ENVIRONMENTAL CHANGES IN HISTORICAL TIMES NEAR KECEL ON THE DANUBE-TISZA INTERFLUVE, HUNGARY. ARCHAEOLOGICAL RESEARCH AND OPTICALLY STIMULATED LUMINESCENCE (OSL) DATING

KÖRNYEZETI VÁLTOZÁSOK A TÖRTÉNETI IDŐKBEN KECEL KÖRNYÉKÉN. RÉGÉSZETI KUTATÁS ÉS OSL KORMEGHATÁROZÁS

NYÁRI DIÁNA[1], KNIPL ISTVÁN[2], KISS TÍMEA[1], SIPOS GYÖRGY[1]

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

[2]Hungarian National Museum Center of National Heritage Protectorate, 1113 Budapest, Daróci út 3.

E-mail: knipli@knipl.hu

Abstract

A major advantage of luminescence dating is that it enables the direct dating of sediments containing quartz. Up till the last couple years Hungarian researches applying luminescence have mainly been concentrating on the dating of loess profiles, and hardly any attempts were made on the investigation of the sediments of historic times, in order to complement archeological findings and results. This work will present a complex analysis based on archaeological research and OSL dating.

The growing 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 on it can be found on the Danube-Tisza Interfluve where the change in climatic conditions and the anthropogenic disturbance both caused aeolian activity during historical times. Therefore the original geomorphological setting of the area transformed, the Pleistocene forms were reshaped by Holocene sand-movements.

The present work will provide good evidence on sand movement in historical times caused by human impact on the environment with the help of OSL dating and archaeological research in the vicinity of the village of Kecel, which is located on the largest blown-sand area of Hungary on the Danube-Tisza Interfluve.

Kivonat

A lumineszcens kormeghatározás legnagyobb előnye, hogy lehetővé teszi a kvarctartalmú üledékek korának megállapítását. Kezdetben Magyarországon ezt a módszert elsősorban löszös üledékek kormeghatározására használták, azonban néhány esetben kísérlet történt történeti korú üledékek vizsgálatára is, melynek célja a régészeti adatok kiegészítése volt.

Az ember környezetre gyakorolt hatása a népességszám növekedése, a mezőgazdasági technika fejlődése, a táj használatának változása miatt a történelem során egyre jelentősebbé vált. Jó példákat találhatunk e folyamatra a Duna-Tisza köze félig kötött futóhomok területein, ahol a klíma változása és az emberi tevékenység együttes hatása többször mozgásba hozta a futóhomokot. A holocén homokmozgások következtében a terület geomorfológiai felépítése megváltozott, a pleisztocén formák átalakultak.

Jelen tanulmány egy Kecelhez közeli régészeti lelőhely feltárása során vett minták feldolgozását és OSL korhatározásának eredményeit mutatja be.

KEYWORDS: ENVIRONMENTAL CHANGES, HOLOCENE, BLOWN SAND, OSL DATING, ARCHAEOLOGY, HUMAN IMPACT

KULCSSZAVAK: KÖRNYEZETI VÁLTOZÁSOK, HOLOCÉN, HOMOKMOZGÁS, OSL KORMEGHATÁROZÁS, RÉGÉSZET, EMBERI HATÁS

Fig. 1.: Blown-sand areas of Hungary

1. ábra.: Futóhomok területek Magyarországon

Introduction, aims

The growing 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 on it can be found on the Danube-Tisza Interfluve where the change in climatic conditions and the anthropogenic disturbance both caused aeolian activity during historical times. (**Fig. 1.**) Therefore the original geomorphological setting of the area transformed, the Pleistocene forms were reshaped by Holocene sand-movements.

The detected earliest blown sand movements on the Danube-Tisza Interfluve took place in the Inter Pleniglacial of the Pleistocene (Sümegi & Lóki 1990; Sümegi 2005) and subsequently there was aeolian activity during the Middle Pleniglacial of the Pleistocene after 25 200 ± 300 year ago (Krolopp et al. 1995; Sümegi 2005). According to earlier researches on the Danube-Tisza Interfluve the most significant aeolian activity occurred during the Upper Pleniglacial (Borsy 1977ab, 1987, 1989, 1991; Sümegi et al. 1992; Sümegi & Lóki 1990; Sümegi 2005). Later, the two cold and dry periods, the Older Dryas and Younger Dryas in the Pleistocene were convenient for aeolian rework (Borsy et al. 1991; Hertelendi et al. 1993) which is supported by radiometric, optical and thermo-luminescenece measurements too (Gábris et al. 2000, 2002; Gábris 2003; Újházy 2002; Újházy 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 1977ab, 1987, 1991; Gábris 2003; Kádár 1956; Marosi 1967; Újházy 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 & Borsy 1955; Borsy 1977ab; Gábris 2003; Újházy 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 1977ab, 1987, 1991; Marosi 1967).

Based on archaeological investigations and OSL measurements on the Danube-Tisza Interfluve aeolian activity occured in the Bronze Age (Gábris 2003; Újházy et al. 2003; Nyári & Kiss 2005a & b; Kiss et al. 2006, 2008; Nyári et al. 2006a & b, 2007a & b; Sipos et al. 2006; Nyári et al. 2009), then the surface became stable for a long period, until the 3rd-4th centuries AD. As later the climate turned dry (Rácz 2006; Persaits et al. 2008) and the anthropogenic disturbance became more significant conditions became suitable for aeolian activity, which is proved by several researchers (Lóki & Schweitzer 2001; Kiss et al. 2006, 2008; Nyári et al. 2006a & b, 2007a & b; Sipos et al. 2006; Knipl et al. 2007; Nyári et al. 2009). Sand movement was also characteristic in the Migration Period, especially during the 6th-8th c. AD, which was the realm of the Avars (Nyári & Kiss 2005a & b; Kiss et al. 2006, 2008; Nyári et al. 2006a & b, 2007a & b; Sipos et al. 2006; Nyári et al. 2009). Subsequent aeolian activity occurred also in the Árpád Age (11th-13th c. AD, Lóki & Schweitzer 2001; Gábris 2003; Újházy et al 2003; Nyári et al. 2006a & b; Knipl et al. 2007; Kiss et al. 2008; Nyári et al. 2009) and when the Cumanians inhabited the territory (13th c. AD, Sümegi 2001; Kiss et al. 2006, 2008; Nyári et al. 2006a & b, 2007a & b; Sipos et al. 2006; Nyári et al. 2009). The latest aeolian activity occurred in the 15th century AD (Nyári et al. 2007a; Kiss et al. 2008).

The present work will provide good evidence on sand movement in historical times caused by human impact on the environment with the help of OSL dating and archaeological research in the vicinity of the town of Kecel, which is located on the largest blown-sand area of Hungary on the Danube-Tisza Interfluve.

The aims of the research were to identify the ethnical groups and their possible activities; to map the geomorphology of the study area; to determine the periods of aeolian activity; to assign the possible types of human activities in connection with climatic changes enabling aeolian activity.

Study area

The 9 km2 large blown sand covered study area is situated on the southern part of the Danube-Tisza Interfluve, southeast from the 54th main road between Kecel and Soltvadkert (**Fig. 2.**).

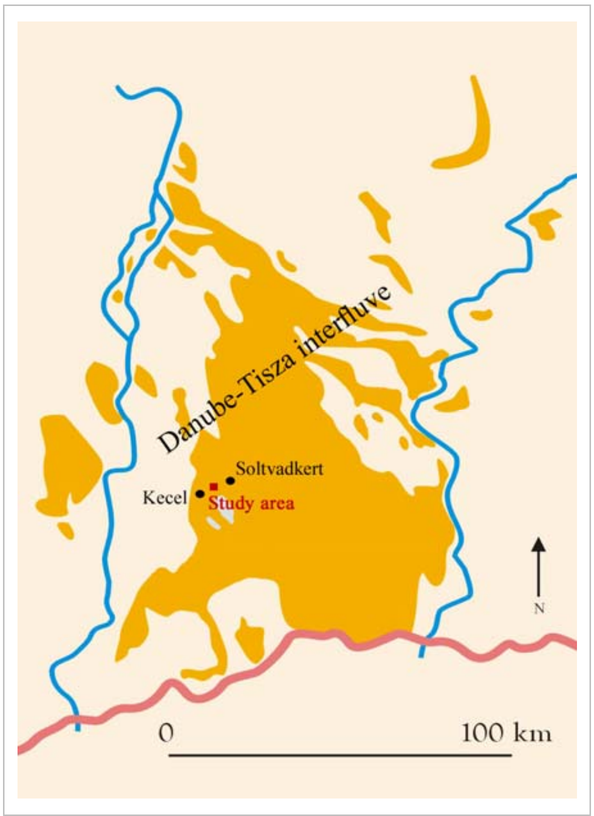

Fig. 2.: The location of the study area

2. ábra.: A vizsgált terület elhelyezkedése

The 320 m long and 6 m wide excavated site was located along a future gas-main on the middle of the study area and acrossed a sand dune with its blowout depression, providing an exceptionally good example on Holocene aeolian reshaping.

Methods

Archaeological investigation

The archaeological excavation area: Soltvadkert-Alsócsábor, Herczeg farm-house is situated from an archeological point of view in an unknown area of the Danube-Tisza Interfluve. The village was not exposed to either systematic field study, or rescue excavation connected with big investments. We can partially understand the history of the region only through the incidental findings exhibited in museums, or through the found areas of the neighboring town, Kecel, in which area field study was done earlier.

By investigating the findings of the site the activities and environment of earlier inhabitants of the area can be revealed. Previous archaeological analyses made in the area (Biczó 1984) 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 on the paleo-environment.

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. The major aeolian morphological units: erosional — transportational and accumulational 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.

OSL measurements

The optically stimulated luminescence (OSL) age determines the last exposure of sediments to sunlight. Therefore, the method is especially suitable for identifying the depositional age of wind-blown sands (Aitken 1998). Altogether five samples were collected from two profiles. Extraction and sample preparation procedures followed the steps introduced by Aitken (1998) and Mauz (2002) and aimed at the separation of quartz grains of suitable (90-150 μm) size. 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. Throughout the measurements the SAR technique, described in detail by Murray and Wintle (2000), was followed. The OSL dates are calculated from the year of 2007, when the measurement was done.

Results

Archaeological investigation

According to these findings we can conclude that the area was almost continuously inhabited from the Copper age till the Middle Age, and numerous other hints in support of this idea might be hidden under ground. What is known from the data in this area (Kecel, Kiskunhalas and Császártöltés,) is that first the inhabitants of the Bodrogkeresztúr culture were living in the area, and in the late Copper age it became the lodging field of the Baden culture. The Bronze Age commences with the appearing of the Makó inhabitants, and then the folks of Nagyrév, Vatya, Halomsíros, Gáva cultures lived at the region, which in turn was the region of the Celtic people in the Iron Age (Biczó 1984; Wicker 2000; Knipl 2004, 2009a, b & c).

During the 1-5th centuries, the fields of Kecel and Soltvadkert were parts of the Sarmatien lodging area, later the Avars and Hungarians inhabited there (Biczó 1984; Wicker 2000; Knipl 2004).

On the area of Soltvadkert-Alsócsábor, Herczeg farm-house, the employees of the Bács-Kiskun Country Museum (György Székely and Mónika Mészáros) did rescue excavation during October-November 2006 and in May 2007.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

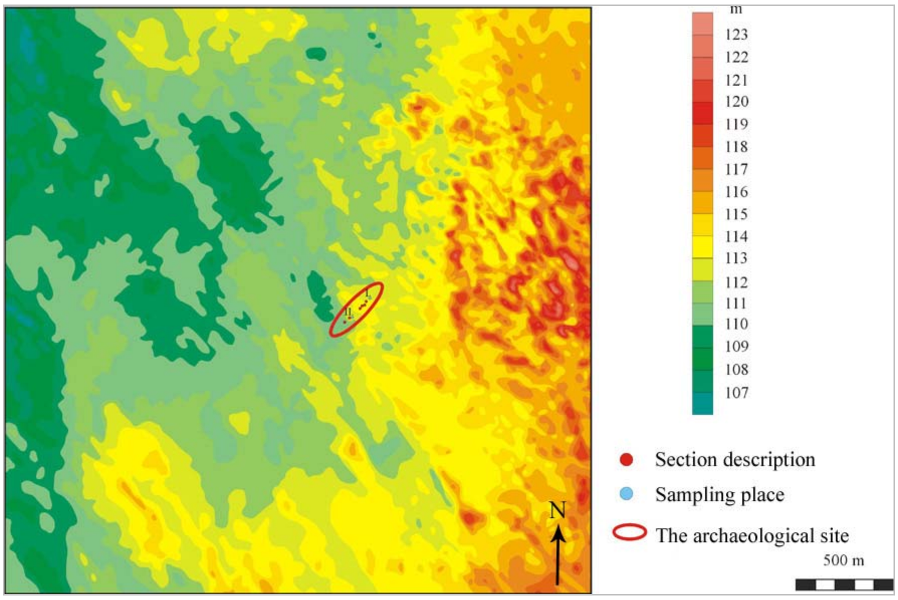

Fig. 3.: The relief map of the study area

3. ábra.: A vizsgált terület relief térképe

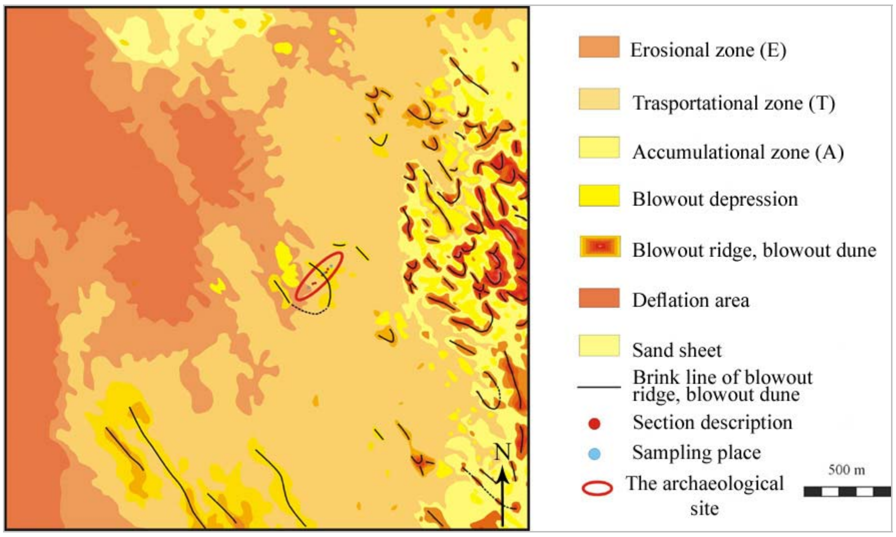

Fig. 4.: The geomorphological map of the study area

4. ábra.: A vizsgált terület geomorfológiai térképe

The excavation was done at the position of a new gas-main, in about 300 m lengths and 6 m widths. At this time 162 objects were found and excavated. According to the findings, in this area we can distinguish the traces of two populations of the following cultures. The first inhabitants arrived at the Migration Period (Avars); they were followed by the Árpád-era Hungarians. Significant part of the excavated objects belonged to the settlement of the Migration Age. (Székely & Mészáros 2007)

Geomorphological mapping

The mapped area is 9 km2 and situated on the southern part of the Danube-Tisza Interfluve (**Fig. 2.**). The altitude of the area varies between 106 and 124 m asl. Based on the relief map (**Fig. 3**.) the western part of the investigated area represents an erosion zone, where according to the gemorphological map the most typical forms are low lying flat deflation areas. On the eastern part, a higher sandy area – transportation and accumulation zone – characterises the landscape and covered by blowout depressions, blowout ridges and blowout dunes, hummocks. The forms stretch from NW to SE, and clearly mark the direction of winds which were the most important agent in shaping the area (**Fig. 4.**).

The Holocene morphological evolution of the investigated area is complex. In most of the cases Pleistocene forms were reshaped and transformed, thus at certain locations the original morphology can hardly be identified. Remobilisation and reshaping was especially intensive during historical times, however it was restricted to smaller patches of land.

Depositional history

Across the sand dune from NE to SW sequence descriptions of eight profiles were made and samples for OSL dating were collected from two profiles along the excavated site (**Fig. 3.**). This enabled us to reconstruct how the former sand dune reshaped because of wind erosion and accumulation.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

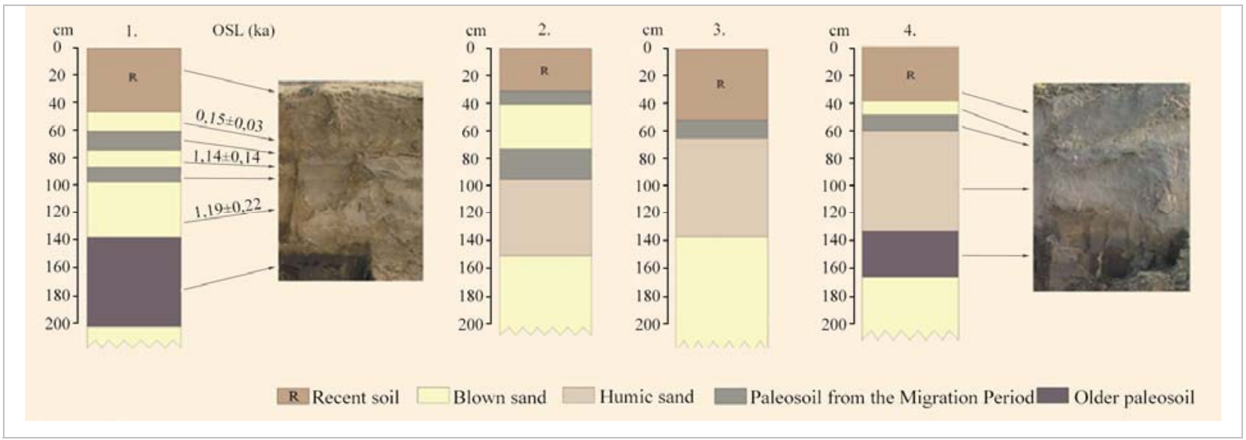

Fig. 5a: Profiles, depositions and OSL data (1)

5a ábra: : A mintaszelvények rétegsora az OSL mérések eredményeivel (1)

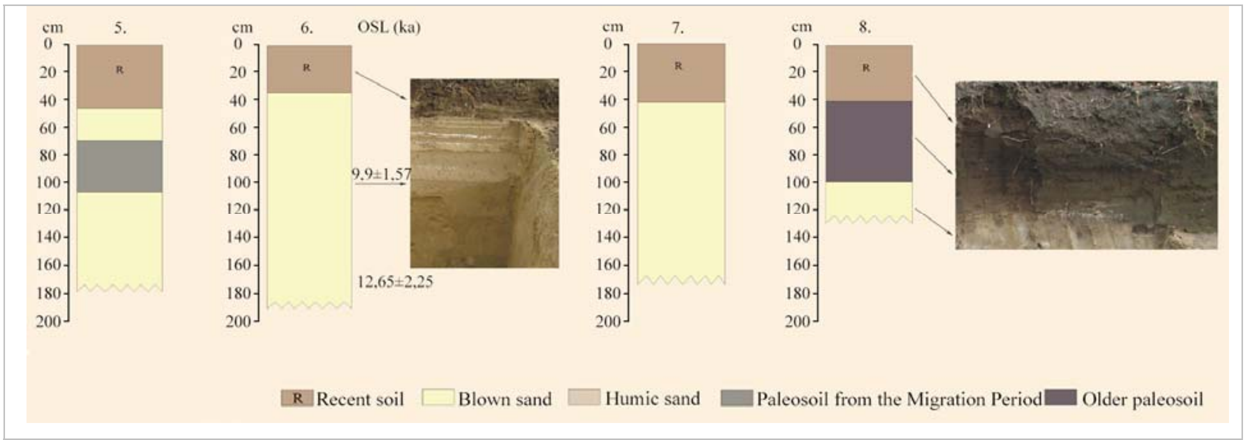

Fig. 5b: Profiles, depositions and OSL data (2)

5b ábra: : A mintaszelvények rétegsora az OSL mérések eredményeivel (2)

Aeolian reactivation and subsequent deposition occurred repeatedly, between 12650±2250 and 9900±1570 during the Pleistocene and early Holocene, thus the sand dune was formed by a thick sand layer within 2000-3000 years. After that the surface stabilized and a soil was evolved under cold and wet climate in the Preboreal phase (Járainé Komlódi 1966, 1969). Around the sand dune in lower lying flats and also in the blowout depression of the dune thicker soil developed during the Holocene.

In the later periods of the Holocene during different historical times sequences of blown-sand layers and soils were formed on the southeast part of the dune. This suggests that the dune was eroded and sand was accumulated on the slipface of the dune. Aeolian reactivations took place 1190±220, 1140±140 and 150±30 years ago according to the OSL measurements and resulted a 40-160 cm thick layer consisted of sand and soil layers (**Fig. 5a-b.**).

Discussion

Partial environmental reconstruction

Age and sedimentological data of the profiles were compared to archaeological evidences. This enabled the reconstruction of the type, intensity and the result of human impact on the paleo-environment.

According to the archaeological evidences, people settled down on the sand dune and neighbouring area in the Migration Period. They were Avars who inhabited the area between the 6st and 9th century. At this time the climate was cold and dry (Rácz 2006), which is ideal for sand movement especially during intensive anthropogenic impact. Human activity meant an intensive burden on the environment resulting bare surface on the higher part of the sand dune, which were scenes of wind erosion under the cold and dry climate which was natural for sand movement. In consequence the dune was eroded and finally a 40-100 cm sand accumulated on the slipface of the dune and in the neighbouring lower lying flat area 1190±220 years ago.

HU ISSN 1786-271X; urn: nbn: hu-4106 © by the author(s)

Then a short period came without sand movement therefore the surface was stabilized and a humic sandy soil was developed. Afterwards blown sand movement happened over again 1140±140 years ago and another 20-40 cm thick sand layer covered the territory of the excavated area.

The youngest sand movement happened 150±30 years ago according to the OSL measurements which is connected with modern times.

Conclusion

The Holocene morphological evolution of the investigated area is complex. The Pleistocene forms were reshaped and transformed during the Holocene, thus at certain locations the original morphology can hardly be identified. Remobilisation and reshaping of the forms were especially intensive during historical times. We stated that the former landscape changed mostly because of the human impact on the environment. Three times spatially localized blown-sand movement in historical times reshaped the original morphology and the soil properties. Today the surface around the sand dune is higher and a dry and weakly humic sandy soil covers the area of the former lower-lying and wet flat area which was filled up by thick organic sediment and soil.

References

AITKEN, M. J. (1998): *An introduction to optical dating: the dating of Quaternary sediments by the use of photon-stimulated luminescence.* Oxford, Oxford University Press

BICZÓ, P. (1984): A keceli határ régészeti emlékei. In: BÁRTH, J.: *Kecel története és néprajza.* Kecel 19–61.

BORSI, Z-né & BORSY Z. (1955): Pollenanalitikai vizsgálatok a Nyírség északi részében. *Közlemények a KLTE Földrajzi Intézetéből* **22** 1–10.

BORSY, Z. (1977a): A Duna-Tisza köze homokformái és a homokmozgás szakaszai. *Alföldi tanulmányok* **1** Békéscsaba, 43–53.

BORSY, Z. (1977b): A magyarországi futóhomok területek felszínfejlődése. *Földrajzi Közlemények* **25** 12–16.

BORSY, Z. (1987): Az Alföld hordalékkúpjainak fejlődéstörténete. *A Bessenyei György Tanárképző Főiskola Tudományos Közleményei* 11/H Földrajz 5–37.

BORSY, Z. (1989): Az Alföld hordalékkúpjainak negyedidőszaki fejlődéstörténete. *Földrajzi Értesítő* **38/3-4** 211–222.

BORSY, Z. (1991): Blown sand territories in Hungary. *Z. Geomorph. N.F. Suppl.-Bd*. **90** 1–14.

BORSY, Z., FÉLEGYHÁZI, E., HERTELENDI, E., LÓKI, J. & SÜMEGI, P. (1991): A bócsai fúrás rétegsorának szedimentológiai, pollenanalitikai és malakofaunisztikai vizsgálata. *Acta Geographica Debrecenina* **28-29** 263–277.

GÁBRIS, Gy., HORVÁTH, E., NOVOTHNY, Á. & ÚJHÁZY, K. (2000): Environmental changes during tha Last-, Late- and Postglacial in Hungary. In: KERTÉSZ, Á. & SCHWEITZER, F.: Physico-geographical Research in Hungary, *Studies in Geography in Hungary* **32** Akadémiai Kiadó Budapest 47–61.

GÁBRIS, Gy., HORVÁTH E., NOVOTHNY, Á. & ÚJHÁZY, K. (2002): History of environmental changes from the Glacial period in Hungary. *Praehistoria* **3** 9–22.

GÁBRIS, Gy. 2003: A földtörténet utolsó 30 ezer évének szakaszai és a futóhomok mozgásának főbb periódusai Magyarországon. *Földrajzi Közlemények* **127** 1–13.

HERTELENDI, E., LÓKI, J. & SÜMEGI, P. (1993): A Háy-tanya melletti feltárás rétegsorának szedimentológiai és sztatigráfiai elemzése. *Acta Geographica Debrecina* **30-31** 65–75.

JÁRAINÉ KOMLÓDI, M. (1966): Adatok az Alföld negyedkori klíma és vegetációtörténetéhez I. *Botanikai Közlemények* **53** 191–200.

JÁRAINÉ KOMLÓDI, M. (1969): Adatok az Alföld negyedkori klíma és vegetációtörténetéhez II. *Botanikai Közlemények* **56** 43–55.

KÁDÁR, L. (1956): A magyarországi futóhomok-kutatás eredményei és vitás kérdései. *Földrajzi Közlemények* **4** 143–163.

KISS, T., NYÁRI, D. & SIPOS, Gy. (2006): Blown sand movement in historical times in the territory of Csengele. In: KISS, A., MEZŐSI, G. & SÜMEGHY, Z. : *Landscape, Environment and Society.* Szeged 373–383.

KISS T., NYÁRI D. & SIPOS Gy. (2008): Történelmi idők eolikus tevékenységének vizsgálata. In: SZABÓ J. & DEMETER G.: *A Nyírség és a Duna- Tisza köze összehasonlító elemzése Tanulmányok Kádár László születésének 100. évfordulóján rendezett tudományos konferenciára*, Kossuth Egyetemi Kiadó, Debrecen 99–106

KNIPL, I. (2004): Császártöltés régészeti topográfiája. *Cumania* **20** 173–204.

KNIPL, I. (2009a): Császártöltés régészeti topográfiája II. (rézkor, bronzkor). *Cumania* **24** 91–133.

KNIPL, I. (2009b): Újabb leletek a császártöltési határban. In: BENDE L. & LŐRINCZY G.: *Medinától Etéig, régészeti tanulmányok Csalog József születésének 100. évfordulójára*. Szentes, 145–147

KNIPL, I. (2009c): Rézkori edények a császártöltési határban. *Múzeumőr* **VII/1**, 30–31.

KNIPL, I., WICKER, E., NYÁRI, D. & KISS, T. (2007): Evidence of human impact on the environment: Blown sand movements in historical times according to archaeological and geomorphological investigations near Apostag, South of Budapest, Hungary. *In: 13th Annual meeting of the European Association of Archaeologists (EAA), Zadar, Croatia, 18-23. September, 2007. Abstracts book* 342–343.

KROLOPP, E., SÜMEGI, P., KUTI, L., HERTELENDI, E. & KORDOS, L. (1995): A Szeged-Öthalom környéki löszképződmények keletkezésének paleoökológiai rekonstrukciója. *Földtani Közlöny* **125** 309–361.

LÓKI, J. & SCHWEITZER, F. (2001): Fiatal homokmozgások kormeghatározási kérdései a Duna-Tisza közi régészeti feltárások tükrében. *Közlemények a Debreceni Egyetem Földrajzi Intézetéből* **221** 175–181.

MAROSI, S. (1967): Megjegyzések a magyarországi futóhomok területek genetikájához és morfológiájához. *Földrajzi Közlemények* **15** 231–255.

MAUZ, B., BODE, T., MAINZ, H., BLANCHARD, W., HILGER, R., DIKAU, R. & ZÖLLER, L. (2002): The luminescence dating laboratory at the University of Bonn: equipment and procedures. *Ancient TL* **20** 53–61.

MURRAY, A. S., WINTLE, A. G. (2000): Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. *Radiation Measurements* **32** 57–73.

NYÁRI, D. & KISS, T. (2005a): Homokmozgások vizsgálata a Duna-Tisza közén. *Földrajzi Közlemények* **129/3-4** 133–147.

NYÁRI, D. & KISS, T. (2005b): Holocén futóhomok-mozgások Bács-Kiskun megyében régészeti leletek tükrében. *Cumania* **20** 83–94.

NYÁRI, D., KISS, T., SIPOS, Gy., KNIPL, I. & WICKER, E. (2006a): Az emberi tevékenység tájformáló hatása: futóhomok-mozgások a történelmi időkben Apostag környékén. A táj változásai a Kárpát-medencében. *„Település a tájban" konferencia kiadványa* 170–175.

NYÁRI, D., KISS, T. & SIPOS, Gy. (2006b): Történeti időkben bekövetkezett futóhomok-mozgások datálása lumineszcenciás módszerrel a Duna-Tisza közén. III. *Magyar Földrajzi Konferencia CD kiadvány*

NYÁRI, D., KISS, T. & SIPOS, Gy. (2007a): Investigation of Holocene blown-sand movement based on archaeological findings and OSL dating, Danube-Tisza Interfluve, Hungary. www.journalofmaps.com

NYÁRI, D., KNIPL, I., KISS, T. & WICKER, E. (2009): Természet és ember találkozása: futóhomok-mozgások az elmúlt 2000 évben Apostag környékén. *Tisicum* **19** 447–456.

NYÁRI, D., ROSTA, Sz. & KISS, T. (2007b): Multidisciplinary analysis of an archaeological site based on archaeological, geomorphological investigations and optically stimulated luminescens (OSL) dating at Kiskunhalas on the Danube-Tisza Interfluve, Hungary. *In: 13th Annual meeting of the European Association of Archaeologists (EAA), Zadar, Croatia, 18-23. September, 2007. Abstracts book* 142–143.

PERSAITS, G., GULYÁS, S., SÜMEGI, P. & IMRE, M. (2008): Phytolith analysis: environmental reconstruction derived from a Sarmatian kiln used for firing pottery In: SZABÓ, P. & HÉDL, R. (eds.) *Human Nature: Studies in Historical Ecology and Environmental History. Institute of Botany of the Czech Academy of Sciences,* Pruhonice 87–98.

RÁCZ, L. (2006): A Kárpát-medence éghajlattörténete a közép- és kora-újkorban. In: GYÖNGYÖSY M.: *Magyar középkori gazdaság- és pénztörténet.* Jegyzet és forrásgyűjtemény. Bölcsész Konzorcium, Budapest 34–35.

SIPOS, Gy., KISS, T. & NYÁRI, D. (2006): OSL mérés lehetőségei. Homokmozgások vizsgálata Csengele területén. *Environmental Science Symposium Abstracts*, Budapest, 43–45.

SÜMEGI, P. (2001): A Kiskunság a középkorban – geológus szemmel In.: HORVÁTH F. (ed.): *A csengelei kunok ura és népe.* Archaeolingua Kiadó, Budapest, 313–317.

SÜMEGI, P. & LÓKI, J. (1990): A lakiteleki téglagyári feltárás finomrétegtani elemzése. *Acta Geographica Debrecina 1987-1988*, **26-27** 157–167.

SÜMEGI, P., LÓKI, J., HERTELENDI, E. & SZÖŐR, Gy. (1992): A tiszaalpári magaspart rétegsorának szedimentológiai és sztatigráfiai elemzése. *Alföldi Tanulmányok* **14** 75–87.

SÜMEGI, P. (2005): *Loess and Upper Paleolithic environment in Hungary. An Introduction to the Environmental History of Hungary*. Aurea Kiadó, Nagykovácsi, 183–211.

SZÉKELY, GY. & MÉSZÁROS, M. (2007): Ásatási dokumentáció, Soltvadkert-Alsócsábor

Herczeg tanya (MOL 3. lelőhely). Katona József Múzeum Régészeti Adattár, Katona József Múzeum, Kecskemét, Régészeti Adattár.

ÚJHÁZY, K. (2002): A dunavarsányi garmadabucka fejlődéstörténete radiometrikus kormeghatározások alapján. *Földtani Közlöny* **132** (különszám) 175–183.

ÚJHÁZY, K., GÁBRIS, Gy. & FRECHEN, M. (2003): Ages of periods of sand movement in Hungary determined: through luminescence measurements. *Quaternary International* **111** 91–100.

WICKER, E. (2000): A halasi határ régészeti emlékei az őskortól a honfoglalás koráig. In: Ö. KOVÁCS & SZAKÁL A.,: *Kiskunhalas története 1.,* Kiskunhalas 57–58, 98–99.