Journal of Env. Geogr. Vol. II. No. 3-4. (2009) pp. 31-36

BLOWN SAND MOVEMENTS AT KISKUNHALAS ON THE DANUBE-TISZA INTERFLUVE, HUNGARY

Nyári, D.[1] **- Kiss, T.**[1]

[1]University of Szeged, Department of Physical Geography and Geoinformatics. 6722 Egyetem u. 2, Szeged, Hungary

Abstract

The largest blown-sand area of Hungary is located on the Danube-Tisza Interfluve. Here the most significant aeolian activity took place during the Pleistocene, however the aeolian transformation of the landscape occurred also in the Holocene and even in historical times. The aims of the study were (1) to reconstruct the relief at different historical periods; (2) to determine the periods of sand remobilisation during historical times; (3) to identify the changing of climatic conditions and possible types of human activities enabling aeolian activity and (4) to specify the spatial extension of sand movements. To reconstruct the spatial characteristic of sand and palaeosoil layers a 3D-model of the deposits at the archaeological site was created using total station measurements and Surfer 8.0 software. In order to determine the exact time of blown-sand movement optically stimulated luminescence (OSL) measurements (6) were applied. Based on the results, the lowermost sandy-loess layer had a late Pleistocene age, on which sequences of palaeosoils and blown-sand layers were formed during the Holocene. The spatial extension of the palaeosoils and sandy layers suggest that the relief has changed significantly over historical times. The former Pleistocene blowout depression has altered because of both the climatic conditions and the human impact on the environment. Blown-sand movements in historical times filled up the blowout depression. The sand sheets reshaped the original morphology and soil properties. Today the surface is more elevated and even, the site is covered by dry and slightly humic sandy soils.

Keywords: environmental changes, Holocene, blown sand, OSL dating, archaeology, human impact

INTRODUCTION

The population, the development of agricultural techniques and the changes in land use caused human induced environmental changes, which became increasingly significant in history. Good examples can be found on the Danube-Tisza Interfluve where the change in climatic conditions and the anthropogenic disturbance together caused aeolian activity during historical times. Therefore, the original geomorphological setting of the area transformed, and Pleistocene forms were reshaped by Holocene sand-movements.

The earliest blown sand movements on the Danube-Tisza Interfluve took place in the Inter Pleniglacial of the Pleistocene (Sümegi P. – Lóki J. 1990, Sümegi P. 2005) and subsequently there was aeolian activity during the Middle Pleniglacial of the Pleistocene after 25 200 ± 300 year ago (Krolopp E. et al. 1995, Sümegi P. 2005). According to earlier researches on the Danube-Tisza Interfluve the most significant aeolian activity occurred during the Upper Pleniglacial (Borsy Z. 1977ab, 1987, 1989, 1991, Sümegi P. et al. 1992, Sümegi P. – Lóki J. 1990, Sümegi P. 2005). Later, the two cold and dry periods, the Older Dryas and Younger Dryas in the Pleistocene were convenient for aeolian rework (Borsy Z. et al. 1991, Hertelendi E. et al. 1993) which is supported by radiometric, optical and thermo-luminescence measurements too (Gábris Gy. et al. 2000, 2002, Gábris Gy. 2003, Ujházy K. 2002, Ujházi K. et al. 2003).

Sand dunes, formed under cold and dry climate in the Pleistocene, were gradually fixed as the climate changed to warm and humid during the Holocene. However, researchers draw attention to the possibility of sand movement in the Holocene too. The warmest and driest Holocene phase (Boreal Phase) was the most adequate for dune formation (Borsy Z. 1977a and b, 1987, 1991, Gábris Gy. 2003, Kádár L. 1956, Marosi S. 1967, Ujházy K. et al. 2003), though, certain investigations claim that the second half of the Atlantic Phase could also be dry enough for the remobilisation of sand (Borsy Z-né – Borsy Z. 1955, Borsy Z. 1977a and b, Gábris Gy. 2003, Ujházy K. et al. 2003). Nevertheless, the latest, usually local signs of aeolian activity can be related to various types of human impact. Former investigations consider that sand movement could occur during the Turkish occupation (16th-17th century AD) and subsequently in the 18th -19th century AD due to deforestation (Borsy Z. 1977a and b, 1987, 1991, Marosi S. 1967).

Based on archaeological investigations and OSL measurements on the Danube-Tisza Interfluve aeolian activity occured in the Bronze Age (Gábris Gy. 2003, Ujházi K. et al. 2003, Nyári D. – Kiss T. 2005a and b, Kiss T. et al. 2006, 2008, Nyári D. et al. 2006a and b, 2007a and b, Sipos Gy. et al. 2006), then the surface became stable for a long period, until the 3rd-4th centuries AD. As later the climate turned dry (Rácz L. 2006, Persaits G. et al. 2008) and the anthropogenic disturbance became more significant conditions became suitable for aeolian activity, which is proved by several researchers (Lóki J. – Schweitzer F. 2001, Kiss T. et al. 2006, 2008, Nyári D. et al. 2006a and b, 2007a and b, Sipos Gy. et al. 2006, Knipl I. et al. 2007). Sand movement was also characteristic in the Migration Period, especially during the 6th-8th century AD, which was the realm of the Avars (Nyári D. – Kiss T. 2005a and b, Kiss T. et al. 2006, 2008, Nyári D. et al. 2006a and b, 2007a and b, Sipos Gy. et al. 2006) Subsequent aeolian activity occurred also in the high medieval period (11th-13th centuries AD, Lóki J. – Schweitzer F. 2001, Gábris Gy. 2003, Ujházy K. et al. 2003, Nyári D. et al. 2006a and b, Knipl I. et al. 2007, Kiss T. et al. 2008) and when the Cumans inhabited the territory (13th century AD, Sümegi P. 2001, Kiss T. et al. 2006, 2008, Nyári D. et al. 2006a and b, 2007a and b, Sipos et al. 2006). The latest aeolian activity occurred in the 15th century BC (Nyári D. et al. 2007a, Kiss T. et al. 2008).

The present research provides evidence on sand movements in historical times caused by changing in climatic conditions and human impact on the environment. The aims of the study were (1) to reconstruct the relief at different historical periods; (2) to determine the periods of sand remobilisation during historical times; (3) to identify the changes of climatic conditions and possible types of human activities enabling aeolian activity and (4) to specify the spatial extension of sand accumulation.

STUDY AREA

The 9 km^2 large blown sand covered study area is situated on the southern part of the Danube-Tisza Interfluve, northeast from Kiskunhalas (*Fig. 1*). The altitude of the area varies between 122 and 138 m a.s.l. Low-lying flat areas dominate the southern part, where greater depressions are situated. On the northern part, a higher sandy area characterises the landscape. The forms stretch from NW to SE, and clearly mark the direction of prevailing winds during aeolian periods (*Fig. 2*).

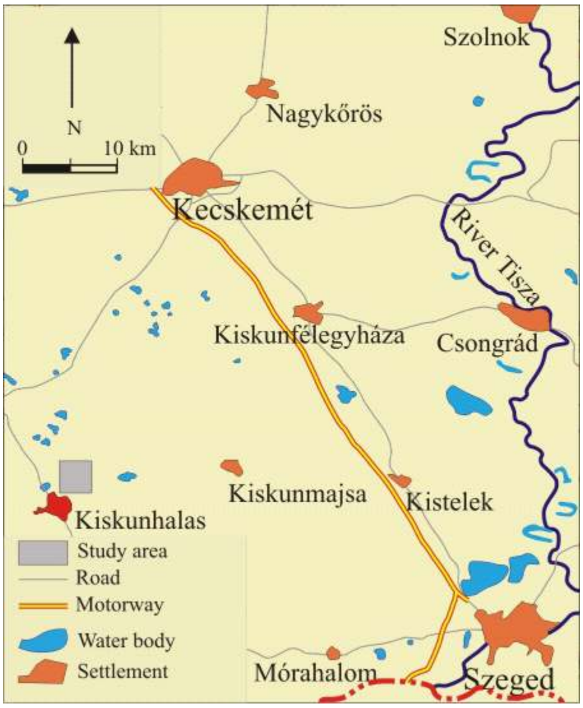

Fig. 1 Location of the study area

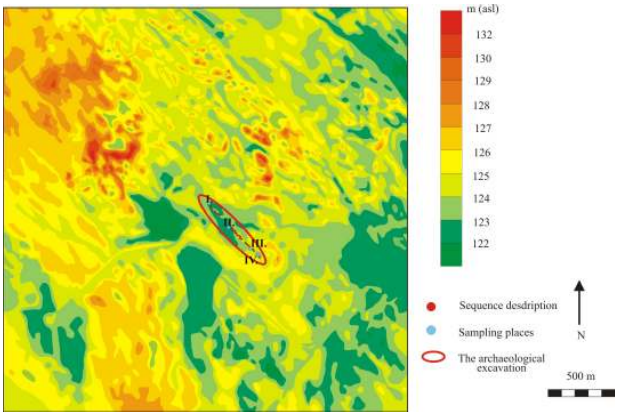

Fig. 2 Relief of the study area, the archaeological site and the sampling places

The 550 m long and 6 m wide, 1.2-2.5 m deep excavated site was located along a future pipeline on the middle of the study area in a blowout depression, providing an exceptionally good example on Holocene aeolian reshaping (*Fig. 2*).

METHODS

OSL measurements

The optically stimulated luminescence (OSL) determines the last exposure of sediments to sunlight. Therefore, the method is especially suitable for identifying the depositional age of wind-blown sands (Aitken M. J. 1998). Altogether six samples were collected from three profiles. Measurements were made on an automated RISOE TL/OSL-DA-15 type luminescence reader at the Department of Physical Geography and Geoinformatics, University of Szeged. Laboratory techniques and measurement protocols can be found (Sipos Gy. et al. 2009).

Investigation of archaeological findings

By investigating the findings of the site the activities and environment of earlier inhabitants of the area can be reconstructed. Previous archaeological analyses (Wicker E. 2000, Rosta Sz. 2007) allowed us to study the morphological situation of findings and to couple historical settlement pattern with landforms. This analysis enabled us to reconstruct the type, intensity and the geomorphological results of human impact.

Geomorphological mapping

The relief and geomorphological map of the investigated area were compiled on the basis of field measurements and 1:10,000 scale topographic maps. First the major aeolian morphological units: erosion-transportation and accumulation zones, the basic morphological features: blowout depressions, blowout ridges, blowout dunes or hummocks, parabolic dunes, sand sheets, deflation areas and the brink lines of dunes were identified.

3D-modelling

To model the landscape at different historical periods a 3D terrain model was created on the basis of layers along the archaeological excavation using total station measurements and Surfer 8.0 software.

RESULTS

Based on the geomorphological map of the area, the northern part of the investigated area represents an accumulation zone, where the most typical forms are blowout depressions, blowout ridges and blowout dunes (hummocks). On the southern part the erosion and transportation zones are situated with unclear boundaries and covered by less of forms, which are predominantly deflation areas, blowout depressions, blowout ridges and sand sheets (*Fig. 3*).

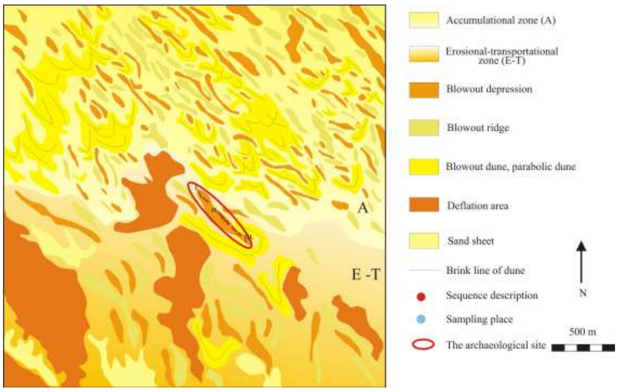

Fig. 3 Geomorphological setting of the study area

Samples for OSL dating were collected from three profiles along the excavated site. Based on the results the lowermost sandy-loess layer was formed at 12.7 ± 1.2 ka in the Pleistocene, on which a 35-110 cm thick soil evolved during 9000 years in the Holocene.

According to the OSL measurements subsequent aeolian reactivations took place 2.9 ± 0.3, 1.74 ± 0.2, 1.59 ±0.2 and 1.2 ± 0.19 ka and resulted a 30-180 cm thick layer consisted of sand and poorly developed soil layers. Sequences of blown-sand layers and soils suggest that the relief of the surface during different historical times was not the same as today. The wind continuously filled up the former blowout depression. Later, as the surface was stabilised again, a relatively thick and dark soil layer could develop.

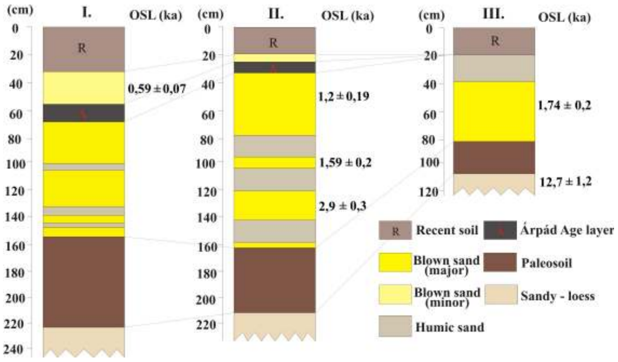

Fig. 4 Profiles, depositions and the OSL data

However, according to the OSL measurements, around 0.59 ± 0.07 year ago aeolian activity restarted and created a 30-100 cm sandy deposit on the top of the layers (*Fig. 4*).

DISCUSSION

The age and depositional data of the profiles were compared to archaeological evidence on the site and in the region (Wicker E. 2000, Rosta Sz. 2007). For the reconstruction of spatial characteristic of land surfaces at different historical periods a 3D model of the layers was created. All these enabled the reconstruction of the type, intensity and the results of human impact on the environment in different historical periods.

Until the 9th centuries BC a blowout depression was located at the excavated area. Its altitude varied between 122-124 m a.s.l. and a very thick soil was developed on the surface (*Fig. 5*). Southeast from the blowout depression a higher sand dune was situated, which is still visible today.

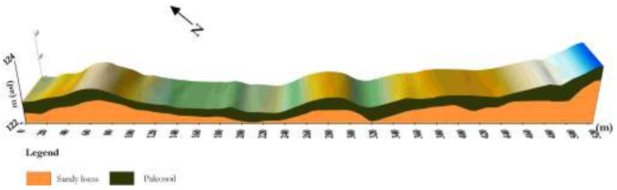

Fig. 5 Surface profile: before the 9th century BC

As the result of several sand movements, 30-180 cm thick sand layer was deposited (*Fig. 6*). In the 9th century BC (OSL: 2.9 ± 0.3 ka) a thin sand layer covered the deepest part of the depression. Since then sand movement took place in the Subboreal Phase, which was cool and wet (Járainé K. M. 1966, 1969), the role of climatic controls on the remobilisation of sand is certainly insignificant. On the other hand the findings around Kiskunhalas from the 9th century BC (Wicker E. 2000) provide an evidence for the presence of a dense result of human disturbance at this time. Subsequently, until the 2nd century BC soil development occurred. During the 2nd-5th century AD Sarmatians inhabited the territory (Rosta Sz. 2007), who were engaged in agriculture and kept large livestock on the pastures. The excavated Sarmatian trenches and wells were found on the elevated surface of the paleosoil, while marks of livestock treading in the deepest part (*Fig. 6*).

Fig. 6 Animal foot prints (foto: István Knipl)

These indicate that the low-lying, wet area of the blowout depression was used for watering, while the higher surfaces were pastures or plough-fields. Sarmatian animal breeders and farmers with large population meant an intensive burden on the environment, thus the chance for wind erosion increased on bare surfaces caused by over-grazing or ploughing. Due to these reasons aeolian activity appeared on the territory in the 3rd and 5th century AD (OSL: 1.74 ± 0.2, 1.59 ± 0.2 ka) and the area of the blowout depression was covered by a sandsheet. However, in this case the role of climatic control could be more significant, as this was the time of the "Roman Warm Period", which generally characterised by warmer and drier weather conditions (Rácz L. 2006). In the 8th century AD (OSL: 1.2 ± 0.2 ka) aeolian activity was possibly induced by the Avars (Wicker E. 2000). At this time the climate was cold and dry (Rácz L. 2006), being ideal for sand movement especially when anthropogenic impact was superimposed. As a consequence of the sand movement between the 9th century BC and the 8th century AD, the blowout depression was filled up, thus a more homogenous surface developed at a higher elevation (*Fig. 7*).

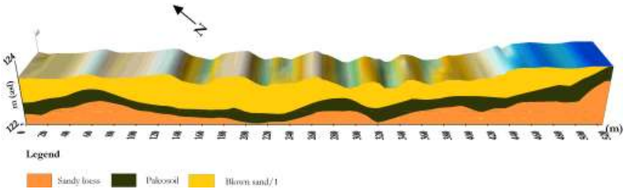

Fig. 7 Surface profile: 8th century BC

Subsequently, a longer stable period came without sand movement, which coincides with the generally more warm and wet "Medieval Warm Period" (Rácz L. 2006). During this time the surface was stabilized and a humic sandy soil developed (*Fig. 8*).

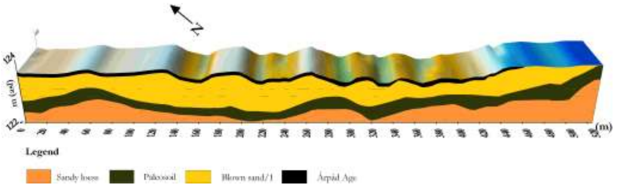

Fig. 8 Surface profile: 13th century BC

People settled down in this area in the Árpádian Period, between the 13-14th century AD. Based on plough marks stretching, from north to south along a 60 m long section (*Fig. 9*), the area functioned as a plowland in the 13th century when a 20-30 cm anthropogenic layer was formed (*Fig. 10*). Based on the stockyards, house remains, potteries and bones later it might have been used for animal husbandry as well as for settling down from the turning of 13-14th centuries (Rosta Sz. 2007).

Fig. 9 Plough marks stretching from north to south (foto: Szabolcs Rosta)

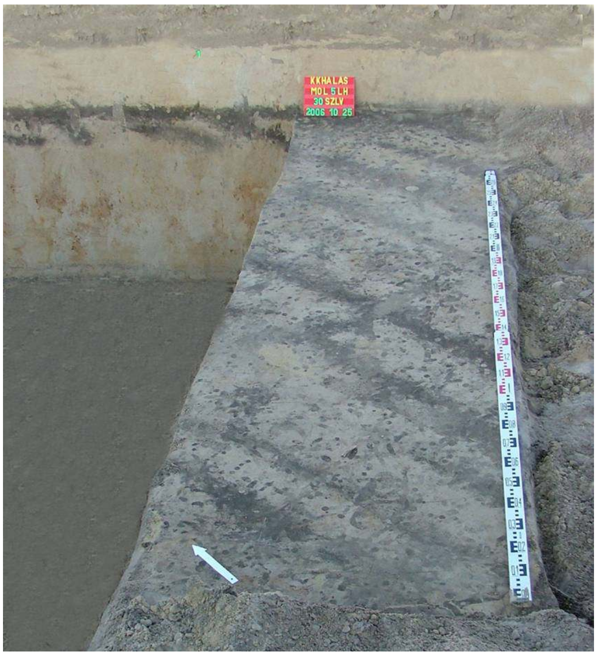

Fig. 10 Anhtropogenic layer above the plough marks

On this palaeosoil, another sand layer can be found (*Fig. 11*), which was formed in the 15th century AD (OSL: 596±68 y). The sand movement is probably also the result of human disturbance as a well was found indicating inhabitance. At this time the climate was generally unfavourable for aeolian activity as it belongs to the "Little Ice Age".

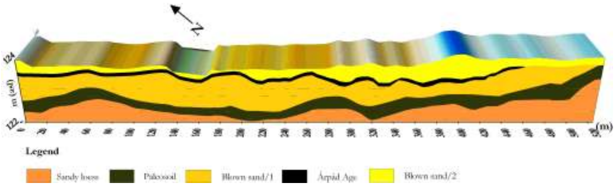

Fig. 11 Surface profile: the 15th century BC

Thus, the aeolian activity levelled the surface even more on the altitude of 124 m a.s.l., which can be seen today. Now the area functions as a plough land and the modern ploughing techniques destroyed the former layers (*Fig. 12*).

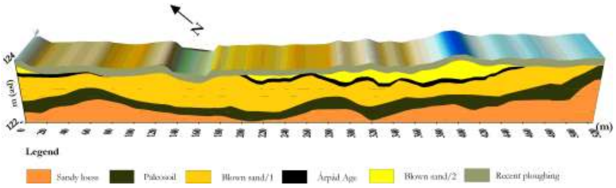

Fig. 12 The surface in 2007

CONCLUSION

The Holocene morphological evolution of the investigated area is complex. The Pleistocene forms were reshaped and transformed, thus at certain locations the original morphology can hardly be identified. Remobilisation and reshaping were especially intensive during historical times (*Fig. 13*). The former landscape changed mostly because of the combined effects of climate and human impact on the environment. Blown-sand movements in historical times filled up the blowout depression.

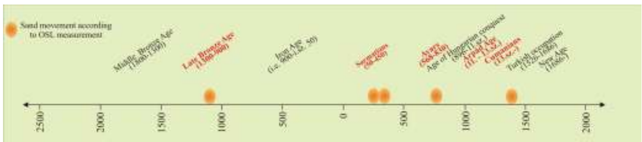

Fig 13 The OSL ages and the archaeological relicts of the area

Sand sheets reshaped the original morphology covered several generations of palaeosoils. Today the surface is higher and more even; a dry and slightly humic sandy soil covers the area of the former low-lying and wet blowout depression which was filled up by thick organic sediment and soil.

Acknowledgments

The authors to thank Szabolcs Rosta and István Knipl for assistance and the archaeological data provided. The authors are also grateful to György Sipos for providing with the results of OSL measurements. The research was supported by the OTKA K62200 and PD73379 research grants.

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