

THE SURROUNDINGS AND THE AGE OF THE UPPER PALEOLITHIC SITE ON SUSAK ISLAND

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Abstract

Our study investigates the paleoenvironmental conditions of an Upper Paleolithic site found in the excavation of the North Adriatic Susak Island. Our research explores the range of the loess and loess-like sediments deposited on rudist limestone which is the substratum of the island. We studied the Quaternary sediments by a coherent paleoenvironmental assessment method. The geomorphological and the various chronological analysis contribute significantly to the extension of our knowledge on the paleoenvironmental conditions of the Upper Paleolithic site (Radiocarbon age is $31,830 \pm 720$ yr BP) on Susak Island.

Keywords: paleoenvironmental changes, Quaternary sediments, Paleolithic sites, Susak

1. Introduction

Loess and loess-like sediments covering the rifts on Susak Island in the Kvarner Gulf.

Susak as large as 3.76 km^2 is an island (Photo 1) in the archipelago located in the Kvarner Gulf (Fig. 1). Its highest point is situated at 98 m a.s.l. A characteristic limestone bench divides the island into a higher northwestern part (60–98 m a.s.l.) and a lower-lying southeastern part (30–50 m a.s.l.), (Fig. 2).

The island is covered by loess and loess-like sediments in varying thickness (50–90 m) depending on the altitude of the underlying rocks, namely the Cretaceous rudist limestone, and in a smaller northeastern area, Eocene karstic rocks.

The loess and the loess-like sediments on Susak Island (Photo 1) belong to the loess formations of the Northern Mediterranean Sea. According to Coudé-Gaussens G. (1991), the Northern Mediterranean loess sediments

can be considered as the local facies of the European periglacial loess, whereas the Southern Mediterranean loess, for instance the loess sediments at the edge of Sahara, can be classed among the desert loess sediments. The loess sequence on Susak Island is one of the most complete eolian sediment occurrence found only in some places in the region of the Dalmatian Islands. The Northern Mediterranean sediment series deposited under periglacial conditions, while the North



Photo 1. The lower surface of Susak loess island (30–50 m a.s.l.) (Photo by Schweitzer, F.)

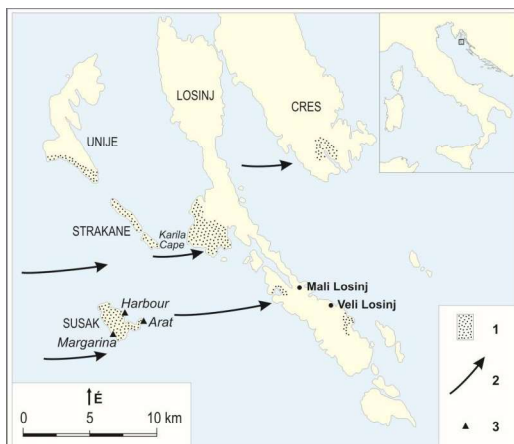


Fig. 1. Susak Island and its neighbourhood in the Kvarner Bay (after Cremaschi 1991)

1. Loess and loess-like sediments
2. Wind directions during loess sedimentation
3. Excavation sites on Susak Island

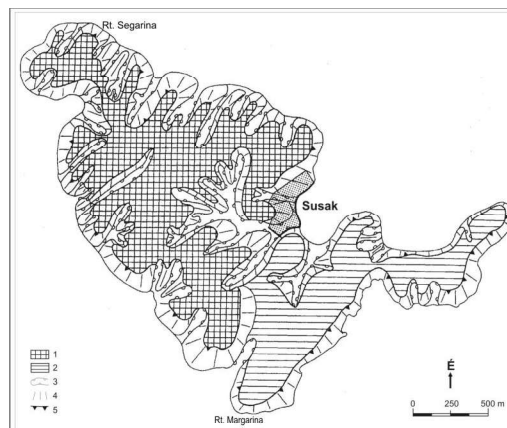


Fig. 2. Geomorphological map of the island

1. The higher level of the plateau (60–98 m a.s.l.)
 2. The lower level of the plateau (30–50 m a.s.l.),
 3. Valleys
 4. Loess bluffs with landslides
- (Kis - Schweitzer 2000)

African sediment series accumulated at the edge of the deserts during pluvial periods (Coudé-Gaussen 1991).

The loess and loess-like sediments occur in both coastal areas of the Adriatic Sea surrounding the whole Mediterranean Basin, namely on the Dalmatian Islands, along the Dalmatian Coast, in the Alpine Foreland, in the Po Plain and in smaller extent in Marche and in the Appenines (Cremaschi 1987, Schweitzer - Kis 2003).

The silt-sized material of the loess and loess-like sediments occurring on the coastline and on the islands of the Northern Adriatic Basin originates from the materials of moraines and outwash plains at the foreland of the Alps and the Appenines. The dust was carried as far as the Po Plain via aeolian, fluvio-glacial and fluvial transport processes (polygenetic theory). During the glacial periods of the Pleistocene the dust continued its journey upon the wings of the western winds from the Po Plain through the Northwestern Adriatic Basin completed dried up because of the falling ocean levels (Fig. 3). The loess originates mainly from the dried up bed sediments of Po River. During the Last Glacial Maximum the level of the Adriatic Sea was 100 m lower than today (in the Northern Adriatic Basin the sea level does

not exceed 50 m even today). The streams of the Po Plain and the outlet glaciers of the Alps were extended in the dried up Adriatic Basin. According to De Marchi (1922) (Fig. 3), during the last glacial period the surroundings of Susak Island was part of the Po Plain having been extended from the current seashore by several hundreds of kilometers in southeast direction. According to Gazzi et al. (1973) and Cremaschi (1990), the loess was blown from the opposite side of the basin towards the island by southwestern winds. The North Adriatic loess deposits owing to the abovementioned circumstances of origin are more weathered than those in the Carpathian Basin, hence they don't completely cover the classical definition of loess.

2. Materials and Methods

We carried out field investigations not only on Susak and Lošinj but also in the Po Plain and in Istria where we studied the excavations and the artifacts. We performed excavation works and levelling as well. The geochemical, sedimentological (traditional and new parameters), geomorphological and comparative chronological analyses produced remarkable results.

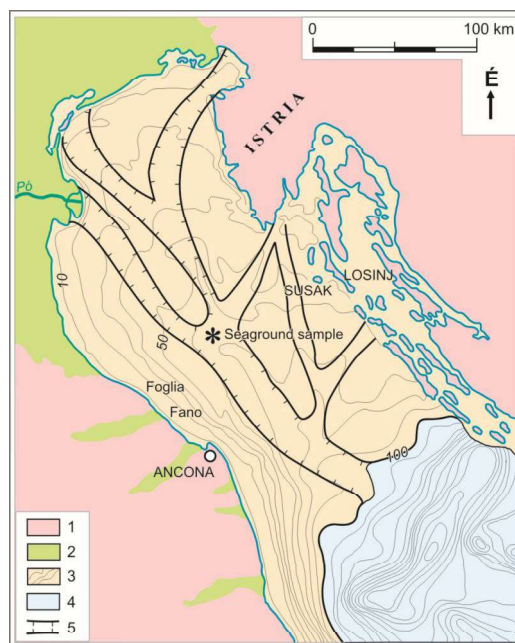


Fig. 3. The locations of Susak Island and the Po Plain during the last glacial period (after Cremaschi, M. 1991)

3. Results

On Susak and on the Dalmatian Islands the loess deposited over fossil sand dunes and abrasion terraces (karstic plateau, Cretaceous rudist limestone) covering terra rossa soils. An evidence for the origin of the loess on Susak Island (Photo 2) is the types of clay minerals in the deposits, namely the prevalence of illite (southern foreland of the Alps) or that of vermiculite (the foreland of the Appenines). The presence of acidic and decalcified loess sediments at the edge of the Alps and the Appenines refers to an already low calcium carbonate content of the sediments prior to the leaching processes. The loess sediments on Susak Island have similarly low CaCO_3 content (10–14%) in contrast with the loess deposits in the Carpathian Basin which have 20–38% CaCO_3 content. Considering the results of the geochemical and the sedimentological analyses of the Susak loess sequence, for instance the clay mineral paragenesis, chlorites and mixed illite-montmorillonite structures can be identified. The smectite



Photo 2. Loess sequences at the Bay of Bok overlying Mesozoic limestone (Photo by Kis, É.)

clay minerals can be found mainly in tephras, whereas the kaolinite formed only in the red clay substratum.

Considering the carbonate mineral paragenesis, both dolomite and calcite occur in the profile. An analysis by Szöör (2003) highlighted that diagenetic formations are cemented by calcite, but dolomite accumulation can also be observed in two horizons of the profile. Based on the results of the thermal treatments, most of the sediments can be classified as protodolomite facies.

During the colder periods of the Late Pleistocene Middle Italy, the Adriatic Basin and partly Northern Italy were characterized by grassy steppes. The pollen and fauna analyses carried out in the region of Gorgona (Cremaschi 1990; Cremaschi et al. 2015) revealed two distinctive ecoregions developed under the moderate changes of climatic conditions:

1. very dry grassy steppe dominated by *Graminaceae*, *Artemisia*, *Compositae* and *Liguliflorae*
2. steppe with *Pinus* and *Betula* species, as well as warm-loving floristic elements

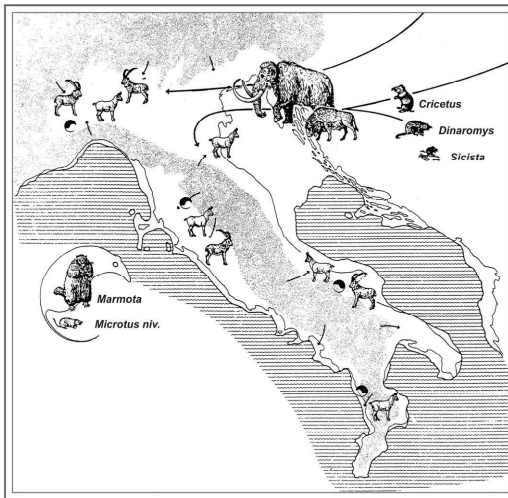


Fig. 4. The migration of mammals during the coldest period of the Late Pleistocene (Sala 1990)

The mollusc-based paleoecological investigations (Fig. 4) and the anthracological analysis of mainly *Pinus sylvestris* samples of the Susak loess sequence carried out by Sümeg (2003) and Rudner (2003) partly confirmed the Italian researchers' results (Cremaschi 1990). According to Sümegi (2003), the faunal analysis of the Susak loess sediments did not find any evidences for the presence of cold-loving faunal elements, but the vertebrate palaeontological finds (Photo 3 and 4) of an Istrian collapsed cave contains marmots, *Microtus arvalis*, *Rangifer tarandus* etc. species (Lenardić 2014) (Fig. 4).

However, the exact spatial coverage and the temporal range of the two ecoregion types have not been clarified yet (Fig. 5).

Several 1–2 m long, distinctive charcoal strata starting from SIII soils and charcoal fragments being rather combustion products than the result of peat formation can be found in the Susak loess excavation (Rudner – Sümegi 2001; Rudner 2003). The burning process can refer to either the location of a Paleolithic fireplace (Photo 5) or spontaneous combustion under dry conditions.

Considering the results of the stable isotope analysis, we can conclude that the red and reddish clays (Schweitzer 2003, Szöör 2003, Kis 2003) locating at the lower part of



Photo 3. Excavation in Marlera (Photo by Kis, É.)



Photo 4. Stone tools, excavation in Marlera (Photo by Schweitzer, F.)

the profile developed under warm and humid conditions, whereas the diagenetic limestone (rhizolites, benches) formed under warm and arid climatic conditions. From among the fossil soils, the red clays and the reddish brown soils evolved in the pre-glacial and interglacial periods, while chernozem soils developed during the interstadials of Würm glaciation. The presence of the diagenetic

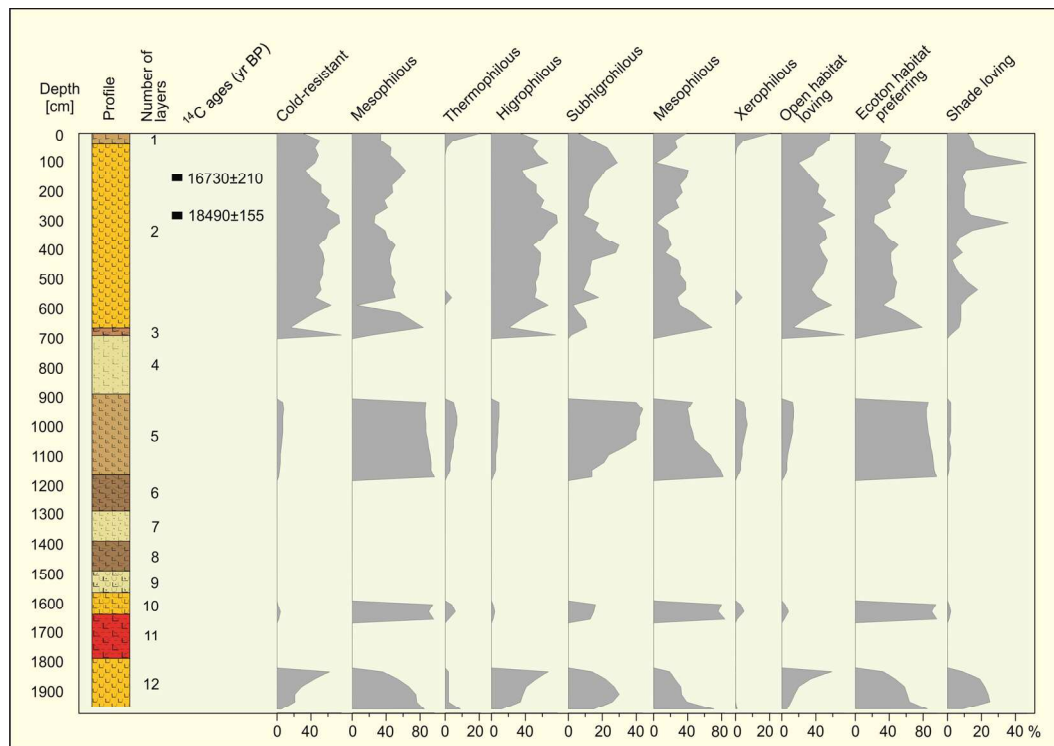


Fig. 5. Figure by Domenance changes of the different palaeoecological groups of mollusk species from the loess sequence at Susak Island (Sümegei 2003)

sphaerulas of the red clay substratum implies to mainly subtropical, warm and humid climate. The fossil soils differ from each other to a great degree. The upper part of the profile consists of sandy skeletal soils, chernozem soils. The middle section includes forest soils, while the lower part is built up by reddish soils. The fossil soil development is in relationship with the warm and humid climatic events, whereas the gypsum and hematite deposits located in the upper part of the profile developed under warm and dry climatic conditions. $\text{Ca}(\text{OH})_2$ and portlandit in the upper part of the profile are the results of the intensive summer evaporation under recent climatic conditions.

As a result of the comparative investigation of chernozem soils based on the semi-pedological analyses we can conclude that the fossil soils located in the 21 m thick upper part of the Susak profile slightly differ from the chernozem soils belonging to similar pedogenetic type in the

Carpathian Basin. The Susak profile includes several thin chernozem horizons which are either embryonal soils or semipedolites accumulated in a dell. Nevertheless, it can be established based on ^{14}C and TL analyses that the chernozem horizons are as old as 31 000 – 39 000 BP years though their precise chronological classification necessitates further investigations.



Photo 5. Charcoal horizons locating above SIII. double soils (Photo by Schweitzer, F.)

Paleolithic sites, soils, tephra horizons, charcoal strata

The Upper Pleistocene loess (Würm loess, Val Sorda loess) including charcoal strata, soils, tephra horizons and in some places Paleolithic sites, for instance in Triest, Sandria, Visoghiano, Susak, Marlera, etc., deposited in several phases.

We found stone tools in the upper double soil horizon in the excavation in Bok Bay on Susak Island (Photo 2, Figure 6, Photo 6, 7, 8). Around the artifacts charcoal fragments and burnt, brick-red loess deposits can be found. According to Ringer (2003), who established the age of the findings, the assemblage is not younger than Middle Paleolithic.

In our opinion, the loess deposit divided (93.3 ± 7.0 ; 98.3 ± 7.3 IRSL) (Wacha L. et al. 2011) by the third tephra horizon (TF 3) comes from the earliest substage of the Würm (Bognár et al. 2003). The latest interglacial soils are partly missing along with the upper-lying, loose sediments of the Riss stage owing to the abrasion processes initiated by the rising sea level during the last interglacial period. Only a calcareous, strongly cemented strata remained untouched which is, in our view, the remnant, or the so called "detritus" of the CaCO_3 accumulation horizon of the last interglacial soils (Photo 2).

At the beginning of the Würm stage the sea level severely decreased again resulting in the expansion of lands which indicated the start of the Würm loess formation 93 000 –

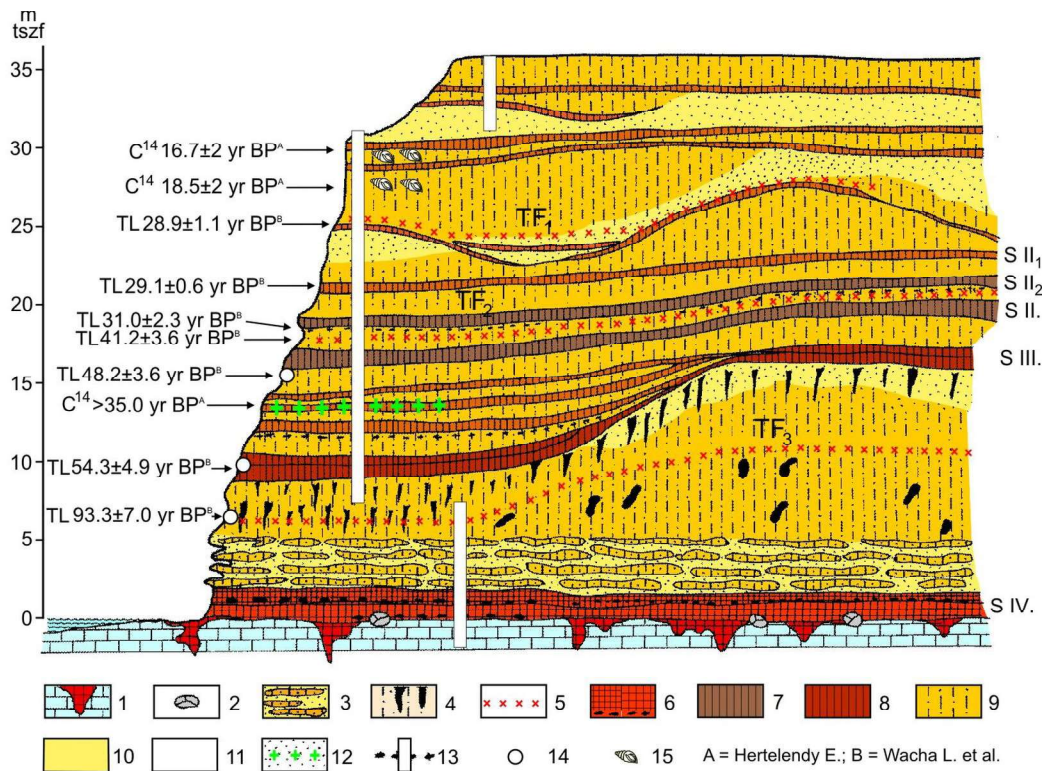


Fig. 6. A geomorphological cross-section of Susak (Compiled by Schweitzer 2000)

- 1 = Mesozoic (rudist) limestone, with infillings of typical red clay in the karstic depressions;
- 2 = ventifact; 3 = sandstone bench; 4 = loess with loess dolls; 5 = tephra horizons (TF1, TF2, TF3);
- 6 = reddish clays horizons of CaCO_3 accumulation; 7 = chernozem paleosols;
- 8 = reddish brown forest soil; 9 = sandy loess; 10 = sand; 11 = charcoal horizon;
- 12 = charcoal horizon with ^{14}C dating; 13 = sampling sites along the Susak profile;
- 14 = Paleolithic artifact finds; 15 = ^{14}C datings of Mollusc fauna



Photo 6. Susak key section with Paleolithic Site
(Photo by Kis, É.)

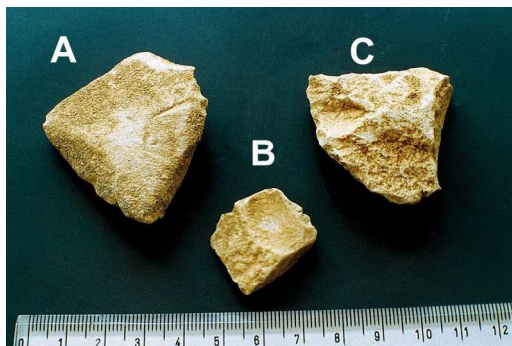


Photo 8. Worked Paleolithic artefacts recovered from Susak (Photo by Schweitzer, F.)



Photo 7. Position of Paleolithic artefacts in fossil chernozem soil (Photo by Schweitzer, F.)

98 000 years ago (IRSL) (Wacha et al. 2011) and the end of the last interglacial period. The loess formation continued until the end of Late Pleistocene.

According to Cremischi (1990), even in the Late Pleistocene (Younger Dryas) broad, loess-covered plains evolved in the Po Plain and in the Italian and Croatian coastal area of the Adriatic Sea. In the Upper Pleistocene the sea level of the Adriatic Sea was 100 m lower than the Croatian and Dalmatian seashores (Melik 1952). At the end of Pleistocene, the polar ice sheets and the mountain glaciers started to melt. As a result of that the Holocene sea level started to rise. Currently, in the surroundings of Susak Island the sea is as deep as 10–40 m.

The middle and upper thirds of the profile are divided by fossil soils, semipedolites, characteristic tephra strata, sandy loess,

buried quicksand dunes, skeletal soils of interdunal depressions (Fig. 6, Photo 2). Fossil soils and semipedolites differ from each other considering their formation circumstances. Fossil soils evolve under warm and humid climatic conditions, whereas the semipedolites develop under arid conditions.

4. Discussion

The results of ^{14}C analysis suggest that the site is of Upper Paleolithic ($31,830 \pm 720$ yr BP), however, other applied methods indicate older age, namely not younger than Middle Paleolithic. In the framework of further investigations, we would like to make a comparison between the Austrian, the Hungarian and the Serbian artifacts cooperating with archeological and Paleolithic experts.

5. Conclusions

In the course of data interpretation a wealth of information could be obtained on climate changes during the past 100 000 BP: extremes of warming and cooling by layers were fixed, lithological units, periods of and gaps in sedimentation identified, boundaries of layers drawn, in situ and redeposited sediments distinguished, circumstances of formation cleared.

For a deeper understanding of the Susak layers the traditional sedimentological parameters were studied together with granulometric parameters newly introduced in Hungary: F_g (finness grade) and K_d -index (degree of weathering). These parameters have been considered as environmental indicators.

Using the above methods 31 horizons were identified along the Susak profile: 11 paleosol layers, 4 sand layers, 13 layers of loess and loess-like deposits, 3 tephra horizons.

Mollusc fauna did not contain any cold tolerant elements at all. This points to a basic difference between the Susak loess and the central and west European loesses where a large amount of boreal-alpine or northern Asian species were recovered from profiles of similar age in general and from loess layers in particular.

From the profile of Susak loess-paleosol sequence human artefacts have been recovered. Recrystallised limestones served as raw material of implements. Based on the technology of elaboration the artefacts cannot be younger than the second half on middle Paleolithic. They represent a modest contribution to the Paleolithic of the Mediterranean.

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