

## DATING OF TOTAL SOIL ORGANIC MATTER USED IN KURGAN STUDIES

M Molnár<sup>1,2</sup> • K Joó<sup>3</sup> • A Barczy<sup>3</sup> • Zs Szántó<sup>1</sup> • I Futó<sup>1</sup> • L Palcsu<sup>1</sup> • L Rinyu<sup>1</sup>

**ABSTRACT.** We investigated Csípő-halom, one of the kurgans that served as a burial place in the Hortobágy area of the Hungarian Great Plain. For pedological description and other studies of the protected mound and its surroundings, only a few monitoring drillings were permitted to get soil samples. On the basis of morphological and visual studies, the structure and layers of the mound were reconstructed. The Laboratory of Environmental Studies of the Institute of Nuclear Research at the Hungarian Academy of Sciences (INR/HAS) performed radiocarbon measurements of soil samples, applying a bulk combustion pretreatment method. The measured <sup>14</sup>C ages of soil samples from reference points, such as the top layer of the mound, the center of mound body, the base layer of the mound, the near surroundings, and the distant surroundings, are in good agreement with the preliminary archaeological concept for this field and give substantial information about the rate of soil generation processes in this area.

### INTRODUCTION

“You are our cathedrals,” wrote the Hungarian poet Gyula Illyés about our burial mounds. In fact, these land elevations are one of oldest and the most valuable pieces of the human heritage of Hungary and the Great Plain. They are the witnesses of past ages, demonstrating the culture of our ancestors, their burial habits, and their relationship to nature.

The isolated burial mounds, called “kurgans,” belong to the landscape of the Great Hungarian Plain. Many of them were actually a settlement, a settlement border, or a guarding hillock. Since 1996, all of the artificially formed mounds in the Hungarian landscape are protected by law, considered as “kunhalom” (cumanian hillock), no matter their origin, purpose, or their time of derivation. According to these laws, every tomb-mound (kurgan), living-mound (tell-telep), defensive and protective mound, and the delineation of county, district, and settlement borders are counted among the wide concept of “kunhalom” (Tóth 1999).

Kurgans were built in the Stone and Iron Ages (4000–1000 BC) until the Hungarian conquest. The ground was piled simultaneously so that the corpse was held in a half-sitting position, with its head shorn (Kovács 1977; Kalicz 1970). These tumuli are more than archaeological findings; they are also special landscape features that have botanical importance, and provide records for the soil sciences (Alexandrovskiy et al. 2001).

Mounds in Hungary were generally built from the surrounding soil. Their outlines are oval. In general, after building up the mound, the construction provided a surface on which the new soil formation could begin. Under the mound, the several thousand-year-old soil surface has been buried so it has preserved the soil forms that existed in the time of the mound’s construction, while the distant surroundings of the mound preserved marks of soil formation since then (Alexandrovskiy 1996). Thus, securing the soil surface around the mound gives important information about the recent soil formation, and it can widen our knowledge about soil development (Gennadiev and Ivanov 1989).

In our research, we applied radiocarbon dating, a powerful tool in soil and archaeological studies. When lacking enough alternative material for the applied dating technique (proportional counting),

<sup>1</sup>Institute of Nuclear Research of the Hungarian Academy of Sciences (INR/HAS), Laboratory of Environmental Studies, H-4026 Debrecen, Bem tér 18/c., Hungary.

<sup>2</sup>Corresponding author. Email: mmol@atomki.hu.

<sup>3</sup>Szent István University, Department of Landscape Ecology H-2103 Gödöllő Páter Károly u 1., Hungary.



Figure 1 Map of Hungary within Europe. Since 1996, laws protect all of the artificially formed mounds in Hungary.

the dating of total soil organic matter was carried out (Magyari et al. 2001; Pessenda et al. 2001). This paper presents the results and availability of  $^{14}\text{C}$  dating of total soil organic matter in the case of the studied kurgan.

#### **MATERIALS AND METHODS**

Csípő-halom is one of the kurgans that served as burial place. It is located in the Hortobágy area of the Hungarian Great Plain (Figure 2). The height of the kurgan is 5.0 m (elevation 95.15 m) (Figure 3). This territory had developed on loess-like sediment. It was possibly slightly disturbed (ploughing, afforestation, or buildings, etc.) and soil formation was undisturbed (prevented from floods, low human influence, protection).

After the general description of the area, the pedological study of the body of the mound was carried out. The instrument used for sampling was a Styl-style double-armed auger. The diameter of the auger was 5 cm; the helical drill was 100 cm long, and the attachable extensions were 100 cm each. The maximum depth of the boring was 10 m (Figure 4).

The principle of the sampling was based on the Birks and Birks (1980) type of palaeoecological network. The first series of drillings was performed on the body of the mound in the higher third of the slope. The purpose was to study the material of the mound and the buried soil. The second series of drillings, located at the foot of the mound, examined the destroyed and regenerated area, and the third one, performed farther from the mound, examined those areas which had not been disturbed by the building. We carried out the boring with 5 replications at each site. We studied differences between the samples regarding color, structure, humidity, and solidity on the site. The content of lime was tested in every 10 cm with 10% HCl, disregarding the dividing lines between the horizons

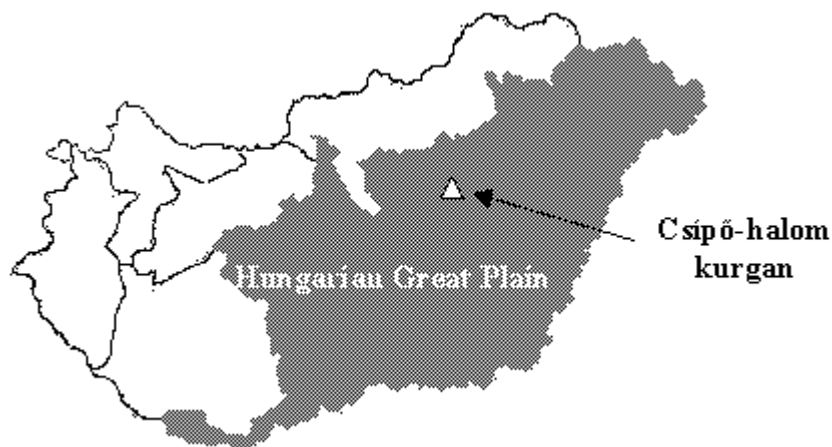


Figure 2 The Csíró-halom kurgan is located in the Hungarian Great Plain



Figure 3 The height of the kurgan is 5.0 m

or layers. We also noted the location of various concretions and morphological features, like roots, tunnels of animals, iron and silica separations, bones, etc. According to these, we could separate the layers and horizons from each other on the scene; accordingly, we classified and prepared the samples for laboratory studies.

Dating of soil samples was performed by the Laboratory of Environmental Studies of the Institute of Nuclear Research at the Hungarian Academy of Sciences. When lacking enough alternative material from soil core samples for  $^{14}\text{C}$  dating (with proportional counters), the total organic matter of the soil samples was dated. After removing inorganic carbonate fraction (0.1N HCl) and the obviously recent macroscopic biomass fragments, 200–300 g of air-dried soil sample was taken for wet chemical oxidation, using  $\text{H}_2\text{SO}_4$  and  $\text{H}_2\text{O}_2$  as oxidants, at 200 °C temperature for 8 hr reaction time in a special combustion system. The produced  $\text{CO}_2$  gas from the carrier  $\text{N}_2$  gas flow was collected in traps with  $\text{Ba}(\text{OH})_2$  solutions (Figure 5). A trap with  $\text{H}_2\text{SO}_4$ , located before the  $\text{CO}_2$  traps, was applied to retain  $\text{SO}_2$ .

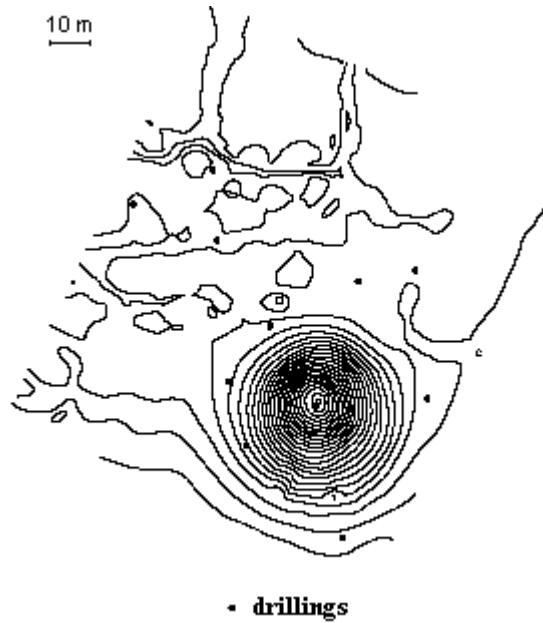


Figure 4 The location of drillings on the mound

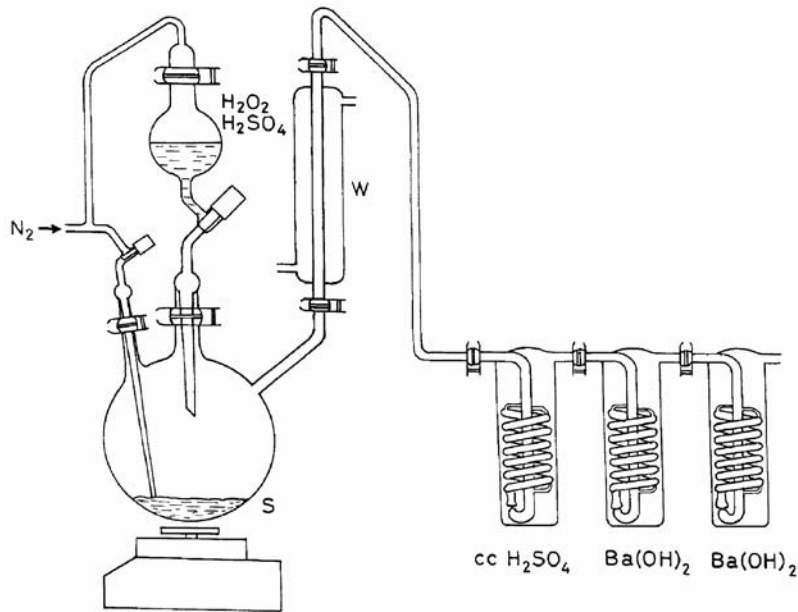


Figure 5 Combustion system applied for chemical oxidizing of soil organic matter

The carbonate precipitate from the traps was digested by 75%  $\text{H}_3\text{PO}_4$ , and the produced  $\text{CO}_2$  gas, after purification in a chromatographic system, was used for  $^{14}\text{C}$  dating (Csongor et al. 1982). This special bulk combustion pretreatment method provides enough gas amount (at least 0.04 mol) for the gas proportional counters (Hertelendi et al. 1989).

**RESULTS AND DISCUSSION**

The depths of the drillings that were carried out on the higher third of the slope were 580 cm, 480 cm, 405 cm, respectively. We bored down to 165 cm deep around the mound (supposedly the building zone) and in the distant surroundings in the same way.

Figure 6 presents the schematic drawing of recorded main layers in the mound and the surrounding area. The structure and layers of the mound were reconstructed on the basis of their morphological and visual studies. The measured <sup>14</sup>C dates are presented in Table 1.

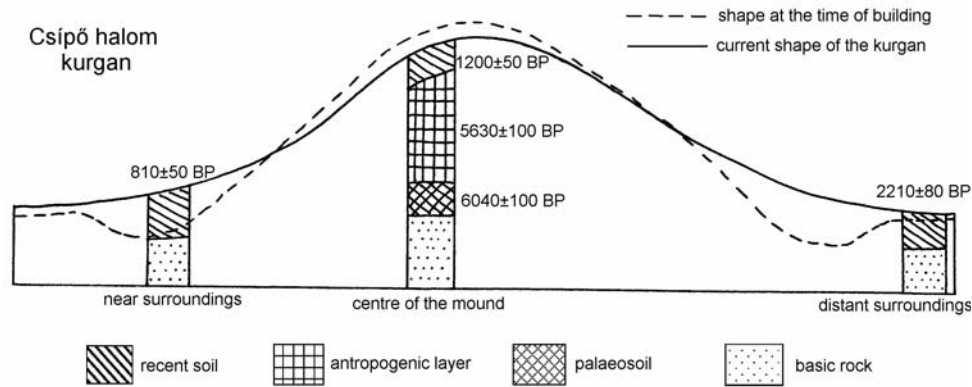


Figure 6 Schematic drawing of recorded main layers in the mound and the surroundings area

Table 1 <sup>14</sup>C dates for the Csípő-halom kurgan. Calibrated ages are given as 1-σ age range (Stuiver et al. 1998).

Laboratory code	Sample	<sup>14</sup> C age (BP ± 1 σ)	Calibrated age (1 σ)
Deb-9071	Top soil of the mound	1200 ± 50	780–880 cal AD
Deb-9086	Anthropogenic core of the mound	5630 ± 100	4550–4360 cal BC
Deb-9087	Buried paleosil	6040 ± 100	5040–4800 cal BC
Deb-9073	Soil of near surroundings of the kurgan	810 ± 50	1200–1260 cal AD
Deb-9070	Soil of distant surroundings of the kurgan	2210 ± 80	360–200 cal BC

In each case, a 20- to 30-cm-deep A-horizon was identifiable on the top of the mound. Under this zone, 50- to 70-cm-deep layers showed lime dynamics, which is a characteristic in the B-horizon of chernozem soils. We could also identify the fur of lime in 3 samples. The <sup>14</sup>C age of this recent layer was 1200 ± 50 BP, which is younger than the lower layers of the body of the mound, and younger than the undisturbed surroundings; this shows that this is a recent layer which formed on the top of the mound.

Under the recent layer of the mound, we could not find the usual basic rock, since the body of the mound consists of the piled, uniformly dark brown, humic soil. The structure of this layer is strikingly different from the upper one, and shows conchoidal fracture when it was dried. The <sup>14</sup>C age of the piled body was 5630 ± 100 BP.

Under this layer, after more or less transition, there is another unified layer (A-paleo-soil) in which we could find hydromorphic marks with clayey texture, solid structure, and bones. Under the A-paleo-soil layer, there was a slightly better structured, dark brown horizon (B-paleo-soil) with higher lime content which changed into loess in a 30- to 50-cm transition. The  $^{14}\text{C}$  measurement of the soil sample of this buried palaeosoil was  $6040 \pm 100$  BP, similar to the upper piled body.

The order of the layers was the same in every sample, only their thickness varied. With the exception of the upper A-horizon, we could not identify the genetical horizons unambiguously. This is particularly important because presently we can only estimate the location of the anthropogenic layer and the buried soil.

In the drillings adjacent to the mound, we found a 20- to 30-cm-deep dusty-crumbly structured A-horizon that changed into the loess basic material with increasing proportions of lime. In the loess, we found lime concretions. The  $^{14}\text{C}$  age of the sample from this zone was  $810 \pm 50$  BP, which confirmed that this was a very young soil that formed on the eroded zone since the building of the kurgan.

The morphological survey of the areas that had not been affected by the building of the mound gave more unambiguous results. On the higher areas, we could identify chernozem soils. Their A-horizon was followed by a clearly identifiable, gradual B-horizon, which contained tunnels of animals. The basic rock is loess in which the marks of the moving groundwater can be identified (blots of iron, spots of rust). On the lower areas, there are solonetz-type alkanian soils; in the basic rock of this level, we observed a stronger effect of water (gley spots). The  $^{14}\text{C}$  age of the sample from this distant surroundings was  $2210 \pm 80$  BP. This measured age showed that the sample from this region is older than the soil of the building zone or the upper recent soil of the mound.

## CONCLUSIONS

As a result of the morphological surveys, we conclude that the layers and horizons can be clearly divided by the outside studies of the sample, and can be used for further identification. The structure of the mound can be ascertained: the mound is covered with new soil formation (1200 BP). Under the mound, the body consists of an anthropogenic core (5630 BP), and the buried soil (6040 BP) has remained protected. The coincidence of the ages of the anthropogenic core and the buried soil are in good agreement with the archaeological concept that the kurgan was built in one step, not step by step over a long period of time. The age of the soil in nearby surroundings (810 BP) also confirmed the preliminary concept that this area was eroded almost to the basic rock for the building of the kurgan, and the new soil formation began after the birth of the mound. The  $^{14}\text{C}$  age of the soil of distant surroundings (2210 BP) was older than the soil samples from the top of the kurgan and the near surroundings, which confirmed that this distant region was possibly undisturbed.

Although these bulk ages obtained after a special pretreatment of the total soil organic matter have to be considered only as maximum ages, the presented  $^{14}\text{C}$  dates are in good agreement with the anthropological concept about the conditions and chronology of the building of the investigated Csíró-halom kurgan.

## REFERENCES

- Alexandrovskiy AL. 1996. Natural environment as seen in soil. *Eurasian Soil Science* 29(3):277–87.
- Alexandrovskiy AL, van der Plicht J, Belinskiy AB, Khokhlova OS. 2001. Chronology of soil evolution and climatic changes in the dry steppe zone of the Northern Caucasus, Russia, during the 3rd millennium BC. *Radiocarbon* 38(2):629–35.
- Birks HJ, Birks HH. 1980. *Quaternary Palaeoecology*. London: E. Arnold Press. 297 p.
- Csongor É, Szabó I, Hertelendi E. 1982. Preparation of

- counting gas of proportional counters for radiocarbon dating. *Radiochemical and Radioanalytical Letters* 55:303.
- Gennadiev AN, Ivanov IV. 1989. Generation of soil and palaeopedology: problems, conceptions, and methodology. *Pocsvovedenije* 10(1):34–43. In Russian.
- Hertelendi E, Csongor É, Záborszky L, Molnár J, Dajkó G, Györfi M, Nagy S. 1989. A counter system for high-precision  $^{14}\text{C}$  dating. *Radiocarbon* 31(1):399–406.
- Kalicz N. 1970. *Claygods. The Memories of Age of Neolithic and Brass in Hungary*. Budapest: Corvina Kiadó. p 48–58. In Hungarian.
- Kovács T. 1977. *Bronze Age in Hungary*. Budapest: Corvina Kiadó. p 51–6. In Hungarian.
- Magyari E, Sümegi P, Braun M, Jakab G, Molnár M. 2001. Retarded wetland succession: anthropogenic and climatic signals in a Holocene peat bog profile from northeast Hungary. *Journal of Ecology* 89:1019–32.
- Pessenda LC, Gouveia SE, Aravena R. 2001. Radiocarbon dating of total soil organic matter and humin fraction and its comparison with  $^{14}\text{C}$  ages of fossil charcoal. *Radiocarbon* 38(2):595–601.
- Stuiver M, Reimer PJ, Bard E, Beck JW, Burr GS, Hughen KA, Kromer B, McCormac G, van der Plicht J, Spurk M. 1998. INTCAL98 radiocarbon age calibration, 24,000–0 cal BP. *Radiocarbon* 40(3):1041–83.
- Tóth A. 1999. *Cumanian Mounds*. Kísújszállás: Alföldkutatásért Alapítvány Kiadványa. 77 p. In Hungarian.