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PLEISTOCENE DEFORMATION OF THE COLLINA DI TORINO INFERRED FROM THE MODELLING OF THEIR FLUVIAL SUCCESSION

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ABSTRACT: Boano P., Forno G., Lucchesi S., *Pleistocene deformation of the collina di Torino inferred from the modelling of their fluvial succession.* (IT ISSN 0394-3356, 2004).
The modelling of the Po plain adjoining the Collina di Torino by Alpine watercourses, now tributaries of the Po, is evidence of the extremely recent setting of the present River Po. Suspended traces of an earlier collector have been preserved on the Western and North-Western slopes of the Collina di Torino, where remains of a terraced succession of surfaces with local fluvial deposits can be find out along the present watersheds. Differentiation and correlation of the individual surfaces according to their elevation and the alteration degree of their sediments has provided a chronological record of the Middle Pleistocene-Holocene.
This succession is the result of the progressive deformation of the distal sectors of the Alpine fans involved in the uplift of the Collina di Torino, which has resulted in deep erosion of the ancient hydrographic pattern as shown by the scarps tens of metres high between the surfaces. It may be supposed that the progressive uplift of the Relief and the NW migration of their outer edge brought initially flat areas into the relief and led to a differential deformation of ancient relief forms and deposits of different ages. Comparison between the chronology of these surfaces and their distribution within an approximately 400-metre difference of level shows that the rate of uplift from the Middle Pleistocene to the Holocene was of the order of 1mm/yr

RIASSUNTO: Boano P., Forno G., Lucchesi S., Deformazione pleistocenica della Collina di Torino dedotta dal modellamento della successione fluviale. *(IT ISSN 0394-3356, 2004).*
Il modellamento del tratto di pianura padana antistante la Collina di Torino da parte dei corsi d'acqua alpini, attuali affluenti del F. Po, consente di ipotizzare l'impostazione estremamente recente del collettore principale nella pianura piemontese. Le tracce di un precedente collettore risultano invece conservate, sensibilmente sospese, sui versanti occidentale e nordoccidentale del rilievo collinare. In questi settori sono osservabili, sulla sommità delle attuali dorsali spartiacque, i relitti di una successione di forme fluviali pianeggianti, a cui sono localmente associati depositi fluviali: i diversi lembi sono stati distinti tra loro e correlati in base alla differente quota e alla diversa alterazione dei sedimenti, consentendo un riferimento cronologico complessivo all'intervallo di tempo compreso tra il Pleistocene medio e l'Olocene.
La successione terrazzata in esame è connessa alla progressiva deformazione del settore distale dei conoidi alpini, coinvolti nel sollevamento della Collina di Torino: tale deformazione ha comportato un sensibile approfondimento erosionale dell'antico reticolato idrografico evidenziato dal modellamento delle scarpate, con altezza di alcune decine di metri, che separano i diversi lembi terrazzati. Il progressivo sollevamento dell'area collinare e la migrazione verso NW del suo margine esterno avrebbero determinato l'inglobamento nel rilievo di aree inizialmente pianeggiati e la deformazione differenziale delle forme e dei depositi riferibili ai diversi intervalli di tempo. In particolare, confrontando il riferimento cronologico dei diversi elementi morfologici e dei sedimenti ad essi associati con la loro distribuzione altimetrica e quindi con il dislivello di circa 400 m che essi presentano, è possibile stimare che tra il Pleistocene medio e l'Olocene si sia verificato un sollevamento con tasso medio di circa 1 mm/anno.

Key words: Collina di Torino, fluvial sediments, deformation, Pleistocene.

Parole chiave: Collina di Torino, depositi fluviali, deformazione, Pleistocene.

THE TERRACED FLUVIAL SUCCESSION

Previous studies

The Collina di Torino forms a relief that rises to an altitude of some 700 m, 500 m above the adjacent Po plain (Figs. 1-2). In geological terms, the Collina di Torino is composed of a succession of Eocene to Pliocene terrigenous marine sediments that rests on an Alpine substratum and has been involved in the Apennine deformation. The relief is separated from the plain by buried tectonic structures known as the "Padan Thrust" (Piana & Polino, 1994) (Fig. 3).

The relief and the plain beside it had a different geodynamic evolution: it corresponds for the Collina di Torino to a marked uplift during the Plio-Quaternary and for the plain to a moderate lowering in Early Pliocene and weak to moderate uplift in the Middle and Late Pliocene and Quaternary (Carraro *et al.*, 1987). The different evolution of these two areas is responsible for considerable changes in the hydrographic pattern during the Quaternary. In particular the absence of the Po sediments in the present Po plain and the wide distribution of the left tributaries sediments point out the absence of this collector during most of the Pleistocene (Carraro, 1976). On the other hand on the Southern slope of the relief and in the adjacent Altopiano di Poirino are preserved remains of a Middle Upper Pleistocene watercourse with a high discharge (a in Fig. 2): this evidence can be ascribed to a previous course of the Po River and suggests a deformation of the area (Forno, 1980; 1982;

Compagnoni & Forno, 1992).

Furthermore, recent preliminary studies on the morphology of the Western slope of the relief reveal a Middle-Upper Pleistocene terraced succession of fluvial surfaces with a broad altimetric distribution connected with the deformation of the relief (Boano & Forno, 1997). This succession suggests the modelling of the Western slope by important ancient watercourses (b in Fig. 2).

Locally, on the Villa Gualino surface, some boreholes have disclosed the discontinuous conservation of lenses of sandy-silty fluvial deposits unconformable with the marine substratum. The results obtained indicate that the succession was shaped by one or more collectors that conveyed the Northern Alpine rivers, especially with the contribution of the Dora Riparia (Forno *et al*., 2002).

Aim of the work and new data

The aim of the work is to carry out a geological study of forms and deposits of the terraced succession of the Western slope of the Collina di Torino, to extend the research to the North-Western slope and to find a preliminary reconstruction of the recent deformation of the area.

Difficulties were encountered owing to the loess cover (Forno, 1979) and because the area is extensively built up and shows local anthropic modifications. However it was found that the modifications thus introduced are generally confined to the widening of existing surfaces and have not led to the creation of man made surfaces.

Surveys carried out in the present preliminary study have shown that both slopes carry the remains of a terraced succession of fluvial surfaces modelled in either the Tertiary substratum or in a thin cover of fluvial sediments and separated by scarps some tens of metres high (Fig. 4).

These surfaces are distributed on the Western and the North-Western slopes in the secondary ridges separating the present valleys. Each fluvial surface covers an area of 5,000 - 200,000 m^2; they are widespread at different altitudes between 630 and 240 m a.s.l. and mostly have a N-S or NE-SW trend, parallel to the main watershed. Their morphology and distribution have thus no link with the current W or NW drainage pattern but are connected with the modelling by ancient watercourses during the uplift of the relief.

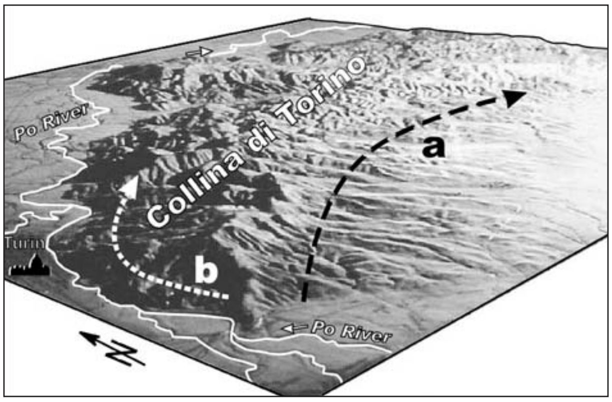

Fig. 2 - Former trend of the Po River to the South of the Collina di Torino (**a**); former path of the watercourse that modelled the terraced succession on the Western slope (**b**).

*Antico percorso del F. Po a Sud della Collina di Torino (**a**); antico andamento del corso d'acqua responsabile del modellamento della successione terrazzata del versante occidentale (**b**).*

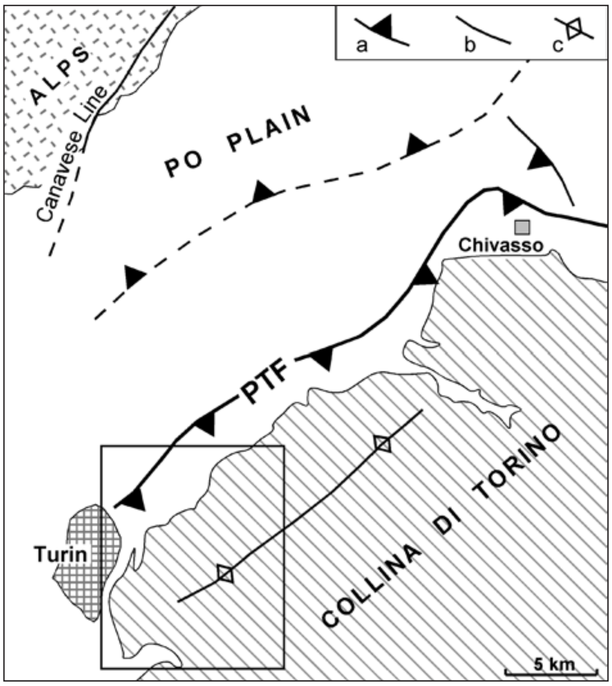

Fig. 3 - Structural diagram of the Piedmont hill reliefs: the Northern boundary of the Collina di Torino is represented by the "Padan Thrust Front" (PTF). Legend: a) buried overthrusts; b) strike slip faults; c) anticlinal axes (modified from Piana & Polino, 1994).

Schema strutturale dei rilievi collinari piemontesi: il margine settentrionale della Collina di Torino è delimitato dal "thrust padano" (PTF). Legenda: a) sovrascorrimenti sepolti; b) faglie trascorrenti; c) assi di anticlinali (modificato da Piana & Polino, 1994).

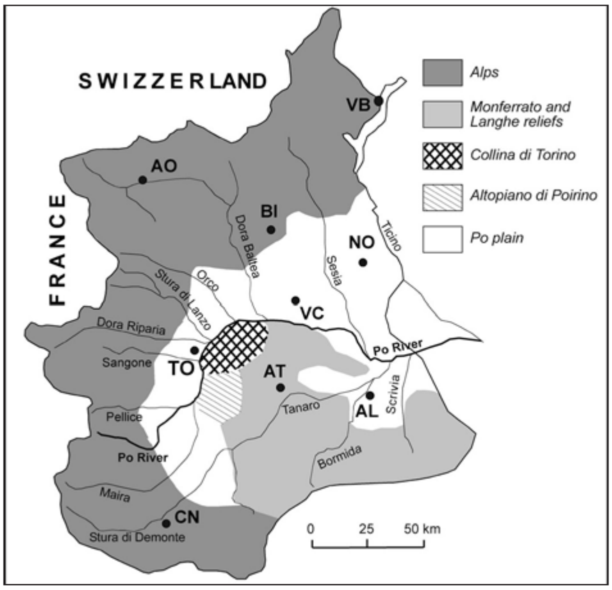

Fig. 1 - Geographical location of the Collina di Torino.

Inquadramento geografico della Collina di Torino.

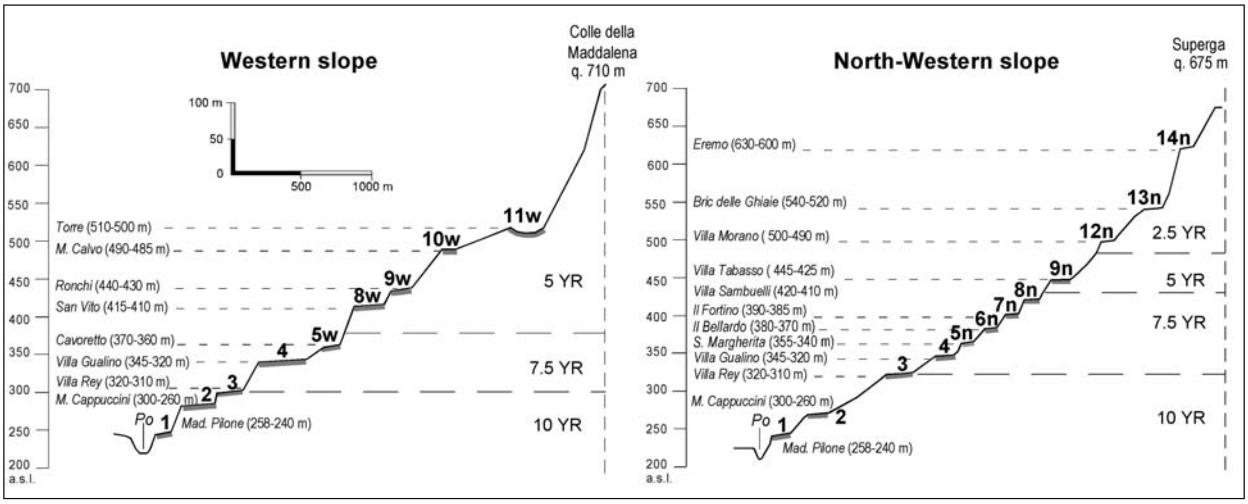

Fig. 4 - Transverse cross-section of the Western and North-Western slopes of the Collina di Torino (height scale exaggerated). The surfaces are numbered from the most recent and in the upper altimetric sector differentiated between the two slopes (**w** for the Western slope and **n** for the North-Western one). For each surface is shown the most significant toponym together with its altitude and Munsell soil colour value.

*Profili trasversali dei versanti occidentale e nordoccidentale della Collina di Torino, con scala delle altezze esagerata. Le diverse superfici sono numerate a partire dalla più recente e differenziate tra i due versanti considerati nella fascia altimetrica superiore (**w** per il versante occidentale e **n** per quello nordoccidentale): per ognuna sono precisati il toponimo più significativo, lo sviluppo altimetrico e l'indice di colore del suolo che le caratterizza.*

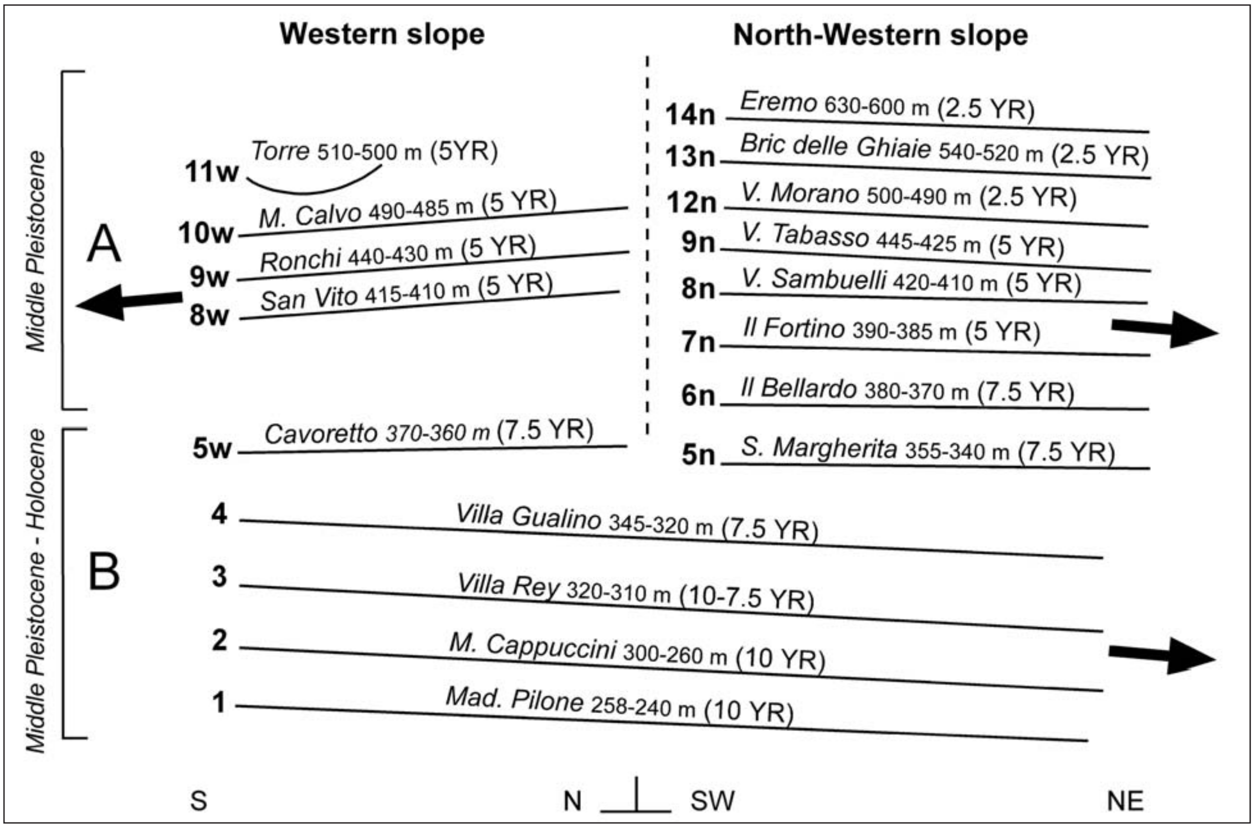

Fig. 5 - Simplified longitudinal profile of the terraced succession of the Western and North-Western slopes. A and B are the upper and lower altimetric sectors. The dashed line indicates a former watershed between the two slopes. The arrows show the drainage direction of the stream net that modelled the succession. Surfaces are indicated as in Fig. 4.

Profilo longitudinale semplificato della successione di forme terrazzate dei versanti occidentale e nordoccidentale della Collina di Torino nelle fasce altimetriche A e B. La linea tratteggiata indica la presenza di un precedente spartiacque tra i due versanti; le frecce indicano la direzione di drenaggio del reticolato idrografico responsabile del modellamento. Per le diverse superfici sono indicati gli stessi riferimenti di Fig. 4.

The surfaces clearly differ in function of their altitude. Those at high levels are considerably deformed, and have been remodelled, dissected and mostly deprived of their original fluvial deposits, whereas those located at the lower altitudes are less deformed, more continuous, better preserved, and most have retained their deposits. There is also a difference between the two slopes. The North-Western slope displays extensive terra-

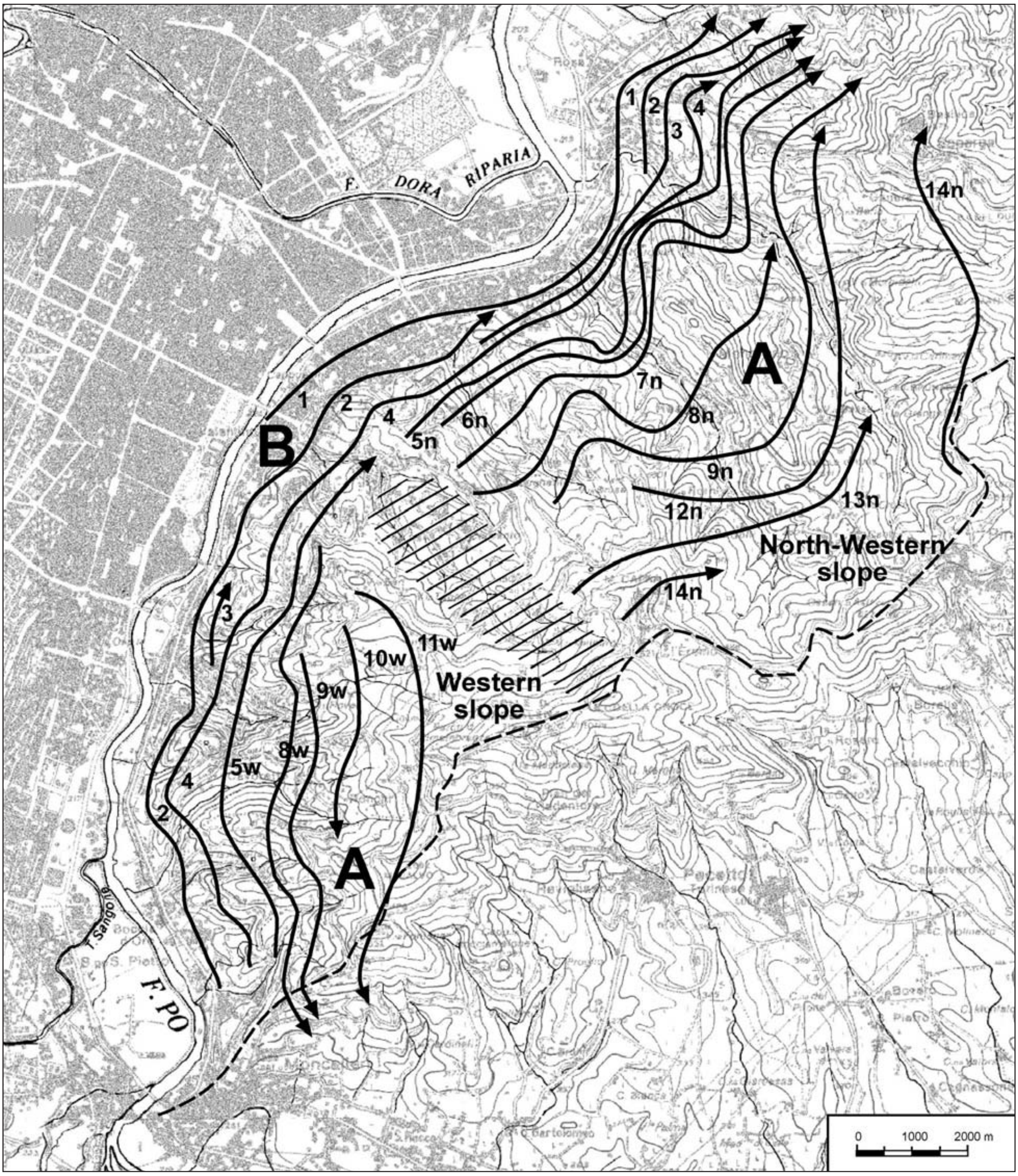

Fig. 6 - Evolution of the stream net that modelled the succession. In the upper altimetric sector (A) there are two watercourses draining in opposite directions, in the lower sector (B) there is only one. The dotted line shows the principal current watershed. The hatched area indicates the former watershed between the two sectors. Surfaces are indicated as in Fig. 4.

Evoluzione progressiva del reticolato idrografico responsabile del modellamento della successione terrazzata collinare: nelle fasce altimetriche superiori (A) è rappresentato l'andamento di due corsi d'acqua drenanti in direzione opposta, in quelle inferiori (B) è indicato lo sviluppo di un corso d'acqua unico. La linea puntinata rappresenta l'attuale spartiacque principale; l'area tratteggiata corrisponde al precedente settore spartiacque tra i due versanti in esame. Per le diverse superfici sono indicati gli stessi riferimenti numerici di Fig. 4.

ces, all inclined to the NE, whereas the Western slope shows a greater variety of forms corresponding to wide meanders and smaller surfaces inclined in opposite directions (North and South). The altimetric distribution of the terraces on the two slopes is also different (Figs. 4 - 5).

The fluvial deposits, where visible, form lenses some metres thick with a clear erosional base. They mainly consist of an unstratified sandy-silty succession, whereas gravelly sediments appear only locally, particularly in the remains of meanders. The pedogenetic evolution of sediments gradually decreases towards the lower surfaces. The Munsell colour index of the soils on the substratum and on fluvial deposits ranges from 2.5 YR to 10 YR (Figs. 4 - 5).

Mapping of the terraces has been followed by their correlation, account being taken of possible changes in the original altimetric setting due to erosion by run-off waters and tectonic deformation. Two criteria were used: the pedostratigraphic criterion for the deposits, and the altimetric criterion for the erosional surfaces supporting the fluvial lenses. They both show that there is a clear correlation between the lower terraced surfaces of the two slopes (B in Figs. 5-6), but none between the upper surfaces (A in Figs. 5 - 6).

CONCLUSIONS

The Quaternary evolution of the Western and North-Western slopes of the Collina di Torino can be preliminarily deduced from data collected in this study. The preferential N-S and NE-SW trend of the terraces parallel to the main watershed and the fact that their distribution differs from that of the present watercourses suggest that they were shaped by a markedly different hydrographic pattern.

Although the distribution of the succession is close to the present trend of the Po, it cannot be referred to this watercourse because its modelling is roughly contemporary with the passage of the river to the South of the Collina di Torino (a in Fig. 2). In fact application of the local pedostratigraphic scale (Arduino *et al*., 1984) to the soils developed on the examinated fluvial sediments has shown that the entire succession of terraces was formed between the Middle Pleistocene and the Holocene. The Upper Pleistocene loess cover is in agreement with this chronological reference (Forno, 1979).

The different morphological features and setting of the upper terraces (A in Fig. 5), particularly the differences in the number of surfaces on the two slopes and their dipping (N-NE and S-SW respectively), suggest that during the lower part of the Middle Pleistocene the Western slope hosted a S-draining and the North-Western slope a NE-draining basin (Fig. 6). The same features and inclination of the lower terraces of the two slopes (B in Fig. 5) and the same number of surfaces, show that during the upper part of the Middle Pleistocene the whole area was part of a single basin drained by a NE-flowing watercourse (Fig. 6).

The particular distribution of the fluvial succession of the Collina di Torino over a 400 metre difference in altitude is the result of the progressive deformation of the distal sectors of the Alpine fans involved in the uplift (Fig. 6). The considerably vertical erosion of the relief by the ancient hydrographic pattern in response to the geodynamic activity is responsible for the formation in the Tertiary substratum of scarps some tens of metres high between the surfaces. The erosional surfaces at the base of the deposits, on the other hand, were worn down by lateral erosion episodes associated with local sedimentation that interrupted the dominant erosional trend.

In the Po Plain instead are preserved the proximal sectors of the Alpine fans, made of a thicker and weakly terraced or superposed alluvial succession that preserves its original geometry. Lateral erosion episodes interrupted by more conspicuous depositional episodes have formed wide erosional surfaces that mark the base of the various sedimentary bodies. The deepening episodes responsible for the low scarps that separate these bodies are reduced with respect to those of the relief. This different behaviour of the plain is the result of its relative stability during the Quaternary by contrast with the marked uplift of the Collina di Torino.

The described terraced succession thus came into being in a sector of the Po Plain that lost its primary shape after its progressive embedding in the relief. This is in agreement with the progressive uplift of the area and the NW migration of the outer buried edge of the relief.

It may be supposed that the present tributary watercourses were set up at the same time in these "new" hill sectors. Their evolution has been responsible for the cutting off of the originally continuous shapes (surfaces and meanders) linked to the previous collectors and then for their preservation only on the watersheds (Fig. 7).

Some conclusions can also be drawn concerning the rate of the deformation during the Quaternary. Comparison of the chronological reference of the morphological elements and the associated sediments with their altimetric distribution (difference in level of about 400 m), shows that the rate of uplift between the Middle Pleistocene and the Holocene was of the order of 1 mm/year.

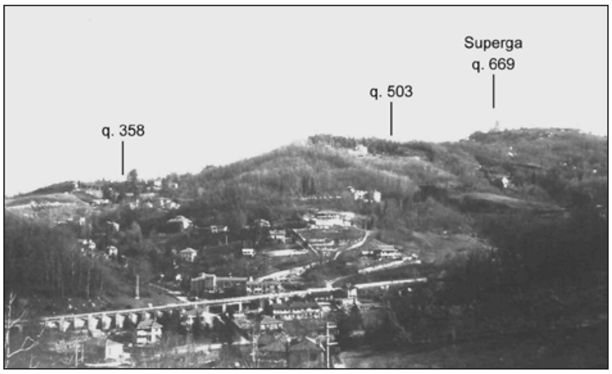

Fig. 7 - View of the terraced surfaces of the Superga ridge from Valle Mongreno: are recognizable three surfaces separated by hight scarps.

Successione terrazzata della dorsale di Superga vista da Valle Mongreno: sono riconoscibili tre superfici terrazzate separate da alte scarpate.

This rate is in agreement with the values drawn from the geodetic levellings undertaken in the period 1897-1957 (Arca & Beretta, 1985), which identify the present maximum uplift values of the entire Piedmont area in the Collina di Torino (> 3 mm/yr).

The presence of erosional scarps with different heights in function of their altitude suggests that the uplift was not constant, but characterized by moments of greater or lesser geodynamic activity.

For a better definition of the ancient watercourses pattern that modelled the fluvial succession examined, mineralogical and petrographic investigation of the sediments associated is still in progress.

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