com-
A mobile GIS application provides a complete description and to support interpretations. Each typology of classified elements has a dedicated list of selectable attributes (Fig. 3), useful both for achieving a complete scientific description of the surveyed features and for indicating relevant features to be considered by technical operators in the geomorphological heritage, for planning and management purposes. As an example, by using SRG² application, badland areas were mapped as part of the geodiversity of the Piemonte region; their full description allowed not only the selection of features to be protected as geomorphosites (according to assessment methodologies; Reynard et al., 2007), but also proper management of the geomorphological risk related to geotourism activity in a dynamic environment.

Fig. 3 Examples of selectable attributes to support interpretation of geomorphological features.
5. Test sites in the geoheritage of the Italian Western Alps

Tests for SRG\(^2\) were performed in the mountain and piedmont areas of the Italian Western Alps (Piemonte and Valle d’Aosta Regions).

In the Upper Susa Valley, Montgenèvre area (along the border between France and Italy) field mapping activities by using SRG\(^2\) were conducted during a national research project devoted to geomorphological analysis in the mountain area of the Torino 2006 Winter Olympic Games (Panizza et al. 2005). Landform distribution and activity were surveyed and compared to landuse patterns and infrastructures. The Upper Susa Valley ski resort area includes the Monti della Luna and Val Thuras geosites (Fig. 4). Here, SRG\(^2\) supported mapping and collecting information of the intense human activity and landuse in the area and also of the long-term gravitational deformations on mountain slopes. Detailed field analysis was based on geomatic maps by satellite monitoring and digital aereo-photogrammetric image processing. Data concerning the territory and vegetation were available for the SRG\(^2\) geodatabase thanks to the partnership with the Upper Susa Valley Forestry Commission and the municipality of Cesana Torinese.

Other applications of SRG\(^2\) were performed in the Aosta Valley, in the Espace Mont-Blanc area and the Gran Paradiso National Park. Both active and relict landforms of glacial environments were surveyed (Fig. 5). Geomorphosites of the Espace Mont-Blanc area were considered in order to enhance the protection of a territory rich in natural and tourist resources. Here, the Miage glacial basin (Mont-Blanc, Italian side) was selected both for its scientific value and geomorphological risks. The Miage glacier is a debris covered glacier characterised by a substantial stability in the area dimension, but with noteworthy volumetric variations in the last decades, related to instability phenomena on the side moraines. The abundant debris cover in the ablation zone is caused by the diffused gravitational instability of the surrounding rockwalls, controlled by particular morphoclimatic and morphostructural conditions on the southern slope of Mont-Blanc. Its easy access makes the Miage a highly frequented tourist area, not only for alpinists. This is why in the case of instability phenomena the amount of people involved could be very large. SRG\(^2\) helped to individualise sectors of natural hazards and their possible interaction with human elements (paths, tracks, alpine roads and shelters). A 3D model of the glacier was also created for spreading scientific information on premonitory signals of the instability phenomena.
Fig. 4  3D view of the Thuras Valley (a) and particular of the geomorphological map obtained using SRG2 application (b).

In the Gran Paradiso National Park, including the high valleys of the Valle d’Aosta and Piemonte Regions around the Gran Paradiso Massif (4061 m), use by both alpinists and tourists of the area has been consolidated since a long time, through the valley itineraries and the glacial high altitude slopes. The on-going climate change
Fig. 5 3D view of the Miage glacier (Mont-Blanc massif) and examples of forms developed for ArcPad to acquire glacial landforms and other characteristics, both in the Espace Mont-Blanc area and in the Gran Paradiso National Park.
A mobile GIS application determines rapid transformation of the mid-high slopes characterised by large fractured rock masses and by the activation of geomorphological instability phenomena.

The authors conducted research by using SRG² to analyse hazards on rock walls and glaciers in sectors of interest for alpine routes and/or hiking tracks (Tribolazione and Trajo Glaciers; Cogne Valley; Fig. 6). For the field surveys, a geomorphological map (Giardino et al., 2000) and a digital track network realised by the University of Torino research unit for the Park were used. In addition, a visual monitoring of the unstable sectors was developed by means of digital instrumentation, in collaboration with Park rangers. Results on the hazard and risk studies were used as teaching material for Park rangers and as popularised information for the general public.

In both above-mentioned case studies, SRG² tests allowed the automatic import with legend transposition of field structured geodatabase data, resulting in the immediate creation of publishable maps. In this way, the field survey became an integral part of a complete and easy-to-update GIS, without other intermediate stages.

Fig. 6 3D view of the Cogne Valley (Aosta Valley - NW Italy) and example of map developed with ArcPad to check trail operability and their characteristics.
6. Conclusion

The experimental mobile GIS application called SRG² (Support to Geological/Geomorphological Surveys) provides a “customised” interface to support field data mapping and to describe geomorphosites in the field. SRG² was aimed at simplifying field data collection activities: tests were successful and also allowed users, once back in the laboratory, to print processed information directly through an automatic graphic refining of the field-data legend in a simplified form.

The direct production of thematic maps “in the field” and immediate “recording” of data in a specific geodatabase seem to be the most promising aspects of the method, which was successfully used not only by researchers but also by technical staff operating in parks and other territorial institutions involved in the inventory and management of geomorphosites. SRG² also allowed a “skill transfer” between researchers and operators to be developed, based on the practical use of geomatics tools. Sector technicians working in the territory full time were given a simplified key to read and interpret instability processes, which will enable them to get easier surveys and detailed description of geomorphosites.

A similar procedure could also be easily used for teaching and/or demonstration purposes for tourists and students. This could be applied in supporting field activities of university students, but also be specifically addressed for training alpine guides and the tourists themselves in geomorphosite knowledge and protection.

References

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