SOME NOTES ON GEOMORPHOLOGICAL AND ARCHAEOLOGICAL ASPECTS IN THE CENTRAL PO PLAIN (NORTHERN ITALY)

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ABSTRACT

Since long time, there have been several attempts to cross-date geomorphological evidence with archaeological data in the Po Plain. From a methodological standpoint, a definition of the relationship between fluvial forms and archaeological sites cannot be expressed by a simple presence/absence ratio but it is necessary to distinguish between surface and buried sites.
The central Po Plain is characterized by a complex distribution of fluvial landforms and deposits. The comparison of geomorphological and archaeological data shows that the sector to north of the R. Po has been very stable during the whole Holocene. Along the main palaeochannels on the Main Level of the Po Plain, fed by ice melting from the Late Pleistocene glaciers, several Bronze Age settlements have been identified.
On the contrary, in the sector south of the R. Po, the landscape was subject to significant changes. In the Modena city area, starting from the end of the Roman Age the watercourses passed from a runoff occurring in deep riverbeds to one hanging over, or at least at the same level as, the surrounding plain. The R. Secchia shifted to the east and the R. Panaro to the west downstream of the town. From the Bronze Age to the Late Middle Ages the R. Po flowed in a belt about 20 km wide shifting from south to north.

KEY WORDS

Geomorphology, Archaeology, Po Plain, Northern Italy.

INTRODUCTION

The evolution of river forms is one of the main keys for understanding the history of human settlements in the Po Plain area.

The distribution of human settlement reflects the geomorphological situation in the chronological period in which they developed (Cremaschi *et al.*, 1992; Cardarelli, 1997).

The settlements were constructed in places where the needs of the communities were best served: i) stable and well-drained land for agricultural use; ii) proximity to lines of communications, which in such areas were usually represented by waterways.

For a long time, there have been several attempts to cross-date geological and geomorphological evidence with archaeological data, on both detailed and wide territorial scales. Further progress has been attempted in the last decades by comparing data obtained from systematic research on fluvial forms, as shown in geomorphological maps, with data contained in the archives set up by archaeological museums and regional archaeological assets offices (e.g. Baroni *et al.*, 1986; Calzolari, 1986; Ferri and Calzolari, 1989; Gasperi *et al.*, 1989; Poggiani and Keller, 1992; Cremaschi *et al.*, 1992; Cardarelli and Cattani, 1994; Cardarelli *et al.*, 2000; Anghinelli A. and Anghinelli S. (2001), Balista *et al.*, 2003, Lugli *et al.*, 2004).

Within this context, this paper describes some case studies regarding the relationships between geomorphology and archaeology in the central Po Plain (Fig. 1). These studies aimed to define the original characteristics of some geomorphological features and their evolution in relation to the reconstruction of the ancient landscape and human presence.

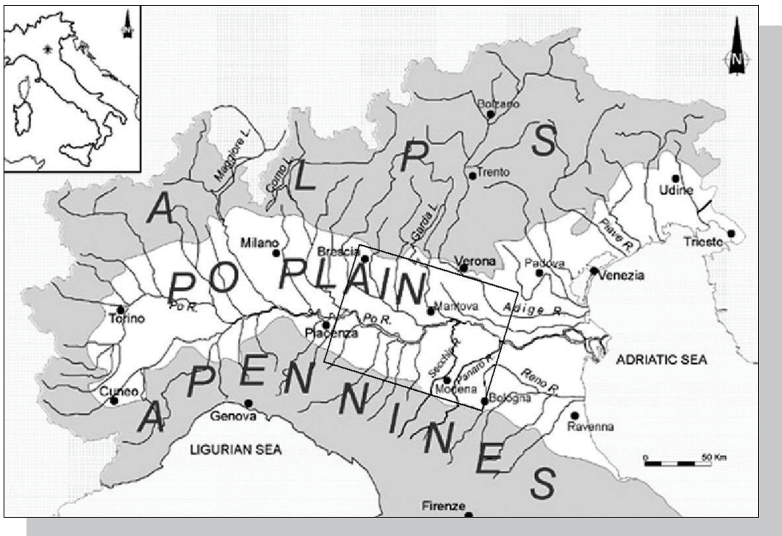

Figure 1 Location of the study area in the Po Plain (see inset).

GEOGRAPHICAL, GEOMORPHOLOGICAL AND GEOLOGICAL OUTLINE OF THE CENTRAL PO PLAIN

The Po Plain is the most extensive plain in Italy: its surface area is approximately 46,000 km², equal to 71% of all the plain areas in Italy and 15% of the nation's territory.

The R. Po is the largest river in Italy, with a length of 652 km, a catchment area of 75,000 km², and a mean annual discharge estimated at 1,515 m³/s (Cati, 1981).

The plain altitude ranges from about 500 m, at the feet of the Alps and the Apennines, to some meters below sea level in the Po delta area and in the Venice area. The boundaries plain/Apennines and plain/Alps are purely morphological; in fact, the geological structures continue as far as the R. Po buried under the quaternary continental sediments (Pieri and Groppi, 1981).

The R. Po area lies between the southern border of the Pedalpine Homocline (alpine structure) and the northern margin of the Ferrara Folds (Apennine structures)(Fig. 2).

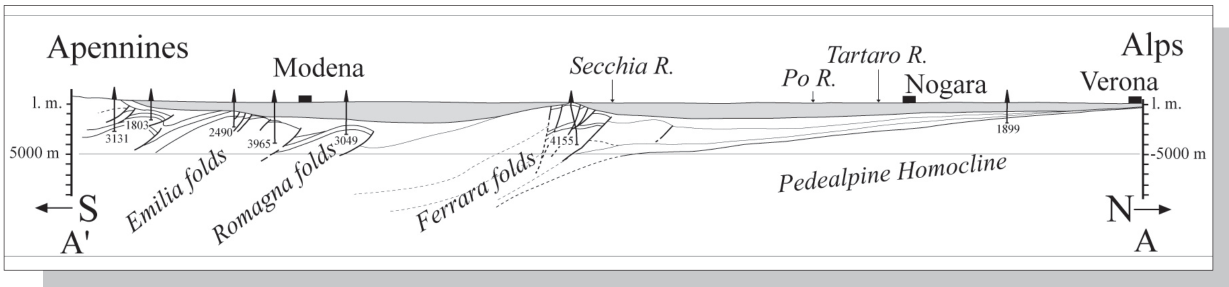

Figure 2 Geological section across the central Po Plain (modified after Pieri and Groppi, 1981). Grey area shows the continental Quaternary deposits. Location of the section is shown in figure 3.

Geomorphological research carried out in the past decades led to many documents at several cales (1:50.000, 1:25.000, 1:10.000) from which was derived the Geomorphological map of the Po Plain at the scale 1:250.000 (Castiglioni *et al.*, 1997) and its Illustrative notes (Castiglioni and Pellegrini, 2001).

River Po flows through the middle of the plain from the southwest, near the Apennine border towards the east. The plain slopes eastward with a southerly slope from the Alps and a northerly one from the Apennines. The geomorphologic characteristics of the opposite plain slopes are different in many ways (Castiglioni *et al.*, 1997). Their top surfaces (Fig. 3) are not coeval, and the northern side of the plain is older than the southern one (Cremaschi and Marchetti, 1995).

The northern border, near the Alps foothills, has glacial amphitheatres which testify to the advance of glacial tongues along the main Alpine valleys as far as their outlets into the plain (cf. Iseo and Garda amphitheatres in Fig. 3). These were derived from Alpine glacial bodies during the Pleistocene periods of peak glaciations. In the Italian Alps the last maximum advance of glaciers took place between 24.000 and 18.000 years B.P. (Orombelli, 1983), when the entire chain was under an ice cap (Pinna, 1996) from which only the highest peaks emerged. In the Apennines, however, only a few mountain tops along the highest part of the chain were affected by glaciation (Panizza, 1977).

In the upper plain of the Po, near both the Alps and Apennine borders, a series of terraces - remnants of older surfaces named in Fig. 3 as the old terraces unit - is well-exposed. These surfaces, which are overlain by deep, rubified soils and polygenetic loess covers (Cremaschi, 1987, 1990), may be interpreted as remnants of sandurs, older than the last glacial maximum in the Alpine border, and bajada or "glacisflächen" (accumulation surfaces, often overlying old peneplains) along the Apennine border. Along the Apennine border they have been generally tectonically tilted towards the plain (Bernini and Papani, 1987), as a consequence of the high rate of the Apennine uplift during the Quaternary. Isolated remnants of these surfaces (Fig. 3) have also been found in the middle of the northern plain (isolated terraces near Casalpusterlengo, Romanengo and Brescia).

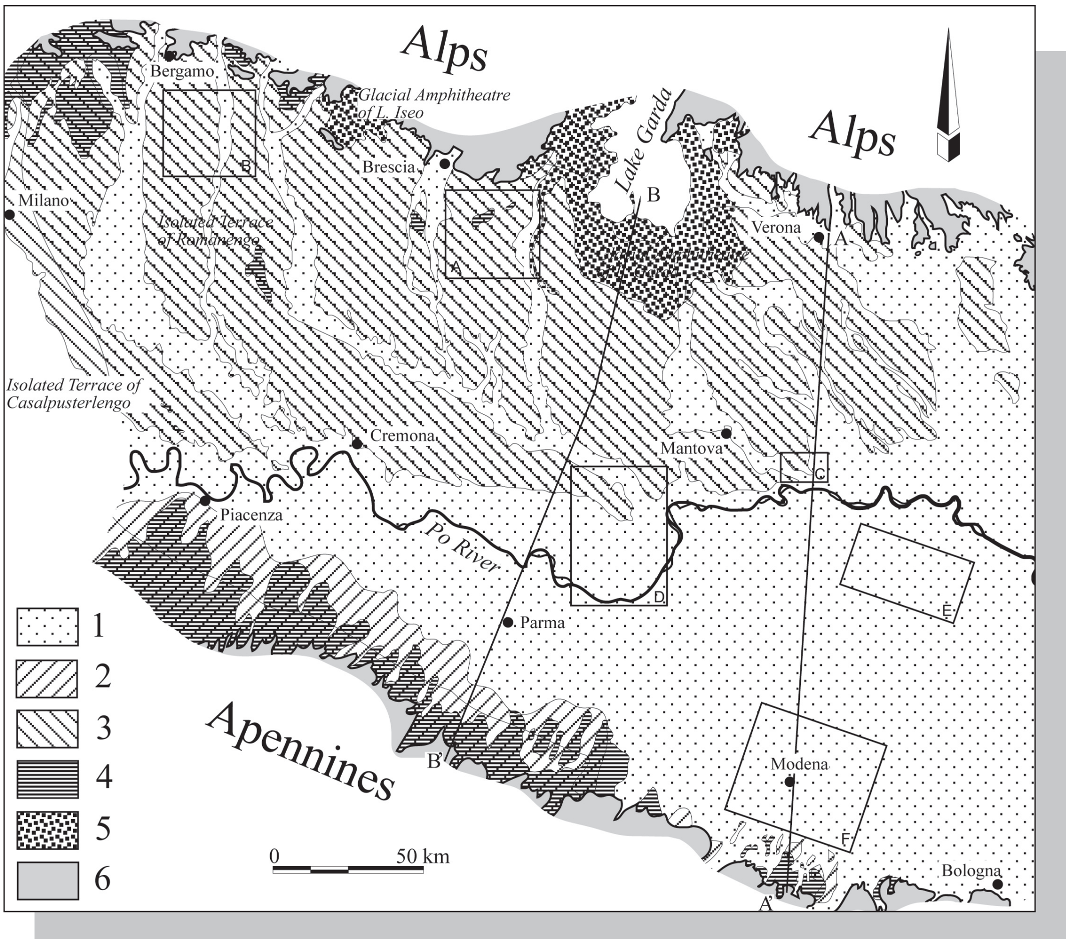

Figure 3 Geomorphological units of the central Po Plain (modified after Marchetti, 2002)

Legend

1 Holocene fluvial deposits unit
2 Late Pleistocene bajada unit
3 Main Level of the Plain unit
4 old terraces unit
5 moraines
6 bedrock

A-A' Location of the geological section in figure 2
B-B Location of the geomorphological section in figure 4
A, B, C, D, E, F Study cases

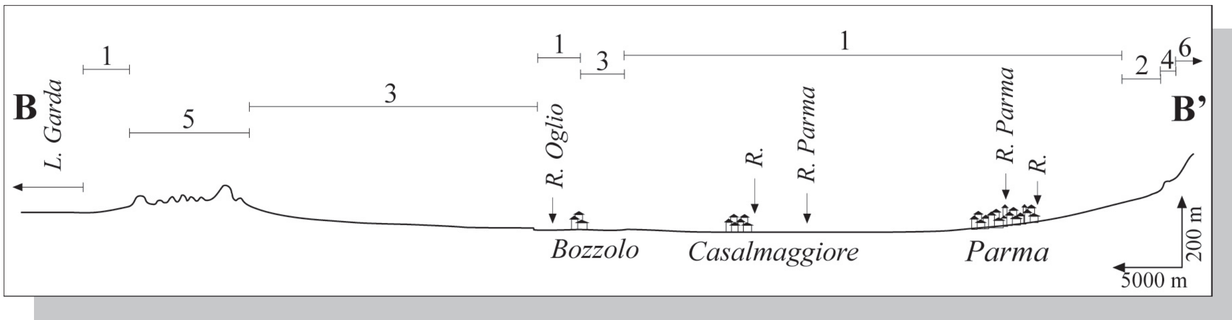

Figure 4 Geomorphological section across the central Po Plain. Location of the section is shown in figure 3. Numbers refer to the geomorphological units.

The northern plain (Figs. 3 and 4), near the old terraces unit and moraine amphitheatres, is almost entirely a fluvial and fluvioglacial megafan coalescence (Guzzetti *et al.*, 1997). At the top, this unit, named here as the "Main Level of the Plain", presents a very low angle surface and may be related to the glacial conditions in the Alps during the last glacial maximum (Marchetti, 1992, 1996). At present, this surface is dissected and rivers that have their sources in the Alps flow in deep entrenched valleys cut into this unit.

Along the Apennine boundary of the Po Plain, less extensive surfaces, corresponding in age to the "Main Level of the Plain" unit and described in Fig. 3 as a Late Pleistocene bajada, crop out. This unit is a fluvial fan coalescence (bajada), mainly developed during the last glacial maximum phases (LGM).

The Holocene fluvial deposits unit (Figs. 3 and 4) occupies the middle of the plain, between the "Main Level of the Plain" unit in the north and the Late Pleistocene bajada unit in the south. The deposits in this area are due to fluvial aggradation of both the Po and its southern tributaries. The Holocene deposits of the Po are bound to the north by a clear scarp which marks the southernmost erosion of the "Main Level of the Plain" unit due to the northward migration of the river during the Holocene. Due to headward erosion, the main northern tributaries (the Alpine ones) flow in large valleys cut into the sediments of the "Main Level of the Plain" unit. However, most of the Holocene plain was formed by the aggradation of the southern tributaries (the Apennine ones).

In this sector of the plain a lot of morphological changes of the watercourses are well-known. In the upper part of the plain, rivers run deep in the alluvial plain whereas in the mid-lower part of the plain they flow elevated over the surrounding areas within artificial embankments**.** Therefore, because of these aspects, the flood hazard, related to morphological factors, is much higher in that second sector of the plain than in the first one.

A long recurrence of inundations concerns the Po Plain with historical records quoted in chronological lists and in official articles of the Italian Ministry for Public Works: the events listed started in the 11th century (Govi and Turrito, 1996). The most extensive information on flood events comes from the period after 1918.

In the Po Plain, the first man's interventions along the rivers (building of artificial banks), although to a minor extent, go back to Etruscan and Roman times. In the following centuries, the works involving the fluvial systems become systematic: beside walls, groynes, check dams, and canalizations, embankments along 400 km course from the mouth of the River Po were built. Since then the rivers' impediment to flooding has caused an increase of riverbed sedimentation with consequent over-elevation of the artificial embankments thus accentuating the hanging conditions of the watercourse over the surrounding plain

In spite of the systematic practice of building artificial banks, breaches due to overflow, siphoning, erosion or collapse of levees were frequent along all the rivers and especially along the River Po. (Govi and Turitto, 1996, 1998; Cardinali *et al.*, 1998; Guzzetti *et al.*, 1998; Castiglioni and Pellegrini, 2001). The banks breaches inundated enormous areas and floodwaters sometimes remained for long periods (from a few weeks to several months) in low-lying parts difficult to drain.

In the 20th century, the demographic expansion required a greater availability of food resources, which could be faced thanks to the extension of farming areas. This was acquired by means of land reclamation practices in the areas which were frequently inundated**.** In order to defend these territories from flood events, the embankments were strengthened and increased in height several times.

METHODOLOGY REMARKS

In the study area, detailed geomorphological investigations have led to the implementation of micro-relief maps, Digital Elevation Models (DEM), maps of surface deposits and geomorphological maps (these documents at large and medium scales were elaborated).

As concerns the archaeological investigations, information retrieval of several kinds of data (historical maps, bibliographic and archive data collection, aerial photo interpretation, field survey and excavations) are at the base of the implementation of archaeological maps.

From a methodological standpoint, though, a definition of the relationship between fluvial forms and archaeological sites cannot be expressed by a simple presence/absence ratio. The presence of archaeological findings overlapping landforms identifies, as a rule, an *ante quem* dating, whereas an opposite relation – that is a landform overlapping buried archaeological findings – is identifiable with a *post quem* dating. First of all, it is therefore necessary to distinguish between sites identified on the soil surface and buried ones. However, it is difficult to compare these two categories: the percentage of buried sites, for example, is considerable in the urban area, where findings of Roman Age can be discovered several metres below the present ground surface whereas in the countryside, buried sites from the same epoch are much more rare. Obviously, this does not reflect archaeological reality but rather various vicissitudes linked to archaeological remains and land-use. The centuries-long human development in urban areas has left a large number of subsoil archaeological remains, starting from those recorded in Medieval and Renaissance chronicles, whilst in the countryside archaeological discoveries have mainly been made thanks to ploughing activity. The latter has brought to light ancient remains buried within one metre of depth. Evidence of this situation, for instance, is clearly shown in the areas immediately south and north of Modena, where archaeological findings of Roman Age are extremely rare compared to adjacent areas (Balista *et al.*, 2003). In this case, the evidence produced by the city centre and the identification of the inundation fan, which in Late Antiquity - Early Middle Ages contributed primarily to the burial of the Roman town, suggests that this gap may be ascribed to the burial of archaeological evidence by that flood. In other words, this gap is not real but only apparent. Indeed, if we had the opportunity to know all the buried evidence in the study area, we would probably have a picture quite similar to that of the areas with superficial remains. The only difference would be that the archaeological remains would be much better preserved, not having undergone the degradational processes caused by prolonged farming activities.

STUDY CASES

The comparison of geomorphological and archaeological data in many places of the central Po Plain allowed many fluvial forms to be dated and to reconstruct the plain evolution. Some study cases located in the plain sector north and south of the R. Po (Fig. 3) will be described.

Plain sector north of the R. Po

The generalized stability of the fluvial and fluvioglacial surface of the "Main Level of the Po Plain" may be emphasized not only by geomorphological studies but also by distribution and relationships between archaeological settlements. Many cases should be presented to underline the presence on the surface of settlements belonging to more than one culture, from Neolithic to Medieval. Younger settlements may be sometimes directly placed on top of older without any fluvial sediment in between or they may be scattered on the same surface, also side by side.

Many of the main archaeological sites on the "Main Level of the Po Plain" are built on the ancient fluvial forms (Cremaschi, 1987, 1990) that may be related to the cold phases of the Last Glacial Maximum. North of the Po River it is common to find Neolithic settlements along the oversized LGM palaeochannels in the low angle plain or distributed on the LGM sandur in the higher angle plain (Fig. 5). The plain between Ciliverghe and Castenedolo hills westward and Holocene fluvial valley of the R. Chiese were built during the cold stages of the LGM. Castenedolo and Ciliverghe isolated relieves are terraces rising about 5 to 20 metres from the Main Level of the Po Plain (Baroni *et al.*, 1990).

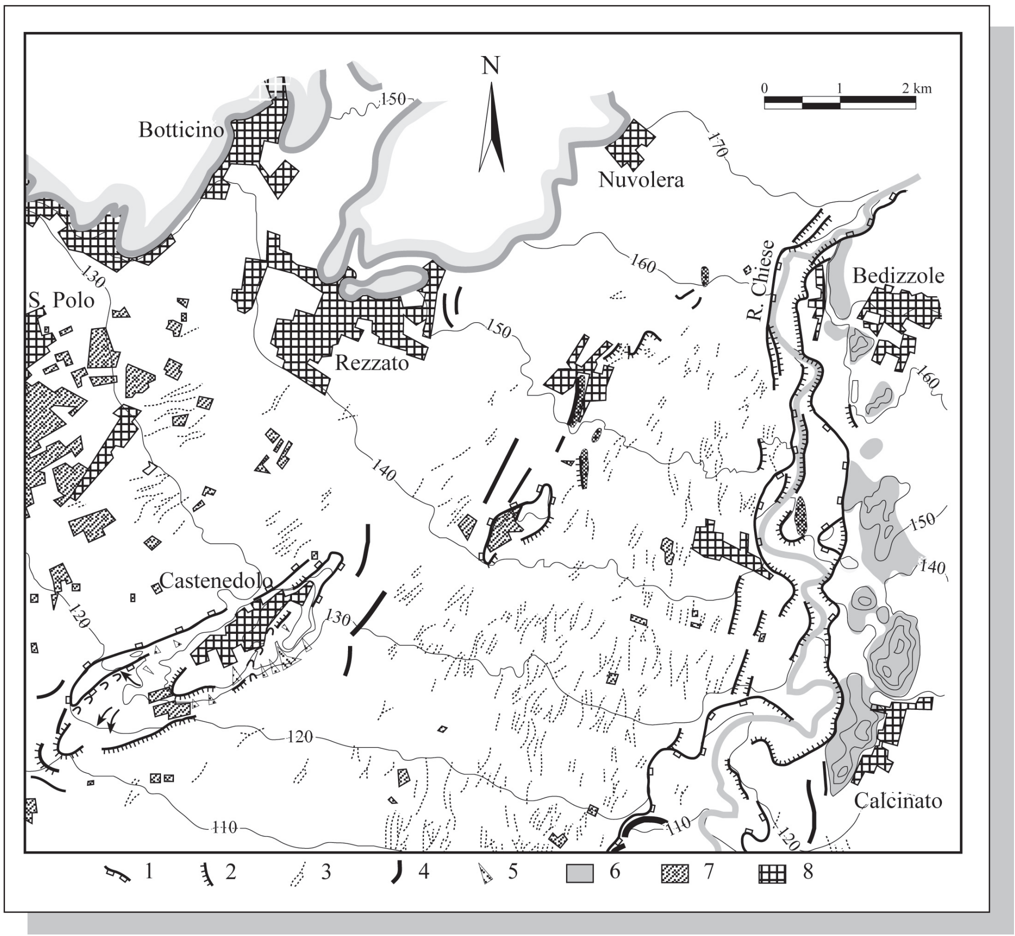

Figure 5 Geomorphological map of the area between Brescia westward and the glacial amphitheatre of L. Garda eastward.
1 fluvial scarp more than 5 metres in height
2 fluvial scarp less than 5 metres in heigth
3 braided palaeochannel
4 meandering palaeochannel
5 scree slopew
6 glacial deposit,
7 quarry,
8 village.

They are covered by strongly weathered fluvioglacial gravel ("Ferretto" – Middle Pleistocene) and polygenic cover of loess (Upper and Late Middle Pleistocene) (Baroni and Biagi, 1988). In a quarry opened in the loess cover some Middle Palaeolithic artefacts were found and studied (Baroni *et al.*, 1986). The isolated relieves of Castenedolo and Ciliverghe (area A in Fig. 3) contributed to bound the megafan aggradation during LGM from the western side of the Garda (grey areas of Bedizzole – Calcinato are the western moraine ridges of the Garda Amphitheatre). The surface of the megafan is characterized by well-defined braided palaeochannels (dotted lines in Fig. 5), while the present hydrography (R. Chiese) presents a meandering pattern.

On the braided plain of the Main Level of the plain all over the Lombardy Region, many findings from Neolithic are documented; in the Bergamo province (area B in Fig. 3) up to 70 km west of Castenedolo, the Archaeological

Maps of Lombardy (Poggiani Keller, 1992) shows the sites: Brusaporto, Chiuduno, Grumello, Tagliuno, Mozzanica, Fornovo S. Giovanni, Trescore Balneario. Many of them are sites from Bronze Age and younger. In addition the Roman centuriation is generally well-preserved directly on the top of braiding pattern surface (Marchetti, 2002).

In the southern boundary of the Main Level of the Po Plain, few kilometres southeast from Mantova (area C in Fig. 3) the relation between archaeological settlements and geomorphology is quite clear. Neolithic and Bronze Age sites are concentrated along the fluvial scarp that bound the Main Level of the Po Plain.

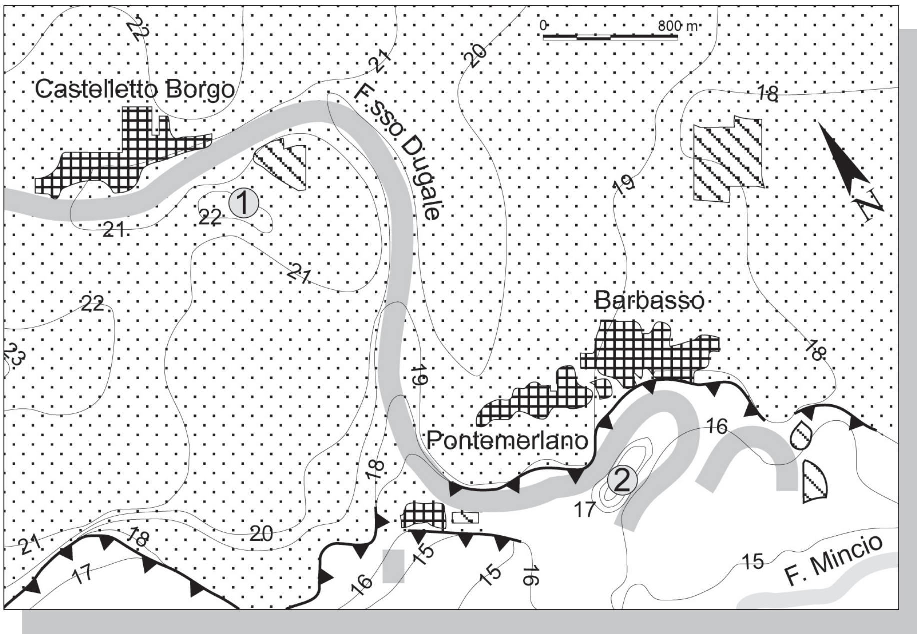

Figure 6 Geomorphological map near Castelletto Borgo. Lines with triangles represent fluvial scarp dividing Main Level of the Plain (dotted area) from Holocene Plain (white area). Areas with oblique lines are quarries, grey lines are overfit palaeochannels. 1 is the location of the Neolithic settlement and 2 of a Bronze Age settlement (Castellazzo della Garolda settlement).

Distal sector of the Main Level of the Po Plain is characterized at its top by sand and silty sediments with a top soil up to one metre depth. The ancient fluvial forms are characterized by meanders that are oversized in respect to the present ones. In the Castelletto Borgo area (Fig. 6), a little river (Fosso Dugale) characterized by a mean annual discharge of less than 1 m^3/s has a curvature radius of its meanders more length than the present R. Mincio which has a mean annual discharge of about 70 m^3/s. Large meanders of Fosso Dugale are the consequence of the higher discharge during LGM.

Along the right bank of the oversized channel of Fosso Dugale a Neolithic settlement, belonging to the VBQ culture, was found (Marchetti *et al.*, 1995). The settlement is localized at top of an alluvial ridge, probably the natural right levee of the ancient river. This location is particularly propitious for several reasons. Settlement is in fact near a perennial course that was fed from deglaciation by spring inside the northern plain. The flood discharge therefore never caused relevant fluvial hazards. The alluvial ridge, sandier than the surrounding silt-sandy plain, is well-drained, while the surrounding territory is fruitful. Also location, in the distal part of the Main Level of the Plain near the edge scarp going down to the Holocene fluvial deposits in the final tract of the R. Mincio, is important. In fact, R. Mincio was an important communication line from the Adriatic Sea to the central Po Plain. Some other settlements, especially at the end of Bronze Age and the Etruscan period, were found in the Holocene fluvial valley. These settlements presented a conflicting situation with fluvial processes but easier commercial facilities (see settlement south of Barbasso in Fig. 6). The most important Etruscan settlement of the area is "Forcello", few kilometres east of these sites (De Marinis, 1986). Forcello was founded in the VI century BCE and was occupied also during the V century BCE. It was the main commercial site in the zone but people fought continuously against catastrophic floods.

Near the southern scarp of the "Main Level of the plain", SW of Mantova (area D in Fig. 3), many human settlements dating from Neolithic to Roman Age are associated to palaeocourses. South of the scarp which divides the Main Level of the Po Plain by Holocene fluvial deposits unit, in the area between the main scarp and the R. Po, many palaeocourses are found. Many of these settlements, from Bronze Age to Roman Age, are disposed along the palaeochannels and are sometimes buried by fluvial deposits (Venturi and Bacchi, 2003).

Plain sector south of the R. Po

The case studies deal with the sector which (areas F and E in Fig. 3) develops from the foot of the Modena Apennine (altitude 110-100 m a.s.l.) till the River Po which flows eastward (altitude 15-10 m a.s.l.).

The particle size of surface alluvial deposits ranges from mainly gravel, in the area south of Modena, to mainly clay in the northern sector. Their thickness varies from hundreds of metres to one thousand metre in relation with the depth of the buried Apennine structures (Fig. 2).

The geomorphological characteristics of this area are mainly the result of the evolution of rivers Po, Secchia and Panaro (Castiglioni *et al.*, 1997; Castiglioni and Pellegrini, 2001). In detail, at the Apennine margin, the watercourses reaching the plain have built up alluvial fans which extend to the north near Modena town. Many ridges caused by the local evolution of ancient watercourses depart from the foot of the fans and continue untill the R. Po; their patterns revealing the recent migration of these rivers. North of Modena town, depressed areas are located in between the fluvial ridges (Castaldini *et al.*, 2003; Panizza *et al.*, 2004).

The first study case (area E in Fig. 3) is a meandering palaeoriver which in literature is known as "Barchessoni palaeoriver". This palaeoriver is situated between Po, Panaro and Secchia rivers in an altimetric depression. This area has been inundated many times by R. Po and therefore the clayey flood-sediments buried the older hydrographical features and archaeological settlements.

The "Barchessoni palaeoriver" (Fig. 7) is well depicted on the aerial photographs, on which two fluvial bends are visible. Pellegrini (1969) defined it as a Po palaeoriver active in the last centuries BCE, Cremonini (1986) as an Apennine

palaeoriver inactive in the Roman time, Calzolari (1986) as an old course of the R. Secchia and Ferri (1988) and Ferri and Calzolari (1989) as a Po palaeoriver active in the IV-III millennium BCE.
In order to understand the domain of the Barchessoni palaeoriver, Castaldini *et al.* (1992) made the ratio between the meander geometry palaeoriver and present day meanders of R. Po, Secchia and Panaro (Tab 1).

N	Rivers	r_m	l_m	a_m
1	A/D	0,45	0,43	0,62
2	A/E	0,41	0,38	0,62
3	B/D	0,68	0,96	0,95
4	B/E	0,62	0,88	0,95
5	C/D	0,54	0,75	0,92
6	C/E	0,50	0,66	0,92
7	A/F	1,66	1,40	1,92
8	A/H	2,50	2,33	2,50

Table 1 Ratio between meanders geometry of the Barchessoni paleoriver and of the paleo and present day hydrography of the rivers Po, Secchia and Panaro (after Castaldini et al., 1992).

Legend

r_m meander radius (km)
l_m meander wavelength (km),
a_m meander amplitude
A meander of the Barchessoni paleoriver
B, C meanders of historical Po paleorivers
D, C meanders of the present day R. Po, F meander of the present day R. Secchia
H meander of the present day R. Panaro.

In addition, the geochemical analysis of the sediments of the Barchessoni palaeoriver were compared with those of the present day rivers Po, Secchia and Panaro (Tab. 2). These data show more similitude between palaeoriver and present day R. Po than between palaeoriver and present day rivers Secchia or Panaro (Castaldini *et al.*, 1992).

Sediments	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	Fe2O3
a	1,67	4,01	11,75	63,73	0,15	2,12	10,30	0,62	0,14	5,52
b	1,99	3,63	11,82	68,28	0,13	2,26	6,71	0,49	0,12	4,57
c	1,65	4,06	13,72	66,54	0,25	2,58	5,59	0,52	0,12	4,98
d	2,28	3,36	9,47	77,24	0,07	1,91	2,94	0,24	0,10	2,39
e	1,39	2,70	7,27	58,92	0,06	1,66	28,27	0,31	0,20	4,73
f	1,10	2,00	6,49	55,27	0,14	1,47	28,25	0,23	0,24	4,81

Table 2 Geochemical analysis (in %) of the sediments of the Barchessoni paleoriver and the present day rivers Po, Secchia and Panaro (after Castaldini et al., 1992).

Legend

a, b, c Barchessoni paleoriver sediment samples
d sediments of the present day R. Po
e sediments of the present day R. Secchia
f sediments of the present day R. Panaro.

In the sector of the plain where the Barchessoni palaeoriver is located, a few hundred archaeological settlement were found, distributed between the 2.300 BCE and the 8th century CE (Balista *et al.*, 2003); in particular the most part of them were found close to Barchessoni palaeoriver (Fig. 7).

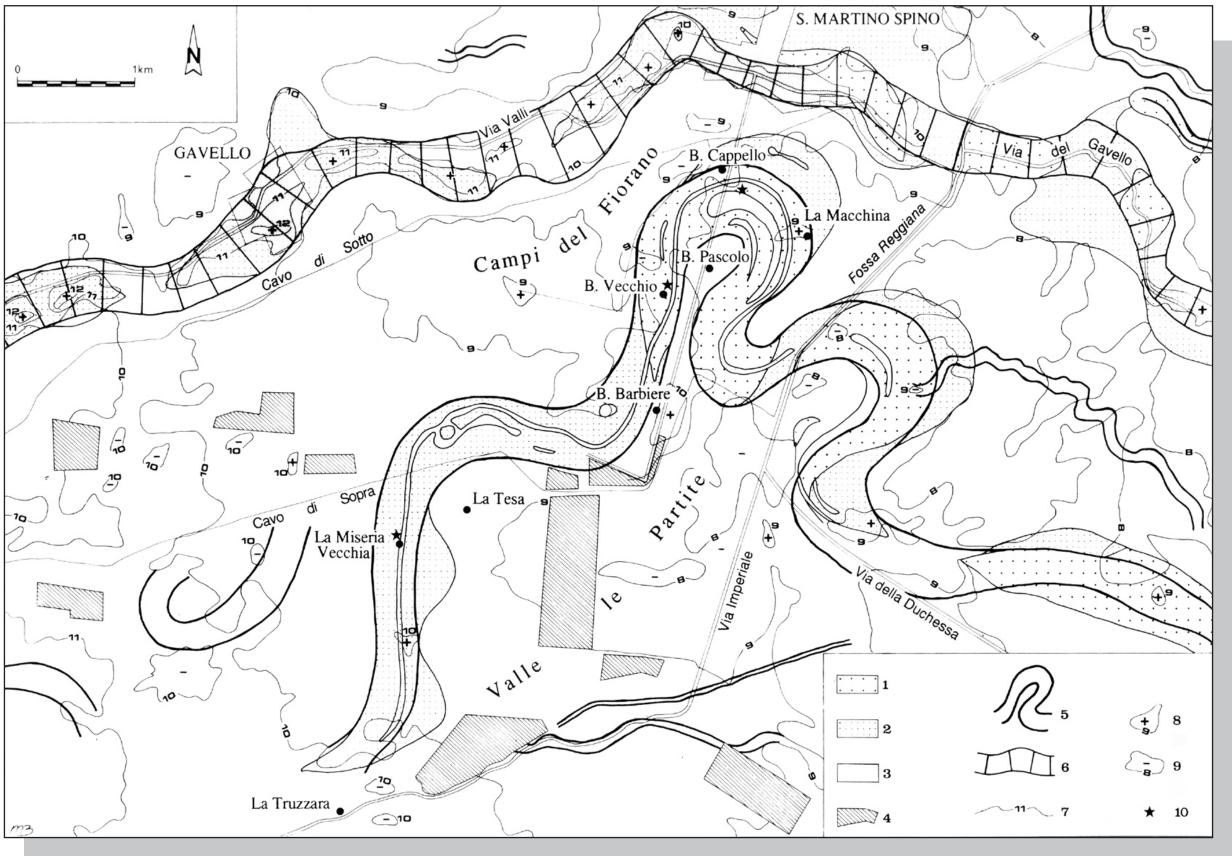

Figure 7 Geoarcheological map of the Barchessoni Paleoriver area (modified after Castaldini et al. 1992)

Legend

1 mainly sand surface deposits
2 mainly silt surface deposits
3 mainly clay surface deposits
4 artificial pond
5 paleoriver at the plain level
6 fluvial ridge
7 isolines (1m contour intervals)
8 buried Roman settlement
9 buried Bronze Age settlement,
10 location of the sediments samples collected for the geochemical analysis.

The archaeological remains have revealed that this palaeo-course of the R. Po was already active in the Bronze Age. In the Iron Age the riverbed had become a small watercourse that nonetheless maintained some vitality throughout the Roman period. The moment in which the complete extinction of the channel took place, remains unknown.

In the Modena town area (area F in Fig. 3), some 800 archaeological sites were identified and integrated into the "Archaeological map of the Municipality of Modena" (Cardarelli and Cattani, 2000). Such a high number of archaeological sites – distributed between the Neolithic and the Early Middle Ages– could give a greater deal of information than any other place in northern Italy.

Castaldini *et al.* (2007) took into account the overlapping of archaeological and geomorphological data, with the implementation into a GIS of geoarchaeological maps subdivided into main epochs (i.e. from Roman period to the Early Middle Ages, Fig.8).

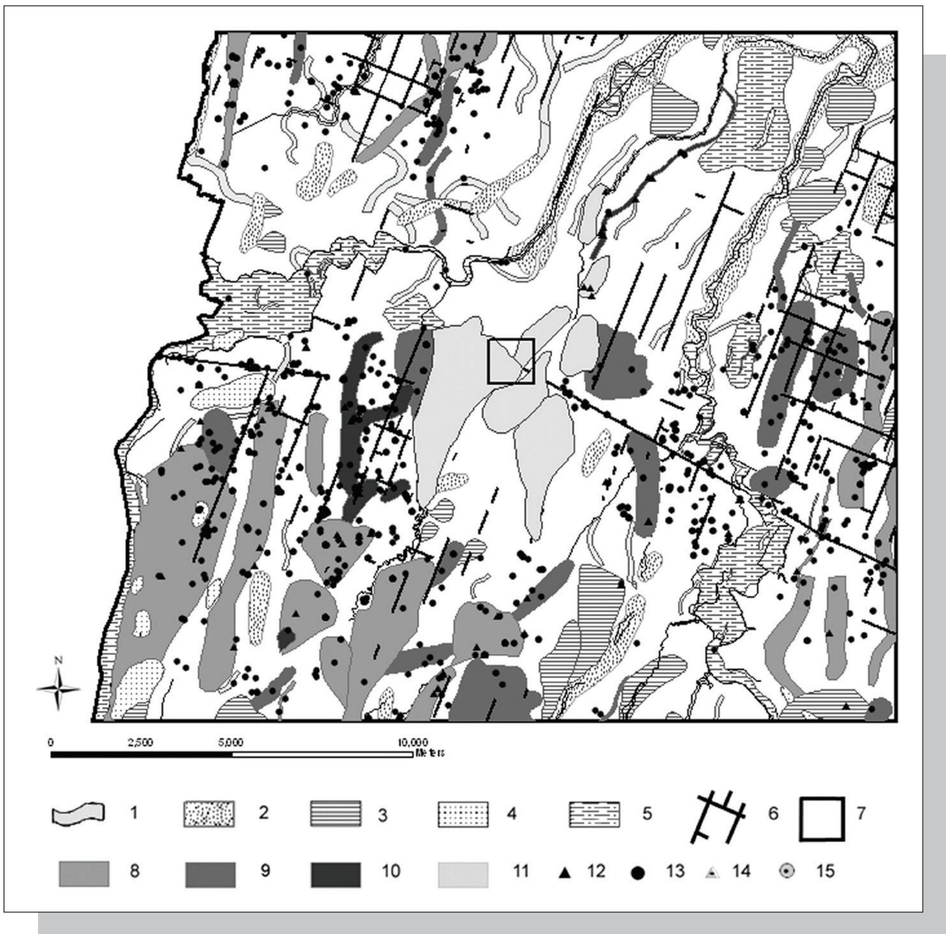

Figure 8 Geoarchaeological map of the Modena Plain with fluvial forms dating from the Roman period to the Early Middle Ages (after Castaldini et al., 2007).

Legend

1 Paleoriver at the plain level
2 Fluvial ridge
3 Alluvial fan and crevasse splay
4 Area with traces of abandoned braided streams,
5 Depression
6 Centuriation
7 Boundary of Mutina (Modena roman town)
8 Neolithic and Bronze Age fluvial form
9 Iron Age fluvial form
10 Roman fluvial form
11 Early Middle Ages fluvial form
12 Surface Roman site
13 Surface Early Middle Ages site
14 Buried Roman site
15 Buried Early Middle Ages site.

Neolithic remains (6000 to 4000 BCE) are extremely rare and sporadic in the Modena territory. Some alluvial fans and ridges south and southwest of Modena show superficial remains which are generally thought to date to the Neolithic; it can therefore be assumed that the formation of these features took place before or during that period. The Copper Age or Eneolithic is poorly represented. Anyhow, the formation of the R. Secchia fan can presumably be ascribed to this period (3300 to 2300 BCE). Later, this alluvial fan hosted some *terramare* on its surface (Cattani and Labate, 1997).

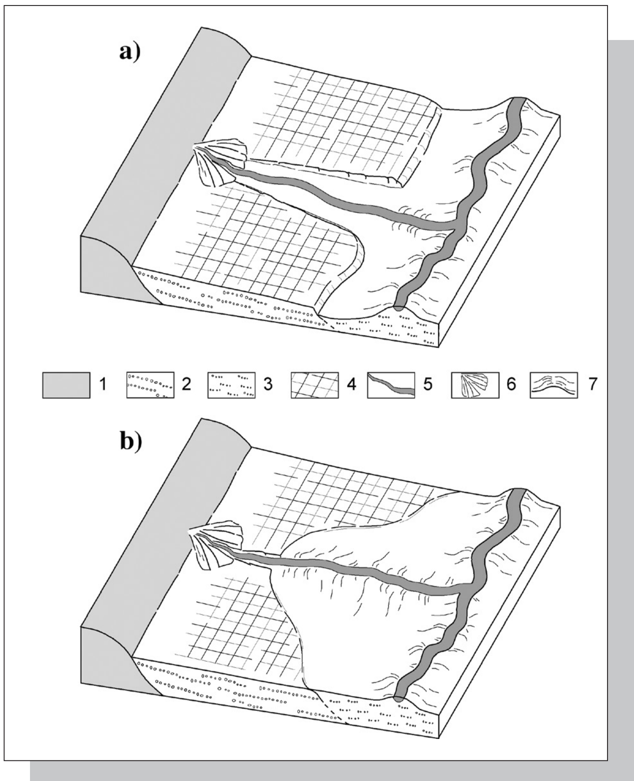

Figure 9 Schematic illustration of the evolution of the Modena area (after Castaldini et al., 2007).

Legend

a Roman Age, b) Present
1 Apennine margin
2 Pre-Roman alluvional plain
3 Roman and post-Roman alluvional plain,
4 Roman centuriation system
5 River
6 Alluvional fan
7 Fluvial ridge.

A series of fluvial forms in the surroundings of Modena are ascribable to a phase immediately preceding or coeval with the Middle and Recent Bronze Age (1600 to 1200 BCE) owing to the presence of buried Neolithic findings or the clear relation between ridges and Bronze Age sites found at the surface. Particularly interesting is the identification of an ancient bed of the R. Panaro – recognised thanks to the identification of fluvial ridges east of Modena – which hosted a couple of *terramare* (Balista *et al.*, 2003).

The Roman Age (2nd century BCE to 4th century CE) is represented in the Modena area by a large number of archaeological findings, which – besides the urban core of the city of *Mutina* – have been confirmed by numerous pieces of evidence, such as farms, villas, necropoles, road infrastructures and traces of the centuriation system (Fig. 8). This system, which was made up of considerable, efficiently managed drainage works and canals, gave a systematic and rational arrangement to the whole area and was one of the components which provided the territory with a certain degree of stability, also from the hydrological viewpoint. Compared with previous periods, the fluvial forms datable to the Roman Age are fewer, whereas the centuriation traces are still evident. This shows how even watercourses were subject to the systematic control and management of a well-organised territory, although in places they have been obliterated by subsequent alluvial deposits.

As regards the course of the R. Panaro, it is interesting to note that from the Bronze Age to the Roman Age a series of its palaeo-riverbeds shifted progressively westwards.

The Roman evidence in the city of *Mutina* is all buried by thick alluvial deposits which preserved the Roman town excellently, as confirmed by the numerous, although punctiform, findings recovered from the urban area. The dating of these events to an epoch of Late Antiquity is widely documented by numerous findings, in particular burial artefacts. It can be inferred that at least one of the alluvial events which characterised the post-Roman stratigraphy of the Modena subsoil can be ascribed to a date around the end of the 6^{th} century. This coincides with the well-known historical source of Paulus Diaconus on the dramatic hydrogeological disarray processes which affected northern Italy around the year 590.

The impact of hydrogeological disarray on the city of Mutina and on the surrounding territory is shown by the thickness of the alluvial layers, which are over two metres thick in some parts of the town. This is confirmed also in the areas immediately to the north and south of the city centre (Lugli *et al.*, 2004) where remains from the Roman Age are buried and have largely been obliterated by centuriation.

The archaeological strata of Modena go down to about 7–8 metres below the present surface level, reaching a depth of 11 metres in places. The medieval and modern layers are on average 2 metres deep; below them there are the alluvial layers at a depth between 3.5 and 4 metres. Further down are found the layers from Late Antiquity and the Roman Age (Cardarelli *et al.*, 2000).

Thanks to this reconstruction, starting from the end of the Roman age, an aggradational-type model of fluvial evolution was hypothesised for the first time (Castaldini *et al.*, 2007). According to this model, the watercourses, even the minor ones, passed from a runoff occurring in deep riverbeds to one elevated with respect to, or at least at the same level as, the surrounding plain within artificial embankments (Fig. 9).

The same type of evolution was described by Giorgi (2000) for the plain surrounding the city of Bologna. Therefore, by taking into account further investigations carried out in adjacent areas, this process could have taken place at a regional scale.

The plain aggradation from the Roman Age could be ascribed to different causes, such as previously occurring processes (northbound shift of the R. Po) or coeval events (climatic changes, subsidence, deforestation, abandonment of the countryside, degradation of the water flow system set up by the Romans).

CONCLUSION

This essay describes how the comparison of geomorphological and archaeological data allowed many fluvial forms to be dated and the stages of geomorphological evolution of the central Po Plain to be traced.
Different situations are in evidence not only due to migrations through time from different side in the Po Plain but also conditioned by geographical boundaries and different geomorphological environments.
The northern sector of the R. Po has been very stable during the whole Holocene. Along the main palaeochannels on the Main Level of the Po Plain, fed by ice melting from the Late Pleistocene glaciers, several Bronze Age settlements have been identified. The great stability after deglaciation, combined with fruitful and well-drained soils, with good water availability were the reasons of Holocene peopling. Main rivers after deglaciation have been confined into large valleys cut into late Pleistocene sediments and gave a large amount of water combined with fluvial hazard particularly reduced. Only when trading and mobility began more important than subsistence, people went into the main valleys and accepted a higher fluvial risk.
On the contrary, in the sector south of the R. Po, the geomorphological and archaeological investigations show that the ancient landscape was subject to significant changes.
Studies show that in the Modena area the watercourses, even the minor ones, passed from a runoff occurring in deep riverbeds to one elevated with respect to, or at least at the same level as, the surrounding plain within artificial embankments and the shifting to the east of the R. Secchia and to the west of the R. Panaro in the area downstream of the town.
In an altimetric depression located at about 10-15 km to south of the R. Po a meandering palaeoriver (Barchessoni palaeoriver) testify an ancient southward position of the R. Po respect its present one. On the whole, from the Bronze Age to the Late Middle Ages the R. Po flowed in a belt about 20 km wide, shifting from south to north.

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