CHAPTER 3

Environmental aspects of the DSP landscape

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3.1 INTRODUCTION | P. ATTEMA

In this chapter various aspects of the environment in the study area are discussed. In particular its geology, hydrology, soils and present land use are dealt with. A basic understanding of the environment and of (sub) recent patterns of land use aids in the explanation of the settlement patterns revealed by the survey and in hypothesizing on related forms of land use in the past (see Chapter 6).

Section 3.2 sets out with an introduction of earth science aspects pertaining to the limestone geology of the study area to which a blanket of dust (loess) was added during the last Ice Age. This is followed by a discussion of climate and natural vegetation. While the geology was mainly studied on the basis of literature and maps available to us, the discussion of climate and vegetation incorporates data from a pollen core taken in Lake Džarylgač in 2005 in a palaeo-environmental project directed by V. Stolba (reported on in Section 3.4). The chapter then moves on to a general discussion of the geomorphology, hydrology and soils in the study area.

In Section 3.3 the focus is on the survey transect. In this section a land type classification is presented compiled by J. Delvigne with W. de Neef on the basis of the former's fieldwork during the 2008 campaign. In the transect Delvigne discerns five land types: (a) the Plateaus/Uplands, (b) the peninsular Hillsides, (c) the Pediment, (d) the Coastal Lakes, and (e) the Lowland Ridge. These are systematically described and include observations in the field.

Part of the fieldwork for this classification consisted of hand augerings. These were carried out in transects in order to obtain soil profiles of the Pediment and Lowland Ridge land types. Also on selected archaeological sites hand augerings were carried out. These served mainly to establish the presence of possible subsurface archaeological deposits, but were also of help in the general reconstruction of soil cover in the transect. Soil augering data of the transects and their locations are presented in Appendices 3.1-4.

Finally, a brief description of (sub) recent land use is given providing insight in the environmental and socio-economic context in which the archaeological record nowadays is found (Section 3.4). Of known biases that affect the recovery of archaeological sites the contrasting surface visibility in the DSP landscape between the ploughed zone and the peninsular Hillsides is the most prominent factor (see Chapter 2.3.1). This is due to the on-going extensive ploughing of the Pediment and Lowland Ridge following the introduction of large scale farming during the Sovjet period. In the present survey this has led to a relatively high recovery rate of pottery scatters in this zone compared to the peninsular Hillsides and the Plateaus/Uplands.

The data that were used to write this chapter derive from the study of literature and maps as well as from field work. Since the available time was limited the picture we present here can only be preliminary. Nonetheless this chapter provides useful information for an evaluation of the settlement evidence found in the survey and its relation to the agricultural potential of the past landscape.

3.2 INTRODUCTION OF EARTH SCIENCE ASPECTS | J. DELVIGNE

3.2.1 Geology | J. Delvigne

In the research area, only limestone is found as bedrock (Fig. 3.1). The oldest limestone is Sarmatian (Middle and Upper Miocene) of age, followed by Meotian and Pontian limestone in the Upper Miocene. After uplift of the area, a planatian surface began to develop in the Early Pliocene, covered by a red weathering loam. Rapid uplift occurred after the deposition of Meotian and Pontian limestone. Following the minor folding that was present in the limestone, three low ridges were formed on the planation surface, running in a SW-NE direction. Differential tectonic movement at the end of the Pliocene and the beginning of the Pleistocene encouraged erosional processes, and during further uplift of the Plateau, gullies were cut, the weathering mantle was removed and, especially in the western parts, dissection took place (Embleton 1983, 387). The research area, situated in the N part of the Uplands, was only slightly dissected.

The Sarmatian limestone of the uplifted central Plateau area is almost horizontally bedded. Because slope angles are small, many dipslope situations, that is gentle slopes created by erosion of the tilted strata, occur.

Where deposits of sharp-edged fragments of limestone and shells are found along ancient coastlines of uplifted blocks, they have the characteristics of fan and delta deposits. These deposits mark locations where rivers flew out into the sea. These rivers cannot have been very long because hardly any rounding off of bedload material is found in these deposits. Because of the angular shape of their components, these deposits have a rather open structure, cemented together at their contact points.

The third geological unit in the research area is unconsolidated loess deposits (Eolian loam) dating from the last and possibly also from the second last Ice Age. This fine-textured material was blown here from more barren, cold desert surfaces that were present at that time in large parts of the continent to the N. This dust was then trapped in the more vegetated tundra fringe around the cold desert. Loess deposits have a characteristic yellow colour, show hardly any bedding and cover the landscape like a blanket. Its original thickness varied and depended to a large extent on the position of the receiving location in the wind field and the local small-scale relief. The leeward side of hill tops typically received a thicker blanket than the windward side. On the hill top itself less loess was deposited because of higher wind speeds there and a drier surface that is difficult for dust particles to adhere to.

Apart from the general loess 'blanket', a few more sizable bodies of loess were encountered that were used as quarries. Loess was probably used to even out farm floors and possibly in the more recent past to bake bricks. These bodies of loess can be over five m thick and for instance 50 m wide. They are interpreted as completely filled in parts of small valleys or of filled-in solution holes in the surface of the limestone. Both examples have been places of considerable local relief in a landscape with predominantly little relief.

The fourth geological unit comprises deposits associated with the sea in the Holocene period. They consist of lagoonal clays, and of the sands of spit barriers and dunes. In the research area they can be found in the Lake Panskoe – Lake Džarylgač region.

Also dating in the Holocene are small occurrences of river deposits in valley floors close to the sea. Some terraces may be distinguished in these deposits.

3.2.2 Geomorphology and hydrology | J. Delvigne

3.2.2.1 Geomorphology

The research area encompasses part of the central Uplands of the Tarchankut Peninsula and part of the coastal zone N of it, between Černomorskoe and Vodopojnoe.

The Uplands constitute an assemblage of well-rounded, not very high ridges, running in a WSW-ENE direction and surrounded by plateau-like surfaces. These surfaces probably represent a period of little or no upheaval in the general uplift of the area, causing the forming of a coastal terrace. The highest ridge in the area is the Tarchankut ridge SE of Černomorskoe with a crest at about 170 m altitude. The ridge that acts as the divide of the peninsula, E of Černomorskoe, has a crestline at about 130 m. Slopes in the Uplands are very gentle and reflect the slightly undulating bedding of the limestone, causing many dipslope-situations. On the limestone surfaces the initial stages of karst phenomena like sinkholes and small dolines can be found (Fig. 3.2).

The land type connecting the Uplands to the coastal zone is formed by the relative steep, sea-facing slopes that represent a period of rapid uplift in between the quiet period that caused the planation of the Plateau at about 130 m and a quiet period with little uplift of recent times. Some ravines are carved into the steepest parts of the slopes and disappear at the lower end of the slopes, where the Pediment begins.

The larger part of the coastal zone is occupied by a wide valley, running in an almost W-E direction and cut by the coastline at a small angle. Lakes and lagoons like Lake Panskoe, Jarylač Bay and Džarylgač Lake are found in this filled-in valley. Inland of the coastal zone, the wide valley narrows into a river valley with marked incised meanders.

NE of the village Mežvodnoe begins the low coastal ridge that separates the N side of the filled-in valley from the sea. Marine erosion accentuated the coastline here by cutting a cliff in the limestone rock.

3.2.2.2 Hydrology

Water in the steppe-climate of the region is supplied in the first place by rain fall with an average annual precipitation between 350-650 mm. In spring, the soil underneath might still be frozen and impervious, giving rise to surface runoff. Some erosion by rivers as well as slope wash can therefore still take place in the present climate.

How much of the surplus of surface water enters the cracks in the limestone underneath will depend largely on the thickness of the loess cover. At a geological timescale, the limestone has not been above sea level for a very long time and will not have developed a large cave system underground. Nevertheless, the water in the soil may stay and flow there in two ways: in the open spaces in shellrock and in cracks in the rock, especially where the flow is confined by clay layers, as is the case in the lower parts of the Sarmatian limestone. There, lines of settlements sometimes mark the contact between clay and porous limestone where groundwater emerges. Because of its open structure, shell rock is a natural aquifer. The water carries enough oxygen to oxidize iron compounds, giving the shellrock its typical yellow colour. The relationship between rock type, rock structure and topography on the one hand and the location of springs and wells on the other, is rather complex and requires a separate study (Fig. 3.3). Most natural wet spots are stretches of valley floors where vertical erosion is blocked by a hard layer and small stones and fine earth are trapped. By digging out these stretches, the valley floor is brought even closer to the groundwater level and may become pools of open water, suitable to water cattle.

3.2.3 General aspects of soils | J. Delvigne & W. de Neef

Soils can be looked at as the types of loose material below the ground surface: the soil material, and as the typical vertical sequences of properties in this loose material: the soil profile.

3.2.3.1 Soil material

Where the land surface is made up of limestone, physical weathering will have attacked this rock and fragmented it into smaller pieces, acting to a large extent on natural bedding planes and folds. In the research area frost action will have been responsible for most of the fragmentation, especially before the deposition of loess in the last Ice Age. Further transport of these smaller pieces down the slope is made easier this way, just as subsequent solution of the rock fragments by the slightly acid rainwater and by organic acids in the soil. As far as solution is concerned, signs of this process are rather scarce, though some beginnings of karstic phenomena like sinkhole depressions were observed.

This dissolution of limestone may add small amounts of non-soluble impurities like clay and Fe- and Mn-oxides to the soil material. Another component of the soil material in the steppe-environment is organic matter that results from the biochemical break-down of dead organic (mainly plant) material. This component also plays an important role in the soil profile and will be discussed there. Finally, to the soil material on any rock type will be added small amounts of windblown dust (loess).

The Crimea lies near the southern fringe of the loess belt. Here, the original thickness of the loess blanket will have been less than two m (Velichko & Nechayev 1984). Loess has a loam texture. Mineralogically, the majority of the particles consists of quartz. Other components are clay, mica, Fe- and Mn-oxides. Fresh loess also contains carbonates and, due to the Fe-oxides, has a yellow-ochre colour (10YR 4/4-6/4). In the present climate, loess can only be weathered any further by solution of the carbonates and the vertical displacement of the Fe- and Mn-oxides. Loess is, however, susceptible to erosion by wind and, in a semi-arid climate especially, to slope wash by running water.

Weathered limestone and loess are the two basic types of autochthonous soil material on the Hillsides and Plateaus of the research area. However, in many places of this area a vertical sequence of soil materials was found that proved to be characteristic of certain parts of the area and may be called a third, partly autochthonous and complex, type of soil material. It can be described as a veneer of weathered limestone on top of a layer of no more than a few dm of loess that is resting on weathered limestone. This three-layered soil profile is sometimes called a triplex soil. The origin of this sequence must be that a thin layer of loess was, at the end of the last Ice Age, deposited on the existing, weathered Pediment. On the upper parts of the Pediment and the slopes above, hardly any loess was deposited. When slope processes restarted at the beginning of the Holocene, from these higher slopes weathered material of limestone was spread over the thin layer of loess on the lower slopes. Conclusions that can be drawn from this are:

(a) The lower boundary of the layer of loess represents the land surface that was present at the time that loess deposition began. Reddish colours in the soil material underneath the loess are signs of more intense soil formation, possibly dating back to a previous interglacial.

(b) The rather uniform, thin layer of loess on the Pediment indicates that the Pediment had, at the onset of loess deposition, virtually the same shape as the present Pediment. This also holds true for the end of the period of loess deposition. The shape of the transect over the Pediment apparently is not very sensitive to the process acting upon it.

(c) The slope process by which weathered limestone is deposited over a loess layer, forming a triplex soil profile, may be a process called solifluction. When snow melts in spring on slopes, where loess is not or no longer present, water may be prevented entering the subsoil because the subsoil is still frozen. The topsoil will become saturated and may slide downslope possibly covering a loess cover further down the slope. Soil sliding may resemble ice floes, when patches of top soil are held together by plant roots. Solifluction is common in a periglacial environment.

3.2.3.2 Soil profile

The zonal soil profile is the chernozem (USDA[30]: Chernozem, FAO[31]: Mollisol), an Ah-(B)-C profile with a thick (up to 1 m), dark and well-structured Ah horizon that typically has developed in lime-rich loamy and clayey soil materials. The high content of humic matter is caused by the dominance of macro-biological break-down of dead organic matter over microbiological destruction by bacteria because bacterial activity is hampered by very low temperatures in winter and dry conditions in summer. In vertical mixing of humic matter bioturbation plays an important role. In many profiles we may see the digging traces of hamster (in Russian *suslik*). On stable surfaces the topsoil may become leached of lime over a few centimeters up to a depth of a few decimeters. Lime may precipitate just below the leached horizon, creating a calcic horizon. The reprecipitated lime often looks like the mycelium of fungi or is concentrated in nodules. At the 'dry end' of the chernozem zone, the soils may contain some sodium on the exchange complex (solonetz) or may contain free salt (solonchak).

Where there is only a thin layer of dark soil material on top of light-coloured carbonate rock, the soil profile is called a rendzina (USDA: Inceptisol, FAO: Regosol).

Ploughing has two effects on the soil profile. It mixes the top 0.3 or 0.4 m of the soil profile. Ploughing also moves top soil material in the ploughing direction, especially where, due to small surface relief, rises are cut off and depressions filled.

3.2.4 The Soil Map of 1967 | J. Delvigne & W. de Neef

In 1967, a soil map of Northwestern Crimea was issued with emphasis on the type of ions on the exchange complex as well as on free Ca and Na ions (Fig. 3.1). Consequently, transitions exist between chernozems, solonetz and solonchak. Also, attention is paid to a varying humus content. Mainly soil associations are mapped, as the soil types distinguished vary according to their position in the landscape.

In an advanced stage of research it might be possible or useful to expand on the chemistry of the soil, for instance when quantitative estimates of agricultural yields are involved.

3.3 Land types and soil observations | J. Delvigne

3.3.1 Land type classification

One of the aims of DSP 2008 was to design a land classification that gives insight into the possible uses of the various parts of the landscape by (pre-)historic man. Because no detailed information on land properties was available to base such a map on, and time to collect that information in the field was limited, a different approach was applied.

In natural landscapes, the various earth science aspects of the landscape like rock type, landform and soil type are to a certain extent interrelated. One might make use of this fact by basing a land classification system mainly or exclusively on landforms, as these are easy to observe in the field and can quickly be mapped.

To choose such landforms or landform assemblages, a transect over the research area and surroundings was drawn on a topographic map, scale 1:45,000, with contour intervals of 4.34 m. Along this transect, five parts of the natural land-

[30] United States Department of Agriculture.
[31] Food and Agriculture Organization of the United Nations.

scape were distinguished and, after a field reconnaissance, were regarded representative of the natural variation in land types (Fig. 3.4). Starting at the highest point along the transect, in the middle of the Tarchankut Peninsula, and moving towards the coast to the N, all five land types are transversed:

– Plateaus/Uplands
– Peninsular Hillside
– Pediment
– Coastal Lake
– Lowland Ridge

The land types will be discussed below as to their general characteristics regarding lithology, landforms, position in the drainage system, and soil (material and profile). Also, some field observations and interpretations of soil augerings are presented. For each land type these will result in a list of properties that could have influenced the use of the land by (pre-)historic man in a positive or negative way, like soil thickness or groundwater depth. Depending on the time spent on this approach, the inventory will become more complete. In due course a land classification, based on a well-defined set of land properties, may be designed and used for mapping.

The inventory is based on the present situation. Some of the land properties that are taken into account, deal with probable differences in environment between prehistoric and present times: e.g. soil thickness.

3.3.2 General aspects of land type Plateaus/Uplands

At about 125 m altitude, there often is a plateau-like 'step' in the landscape on which a coherent pattern of shallow drainage channels is visible. Standing out in this plateau-landscape are small, SSW-NNE trending ridges, some with kurgans on their crests (Fig. 3.5).

The slopes are gentle. Nevertheless, denudation must have been active, because the soils are thin and the surface is smooth. The smooth surface is controlled by the top of a resistant limestone bed. Quite often the limestone is exposed, showing a dipslope situation and a soil cover generally not more than 0.3 m thick. It may well be that the bedrock is folded into a series of anticlines and synclines, as many hill ranges and valleys in the area have a SW-NE orientation. This orientation represents a major tectonic orientation in the Crimean Peninsula.

It is not known how thick a layer of loess the Plateau has received at the end of the last Ice Age (Valdai Ice Age). At the moment there usually is less than 0.3 m of loamy and stony soil material on the Plateau. We found one exception, above the head of a ravine on the Hillsides, where over two m of loess occurred (Section 3.3.2.1). At this place, there must have been a depression or cavity in the limestone surface. A possible overall loess cover of the Plateau may have been reduced to a few local occurrences. For the evaluation of the environment for prehistoric man, it is important to know whether or not a (large) loess cover was still present in prehistoric times. At the moment, the Plateau surface appears exhumed, without rills or gullies. The natural vegetation cover appears to be a good protection against rain drop and running water erosion, as the cover is composed of a mat of mosses, dead vegetation parts and living leaves that spread out over the soil surface. On the other hand, burrowing animals make heaps of loose soil material without such a cover.[32] Agricultural use, especially ploughing, even when it only means scratching the soil surface, will encourage soil erosion by wind and water.

In the western part of the Plateaus/Uplands, e.g. at Hill 12, limestone is found at the surface in the lower and steeper parts of the landscape and loess in the higher and flatter parts. Apparently, before loess was deposited, the limestone had a weathered, undulating surface showing some karstic phenomena. Clearly incised valleys were also present. At the end of the last Ice Age, a blanket of loess filled the V-shaped valley, creating gentle transitions into the Plateau landscape. Erosion after the Ice Age apparently laid bare parts of the incised valleys. This erosion must have been observed (and maybe caused) by prehistoric man. As a consequence of this erosion, slope angles in the upper, loess-covered parts of the landscape increased, causing some soil erosion by solifluction (Fig. 3.6). Although solifluction was observed by means of vegetated patches ('floes') of topsoil that are saturated with water and slide down the slope with bare patches in between, no rills or gullies were found as signs of superficial water erosion in the loess landscape, and deposition of washed-down

32 We refer here to the rodent *Suslik*, which is any of the 13 species of Eurasian ground squirrels belonging to the genus *Spermophilus*.

loess material at the foot of slopes is also absent. At Hill 10, a pit was dug in loess where foundation stones of a Hellenistic house were found (**DSP07-H10-01** Feature 2; soil profile presented in Section 3.3.2.1). The depth of the stones did not indicate any soil erosion or soil accumulation, as the soil profile inside and outside the pit fits onto each other.

Is the reason for this difference with the more maritime climate zones of Western Europe the more limited role of slope wash in the research area, and that the little slope wash that does occur, is completely washed into the sea each time? Or is soil erosion here rather a matter of wind than of running water?

3.3.2.1 Hill 10

Hill 10, trial trench 10[33]

On the side of this trench the soil profile was described[34]:

0-0.28	10YR 3/2 (d), 10YR 2/2 (m) loam; 0-0.15 m decalcified
0.28-0.96	10YR 4/3 (d), 10YR 3/3 (m) loam
0.96	Bottom of pit

Hill 10-1, trial trench 1, pit 1

General depth of pit is 0.96 m. In the centre an augering was carried out of 0.85 m depth. In depth beneath the surrounding surface, the profile description is:

0-1.6	7.5YR 5/4 (m) loam
1.6-1.8	10YR 5/4 (m) loam with grit
1.8	End, very hard

3.3.2.2 Hill 12

On Hill 12, S of the site researched geophysically, two augerings were conducted at the location indicated by the survey team as a possible site. They had noticed that the soil in this area was darker, more "humic" than in the surrounding area, although this part of the slopes was unploughed. The vegetation in this landscape type consists of grass and herbs, no trees or shrubs grow here.

In the second layer in core 12, between 0.27 and 0.5 m below the surface small pottery fragments were detected. Being 0.23 m, this layer is not very thick, and seems intact. More augering is needed to find out what the extent of this layer is, and how it is related to surface finds.

3.3.2.3 Hill 13

This location is situated at the N end of a spur. On both the eastern and western side, the spur is bordered by ravines. On the spur are two small elevations of approximately 2.5 m, one W and one E. There is no agricultural activity on the slopes. Three augerings were carried out, one on each elevation and one in between. In the augering on the eastern elevation, the compact, heterogeneous layer below the topsoil is noteworthy. This may be a cultural layer as in it three pieces of bone were found, indicating that the hill became higher since its original formation. It is uncertain whether this was a natural or an artificial process. Further augerings are needed in order to determine the nature of layers 2 and 3.

The soil in the augering in the lower part between the two elevations was very hard and compact, making it impossible to continue augering beyond 1.4 m. In the third layer, intact plant remains were found.

3.3.2.4 Loess pocket on limestone plateau

The lithological control of the Plateau implies that the rim of the Plateau is sometimes visible as a small rock ledge. Where there is a ravine on the slope, above the rim there will be a saucer-shaped part of the Plateau where slope wash towards the ravine is stronger and the Plateau is slightly lower. In this limestone environment an augering (G1) was carried out to characterize the soil. A depth of 2 m was reached. The profile of this augering can be found in Appendix 3C. Because there are many small outcrops of limestone around, this must be a filled-in depression in the limestone landscape at the beginning of the loess-deposition; possibly an erosional or karstic land form.

[33] J. Delvigne, P. Attema, T. Smekalova, A. Čudin, 12 May 2008.

[34] Soil colours according to Munsell Soil Color charts, d, m soil in dry (d) or moist (m) state.

3.3.2.5 Quarry with fan-delta deposits (Fig. 3.4)
This quarry is located at the outer edge of a Plateau. The quarry is not very high (ca 6 m) and more than 100 m wide and long.

At various places in the wall, thin beds of rather coarse fragments of limestone were visible. Because of the sharp-edged, chaotic structure of the composing stones, there is not enough fine material to fill the open spaces between the stones and the total structure is rather open. The composing laminae dip at about 30-40 degrees; at their lower side, the laminae show a concave break of slope. The deposits are interpreted as delta deposits. In other places, the concave lower end of the laminae is missing. These deposits are interpreted as (fluvial) fan deposits. Both types of deposit indicate that once, when the sea level was higher or the land level lower, a river must have opened up into the sea at this point. This river cannot have been very long, as the limestone fragments that are transported to the coast by this river, are hardly rounded.

3.3.2.6 Stone circles on Plateau (Fig. 3.2)
On the flattish part of the Plateau, several stone circles had been recognized in 2007 and their origin attributed to human activity (possible Bronze Age tombs). The stone circles consist of a number of large, flat slabs of limestone, together roughly having a circular shape and a diameter of 4 to 10 m. The openings between adjacent slabs are only a few cm wide and have more the character of somewhat widened cracks than of independently bordering edges. This point of view even becomes more convincing where two thin slabs lie on top of each other. Openings between individual stones have the same shape in both layers, making it more likely that they are cracks that developed simultaneously in originally larger blocks. The circular appearance is not so much caused by a circular circumference but more by a roughly circular mass of dark fine earth, somewhere in the middle of the group of slabs that make up a 'stone circle'. It seems more likely that this heap of soil in the centre is pushed to the surface by digging hamster that are common animals here. Maybe this soil remains moist somewhat longer, causing a bit more dissolution. In the soil in the centre there is some enhanced dissolution, causing this soil to be somewhat 'cleaner' (free of limestone gravel).

On close inspection the origin of the stone circles as man-made features was thus refuted. They are now interpreted as a karst phenomenon (see also Chapter 4.4 for an excavated example of such a 'stone circle').

3.3.3 General aspects of land type Hillsides

The second land type is formed by the peninsular Hillsides between the Plateaus/Uplands on the inland side and the lower parts of the landscape on the coastal side, covering a vertical distance of some 70 m (Fig. 3.7). This vertical distance probably represents a period of relative strong uplift of the inland parts of the peninsula. Weathered limestone, moved down the slopes of the uplifted parts, must have washed away easily at the coastline, thus maintaining steeper slopes than inland. In fact, there even might have been cliffs off the coast, as is the case in present times. At the moment, slope angles generally vary around 10-12 % and the soils are thin. At irregular intervals, the Hillsides are dissected by ravines. Ravines are the places where springs may be found.

Erosional phenomena could well have developed on the Hillsides before the deposition of loess. Because of the significance of loess in land use, ravines should be checked for the occurrence of pockets of primary deposited loess and for loess that has been washed down from above. One such an occurrence was found, at quarry no. 1 (Section 3.3.4.3), where a layer of at least 4 m of loess was exposed. The absence of non-loess components and absence of stratification makes it likely to be a primary loess deposit. Possibly, it was deposited at the lee side of a ravine incision or coastal cliff, as only 100 m away, in quarry no. 2 (Section 3.3.4.3), limestone was found at the same level as the loess.

Ravines can also have been used to store drinking water for man and cattle. Both those that have been deepened as those that have only been dammed off, could have served such a purpose (Chapter 5.1.6). While driving around, both types were observed. From such observations it cannot be concluded, whether they are prehistoric or recent.

3.3.4 General aspects of land type Pediment

The Pediment is the land type that extends from the peninsular hillsides at a much smaller slope angle towards Lake Džarylgač (a typical slope angle being 5%) (Fig. 3.8). It is regarded as a 'wash'-surface, created both by erosional slope wash on weathered rock and depositional slope wash leaving behind washed-down material. Like on the Plateau, many places were observed where limestone rock constituted the surface of the Pediment or were only covered by a thin veneer of loose soil material. In this land type the ravines associated with the Hillsides above, usually become less incised and gradually disappear down the Pediment.

To gain more insight into the character of the Pediment, two locations were observed in more detail: the lower part of Hill 11-01 and survey field DSP08-F04. The former is situated on the higher part of the Pediment and is characterized by a ravine system cut into limestone rock. The bedding of the limestone is as usual almost horizontal but difficult to determine as the limestone is broken into irregular blocks and stones, rarely protruding much above the surface.

Where a ravine cuts through a more resistant limestone bed, the bed is exposed in a horseshoe shape, the opening pointing to the upper side of the ravine. When a slope surface is developed in limestone containing a more resistant bed, a more or less clear rim of limestone slabs is exposed. At a few places in the area in between rims, loess-like soil material was visible. In more stable positions, stonefree and over 0.15 m leached chernozem soils had developed.

Field DSP08-F04 is a large (2 km x 2 km) ploughed field at the lower side of the Pediment where 15 hand augerings were carried out along a transect from high to low to get an impression of the soil material and soil profile in a part of the landscape where one would expect accumulation of slope wash material. The description of the soil profiles along the transect is presented separately (Appendix 3A), the interpretation and results are presented here (Section 3.3.4.1).

3.3.4.1 Interpretation of soil augerings along the transect across the Pediment

3.3.4.1.1 Introduction

Along a transect across the major part of the Pediment on the S side of Lake Džarylgač, 15 hand augerings were carried out in a large surveyed field (DSP08-F04; Fig. 2.13). Already from a distance some whiter and some redder zones could be distinguished in this ploughed field. The transect and the augering points were chosen to include the centres of these zones. The Pediment surface along the transect is slightly concave and slopes down from 44 m altitude to sea level over a horizontal distance of about 1,300 m.

Aim of the augerings was to obtain information on the nature and variation of the soil material and soil profile and to gain understanding of their genesis and significance to agricultural use by prehistoric people.

3.3.4.1.2 Soil material

In the more humid climate of Western Europe, a concave lower part of a slope is usually shaped by the downslope transport of soil material by the processes of slope wash and other types of mass movement. The thickness of this colluvium, with a maximum in the centre of the concave part, reflects that genesis of diffuse accumulation lower down the slope. As this colluvium often covers old soil profiles, it means that since the formation of the older soil profile, the supply of soil material from above has exceeded the downslope export of colluvium. This can often be attributed to human cultivation of the land.

Along the transect, the depth below the surface at which bedrock was reached, did not increase much down the slope, from 0.55 m on average over the seven upper augerings to 0.8 m over the seven lower augerings. This means that slope wash is not very strong. This is supported by the absence of rills. Not just the drier climate is responsible for less soil movement. The soil material here is lime-rich and contains quite a bit of organic material, creating a well-developed soil structure with good water-absorbing properties. Also, the human use of the land has not been as intense here as in Western Europe.

Bedrock underneath the soil material consists of limestone. From the soil profile descriptions it is learned that almost always there is in the profile a layer with a loam texture and a colour that has a strong resemblance to loess. It could well be a more or less *in situ* loess layer. An alternative explanation for the origin of this loam is as a leftover of weathered limestone. However, the weathering of limestone produces clay, not loam. The fact that, where the loam layer is thick, it has all the characteristics of loess (as in augering T10), makes it likely, that where the layer is thin, its origin is also loess with a possible admixture of weathered limestone. On this Pediment, being the upwind side of a hill, it is not surprising that the thickness of the loess layer is small. On the lee side, one would expect a thicker layer.

3.3.4.1.3 Colour contrasts in ploughed fields

The colour contrasts between whiter and redder zones in this field that were observed from a distance, turned out to be zones with more limestone fragments at the surface (whiter zones) and zones where the loam in the topsoil is somewhat redder (7.5YR in stead of 10YR), respectively.

The whiter zones might have been slight rises in the weathered limestone bedrock. Ploughing of the field has flattened the surface, thereby removing the topsoil of rises in the surface and the weathered limestone. The redder zones probably are places where the loess is slightly deeper weathered.

3.3.4.1.4 Interpretation of soil augerings at two archaeological sites

Five augerings carried out in a row, were conducted across site DSP08-F04-07. This site is a ploughed scatter of Hellenistic pottery on the NW end of survey field DSP08-F04, W of an erosion ravine that runs towards Lake Džarylgač. The row of augerings runs N-S, at 25 m interval. The southernmost augering location lies between augering 14 and 15 in the long augering transect.

Noteworthy is, that in three augerings conducted in the core of the archaeological site, a very hard, compact layer is present above a softer layer of loamy clay. In augerings at either side of these, this layer was not detected. In the northernmost augering, the soft layer lies directly below the ploughed topsoil. In the southernmost augering, between augering 14 and 15, the hard layer is present above a loam layer which is neither plastic nor soft. The hard layer may owe its compactness to the precipitating of lime.

The limestone bedrock was reached at 1.1 and 1.83 m below the surface, respectively. The ploughed topsoil is 0.4 to 0.45 m thick. The intact layers between the topsoil and the bedrock are therefore 0.7 to 1.4 m thick. The hard, compact, yellowish-brown loam layer possibly is the finds layer of the archaeological site: in one case, archaeological remains were found in this soil layer. However, in none of the other augerings, archaeological remains were detected.

Two augerings were conducted at site DSP08-F04-17. This site was found in the same field as the previous site, but further to the S, and 300 m E of the augering transect. The site is also classified as a Hellenistic scatter. The soil at the find location is notably lighter in colour than the surrounding area. The site lies roughly in the middle of the field, W of an unploughed area. In the unploughed area no augerings were conducted, as the farmer was just starting to plough this part.

In one of the two augerings, the second, dark yellowish-brown layer may be interpreted as a finds or culture layer. Small pottery fragments were detected in this layer. More research through augering would be necessary to check, whether this layer is indeed the culture layer of the find location on the surface, and how far this layer extends.

The bedrock was reached at a deeper level than in the augerings at the N side of this field, at 1.48 and 2 m. The two augerings in the cross-area transect nearest by, 300 m to the W, had a soil thickness of 0.75 m (augerings T7 and T8).

3.3.4.2 Loess quarry next to limestone trench (Fig. 3.9)

On the way to the E Plateau, just after leaving the asphalt road, the main track is winding along the edge of a loess quarry with its base about 3 m below the track. 100 m to the S side of the track there is a trench exposing limestone beds up to a sharp, wavy boundary with loamy material on top. The quarry lies at the boundary of the land types Hillsides and Pediment.

In the walls of the quarry (quarry 1) the top two m are exposed:

0-20	10YR 4/3 (d) loam, well structured (loess)
20-40	10YR 4/4 (d) loam, well structured
40-60	10YR 4/4 (d) loam
60-100	7.5-10YR 4/4 (d) loam

Between 1 and 4 m below the surface, a network of round, tubular openings with a diameter of about 1 cm is found in the loam. On the inside, the tunnels are coated with grey-brown humic clay. Some smaller tunnels are completely filled with it. Lime migrates in the soil in this climate in a different way, as is shown by the occurrence of so-called lime-mycelium deeper than 0.5 m.

The slope above the quarry has an angle of 4%.

The trench 100 m away (quarry 2) is about 100 m long and about 5 m wide. In the middle it is about 3.5 m deep, sloping up to both ends. Probably it was dug to check the size of the loess body. In the seaside wall of the trench there is a sharp, wavy boundary between the loess-like deposits on top and the weathered limestone underneath. The loess-like layer might be a colluvial layer.

To learn about the landform that has been filled-in with loess and made the loess-quarries possible, one augering was carried out halfway between the track and the limestone trench (augering G2) and another on the other side of the track close to the track (augering G3). The descriptions of the profiles found in these augerings can be found in Appendix 3C. The soil profiles from these augerings unfortunately do not give enough information to decide on the landform present before the loess was deposited.

3.3.4.3 Red soils in ploughed field on the Pediment

Like the large field, where the transect runs through, there are other fields that show zones of redder colour, as well as darker zones. To check whether a redder soil is only a matter of redder loam, three augerings (G6, G7, and G8) were carried out in other 'red' zones. The soil profile descriptions of these augerings can be found in Appendix 3C.

3.3.5 General aspects of land type Coastal Lakes

Coastal Lakes are drowned parts of a river valley or former bays or lagoons (Fig. 3.10). Rivers, coastal currents and waves have delivered the sand that has helped building spits and bars that have closed them off and turned them into lakes. Depending on how and to what extent lakes are closed off, they can either be salty or contain fresh water. Usually, Coastal Lakes are not very deep, as quite a bit of the bed load of the river that opens into a lake, has been or is deposited there (Section 3.2.2). These sediments may be regarded as 'correlative sediments': periods of strong or little sedimentation in the low parts of the river system should correlate with periods of strong or little erosion in the higher parts of the catchment. This means that to a certain extent changes in environmental conditions can be derived from changes in the corresponding, correlated sediments. Periods of loess erosion (by surface wash) in the higher parts of the catchment may be recognized this way.

At least at the N side of the lake, wave action has formed a cliff in loess deposits that are over 5 m thick. Near the water line, the loess has been hardened by calcite crystals.

3.3.5.1 The Coastal Lake augerings (Fig. 2.13)

Augering T16 of the transect across the Lowland Ridge is similar to augering T15 on the other side of the Coastal Lake (transect across Pediment). The soil profile descriptions of both augerings can be found in Appendix 3A. As mentioned in Section 3.3.6.1, a thickness of 2 m of loess was observed here although the lakeside cliff nearby suggests that the sediment has a thickness of more than 3 m. This thick sediment in the lowest part of the research area may be the result of Eolian deposition of loam in a large valley, the present Lake Džarylgač. It is also possible that the loam was deposited at the bottom of the lake after being eroded off the slopes of the catchment during the Holocene. At the lakeside cliff, it could be observed that the lower layers of loam were reddish in colour. This colour may be the result of oxidation of iron compounds in the loam or in emerging groundwater.

3.3.5.2 The cliff on the northern lake shore (Fig. 3.10)

Over a distance of hundreds of meters along the N side of the lake, the cliff is about 5-6 m high. Middle part of it is well exposed:

– near the waterline there appears to be reddish stone. More probable it is loess loam cemented together
0.5-1 m above water level, 7.5YR 4/6 (m) clayey loam; many cementations by calcite-crystals
1-2.2 m above water level, ditto colour loam. Some pieces of limestone
1.5 m from this point in small pit, 10YR 4/3 (d) = 10YR 3/3 (m) loam

3.3.6 General aspects of land type Lowland Ridge/Coastal Cliff

The final land type in this classification consists of the Lowland Ridge (Fig. 3.11). It alternates with the Coastal Lakes and bays in building the coast, as the coast line cuts the parallel river valleys and Lowland Ridges at a small angle. The Lowland Ridges are neither high nor steep. At the coast marine erosion has cut a cliff, that can be more than 25 m tall and shows that the core of the ridge is composed of limestone, which at the cliff is covered by up to a few meters of loess. The Lowland Ridge can be regarded as developing autonomously.

To obtain an impression of the variations in soil materials and soil profiles across the ridge, a number of hand augerings was carried out along a transect. The results of these augerings are presented separately (Appendix 3B).

The ridge is slightly undulating. Because of ploughing, the undulations are visible by a regular alternation of dark and light zones, respectively showing the A and C horizon of the soil profile. Probably these horizons occur in weathered loess, in which case the undulations may be formed by wind. At the outskirt of the village Meževodnoe a quarry (quarry no. 4) was found in at least 5 m of loess (Section 3.3.6.2). The loess may well be filling an erosional valley in the limestone ridge.

Has the presence of a loess pocket in any way influenced the choice of the settlement location? Like quarry no. 4, which is close to Meževodnoe, quarry no. 1 is also close to a settlement (Section 3.3.4.3).

3.3.6.1 Interpretation of soil augerings along a transect across the Lowland Ridge (Fig. 2.13)

3.3.6.1.1 Introduction

A total of 14 augerings were conducted in a transect N of Lake Džarylgač, at 100 m intervals. Augering T16 was conducted at the lowest point, on top of the cliff at the lake (3 m above water level). Elevation difference with the highest augering location on top of the lowland hill, at augering T26, is 40 m. The northernmost augering location, near the coastal cliff on the Black Sea shore, was 30 m above sea level. The augerings are described in detail in Appendix 3B. Some general conclusions are presented here.

3.3.6.1.2 Soil material

The augering section shows a gradual decrease of soil depth between augerings 16 and 22. At augering T16, on top of the lake cliff, a depth of 2 m was reached without reaching underlying bedrock. Indeed, the cliff rose approximately 3 m above lake water level, and most likely continued below. Unfortunately, it was not possible to determine the depth of local bedrock on the lake shore. Contrastingly, bedrock was visible directly at the surface at augering location T22. The bedrock appears to be steeper at the S slope of the Lowland Ridge than at the N slope. The minimum depth of soil upslope implies that either less soil was deposited originally, or that more has eroded and moved downslope.

Augering T22 was conducted approximately 400 m S of the ridge top, in a fallow area partly overgrown with grass. In the section, this location appears to be a slight outcrop in the slope. With winds coming predominantly from the N, it is remarkable that a seemingly sheltered part of the ridge would be without Eolian loam sediment. In augering T26, a location on top of the coastal ridge and most exposed to northern winds, a 1.12 m thick loam sediment was observed. Therefore, it seems more likely that other erosional processes than Eolian movement of loam resulted in the uncovered bedrock.

South of sediment-less augering T22, the section shows an increase in sediment depth towards the lakeshore. Augering T18 is located slightly lower than the augerings to the N and S (19 and 17 respectively), in a depression of the slope. This may well be a pocket in the underlying limestone, however the loam fill has a similar depth as the soil on both sides.

The three augerings T23, T24 and T25, at 100 m from each other between the ridge top (T26) and the location where bedrock was observed at the surface (T22), yielded loam layers of 0.25 m or less. At augering T22, approximately 40% of the surface was covered with limestone fragments, and also augerings T24 and T25 were conducted at locations with many limestone parts on the surface. In augerings T23 and T24, the soil consisted of loam mixed with limestone, in augering T25, no limestone particles were observed. The many limestone parts on the surface at this part of the slope suggest that loess erosion has taken place, followed by limestone weathering (?). Limestone fragments must have moved over the loam from a point where weathered limestone was right at the soil surface.

At 40 m from the coastal cliff, the sediment was 0.7 m thick. Here the slope flattened out to an almost level surface. At the coastal cliff itself, a loam sediment several m thick was observed on top of the limestone rock.

3.3.6.1.3 Soil profile

On top of the coastal ridge, loam sediment with a thickness of 1.12 m was observed. Unfortunately, it is not known to what extent soils have been disturbed, when the asphalt road following the highest parts of the coastal ridge was built, yet augering 26 was conducted in an almond yard where no severe levelling seemed to have taken place. No stones were observed on the surface at this location, and a very dark top layer was present over lighter, undisturbed loam layers. The three augerings conducted on the N slope of the coastal ridge, from augering T26 down to the Coastal Cliff, all show comparable dark topsoil. The soils in these augerings are less thick than in augering T26. Augering T28 yielded a dark loam layer directly on top of the bedrock, in augering T27 a thin, lighter-coloured loam layer was present between the dark topsoil and bedrock. The very dark topsoil in augerings T26 through T29 suggests that circumstances must have been stable enough for soil formation. Indeed, at the almost level surface of augering T29, humic material formed a 0.37 m thick dark topsoil in a 0.7 m thick loam sediment. The colour of the topsoil in these four augerings is typical for chernozems.

None of the topsoils S of augering T22 are as dark as those observed on the N slope of the coastal ridge. In augering T16, the topsoil is brownish, as are those in augerings T18, T19, and T21. The underlying loam layers of augering T16, T17 and T18 have lighter colours typically seen in loess sediments. The soil samples seen in augerings T16 through T21 can be classified as underdeveloped chernozem soils, where humic material on the surface has not developed completely into a thick, dark top layer. Overall, it seems that darker topsoils occur in level parts of the research area.

3.3.6.1.4 Differing soil colour values

At augering location T19, a reddish loam layer was observed below a darker, brownish top layer. The soil sample was taken at a very gently sloping part of the coastal ridge. Together with loess quarry 4 (Section 3.3.6.2), this was the only location N of Lake Džarylgač where a 7.5YR Munsell value was measured. The reddish colour is either the result of post-depositional weathering of loess where it was in a stable-surface situation (where the profile development intensifies because there is no removal of material from the top) or it is a remnant of a pre-loess weathering of limestone, which has eroded away elsewhere. The augerings to the N and S on the same slope did not yield a similar red value.

3.3.6.2 Loess quarry 4 near Mežvodnoe (Fig. 3.12)

This quarry has a SW-NE orientation, the same as the coastline. The quarry bottom is a depression in the landscape, with a (dry) overflow towards the village.

The main wall (at a bend) of this quarry shows some 5 m of loess. The profile in estimated figures:

0-0.5 m	Greyish yellow, not structured
0.5-2 m	'Bleached' greyish yellow, moderately structured (some cracks)
2-4 m	Most red colour (7.5YR 6/6), best structured
4-4.5 m	Olive-green (10YR 6/6), massive

Looking at the profile at the bend, the exposed part of the profile diminishes to the right. At the end is a sub-recent tile kiln.

3.3.6.3 Interpretation of augerings at a Bronze Age site on the Lowland Ridge

Two crossing rows of, altogether, 11 augerings were conducted at a Bronze Age site (DSP08-F06-01) found during the 2008 intensive survey of a ploughed field on the S coastal ridge slope. The main objective of these augerings was to establish how thick the sediment was at the site, and whether intact culture layers could be located. The soil profile descriptions can be found in the site entry in Appendix 1. The survey team observed that the surface at the site was more greyish than the surrounding ploughed field.

In nine of the 11 augerings at this site, bedrock was reached within 0.5 m below the surface. All of these augerings were conducted within the find concentration. The four augerings conducted outside the defined site borders all yielded a lighter brown, intact loam layer (10YR 5/4) underneath the humic topsoil. In augering S27, this layer was only 5 cm thick.

From these augerings, it can be concluded that the soil colour of the top soil is most likely influenced by human activity to the extent of the site boundary. Further research on the humic content and geochemical values of the top soil may add to our understanding of these activities, but this has not yet taken place. Unfortunately, this part of the coastal ridge was heavily ploughed and augerings at the site have not proven it likely for an intact finds layer to be present.

3.3.6.4 Soils of a Bronze Age site near Skalistoe (Coastal Cliff)

Four augerings were conducted at site DSP08-F03-02 (Skalistoe 2). The site is located in a shallow depression east of a ravine, which was heavily overgrown during the 2008 campaign. The field west of the ravine had not been mowed or ploughed in 2008 and was therefore not investigated by the survey team.

Two augerings were conducted in the grassy field west of the ravine, and two augerings within the site nucleus in the ploughed field. The objective of these augerings was to establish the thickness of the sediment and to see whether intact cultural layers containing archaeological indicators could be observed. The full augering descriptions can be found in the site description in Appendix 1.

The two augerings in the grassy field (10 and 60 m SW of the ravine) yielded very compact, hard loam soils containing limestone fragments. Depths of 30 and 70 cm respectively were reached, after which soil got too hard to penetrate, yet larger limestone parts suggest that bedrock was close.

Augering 3, within the site nucleus (10 m E of the ravine), yielded a similar profile with bedrock at 30 cm. Augering 4 (60 m E of the ravine), however, had a 116 cm thick soil profile. Here, the top 50 cm of loam showed no effervescences when tested, the underlying loess layer (50-116 cm) effervesced indicating a lime content. Bedrock was not reached due to the great compactness of the soil beyond 116 cm.

In contrast to site DSP08-F06-01, no variation in the colour of the top soil or humic content was observed to correspond with the pottery concentration. In none of the four augerings, archaeological indicators were recorded. Although augerings 1-3 showed shallow soils, the thickness of the sediment in augering 4 seems promising for possible intact layers in the eastern part of the site.

3.3.7 Triplex soils and landscape development

Loess is a wind deposit and is, contrary to water deposits, capable of covering a complete landscape. Towards the end of the last Ice Age, as the climate had become very dry, such a cover was probably formed over the limestone landscape of the Northwestern Crimean peninsula, thereby bringing slope processes to an end. At the beginning of the Holocene, the climate changed towards its present state, starting slope processes that are in accordance with the present climate. Although these slope processes have affected the post-loess landscape for about the same period of time (10,000 years), their effects on the landscape must have created typical local differences. From a theoretical point of view, the following effects on soils and landscape can be expected:

– Where a continuous layer of loess has been left behind, the top soil material remains loess, lying on top of the pre-loess limestone weathering profile. A landscape characterized by loess deposition will show rounded, gentle forms. Loess erosion is predominantly caused by slope wash and will result in rills and gullies. Some of the removed loess may have accumulated further down the slope, creating a layer of increased thickness and mixed composition.

– Where the loess has in patches or certain zones of hill slopes been removed, limestone weathering profiles should be found at the surface in the eroded patches. The limestone weathering products may spread out over the loess downslope of the patch, thereby creating a zone of mixed material or limestone weathering products on top of loess.

– Where the loess has completely been removed, the exposed land surface will be the pre-loess land surface. However, local landforms of strong relief like ravines or sinkholes, may still be completely filled by loess, creating a landscape in which the observer can be fooled by the landforms.

3.4 Paleo-limnological investigations in Lake Džarylgač | V. Stolba, D.A. Subetto & T.V. Sapelko

The Džarylgač Lake, along with the adjacent lakes of Sasyk and Karlav as well as the Bakal' Lake to the NE and lakes Karadža and Kipčak to the SW, constitutes the Tarchankut group of the Crimean saline lakes.

A valuable summary of the former studies conducted at the lake in the 1920s by A.I. Dzens-Litovskij and others can be found in the volume *Soljanye ozera Kryma [Saline lakes of Crimea']* (Kurnakov et al. 1936), which still remains the basic reference work on the topic. In 2005, limnological investigations of Lake Džarylgač were carried out by an international team within the framework of a cross-disciplinary project 'Northern Black Sea in the 1st Millennium BC: Human history and climatic changes' (Stolba et al. 2006; Subetto, Sapelko & Stolba 2007; Subetto et al. 2007a; 2007b; 2008).

The lake with a total area of ca. 78 ha renders itself a submerged mouth of the Vodopojnoe Ravine, which, becoming gradually isolated from the sea by a sandbar, transformed into a lagoon and subsequently into the highly mineralized coastal lake. Its N and S shores are actively abrading. The over 600 m-wide sandbar, which separates the lake from the sea, consists of the oolitic limestone kernels of the Neogene period and shell debris. Along with the modern specimens the latter often includes the shells of extinct molluscs such as *Cardium tuberculatum*, *Tapes Colverti* etc. (Dzens-Litovskij 1933, 586; Longinov 1955, 158, 165; Zenkovič 1960, 144). The modern level of the lake is 0.4 m below that of the sea (- 0.7 m according to Longinov's measurements in 1945), the depth not exceeding 1.1 m.

The sampling of the one chosen site in the W part of the lake (489180 / 5047189, see Fig. 3.4) carried out in 2005 retrieved a 4.15 m-long sediment sequence which has been analysed for lithostratigraphy, pollen stratigraphy as well as diatoms and ostracods.

The bottom sediments are represented by grey, yellowish-grey and greenish-grey silts with a high content of mollusc shells. Unlike the sediments of Lake Saki studied by the same team in 2005, they do not feature a clearly expressed layered structure, a characteristic only observed in the upper 1.5 m section of the core. This made the correlation between the varve chronology and the absolute radiocarbon dating virtually impossible. The AMS C14 dates have been produced at the Radiocarbon Laboratory of the Institute of Physics and Astronomy, University of Aarhus, for various parts of the sequence. They place the beginning of marine sedimentation connected with the New Black Sea transgression, when the risen sea penetrated into the ravines and river valleys at around 7200-7050 cal BP, giving an average sedimentation rate of about 0.6 mm per year. Changes in the associations of ostracods observed along the retrieved sediment sequence and compared with the absolute radiocarbon dating allow the detailed reconstruction of the lake's history (Neustrueva et al. 2007; Subetto et al. 2007a). The transition from the open sea environment conditions to the lagoon is likely to have taken place around 5,590-5,350 BP, with the complete separation from the sea and the formation of saline lake to occur ca. 4,700 calendar yr BP.

The retrieved pollen data have been used to reconstruct the changes in vegetation and climate (Sapelko & Subetto 2007). Whereas the earlier phase of the Atlantic period was characterized by xerophytization of the steppes and lower share of tree species in conditions of warming climate, the later, more humid and cooler phase of this period was accompanied by expansion of forests, in which mixed oak stands (*Quercetum mixtum*) prevailed. The subsequent Subboreal is characterized by warmer and drier climate as well as by major appearances of crop cereals. The arboreal pollen spectra, in which *Pinus*, *Betula* and *Alnus* now preponderate, give way to *Chenopodiaceae* and *Artemisia* species, which mark the transition to arid and semi-arid steppe vegetation. Some increase in humidity is observable after 3,680±55 BP, as indicated by a rising proportion of tree pollen. The increase of tree pollen (20-40% of the assemblage), *Pinus*, *Picea* and *Abies* being predominant, also marks the transition to the Subatlantic period (2,575±41 BP), in which, as evidenced by pollen of crop cereals, the human factor plays an important role. The formation of modern vegetation takes place in the second half of this period.

3.5 (sub) recent land use | p. attema

The most prominent economic resource of the Crimean landscape is its potential for large scale agricultural production because of the fertility of its soils and the generally flat landscape. This potential was recognized by the Soviet planners, when Crimea was included in the Ukrainian Soviet Socialist Republic in 1954. Up to 1991, when the Autonomous Republic of the Crimea was formed, the main agricultural producers in Ukraine were collective and state farms (kolkhozes and sovchozes). Remains of abandoned Soviet farms, now often in ruinous state and used as quarries for building materials by local villagers, are ubiquitous in the study area as a testimony to the period (Fig. 3.13)

From our discussion of land types in the study area, it seems only logical that the Pediment and the Lowland Ridge were singled out as most suitable areas for large scale crop cultivation on tractor ploughed fields. This is because of their gentle relief, low stoniness, and fertile soils. In the current local agricultural economy following the land reforms of the 1990s, these areas are still under the plough in a rotation system (mainly cereals and sunflowers). For the survey this meant that as a rule no adjacent fields could be surveyed, adjacent fields being alternately ploughed.

However, also parts of the Hillsides and Plateaus/Uplands were subjected to large-scale farming as part of a more general trend in the former Soviet agricultural policy of pushing agriculture into zones less suitable for large-scale farming. Apparently this happened also in our study area. Air photos and geomagnetic maps clearly show traces of former land use, part of which can possibly be attributed to ultimately failed attempts at large scale farming of marginal parts of the Hillsides. Other traces visible on especially the geomagnetic maps may be remnants of smaller scale ploughing activity in recent times (Figs. 4.152-153, 4.235, 4.249).

Nowadays the Hillsides are for the greater part being used as pastureland, although on hills with sufficient soil cover crop cultivation continues. This is conform the current tendency in Ukrainian land use development, which shows a considerable decrease in arable land, followed by increases in pastureland and abandoned land (Kucher 2007, 6).

During the Soviet period, individual households played an insignificant role in the production of crops and were mainly operated by kolkhoz and sovchoz members on small land plots (Kucher 2007, 4). In the study area such small land plots are still exclusively found in the vicinity of the small villages that dot the landscape, while grazing takes place in the surrounding steppe. This is a settlement and land use pattern that continues that of the 19th century AD Tatar period and probably earlier. Where substantial cash crop cultivation takes place, this is nearly always on vast parcels of up to 2 km². From 1992 onwards, agricultural land in Ukraine increasingly went over to at first mostly collective and from 2000 on to private ownership (Kucher 2007, fig. 6).

A drawback of large-scale farming is soil erosion. According to Kucher (2007, 8) soil erosion is the most significant environmental issue in Ukrainian agriculture, while also a significant decrease in soil fertility has been noted. It is estimated that almost 40% of agricultural land is subject to water and wind erosion (see also Van Zon 2000). Indications of erosion were indeed observed both in the lower areas (Lowland Ridge and Pediment) and in the higher areas (Plateaus/Uplands, Hillsides).

From the perspective of site recovery we may conclude that post-war developments in land use have led to an increased visibility of the archaeological surface record in the Pediment and Lowland Ridge, while recent developments have reduced its visibility on the Hillsides and Plateaus/Uplands. This however only holds for settlement sites, not for the burial mounds (kurgans). In the former land types, settlements will typically surface as pottery scatters, in the latter land types, these can only be detected when there are stone structures present, although pottery scatters do occur sporadically. Because of their elevation, kurgans will have an equal chance to be detected in all land types. It follows that settlement sites, that in the archaeological record consist of pottery scatters only, are likely to be underrepresented on the Hillsides and Plateaus/Uplands, despite the adjusted methodology (see Chapter 2.3.1.2).

From the perspective of the evaluation of ancient land use the following aspects need to be considered:

– It is highly likely that the high estimations of soil erosion and substantial loss of soil fertility in Ukraine due to the negative impact of post-war large-scale farming practices also apply to our study area. This would mean that in the past, the soil cover on the whole may have been thicker and that soil fertility was higher. This may imply that the present-day contrast in the productive potential of crops between Lowland Ridge and Pediment on the one hand and Hillsides and Plateaus/Uplands on the other may have been less marked in the past, considering that today's requirements for mechanical ploughing to farm preferably only slightly undulating vast surfaces does not apply for past farming practices.

– Kucher (2007, 9) asserts that in the southern part of Ukraine, irrigation is essential for agriculture. As non-saline surface water is largely absent in the study area, the success of farming on a substantial scale in the past must have been heavily dependent on precipitation. With respect to the pre-war settlement pattern of 19th century AD Tatarian villages, it has been observed that their settlement locations coincide with those locations in the landscape where the groundwater level was within reach of man-made wells (Chapters 5.1.6). One of the central elements in these Tatar village communities is the communal well (Fig. 5.1). The hydrological situation indicates therefore that large-scale farming in the Crimea in the past, as supposed to have been undertaken during the Early Hellenistic period (see Chapter 6.3), may have been very vulnerable to periods of drought. Artificial and natural water pools in the ravines will have favoured extensive grazing on the Hillsides.

Salt needed for man and his animals could be extracted from the Coastal Lake, where salt works are recorded on the 1897 topographical map. The likelihood of salt extraction from these lakes in antiquity is discussed in Chapter 6.3.3. Detailed information on sub-recent topography and land use in the survey area is given in the catalogues of surveyed fields and hills (Chapter 4.4 and 4.5).