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3D Geological visualizations of geoheritage information in the Monviso Massif (Western Alps)

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ABSTRACT

Geoheritage information comes from areas that, for their peculiar features, are of geological interest (i.e. geosites). An important activity for geosites management consists of developing and applying useful digital tools for sharing information. The PROGEO-Piemonte (PROactive management of GEOlogical heritage in the PIEMONTE region) is an example of a project wherein different IT applications have been implemented for collecting, storing and spreading geoheritage information. The most important of these applications consists of building 3D visualizations of geological features through the Arpa Piemonte Geoportal, which hosts a GIS-based 3D viewer loading high resolution DTM and aerial images. Lithostratigraphic, structural and geomorphological features occurring in the Monviso Massif in the Western Alps are selected from geological map databases, processed by GIS tools and draped over the terrain model. 3D visualizations give realistic and easy-to-read representations of geology around geosites or along geological trails, and contribute to overcome problems that commonly occur in transferring contents of geological maps to non-expert users.

KEY WORDS: geoheritage, GIS, Monviso meta-ophiolite, tectonic contact, glacial landform.

INTRODUCTION

Geoheritage information corresponds to geological fetaures and sites (i.e. geosites) that, for their peculiar characteristics, are scientifically important and can be used both for research, geoconservation and geotourism. An important activity for management of these kind of data consists of developing and applying useful digital tools for storing, processing and sharing information (Cayla, 2014).

In our approach (Balestro et al., 2015a), IT applications to the frame of geoheritage and geosites, consists of three main working steps which correspond to (*i*) digital geological mapping, (*ii*) realization of geological map databases and (*iii*) building of 3D geological visualizations.

The first step consists of mapping geology around geosites and collecting geoheritage data by means of GPS technology and GIS (mobile) applications loaded on rugged handheld devices. Field data are then stored in map databases and processed by GIS (desktop) tools. In the third step, 3D geological visualizations are built through a GIS-based 3D viewer (Fig.1) that draps meaningful geological features over digital terrain models and aerial images. These 3D visualizations have not the capabilities of real 3D geological models (i.e. numerical models that actually allow building and checking geometry of geological units; see e.g. Zanchi et al., 2009), but allow giving realistic and easy-to-read representations of geology around geosites or along geological trails.

THE PROGEO-PIEMONTE PROJECT AND THE MONVISO MASSIF

Digitalization and 3D geological visualizations of geoheritage information have been particularly developed in the frame of the PROGEO-Piemonte (PROactive management of GEOlogical heritage in the PIEMONTE region) project. The latter aims to inventory geosites in the Piemonte region (NW Italy) for promoting both their conservation and divulgation. Following the methodological approach of the ProGEO association (http://www.progeo.se), the project and its multidisciplanry group also aims to develop new techniques for recognizing and managing the rich geodiversity of the Piemonte region at different scales (Giardino et al., 2012). Within the project, nine geothematic areas have been chosen, each one being characterized by high potential for scientific studies and enhancement of public understanding of science. One of the PROGEO geothematic area is the Monviso Massif (Rolfo et al., 2014a), which corresponds to one of the most outstanding symbol of the Alps lately recognized as a Biosphere Reserve (MAB Programme of UNESCO).

The Monviso Massif is particularly characterized by the occurrence of well-exposed meta-ophiolite sequences and spectacular glacial landforms. All along these geological features an Ophiolite Geopark with different geological trails has been developed in the upper Po Valley (Rolfo et al., 2014b). The main geological trail allows to walk *i*) across an

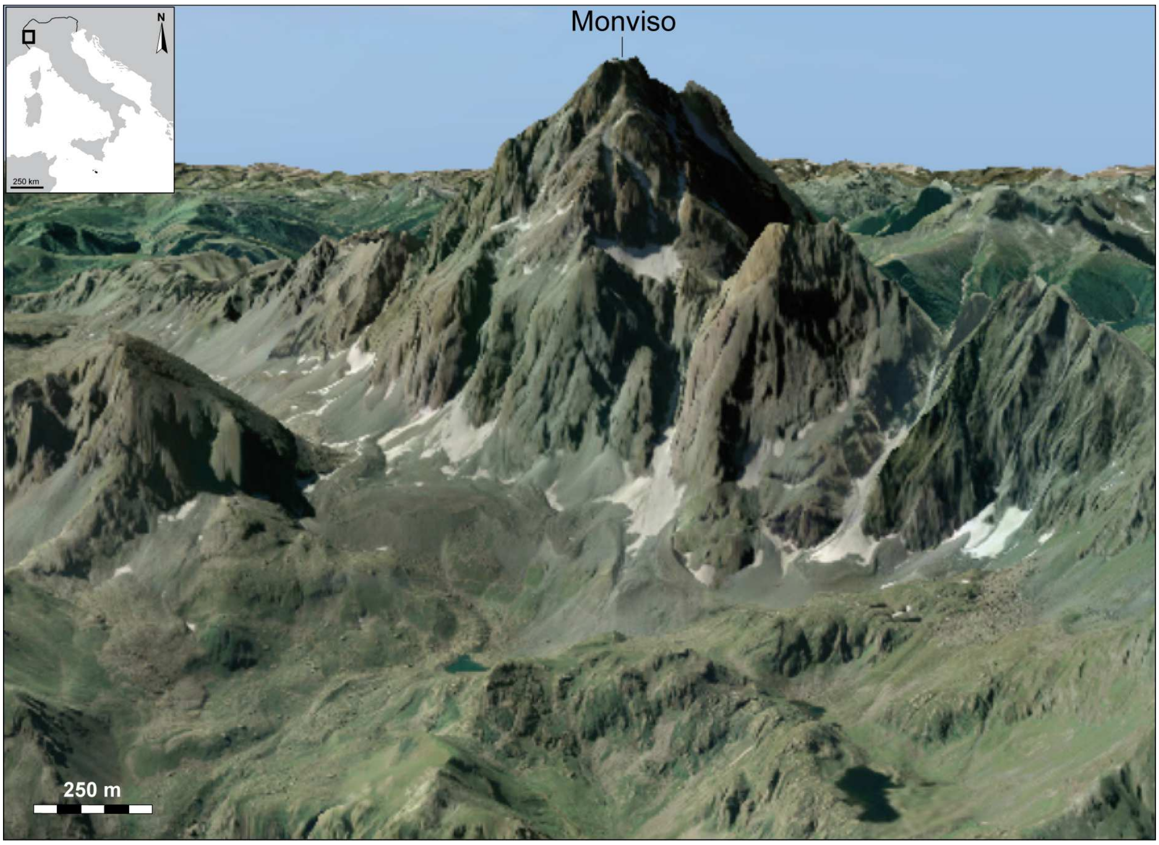

Fig. 1 – 3D virtual view (looking South) of the Monviso Massif.

ancient ocean (i.e. the Monviso Meta-ophiolite Complex; Balestro et al., 2014; Balestro et al., 2015b) and *ii*) on glacial landforms related both to the Last Glacial Maximum and to the Little Ice Age (Balestro et al., 2011; Balestro et al., 2013).

The Monviso Meta-ophiolite Complex is a remnant of the Jurassic Western Tethys that was subducted and stacked in the axial sector of the Western Alps. During Alpine tectonic, original ophiolite sequences (i.e. serpentinized peridotite, gabbros, basalt and sediments), were metamorphosed under eclogitic conditions and dismembered into different tectonic units that characterize the inner architecture of the Monviso Meta-Ophiolite Complex.

The present-day morphology of the Monviso Massif mainly results from glacial modeling during Pleistocene glaciations. Glacial deposits related to the Last Glacial Maximum and to the subsequent glacier retreat are in particular extensively preserved at the head of the Po Valley.

3D GEOLOGICAL VISUALIZATIONS

Meaningful lithological, structural and geomorphological features occurring in the Monviso Massif are selected from geological map databases, processed by GIS tools and draped over terrain models through the Arpa Piemonte Geoportal (http:// http://webgis.arpa.piemonte.it/geoportale). The latter hosts a GIS-based 3D viewer that loads high resolution DTM (5 meters) and aerial images (50 cm/pixel), and enables 3D visualizations of landscapes (Fig. 1) and geoheritage information.

An example of meaningful geomorphological feature corresponds to the glacial landforms occurring at the base of the Monviso north face (Fig.2). The boundary between different glacial deposits and the related moraine ridges are directly imported in the 3D viewer. Draping of these linear features over aerial images supports visualization of geomorphology from different point of views (and distances).

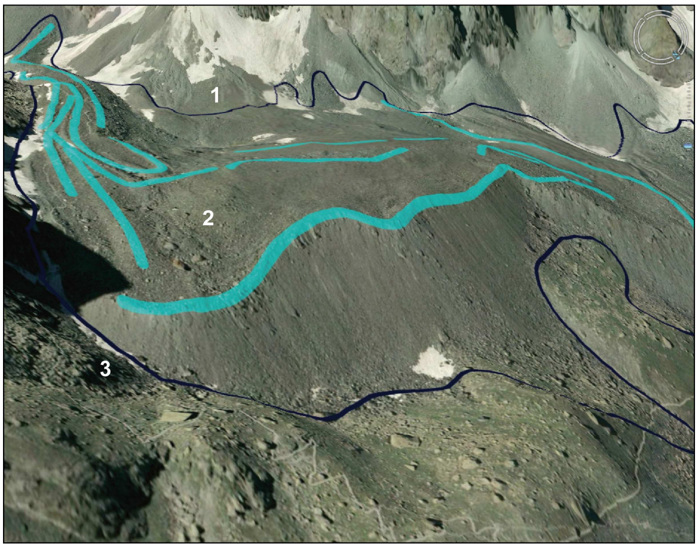

Fig. 2 – 3D visualization of the moraine ridges (light blue line) occurring at the base of the Monviso north face. The dark blue line shows the boundary talus deposits (1), glacial deposits of the Little Ice Age (2) and glacial deposits of the Last Glacial Maximum (3).

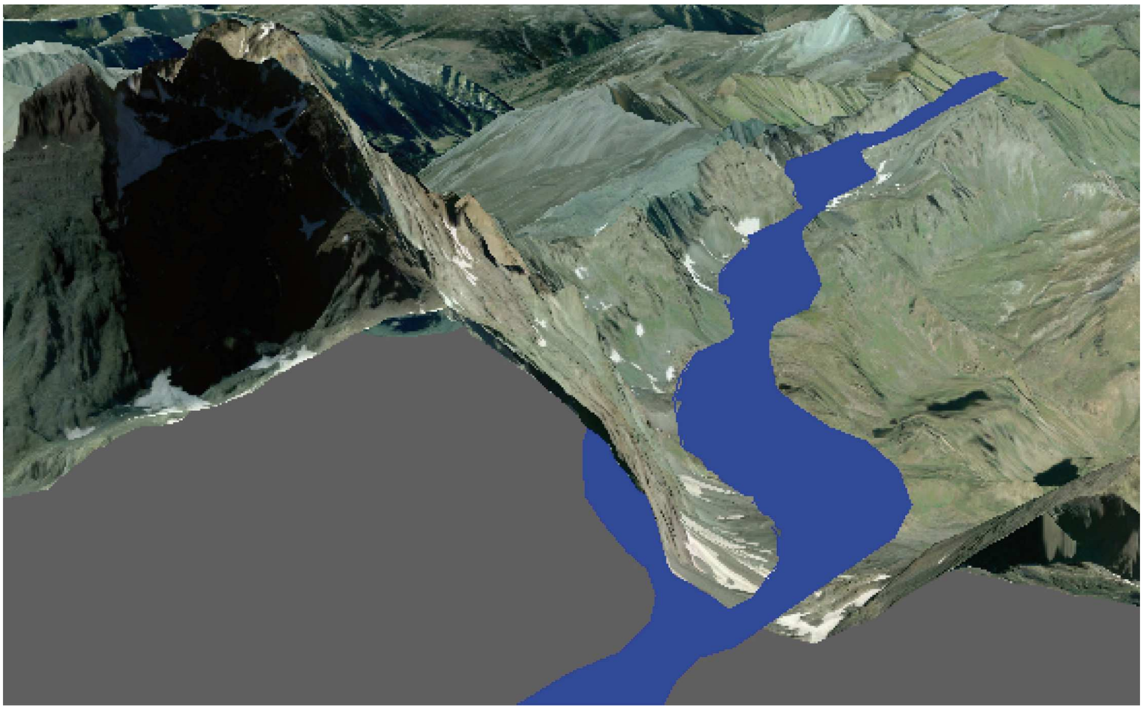

Fig. 3 – 3D visualization (looking North) of the main tectonic contact (blue surface) occurring within the Monviso Meta-ophiolite Complex. Underground view of the plane is obtained by creating a hole in the terrain model.

An example of meaningful structural feature is the tectonic contact that separates the two tectonometamorphic units occurring within the Monviso Meta-Ophiolite Complex. The tectonic contact correspond to a linear features that is extracted from the map database, transformed into a 3D plane through a dedicated script and imported in the 3D viewer.

The workflow for the generation of this 3D plane consists of different steps that include (*i*) transformation of the original linear feature into a new polygon feature through a buffer operation, (*ii*) generation of a new 3D polygon through DTM interpolation, (*iii*) generation of a new 3D point layer from vertices of the 3D polygon, (*iv*) correction of the “z” values of vertices according to the dip of the plane, and (*v*) transformation of the 3D point layer into a new linear layer, from which a final 3D polygon representative of the tectonic contact is created.

The projection of the generated 3D polygon in the 3D viewer allows both surface and underground visualization of the tectonic contact (Fig. 3). In this way, structures can be easily represented and explained also to non-experts users.

CONCLUSIONS

Sharing and spreading of geoheritage information are nowadays widely enhanced by use of IT applications. GIS-based 3D visualizations particularly allow building realistic and easy-to-read representations of geology around geosites or along geological trails.

Virtual observation of landscapes and geomorphology from different point of view and at different scale, is a useful integration of real-world observations.

Moreover, 3D visualizations enable easy-to-read representations of complex and inferred map-scale structures, so that the problems that commonly occur in transferring contents of geological maps to non-expert users can be (partly) overcome.

Although these visualizations have not the capabilities of real 3D geological models, they are also useful for field geologists that can easily visualize their map interpretations (and related uncertainties).

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