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SOIL AND ARCHAEOLOGICAL EVIDENCES OF THE PERIODS OF THE TELL DEVELOPMENT OF SZÁZHALOMBATTA-FÖLDVÁR

Abstract - The reconstruction of 4,000 years of history – from the middle Early Bronze Age (2000 BC) till present day – became possible on the Százhalombatta tell and its environment with the coordination of the archaeological finds with changes within the soil cover. The field survey and the drillings demonstrated a number of changes that had taken place in the area in various ages. The soil samples were analysed for some soil properties like texture, $CaCO_3$ content, humus content and total P content. It was possible to follow the changes in time not only on the tell itself but within the fortification ditch as well. During the Bronze Age (2200-1400 BC) (Raczky *et al.*, 1992), the accumulation of cultural layers was 4 m on average. Each of the coring samples from this 4 m-thick sequence was extremely rich in phosphate. Assuming that the tell was inhabited for more than 800 years, average phosphate content represents an annual accumulation of 1 t of bone.

Key words - Soil formation, tell, P intake, Bronze Age, Hungary.

Riassunto - *Suoli e archeologia dei periodi dello sviluppo del tell di Százhalombatta-Földvár*. La ricostruzione di 4.000 anni di storia – dalla Media Età del Bronzo (2000 a.C.) ad oggi – è stata possibile per il tell di Százhalombatta e l'ambiente circostante per mezzo dell'integrazione dello studio dei reperti archeologici con quello delle variazioni della copertura dei suoli. Ricognizioni di campagna e perforazioni hanno posto in evidenza una quantità di mutamenti che hanno avuto luogo nell'area in varie epoche. Sono state analizzate le caratteristiche pedologiche di campioni di suoli, quali tessitura, contenuto in $CaCO_3$, humus e P totale. È stato possibile ricostruire i mutamenti non soltanto nell'area del tell, ma anche nel fossato difensivo. Durante l'Età del Bronzo (2200-1400 a.C.) (Raczky *et al.*, 1992) si sono accumulati in media 4 m di livelli culturali, e ciascuno dei campioni carotati da questa sequenza si è dimostrato estremamente ricco in P; assumendo che il tell sia stato abitato per più di 800 anni, il contenuto medio in fosfati rappresenta l'accumulo di 1 tonnellata di osso per anno.

Parole chiave - Formazione del suolo, tell, accumulo di fosforo, Età del Bronzo, Ungheria.

INTRODUCTION AND GEOGRAPHIC AREA

It is a common place to say that human activity leaves an imprint not only on its environment but on the soil as well. As we all know the soil is like a book; it keeps a good record of all kinds of activities that affected its structure. In our case this activity is the human impact on the site, which started four thousand years ago and was continuous until just recently.

The understanding and interpretation of the complete history of the Százhalombatta-Földvár is more complex than that of the customary one-layer archaeological sites (Vicze, 2000). The site itself is situated on a high plateau on the right side of the bank of the Danube River. This plateau actually is the northern-most end of the Mezőföld, which is the name of the high, elevated western part of the loess-plain comprising the centre of the Carpathian Basin. The loess predetermined the human history of this site. Human communities settled here due to the presence of the loess, and on the other hand owing to the high, elevated location of the site, dominating over the surrounding landscape.

METHODS

Soil samples were analysed for a number of soil properties. These included soil texture, characterised by the K_A index, $CaCO_3$ %, humus %, and total P (Füleky, 1973). Other properties were also recorded, but principally the above-mentioned were used when drawing conclusions. The upper limit of plasticity according to Arany (K_A) is an index which describes soil texture and thus indicates whether the soil in question is sand, loam or clay. Values of this index of less than 25 indicate coarse sand, 25-30 sand, 30-38 sandy loam, 38-42 loam, 42-50 clay loam, 50-60 clay and > 60 heavy clay. With the help of this index it is possible to determine where an unknown soil layer originated, and whether it was always located in its present position. Obviously, this requires the knowledge of the original geological and soil structure of the given area, which can than be compared with the investigated layer. In the case present it is very important to find the grey sand layer with a K_A value of around 30, since this formed the last soil surface prior to the Bronze Age. The lime content ($CaCO_3$ %) and the pH, which are closely correlated with it, are important chemical properties of the original geological and soil layers, so they play a significant role in the identification of unknown layers. The determination of the value of K_A is important since the soil texture only changes very slightly in the course of natural soil development. On the other hand, neither the lime content nor the pH remain constant during natural soil development and human intervention. Changes in these two properties compared to the values of the original layers generally indicate the effect of natural process-

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es. Two other important characters of the soil are the humus content and the phosphorus content. The values of both may gradually increase in the course of natural soil formation, depending on the climatic conditions; the humus layer thickens or deepens, or the quantity of humus increases with time in a given surface layer. A higher humus content is generally indicative of a long period of surface or subsurface exposure. In other words, it is usually possible to draw conclusions about natural processes from the humus content. By contrast, the total phosphorus content is an excellent indicator of human activity. The quantity of phosphorus in Hungarian soils is generally around 1,000 mg kg^{-1} (Füleky, 1983). If higher or much higher values are recorded, this can only be attributed to human activity. It can be said that the total P quantity is directly proportional to the intensity of the activities of the humans living on the area, the length of time the area was inhabited, the population density and the diet of the inhabitants (Füleky, 1994).

Results

During the beginning of the second millennium BC small human communities entered the Carpathian Basin from the South, introducing a special way of life, including a new settlement system and economy (Bóna, 1961, 1962, 1992). The primarily agrarian-based economy of those communities was based on the very fertile loess. A small social group of this society settled on the high bank of the present-day Százhalombatta and with that launched the four-thousand-year-long history of the site. These first human settlers picked the location of their site very carefully. The area chosen was a relatively secluded area, with natural borders like the small stream on the western and southern side, an erosion ditch on the North and the River Danube on the East (Poroszlai, 2000; Vicze & Nagy, 2003). During this initial phase of the settlement's history a relatively intense erosion of the top soil could be documented. This was partly due to the surface clearance and partly due to the first building structures like the storage and/or debris pits, and the small ditch bordering the settlement (Varga, 2000), which were all cut into the sub soil (Fig. 1a, b).

However the construction of the houses had an opposing effect. For the first time, during the Bronze Age, houses were built with the use of non-organic material, *i.e.* clay, as well. Thus a wooden frame of posts and beams was plastered all over (even the floor) with yellow clay (Poroszlai, 1996, 2000a) found in the nearby stream valley (Wallace, 2001). With this wattle-and-daub building technique the prehistoric houses could be turned into long-term living quarters. This and the excellent fertility of the soil made it possible for the community (and all the other similar communities on the Great Hungarian Plain) to stay and live on the same location for more than 800 years (Bóna, 1992). In case a house had to be rebuilt it was done on top of the levelled remains of the previous one (Vicze, 1992). This permanent living resulted in the accumulation of household debris leading to the build-up of an artificial mound, archaeologically called a tell. The development of the settlement and that of the community is well reflected in the growth of the site both vertically and horizontally. By the time around 1500 BC the settlement reached its largest Bronze Age extension (Fig. 2a).

This was the period when the erosion ditch to the North of the settlement was turned into a 5 meter deep fortification ditch (Vicze excavation reports 2001-2002) and connected to the natural stream-bed situated on the western and southern side (Tab. 1). The village or rather its more rural section extended over on the other (north-north western) side of the major ditch construction (Varga, 2000: Fig. 4).

At the end of the Middle Bronze Age (Fig. 2b) a major change occurred in the social and political framework within the Carpathian Basin, which resulted in the abandonment of the permanent tell-settlements (Bóna, 1958; Kovács, 1975). From this moment onwards the accumulation of cultural layers stopped and the nature of the human impact became of a different kind. After the abandonment of the tell site, natural erosion started to take effect for a couple of centuries, until the strategic location of the place became important again for the people of the Late Bronze Age around 1000 BC (Fig. 3a) (MRT 7; Poroszlai, 1993; Holport, 1993; Vicze & Nagy, 2003).

By this time the big fortification ditch appears to have filled up at quite a fast rate (Vicze excavation reports 2001-2002). Both the economy and way of living of the society of this period differ immensely from those of the earlier times (Kőszegi, 1988). The households are more complex and contain several structures, including much smaller and half-sunken houses, with pits and other specialised outer buildings like hearths, barns etc. These houses are constructed mainly from organic matter with a much smaller amount of earth and clay as a building material (Marton, 1996). If a house of this period collapsed the owners moved on to another location within the settlement. The inner settlement pattern thus is dispersed with the households spaciously placed from one and other (Horváth *et al.*, 2003). The function of the partly filled Middle Bronze Age fortification ditch is not clear, although it seems to be used as a natural debris area (Vicze excavation reports 2000-2001). The dawn of the Iron Age brought no difference in the way of living and building traditions (Fig. 3b). The only change in the over all settlement pattern is that by this time the total area of the plateau was occupied and the natural bank of the stream on the north-western side of the site has been artificially enforced (MRT 7). With this primary fortification they created the earliest phase of the huge Late Iron Age (Celtic) fortifications visible even today (Vicze & Nagy, 2003). Sometime during the late Iron Age significant changes occurred within the structure of the society, which was most probably reflected within the change of the settlement structure. Beside the reinforcement of the outer fortifications with stones, wooden frames, and wooden parapets, inner divisions from earth-works were constructed as well (Harding, 1986). One of these inner walls made good use of the faint remnants of the Bronze Age fortification

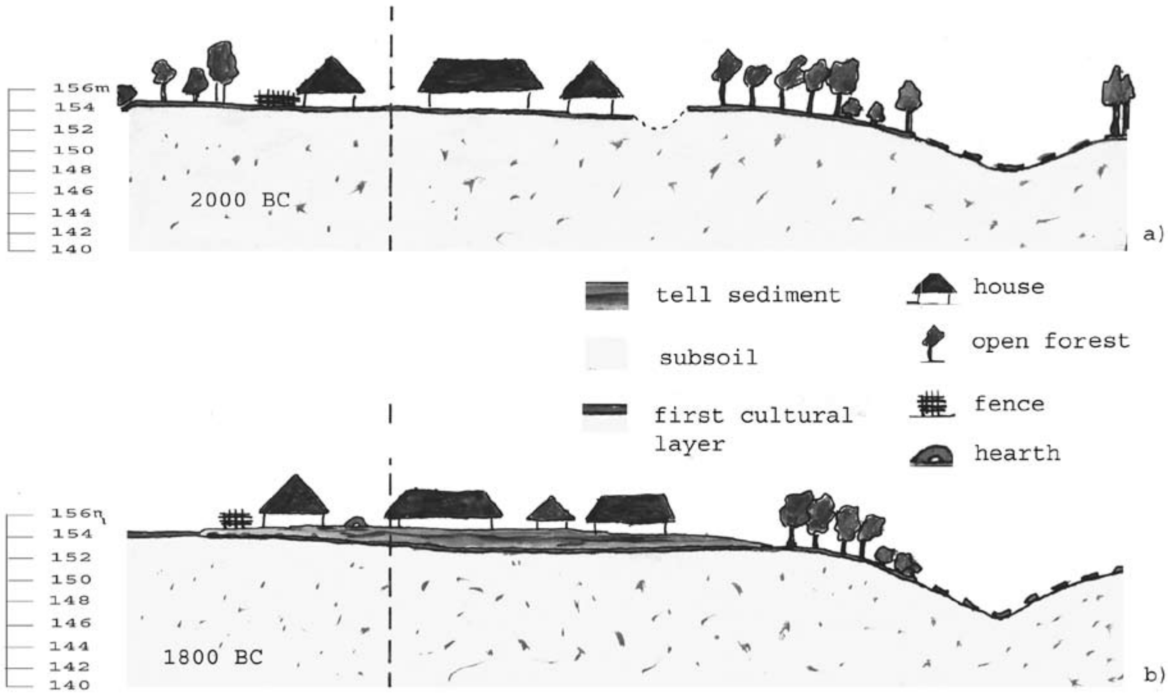

Fig. 1 - The hypothetical view of the tell and its immediate surroundings between 2000 BC and 1800 BC.

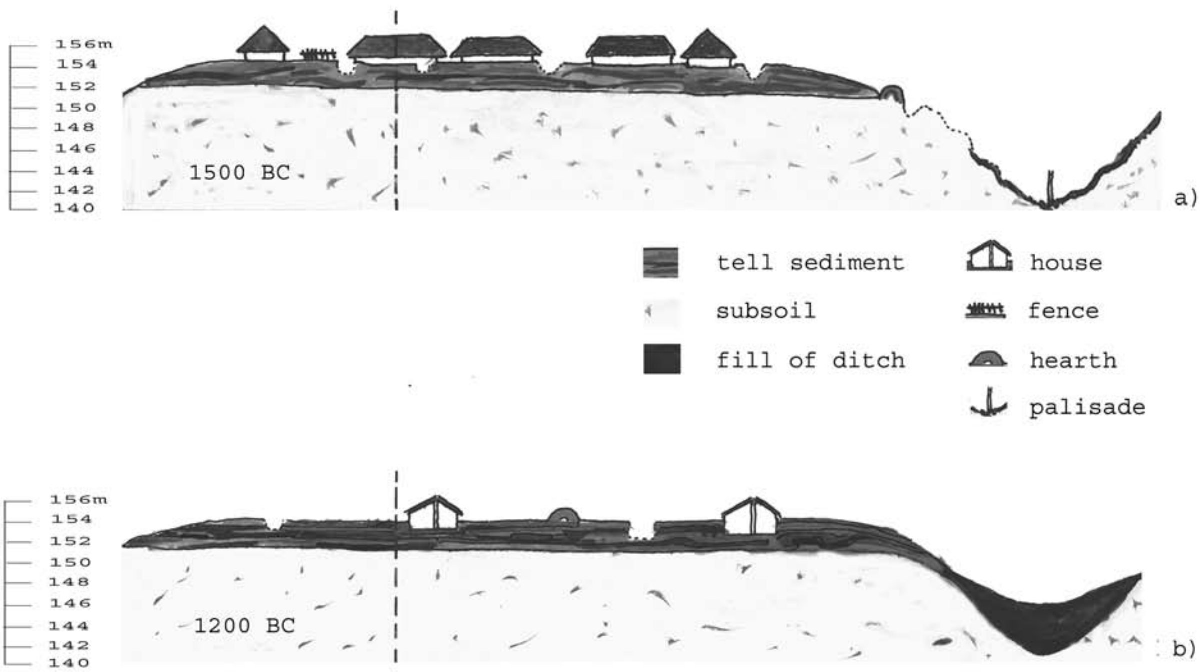

Fig. 2 - The hypothetical view of the tell and its immediate surroundings between 1500 BC and 1200 BC.

Tab. 1 - Analytical data of soil samples taken within the ditch.					
Sample	**K_A and texture**	**pH_{KCl}**	**$CaCO_3$ %**	**Humus %**	**Total P (mg kg^{-1})**
F 1	37 sandy loam	7.14	13.9	1.23	3,046
F 2	37 sandy loam	7.25	14.3	0.7	2,697
F 3	35 sandy loam	7.17	18.9	0.42	1,784
F 4	36 sandy loam	7.11	15.5	1.16	2,985
F 5	36 sandy loam	7.07	12.5	2.45	3,526
F 6	39 loam	7.56	17.1	0.75	2,916
F 7	36 sandy loam	7.71	16.2	0.95	3,412
F 8	35 sandy loam	7.80	16.2	0.95	2,578
F 9	39 loam	7.90	17.2	1.08	3,056
F 10	33 sandy loam	7.55	17.4	1.25	2,834
F 11	33 sandy loam	7.28	26.1	0.83	1,126
F 12	33 sandy loam	7.40	16.9	0.92	2,256
F 13	36 sandy loam	7.25	18.5	1.07	3,298
F 14	37 sandy loam	7.20	19.4	1.37	2,494
F 15	35 sandy loam	7.24	19.1	1.88	2,665
F 16	33 sandy loam	7.29	11.7	2.34	2,639
F 17	33 sandy loam	7.28	10.1	2.33	2,738
F 18	36 sandy loam	7.60	21.2	1.22	2,452
F 19	31 sand	7.46	17.9	1.55	1,790

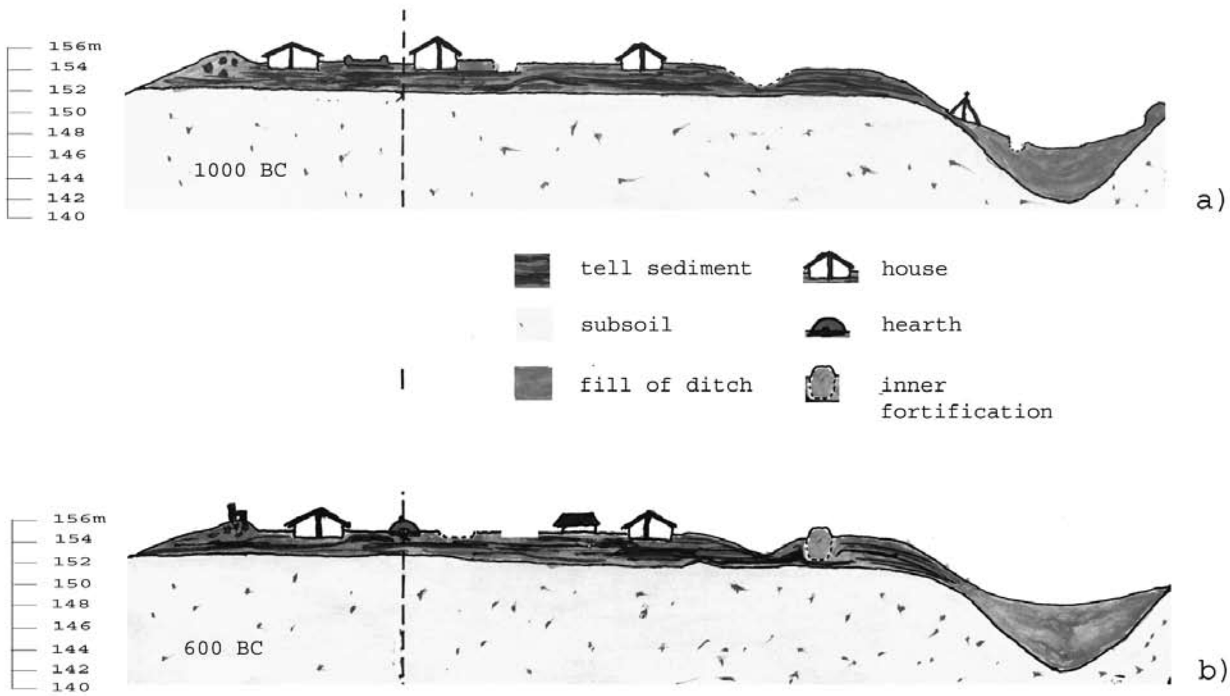

Fig. 3 - The hypothetical view of the tell and its immediate surroundings between 1000 BC and 600 BC.

ditch. The Iron Age small wall and its ditch run parallel to the Bronze Age one. The remains of the Bronze Age ditch had a double use during this time. One was probably a natural draining function, the other is to give more emphasis to the Celt-period wall. With the end of the Iron Age the outstanding impact of the location has ended as well.

During the Roman period the River Danube was used as one of the main trading arteries of the Empire, thus sites for military camps and settlements were close to the water with good harbour possibilities. Other sites with high banks, such as our site, were used for lookout-post only. The foundation of a small Roman watchtower oriented towards the river was found on the Bronze Age part of the site (Fig. 4a) (Vicze & Nagy, 2003).

The archaeological history of the Százhalombatta site ends here, but as was mentioned at the beginning, the soil records all human activities. While we were concentrating on understanding the function and the several erosional phases of the Middle Bronze Age ditch, it became apparent that most of the deterioration of the site happened during the last 200 years (Vicze, 2001). First the creation of vineyards during the XIX century damaged the top 80-140 cm context of the whole site (Fig. 4b). The farmers soon realised that the remnants of the Bronze Age ditch could be turned into an ideal warm pocket, so they levelled and terraced the whole area by taking the soil from the side of the Bronze Age tell settlement. Nevertheless, the main destruction of the South part of the original site started with the foundation of a brick factory in 1893. The clay, which was perfect for the wattle-and-daub houses of the Bronze Age, seemed also to be perfect for modern bricks and tiles as well. Between the foundation of the factory and its final termination in 1981, the clay mining had already removed a good part of the Bronze Age tell and the probable Southern half of the Iron Age fortification (Fig. 5).

Concerning the present morphology of the site we had to realise that the brick factory was not just destroying the site on one hand but was re-building it on the other. The top 4-5 m of the clay quarry (actually including the Bronze Age tell) was a «useless» disturbance for the mine, so it had to be cleared away. This way, all the disturbed soil was removed from the top of the Southern side and was re-dumped on the Western side of the site, thus raising the surface on top of the earliest prehistoric settlement by two meters (Fig. 5).

All the above cited structural and morphological changes in time and space could be followed and reconstructed with the close co-operation between archaeology and soil science (Füleky, 2001).

Before the first Early Bronze Age settlers the area was covered with woods, as proved by the presence of the B horizon of the original soil beneath the archaeological deposition (Tab. 2).

4,000 years ago the people of the Early Bronze Age settled on the A horizon of this soil, which was more sandy in some places, and loess in others. Beneath the

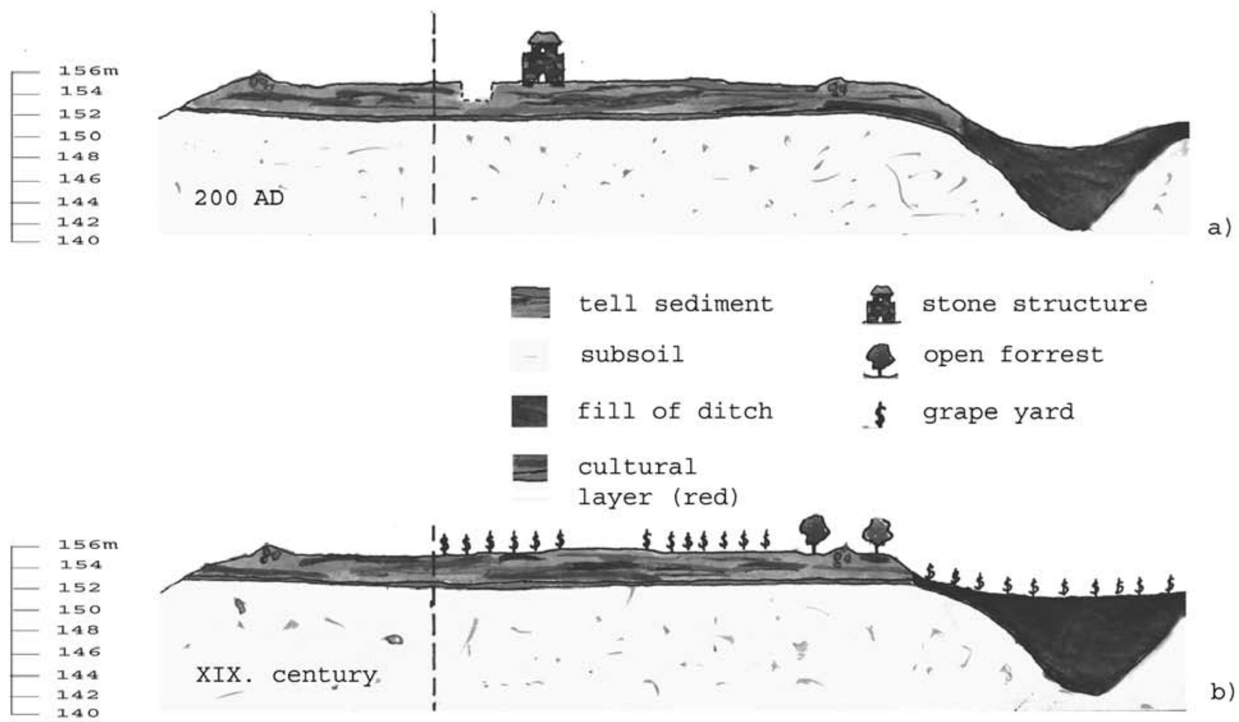

Fig. 4 - The hypothetical view of the tell and its immediate surroundings between AD 200 and in the XIX century.

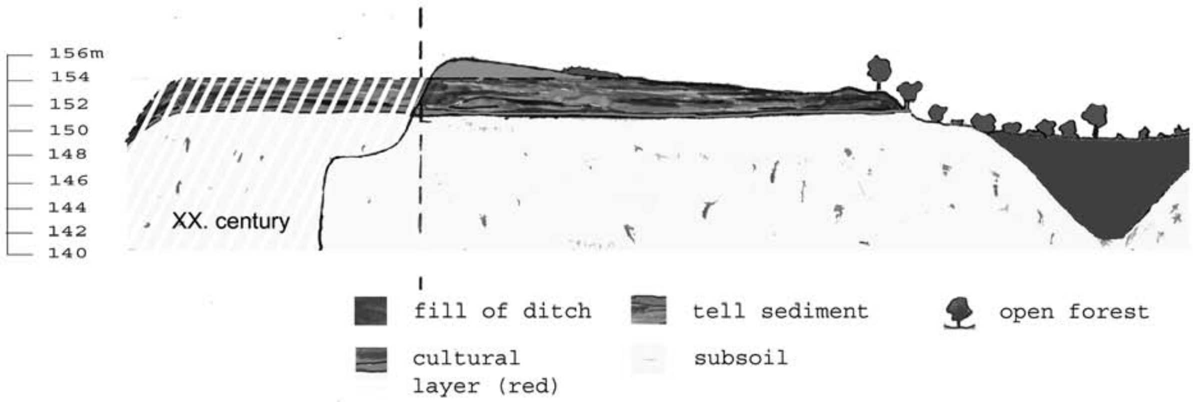

Fig. 5 - The hypothetical view of the tell and its immediate surroundings in the XX century.

Tab. 2 - Soil and geological profile below the western part of the Bronze Age tell settlement.

Horizon (cm)	Soil layers	K_A and texture	$CaCO_3$ %	Humus %	Total-P (mg kg^{-1})
A_{cult} 0-140	Brown mixed	38 loam	10.5	1.88	2,004
A 140-160	Brown	30 sand	1.1	0.80	791
B 160-190	Reddish-brown	32 sandy loam	0.6	0.44	670
C 190-240	Grey sand	30 sand	20.6	0.31	779
240-250	Iron crust	37 sandy loam	11.6	0.10	488
250-	White tubercular limestone	45 clay loam	40.9	0.30	730
-	Grey loamy marl	47 clay loam	21.8	0.14	725
-	Grey clay marl	-	-	-	-
-	Greyish yellow marl	-	-	-	-

tell most frequently the already mentioned brown B horizon was present, but in other places only the grey-white sandy base-soil could be detected, indicating the original soil surface (Fig. 6).

During the Bronze Age the accumulation of cultural layers was 4 m on average. Each and every coring sample of these 4 m was extremely rich in phosphate content (Tab. 3).

On average this measure was 4,000 mg P/kg while in the A horizon of the original soil this was 1,000 mg P/kg. All this indicates a very intensive human occupation on the tell. Besides this the high concentration of phosphate allows us to calculate the amount of food resources consumed in the settlement.

Calculation of the phosphorus balance

On average, the phosphorus content of the soil rose from an initial value of 1,000 mg P/kg soil to 4,000 mg P/kg soil. During this period the mass of the soil increased by 35,000 t in the tell.

An increase of 3,000 mg P/kg soil (= 3,000 g P/t = 3 kg P/t = 3 t P/1,000 t) for 35,000 t soil is equivalent to $3 \times 35 = 105$ t P.

Among the foodstuffs and building materials used by the inhabitants, wood contains 0.1% P, vegetables contain 0.1% phosphorus, while bones contain 12% P.

Assuming that the 105 t P accumulated on the area of the tell derived only from bones, this would require 871 t of bones.

Assuming that the tell was inhabited for more than 800-year, this represents an annual accumulation of 1 t of bones.

Coring in the centre of the settlement indicated the presence of an inner circular ditch. The examination of the soils from these samples made it possible to identify the overlying cultural layer, which comprises the floor and wall remains of the prehistoric buildings.

The analyses of the soil made it possible to follow the changes in time not only on the tell itself but within the fortification ditch lying beside it as well (Tab. 1).

The different processes of the original digging, re-digging, and both natural and artificial filling of the ditch could also be observed in the soil fills of the ditch. The comparison between the excavated finds and the humus-, texture-, pH-, lime-, and phosphate content of the soil samples gave evidence for the age of the soil depositions.

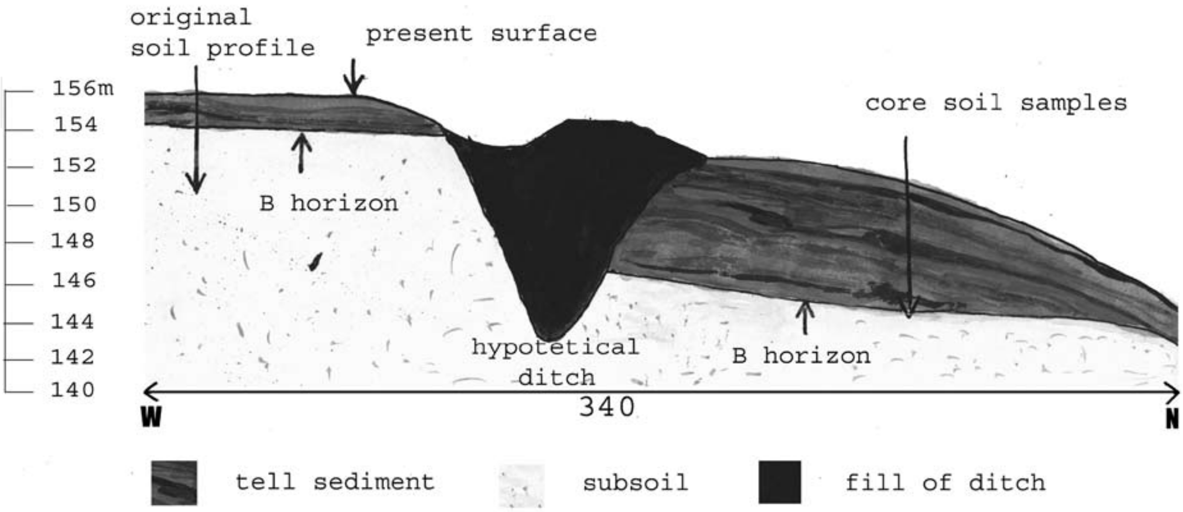

Fig. 6 - E-W cross section of the tell.

Tab. 3 - Analytical data of soil samples taken within the area of the Bronze Age tell at Százhalombatta. The coordinates of the drilling are 34/70-115.

Depth (cm)	K_A and texture	$CaCO_3$ %	Humus %	Total P (mg kg^{-1})
0-70	44 clay loam	19.71	1.95	4,641
70-110	48 clay loam	21.69	2.00	5,317
110-175	44 clay loam	16.56	1.95	6,301
175-205	42 clay loam	12.66	1.31	5,358
209-237	42 clay loam	17.09	1.63	5,727
237-275	43 clay loam	21.39	1.48	4,595
275-283	45 clay loam	20.75	1.35	4,968
283-353	36 sandy loam	11.03	0.87	2,783
353-390	42 clay loam	18.04	2.35	3,655
390-405	34 sandy loam	2.72	1.13	1,095
405-440	37 sandy loam	2.44	0.42	1,009
440-465	39 loam	22.20	0.23	928
465-	34 sandy loam	21.49	0.41	1,173

The morphological analysis of the area showed that in some instances natural erosion-ditches formed the bases for the later artificial ones.

Conclusions

The reconstruction of 4,000 years of history – from the middle of the Early Bronze Age (2000 BC) till present day – became possible on the Százhalombatta tell and its environment by the co-ordination of the archaeological finds and by following the changes within the soil cover.

The analyses of the soil made it possible to follow the changes in time not only on the tell itself but within the fortification ditch lying beside it as well.

During the Bronze Age the accumulation of cultural layers was 4 m on average. Each coring sample of these 4 m was extremely rich in phosphate content

All this indicates a very intensive human occupation on the tell. Besides this the high concentration of phosphate allows us to calculate the amount of consumed food resources on the settlement.

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