The contribution of geomorphological mapping to environmental tourism in protected areas: examples from the Apennines of Modena (Northern Italy)

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Abstract. This paper considers the contribution of geomorphological documents and the criteria and methodology used for the implementation of tourist - environmental maps in two protected areas located in hilly and mountain areas of the Apennines of Modena (Northern Italy). The hilly area is the Natural Reserve of Salse di Nirano; the *"Salse"* are small mud volcanoes formed by emissions of salt water mixed with mud and pushed up by methane rising to the surface along ground discontinuities. The mountain area consists of the Upper Tagliole Valley, located within the Frignano Park; it is mainly characterized by glacial and cryogenic landforms.

Geomorphological maps and Digital Terrain Models (DTM) have been produced. Geo-tourist maps were derived from the geomorphological maps; the geo-tourist maps combine the most evident geomorphological features with fundamental tourist information. The goal was to produce maps that could be easily interpreted by tourists to help them understand the landscape.

The geo-tourist maps and the DTM are the cartographic documents characterising tourist-environmental maps; these are thematic pocket foldable maps printed on both sides with illustration notes both in English and Italian. In addition, the tourist-environmental maps contain a synoptic description of the geological, geomorphological, botanical and zoological aspects, accompanied by photographs and information on excursion trails, visitor centers, behaviour rules, refreshment points and overnight-stay places and, finally, cultural and tourist attractions in the protected and surrounding areas.

The tourist-environmental maps form part of the initiatives taken by Public Boards to improve the knowledge, utilisation and appraisal of the environment of protected areas. These studies show how geomorphological investigations can effectively contribute to the production of maps which can be used in the field of environmental tourism.

1. Introduction

In the past decade several papers, research projects and scientific meetings have been carried out at an international level regarding the preservation of geological heritage (whose elements are defined, according to the various authors, as "Earth science sites", "Geologic Assets", "Geotopes", "Geosites" or "Geomorphosites") (Reynard, 2004) and its diffusion and appraisal also outside the realms of academic research (for example, Wimbledon *et al.,* 1995; Eberhard, 1997; Barrettino *et al.,* 1999; Panizza, 2001; Piacente and Poli, 2003; Reynard *et al.,* 2003).

Very recently, within the framework of the 32nd International Geological Congress (Florence, Italy, 20-28 August 2004), many oral and poster presentations focused on "Geological Heritage and Tourism" and "Cultural Heritage: International Approaches and Perspectives" (Italy, 2004). Also within the framework of the 6th International Conference on Geomorphology (Zaragoza, Spain, 7–11 September 2005) special sessions on "Geomorphological sites: Research, Assessment and Improvement" and "Natural-Cultural Heritage" were held (Gutierrez et al., 2005).

Moreover, the "Recommendation Rec (2004) 3 of the Council of Europe on conservation of geological heritage and areas of spe-

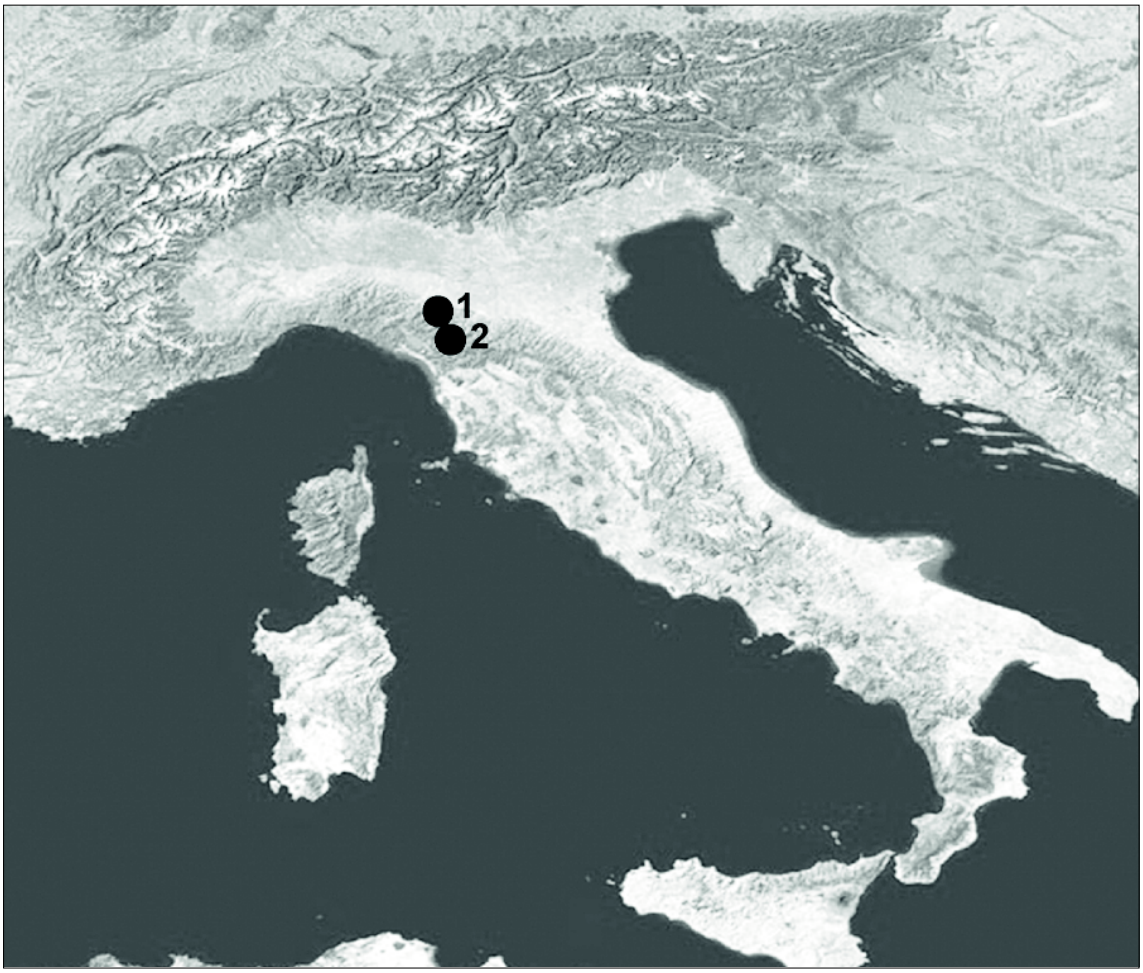

Fig. 1. Location of the study areas: 1) Regional Natural Reserve of Salse di Nirano; 2) Upper Tagliole Valley (Frignano Park)

cial geological interest" underline the importance of the Earth Heritage and Geodiversity and the tools to create opportunities for education, recreation and tourism (Panizza, 2005).

This paper considers the contribution of geomorphological documents and the criteria and methodology used for the production of tourist–environmental maps in two protected areas located in hilly and mountain, areas of the Apennines of Modena (Northern Italy)(Fig. 1).

2. Geographical, geological and geomorphological settings of the study areas

The Province of Modena is located in northern Italy, in the Region Emilia-Romagna; the southern sector of its territory belongs to the Northern Apennines whereas the northern sector belongs to the Po Plain. The Apennine sector has an altitude ranging between about 150 m a.s.l. along its margin and about 2,000 m a.s.l. along the watershed between the Adriatic and Tyrrhenian sides of the Apennines; the highest peak is Monte Cimone (2,165 m a.s.l.).

The main geological units forming the Apennines of Modena are as follows (Bettelli *et al.,* 1989).

1) Tuscan Units, made up of Tertiary siliciclastic deep-water turbidites, continuously cropping out along the Apennines chain's axis and mainly representing the infilling of distinct migrating Tertiary foredeep basino.

2) Ligurian Units made up of deep-sea sediments including Jurassic Ophiolites followed by thick sequences of Cretaceous to Eocene calcareous or terrigeneous turbidites.

Fig. 2. Aerial view of the Regional Natural Reserve of Salse di Nirano. The sub-circular shaped depression, at the bottom which the mud volcanoes are found, and the "calanchi" (badlands) are quite evident (photo L. Callegari).

3) The mainly terrigenous epi-Ligurian sequences of the Middle Eocene to the Late Messinian, unconformably resting on the previously deformed Ligurian Units. The epi-Ligurian sequences and the Ligurian Units are exposed in the middle Apennine.

4) The belt of Plio-Quaternary marine terrigenous deposits unconformably overlying the Ligurian Units and the epi-Ligurian sequence cropping out at the Apennine margin and dipping under the alluvial deposits of the Po Plain.

An account of the geographical, geological and geomorphological setting of the two study areas follows.

Regional Natural Reserve of Salse di Nirano. The hilly area, includes the Regional Natural Reserve of Salse di Nirano located in the Apennines of Modena margin (Fig. 2). The *"Salse"* are small mud volcanoes formed by emissions of salt water mixed with mud and pushed up by methane rising to the surface along ground discontinuities. The Natural Reserve covers an area of 207 ha and ranges in elevation from 140 m to 308 m a.s.l.; the extent of the area covered by the *"Salse"* is about 10 ha, in an altitude ranging between 200 m to 220 m a.s.l. It is therefore a lowhill territory, with a mean annual precipitation of about 800 mm and a mean annual temperature ranging between 12 and 13 °C.

Within the Italian territory, the *salse* can be found in many Apennine areas. Since they are one of the most developed pseudo-volcanic phenomenona of the whole Italian territory, Salse di Nirano have always aroused great interest and were first described by Pliny The Elder, around 50 A.D., in his monumental work "Naturalis Historia". Many other authors followed (for example Stoppani, 1873; Bertacchini *et al*., 1999; Gorgoni, 2003). In 1982, the Natural Reserve of Salse di Nirano was established in the area by the Emilia-Romagna Region with the aim of

Fig. 3. Cone-shaped mud volcanoes. They show a clear alignment in correspondence with a fault/fracture (photo J. Valdati).

safeguarding and preserving the natural and environmental characteristics of the site.

The form of the craters depends on the density of the muddy mixture: if it is dense, "cones" of various height (single, double or multiple) may develop (Fig. 3); if it is liquid, ground level "pond-shaped mud-volcanoes" occur. Due to the affinity to real volcanoes, the *salse* are also called "mud volcanoes" (Bertacchini *et al*., 1999).

The origin of the *salse* is linked to the presence, at a depth of hundreds or a few thousands meters, of methane accumulations. The methane rises upwards along discontinuities in the ground (fractures or fault lines), meets saline waters accumulated in water-bering strata and carries it up to the surface. The waters, seeping through clayey sediments, dilute, and the latter sediment become muddy. The clay materials ejected from the craters cover the surrounding ground with mudflows The number of craters can vary with time, as does their location: in the case of Nirano, the cartographic and photographic documents indicate a considerable stability during the last hundred years. A recent detailed survey has identified nearly forty craters (Gorgoni, 2003).

From a lithologic point of view, in the Natural Reserve of Salse di Nirano only marine silt-clay soil types (Plio-Pleistocene age) are exposed. The main streams are Rio Chianca, Rio delle *Salse* and Rio Serra. Some small ponds, marshy areas and swamp deposits are also found.

The main anthropogenic landforms include an abandoned quarrying area and an artificially flattened area corresponding to a disused farming area (a worm "farm" for anglers). Nearly everywhere it is possible to observe badlands *("calanchi")* in most cases stabilized by vegetation. The *calanchi* are one of the most spectacular landforms of erosion of the Apennine margin (Fig. 2). They are typically composed of clayey soils and are characterised by a very fine drainage network and short, steep slopes with narrow interfluves.

The deposits are mostly made up of very fine materials deposited by the main watercourses or by rill-wash on the slopes. Landslide bodies are quite common; they

Fig. 4. The glacial cirque in the north-eastern slope of M.Rondinaio (1964 m a.s.l.) remodelled by cryogenic, nivation and slope processes (photo D. Castaldini).

include small earth flows. Most landslide deposits have been colonized by vegetation which has contributed to stabilize them.

2.2. The Upper Tagliole Valley

The Tagliole Valley is one of the most important valleys of the Apennines of Modena owing to the characteristics of the landscape. It is located in the Park of the High Apennines of Modena, or Frignano Park. The main hamlets of the valley are Le Tagliole (1,158 m a.s.l.), Ronchi (1,146 m a.s.l.) and Rotari (1,218 m a.s.l.). In this area winter tourism is not developed as much as in other areas of the Modena Apennines like, for example, in the Mt. Cimone area. The valley is frequented by excursionists, especially in the summer, owing also to the presence of several lakes

The climate is considerably influenced by several geographical factors, among which are the altitude and location near the watershed. Below 1,000 m a.s.l., the average annual temperature is about 10°C, whereas above this elevation it progressively decreases to 6°C in the area around the watershed. Annual precipitation ranges from 1250 mm in the lower part to over 2,000 mm in the upper part.

The geomorphological studies in the upper sector of the Apennines of Modena, started at the end of 19th century. In the last decades, the geomorphological features of this area were described by Carton and Panizza (1988), Ferrari and Panizza (1992) and Bertacchini *et al.* (1999).

The study area, corresponding to the Upper Tagliole Valley, with elevations ranging from 1,480 a.s.l., to 1,990 m. a.s.l., is mainly characterised by glacial and cryogenic landforms (Carton and Panizza, 1988). The Macigno Formation (Mid-Upper Oligocene - Lower Miocene?), belonging to the Tuscan Units, is exposed in the Upper Tagliole Valley. It is made up of sandstones with interbedded thin beds of pelitic sediments dipping northwards.

The head of the valley is located in the wide glacial cirques of Monte Giovo (1,991 m a.s.l.) and Monte Rondinaio (1,964 m a.s.l.)(Fig. 4). The cirques have vertical faces which have undergone slope, cryogenic and running water processes. Their scarps are therefore covered with debris produced by various processes. The rock glacier found at the bottom of the cirque of Monte Giovo is of particular interest. At various altitudes, vast glacial deposits and numerous moraine ridges

Fig. 5. Panoramic view of Lake Santo which is the largest lacustrine basin of the whole Apennines of Modena (photo J.Valdati).

are found. Owing to the barrage of runoff waters, glacial landforms have determined the formation of the Lakes Torbido (1,675 m a.s.l.), Turchino (1,613 m a.s.l.), Baccio (1,554 m a.s.l.) and Santo (1,501 m a.s.l.) (Fig. 5), together with other small depressions which are now completely filled with swamp deposits. The running water processes have also formed gullies, gorges and waterfalls. Various glacial traces testify the presence of glaciers during the last glacial period (Würm) which ended about 10,000 years B.P. The considerable difference in height between the highest peaks and the valley floor (1,000-1,100 m) witnesses the high relief energy of the Tagliole Valley.

3. Study methodology

In order to provide information about the physical landscape of each study area, a geomorphological map and a Digital Terrain Model (DTM) have been produced by means of ArcView GIS computer programme. The Regional Technical Map (CTR) of the Emilia-Romagna Region, at the 1:5,000 scale, was used as the topographic basis for their elaboration. Detailed morphological aspects are illustrated in a geomorphological map, produced from bibliographic research, analysis of aerial photographs of various periods (1973, 1994 and 2000) and field survey. In producing the geomorphological map of the study areas the legends used for recent geomorphological maps (for example Gruppo Nazionale Geografia Fisica e Geomorfologia, 1995; Castaldini *et al.*, 1998; Pasuto *et al.*, 2005) were applied with some modifications.

The general morphological picture of each study area is effectively provided by the DTM which was computer-elaborated through the transformation of altimetric data (5 m equidistance contours) into a Triangular Irregular Network (TIN). A geo-tourist map was derived (with appropriate simplifications and integrations) from the geomorphological map (Fig.. 6). A geo-tourist map can be con-

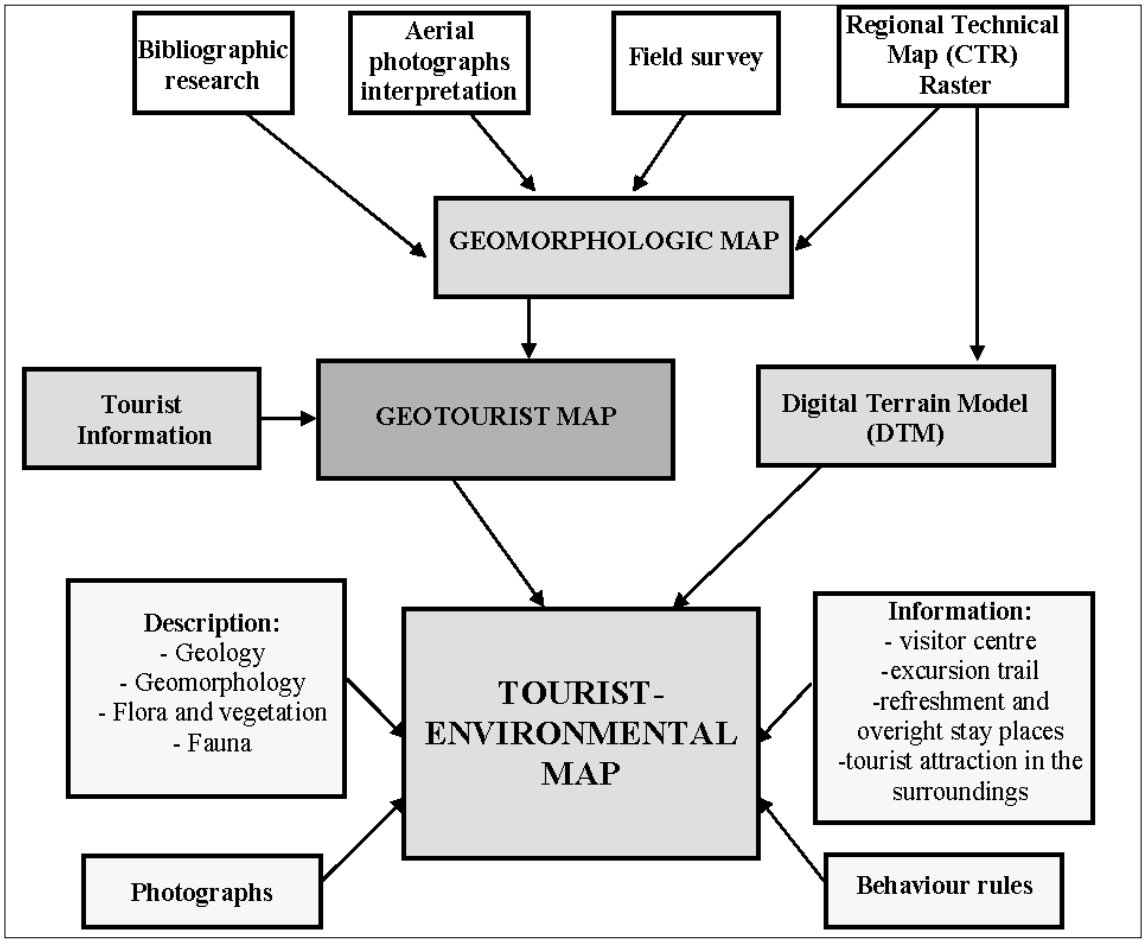

Fig. 6. Scheme of elaboration of the various documents.

sidered as a thematic map. The latter are maps which focus on a particular aspect and, consequently, are aimed at specific users. First of all, in the preparation of a thematic map, the set of data that are going to be most utilised must be chosen, so that a language and mapping system are set up (Papotti, 2002). Therefore, a geo-tourist map combines the most evident geological and geomorphological aspects with basic tourist information (for example parking places, footpaths, picnic areas, overnight-stay places, etc.). The aim was to produce maps that could be easily interpreted by tourists to help them understand the landscape. In detail, the legend was divided into two clearly distinct categories. In the first the symbols representing the geological and geomorphological aspects are illustrated, whereas in the second category the symbols concerning tourist information are shown. Regarding the geomorphological aspects, the geo-tourist map illustrates all the elements of the landscape that a tourist can observe and identify. An effort was made to use simple, clear and graphically pleasing symbols with short captions, avoiding specialized terminology. In any case, the legend adopted is scientifically correct. As for tourist information, this has been indicated with the commonly used symbols for tourists. In the geo-tourist map and in the DTM the excursion trails are shown in order to facilitate the interpretation of the landscape and the elevation points for the tourist willing to walk along the trails suggested.

The geo-tourist maps and the DTM are the cartographic documents characterising tourist-environmental maps (Fig. 6). The tourist-environmental maps are foldable, pocket-size, maps printed on both sides which

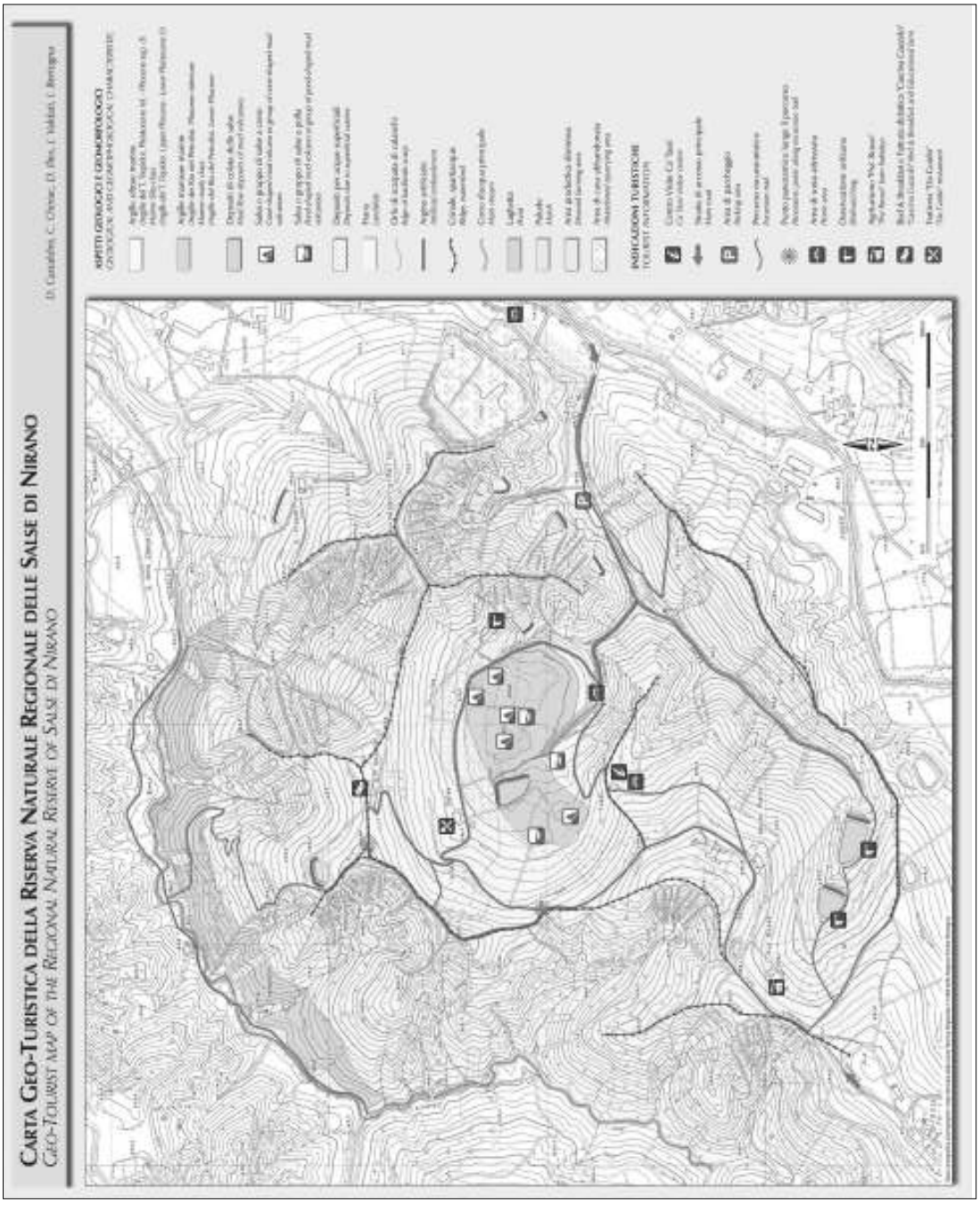

Fig. 7. Front side of the tourist-environmental map of the Regional Natural Reserve of Salse di Nirano

the tourists can consult in the field while visiting the protected areas. These are maps with illustration notes both in English and Italian. In addition, the tourist-environmental maps contain a synoptic description of the geological, geomorphological, botanical and zoological aspects, accompanied by photographs and information on excursion trails, visitor centres, code of behaviour, refreshment points and overnight-stay places and, finally, cultural and tourism attractions in the protected and surrounding areas. Taking into account the use in the field of the maps, the descriptions contain concise information; the tourist who wishes to obtain more detailed information on the different topics can do so at home reading relevant books.

These maps have been called "tourist–environmental" maps because, besides the most evident geological and geomorphological aspects and basic tourist information, they provide further information (such as information on the flora, vegetation and fauna) concerning the environment.

The tourist - environmental maps of the study areas

In this section the main characteristics of the tourist-environmental maps of the study areas are described. These documents, which were originally produced in colour, are here presented in black and white and at a smaller dimension (the original dimensions are 48 cm x 63 cm).

Regional Natural Reserve of Salse di Nirano. The tourist-environmental map of the Regional Natural Reserve of Salse di Nirano was printed with the financial support of the Municipality of Fiorano Modenese in the year 2004 (Barozzini et al., 2004).

The front side (Fig. 7) contains the geo-tourist map of the Reserve and its description. Regarding the geomorphological aspects, the geo-tourist map shows all the elements of the landscape that a tourist can observe and identify. In particular with regards to the mud volcanoes ("*salse*") – the main attraction of the Reserve – symbols graphically indicatine both the "cone-shaped" forms and the "pond-shaped" formes have been used on the map so that the tourist can immediately locate them.

As for tourist information, the commonly used symbols for tourist maps have also been adopted in this case. They include:

1) General information (for example, Ca' Tassi visitor center, excursion trails, panoramic points along the excursion trails, picnic areas).

2) Wildlife information (bird-watching points).

3) Logistic information (main access roads, parking places, refreshment and overnight-stay places, consisting of a restaurant, a holiday farm and a bed & breakfast).

For further details on the geo-tourist map of the Reserve refer to Castaldini *et al.* (2005 b).

The other contents on the front side of the tourist-environmental map include:

i) The title of the tourist-environmental map, the list of the authors, the location of the Reserve.

ii) The description of the excursion trails which are proposed in order to appreciate the natural environment. These include: a) "*Salse*" trail (allowing the mud-ejecting points to be observed from both close up and panoramic viewpoints); b) Walk around the ponds (where birdwatching can be practiced); c) Walk from the *Salse* Valley to the Chianca Valley (along this trail it is possible to observe closely, *"calanchi"* and a typical example of a marsh. 4) *"Calanchi"* trail (the observation of several examples of badlands).

iii) The services offered at the "Cà Tassi" Visitor Centre. The Centre can receive visitors and school groups and, besides the possibility of hiking guides, one can find a naturalistic museum and library, the auditorium and multi-function room and shopping facilities.

iv) The behaviour rules which the visitors should follow due to the high vulnerability of the mud-ejecting points.

The back side of the tourist-environmental map (Fig. 8) contains the DTM which provides the general morphological picture of the territory. By examining it, the presence of a sub-circular shaped depression, similar to a

Fig. 8. Back side of the tourist-environmental map of the Regional Natural Reserve of Salse di Nirano

caldera, is quite evident even to non-experts. The most recent hypothesis is that the depression could be the result of a collapse in correspondence of a "mud-diapir" at the end of its uplifting activity. On the floor of this depression the mud volcanoes are found. Also the *"calanchi"* (badlands) are quite evident. The DTM clearly shows that these landforms are absent only in the southern part of the Reserve. Furthermore, the excursion trails have been indicated in order to provide the visitor with information on their elevation development.

The other contents on the back side of the tourist-environmental map include:

i) Description on the Reserve and *Salse* phenomenon (refer to section 2.1).

ii) Information on the guided visit and the opening time of Cà Tassi Visitor Centre and on the refreshment and overnight stay places of the Reserve;

iii) Description of the flora and vegetation. The *salse* comprise a very particular environment because the saline mud and the physical characteristics of the clays favour the survival of only those vegetation species that can adapt to this type of environment. Those species, defined as *halophiles* (salt resistant) and *xerophiles* (tolerant to dry conditions), costitute a peculiarity within the flora community of the Salse di Nirano area. The most tolerant species to the saline conditions is the *Puccinellia borreri*, a graminaceous plant which lives near the craters abundantly during spring time. The flora of the badlands is characterized by dense shrubs dominated by brooms which cover the slopes.

iv) Description of the fauna. Due to the limited extent of the Reserve, the fauna does not differ significantly from that of the surrounding hilly territory. Species living in areas characterised by stretches of cultivated and uncultivated fields, shrubs and small woods can be found, such as roe deer (*Capreolus capreolus*) and porcupine (*Hystrix cristata*). Among the birds, open areas are frequented by raptors such as the buzzard (*Buteo buteo*) and the kerstrel (*Falco tinnunculus)*

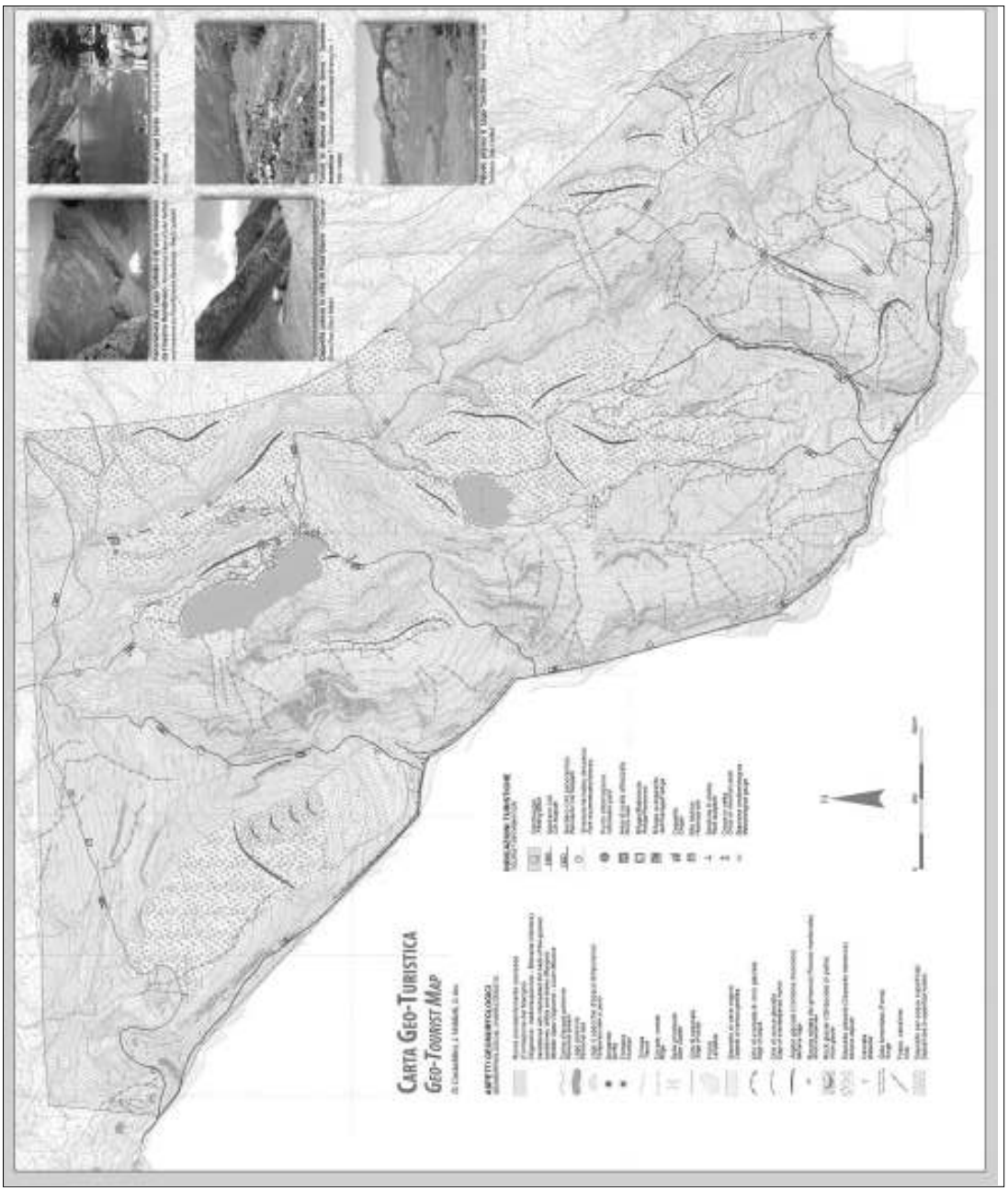

Fig. 9. Front side of the tourist-environmental map of the Upper Tagliole Valley (Frignano Park)

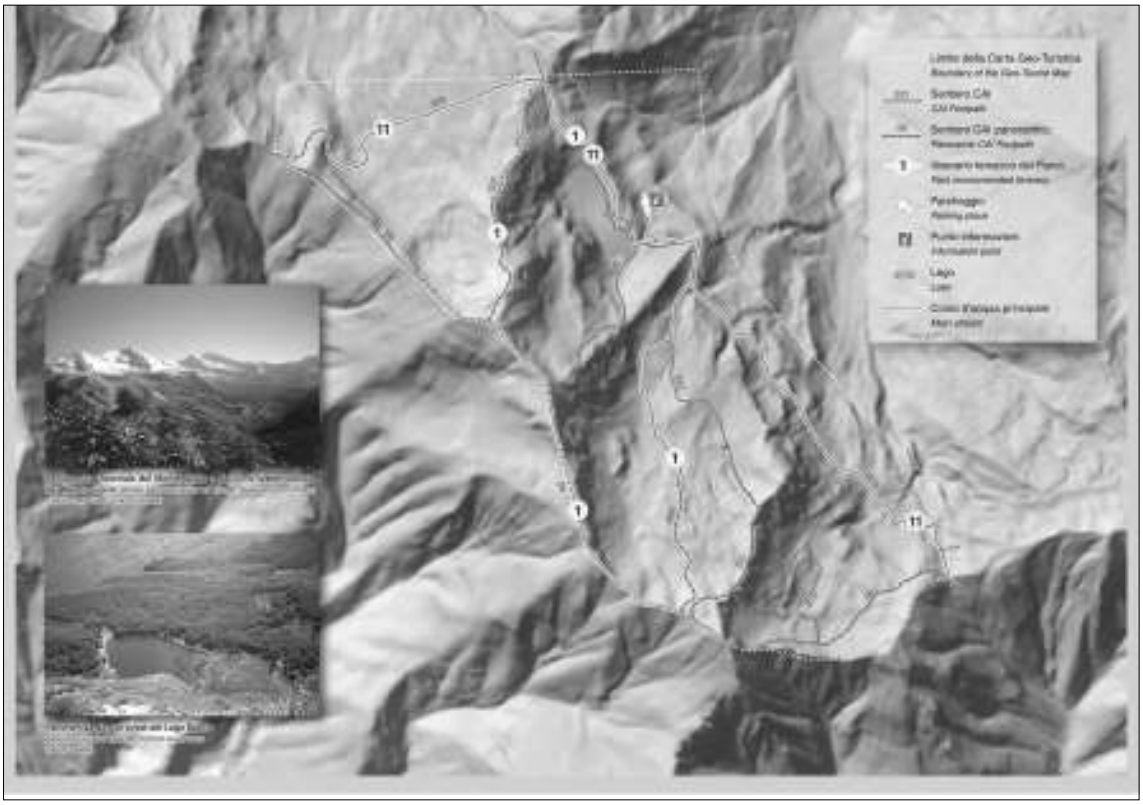

Fig. 10. Back side of the tourist-environmental map of the Upper Tagliole Valley (Frignano Park)

v) Indication of the tourist attractions in the surroinding areas including the Sanctuary of the Virgin Mary in Fiorano, the Spezzano Castle, the Ferrari Cars Gallery in Maranello and the spa in Salvarola Terme

4.2 Upper Tagliole Valley (Frignano Park). The tourist-environmental map of the Upper Tagliole Valley (Frignano Park) was printed with the financial support of the Frignano Park in the year 2005 (Castaldini et al., 2005 a). The structure of this map is quite similar to that of the Natural Reserve of Salse di Nirano.

The main element of the front side (Fig. 9) is the geo-tourist map. Regarding the geomorphological aspects, the geo-tourist map illustrates, with simple, clear, graphically pleasing symbols and short captions, the elements of the landscape which have been described in section 2.2. As for the tourist information, the map includes logistic information (such as parking place, picnic areas, refuges, information point) as well as general information (such as footpaths and park recommended itineraries, chapels, historical sites, rock sculptures, crucifixes on mountain peaks and meteorological station). Most of the tourist facilities are located near Lake Santo and are easy to reach.

The other contents on the front side of the tourist-environmental map include:

i) The title of the tourist-environmental map, the list of the authors, and the location of the Tagliole Valley.

ii) The description of the excursion itineraries. The Upper Tagliole Valley offers many opportunities to conduct excursions since the area is characterised by eight well signed footpaths of the Italian Alpine Club (C.A.I). In particular, two thematic itineraries of the park are recommended. One is a geomorphological route focusing on the landforms created by glaciers, which occupied the Tagliole Valley some 10,000 years ago. The other route runs along two stretches of the ancient "Via dei Remi", a road utilised in the 18th century for the transport of timber to Pisa, where the material was used for shipbuilding.

ii) Description of information points and visitor centres where tourist-environmental information on the Upper Tagliole Valley and the Frignano Park is available.

The back side of the tourist-environmental map (Fig. 10) includes the DTM. On closer examination, the Upper part of the Tagliole Valley can be observed. The Torrent Tagliole flows across this valley from south to north at an altitude ranging from 1,400 to 1,050 ma.s.l. On the western-side of the torrent, at the head of the valley, the wide glacial cirques of Monte Rondinaio and Monte Giovo are quite evident. Lake Santo, with its typical "bean-shaped" form, and Lake Baccio, a sub-circular small impoundment, are also evident. Furthermore, the footpaths and recommended itineraries, parking places and information points are indicated on the map.

The other contents on the back side of the tourist-environmental map include:

i) The illustration of the Park of the High Apennines of Modena, or Frignano Park, which was established in 1988 by the Emilia-Romagna Region (the term "Frignano" is derived from the ancient pre-Roman people of "Liguri Friniati"). This Park safeguards a considerable area of the Apennines of Modena in the proximity of the Tuscan-Emilia watershed and stretches over an area of 15,791 ha. The highest peaks of the Northern Apennines are foundwithin the Park, including Monte Cimone (2,165 m a.s.l.), Monte Giovo (1,991 m a.s.l.), Monte Rondinaio (1,964 m a.s.l.), Monte Libro Aperto (1,936 m a.s.l.), Monte Femmina Morta (1,881 a.s.l.) and Monte Spigolino (1,827 m a.s.l.). The protected area is subdivided into zones having different levels of conservation: the actual Park covers an area of about 9,000 ha and the so-called pre-Park covers an area of about 6,000 ha. The Park is managed by a consortium of public boards whose administrative centre is located in Pievepelago. The park's protected areas are located in seven municipalities.

ii) Description of flora and vegetation. The arboreal vegetation of the Upper Tagliole Valley, situated at an altitude above 1,000 m a.s.l., is characterised by deciduous broad-leaf mesophyll woods with a domination of beech trees (*Fagus sylvatica*), associated with other mixed broad-leaf species, mainly found at lower altitudes. At higher altitudes, beyond the treeline, the beech woods give way to meadows and scattered shrubs with a widespread dominance of bilberry (*Vaccinium myrtillus*) and cranberry (*Vaccinium gaultherioides*) shrubs. Wetland environments, consisting of ponds, temporary marshes, peat bogs, springs and streams, are populated by species whose southernmost habitats are found in the Tuscan-Emilia Apennines, such as *Eriophorum scheuchzeri* and *Swertia perennis.* Small insectivore species (*Drosera* and *Pinguicula*) grow in the peat bogs rich in sphagna and *Cyperaceae*.

iii) Description of fauna. Generally speaking, the animal species commonly found in beech woods and high mountain meadows of the Northern Apennines are present in the Upper Tagliole Valley, although the widespread presence of glacial landforms allows a higher concentration of species typical of rocky habitats and wetlands. The Black redstart (*Phoenicurus ochrurus*), the Northern wheatear (*Oenanthe oenanthe*) and the Water pipit (*Anthus spinoletta*) are commonly found in high mountain meadows. Among the most typical mammals of this habitat, the Snow vole (*Chionomys nivalis*) is worthy of note. Small rodents are the favourite prey of the European asp (*Vipera aspis*), a rather rare reptile. The numerous wetland places host the European common frog (*Rana temporaria*), the Italian Alpine newt (*Triturus alpestris apuanus*) and the European common toad (*Bufo bufo*). Various ichthyic species, coming also from the Po Plain, have been introduced in Lake Santo and Lake Baccio, where they live together with the Brown trout (*Salmo trutta*), which is the only autochthonous species of this area.

iv) List code of behaviour.

v) Useful information for guided visits and other information related to the two

Excursion Centres (important meeting points for hosting organised groups of visitors within the Park boundaries) and the four refuges located near Lake Santo.

vi) Description of the tourist attractions in the surroundings which include Pievepelago (a large village with a picturesque centre), Ponte della Fola (a 15th century bridge which is the only example of a two-arch cambered bridge in the Northern Apennines), Roccapelago (an impressive medieval settlement built on top of a rocky cliff), the so-called **"**Celtic huts" (unusual rustic sandstone buildings with step-like sloping tops and roofs originally covered with straw), the picturesque hamlet of Sant'Anna Pelago**,** the Romanesque Oratory of San Michele Pelago (with rare apse decorations going back to the late 12th century), Fiumalbo (a village with very ancient origins recognised as a "city of art") and the medieval village of Riolunato.

5. Conclusions

The tourist-environmental maps described in this paper are part of the initiatives taken by public boards (a local administration and a park) for improving the knowledge, utilisation and appraisal of the environment of protected areas. These maps therefore were produced to meet the ever-growing educational needs of public boards and to contribute to transfer of information from scientific research to possible users and local communities.

The geo-tourist maps, found on the front side of the tourist-environmental maps, are original documents within the framework of geomorphological studies. The aim was to produce maps that could be easily interpreted by tourists with an average education and help them to understand the surrounding landscape.

The geo-tourist maps and the DTM (found on the back side of the tourist-environmental maps) have been produced by means of ArcView GIS computer programme. Therefore, since these documents are presented in the digital format, they can be easily updated and/or integrated with additional data.

The text of the different topics described in the tourist-environmental maps (geological, geomorphological, botanical, zoological and logistic aspects), has been implemented by university experts with the collaboration of representatives of the protected areas. Therefore it should be amphasized that this work was proposed and produced thanks to the aggregation of university researchers with the cooperation of public boards.

The tourist-environmental maps were printed with the financial support of the Municipality of Fiorano Modenese and of the Frignano Park which manage the studied protected areas. The maps are sold at visitor centres and at information points within the protected areas. These studies show how geomorphological investigations can effectively contribute to the production of maps which can be utilised in the field of environmental tourism.

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