EXAMPLES OF MORPHODYNAMIC CARTOGRAPHY AIMED AT LAND-USE PLANNING (MARCHES REGION, CENTRAL ITALY).

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ABSTRACT

This work, besides proposing an especially designed morphodynamic legend (particularly aimed at land-use planning), furnishes some preliminary data and observations on two sample areas belonging to the Marche region (Adriatic side of Central Italy), which are useful for the interpretation of the recent and active geomorphologic evolution.

Evolutionary trends are mapped and described of the main morphodynamic processes characterizing the above said sites, which have been chosen for their representativeness of different geomorphologic environments and can be synthetically described as follows:

1) coastal area, generally retreating also as a consequence of man's activities, made up by sandy-gravely beaches of historical age.
2) high-to-medium hills modeled on turbiditic sediments (Messinian - Pliocene), with minor human intervention and largely affected by different types of mass movements.

The work is based upon the results of multi-decennial field surveys (locally starting from the '50s or even before), widely integrated with data deriving from the analysis of other available documents (historic reports, topographic maps, aerial photographs etc.).

The above information has been used to feed a georeferenced data base handled by a geographic information system, thus allowing for their handling and analysis the use of computer assisted techniques which permitted quantitative evaluation of activity rates and intensities of the main morphogenetic processes, and therefore of changes in the related landforms and deposits.

On the basis of the above analyses and using automated mapping techniques, sample maps have been produced for each study area, aiming at meeting both the needs of the potential end users (i.e. easy data interpretation and practical usefulness) and the requirements of the producers (mainly low cost and time of production of documents, and easy data handling). With this end in view, a special legend has been elaborated and used capable of giving complete and clear information on morphodynamic trends through simple color maps. In this paper, because of editorial restrictions, slightly simplified black-and-white maps, produced with a normal laser printer, are included.

1. INTRODUCTION

This work is aimed at defining and testing (starting from already widely adopted representation methods) an easy but effective mapping method for representing recent morphodynamics, using computer assisted techniques. The proposed legend, besides representing present evolutionary trends of main morphogenetic processes, furnishes a quantitative (or, at least, semiquantitative) evaluation of activity rates of connected landforms and deposits.

The basic idea was to analyze time trends of some landforms using a PC based geographic information system (ILWIS), mapping the results through an especially created legend which is capable of clearly illustrating recent geomorphological evolution. With this end in view, two sample areas have been selected (Fig. 1) which are representative of different morphogenetic environments: the shoreline close to the Chienti River mouth (area 1) and the hilly neighborhood of the village of Monte San Martino (area 2). In these sites, intensive surveys were carried out both using aerial photographs and in the field, as well as archive researches; the results of these studies were used to feed a georeferenced data base and then, through the use of a PC based geographic information system, to elaborate thematic maps depicting the evolution of the investigated processes.

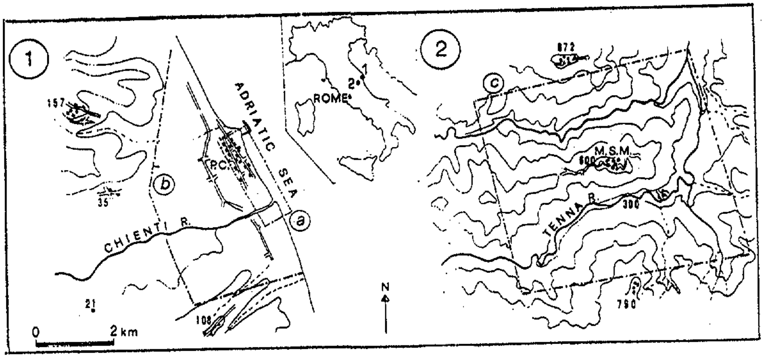

Fig. 1 - Location map. 1) River Chienti mouth area. Legend: a) study area for evolution during the last century; b) study area for the evolution during the last 7 millennia; P.C.) Porto Civitanova. 2) Monte San Martino area. Legend: c) study area; M.S.M.) Monte San Martino.

2. DESCRIPTION OF THE STUDY AREAS

During the last millennia, width and depth of the River Chienti were strongly reduced (it was navigable up to the beginning of the Middle Ages), and the mouth progressively changed from a wide funnel-like estuary to a small slightly protruding one (Fig. 2). At the same time, the shoreline immediately to the North of the mouth slowly and progressively advanced giving origin to a not very wide belt of sandy and gravely deposits (Fig. 2).

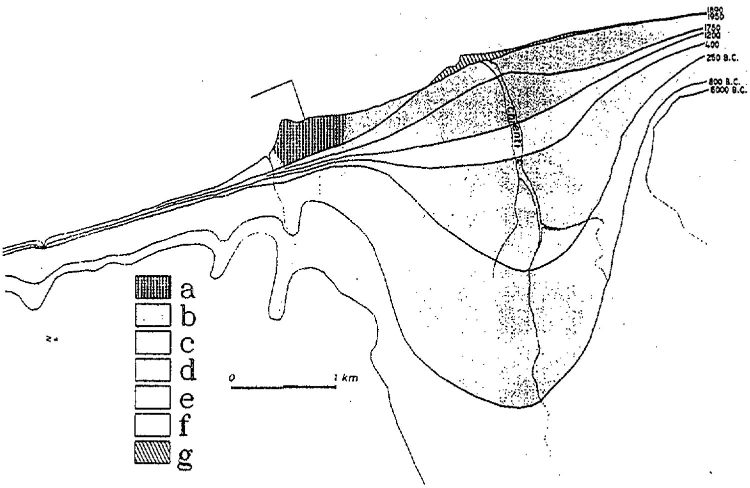

Fig. 2 - Morphodynamic map of the River Chienti mouth area for the last 7000 years. Legend: a-f) coastline advance (a - >4 m/yr; b - >1 m/yr; >0.5 m/yr; >0.25 m/yr; >0.1 m/yr; ≤ 0.1 m/y); g) retreat.

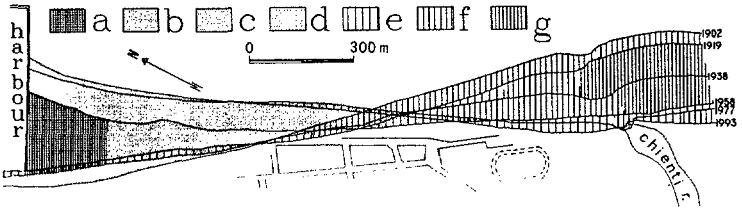

Fig 3 - Morphodynamic map of the River Chienti mouth area for the last century. Legend: a-d) coastline advance (a - >3 m/yr; b - >1.5 m/yr; c - >0.75 m/yr; d≤ 0.75 m/yr); e-g) retreat (e -≤ 0.75 m/yr; f - ≤ 1.5 m/yr; g - >1.5 m/yr).

Then, during the last century, the river mouth inverted its tendency, starting to retreat whilst to the North (also as a consequence of the construction of a pier) the beach increased its rate of advancing (Fig. 3).

Previous studies in the area mostly aimed at highlighting variations of the shoreline and of the river mouth during the last century [1, 2, 3, 4], sometimes introduced changes in classical methods of representation. In the western portion of the Monte San Martino area (Fig. 1), the slightly bent turbidites of the *Formazione della Laga* (lower Messinian) crop out, whilst in the eastern portion the flysch is unconformably overlaid by more recent (middle-upper Pliocene) terrains, constituted by some 80 m thick calcarenites followed by clays, gently dipping eastward.

The above said sequences are deeply cut by two rather narrow river valleys trending ca. E-W, whose slopes are widely affected by mass movements of different type and dimension [5], and badlands [6] (Fig. 2). Altitude ranges from ca. 650 m to ca. 250 m a.s.l. The two main rivers crossing the area generally have an erosive behavior; local flooding have been recently recorded along the valley bottom, mostly as a consequence of minor damming phenomena connected with reactivation of mass movements (Fig. 2).

For the Monte San Martino area, detailed surveys have been carried out for a long time and thematic maps have been produced, sometimes also adopting new methods for the representation of some themes, thus modifying already experimented legends for medium-to-large scale geomorphological maps [7, 8, 9, 10, 11, 12].

3. DISCUSSION

For each of the two sites, information deriving from field investigations, aerial photo-interpretation and archive researches have been stored in a georeferenced database based upon a digital topographic map at 1:10'000 scale (kindly furnished by the Regione Marche).

In the two areas, three main morphogenetic processes have been identified: marine erosion and sedimentation (Area 1), mass movements (Area 2) and fluvial erosion and flooding (Area 2); different methods have been adopted to evaluate the evolutionary trends and rates of each of them.

Beach advance and retreat (area 1, Figs. 2, 3) has been calculated simply rasterizing all the dated shorelines and interpolating between each successive couple of them (thus obtaining the position of the beach at any intermediate moment) and then calculating the first derivative of this "digital time model".

A similar method has been used to evaluate the retreat fluvial scarps too (Area 2).

For mass movements (Area 2), given the impossibility of adopting such a system, the evaluation has been based upon data deriving from direct field observations of displacements, which cover a long time span (more than 30 years). Moreover, for these phenomena, the type of activity - i.e. continuous, alternating or intermittent [13] - has been taken into account, too.

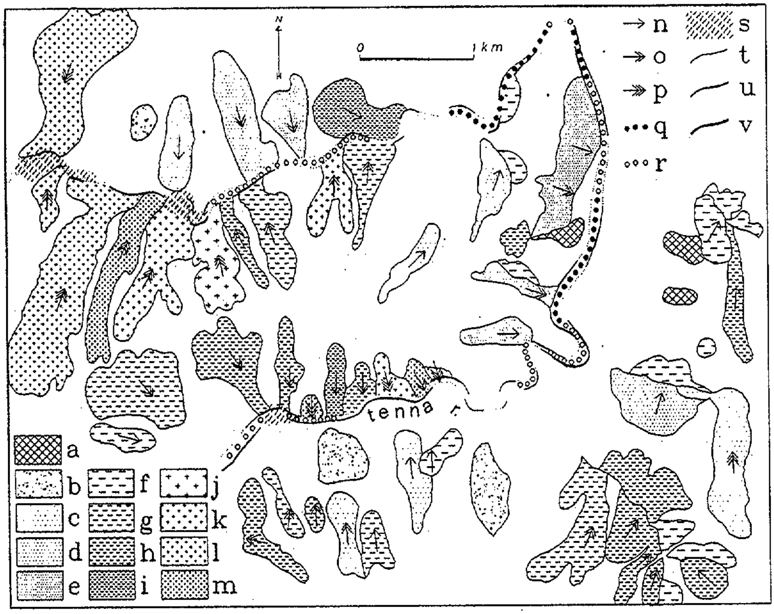

Fig. 4 - Morphodynamic map of the Monte San Martino area. Legend: a) artificially stabilized landslide; b) landslide with non-measurable movement; c-e) landslide with continuous activity (c - Ira≤50, d - Ira≤75, e - Ira>75); f-i) landslide with alternate activity (f - Ira≤25; g - Ira≤50, h - Ira≤75, i - Ira>75); j-m) landslide with intermittent activity (j - Ira≤25; k - Ira≤50, l - Ira≤75, m - Ira>75); n-p) magnitude order of maximum speed of the landslide (n - m/h; o - cm/h, p - mm/h); q-r) downcutting river reaches (q - >5 cm/yr; r ≤ 5 cm/yr); s) flood prone areas; t-v) retreating fluvial scarp (t ≤0.2 m/yr; u - ≤0.5 m/yr; v - >0.5 m/yr).

To represent the results of the above study, a special legend has been created in which classes of evolutionary rates are represented by progressively more intense shades of colors (in this paper replaced by different hatching, given the restriction to B/W maps), which are representative for different morphogenetic processes.

For shoreline retreat differently spaced line hatching has been adopted, whilst to indicate its advance different shades of gray have been used (Figs 2, 3).

For landslides (Fig. 4), different types of hatching indicate different types of activity, whilst different hatching spacing represent classes of an index of recent activity (Ira) obtained calculating for each landslide the areal percentage of recently (1960-1995) reactivated movements. For these phenomena, an arrow has been added, too, which indicates both the direction and the magnitude order of maximum observed speed of the movement (information useful for evaluating risk). Those landslides which have been artificially stabilized or did not show any appreciable movement during the 35 years of observation, have been indicated by different types of hatching (Fig. 4).

Since spatial variations of fluvial scarps in the period of observation are too limited to allow the use of hatched or shadowed areas, it has been decided to indicate the classes of retreat using lines having different thickness (Fig. 4). River downcutting rate has been classified into two groups, represented by filled or empty circles; flood prone areas are indicated by a wavy hatching.

4. FINAL REMARKS

The proposed mapping system combines advantages for both surveyors (and cartographers), and end users (i.e. managers, politicians etc.). In fact, notwithstanding the fast and easy handling of data (including fully automated classifying procedures and production of maps), results are accurate and detailed enough to furnish a clear and reliable description of the main factors of recent and present landscape evolution. Moreover, the resulting maps are really easy to be interpreted also by people who have not been specifically trained in geomorphology or hazard mapping.

In conclusion, if properly applied the proposed mapping method could significantly help land-use planners and managers to obtain in a short time a sound enough knowledge of a territory, and therefore to decide on the best future interventions and to plan properly land use destination.

Unfortunately, the sample maps included in this paper have lost much of their clarity and immediateness because of the use of hatching instead of colors and of their small scale.

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