

Using Archaeological GIS in Zala County

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Abstract

This paper is concerned with two interconnected GIS applications used by the Zala County Museum Organization. The system is still in its development phase, partial results, however, can already be presented. The first of the two systems covers the excavated sites, storing all data related to the site (spatial coordinates, object descriptions, photos, drawings), descriptions and depictions of the unearthed findings (inventory, artefact photos and drawings), as well as the results of scientific research. This information system supports the scientific assessment of archaeological sites. The result is a system that handles all the data of archaeological objects. Special maps can be generated by queries based on periods, object types and available findings. The second system processes archaeological sites based on topographic field surveys. Its goal is to produce an up-to-date inventory of all the archaeological sites in Zala County. It contains all the data collected during field surveys and additional information may be appended when new findings emerge. The result is a modern and efficient database for archaeological impact studies, researches and excavations preceding larger constructions.

1. Introduction

Our predecessors' cultural heritage, the surviving material and the architectural remains of bygone periods are irreplaceable, unique and non-renewable sources of humankind's past and present. The excavation, rehabilitation and preservation of archaeological sites for future generations – beyond the valuation of historical, aesthetic and financial values embodied by the remains – is also a moral obligation. The implementation of this obligation involves professional – especially archaeological and architectural – questions, and legal, financial and technical tasks as well.

The Cultural Heritage Protection Act LXIV/2001 deals with the conditions of recovery, scientific treatment, preservation, protection, sustainable utilization and publication of cultural heritage accumulated by national and universal history.

The recovery of the archaeological sites along the motorways M7 and M70, and in the territory of related projects can be considered the largest enterprise in the history of the Zala County Museum Organization. These investigations are still going on along with several other excavations carried out in our county. The work is directed by experts with a great deal of experience accumulated during previous large-scale archaeological projects in Zala County, such as the archaeological expedition preceding the inundation of Kis-Balaton, the recovery of the sites in Hahót Valley, as well as the regional investigation of Kerka Valley. The professional scientific treatment of these area excavations also demanded great meticulousness. Ensuring the query and comparative analysis of archeological data was always an important objective. Every effort has been continuously made to compile our different documentations and inventories to a high standard. These documents were produced until 1999, the start of the rescue excavations, almost entirely on paper. From the mid 1990s we were already in the possession of computers, but these served only for the preparation of the descriptive texts of the archaeological documentation. The spread of large-scale building investments in Hungary involved – as a consequence of the Heritage Act – the multiplication of area excavations and the employment of the accomplishments of the “digital revolution”. In Zala County we started to use digital devices for fieldwork as well as for scientific treatment in 1999. We are fortunate to have young archaeologists in our institute who have a good knowledge of GIS. Our paper presents a GIS based on excavation documentation and museum inventory that supports archaeological research methods and that exploits high-tech IT instruments and techniques, thereby revolutionizing archaeological investigation and scientific treatment.

2. Why is there a need for a geographical information system?

Recent contracted archaeological projects in Hungary, such as motorway rescue excavations, have revealed a considerable amount of finds. The processing and interpretation of the increased amount of artefacts could not have been done with traditional methods. The number of excavated archaeological features sometimes reaches several thousands. The excavated area is also considerably bigger than the area (500–1000 m²) of previous excavations.

The processing, understanding and interpretation of this increased amount of data would be very difficult with traditional methods. One solution to the problem is computerised data processing. For this reason the development and extension of advanced computer techniques are crucial to Hungarian archaeological research. The increased use of computers also helps the archaeologist to evaluate and interpret the data in a more effective way. The use of word processing, data sheet processing or database programs allows us to process and understand the data more effectively, however, the complexity of data calls for a better solution. There is an increased demand for a system which would be able to handle all the documentation of an archaeological excavation, such as drawings (profiles, outlines, cumulative maps and individual finds), description of archaeological features, inventory of finds and photos within the system.

One solution to the problem is the application of a geographical information system (GIS) in archaeology. The use of GIS for processing archaeological data enables us to publish the results faster, but more importantly it allows a more complex examination of the data that gives a better understanding of the past. Archaeology is considered to be a special branch of the social sciences, which brings to life its own subjects of investigation through excavation. The spatial distribution of objects and finds is crucial for understanding the past. Topographical surveys and plotting archaeological sites, features and objects on maps, have always played an important role in archaeological investigations. The application of GIS in archaeology offers the modernisation of the traditional methods (CZAJLIK – MARTON – HOLL 1997).

2.1. Use of GIS in Archaeology

- **Data processing**
The use of GIS makes us able to process data from excavations in a more efficient way. All the documentation of an archaeological excavation such as texts, drawings and photos can be handled within the same system. The system is able to visualise archaeological features according to periods. This makes researchers able to visualise and process the archaeological features and finds from individual periods. The use of queries shows only the data that meets the chosen requirements.
- **Potential of spatial analysis**
Spatial analysis can be used to answer space-related questions. Thus, spatial analysis provides information on certain parts of the archaeological site (“What can be found in the chosen part of the site?”), related to circumstances (“In which part of the site can certain objects be found?”). It is also possible to represent the relationship between archaeological features. The relationship between features can be crucial when the archaeological site exhibits features from different periods.
- **Visualisation**
Visualisation can be made with signs, graphics or pictures. The database that holds the information appears separately.
The use of appropriate coordinates makes it possible to visualise the archaeological site in a 3D model. This is a more complex task which leads to 3D modelling.
- **Data Backup**
The safe storage of data is vital for computer systems. GIS systems provide the storage facility for excessive amounts of irreplaceable data. Access to the data may be controlled. Thus only administrators can change or delete data, while other users have access only to use the data.
- **Metrical Analysis**
The data also enables us to do spatial analysis and statistics. The spatial data provide important means for measuring distance between features and define areas for the purpose of research.
The measured data for each feature provide computable data. A GIS system is able to calculate and visualise the average depth of archaeological features, or the average spatial distribution and density of objects.

2.2. Aims

One of the main aims is to develop a GIS system which provides interpretative solutions for any archaeological site. The database for the GIS system should be designed to be able to facilitate any excavation in Hungary, irrelevant of the period and size of the excavation.

One of the crucial problems in Hungarian archaeological research is that there is no standardised methodology for data processing. As a result, the different data processing methods and databases used by researchers are incompatible with each other. For this reason it is important to standardise the data processing in a way that the applicability of the database is not affected by the size and nature of the data, but at the same time the quality of the data must be maintained (REZI KATÓ 2003).

A further aim is to analyse and compare contemporary archaeological sites. Moreover, the appropriate data would allow us to analyse and compare changes in the environment and economical practices through time.

This paper considers two levels of the application of a GIS system. The following section outlines a complex GIS system of an excavation. This is followed by an outline of a GIS system of known archaeological sites in Zala County.

3. The planning and development of a GIS system

3.1. The beginning

Before 2001, the documentation of archaeological excavations in Zala County was achieved mainly in a traditional way, although some digital equipment was used. The documentation of the rescue excavations for the M7-M70 motorways were mainly accomplished by the means of computers. The photographs were also taken with digital cameras. The cumulative and section drawings were accomplished manually, then the drawings were transferred to a tracing paper. The description of the archaeological features were written by hand and we did not have a standardised system of recording the data.

The first aim was to transfer the drawings to a computer interface. This allowed us to accomplish the documentation faster, but also, and more importantly, in a more precise way.

3.2. Digitising of drawings

We started digitising the drawings of previous seasons in 2002. To achieve this task we used the AutoCad Map software. This software was chosen because it is extensively used, its level of precision is very good and it is easy to learn on a user level. Training facilities of the use of the software on beginner and intermediate levels were accessible to us. A further advantage is that it uses international standards, which later allowed us to convert the digitised drawings into a GIS system.

The Digitising involves the scanning of the drawings of archaeological features (outlines, sections). The raster image is then transformed into a vector image with the appropriate software. The drawn lines are highlighted and the graticules of the plotting paper is deleted. After this process the less complicated drawings are automatically vectorised, while the complicated drawings are semi-automatically vectorised. The more elaborate drawings are then transferred into the AutoCad Map program. In the program the possible mistakes made during vectorising are corrected and the finished drawing is then placed onto a prepared template. This procedure may seem complicated at first, however, with good organisation and practice it is faster and more precise than the traditional reproduction of drawings on tracing paper.

The cumulative map is accomplished by the means of vectorised drawings. Every excavated feature is given at least two measuring points which are indicated on the drawings. The spatial data of these measuring points is recorded with a total station (see the method below). The edited drawings are then placed onto these two measuring points. The drawings are processed in the mapping system of Integrated National Projection System (*Egységes Országos Vetületi Rendszer*), which is the basis of our GIS system.

3.3. The digital documentation of an excavation

The integration of the drawings into a digital system is followed by the transferring of the full documentation of an excavation into a digital format. The digital format in opposition to “paper format” allows easier, faster, but more

importantly, more efficient ways of data processing. The adoption of advanced techniques also make us able to live up to the requirements of regulations and laws regarding documentation. The Directorate of the Museums of Zala County uses the following documenting system, which is ascribed by statutory rules:

- Text documentation
 - Interim report of excavation;
 - Excavation diary;
 - Description of archaeological features.
- Maps and drawings
 - The place of the excavation on a 1:10 000 topographical map (digital);
 - Cumulative map, drawings of archaeological features.
- Photos (.jpg)
 - Photos of outlines, features, working progress;
 - Subject picture;
 - Aerial photos, landscape photos.

The considerable amount of data at an excavation poses a problem, because the complex work of processing all the data would require the use of different softwares, which would handle the data independently from each other. The next logical step seemed to be to develop a system that can handle the different arrays of related data.

We wanted to find a system that is able to handle different types of data (text, table, photos) simultaneously on a single interface, so that one can work with the whole data or with individual features while still able to access all the available data on the concerned feature. The solution lies in a system that is able to integrate different types of data. One solution to the problem is a web-based system that can process different types of data. Such a system is, however, not suitable for data analysis. The ultimate solution to the problem is the development of an archaeologically driven GIS system. This system would be able to handle and integrate different types of data. Thus all the digital data could be handled and manipulated within one system. It is also an important attribute that such a system can handle massive amounts of data, and that queries can be applied to all the data entered at the same time, irrelevant of the type of the data (text, table, photo). The results of queries can be visualised on a different map and can be saved for further analysis or processing. Moreover, with the appropriate data we can analyse and compare changes in the environment and economical practices through time.

4. The operation of a GIS system on a site level

4.1. The applied data

4.1.1. Geometric data

At the excavation, the geometrical data of the archaeological features are recorded. The spatial positioning of the features is recorded through measuring points. The co-ordinate system that is used is the Integrated National Projection System. The base of the measurement is the Hungarian geodetic benchmark system. By using the positions of these points by the means of total station we establish the base point(s) of the excavation. If there is no benchmark in close vicinity of the excavation a GPS is used to establish the base point. The measurements of the archaeological features are related to the base point. These measurements determine the 3D coordinates (x, y, z) of the trenches, archaeological features and the most important finds.

Each measurement point is given an ID number that incorporates the ID number of the archaeological feature and the point number. It is enough to measure these points only, because after digitalising and geo-referencing the drawings, any geographical point of the feature or object is known¹.

¹ There are other available methods for determining the geographical position of archaeological features and their representation on maps. A commonly used method is to measure each characteristic point of the feature. With this method the linking of measured points gives the outline of the feature. Another commonly used method is to represent the features on a trench-surface drawing. In this method, the most important points of the grids within the excavated area are measured. The sections are then joined together as the grids are assembled. The discussion and comparison of these methods, however, are beyond the scope of this paper.

The processing of data (digitising of drawings, georeferencing, visualisation of drawings on maps) runs parallel with the excavation. This is important because should any mistake appear, it can be cross-checked with the on-going excavation and be corrected. Also, the excavation is still running and can be used as a reference to control the validity of digitised data. As a result, by the time the excavation is finished, the digitising of drawings is also more or less finished.

4.1.2. Descriptive data

The descriptive data can be divided into two parts. The first part concerns the excavation in general and the second one concerns the archaeological features. The first part gives a summary of the excavation. The summary of the excavation includes the interim report, excavation diary, inventory of drawings and photos of archaeological features and objects and the list of co-ordinates of measurement points for features, trenches, base-points and benchmarks.

The second part of the documentation concerns the description of archaeological features. This description incorporates all the data about the archaeological features and objects on a recording sheet.

4.2. The database

As it has been mentioned above, the description of archaeological features and objects are integrated into a database. The necessary data to build up a database is recorded on a recording sheet (Fig. 1). The recording sheet includes the following categories:

2004. Dátum:

716 NAGYRÉCSE - BARÁKA-DŰLŐ

Objektum szám:

Rétegek:

Számvény: Pozíciószám:

Hozzá tartozik:

Leírás:

Méretek (cm):

Hossz: Szélesség:

Átm: M:

LELETANYAG

Kor	Fém	Cseré	Anyagnem
<input type="checkbox"/> bronz	<input type="checkbox"/> vas	<input type="checkbox"/> agyag	<input type="checkbox"/> kerámia
<input type="checkbox"/> réz	<input type="checkbox"/> ólom	<input type="checkbox"/> kő	<input type="checkbox"/> üveg
<input type="checkbox"/> bronz	<input type="checkbox"/> vas	<input type="checkbox"/> agyag	<input type="checkbox"/> kerámia
<input type="checkbox"/> réz	<input type="checkbox"/> ólom	<input type="checkbox"/> kő	<input type="checkbox"/> üveg

Műzes és másanyag (cm):

Fém: Összesítő:

Fig. 1. Object data sheet.

- Feature ID: (individual ID number)
- Function of feature: (stakehole, posthole, clay pit, storage pit, fireplace, kiln, oven, etc.)
- Period: Absolute and relative chronology of features according to the finds
- Outline of the feature: The appearance (shape, colour) of features before they are excavated
- Filling and stratigraphy of features: The nature of filling and possible layers within the feature
- Shape of feature: The shape and description of the excavated feature (outline, profile and bottom)
- Finds: Summary of finds (type, period) – detailed descriptions of these finds are entered into the inventory, which is linked to this description

The digital format of an inventory database is linked to the above database. The inventory incorporates all the excavated materials. The results of ¹⁴C, charcoal, archaeobotanical, lithic and daub analyses are also linked to the above mentioned databases. The nature and complexity of data varies. We came to a consensus to use similar descriptions so the data could be later compared and to be compatible with one another (for a more detailed description of this problem, see REZI KATÓ 1995).

4.3. Establishing the link between the measured (geometrical) and the descriptive data

For the GIS system we created, we use the software ArcGIS 8.3 that has been developed by ESRI. We chose this software because it uses an international standard (.shp) that is recognised by many GIS systems. Also, its ability to integrate data is very good and it is able to handle extensive amount of data at the same time. The structure of the program also meets our requirements, since the software is designed in such a way that users can tailor the datasheets and applications according to their needs. This makes the program user friendly even for those who do not know the working principles of the program. The development of such an interface is our plan for the future.

For testing the developed GIS system, we modelled the excavation of Letenye–Lapuleveles-dűlő that was excavated in 2002.² The link between different types of data (drawings, texts) was accomplished in ArcGIS.

In the following section an outline is given about how the system is built up and how the data is integrated. The AutoCad drawings were converted into ArcGIS. The drawings of the features were converted into polygons. Then the polygons were given an ID number (*Fig. 2*). This ID number is the same as the feature ID in the recording sheet. The feature ID represents the link between the polygons and the databases. The relationship between the polygons and databases is one to one. Thus, one record stands for one feature. The database of the recording sheet of feature descriptions is linked with the inventory database. The inventory database includes the identification and detailed description of the finds. These records are linked to the main table in such a way that several records in the inventory may be linked to one record in the main table. The results of ¹⁴C, charcoal, archaeobotanical, lithic and daub analyses can be similarly integrated into ArcGIS. The photos of archaeological features and finds, and the digitised drawings are linked with the archaeological feature through a hyperlink. The general descriptions of the excavation, such as interim reports, excavation diary and aerial photos, are linked with the area of the excavation and can easily be accessed. This system allows us to access all the available data faster and in a more efficient way.

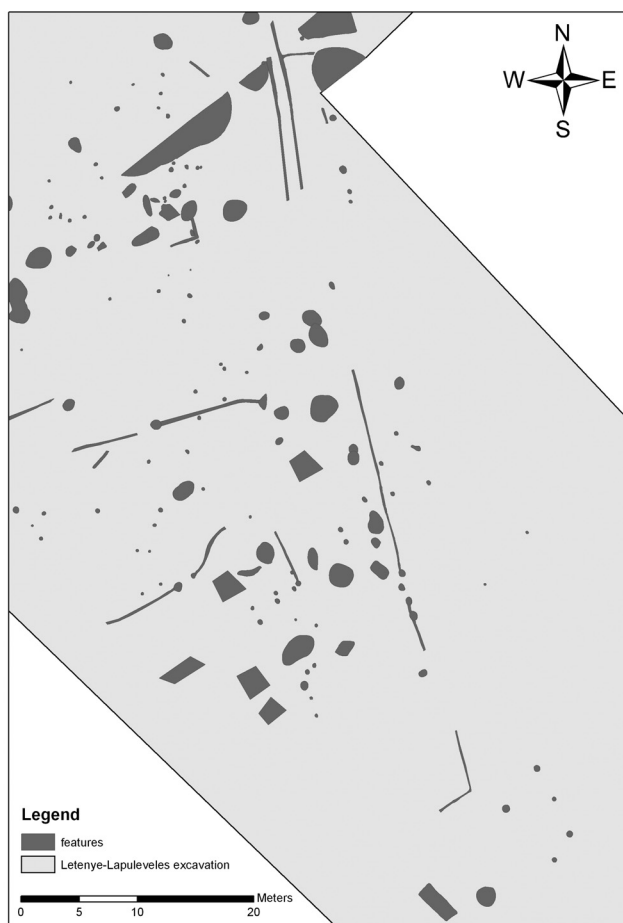


Fig. 2. Site map inserted into GIS.

² The leader of the excavation was Csilla Szárász who also participated in the development of the modelling.

5. The application of the GIS system for an archaeological site

The available data of the archaeological site can be accessed on one interface. This interface is the cumulative map of the excavation. Within this map the excavated area and the archaeological features are visualised as different layers. Each archaeological feature is linked with all the available data (description of feature and finds, drawings, photos) from that feature. The links between the different databases allows us to make queries. The results of queries are visualised on a different map. These “result maps” provide us with information about the spatial distribution and relations of objects and finds which belong to the same period. The spatial distribution of special finds can be also easily mapped. The use of queries helps us to visualise certain periods within a multi-period site. This practice also allows us to work more effectively with features and finds that belong to the same period.

The results of the application of a GIS system from different sites allow us to analyse and compare the data which is constitutive towards a better understanding of the past.

6. Topographical GIS

6.1. Goals and advantages of Topographical GIS

The demand for quick and easy availability of all data concerning archaeological sites, stored in a museum’s different collections, is simultaneous with the establishment of museums. This means a search through three basic collections (the documentation department, the photo archives and the archaeological inventory) which is a time-consuming task even in an ideal situation where the index card systems of the collections are thorough and kept up-to-date. At first, GIS in Hungary had been used to elaborate site registration systems about 10 years ago. These geographical information systems, planned to encompass a national level, were discontinued (REZI KATÓ 1995; CZAJLIK – HOLL 1997).

We began to work on the digital archaeological site register of Zala County in 2004 to integrate and modernize our records.³ We are attempting to create a system that enables the integration of basic information from different sources and this way we can avoid leafing through the collections’ inventory books or index cards for the required data. The rapid multiplication of archaeological tasks demands quick access to reliable and correct information. A site register based on GIS has – besides easy and fast manageability – important scientific results, e.g. queries parametrised by period or the compilation of geographical positions. Three museums exist within the Zala County Museum Organisation. Data collection was started with sites located in the area of collection of Göcseji Museum, Zalaegerszeg.

6.2. Basis of Topographical GIS

The site register is based on the digital form of the topographical Integrated National Projection map, on the scale of 1:10 000, plotted after 1976. The archaeological sites of Zala County are depicted on this map and the descriptive texts are added in the form of a database. We are in a favourable position from the point of view that we can rely not only upon descriptions or sketches, but also on the earlier (stereographic and Gauss-Krüger projection, plotted between 1952 and 1980), conventional (printed on paper) map-sheets from our Museum Organization. The sites discovered after 1990 have already been marked on these sheets, above all the ones found in the framework of the archaeological topographical preparatory works, which started in the mid 1980s.⁴ Consequently, the geographic positions of sites discovered in the course of the topographical surveys and marked on the map sheets are traced on the digital map. The method of tracing is that: coordinates of the site’s centre are transferred to the digital map. The site itself is depicted in ArcGIS as a polygon, relying upon its extent and direction of longitudinal axis (*Fig. 3*).

³ The elaboration of this site register is the product of teamwork. The initiator was Tibor Frankovics, technical project manager of the Department for Contract Archaeological Excavations, who needs comprehensive and up-to-date information for his preliminary proceedings. István Eke GIS-specialist constructed the system and the database. The database and system is maintained and developed by Bea Kámán, under the guidance of Judit Kvassay and István Eke.

⁴ The survey was led in the southern part of the country (previously the Nagykanizsa district) by Dr László Horváth, director of the Museum in Nagykanizsa; and Dr László András Horváth and Dr Katalin H. Simon in the northern territory (parts of the previous Zalaszentgrót and Zalaegerszeg districts).

Since the second half of 2003, the limit points of the contract archaeological excavations have been fixed by Total station, and the geometric points of recently surveyed sites by GPS-receiver. Depiction of sites relies on the fixed points. Modern instruments make data recording in the fields easier, quicker and more accurate.



Fig. 3. Conventional and digital depiction of topographical data.

Depiction of all sites (known only from descriptions and sketches, marked on map sheets and fixed by modern techniques) on digital maps can be already considered a great achievement, as this enables a simultaneous view and edition traces of earlier settlements, recorded at different times with different methods. At the same time, the archaeological sites of a modern settlement or of a river valley can be depicted using queries. Later on, with the help of GIS commands, sites along a stretch (bufferzone) can be easily identified. In addition to the geometric data, all the important archaeological information (age of finds, character of features, circumstances of survey, activities carried out on the site, related documents) is linked to the map-depiction in the related database, which enables more detailed and scientific queries. The link between map-elements and the database is an ID that conforms to the site-registration numbers of the Hungarian Cultural Heritage Office (KÖH).

6.3. Sources of data

Sources of elaborated data include all kinds of reports from the museum's documentation department, based on archaeological literature, as well as historical data concerning medieval settlements. Reports on archaeological topographic surveys make up the main group of sources. Information of newly detected sites can be mainly gained from these reports. Identification of earlier finds and localization of sites known from old documents and literature are mostly missing. (To complete these detections is one of our future tasks.) At the same time, we would like to be able to localize deserted medieval villages, known from historic literature.

We began completing the database with the data of the surveys made in the framework of the preliminary works for the planned second volume of the Archaeological Topography of Zala County (this volume was intended to cover the northern part of the county).⁵ The choice is obvious, as reports of systematic field surveys, repeated in several seasons from this territory, are available and the localization of sites are known from earlier fieldwork or the literature has been partly completed. The second step can be the gathering of data from the southern area of collection of Göcseji Museum.

6.4. Programmes used, appearance, operation

An MS Access type relational database is connected to the digital base-map with the help of the above mentioned ArcGIS software. The database contains three main groups of data: the site's geometric values (Integrated National Projection coordinates of the site's centre, altitude, direction of longitudinal axis, extent), archaeological information (number in cadastral survey, character of features, age of finds, circumstances of survey), and sources (collector of data, activities performed on the site, documentations, bibliography). Appearance and operation is the same as in the case of the site level (see section 5).

⁵ The preliminary fieldwork of this volume was conducted between 1985 and 2000.

The integration of the site and the topographical levels of archaeological GIS can be established with connecting data as referred to e.g. by Jankovich (JANKOVICH 2003).

6.5. Possible development, long-term planning

Our primary task is the improvement of data structure which yields more detailed queries. This demand occurred during the completion of the GIS database.

The expansion of already existing digital map sets with separate, vector-format detail-maps (terrain model, water-courses, settlement, road and railway network) would be an ideal solution. The separation of these levels enables the edition of different types of maps, e.g. using only terrain models and watercourses may form the basis for drawing a customary archaeological distribution map. 3D models can be generated with the help of ArcGIS, which demonstrates the relationship between terrain and site.

Considerable progress has been made in the digitizing of 18–19th-century topographical and cadastral maps. The integration of these maps with our archaeological GIS may primarily help with the localization of deserted medieval villages, and at the same time they may be used for plotting sites identified only by its owner's name.

ArcGIS is also suitable for georeferencing aerial photos, which might be appended to the GIS database.

It is among our long-term plans to process the sites from the territory of the two other museums' area of collection, based on further demand. In the case of Balatoni Museum, Keszthely, most sites of its area of collection have already been published in the Archaeological Topography of Hungary, Volume 1. The creation of a database could be a good opportunity for recapitulating the changes that have occurred since the appearance of the book. In Thúry György Museum, Nagykanizsa – similarly to Zalaegerszeg –, systematic fieldworks has already been done for the first planned volume of Archaeological Topography of Zala County.

We consider it important to enable the enlargement and the maintenance of the system after filling up the database with basic information gets completed. We must design an adequate procedure that ensures the recording of new sites and the adding of new data regarding registered sites. This is the only way to create and maintain an up-to-date register.

7. Summary

We wished to demonstrate what kind of results may be achieved by applying up-to-date IT instruments and procedures to the processing of archaeological sites and surveys. The system presented here, still under construction, could be a good example for collecting large quantities of valuable information in a comprehensive, nation-wide system that would enable an easy access to all the data accumulated during more than one hundred years of Hungarian archaeology. Creating such a system, however, would require a nation-wide collaboration of all parties involved.

Bibliography

- Czajlik Zoltán – Holl Balázs (1997). Magyarország régészeti lelőhelyeinek hálózati térinformatikai adatbázisa (tervezet). In: *Múltunk jövője 97*. Budapest: 28.
- Czajlik Zoltán – Marton Ádám – Holl Balázs (1997). Az M3-as autópálya régészeti leletmentéseinek térinformatikai feldolgozása. In: *Utak a múltba: Az M3-as autópálya régészeti leletmentései*. Budapest: Magyar Nemzeti Múzeum és Eötvös Loránd Tudományegyetem Régészettudományi Intézet.
- Jankovich Bésán Dénes (2003). Régészeti lelőhelyek nyilvántartása. In: Visy Zsolt (ed), *Régészeti műemlékek kutatása és gondozása a 3. évezred küszöbén*. Pécs: 5–13.
- Rezi Kató, Gábor (1995). Archaeological GIS in the Hungarian National Museum. *Folia Archeologica* 44: 243–251.
- Rezi Kató Gábor (2003). A régészeti műemlékek központi adattárától a régészeti műemlékek egységes adatbázisáig. In: Visy Zsolt (ed), *Régészeti műemlékek kutatása és gondozása a 3. évezred küszöbén*. Pécs: 15–19.

