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THE ANCIENT MORPHOLOGY OF THE PO PLAIN IN THE AREA OF BOLOGNA (ITALY)

ABSTRACT: GIORGI G., *The Ancient Morphology of the Po Plain in the area of Bologna (Italy).* (IT ISSN 0391-9838, 2000).

A multidisciplinary approach has permitted to reconstruct the ancient morphology of the Po Plain north of Bologna. Covering an area of about 766 square kilometres, the territory is characterized by the presence of a considerable number of fluvial ridges. At the time of the Roman colonisation in the II century B.C. the plain was far more even as compared to today. The absence of ridges is borne out by the large number of archaeological finds that have been found in situ. Streams flowed carving their sediments, as is still the case along the left side of the Po. Roman *centuriazione* patterns confirm this hypothesis. *Centuriazione* is a land subdivision practice adopted by the Romans which strongly takes into account the morphological aspects of a territory as one of its functions was to facilitate surface water flow-off. If ancient morphology had been characterized by ridges and depressions, as is the case today, this type of system would have been unsuitable to ensure drainage. For it to have effectively performed this essential function the morphology at the time must have been far more uniform and homogeneous than what it currently is.

The process of aggradation, which has given rise to the formation of the numerous ridges found today, presumably began in the third century A.D. and continued throughout the Middle Ages. The riverbeds thus came to find themselves above the level of the surrounding plain so that the hydraulic set up was upset and large portions of the territory were lost control of.

KEY WORDS: Fluvial Plain, Archaeology, Late Quaternary evolution, Digital Elevation Model, Po Plain, Bologna area (Italy).

RIASSUNTO: GIORGI G., *La morfologia della Pianura Padana, settore bolognese, in epoca storica.* (IT ISSN 0391-9838, 2000).

L'uso di approcci multidisciplinari ha permesso di ricostruire l'antica morfologia della pianura padana a nord di Bologna. L'area studiata è di circa 766 km^2, ed è caratterizzata dalla presenza di numerosi dossi fluviali. Nel II secolo a.C., durante il periodo della colonizzazione romana, la pianura appariva molto più regolare rispetto a quanto appaia al giorno d'oggi. La quota di rinvenimento di reperti archeologici non rimaneggiati, dimostrano l'assenza di evidenti dossi fluviali. I corsi d'acqua scorrevano incisi all'interno dei propri sedimenti, come avviene attualmente nella parte sinistra del bacino del Po. Il modo in cui è organizzata la centuriazione romana conferma detta ipotesi. La centuriazione è un metodo, utilizzato dai romani per la suddivisione del territorio, che teneva fortemente conto degli aspetti morfologici, in quanto ad essa erano attribuite anche funzioni di drenaggio delle acque superficiali. Essa non avrebbe certamente svolto la sua funzione se la morfologia fosse stata simile a quella odierna, a causa dei rilievi e delle depressioni che attualmente la caratterizzano. La sua efficienza era determinata esclusivamente dalla presenza di una morfologia più omogenea rispetto a quella attuale.

L'aggradazione, che ha formato i numerosi dossi, ebbe inizio a partire presumibilmente dal III secolo d.C., continuando per tutto l'alto medio evo. Gli alvei dei corsi d'acqua si sono venuti perciò a trovare a quote superiori a quelle del piano circostante, sconvolgendo così l'assetto idraulico della pianura e determinando l'abbandono di grandi porzioni dei territori da parte dell'uomo.

TERMINI CHIAVE: Archeologia, Evoluzione tardo Quaternaria, Modelli digitali altimetrici, Pianura Padana, Pianura di Bologna.

INTRODUCTION

An exhaustive description of the main morphological features typical of plain landscapes can be found in two recent publications (M.U.R.ST., 1997a; Castiglioni, 1999). These characteristics fall under three main categories: those of piedmont and transitional regions; coastline ones; and those typical of flood plains.

Flood plain features depend on the action of streams, and riverbeds either sunk beneath or flowing above the general level of the surrounding plain. On the left side of the River Po, for instance, tributaries, such as the Mincio, Oglio, Adda, and Ticino, are generally imbedded, while on the right side they are pensile.

The sloping flanks (0.2-0.4%) of the fluvial ridges make it very difficult to visually determine whether or not the beds are actually pensile. Differences in altitude can only be properly gauged through a micromorphological analysis of contour lines (Giorgi, 1990).

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Given that the ridges in the area under study are of recent formation, the scope of the present paper is to show that at least two thousand years ago the landscape in this area was similar in appearance to that currently extant north of the Po and that the streams running through it were then imbedded in the surrounding alluvial plain. Moreover the burial of Roman artefacts and structures under several metres of sedimentary deposits is ascribable to the formation of fluvial ridges.

Most of the plain surrounding the city of Bologna falls within the territory examined. It covers an area of 766 square kilometres located more or less between the course of the Panaro River to the West and that of the Idice River to the East (fig. 1). Human settlement in the area dates back about 3,500 years to the Bronze Age, but a more sporadic presence before then cannot be ruled out (Forte, 1991; Minozzi Marzocchi, 1991; Bottazzi, 1991).

As the study concerns the evolution of a continental area over two to three thousand years dating was performed only for indisputable in situ findings and on the basis of pedological evidence. Detailed altimetric assays were made by digitalizing points quoted on a map with a scale of 1:5,000 and subsequently processing the data by means of appropriate cartographic software.

ARCHAEOLOGICAL FINDS

The Roman *centuriazione* of the territory under study is of great historical importance and remarkable visual impact (fig. 2). It is essentially the grid used by the Romans to reclaim and mark out into plots the land assigned to settlers in 189 B.C.. A network of co-ordinates are traced out on the ground (Chevallier, 1960) starting from two main axes set at right angles to each other called the *decumanus maximus* and the *cardo maximus*. The plots were then obtained by drawing lines parallel to these axes every 20 actus (about 710 metres). These partitions are still partly visible today and are made especially evident by the routes of country byways and by pathways and lanes separating one field from the other.

Two areas on the fringes of the territory under study, one around S. Agata Bolognese the other near Granarolo dell'Emilia and Budrio, still perfectly preserve this pattern. Elsewhere faint traces can still be gleaned or have utterly disappeared, such as in proximity to the River Reno and the Samoggia Stream. The *centuriazione* over most of the territory dealt with in the study was centred on Bononia, while a grid East of the Idice River off-set clockwise by several degrees with respect to the former was part of the territory of Claterna, which corresponds to the modern-day district of Maggio in the municipal territory of Ozzano dell'Emilia.

Forty-six in situ finds have been taken into consideration (Minozzi Marzocchi, 1991; Scarani, 1968; Silvestri & Piletti, 1982). Some of these are connected with gravesites, others relate to dwellings, and several are objects of everyday use (table 1). Thirty-one belong to Ancient Roman times, eight to the Iron Age, and eight to the Bronze Age. Site 37 has yielded several finds that were made during a digging campaign conducted within the boundaries of the *centuriazione* grid. The material belongs not only to the Roman period but also to that of Celtic occupation and to the Iron and Bronze Ages, thus witnessing to the long-

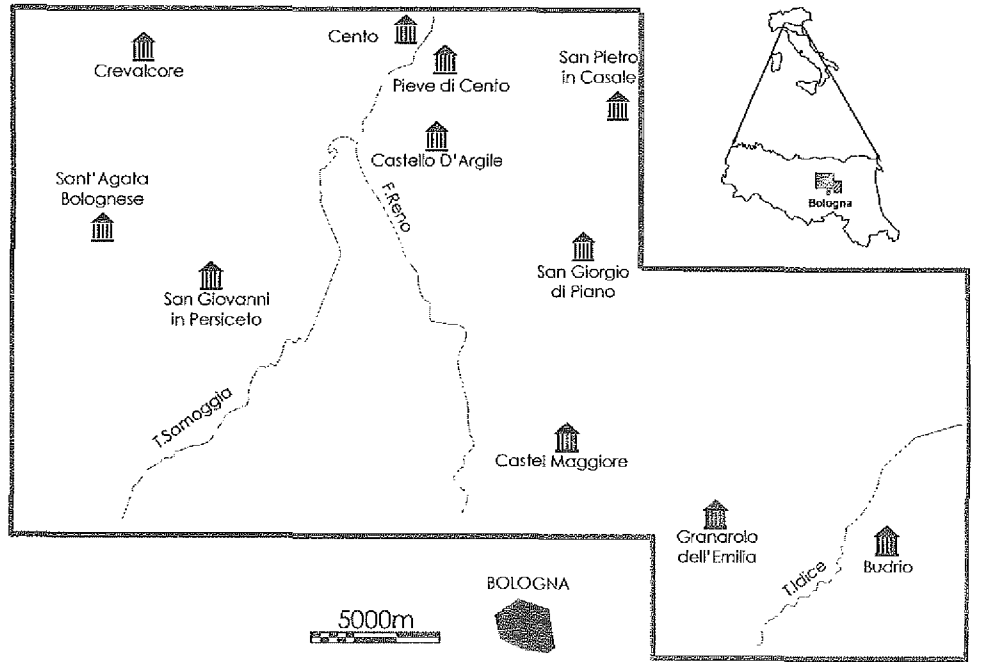
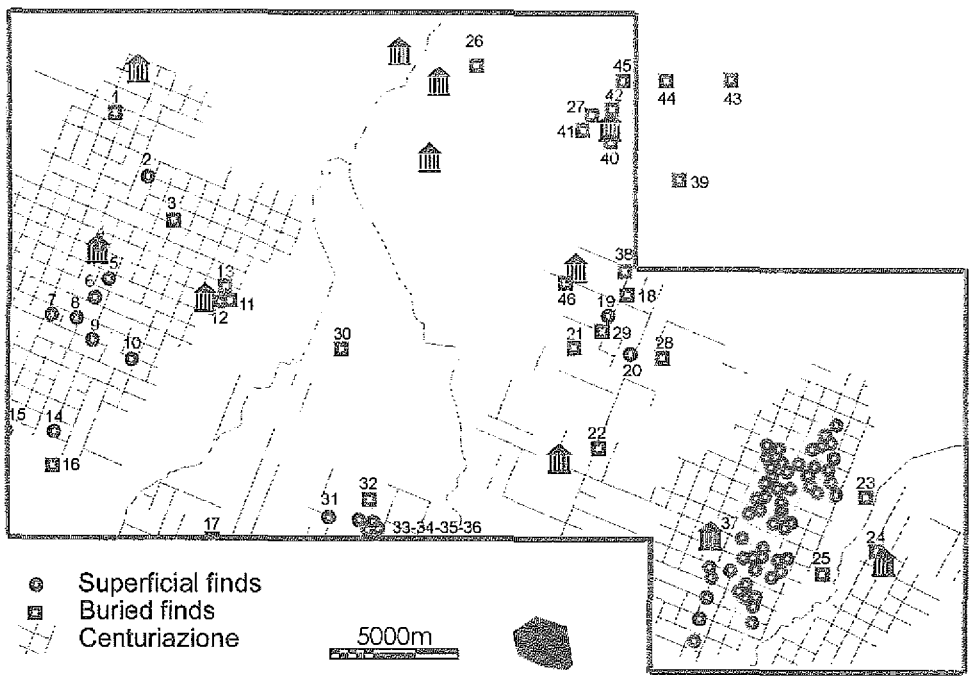


FIG. 1 - Area of study (Northern Italy).

FIG. 2 - Location of find-spots and of the Roman *centuriazione*.



standing and continuous presence of human settlement at the site. Three specimens, Nos. 39, 43, and 44, derive from outside the area under study. They have nevertheless been taken into consideration so as to gain a better understanding of the level of Roman remains, as will be explained more thoroughly further on.

The findings have generally been made in the topsoil during ploughing. Findings from deeper layers are far less frequent and have largely been made by chance during digging operations. It is worth noting that the surface finds have been made where the *centuriazione* has been preserved while the deeper ones are prevalently connected with areas where the grid is missing. The greatest depth at which these specimens have occurred is around six to seven metres, and in one case as much as ten metres below ground level (Cremonini, 1987b).

MORPHOLOGY

As the territory under study is rather featureless due to the lack of outcrops which may be easily perceived by the naked eye, a detailed altimetric assay had to be conducted to determine its morphological characteristics (Giorgi, 1996). For this purpose a digitizing was made of elevation points quoted on maps on the scale of 1:5,000 published by the Emilia-Romagna regional authority. 41,978 points were thus collected and used to construct the digital elevation model from which was derived a representation with contour lines having contour interval of one metre (fig. 3).

The contour map reveals a great number of elongated ridges generally running in a North-South direction; the incision observable in the southeastern corner is ascribable to the erosion caused by the Idice Stream flowing in its natural bed. The age of these features was determined partly on the basis of previous studies (Castaldini & Raimondi, 1985; Cinti & Giorgi, 1989; Giorgi, 1998).

The fluvial ridges in the area are ascribable to the rivers Reno, Panaro, Samoggia, Savena, and Idice (fig. 4). The Reno River is responsible for the numerous ridges to be found in the central area of the study. Some of these ridges can be classified as deriving from an ancient course of the River, (of which there is no historical record but which may have been flowing already towards the end of the Roman period), while others are associated with a subsequent course characterized by many diversions. The former and more easterly running course originates to the North of Bologna and heads northwards to Castel Maggiore, San Giorgio di Piano, and San Pietro in Casale. A little North of Castel Maggiore a branch, only slightly raised above the level of the plain, appears to the right where the Canale Navile, built in the Middle Ages, runs. Albeit featuring many diversions, the Reno's most recent ridge essentially follows the river's current course. Its southern part it runs in a more westerly direction by about two kilometres as compared to the previous ridge. Several deviations, largely of medieval origin, are to be encountered at Castel d'Argile. These deviations witness to the direction in which the Reno flowed when it was a tributary of the Panaro or when it emptied out into a swamp in the low-lying lands to the right, between San Pietro in Casale and Pieve di Cento. The River was subsequently channelled between Cento and Pieve di Cento into its current bed.

TABLE 1 - Age, kind and depth of archaeologic finds

No.	Age	Kind of find	Depth (m)
1	Roman	Bricks	8-10
2	Roman	Bricks	Surface
3	Iron	Grave	1,5
4	Iron	Grave	Surface
5	Bronze	Settlement	Surface
6	Bronze	Potteries and bones	Surface
7	Bronze	Settlement	Surface
8	Iron	Grave	Surface
9	Iron	Grave	Surface
10	Roman	Bricks and coins	Surface
11	Bronze	Settlement	0,8-1,8
12	Roman	Bricks e potteries	Surface
13	Iron	Graves	1,7
14	Roman	Bricks	Surface
15	Iron	Graves	Surface
16	Roman	Grave	1,4
17	Bronze	Bricks	2
18	Roman	Bricks and amphorae	1,5
19	Roman	Settlement	Surface
20	Roman	Bricks e potteries	Surface
21	Roman	Bricks	6-7
22	Roman	Bricks e potteries	2,2-3,5
23	Roman	Graves	4
24	Roman	Miscellaneous	4,5
25	Iron	Settlement	7
26	Roman	Bricks and amphorae	3
27	Roman	Bricks	2
28	Roman	Grave	2,2
29	Roman	Graves	1,5
30	Roman	Settlement	1,2
31	Roman	Plow layer	Surface
32	Roman	Graves	2
33	Bronze	Settlement	Surface
34	Roman	Bricks	Surface
35	Roman	Bricks	Surface
36	Bronze	Settlement	Surface
37	Bronze, Iron, Celtic, Roman	Miscellaneous	Surface
38	Roman	Road	2
39	Roman	Mosaic	1-1,5
40	Roman	Bricks	2
41	Roman	Bricks	2,5
42	Roman	Building	1,5
43	Roman	Tomb	1,8
44	Roman	Bricks	1
45	Roman	Bricks	3
46	Roman	Miscellaneous	2,2

To the East of ridges of the Reno River are to be found those formed by the Savena River. After a short initial stretch of only one ridge, a fork appears North of Granarolo dell'Emilia. The northeasterly branch corresponds to the course of the River until the sixteenth century, while the one turning in a Northerly direction to that active until the mid-eighteenth century, before its artificial immission into the Idice River. The ridges of this latter river are in the most Easterly corner of the area under study. The branch running by the town of Budrio is very ancient, certainly dating back to the early Middle Ages, while the one running SSW-NNE corresponds to the current course of the River.

The ridges to the West of the Reno River derive from the Samoggia River and its tributary, the Lavino Stream, as well as from the Panaro River. A barely visible ridge in very low relief South of San Giovanni in Persiceto datable to the early Middle Ages is probably ascribable to the Samoggia. The Panaro, which currently runs west of the area of study, has undoubtedly affected the local morphology. Throughout the Middle Ages, before it was artificially deviated, the Panaro River flowed and emptied out into marshes around Crevalcore.

A comparison of ridge distribution patterns with those of the *centuriazione* shows that the former prevail wherever the latter are missing. The only exception is the territory around Crevalcore where the persistence of the Roman agrarian grid system is ascribable to the local road network which links up the area with the roads running further South. The system's endurance can be accounted for by the works ceaselessly undertaken by man after each flooding to recover the primitive set up of the fields and to ensure local transitability (Paoletti, 1989).

PEDOLOGY

Reference was made to the pertinent literature for pedological analysis (AA.VV., 1994; Casalicchio & *alii*, 1979; Regione Emilia-Romagna, 1999).

Especially during the last century soils have undergone profound changes due to mechanization. The pedological profile, at least in the top fifty to sixty centimetres and at times even deeper, has been radically altered making soil classification extremely difficult.

The soils of a strip stretching between Castel Maggiore and San Pietro in Casale in the central area of the territory reveal a partial decarbonation in their superficial horizons and in-depth accumulations in the form of concretions. Of medium texture at the surface they tend to be coarser deeper down. Exhibiting a relatively lengthy pedogenesis, they can be classified as Fluventic Ustochrept soils.

The soils around Granarolo dell'Emilia and S. Agata Bolognese are totally decalcified on the top and in depth are very calcareous. As for the previous ones they can be classified as Fluventic Ustochrept soils, even though their evolutionary characteristics are more marked.

The remaining soils are scarcely if at all evolved and have been formed recently (entisols). Those to be found in proximity to the ridges are strongly calcareous and tend to be sandy, while those in the hollows of former marshlands feature a clayey texture and occasionally organic matter and traces of hydromorphism.

The areas with completely decarbonated inceptisols, which testify to a prolonged action of pedogenic factors in the soils, have enjoyed a long period of morphological stability (Bos & Sevnik, 1975) and have therefore presumably not received any alluvial material for a great length of time. They reach as far back as the Mesolithic period (about 10,000 years B.P.) up to Roman times. The soils with decalcification characteristics not as marked as the former are probably of more recent origin. The presence

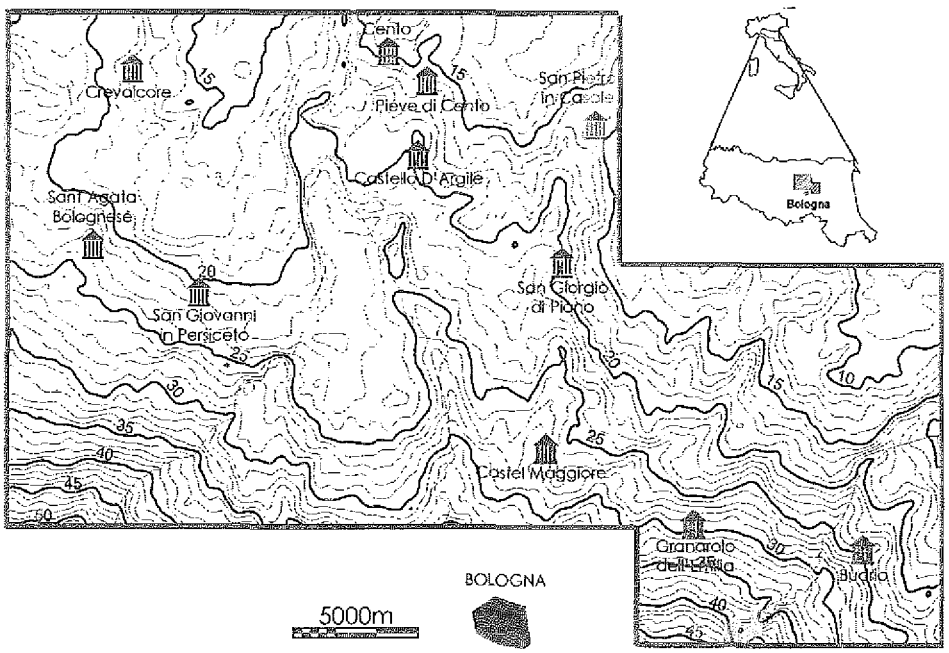


FIG. 3 - Contour map of the current topographical surface (contour interval = 1m).

of entisoils, generally dating back no more than a thousand years, witnesses instead to a morphological instability that has lasted till the present (Birkeland, 1974 - Regione Emila-Romagna, 1999).

The available pedological data do not permit to fully develop the discussion as to the pedological evolution of these soils. This aspect bears investigating to a greater extent and depth in far more detailed studies in the future.

What clearly seems to emerge is that the more evolved soils are encountered in association with features of the *centuriazione* and that archaeological remains are found close to the surface.

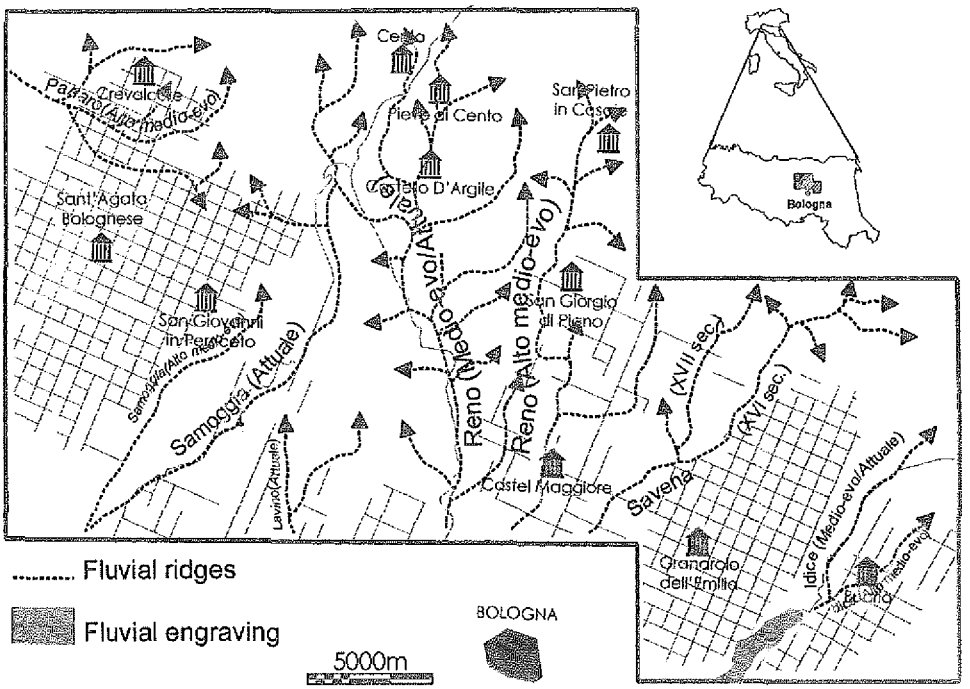


FIG. 4 - Ridge distribution.

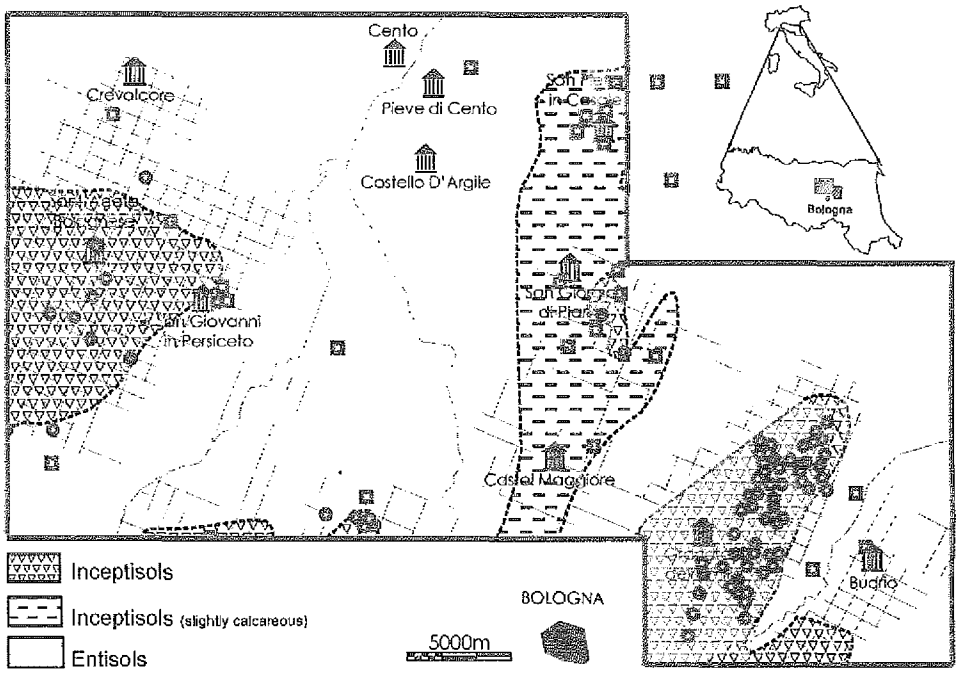


FIG. 5 - Pedological chart.

TOPOGRAPHICAL SECTIONS

So as to better understand the morphological evolution of the area were made three topographical sections. Two of these sections, which are parallel to each other and run in a NW-SE direction at an inclination of 22°, practically match up with the decumans of the Roman grid system, while the third is almost normal to the first two (fig. 6). The sections were purposefully assigned this direction as it was presumed that the Roman grid system had been laid out taking into account the local morphology so that the cardinals must have followed the line of greatest inclination and the decumans the lines of equal height (Chouquer, 1981). This assumption was born out by sections BB' and CC' where the Roman plane is clearly at more or less the same level. This is all the more apparent in section CC' where the ancient plane, whether emerging at the surface or buried, is uniformly at an altitude of around fifteen meters above sea level.

Section BB' goes from Budrio to S. Agata Bolognese covering an overall distance of about thirty-six kilometres. Ridges ascribable to the Savena, Reno, and Samoggia Rivers located at the centre of the section are clearly above the level of the Roman plane. Throughout the section the Roman plane is fairly consistently set at around twenty metres above sea level.

The orientation of section CC', which runs for almost thirty-three kilometres about 3,600 metres further north, is the same as that of the other sections. The Roman plane is at a fairly uniform altitude of between fourteen and seventeen metres above sea level. It crops up between the ridge of the Savena, which was let go in 1776, and the ancient ridge of the Reno, and then becomes submerged under the enormous amount of sedimentary debris carried down by the Reno and Samoggia Rivers.

Section AA' runs for about seventeen kilometres in a SSW-NNE direction. At its highest point to the South the Roman plane is clearly under a light covering of sediments deriving from the Samoggia and Panaro Rivers, while to the North it crops up over a wide area. Towards the final tract the plane drops sharply beneath a considerable amount of sediments deposited by a branch of the Panaro River active up to 1375 (Cremonini, 1987a; Veggiani, 1985). The submergence of the Roman plane continues even beyond the Northern boundary of the section. In fact, Roman tiles have been found at a depth of eight metres near Rivara, a locality a few kilometres North of Crevalcore (Cremaschi & *alii,* 1980).

MORPHOLOGICAL EVOLUTION

Significantly, in areas of ancient soils the Roman grid system is still intact and specimens are to be found at the surface. Vice versa, in areas characterized by recent soils the *centuriazione* is missing and the finds are buried even many metres deep. Moreover, the configuration of the sections is such as to lend support to the contention that the morphology of the area was more uniform during Roman times.

Such uniformity can only be explained by supposing that the ancient courses of the rivers were not pensile, as

FIG. 6 - Topographical sections.

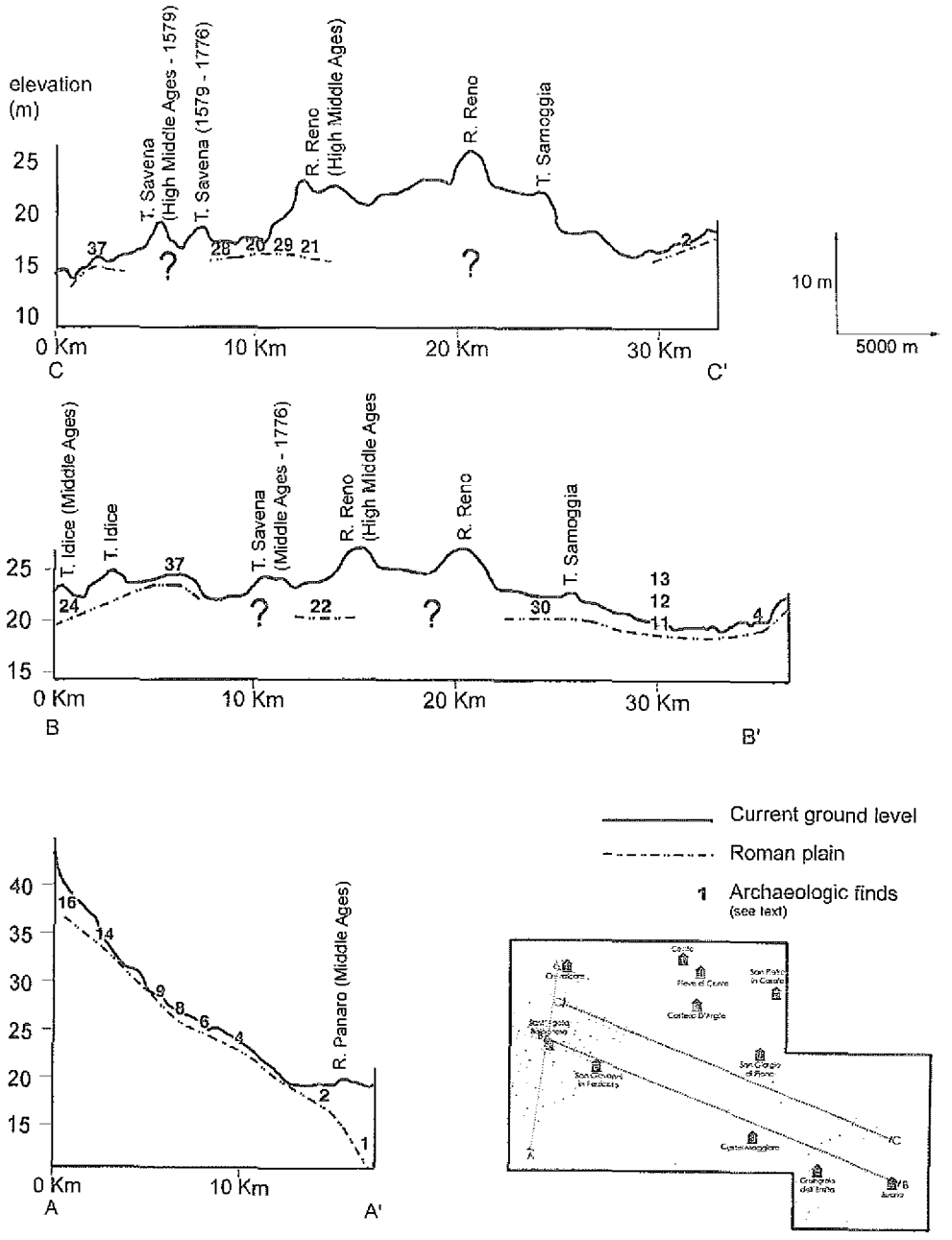


Fig. 6: Topographical sections

instead is the case today. The rivers must have run deep within their beds, as witnessed by the incision of the Idice in the South Eastern part of the area studied.

The contiguity of surface archaeological finds with ones many metres deep down confirms the presence of these incisions, as is the case in the Northern part of section AA' where the Roman plane suddenly sinks down to as many as ten metres below ground level. Different subsidence rates from place to place were once propounded to account for this phenomenon. The presence of ancient erosion surfaces in proximity to streams would however appear to be a far more likely explanation (Veggiani, 1987b).

A number of other observations tend to confirm the presence of these incised surfaces. Where the morphology is characterized by ostentatious ridges the confluence of water courses is inexistent or rare, the only ones to be found in the area being man-made, and namely those of the Savena into the Idice, and the Samoggia into the Reno. The reason for this depends on the generally different sedimentation rates of the major courses compared to those of the tributaries, which means that the beds of the former are above those of latter so that an obstacle is set up inhibiting any confluence. Under such circumstances the minor streams are forced to spill over on to the lower ground lo-

cated between the ridges of the main courses thus swamping the terrain as they are prevented from draining away. This was the scenario in the Emilia-Romagna plain until the first reclamation works, undertaken during the Renaissance, began altering the hydraulic set up of the region. For the tributaries to be able to effectively flow into the major rivers the beds of the latter must be beneath those of the former. Such a condition occurs along certain stretches of the rivers where erosion prevails over sedimentation. If it can be demonstrated that two streams, currently running separately along ridges, were once confluent then it can be reasonably assumed that they both flowed well set deep within their beds (fig. 7).

A number of investigators analyzing the alluvial deposits in terrain located immediately North of Bologna have shown that the Savena once flowed into the Reno (Elmi & *alii*, 1984; Viel & *alii*, 1997). The sediments concerned are deposited at a depth of between twenty and five metres below the level of the surrounding countryside, which coincides with that of the Roman plane. The separation of the two streams presumably took place towards the end of the Roman period or sometime immediately thereafter. The Savena was thus forced to turn Eastward and to run over. It was only towards the middle of the eighteenth century, to prevent the recurrent flooding out of the River over the more sunken areas around Bologna, that its course was artificially deviated and made to flow into the Idice a bit further downstream of where it issued out into the plain. In historical maps, the most detailed of which may be considered that of Andrea Chiesa dating to between 1732 and 1739, the Savena is shown directing itself westward, after reaching the plain, and heading towards the course of the Reno lapping up against the city walls of Bologna. Not being able to overcome the slope formed by the abandoned ridge of the Reno itself, the Savena would then turn eastward thus sprawling out and flooding the lowlands around the current border between the Provinces of Bologna and Ferrara.

Such a massive aggradation, which started to take place more or less towards the end Roman times and resulted in the filling in of the hollows and the subsequent raising of the ridges, can be ascribed to a number of causes, among which the following:

a) Climatic changes. Various phases of climatic deterioration have been recorded over the last millenniums (Orombelli & Ravazzi, 1996). The first, occurring between 3300 and 2500 B.C., marks the end of the hot postglacial era, also known as the Atlantic phase, and corresponds to a period of heightened pedogenesis and stability (Cremaschi, 1987). The second and third phases last between 1400 and 1300 B.C, and 900 and 300 B.C., respectively (Mayr, 1964). Other more recent climatic variations have also been recorded. An optimum secondary climatic characterized by dry and mild weather occurred during the Roman period around 300 and 400 B.C., while conditions deteriorated again between 400 and 750 A.D. (Veggiani, 1987a). According to several authors, during periods of scarce precipitation making for a poor sedimentary load, rivers tend to become entrenched in their beds, whereas in periods of intense rainfall aggradation phenomena occur with deposits being built up in the beds (Cremaschi, 1987; Veggiani, 1983).

b) Variations in river courses. The northward migration of the Po is of great consequence as it is collects the waters of almost all the Apennine Rivers and therefore represents the local base level. It has already been proven by a number of investigators that anciently the River flowed further South (Castaldini, 1989; Veggiani, 1974; Veggiani, 1987b), being a far South as S. Giovanni in Persiceto during the Pleistocene (Gasperi & Pelligrini, 1984). As the main River of the Po Plain moved northwards, even though by only a few kilometres, the courses of the Apennine streams were forced to stretch out. The effect of this was to shorten the average gradient of the main courses of the rivers and consequently to diminish the speed of the current, thus increasing sedimentation.

c) Subsidence. This phenomenon is much more active South of the Po as compared to the North of the Po Plain (Arca & Beretta, 1985; M.U.R.S.T., 1997b), and this may have contributed to large sedimentary build up.

d) Land desertion. This phenomenon probably quickened the process of general morphological upheaval which, in any case, was already under way. Land desertion, initiated around the fourth century A.D., was most certainly caused, in addition to the rampant political and economic disruption of the period, by the frequent river floodings, as recorded in the Chronicles of the contemporary historian Paolo Diacono (Veggiani, 1991).

All the above factors have undoubtedly affected the hydraulic characteristics of the Apennine streams. Which was

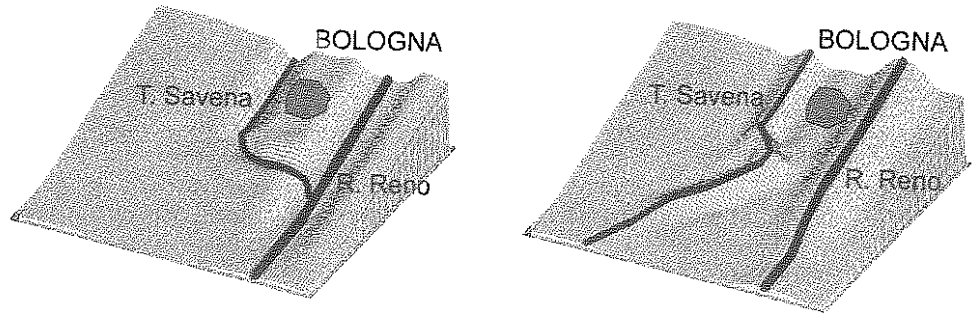


FIG. 7 - Morphological diagram showing how confluent waters tend to diverge under aggradation conditions.

the most prevalent is, at this stage and with the knowledge available, difficult to establish.

The first floodings of the higher grounds can safely be said to have already occurred at least as early as the end of the second century after Christ. Two archaeological finds clearly bear this out. One is a set of farm buildings near S. Pietro in Casale which appears to have been suddenly covered over by sediments without any trace of having been previously abandoned (Ortalli, 1991a). The other is a necropolis discovered just outside the area of the study (Ortalli, 1991b). The phenomenon did not occur all at once, reaching various localities in the plain at different times. The Roman villa close to Russi near Ravenna discovered beneath ten metres of alluvial sediments seems to have been abandoned progressively starting from the fourth century (Scagliarini, 1971). Traces of a waterway, which was probably navigable, have been found at the site, thus confirming that the villa was located on low ground associated with a fluvial incision. Alluvial sedimentations probably began occurring and spreading in a period from between the second and fourth century.

Archaeological specimens Nos. 23, 24, and 25 also provide evidence of this general silting up process. The depth at which these specimens were found (four to seven metres) in a locality near the current incision of the Idice, which is about five kilometres further south, testifies to the fact that the incision must have at one time reached out much further north than its present position. This incision was particularly important as it marked the boundary between two different orientations of the *centuriazione*, namely the Bononia one to the West and the Claterna one to the East.

The aggradation phenomenon continued more or less unabated for many centuries, slowing down only upon the first reclamation works being undertaken. The various settlements were thus slowly covered over, starting from the more low laying ones and those close to the streams.

To gain a clearer picture of the primitive morphology of this part of the plain an attempt was made to work out its ancient altitude above sea level based on the altimetric data from the in situ findings (fig. 8). By means of one metre equidistant contour lines the map thus obtained provides a fairly reliable picture of the features characterizing the plain during Roman times. Owing to a lack of archaeological finds, however, it cannot be said to fully account for the whole area, especially for the central part around the Reno axis.

In any case, the map so derived shows that the ancient morphology south of an ideal line more or less linking Sant'Agata Bolognese and San Giorgio di Piano was very plain and uniform, with the altimetric contour lines running fairly parallel to the axes of the decumans. The undulations appearing in the North suggests the presence of ancient ridges. The most noteworthy is the one ascribable to the Reno next to the modern-day town of San Pietro in Casale, which was most certainly active during Roman times. Another ridge which emerges from the projection North of Sant'Agata Bolognese may coincide with a course once followed by the Panaro.

The depth of the Roman plane below the current ground level was determined by subtracting the digital elevation model of the former from that of the latter (fig. 9). The grey shaded parts in the figure refer to areas of the territory where the Roman plane is to be found buried at less

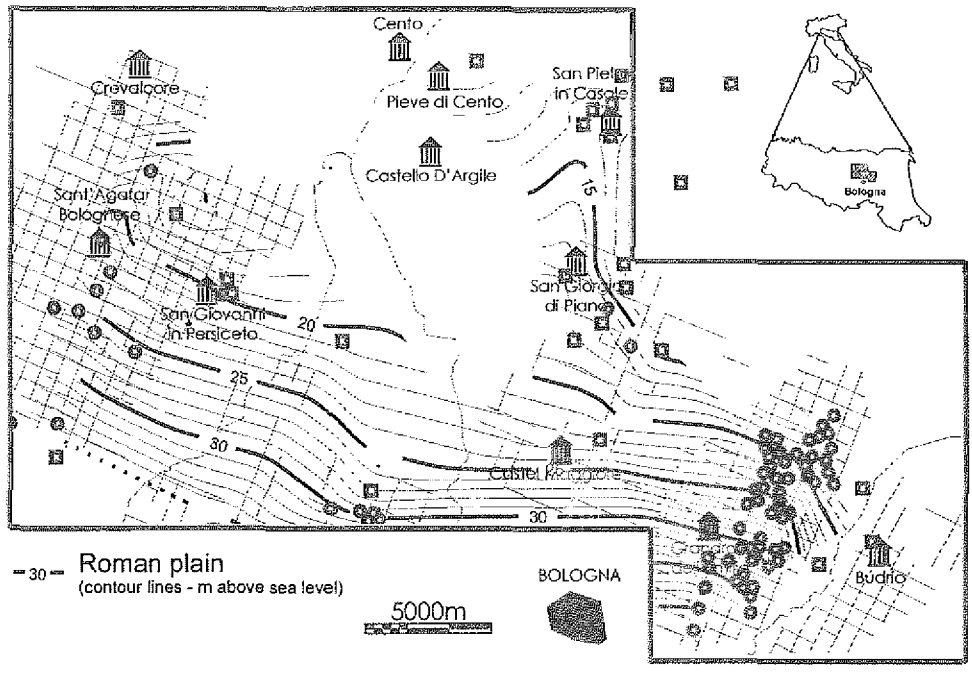


FIG. 8 - Contour map of the Roman plane as inferred from in situ finds.

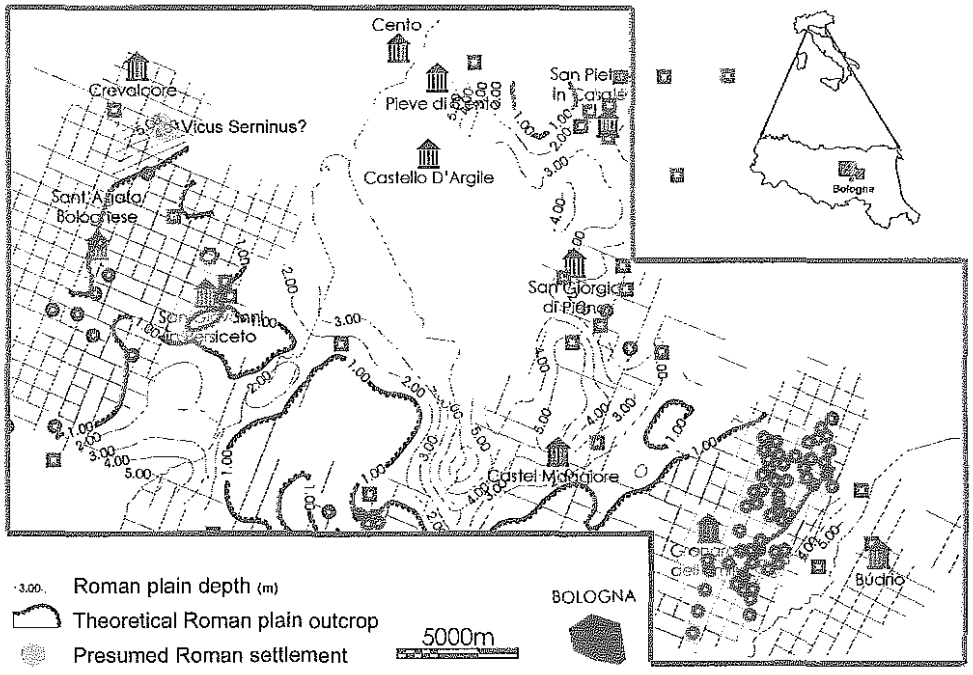


FIG. 9 - Depth of the Roman plane compared to the current surface.

than one metre, while the actual depth below the current ground level is given by the contour lines. The areas of Granarolo dell'Emilia and Sant'Agata Bolognese are once again those where the Roman plane is seen to come up to the surface. The model also shows an emergence of the ancient plane over a vast area between the Reno and the Samoggia. In actual fact, there is no evidence of *centuriazione* and neither have any archaeological remains been found in the top soil, except for some in the Southern part. The only viable explanation for this apparently peculiar circumstance is that there once must have been a fluvial incision, perhaps originating from the Lavino or Samoggia, which was subsequently filled and abandoned as the Reno ridge was gradually built up.

Continued alluvial sedimentation may also be deemed to be responsible for the cancellation of a Roman settlement often mentioned by a number of Latin authors, namely Vicus Serminus. Cited both in the *Itinerarium Antonini* and *Tabula Peutingeriana*, the settlement was located eighteen miles (a Roman mile equalling 1,480 metres) from Bononia, thirteen from Mutina, and twenty from Vicus Varianus (another settlement close to the modern-day municipal town of Vigarano Mainarda at about ten odd kilometres West of Ferrara) (Bottazzi, 1988). On the basis of these three distances, the settlement can most likely be presumed to have been located close to Guisa Pepoli at about two kilometres South-East of Crevalcore (fig. 9). And in fact, many metres of alluvial deposits have built up on this site starting from Roman times up to the Middle Ages.

The fate of Vicus Serminus affords a possible explanation for the survival of only eleven towns out of the twenty-four which, according to Plinius, once existed in the Augustean Region, more or less corresponding to the modern-day Region of Emilia-Romagna. Of the lost cities only two, Claterna and Veleia, have so far been located, while no trace remains of the others (Dall'Aglio, 1997).

CONCLUSIONS

Till about 2000 years ago the Po Plain was morphologically similar to the current landscape North of the Po, in particular in the Lombard Plain, with incisions marking the territory in association with the main waterways. Over the centuries, alluvial sediments have not only filled in the primitive depressions in which the rivers flowed but a good deal of the higher grounds as well. Clearly the settled and gridded territory in this area , which was colonized as early as the second century B.C., is largely buried with only the more marked features surfacing (fig. 10).

At the time of the Roman conquest and colonization of Emilia the hydraulic problems confronting the settlers were scarce, at least in the ten kilometre wide strip North of the Via Emilia, as the rivers flowed below the level of the surrounding plain. If this had not been so, that is if even then the beds of the waterways had been pensile, the natural landscape would have certainly been more similar to that which characterized the region before the great reclamation works of the Renaissance. The Roman settlers would thus have been obliged to carry out extensive reclamation works to provide adequate flood plains and build up suitably tall river banks. In this case the first land to be

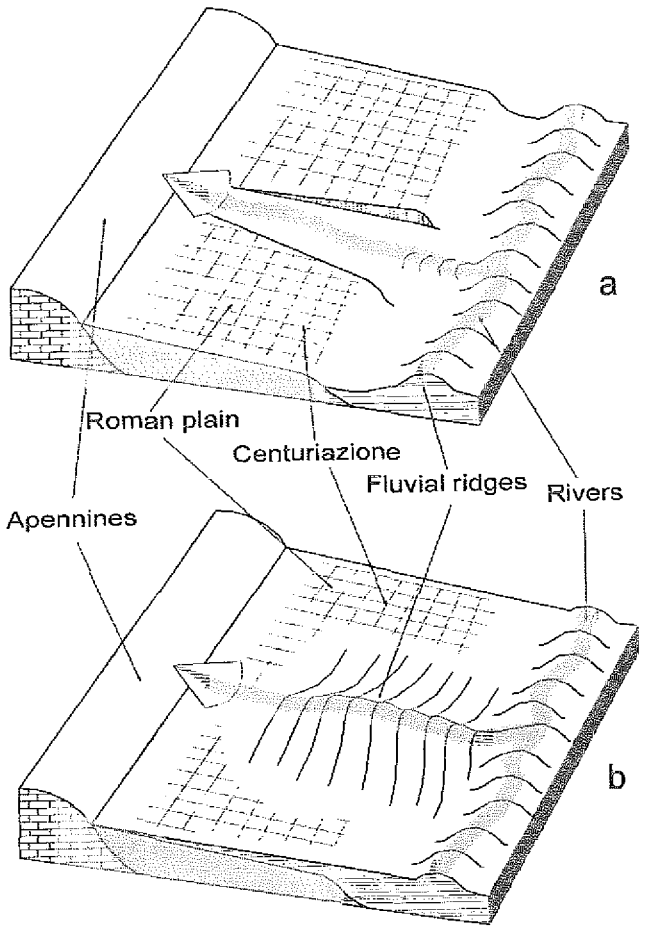


FIG. 10 - Schematic representation of the Roman (a) and current (b) levels of the Bologna Plain.

colonized would have been that on the high ground of the abandoned ridges, while the low ground between the ridges would have been ignored. Pursuant to the principle that any intervention had to take into due account the natural morphology of the territory (*secundum naturam loci*) so as to best ensure run off (Tozzi, 1974), the orientation of the axes of the centuriazione would have varied from place to place depending on the direction of the axes of the ridges. Instead, the centuriazione seems to have been made to favour to the utmost the creation of an extensive, well marked- and laid-out field system, suggesting the absence of any substantial environmental obstacle. It may be reasonably assumed that gridding was made in the stretch of territory South of the ideal line linking Crevalcore with San Giorgio di Piano, where the morphology appears to have been more homogeneous with the rivers flowing deep within their beds below the level of the plain. The pensile waterways probably ran to the North of this area so that this territory was far more subject to inundation (Cremaschi & *alii*, 1980).

The phenomenon of alluvial sedimentation continued up-stream involving various settlements and reaching as far as the outskirts of Bologna, with the neutral point, which represents the border-line between the prevalence of a waterways deposition and erosion activity, considerably retreating (Trevisan, 1968).

As can be inferred from the above considerations, it is utterly impossible to establish the exact hydrographic setup during the high period of Roman occupation; subsequent aggradation has in fact completely obliterated any trace of the ancient river beds so that today it can only be approximately guessed at. All the courses which can still be identified date back to no later than the early Middle Ages, with perhaps the only exception being that of the ancient ridge of the Reno which probably dates back to between the third and fourth century A.D.. A residual trace of the ancient fluvial incisions can however still be identified, namely that of the already cited Idice up-stream of Budrio, which has been perfectly preserved.

REFERENCES

AA.VV. (1994) - *I suoli dell'Emilia-Romagna*. Servizio Cartografico, Regione Emilia-Romagna, 83 pp.

ARCA S. & BERETTA G.P. (1985) - *Prima sintesi geodetica-geologica sui movimenti verticali del suolo nell'Italia settentrionale (1897-1957)*. Boll. Geodesia e Scienze Affini, 44 (2), 125-156.

BIRKELAND P.W. (1974) - *Pedology, weathering and geomorphological research*. Oxford University Press, 285 pp.

BOS R.H.G. & SEVINK J. (1975) - *Introduction of gradational and pedomorphic features in descriptions of soils*, J. Soil. Sci., 26, 223-233.

BOTTAZZI G. (1988) - *Le vie oblique nelle centuriazioni emiliane*. In «Vie romane tra Italia centrale e pianura padana», Aedes Muratoriana, 149-191, Modena.

BOTTAZZI G. (1991) - *Programmazione ed organizzazione territoriale nella pianura bolognese in età romana ed alcuni esiti alto-medievali*. In: Atti del convegno «Romanità della Pianura», Amm. Com. S. Pietro in Casale, 43-113, Bologna.

CASALICCHIO G., GIORGI G., GUERMANDI M., PIGNONE R. & VIANELLO G. (1979) - *Carta pedologica: fattori pedogenetici ed associazioni di suoli in Emilia-Romagna (con carta dei suoli alla scala 1:200.000)*. Collana Orientamenti Geomorfologici ed Agronomico Forestali, Pitagora, Bologna, 144 pp.

CASTALDINI D. (1989) -*Evoluzione della rete idrografica centropadana in epoca protostorica e storica*. in «Insediamenti e viabilità nell'alto ferrarese dall'età romana al medioevo», 114-134, Cento.

CASTALDINI D. & RAIMONDI S. (1985) - *Geomorfologia dell'area di pianura padana compresa fra Cento, Finale Emilia e S.Agostino*. Atti Soc. Nat. Mat. di Modena, 116, 147-176.

CASTIGLIONI G.B. (1999) – *Geomorphology of the Po Plain*. Suppl. Geogr. Fis. Dinam. Quat., III, T.3, 7-20.

CHEVALLIER R. (1960) - *La centuriazione e la colonizzazione romana nell'VIII regione augustea Emilia-Romagna*. L'Universo, 40, 1077-1104.

CHOUQUER G. (1981) - *Les centuriations de Romagne orientale. Etude morphologique*. In «MEFRA», 93, 823 pp.

CINTI G. & GIORGI G. (1989) - *Analisi e ricostruzione della evoluzione morfologica di un'area padana in provincia di Bologna*. Mem. Soc. Geol. It., 42, 21-27.

CREMASCHI M., BERNABÒ BREA M., TIRABASSI J., D'AGOSTINI A., DALL'AGLIO P.L., MAGRI S., BARICCHI W., MARCHESINI A. & NEPOTI S. (1980) - *L'evoluzione della pianura emiliana durante l'età del Bronzo, l'età romana e l'alto medio evo: geomorfologia ed insediamenti.* Padusa, 16, 53-158.

CREMASCHI M. (1987) - *Paleosols and vetusols in the central Po plain (Northern Italia).* Studi e ricerche sul territorio, 306 pp., Unicopli, Milano.

CREMONINI S. (1987) - *La bassa pianura modenese. Evolugrafia dei domini fluviali di Secchia e Panaro.* In: «L'Emilia in età romana», 85-96, Aedes Muratoriana, Modena.

CREMONINI S. (1987) - *Questioni preliminari allo studio morfoanalitico della bassa pianura modenese.* Quaderni della Bassa modenese, I (2), 5-12.

DALL'AGLIO P.L. (1997) - *Il territorio di Cervia in età tardoantica.* In: «Storia di Cervia», *I*, 117-136, Ghigi, Rimini.

ELMI C., BERGONZONI A., MASSA T. & MONTALETTI V. (1984) - *Il territorio di pianura del Comune di Bologna: aspetti geologici e geotecnici.* Giorn. Geol., ser. 2, 46 (2), 127-152.

FORTE M. (1991) - *Il territorio a nord di Bologna nella età del ferro.* In: Atti convegno «Romanità della Pianura», Amm. Com. S. Pietro in Casale, 1-22, Bologna.

GASPERI G. & PELLEGRINI M. (1984) - *Strutture geologiche e idrografiche della bassa pianura modenese.* In: Atti convegno «Mirandola e le terre del basso corso del Secchia», 76-114.

GIORGI G. (1990) - *Elaborazione dei dati altimetrici nello studio della geomorfologia di pianura: l'area di Granarolo dell'Emilia.* L'Ateneo Parmense-Acta Naturalia, 26 (3-4), 153-164.

GIORGI G. (1996) - *The digital elevation model of the bolognese and ravennate plain (Italia).* Proceedings 1st European Congress on Regional Geological Cartography and Information Systems, Bologna, 1, 369.

GIORGI G. (1998) - *Evoluzione morfologica della pianura bolognese.* Atti 79° Congr. Naz. S.G.I., Palermo, 494-497.

MAYR F. (1964) - *Untersuchungen über Ausmass und Folgen der Klima und Gletscherschwankungen seit dem Beginn der postglazialen Wärmezeit.* Zeit. Geomorph., 8 (3), 257-285.

MINOZZI MARZOCCHI M. (1991) - *Carta archeologica preliminare della media bassa pianura bolognese.* Atti convegno Romanità della Pianura, Amm. Com. S.Pietro in Casale, 115-145, Bologna.

M.U.R.S.T. (1997a) - *Carta geomorfologica della Pianura Padana.* S.E.L.Ca., Firenze.

M.U.R.S.T. (1997b) - *Carta altimetrica e dei movimenti verticali del suolo della Pianura Padana.* S.E.L.Ca., Firenze.

OROMBELLI G. & RAVAZZI C. (1996) - *The late glacial and early Holocene: chronology and paleoclimate .* Il Quaternario, 9, 439-444.

ORTALLI J. (1991a) - *L'impianto rustico produttivo di età romana dagli scavi del centro sportivo di S. Pietro in Casale (Bologna).* In: Atti del convegno «Romanità della Pianura», Amm. Com. S.Pietro in Casale, 175-193, Bologna.

ORTALLI J. (1991b) - *Il sarcofago romano da Maccaretolo (S.Pietro in Casale, Bologna).* In: Atti del Convegno Romanità della Pianura, Amm. Com. S. Pietro in Casale, 147-173, Bologna.

PAOLETTI M.L. (1989) - *Continuità della centuriazione: fossi filari e strade.* In: Catalogo della mostra «Misurare la terra: centuriazione e coloni nel mondo romano», 261-267, Ed. Panini, Modena.

REGIONE EMILIA-ROMAGNA (1999) - *Carta geologica di pianura dell'Emilia-Romagna.* Ufficio Geologico della Regione Emilia-Romagna, Bologna.

SCAGLIARINI D. (1971) - *La villa romana di Russi (Ravenna). Campagna di scavo 1969.* In «La villa Romana. Giornata di Studi», 117-142, Faenza.

SCARANI R. (1968) - *Osservazioni sulla documentazione archeologica del comprensorio fra San Giovanni in Persiceto e Nonantola.* Strada Maestra, 1, 19-29.

SILVESTRI E. & PILETTI F. (1982) - *Insediamenti romani nelle maglie centuriali di Budrio e Castenaso.* In: Atti della giornata di studi «Il territorio di Budrio nell'antichità», 26-47, Comune di Budrio, Budrio.

TOZZI P. (1974) - *Saggi di topografia storica.* Pubbl. Fac. Lett. e Fil. Univ. Pavia, 19, Firenze.

TREVISAN L. (1968) - *I diversi tipi di alvei fluviali e la loro evoluzione.* Acc. Naz. dei Lincei, Quaderni, 112 pp.

VEGGIANI A. (1974) - *Le variazioni idrografiche del basso corso del Po negli ultimi 3000 anni.* Padusa, I-II, 22 pp.

VEGGIANI A. (1983) - *Degrado ambientale e dissesti idrologici indotti dal deterioramento climatico nell'alto medioevo in Italia. I casi riminesi.* Studi romagnoli, *34*, 125-146.

VEGGIANI A. (1985) - *Esame delle cause antropiche dei dissesti idrogeologici e delle variazioni idrografiche della pianura Padana indicate da Leandro Alberti (1479-1553) nella «Descrittione di tutta Italia».* Atti S.IT.E, 979-982.

VEGGIANI A. (1987a) - *Territorio, Ambiente, Clima. Le trasformazioni nei tempi protostorici. Emilia-Romagna: parte orientale.* Studi e documenti di Archeologia, 3, 73-80.

VEGGIANI A. (1987b) - *Stratigrafie archeologiche e abbassamento del suolo nella pianura emiliano-romagnola.* Studi Romagnoli, 38, 331-352.

VEGGIANI A. (1991) - *Fluttuazioni climatiche e trasformazioni ambientali nel territorio imolese dall'alto medioevo all'età moderna.* in «Imola nel medioevo», 41-102, Imola.

VIEL G., TOMASSETTI C., MONTAGUTI M. & FRASSINETTI G. (1997) - *Pianificazione ambientale delle aree metropolitane: il bolognese, primi risultati.* in atti del convegno «Geologia delle Grandi Aree Urbane», 24-28, Bologna.

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