# ANTÆUS

# 37

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# ABBREVIATIONS

| | |
|---|---|
| ActaArchHung | Acta Archaeologica Academiae Scientiarum Hungaricae (Budapest) |
| ActaEthnHung | Acta Ethnographica Academiae Scientiarum Hungaricae (Budapest) |
| ActaOrHung | Acta Orientalia Academiae Scientiarum Hungaricae ( Budapest) |
| ActaMusPapensis | Acta Musei Papensis. A Pápai Múzeum Értesítője (Pápa) |
| Agria | Agria. Az Egri Múzeum Évkönyve (Eger) |
| AH | Archaeologia Historica (Brno) |
| AHN | Acta Historica Neolosiensia (Banská Bystrica) |
| AJMK | Arany János Múzeum Közleményei (Nagykőrös) |
| AKorr | Archäologisches Korrespondenzblatt (Mainz) |
| Alba Regia | Alba Regia. Annales Musei Stephani Regis (Székesfehérvár) |
| AnalCis | Analecta Cisterciensia (Roma) |
| AnnHN | Annales Historico-Naturales Musei Nationalis Hungarici (Budapest) |
| Antaeus | Antaeus. Communicationes ex Instituto Archaeologico (Budapest) |
| Antiquity | Antiquity. A Review of World Archaeology (Durham) |
| AR | Archeologické Rozhledy (Praha) |
| ArchA | Archaeologia Austriaca (Wien) |
| ArchÉrt | Archaeologiai Értesítő (Budapest) |
| ArchHung | Archaeologia Hungarica (Budapest) |
| ArchLit | Archaeologia Lituana (Vilnius) |
| ArhSof | Археология. Орган на Националния археологически институт с музей – БАН (Sofia) |
| ARR | Arheološki Radovi i Rasprave (Zagreb) |
| Arrabona | Arrabona. A Győri Xantus János Múzeum Évkönyve (Győr) |
| AV | Arheološki Vestnik (Ljubljana) |
| Balcanoslavica | Balcanoslavica (Prilep) |
| BÁMÉ | A Béri Balogh Ádám Múzeum Évkönyve (Szekszárd) |
| BAR | British Archaeological Reports (Oxford) |
| BMÖ | Beiträge zur Mittelalterarchäologie in Österreich (Wien) |
| BudRég | Budapest Régiségei (Budapest) |
| Castrum | Castrum. A Castrum Bene Egyesület folyóirata (Budapest) |
| CommArchHung | Communicationes Archaeologicae Hungariae (Budapest) |
| Cumania | Cumania. A Bács-Kiskun Megyei Múzeumok Közleményei (Kecskemét) |
| DBW | Denkmalpflege Baden-Württemberg (Stuttgart) |
| EMÉ | Az Egri Múzeum Évkönyve (Eger) |
| EurAnt | Eurasia Antiqua. Zeitschrift für Archäologie Eurasiens (Bonn) |
| FolArch | Folia Archaeologica (Budapest) |
| FontArchHung | Fontes Archaeologici Hungariae (Budapest) |
| GMSB | Годишник на музеите от Северна България (Варна) |
| GZM | Glasnik Zemaljskog muzeja Bosne i Hercegovine u Sarajevu (Sarajevo) |
| GZMS | Glasnik Hrvatskih Zemaljskih Muzeja u Sarajevu (Sarajevo) |
| HAH | Hereditas Archaeologica Hungariae (Budapest) |

| | |
|---|---|
| Hesperia | Hesperia. Journal of the American School of Classical Studies at Athens (Princeton) |
| História | História. A Magyar Történelmi Társulat, majd a História Alapítvány folyóirata (Budapest) |
| HOMÉ | A Herman Ottó Múzeum Évkönyve (Miskolc) |
| INMVarna | Известия на Народния музей – Варна (Varna) |
| IstMitt | Istanbuler Mitteilungen (Tübingen) |
| JAMÉ | A nyíregyházi Jósa András Múzeum Évkönyve (Nyíregyháza) |
| Jászkunság | Jászkunság. Az MTA Jász-Nagykun-Szolnok Megyei Tudományos Egyesület folyóirata (Szolnok) |
| JbAC | Jahrbuch für Antike und Christentum (Bonn) |
| JPMÉ | A Janus Pannonius Múzeum Évkönyve (Pécs) |
| KMMK | Komárom-Esztergom Megyei Múzeumok Közleményei (Tata) |
| LK | Levéltári Közlemények (Budapest) |
| MAA | Monumenta Avarorum Archaeologica (Budapest) |
| MacAA | Macedoniae Acta Archaeologica (Skopje) |
| MAG | Mitteilungen der Anthropologischen Gesellschaft (Wien) |
| MBV | Münchner Beiträge zur Vor- und Frühgeschichte (München) |
| MHKÁS | Magyarország honfoglalás és kora Árpád-kori sírleletei (Budapest) |
| MittArchInst | Mitteilungen des Archäologischen Instituts der Ungarischen Akademie der Wissenschaften (Budapest) |
| MFMÉ | A Móra Ferenc Múzeum Évkönyve (Szeged) |
| MFMÉ StudArch | A Móra Ferenc Múzeum Évkönyve – Studia Archaeologica (Szeged) |
| MMMK | A Magyar Mezőgazdasági Múzeum Közleményei (Budapest) |
| MŰÉ | Művészettörténeti Értesítő (Budapest) |
| MŰT | Művészettörténeti Tanulmányok. Művészettörténeti Dokumentációs Központ Évkönyve (Budapest) |
| NÉrt | Néprajzi Értesítő (Budapest) |
| NMMÉ | Nógrád Megyei Múzeumok Évkönyve (Salgótarján) |
| OA | Opvscvla Archaeologica (Zagreb) |
| Offa | Offa. Berichte und Mitteilungen des Museums Vorgeschichtliche Altertümer in Kiel (Neumünster) |
| PA | Památky Archeologické (Praha) |
| Prilozi | Prilozi Instituta za povijesne znanosti Sveučilišta u Zagrebu (Zagreb) |
| PrzA | Przegląd Archeologiczny (Wrocław) |
| PtujZb | Ptujski Zbornik (Ptuj) |
| PV | Přehled výzkumů (Brno) |
| PZ | Prähistorische Zeitschrift (Berlin) |
| RégFüz | Régészeti Füzetek (Budapest) |
| RGA | Reallexikon der Germanischen Altertumskunde (Berlin) |
| RT | Transylvanian Review / Revue de Transylvanie (Cluj) |
| RVM | Rad Vojvođanskih muzeja (Novi Sad) |
| SbNMP | Sborník Národního Muzea v Praze (Praha) |
| Scripta Mercaturae | Scripta Mercaturae. Zeitschrift für Wirtschafts- und Sozialgeschichte Gutenberg) |
| SHP | Starohrvatska Prosvjeta (Zagreb) |
| SlA | Slovenská Archeológia (Bratislava) |
| SlAnt | Slavia Antiqua (Poznan) |

| | |
|---|---|
| SlSt | Slovanské štúdie (Bratislava) |
| SMK | Somogyi Múzeumok Közleményei (Kaposvár) |
| StComit | Studia Comitatensia. A Ferenczy Múzeum Évkönyve (Szentendre) |
| StH | Studia Historica Academiae Scientiarum Hungaricae (Budapest) |
| StSl | Studia Slavica Academiae Scientiarum Hungaricae (Budapest) |
| StudArch | Studia Archaeologica (Budapest) |
| Századok | Századok. A Magyar Történelmi Társulat folyóirata (Budapest) |
| TBM | Tanulmányok Budapest Múltjából (Budapest) |
| Tisicum | Tisicum. A Jász-Nagykun-Szolnok Megyei Múzeumok Évkönyve (Szolnok) |
| USML | Utrecht Studies in Medieval Literacy (Turnhout) |
| VAH | Varia Archeologica Hungarica (Budapest) |
| VAMZ | Vjesnik Arheološkog muzeja u Zagrebu (Zagreb) |
| VMMK | A Veszprém Megyei Múzeumok Közleményei (Veszprém) |
| WiA | Wiadomości Archeologiczne (Warszawa) |
| WMMÉ | A Wosinsky Mór Múzeum Évkönyve (Szekszárd) |
| ZalaiMúz | Zalai Múzeum (Zalaegerszeg) |
| Zborník FFUK, Musaica | Zborník Filozofickej Fakulty Univerzity Komenskóho. Musaica (Bratislava) |
| ZbSNM | Zborník Slovenského Národného Múzea. História (Bratislava) |
| ZfAM | Zeitschrift für Archäologie des Mittelalters (Köln) |
| ZHVSt | Zeitschrift des Historischen Vereins für Steiermark (Graz) |
| Ziegelei-Museum | Ziegelei-Museum. Bericht der Stiftung Ziegelei-Museum (Cham) |
| ZRNM | Zbornik Radova Narodnog Muzeja (Beograd) |

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ELEK BENKŐ

# THE MEDIEVAL WATER SUPPLY SYSTEM OF PILIS ABBEY

**Zusammenfassung:** Die ehemals im Pilisgebierge, am Rande des Dorfes Pilisszentkereszt erbaute und bis zur Neuzeit vollkommen zerstörte Zisterzienserabtei war eine vom König in Auftrag gegebene kirchliche Institution (1184), die größtenteils von ausländischen Steinmetzen umgesetzt wurde. Nicht nur die Mauern und Schnitzereien der Kirche und des Klostergebäudes ließen auf die Großzügigkeit des begründenden ungarischen Königs, Béla III. und später András II., bzw. Königin Gertruds schließen, sondern auch das Niveau und das breite Spektrum der angewandten Baulösungen. Das Kloster und die dazugehörigen Wirtschaftsgebäude, darüber hinaus der hohe Standard der technischen Anlagen (Wasserleitungen, Mühle, Schmiedewerkstatt etc.) wiesen auch im 14.–16. Jahrhundert auf die Anwendung zahlreicher neuartiger technischer Lösungen hin. Dazu trug der praktische natürliche Umstand bei, dass der aus Kalkstein bestehende Pilis-Berg über große Karstwasservorräte verfügte und sich in der unmittelbaren Umgebung des Klosters eine reichhaltige Quelle und fließend Wasser befanden.

In den Jahrzehnten nach der Begründung des Klosters hatte man oberhalb der Abtei einen künstlichen Teich angelegt, der anfangs eine Getreidemühle und später die Maschinen einer Schmiedewerkstatt betrieb und schließlich spülte das Wasser über einen eingemauerten Abwasserkanal aus Stein die große Latrine des Dormitoriums, bzw. des Infirmariums und mündete in den unweit fließenden Bach.

Die westliche Grundmauer der am Anfang des 13. Jahrhunderts erbauten Kirche barg eine aus Quadersteinen gemauerte, breite Abflussrinne, die der Ableitung des in großen Mengen vom Hang des Pilis-Bergs herabfließenden Regen- und Schneewassers diente.

Den Kreuzgang, der ungefähr zur selben Zeit entstand, wie die Kirche, hatte man mit einem Brunnenhaus versehen, das einen Springbrunnen barg, dessen Ebenen abwechselnd aus rotem Marmor und weißem Kalkstein gefertigt waren. Im Verlauf des Mittelalters ergänzte man den Brunnen mit einem Wasserleitungssystem, das mit unterschiedlichen Techniken und in verschiedenen Richtungen angelegt worden war.

Die älteste, aus gehauenen Steintrögen gebaute Wasserleitung ist gleichaltrig mit dem Kreuzgang und dem Brunnenhaus, ihre Trasse hatte man noch während der Verlegung des Fundaments angelegt. Wir nehmen an, dass man vorhatte, die Tröge mit Bleirohren zu versehen, jedoch haben wir dafür keine handfesten Beweise gefunden.

Im Verlauf des 14.–15. Jahrhunderts tauschte man die bisherigen Steinleitungen gegen Rohre aus gewölbten Firstziegeln, bzw. ineinander gefügte Keramikrohre aus. Diese verlegte man in eindeutig geringerer Tiefe und flüchtiger, als die früheren.

Sowohl die erste, der Orientierung dienende Ausgrabung unter der Leitung von Péter Gerecze (1913), als auch die umfassenden Aufdeckungsarbeiten von László Gerevich (1967–1982) trugen in erster Linie der Klärung einzelner Gebäudeteile bei, und zielten nicht auf vertiefte Analysen technischer Anlagen ab. Dennoch wurden im Rahmen dieser Arbeiten Daten erfasst, die trotz ihrer Unvollständigkeit brauchbar waren und während unserer Rekonstruktion, mit den Ergebnissen der geophysischen Messungen der letzten Jahre ergänzt, verwendet werden konnten.

**Keywords:** Cistercian monastery, aqueduct, artificial lake, mill, medieval period

The Pilis Cistercian monastery, which had been completely destroyed by the modern age, was located on the border of Pilisszentkereszt. The ecclesiastical institution founded by King Béla III in 1184 was erected by foreign masons. The main mass of the Pilis abbey decorated with many carved details, including carvings of red marble, had already been constructed by the early 13th century. In the Late Middle Ages, further buildings were added to it, which made it one of the richest and

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definitely the most influential Cistercian monasteries in medieval Hungary. The generosity of the founder followed by that of King Andrew II and Queen Gertrude is reflected not only in the walls and carvings of the church and monastery but also in the quality and variety of the technical solutions used. The monastery and its outbuildings, as well as its facilities (the aqueduct, the mill, the blacksmith's workshop, etc.) equally employed many technical innovations between the 14th and 16th centuries. The building complex was destroyed by the Ottomans in 1526. Although the ruins are barely visible on the surface, the site and its surroundings have not been built up to this day, which created unique opportunities for research into environmental and technical history.

The practical and economic activities of the Cistercian monks have traditionally been highly regarded by researchers. They have pointed out that it was the monks skilled in water management, forestry, and the exploitation of subsoil resources who converted the remote wooded or swampy areas into carefully cultivated monastic landscapes using many new technologies. Although we have a more refined view of this question today, we do not question its fundamental veracity, adding that it took longer to build the various facilities and obtain the results associated with them. It was not otherwise in the case of the Pilis monastery, either.

For the Cistercians – as for other monastic communities – water was of paramount importance, both in a liturgical-symbolic sense and in the practice of daily life.[1] The monks washed their hands before meals in the fountain house found outside the monks' dining room *(refectorium),* which was accessible from the cloister. They also used the fountain for drinking water, for the weekly washing of the feet *(mandatum),* as well as for shaving a tonsure, cleaning their clothes, and other practical activities. The mills of the monasteries, as well as the bellows and hammers in the iron foundries and smithies were operated with water. Additionally, water was needed for animal husbandry and horticulture. It was therefore of fundamental importance to supply monasteries and other ecclesiastical communities with water from the onset.

Before presenting local data, we should briefly describe the natural conditions of the Pilis Abbey, with special regard to its water resources.

The abbey was established in the Pilis Mountains, to the east of the peak Pilis-tető (756 m) that the mountains were named after, in the flaring valley of the right-hand tributary of Dera (Kovácsi) stream, near today's Pilisszentkereszt. The plateau selected for the construction, which was already inhabited in previous ages, rises 15–20 m above the valley plain, and then ascends increasingly steeper towards Pilis-tető in the west. The relatively fast-flowing Dera (formerly called as Kovácsi) stream running under the monastery is an ideal watercourse for damming a lake. The stream runs along a geological fault line: to the north of it lies the volcanic andesite block of the Visegrád Mountains, while to the south-west of it stretches the mountain range of the Pilis largely made up of limestone. The greyish-white Dachstein limestone formed at the end of the Triassic period, about 220-210 million years ago, dissolves easily in water, which results in caves and cavities. This allowed the limestone layer to capture a significant amount of karst water. One of the springs of karst water is located in the immediate vicinity of the monastery. It was an important source of drinking water to the abbey. The water yield of the spring (called Klastrom-forrás, i.e. "Monastery spring") is still considerable today.

Research on the building that preceded the foundation of the monastery (which was probably a royal manor house with a chapel) has not revealed any data about its water supply so far, and much the same can be said of the early Cistercian monastery built at the end of the 12th century. The latter formed the earliest, eastern wing of the later completed quadrangle – the walls of which clearly separated from the later masonry. It comprised rooms indispensable for monastic life (the chapel, the chapter hall, the monks' hall, and the upstairs dormitory). In the early 13th century, the new church with three aisles and a transept (the predecessor of which can only be identified from

[1] *Rüffer 2017.*

sporadic details and carved fragments) and the adjoining, closed quadrangle were constructed. The building of the Cistercian abbey with a "classical" (since the 1950s called "Bernardine") groundplan was accompanied by "classical" solutions for water supply and use. The first and most spectacular element of this was the octagonal fountain house *(lavatorium)* accessible from the cloister, located outside the monks' dining room *(refectorium).* Inside the fountain house there was a lavabo with superimposed basins of red marble and white limestone, connected to the aquaduct established with various techniques and tracks in the medieval period *(fig. 6–7, 10).* The excavations also brought to light some sections of stone sewers which were used to drain rainwater, water overflowing from the artificial lake built above the monastery (which operated the mill and then cleaned the latrine of the monastery), as well as wastewater leaving the fountain house. It needs to be emphasised that these do not represent unique, exceptional inventions (even in the case of the royally founded Pilis monastery erected with great financial effort and employing excellent specialists), but regularly emerging facilities in Cistercian monasteries. However, their details naturally reflect the local conditions and the possibilities of the founders.

Although both the first exploratory excavations of the ruins led by Péter Gerecze (1913)[2] and the large-scale excavations supervised by László Gerevich (1967–1982)[3] were fundamentally conducted with the aim of identifying the individual parts of the building instead of carrying out an in-depth investigation of the technical devices, they also recorded useful pieces of information about the old water supply system. Unfortunately, the excavations led by Péter Gerecze – which were carried out in the cloister and, particularly, on the area of the fountain house – also caused irreversible damages due to the use of excavation techniques typical of the early 20th century. The interior of the relatively well-preserved fountain house containing the remains of the lavabo richly decorated with carvings, the potential remains of the floor and lavabo foundations, as well as the water conduits running to and from the fountain have been largely destroyed. As a result, the subsequent excavations led by László Gerevich were not able to record these details *(fig. 7. 4)*, even though the readily visible parts of the water supply system that could be investigated caught the attention of the excavation supervisor, who focused mainly on architectural questions. He entrusted their survey to Balázs Erdélyi, a young architecture student assisting in the Pilis excavations. After careful levelling, the drawings were made by Endre Egyed, who had wide experience in geodesy and architecture. Consequently, the remains have been carefully recorded in drawing during this excavation that was not up-to-date even according to contemporary standards. (The notes in the field notebook written by the excavation supervisor are unfortunately much sketchier.) The excavation records left to us – together with the finds taken to the museum, archival photographs, and the recently made geophysical surveys – allow the reconstruction of the overall picture, which is quite an exceptional case in the practice of Hungarian archaeology. This was greatly aided by the fact that the monastery and its surroundings are not built up, so the site is ideal for carrying out non-invasive archaeological surveys. It must be emphasised though that this picture contains many hypothetical elements that could only be clarified with authenticating excavations. In some cases, even a closer dating of certain sections within the medieval period is difficult.

In the following, the individual water conduits and their associated artefacts will be presented separately, grouped according to their functions, contexts, and ages.

2 For the summary of the findings made during the excavation supervised by Péter Gerecze, see *Takács 1992* 1–7, 15–17.

3 *Gerevich 1983; Gerevich 1984; Gerevich 1985.*

*The artificial lake, the mill race, and the vaulted drainage canal*

One of the first and fundamental aims of geodesy during the series of excavations carried out in the Pilis between 1967 and 1982 was to survey the building complex of the Pilis monastery and the surrounding stone walls. These structures had been destroyed to the ground by modern times, but their traces were marked by higher stony tracks running straight, mostly covered by shrubs.

The surveys have also revealed that there is a completely filled-up lake in the highest part of the distorted rectangular area enclosed by walls. The lake bed, which is almost imperceptible in its present state *(fig. 1. 3),* was supported on the eastern side by an earth dam and was separated from the rest of the abbey by a stone wall built subsequently to the surrounding walls of the monastery on the outside *(fig. 1. 5).* The artificial lake deepened to the limestone substratum took up an area of about 80×25 m when completely filled with water. Based on a test trench dug during the archaeological excavation supervised by Gerevich, its deepest point was at an altitude of 361.62 m. Our core prospection (by Ákos Pető and Gábor Serlegi) carried out for authentication in 2017 confirmed this somewhat blurred level information (361.5 m). As it was discovered later, this lake played a key role in the water supply of the abbey, along with a nearby spring (and other potential springs that have dried up by now).

The construction date of the lake could not be determined at the time of the excavation by Gerevich, but important observations have been made in connection with this as well. It was discovered that the digging of the lake bed disturbed the burials of an Árpádian-period cemetery established before the founding of the monastery. Some human bones were discovered even in the earthen dam of the lake. It was also ascertained that the dam was constructed when the medieval ground surface was already covered with fragments and debris from intense stone dressing associated with large-scale building activities in the early 13th century. Archaeological finds suggest that the lake may have been subjected to a particularly intense use in the late medieval period when a multi-room iron ore smelter operated by hydropower was built next to the dam. The deep stone trench of the water wheel made of carefully carved ashlars, belonging to the workshop and the initial part of the large stone-walled and vaulted canal transporting water to the monastery were also unearthed. We have detailed drawings and archival photographs about these sections and our description below will be largely based on them.

In 1980, László Gerevich had the sediment layers of the lake cut through, and the following year (1981), samples were also taken for palynological analysis. They were studied at the Botanical Research Institute of the Hungarian Academy of Sciences, under the supervision of Prof. Bálint Zólyomi. Unfortunately, the sediment that filled the lake bed had dried up several times over the centuries and thus contained only degraded plant remains. Nevertheless, the analysis revealed a considerable amount of walnut pollen, which demonstrates that there was an orchard next to the monastery. From the otherwise poorly preserved pollen, researchers inferred that the clearings around the monastery were mainly used as hayfields and orchards. The small proportion of cereal pollen suggests that there was less arable land at that time, and there were not many signs of animal husbandry or grazing, either. The surrounding forests comprised beech, hornbeam, and oak trees. However, the value of these instructive findings was significantly lessened by several factors (such as the fact that only a short, 60 cm part of the whole sample was subjected to a thorough analysis, the unfortunate scarcity of pollen grains, and the complete lack of possibilities for dating within the medieval period with contemporary methods).[4] In order to fill these gaps and adopt the modern methods of environmental archaeology, the sediment of the lake was re-examined in 2002 under the supervision of Pál Sümegi. Using manual labour, the research team dug a 180 cm deep geological trench across the layers deposited above the Triassic Dachstein

[4] *Zólyomi – Précsényi 1985.*

limestone bedrock at the apparently deepest point of the lake bed, which had been almost completely filled up since the medieval period. Afterwards, they carried out sedimentological, geochemical, archaeobotanical, anthracological, and pollen analyses on the soil samples taken. The results have been published in a separate study.[5]

The new findings did not differ significantly from the results of the analyses performed by Zólyomi and Precsényi, but they proved to be more detailed. The lake was once surrounded by forest-steppe vegetation with patches of wood comprising a significant number of fruit trees. Based on the proportion of oak, elm, and ash trees, as well as alder and willow trees, the garden-like vegetation could have been surrounded by oak and alluvial forests.[6] The total amount of cereal crops was not significant either. Oat *(Avena)* was dominant among the pollen grains of cereals. Based on the data, we can reconstruct horticultural farming, orchards, and possibly vegetable gardens. There was also a considerable amount of fly ash in the samples examined, suggesting a considerable human community.

In the sediment layer filling the lake bed, just above the rocky bottom of the lake, a piece of charred wood (D-AMS 016721) and a fragmented walnut shell (D-AMS 017667) were found, which were suitable for radiocarbon dating. The results of the two measurements coincided with each other.[7] They both pointed to a period between the second half of the 12th century and the beginning of the 13th century. This relatively broad interval of time itself does not make it possible to decide whether the artificial lake was established during the existence of the royal manor house built before the monastery or during the first decades of the monastery founded in 1184. However, because we can exclude the early phase of the radiocarbon interval between the 11th and 12th centuries due to the existence of an Árpádian-period cemetery, which was used before the founding of the monastery, we can only take into account the later phase of this period (i.e. the second half of the 12th century or the early 13th century). This clearly suggests that the lake came into existence after the Cistercian monastery was founded, which is supported by the fact that the medieval ground surface under the dam was covered by debris from stone carving suggestive of major building activities in the early 13th century. This layer was naturally above the burials found 60 cm deeper than the Árpádian-period ground surface. The exact chronology of the construction of the dam is unknown. However, the earthen bank with an inner stratification presumably reached its final size after several phases of construction.

The results of earlier investigations proved to be incomplete regarding the precise extent of the lake bed, its possible inner structure, and the exact line of the dam. Thus, we explored the site again with logging-while-coring in 2017 (Ákos Pető, Gábor Serlegi) followed by field measurements and a magnetometer survey in 2019 (Gábor Serlegi, Bence Vágvölgyi). The survey revealed that to the south of the floodgate the dam along the west wall of the workshop must have turned to the south-west in a curve. Otherwise, due to the level conditions, the water could have easily left its bed endangering the deeper-lying buildings of the monastery, especially a building (a guesthouse) found nearby *(fig 1. 5, fig. 11).* Based on the excavation records, it appears that on this section, the inner side of the dam facing the water was lined with a stone wall, a curved section of which was observed during the excavations led by Gerevich *(fig. 2. 3).*

A magnetometer survey of the area suggests that above the lake, on the inside of the western wall enclosing the monastery, there were small stone structures (outbuildings?). Geophysical measurements did not detect any structure in the lake bed *(fig. 1. 4).*[8] Based on the terrain model

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5 *Sümegi – Jakab – Benkő 2021* 262–267.

6 *Zólyomi – Precsényi 1985.*

7 *Sümegi – Jakab – Benkő 2021* 264.

8 The survey was carried out by Gábor Serlegi and Bence Vágvölgyi (HAS RCH Institute of Archaeology).

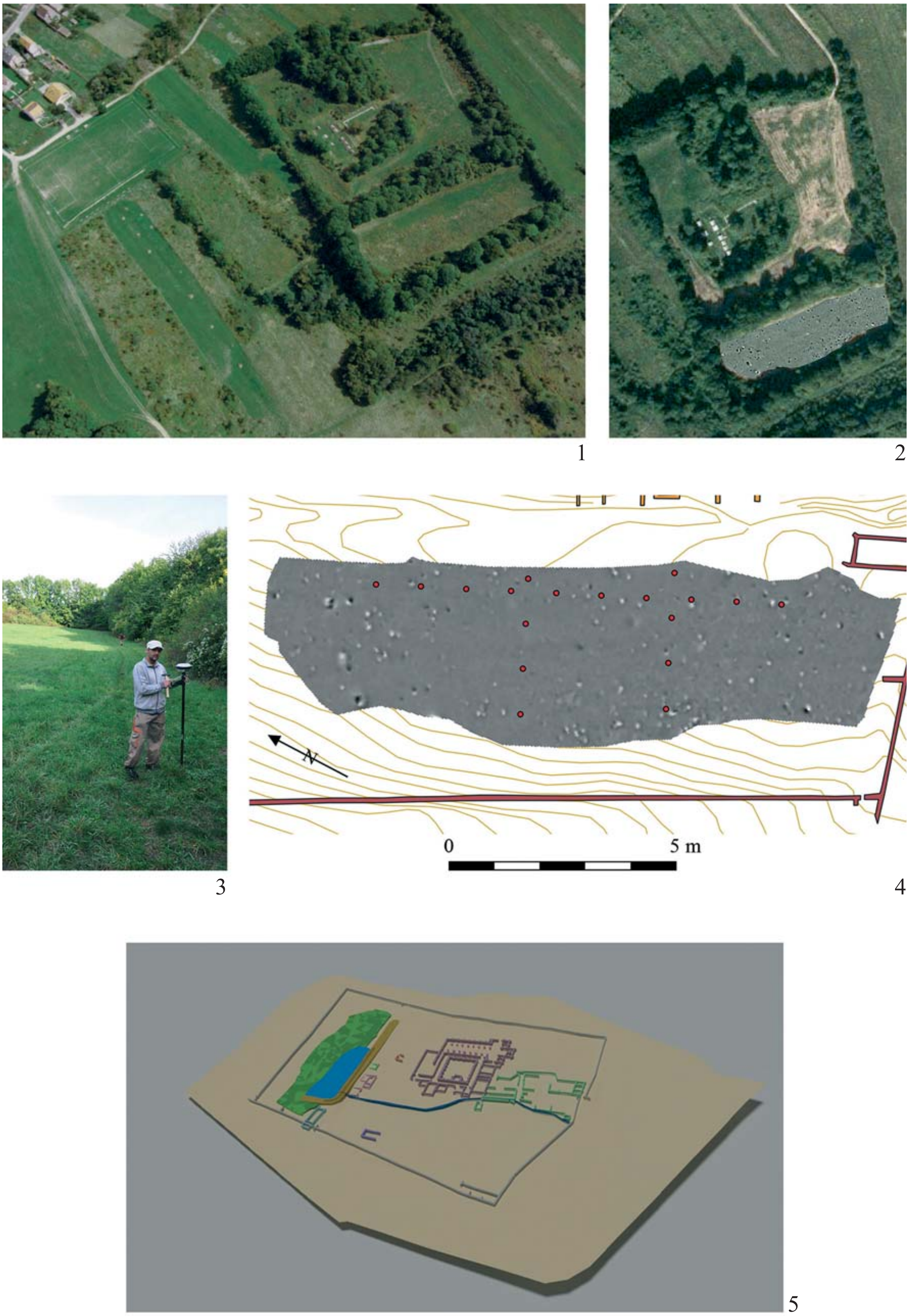


Fig. 1. 1–2. Pilisszentkereszt-Klastromkert, the ruins of the Cistercian monastery (Photograph: Zsuzsa Miklós); 3. The site of the filled-up artificial lake (Photograph: Elek Benkő); 4. Magnetometer survey (Survey: Gábor Serlegi and Bence Vágvölgyi); 5. The artificial lake and its drainage channel in a terrain model (Model: Gábor Serlegi)

of the area, the largest extent of the old lake must have been 80×25 m, and its water surface was slightly above the 364 m elevation contour line at that time.

It was assumed as early as the excavations in Pilisszentkereszt that the Dera stream flowing under the monastery fed into a lake suitable for the operation of a water-mill. This idea was also supported by mill sites of medieval or modern origin discovered elsewhere in the valley of the stream. Vilmos Balás, the supervisor of the excavation, who was particularly interested in technical features of the terrain, investigated "heaps suggestive of building ruins on the right side of the Dera stream, closer to the excavation site" in 1981, where the fragment of a millstone was also discovered. The "heap of earth" observed there was cut across with a trench, but it did not yield any find of dating value.[9] Core taking in the area in 2014 did not detect sediment layers typical of medieval fishponds. Consequently, the existence of a medieval dammed lake under the abbey has not yet been verified there. Nevertheless, in a lower part of the Dera (Kovácsi) stream, about 5 km from the site of the Pilis Cistercian abbey, near the Árpádian-period village of Kovácsi, under the medieval monastic grange,[10] cores taken from the widening bed of the stream yielded the remains of a medieval lake and sediment layers suitable for analysis in it.[11]

In the light of all this, at the present stage of the research, it seems certain that in the immediate vicinity of the Pilis monastery there was only one medieval lake that could operate a mill and other industrial facilities, namely the artificial lake within the walls of the monastery.

Water from the relatively small lake, fed by rainwater and presumably several springs that have dried up by now, poured on the wheel operating the machines in the workshop through a cylindrical conduit with a flaring mouth. The pipe carved from Andesitic tuff was 25 cm in diameter *(fig. 3. 1).* It was laid near the deepest point of the lake bed (its bottom was at 362.14–362.15 m) and ran through the dam of the lake. This means that at the deepest point of the lake, there was always some water in the lake bed, even after the maximum amount of water had been drained off. Presumably, this was intended to prevent the clogging of the pipeline, but this may have also required regular cleaning of the lake bed. The shape of the carved stone at the end of the conduit suggests that the pipe could be closed with a latch after the flaring part. Unfortunately, we have no written record of the rare technical equipment excavated at the end of the series of excavations (1979–1980) in the Pilis Mountains.

The level conditions suggest that water flowed from the stone conduit onto the overshot wheel. The wheel itself rotated in a ditch very carefully walled with Andesitic tuff ashlars and lined with smooth, rectangular sandstone slabs at the bottom *(fig. 3. 2–8).* The mill race which slightly widened in the east was 1.5–1.6 cm wide and 6.15 m long. Its bottom moderately sloped eastwards. The altitude of the bottom at the western end was 356.28 m, at the eastern end it was 356.14 m (so the conduit sloped 14 cm in 6 m). The bottom of the shaft hub of the wheel was discovered at 359.37 m. Thus, the centre of the rotating shaft must have been somewhat higher than this. Considering the level conditions of the narrow stone conduit that directed water onto the wheel, the diameter of the wooden water wheel must have been around 5 m *(fig. 2. 4).*

The sidewalls of the canal built of ashlars showed limescale and traces of erosion caused by running water. The silty layer covering the bottom of the ditch (comprising pieces of stone and mortar, fragments of roof tiles and iron nails) was covered by a layer of "building remains" and an approximately 14 cm thick burnt layer. The latter suggests that some kind of wooden building may have stood above the wheel. The finds discovered there date between the 13th century and the early modern period (the 16th and 17th centuries).

9 From the notebook of Vilmos Balás, work foreman, 5–6 May 1981 (Archive of the HAS RCH Institute of Archaeology).

10 *Laszlovszky et al. 2014; Laszlovszky – Stark 2017.*

11 *Sümegi – Jakab – Benkő 2021* 267–274.

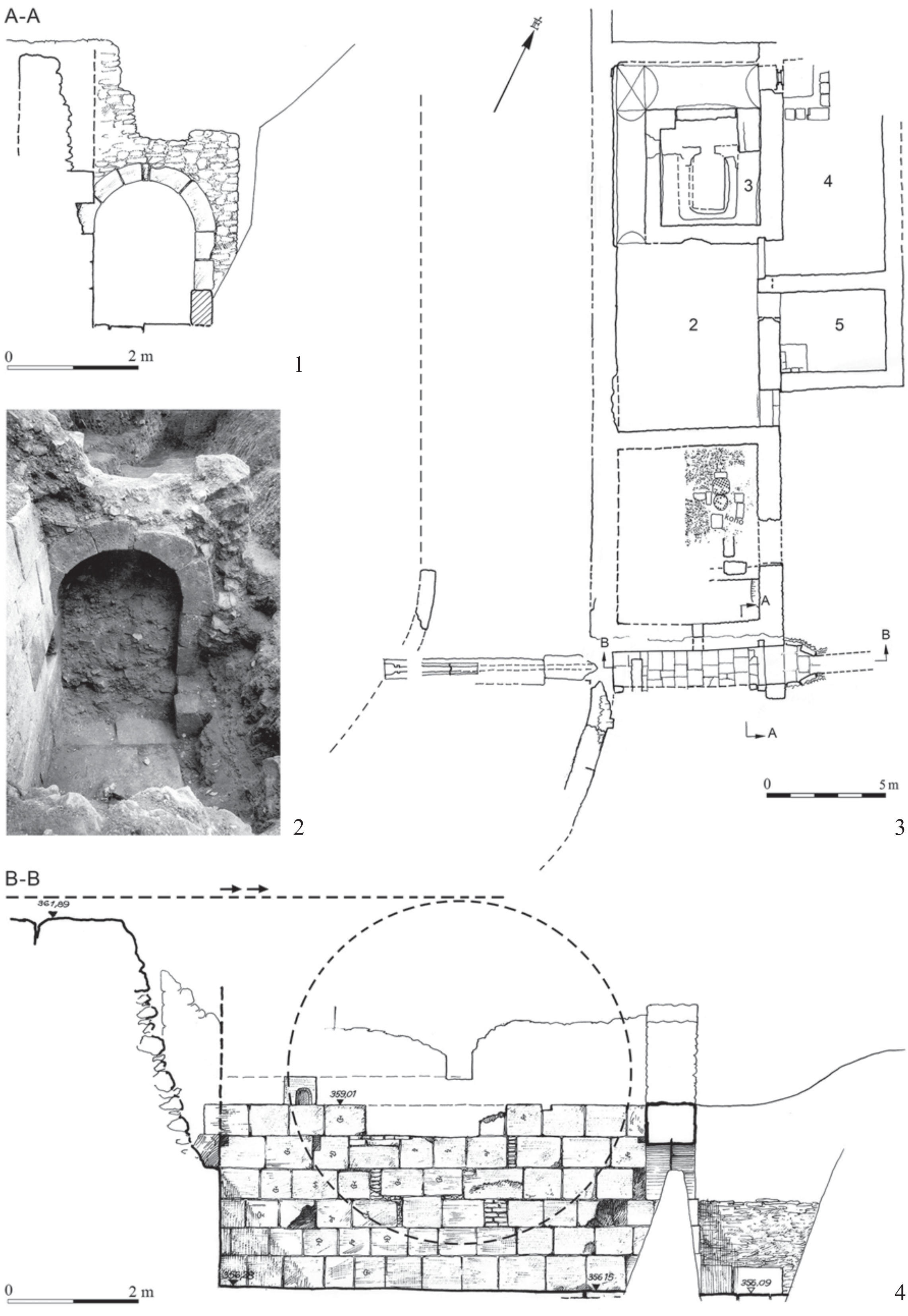


Fig. 2. 1–2. Pilisszentkereszt-Klastromkert, the walled mill race with the opening of the drainage channel (Survey: Endre Egyed, photograph: Lajos Sugár); 3. The workshop of the Cistercian monastery with the aqueduct and the mill race crossing the dam to the south of it; 4. The ashlar wall of the mill race with masons' marks and the location of the water wheel (Survey: Endre Egyed)

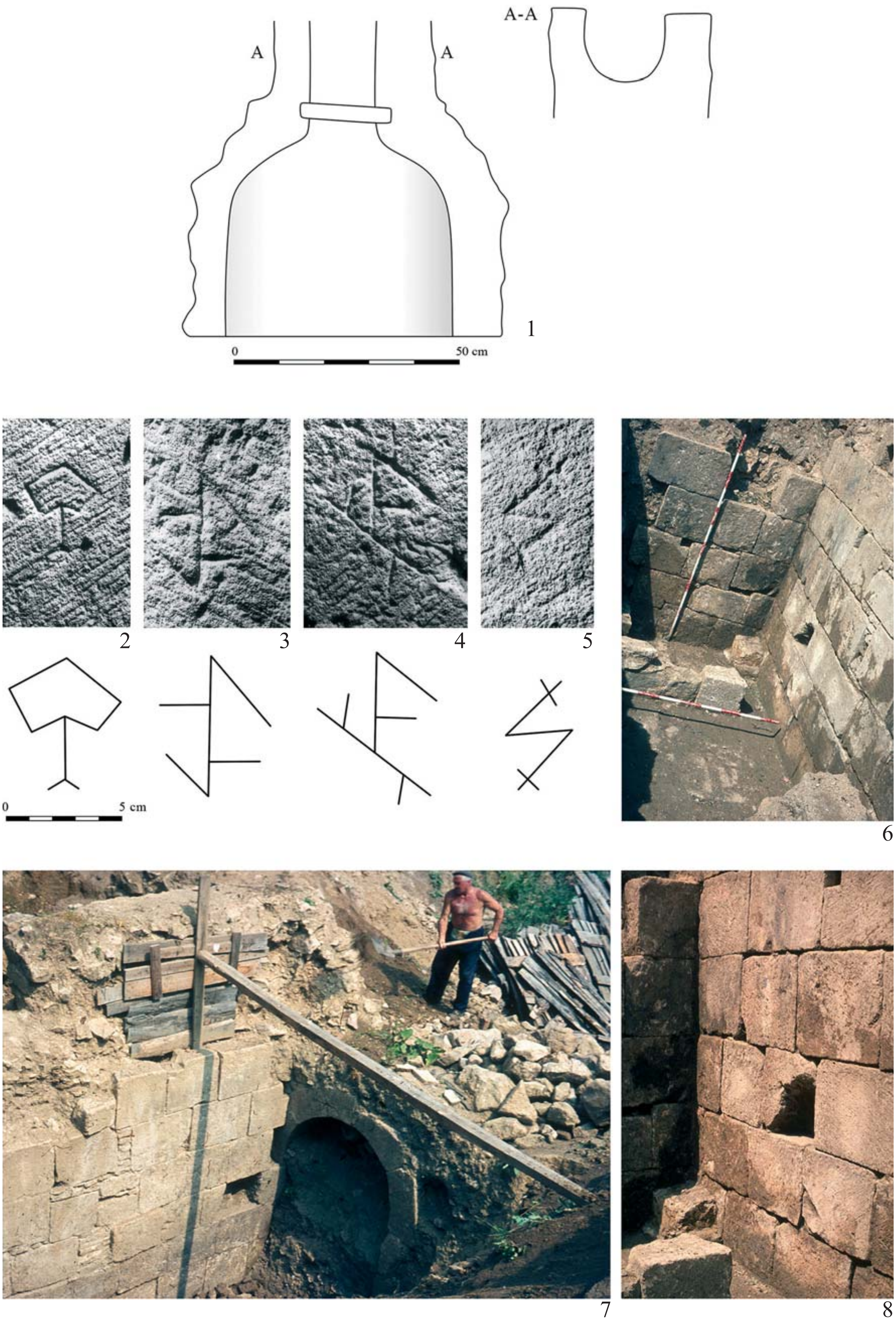


Fig. 3. 1. Pilisszentkereszt-Klastromkert, the stone conduit transporting water from the artificial lake onto the mill wheel terminating in a funnel with a notch made for the latch (Drawing: Zsóka Varga after sketches made by Endre Egyed); 2–5. Masons'marks on the ashlars of the mill race (Photographs: Lajos Sugár); 6–8. The excavation of the mill race and walled channel (Photographs: Lajos Sugár)

It should be mentioned that a remarkably large number of ashlars with masons' marks were built in the masonry of the wheel trench *(fig. 3. 2–5).* These masons' marks differ from the early mason's marks of the Pilis abbey dated to the beginning of the 13th century. Imre Holl found their analogues on stone carvings dated the second half of the 14th century.[12] Fragments of brick and roof tiles were observed between the stones of the sidewalls at some places.

The observation above suggests that – although the lake itself had been established earlier – the walled mill race was not completed in its present form until the 14th century, which seems to confirm that the latrine – used by the inhabitants of the infirmary in addition to those of the monastic dormitory – receiving water from the mill was added later to the 13th-century building block *(fig. 4. 4).* This facility evidently had some kind of antecedent, as the dormitory was upstairs in the earliest, 12th-century wing of the building. However, this was not discovered during excavations, nor was the early flour mill that preceded the metalworking workshop. The existence of the latter is suggested by the fragments of millstones discovered as stray finds in the area of the monastery.

The deep ditch of the water wheel is closed in the east by an arched, gate-like opening (height: 2.2 m, *fig. 2. 1–2, fig. 3. 7*), after which the trench continued into a vaulted stone channel that was about 62 cm in width and 60–62 cm in height *(fig. 4. 4).* A short section of this large structure was discovered on the south-eastern side of the monastery as early as 1968 and was referred to as the "main sewer". Its continuation was not found at that time. "The base is made of smooth rectangular stones and its semi-circular vault is built of bricks." The drawings made during the excavation confirm that the bottom of the channel was made of large flat pieces of stone, but the other parts of the vault appear to have been constructed of stone slabs rather than bricks. The exact track of the channel was not identified during the excavations by Gerevich. It was detected by the extensive geophysical measurements of 2003–2004.[13] These measurements clearly showed that the channel ran straight from the trench of the mill wheel to the north. Then, it changed its direction to the north-east at the level of the former refectory and ran towards the monastic latrine. This corresponded to the general practice of medieval Cistercian monasteries. According to this, a longitudinal, walled channel was constructed under the seats of the large toilet block upstairs, behind the dormitory. A watercourse, usually a stream, was led through this, which continuously removed the contents of the latrine. An excellent example of this is the 13th-century latrine block of the Cistercian abbey of Royaumont (Île-de-France), with a 32 m long and 2.35 m wide walled stone channel, as well as 31 openings in the vault connected to the upstairs lavatories *(fig. 4. 1).*[14] A similar facility survived in the Cistercian monastery in Zwettl, Austria *(fig. 4. 2–3).* The foundation walls of the Pilis latrine were excavated at the end of excavations supervised by Gerevich. Apart from a ground plan showing the periodisation – that is, the construction order – of the walls, little documentation is left of it. However, it still reveals that the large common latrine of the dormitory and the infirmary built on its eastern side followed the usual tradition of Cistercian monasteries: its superstructure rested on long, parallel walls and the water coming from the artificial lake could wash through the bottom of the latrine covered with stone slabs between the walls. Leaving the latrine, the water could run towards the Dera stream meandering below the abbey *(fig. 4. 4).* The length of the Pilis latrine was 24 m.

An intriguing discovery of the 2003–2004 geophysical survey was that a minor channel forked off from the large channel on the farmyard of the monastery (which must have contained workshops, storehouses, wagon sheds, and stables). The shape and function of the minor channel could only be revealed by authenticating excavations but its existence was presumably related

[12] *Holl 2000* 133.
[13] *Benkő 2010.*
[14] *Renaud 1999* 65.

to keeping the farmyard clean. Apparently, this minor branch also crossed the stone wall of the monastery and led to the Dera stream *(fig. 11)*. In the middle of the farmyard, the mark of a rectangular (6×5 m, inside dimensions: 4×3.5 m), dug-in, and most probably walled feature could be seen, which may belong to the remains of a large well or cistern.[15] Interestingly enough, the monastic court in the middle of the cloister had no dug well. Water was provided by the fountain standing in the southern walkway of the cloister.

The channel draining the water of the artificial lake was filled with earth mixed with rubble. The finds discovered in the backfill (glass and pottery shards, including many roof tile fragments; iron artefacts, including a substantial number of iron nails) also shed light on the time when the channel was used, as they can be dated to the 13th and 14th centuries. Of these, the earlier ones are particularly important to us, because they can be associated with beginnings. These include, for example, the high-quality – largely matching – colourless glass fragments of a large jar decorated with applied cobalt blue glass threads. This object discovered in the channel was reconstructed in a drawing. László Gerevich still dated it to the 10th century with uncertainty and listed it among the finds pre-dating the foundation of the monastery.[16] However, after further research, Imre Holl dated the artefact – which is still without exact analogues today – to the period between the second half of the 13th century and the beginning of the 14th century, and carefully hypothesised that its provenance was in Southern France or somewhere else in the Mediterranean.[17]

To summarise the observations related to the fishpond of the Pilis monastery, this artificial lake date back to the 13th century, but the earliest facilities (the mill, the early drainage channel) associated with it are unknown. Only the earthen dam bordering the lake bed on the east might still date from the 13th century. The other facilities were presumably destroyed when the walled ditch suitable for the installation of the large water wheel and the connected vaulted stone channel were completed in the 14th century. The latter ran to the large latrine block of the monks' sleeping quarters and the infirmary, which was built later to the eastern side of the dormitory. Since the monks' dormitory belonged to the earliest part of the building, it certainly had an early latrine at the south end of the building, but its remains were either not covered or were undetected by the excavations. This hypothesised early latrine on the short, southern side of the dormitory suggests that the vaulted stone channel may have been built along the track of a former sewer, as water necessarily had to flow behind the monks' hall and the sleeping quarters for sanitary reasons. Unfortunately, there is still no relevant archaeological evidence on this question.

It seems probable that the water wheel originally belonged to a flour mill; otherwise, the large fragments of millstones discovered in the excavation area could not be interpreted. When discussing the authentication core taking at the site, we have mentioned that the Dera stream under the monastery was not dammed into a mill pond in the medieval period. Consequently, it was only the water of the artificial lake above the monastery that could operate a gristmill in the immediate vicinity of the abbey.

Considering the wider region, however, the Pilis abbey was not short of mills. We have already referred to the old Cistercian grange and the lake located near the lower part of the Dera (Kovácsi) stream, about 5 km from the territory of the Pilis Cistercian abbey, in the area of the Árpádian-period village of Kovácsi, near today's Pomáz. Another mill of the monastery operated next to the Danube, in the area of Békásmegyer.[18] Further research is needed to clarify which of the seemingly modern lake and mill sites located in the valley of the Dera stream could have been medieval and in the possession of the Pilis abbey.

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15 *Benkő 2010* 412, fig. 6.
16 *Gerevich 1984* fig. 15; *Gerevich 1985* fig. 6.
17 *Holl 2000* 18–19, fig. 21.
18 *Ferenczi 2014.*

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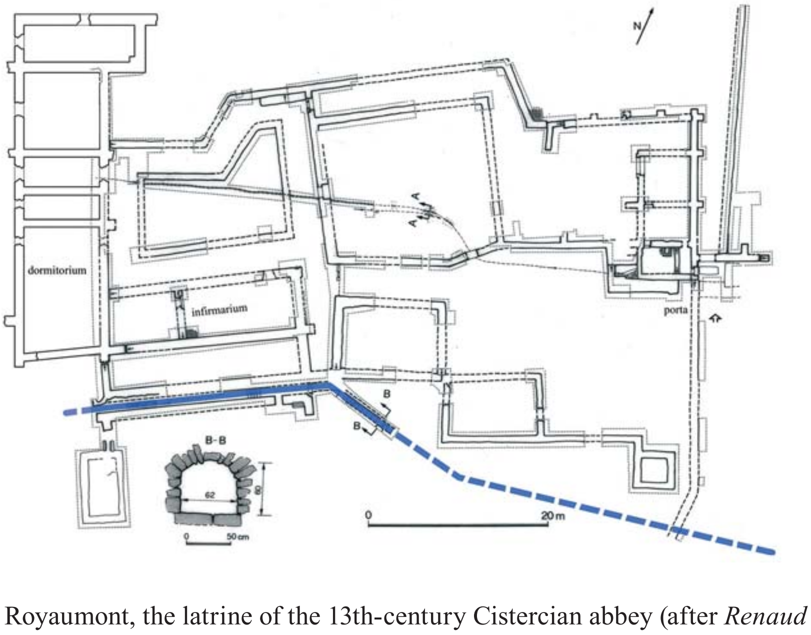


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Fig. 4. 1. Royaumont, the latrine of the 13th-century Cistercian abbey (after *Renaud 1999*);
2–3. Zwettl, the reconstructed shaft of the latrine in the Cistercian monastery (Photographs: Elek Benkő);
4. Pilisszentkereszt-Klastromkert, the upstairs dormitory, the infirmary, and the eastern wing of the building with the latrine and the water conduits in the Cistercian monastery (Drawing: Endre Egyed)

In the 15th century, the function of the mill wheel of the Pilis monastery changed. Instead of flour milling, it became part of a workshop that carried out iron ore smelting and blacksmithing, leaving large quantities of slag behind. Archaeological data suggest that these activities continued for a few decades even after the monastery was set on fire by the Ottomans in the autumn of 1526, but monastic life in it ceased to exist forever. In regions rich in iron ore, the medieval Cistercian monasteries were also engaged in iron ore smelting. The smelting masters of the Walkenried monastery in the Harz Mountains, for example, are mentioned in the first half of the 13th century. In the area of the Heiligenkreuz monastery, the late medieval mother house of the Pilis abbey, smelting was carried out in the late medieval period.[19] The processing in the Pilis probably depended on the small amount of local iron ore. However, this question still awaits in-depth examination by researchers.

### *Rainwater drainage channel outside the western façade of the monastery church*

Right in the first year of the long series of excavations led by László Gerevich, it was discovered that the western foundation wall of the church was much wider than it was customary, and a section of wide foundation ditch extending westwards from under the rising wall comprised a large channel with walls made of ashlars and covered by thick rectangular stone slabs *(fig. 5).* Its function can be interpreted precisely in the knowledge of the site. The artificial terrace of the hill cut into the hillside rising sharply towards the west was exposed to a considerable amount of rainwater and thawed snow coming from the hill. This could have flooded the church through the western gate. The 125 cm high and 68 cm wide feature (narrowing to 50 cm at the bottom), which can be partly still crossed today, was meant to drain away this mass of water coming down suddenly. It ran along the full width of the western façade, but the excavations could not reveal where and through which openings it absorbed the water coming from the hillside. The channel started at the south-east corner of the longhouse of the church, passed in front of the western façade, then turned eastwards at the north-east corner and began to move away from the building. Its exact line has not been detected, but we can assume that turning to the north-east, it left the area of the monastery enclosed by walls before reaching the axis of the northern transept, as the burials of the churchyard were already there *(fig. 11).* The channel was filled with clay washed in by the water pouring down, as well as the "rubble of a destroyed building". László Gerevich suggested that the channel could be earlier than the western end wall of the church, but this is not supported by the records available to us. It seems that the channel made of ashlars was built when the church was founded. The level data of the channel also help to understand the ground-level conditions outside the western façade. It is striking that the bottom of the channel in front of the western wall (355.95 m) lies only 17 cm deeper than the floor of the nave (356.12 m), which practically means that the channel, as a whole, is found higher than the church floor *(fig. 5. 6–7).* This clearly suggests that the ground level on the western side of the church, towards the Pilis Mountains, was already very high. From the western church gate, the main nave could be accessed through steps, crossing about a 1.6 m difference in the levels. The drainage of rainwater – using different techniques – has also been proposed in the case of other Cistercian monasteries.[20]

[19] *Schich 1980* 230–232.
[20] *Kinder 1995* 113.

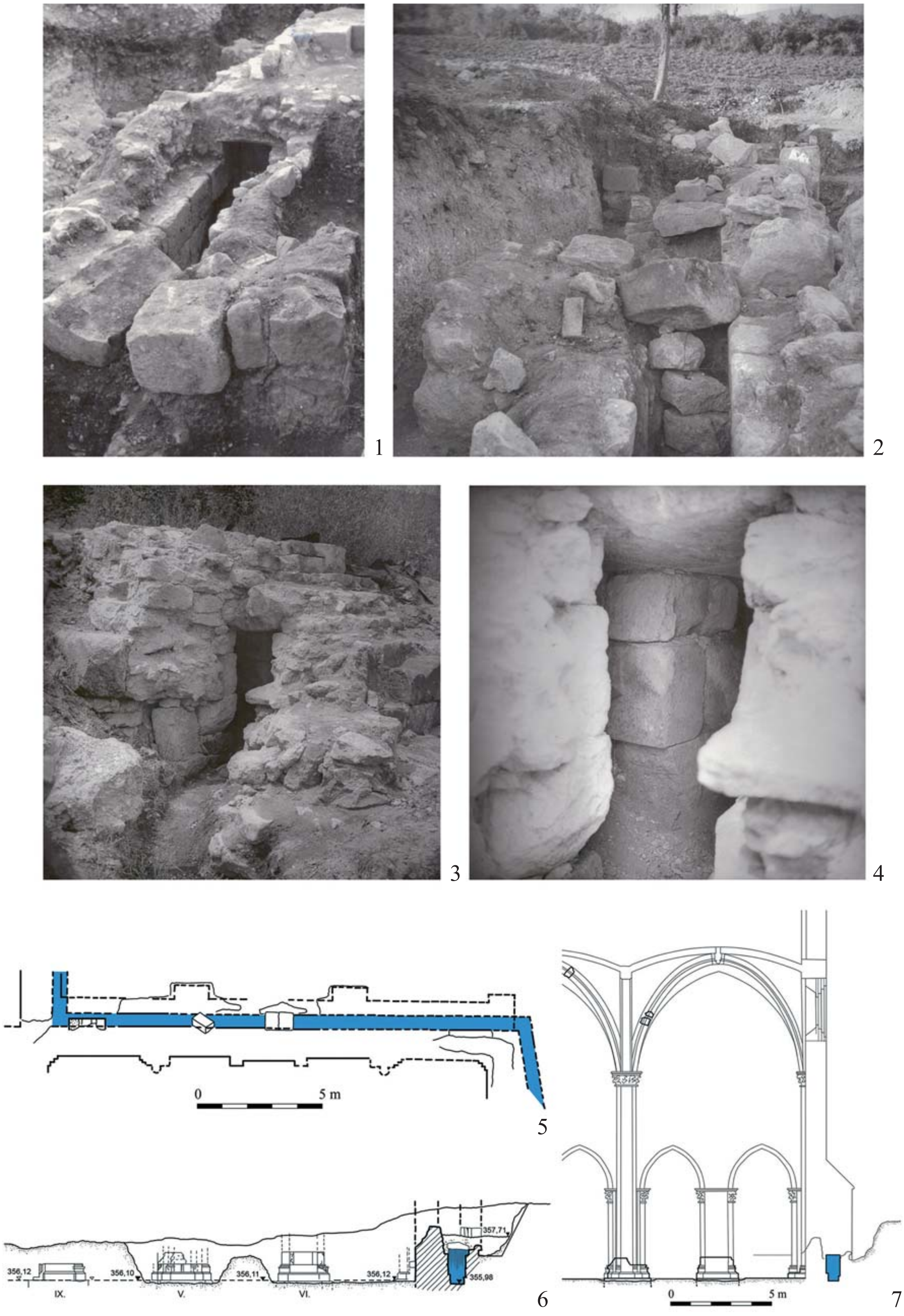


Fig. 5. 1–4. Pilisszentkereszt-Klastromkert, the remains of a sewer built into the western wall of the church in the Cistercian abbey (Photograph: Lajos Sugár); 5–6. The floor plan and cross-section of the sewer; 7. The position of the drainage channel in the longitudinal section of the church, a reconstruction (Drawing: Endre Egyed)

### *The fountain house and the early aqueduct*

The earliest aqueduct of the Pilis Cistercian monastery, made of carved stone elements, is demonstrably contemporary to the monastery and the fountain house accessible from the southern walkway of the cloister, built in the first third of the 13th century. The aqueduct continuously transported water to the *lavatorium* from the Klastrom spring (and possibly other nearby springs that have dried up by now). In terms of its chronology, it is telling that its line crosses the walls of the cloister at several points. In each case, the aqueduct passed through the wide and carefully laid foundations of the monastery walls, when it was constructed. (For example, under the eastern walkway of the cloister, the half-cylindrical stone channel passes through the buttress foundations of the cloister protruding into the monastery court. It would have been pointless to construct it later with great destruction.) The fountain house itself – although its building belongs to a different stage within the construction of the cloister, as indicated by the separation of its wall foundation *(fig. 10)* – was built in the first third of the 13th century, which is confirmed by the style of its carvings *(fig. 6. 1–5).* The fountain house found in the middle of the southern walkway of the cloister, just outside the refectory, has a composite stone fountain in it that provided the monks with permanent running water. Such fountain houses played a key role in the life of Cistercian monasteries as they offered the monks the possibility for washing their hands before entering the dining hall, as the *Liber usuum* prescribing the rituals and daily activities for the Cistercian monks puts it: *ablutis igitur manibus et detersis intrent refectorium*.[21] Its other functions have been summarised above.

The fountain house is the least known part of the cloister in Pilis. In addition to the excavation techniques employed during the investigations supervised by László Gerevich, it was mainly caused by the fact that the exploratory excavation led by Péter Gerecze in the early 20th century significantly disturbed the remains. The ruins were also severely disturbed later as a very deep and wide pit was discovered at the site of the fountain house during the excavations in 1967, which destroyed a considerable part of the remains *(fig. 7. 4)*. The extent of the subsequent disturbance is demonstrated by the fact that one of the fragments of a statue belonging to the 14th-century chancel screen erected in the nave was also discovered here.[22] The foundation of the fountain house (for which stones from the masonry of an earlier building were also used) held walls covered with ashlars. Inside the building that led to the cloister, no floor, lavabo foundation, and conduit remains were discovered, or they could not be observed. There was no trace of the old level conditions and the flooring, either. Based on analogues, we may assume that the old ground level inside the fountain house was the same as that of the cloister.[23] The octagonal building, supported with small buttresses at its corners, had a stone vaulted ceiling held by the leaf capitals of half-columns placed in the corners *(fig. 6. 3)* and by profiled cornice sections *(fig. 6. 4–5)*. The main elements of the vaulted ceiling were the carved ribs with a profile similar to the ribs used in the nave of the church, but smaller in size *(fig. 6. 1–2).* The existence of the vaulted ceiling is also suggested by the fact that the buttresses of the fountain house had much deeper foundations than the sidewalls of the octagon.

No parts of the lavabo built in the middle of the fountain house survived *in situ*. Imre Takács carried out its reconstruction based on the discovered stray stone carvings. Many of these pieces

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[21] *Liber usuum Sacri Cisterciensis Ordinis.* Parisiis, 1643, 168; *Simon 1997* 5.

[22] From the notebook of Vilmos Balás, work foreman, 1974: "a madonna was discovered among the old ruins of the fountain house" (Inv. no. 76.263).

[23] Under fortunate circumstances, the operation of the monastic fountain is indicated by major wall foundations and aqueduct remains, as in the case of Durham (*Lillich 1982* 142; *Coppack 1999* 40) or Eberbach (*Liebert 2015* 47).

had been lost decades earlier, so only drawings or photographs were available for research. This makes the identification of the individual details and dimensions somewhat uncertain.

The lavabo with a composite structure stood in a stone basin 3.2–3.3 m in diameter, the base of which was assembled from white hard limestone elements. The remaining carvings reveal that the bottom of the basin was made sloping so that the water pouring in it from above would enter the drain found in the middle of the fountain *(fig. 6. 10, fig. 7. 3).* The curved side panels of the basin carved from red marble were fixed to this pedestal with pegs. These side panels surrounded the 55 cm high cylindrical basin *(fig. 6. 9, fig. 7. 3, 5).* In the middle of the basin, there was a thick marble column, supplemented by six additional pillars placed radially, crowned by a flat red marble capital decorated with leaves *(fig.6. 11).* This held a large red marble fountain dish (diameter: approx. 2.5 m, *fig. 6. 7*), from which water flowed into the lower basin and then down the drain. In the centre of the large red marble dish, a large cylindrical column was placed, which was bored through vertically (diameter: 7.5 cm). This column had a base and presumably a capital too, on which a smaller dish was placed. The dish was made of limestone and had openings for spouts placed under the rim *(fig. 6. 8).* A slender pinnacle was attached to the upper basin, and it had a vertical borehole of the same size as that of the column mentioned above *(fig. 6. 6).* From this pinnacle, water flowed through narrower holes in four directions. According to this reconstruction, the height of the fountain was above 2.65 m *(fig. 7. 3).*[24] Subsequently, Imre Takács made some modifications. He added one more small-sized dish at the top of the fountain. The base of the lavabo is made of white limestone. The side panels of the basin, the central pillar, and the lower, large fountain dish were carved from red marble, while the two dishes above it together with their columns, as well as the pinnacle crowning the structure were made of white limestone *(fig. 7.* 5).[25]

According to the assumption made by Imre Takács, the lower basin of the fountain – when fully filled with water – could act as a water tower providing the necessary water pressure for the complex water supply system of the monastery built of stone and ceramic elements.[26] Recent research has significantly modified this view in several respects. On the one hand, the network only seems to be too complicate, because we have to reckon with stone and ceramic pipes that existed successively in time. The water pressure in them – as we shall see below – must have had a source with a stone conduit lying higher than the monastery. The lowermost tray of the fountain found at the floor level and enclosed by a wall consisting of thin curved segments carved from red marble probably only served for collecting splashing water that came from the fountain dish above instead of storing a large amount of water that was already contaminated from use. On-site research carried out since the 1990s, as well as the in-depth evaluation of the archaeological records clarified several details related to this question.

The drinking water infrastructure of the Pilis monastery started at the still working and used Klastrom spring, located to the north-west of the building complex, just 40 m from the outer stone walls of the abbey. Field surveys revealed that debris from a destroyed medieval stone building (or more buildings) can be observed on the surface in the thicket surrounding the spring. In the same place, a copper coin of Béla III (1172–1196) was discovered during the excavations supervised by László Gerevich. We assume that the spring was inserted into a stone socket and a small building was erected over the walled basin. The water pressure was provided by the difference in the altitudes of the spring and the *lavatorium* in the cloister. (Today the altitude of the spring is around 372 m above sea level. The bottom of the medieval reservoir dug in the ground evidently lied deeper than this.) Near the fountain house, the elevation of the floor of the cloister paved with

[24] *Takács 1992; Takács 1994* 239–240.
[25] *Takács 2007* 36–38.
[26] *Takács 1992* 10.

bricks was at 355.69 m. The atmospheric pressure was therefore approximately 1.5 atm, which ensured that water also reached the upper spouts of the tall fountain. The walled structure (well house/cistern) built around the spring has parallels in the Benedictine abbey of Prüfening (with Romanesque antecedents)[27] and the Cistercian abbey of Royaumont.[28]

The upper section of the water supply system leading from the spring to the monastery is not known (its hypothetical line is marked with a red dashed line on *fig. 11*), neither do we have exact data on where the pipeline may have entered the inner area of the monastery. It certainly came from the direction of the lay brothers' *(conversi)* building, as the furthest section of the aqueduct running to the fountain house was found under the eastern corridor of the lay brothers' wing, parallel to the western part of the cloister. However, it is uncertain whether the conduit entered the quadrangle at the corner of the church, where it could have been built into the wall foundation under the western water drainage channel lying relatively high, or it crossed the building of the *conversi* in an east–west direction. It remains the task of future authenticating excavations to decide this question.

The body of the conduit was made up of matching blocks of stone hollowed like troughs. Sometimes, the channel in the conduit was formed by two stone troughs with semi-cylindrical cavities turned towards each other (the size of the channel with a standing oval cross-section thus created was 14×22 cm). In other cases, the lower stone troughs were covered with thick stone slabs, which were fixed with mortar *(fig. 8. 1–2, fig. 10)*. According to Western tradition, thick lead pipes were laid in these longitudinal cavities. The best-known example of this solution is known from the Benedictine monastery of St. Emmeram in Regensburg, where Peringer II (1177–1201) built an approximately 3 km long aqueduct around 1200, which conveyed water from a distant spring to the monastery. The tombstone of the abbot, who died in 1201, also commemorates this extremely important facility, specifically mentioning the lead pipeline: *obiit sanctae memoriae Perngerus abbas huius loci, qui fecit aquaeductum plumbeum*. The original stone troughs of the Regensburg aqueduct have survived to this day, but the lead pipes inside were replaced around 1580 *(fig. 8. 5)*.[29] The excavations did not yield lead pipes inside the early aqueduct of the Pilis monastery, but these may as well have been removed from the stone conduit damaged in several sections either already in the medieval period, or at the time of the destruction in the 16th and 17th centuries. In principle, we can also imagine that here the relatively short pipeline with a significant inclination was designed without a pipe as it was considered sufficient to thicken the troughs to maintain pressure and leak-tightness. This may be confirmed by the fact that the troughs were covered in some places with a thick layer of limescale on the inside. It is an important observation that the masonry surrounding the troughs contains pieces of roof tiles in addition to small stones, which is another proof of that the first tiling of the building (complex) took place in the Árpádian period.

On leaving the corridor of the lay brothers' wing, the aqueduct turned eastwards and crossed the western walkway of the cloister through its foundation and entered the court of the monastery. László Gerevich uncovered a relatively long, intact section of the aqueduct in the court *(fig. 10A–A)* where it descended 29 cm in 7.5 m (i.e., about 4 cm in 1 m). The aqueduct passed along the north side of the fountain house, where – according to a drawing made by Péter Gerecze – a short section branched off at a right angle to the main line and led towards the inside of the fountain house. It was not discovered during the excavation led by László Gerevich, so the drawing made by Gerecze was projected onto the excavation plan. In the absence of concrete evidence, the assumption recorded by László Gerevich in the excavation notebook, namely that the short

[27] *Gieß 1999.*
[28] *Raynaud – Wabont 1998* 72.
[29] *Regensburg 1995* 142–144; *Reidel 1999; Liebert 2015* 30.

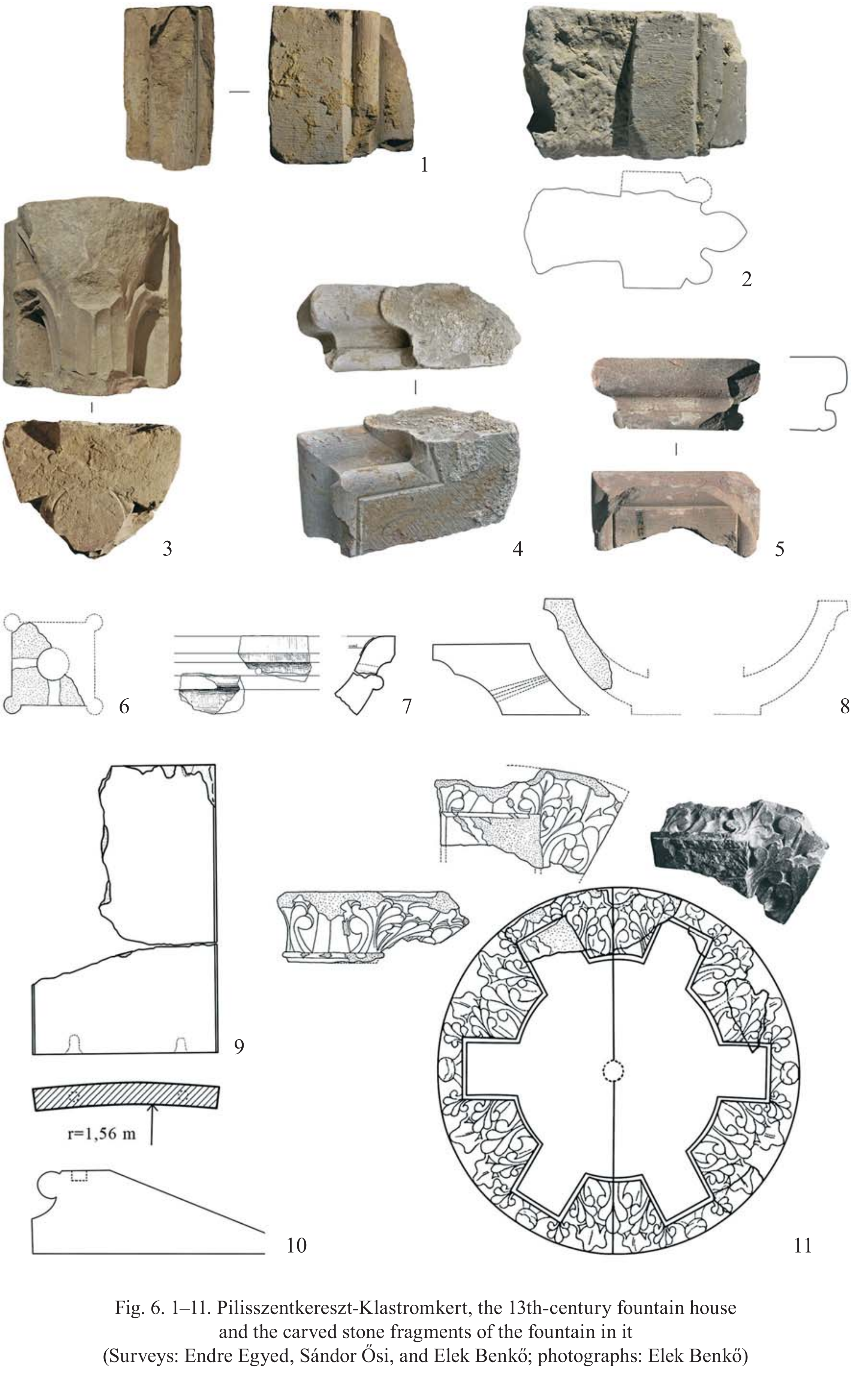


Fig. 6. 1–11. Pilisszentkereszt-Klastromkert, the 13th-century fountain house
and the carved stone fragments of the fountain in it
(Surveys: Endre Egyed, Sándor Ősi, and Elek Benkő; photographs: Elek Benkő)

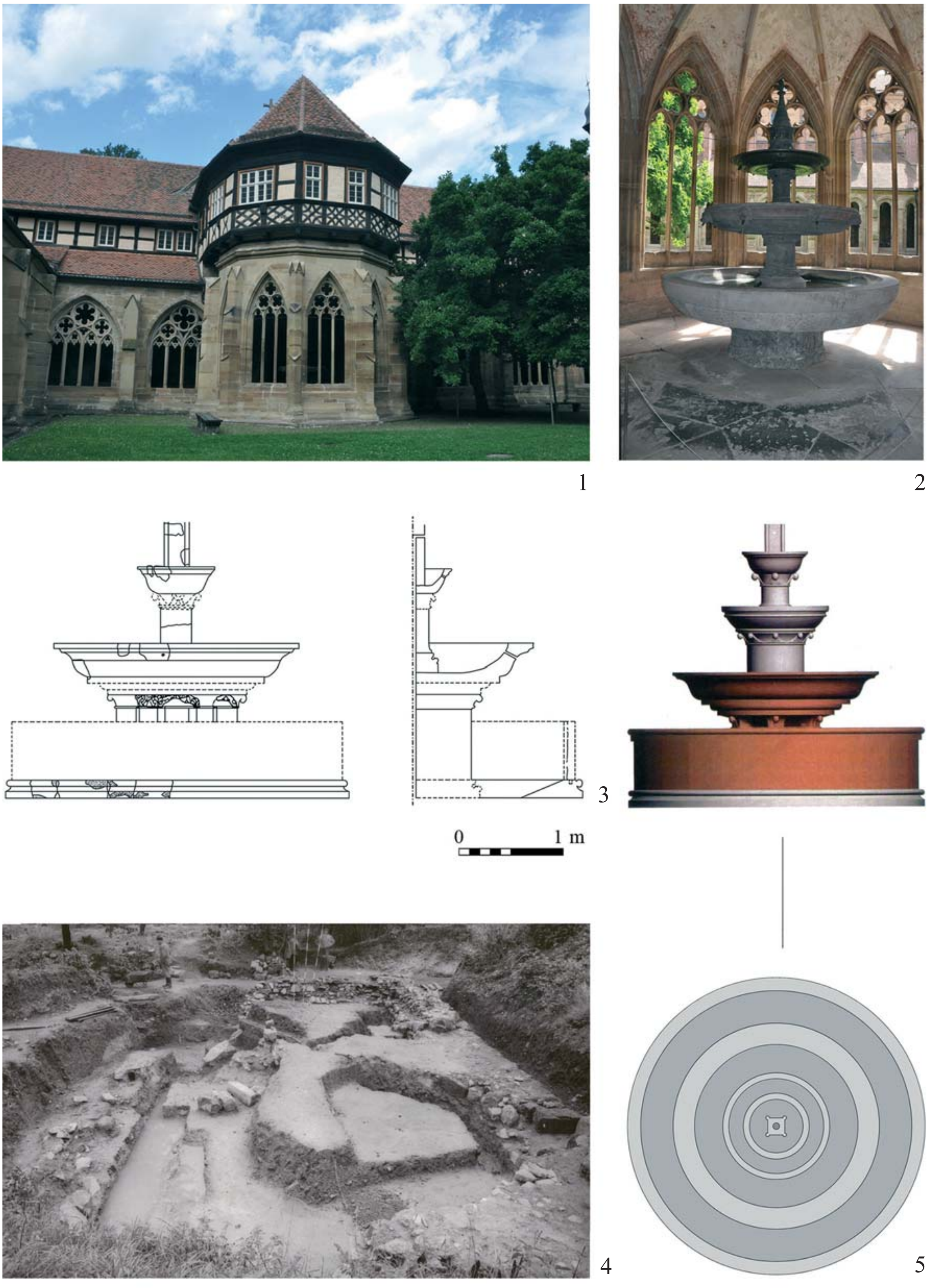


Fig. 7. 1–2. Maulbronn, Cistercian monastery, fountain house and *lavabo* (Photographs: Elek Benkő); 3. The reconstruction of the fountain in Pilis Abbey (after *Takács 1992*); 4. The heavily damaged remains of the fountain house at the time of the excavations led by László Gerevich (Photograph: Tibor Kádas); 5. A modified reconstruction of the fountain (after *Takács 2007*)

section of conduit heading for the middle of the fountain house may have had some kind of closing mechanism, cannot be substantiated – although it seems probable.

The conduit in which clean water flowed under pressure did not terminate at the fountain house, but continued on to the walls of the cloister walkway facing the garden. Getting there, it turned southwards at a right angle, and then it ran to the south-east under the calefactory, which was added to the building complex subsequently. Its continuation has not been unearthed, but based on the floor plan it obviously fed into the large vaulted channel leading the water of the artificial lake towards the latrine *(fig. 10)*. In terms of its function, this section must have served as an overflow outlet for the continuously flowing lavabo in the fountain house. At the same time, it is also conceivable – although there is no concrete evidence for it – that there was one more access point of water supply for the kitchen at the final section of the aqueduct.

On the east side of the fountain house, the bottom of the stone trough of the aqueduct ran about 1 m below the late medieval pavement and gradually deepened in the direction of flow. The aqueduct leaving the cloister to the south was found 150–160 cm deeper than the late Gothic surface (355.77 m).

The stone aqueduct needed maintenance or thorough cleaning in the mid-14th century at the latest. In the late medieval period, a wide ditch was dug in the south walkway of the cloister to access the aqueduct. Subsequently, the stone conduit was covered with mortar, which comprised fragments of roof tiles and floor tiles *(fig. 8. 1–2)*. A brick (4×12×24 cm) was also discovered there. The backfill of the trench also yielded plain and patterned floor tiles from the 14th century. It was observed that the stone laid on the stone trough had once been broken. The original yellow mortar joining the troughs seemed identical to the mortar used in the wall foundation of the cloister and clearly differed from the white mortar used in the wall surrounding the stone channel. It was filled with soil mixed with loam.

Archaeological excavations carried out in the Benedictine monastery of Blaubeuren (Baden-Württemberg) brought to light a close analogue to the Pilis aqueduct in terms of the direction of the conduits. Similar to the latter, the aqueduct to the late medieval (1482) fountain house came from the direction of the lay brothers' wing in the west. Then, running below the dormitory, it continued its way eastwards, in the direction of a nearby stream.[30]

Unfortunately, the excavations did not solve one of the fundamental questions concerning the early aqueduct: how was wastewater drained from the fountain house? No such pipeline was found in the heavily disturbed area, although it certainly existed. Moreover, there must have been a sewer not only in the Árpádian period but also in the late medieval period, as the fountain house operated continuously until the destruction of the monastery in the 16th century. In our view, this early sewer must have run roughly along the later pipeline constructed of ceramic pipes (more on this below). We observed that this late pipeline followed at several points the track of an earlier stone channel constructed for the gravity-based drainage of wastewater without pressure, which also headed for the Árpádian-period gatehouse built on the eastern side of the abbey. Its approximate path can therefore be reconstructed with the help of the later ceramic pipeline *(fig. 11)*. We assume that, similar to the ceramic pipeline, the early sewer left the fountain house on the eastern side after collecting the water flowing at the bottom of the lowest stone basin. Then, passing under the eastern walkway of the cloister and the eastern building block of the monastery, it ran in a sloping terrain through the inner courtyards of the abbot's wing towards the gatehouse. Its structure differed significantly from that of the stone trough construction transporting drinking water. It was a rectangular channel composed of columnar blocks of stone (inside width: 18 cm, height: 22 cm). The channel had no mortar or masonry on the outside. The silt and limescale found in it suggest that the wastewater flowed freely in it. At the south-west

[30] *Simon 1997* 223.

corner of the gate, the sewer broadened into a shaft built of ashlars (inside width: 50 cm, height: 55 cm) and covered with large stones on top *(fig. 11).*[31] It was presumably made to settle and clean the sewage, but it was clearly neglected towards the end of its use. It is filled with silty soil mixed with debris with a thick layer of limescale on top of it. The section of the sewer excavated next to the gatehouse yielded 13th-century and late medieval pottery, the shoulder fragment of a small bronze bell (with a small detail of an inscription framed with a band of intertwining strands) dated to the 13th/14th century.[32] The slightly used water flowing from the fountain house arrived in the southern room (kitchen?) of the gatehouse. However, the excavations did not reveal how the water was used there, and they did not discover either how its track continued outside the monastery walls towards Dera stream. Late Árpádian-period finds yielded by the sewer suggest that this section was indeed part of the early system that drained from the fountain house and was used for a long time, as evidenced by late medieval finds. It was laid clearly deeper than the late ceramic pipeline, which run just below the medieval ground surface.

### *Aqueduct made of roof tiles suitable for monk-and-nun roofing*

North-west of the fountain house, in the monastery garden, there was a short section of the aqueduct assembled from arched roof tiles turned towards each other *(fig. 8. 8–10, fig. 9. 13–14).* It ran somewhat to the north of the previous aqueduct as if they wanted to direct the drinking water of the fountain house on a new route with a new pipeline. The large, thick roof tiles (length: 64.7–67.5 cm) suitable for monk-and-nun roofing did not show any sign of previous use. No trace of mortar or limescale could be seen on them, either. Similar pieces have not been found anywhere else during excavations carried out in the Pilis, where the local tradition of monk-and-nun *(Klosterziegel)* roofing cannot be demonstrated, even though a considerable number of roof tile fragments came to light. However, they all belong to rectangular, flat tiles as well as semi-cylindrical tiles, which were different from the arched tiles above. The semi-cylindrical tiles were laid over the joints between the raised sides of the flat tiles. The pieces above appear to have been acquired specifically for constructing a new section of the aqueduct.

Of course, an aqueduct assembled of arched roof tiles laid down and turned towards each other without fixing them together could not be used on its own. (In this part of the monastery, we cannot expect the drainage of sewage or rainwater. Furthermore, a channel assembled without mortar would not have been suitable for this either). Therefore, we assume that the roof tiles put together may have originally protected a new lead pipeline from external damage. It could carry drinking water on a new route to the point where the short section branched off at a right angle towards the inside of the fountain house.

The excavated part of the aqueduct inclined downwards about 8.7 cm per meter in the direction of the *lavatorium*. Its peculiarity (which we will also see in the case of the ceramic pipeline below) is that, unlike the previous stone conduit, it runs at a strikingly shallow depth compared to the late medieval ground surface. Only the part next to the fountain house is known but the section the Klastrom spring mentioned above is not. Therefore, we neither know the exact track nor the way this new pipeline ran through the foundation walls it crossed.

The age of the pipeline can be determined approximatively on the basis of the roof tiles, which unfortunately can only be dated within a wide range. The pieces that are broad at one end and have a gradually tapered, narrow termination at the other end (the shape of which allows a more precise and firm fixing) do not belong to the earliest (11th–13th-century) horizon of the medieval

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31 *Holl 2000* 213, Taf. 24. C–C.

32 *Holl 2000* 106, Abb. 38. 3.

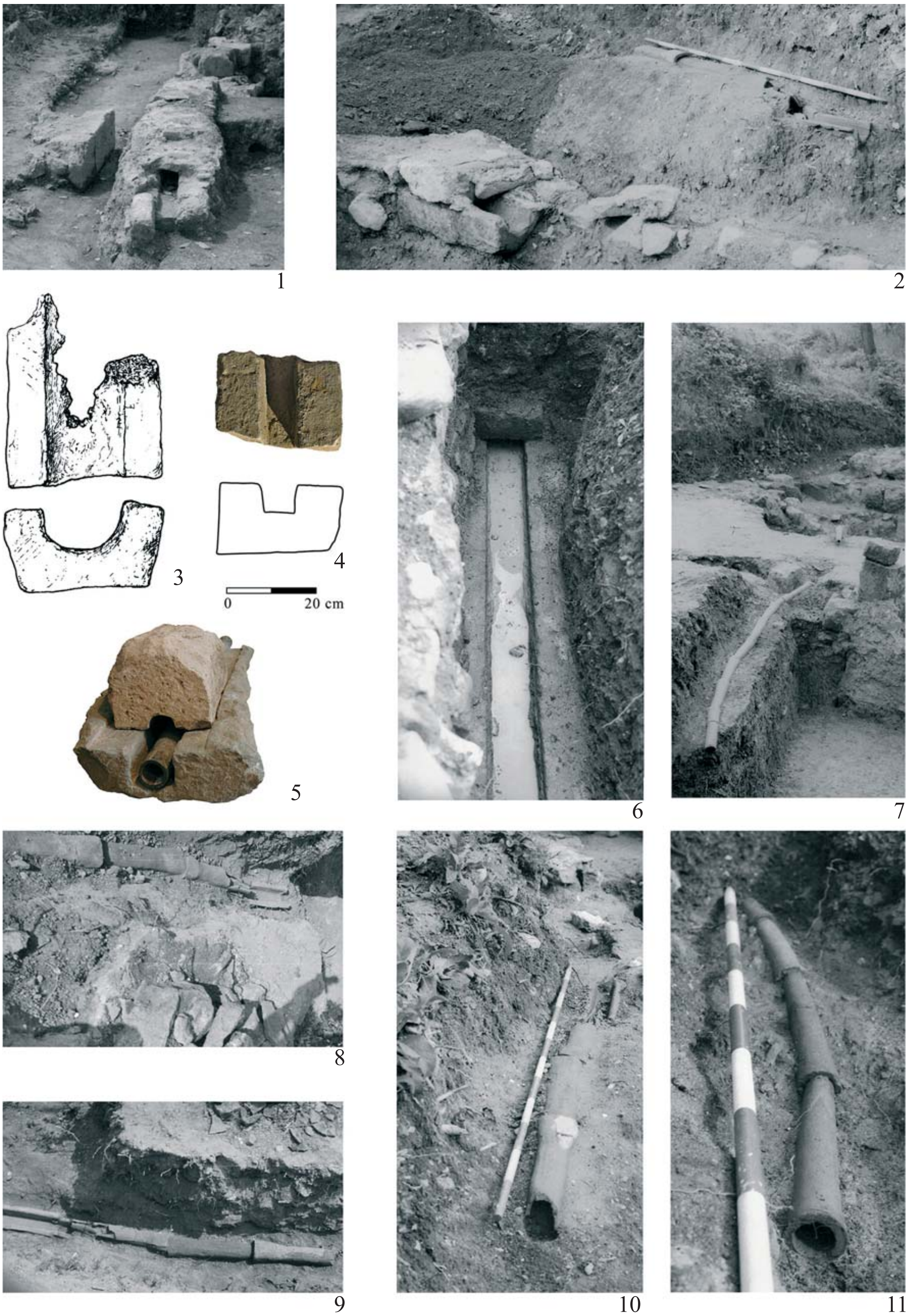


Fig. 8. 1–2, 6–11. Pilisszentkereszt-Klastromkert, sections of the medieval aqueducts (Photographs: Lajos Sugár and Tibor Kádas); 3–4. Carved stone elements of the 13th-century aqueduct (Drawing: Endre Egyed, photograph: Elek Benkő);
5. a section of the Regensburg aqueduct, circa 1200 (Photograph: Elek Benkő)

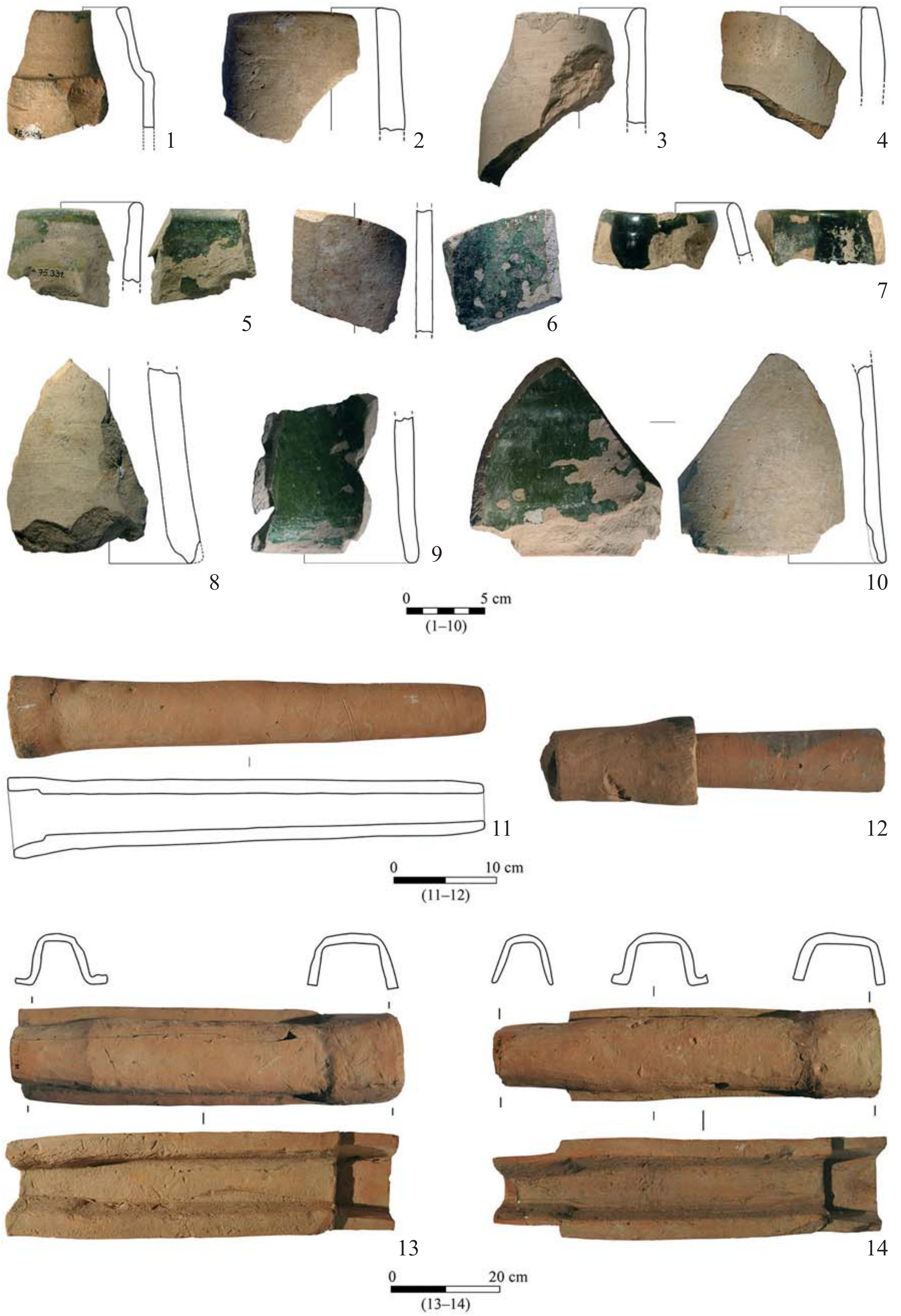


Fig. 9. 1–10. Pilisszentkereszt-Klastromkert, fragments of late medieval glazed ceramic pipes; 11–12. late medieval ceramic pipes without glaze; 13–14. 14th-century (?) roof tiles used for aqueducts (Photograph: Elek Benkő)

arched tiles.[33] According to scholarly literature, their earliest dated analogues come from the period between the late 13th and late 14th centuries[34] and remained in use to the modern period. In the vicinity of the Pilis monastery, similar but not exactly identical items were used to cover the 14th-century church chancel of the Pauline monastery in Kesztölc-Klastrompuszta.[35]

### *A new aqueduct made of ceramic pipes*

In the decades before the monastery was destroyed in the late fifteenth or early 16th century, the entire aqueduct was renewed after the lead pipes in the old channel probably decayed and the drainage section was also clogged with scale and sediment. Fragments of several wheel-thrown ceramic pipes of light red or light brown material covered with green glaze on the inside have been found from this period *(fig. 9. 1–10).* These pieces were discovered in the area extending from the wing of the lay brothers on the western side of the cloister to the eastern walkway of the cloister and the fountain house, but some were also discarded to the late medieval rubbish heap next to a more distant workshop. We cannot determine the length of the pipes from the small fragments, and no archaeological observation has been made as to the exact track along which they were laid, but the individual fragments were scattered roughly in the area where the drinking water was supposed to reach the quadrangle from the spring. The stray finds represent various types, but it is a common feature of theirs that they taper at one end after a sharp shoulder (outer diameter: 6–8.8 cm) and widen evenly at the other end (outer diameter: 10.6–14.8 cm). At their tapered end, where the pipes are the narrowest, the diameter is 4.6–6.4 cm on the inside. Due to the lack of context, we could not determine the exact age of the stray fragments, but based on their material and glazing they are clearly late medieval (from the 15th–16th centuries).

In the late medieval period, not only the track and structure of the drinking water pipeline leading to the fountain house changed but a new pipeline running from the fountain house through the abbot's wing to the gatehouse was built, too *(fig. 8. 7, 11, fig. 11).* It transported wastewater through the gatehouse to the stream on a sloping terrain, without pressure. In this case – as far as can be ascertained from the incomplete excavation observations – the track did not change significantly, but the channel with a square cross-section made of stone slabs was replaced by a pipeline consisting of 44.1–45.4 cm long ceramic pipes fit into one another. The smallest inside diameter of the ceramic pipes was 2.6–2.7 cm. All the pieces were unglazed *(fig. 9. 11–12).* There is no evidence for the use of mortar where the pipes were joined,[36] but it was observed that the pipeline leaving the fountain house was surrounded by a 10–20 cm thick layer of clay. The track of this new ceramic pipeline only roughly followed that of the stone conduit. When it was laid, the subsequent cutting through of the thick wall foundation was avoided as much as possible and the pipes were rather led through the entrances. Additionally, it ran along the corridors and across the inner courtyards of the abbot's wing on the east. Its foundation ditch was clearly shallower than that of the earlier stone conduit. The pipes ran strikingly high in late medieval debris, just a little below the contemporary ground surface, which is clear evidence of the late origin of the ceramic pipeline. It descended 6.5 cm per metre in the monastic court that had a horizontal ground surface. Several parts of the pipeline were subsequently disturbed.

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33 *Goll – Knapp 2008; Morel 2009; Kruse 2014.*

34 *Claus 1997* 44.

35 *Kovalovszki 1992* 196, fig. 8. 2.

36 During the careful construction, thin mortar was poured onto the ceramic pipes of the medieval pressure pipeline in the trench lined with stone tiles. As a result, the aqueduct was solidified into a uniform, pressure-resistant block. *Wild 1992; Bingener – Flosdorf – Haasis-Berner 2002* 34.

It is conspicuous that the unglazed ceramic pipeline draining water from the fountain was made with a much narrower cross-section than the previous stone conduit. Moreover, it was even narrower than the pipeline made of glazed ceramic pipes that seemed to be contemporary. It is uncertain whether this was due to the decreasing water yield of the springs, or to the fact that, in the late medieval period, water was also led to the kitchen and the wing of the lay brothers – along a still unknown track – and thus only little water was left for the fountain standing in the cloister, which could now be transported in a pipeline with such a small cross-section to the lower-lying abbot's wing and the gatehouse.

The ancient technique of aqueducts made of ceramic pipes emerged sporadically in the 11th century but became more commonly used in the monastic water supply system after 1200 (e.g. in the Cistercian monastery of Maubuisson,[37] around 1238; in the Dominican monastery of Zurich[38], in the mid-13th century; in the Cistercian nunnery of Alzey,[39] in the 13th century). Beginning with the 13th and 14th centuries, it also appeared in urban use (Siegen) as a much cheaper alternative for lead pipes.[40] However, the majority of the examples date from the late medieval and modern periods.[41]

According to the excavation notebook of László Gerevich, this ceramic pipeline was established as late as the 16th century, but this has not been evidenced in more detail. Based on our current knowledge, we do not have data for more precise dating within the period between the 15th and early 16th centuries. We can, therefore, only guess whether the modification of the water supply system may be connected to one of the major, late medieval constructions of the Pilis monastery (like the construction of buildings in the abbot's wing during the reign of King Sigismund), or it was – with more likelihood – the indirect effect of reforms that ended the 15th-century decline of the Pilis monastery (1478: measures taken by King Matthias to reform the Cistercian monasteries in Hungary, 1494: measures taken by the Cistercian abbot of Heiligenkreuz in Pilis). Here, we refer primarily to the archaeologically observed constructions of the abbot's wing by Stephen, the abbot of Pilis (1497–1512), which must have included the renewal of the old water supply system with great likelihood.[42]

When summarising our observations, it should be emphasised that the reconstruction of the water conduit system of the Pilis monastery – although it tried to rely on archaeological data that seemed accurate – was based on the incomplete observations and records of excavations that were not up-to-date even according to contemporary standards, and thus it has many missing details or elements that need to be modified in the future *(fig. 11)*. Nevertheless, it can be stated that the two 20th-century excavations carried out in Pilisszentkereszt brought to light the most complex monastic water supply system of Árpádian-period Hungary,[43] where the functions and the network of pressure pipelines and sewers can be reconstructed relatively well, together with late medieval repairs and additions. Since the abbey was destroyed in the 16th century, its water conduit system was not modified in the early modern period. Thus – apart from the early modern disturbances and the systematic demolition of the walls – the medieval conditions could be studied more distinctly. Unfortunately, this rare opportunity could not be fully exploited due to the poor excavation technology employed.

37 *Benoit – Wabont 1991* 185.
38 *Wild 1992.*
39 *Grewe 1991* 34; *Kosch 1991* 106.
40 *Bingener – Flosdorf – Haasis-Berner 2002.*
41 *Zäschke 1981; Nagy –* Čurný *2011.*
42 *Békefi 1891* 267–274; *Benkő 2007* 26–27.
43 Recent archaeological research in Hungary has focused primarily on medieval towns, especially Buda *(Végh 2011)* and Székesfehérvár *(Siklósi 2003; Kolláth 2021).*

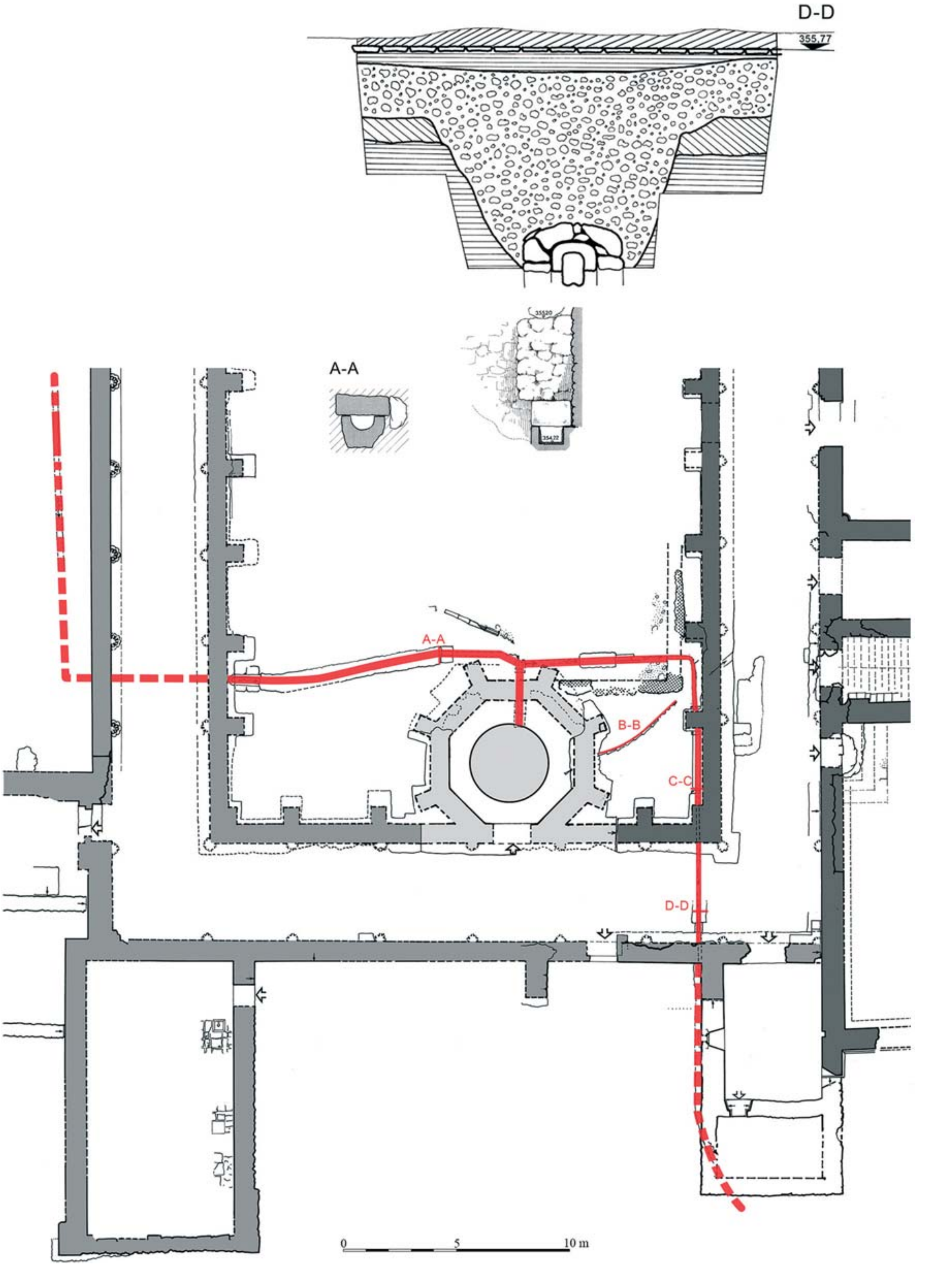


Fig. 10. Pilisszentkereszt-Klastromkert, the cloister garden, with the construction periods of the cloister and the fountain house, as well as the line of the 13th-century (A-A, C-C, D-D) and the 15th–16th-century (B-B) aqueduct
(Designed by Elek Benkő after the surveys by Endre Egyed)

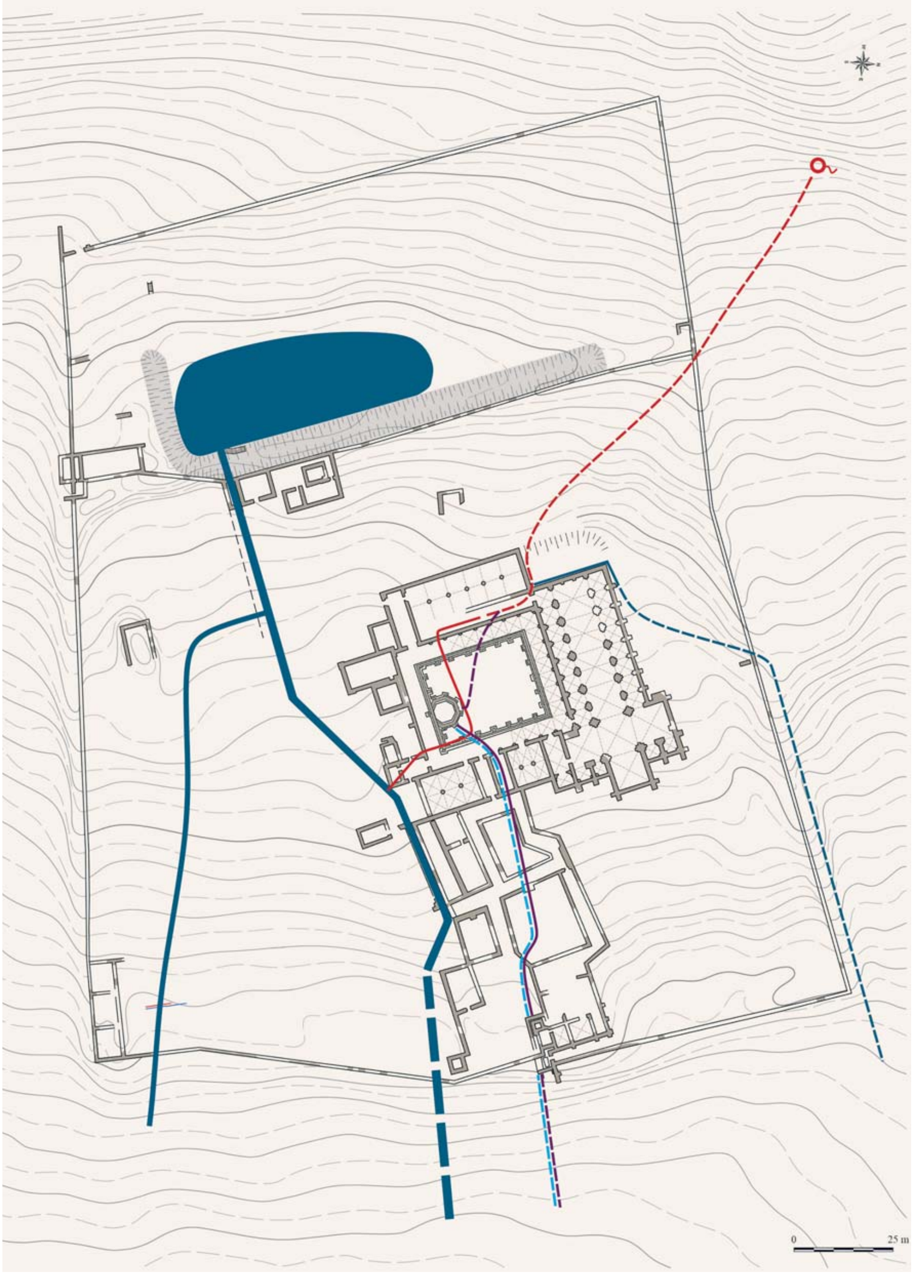


Fig. 11. The reconstructed system of water channels belonging to Pilis Abbey.
Dark blue: the drainage of rainwater from the western façade of the church (13th century) and the runoff of water from the artificial lake (14th–16th centuries); red: drinking water coming from the Klastrom spring (13th century); purple: the expansion of drinking water pipelines (14th century?); light blue: drinking water pipeline towards the abbot's wing (15th–16th centuries)
(Designed by Elek Benkő after the survey by Endre Egyed)

Compared to the similar facilities of major Western European ecclesiastical institutions (e.g. Canterbury[44]), including the most prominent Cistercian abbeys (Eberbach,[45] Maulbronn[46]), the water conduit system of the Pilis monastery can be regarded as a modest establishment – although it is an outstanding architectural achievement with royal foundation and support (unfortunately, due to the lack of local research, a comparison with similar Cistercian monasteries in Hungary is not yet possible). It was fundamentally constructed for supplying water to the fountain house built in the cloister and the separate wing built for the abbot. According to our present knowledge, no running water was led to the wing of the lay brothers, the kitchen, and the – only little-known – infirmary, although this picture may be altered by future excavations. This may also have been in connection with the relatively low number of monks and lay brothers. The situation was simplified by the geological and topographical conditions, such as the close proximity of the karst spring abundant in water and the artificial lake, and the sloping of the terrain towards the valley. These considerably aided the construction of aqueducts and sewers, and the nearby fast-flowing stream could carry away all the wastewater of the monastery. Interestingly enough, the frost line was not taken into consideration when the late medieval ceramic pipeline was laid down. This may have been caused by the hasty and superficial work, as well as the assumption that the constantly running water could not freeze at such shallow depths in an average winter. The refinement of the details of the Pilis water supply system and the complementing of the overall picture obtained so far is only possible through authenticating excavations.

## REFERENCES

*Békefi 1891* — R. Békefi: A pilisi apátság története [The history of Pilis Abbey], 1184–1541. Pécs 1891.

*Benkő 2007* — E. Benkő: A pilisi apátság régészeti kutatása [Archaeological research at Pilis Abbey], in: L. F. Hervay – E. Benkő – I. Takács: Ciszterci apátság Pilisszentkereszten. Budapest 2007, 13–28.

*Benkő 2010* — E. Benkő: A pilisi ciszterci monostor geofizikai kutatása (Geophysical research at Pilis Cistercian Monastery), in: E. Benkő – Gy. Kovács (eds): A középkor és a kora újkor régészete Magyarországon / Archaeology of the Middle Ages and the Early Modern Period in Hungary I. Budapest 2010, 401–419.

*Benoit – Wabont 1991* — P. Benoit – M. Wabont: Mittelalterliche Wasserversorgung in Frankreich. Eine Fallstudie: Die Zisterzienser, in: *Wasserversorgung im Mittelalter 1991* 185–226.

*Bingener – Flosdorf – Haasis-Berner 2002* — A. Bingener – G. Flosdorf – A. Haasis-Berner: Die Wasserversorgung einer mittleren Territorialstadt im späten Mittelalter und in der frühen Neuzeit – am Beispiel der nassauischen Landstadt Siegen. Scripta Mercaturae 36/2 (2002) 1–38.

*Claus 1997* — M. Claus: Mittelalterliche Hohlziegel von Dietfurt. Ziegelei-Museum 14 (1997) 37–46.

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44 *Grewe 1991b.*

45 *Liebert 2015.*

46 *Seidenspinner 1989; Seidenspinner 2010;* on the question, in general: *Schich 1999; Rüffer 2017.*

*Coppack 1999* G. Coppack: Free-Standing Cloister Lavabos of the Twelfth and Thirteenth Centuries in England, their Form, Occurrence, and Water Supply, in: *Wasser, Lebensquelle und Bedeutungsträger 1999* 37–43.

*Ferenczi 2014* L. Ferenczi: Molendium ad Aquas Calidas. A pilisi ciszterciek az állítólagos Fehéregyházán. Történeti, topográfiai és tájrégészeti kutatás a pilisi apátság birtokán (Molenium ad Aquas Calidas. The Cistercians in the Alleged Village of Fehéregyháza. Topographical and Landscape Archaeological Investigations on the Estate of the Pilis abbey). StComit (2014) 145–160.

*Gerevich 1983* L. Gerevich: Ausgrabungen in der ungarischen Zisterzienserabtei Pilis. AnalCis 39 (1983) 281–310.

*Gerevich 1984* L. Gerevich: A pilisi ciszterci apátság [The Pilis Cistercian Abbey]. Szentendre 1984.

*Gerevich 1985* L. Gerevich: Ergebnisse der Ausgrabungen in der Zisterzienser-Abtei Pilis. ActaArchHung 37 (1985) 111–152.

*Gieß 1999* H. Gieß: Das romanische Brunnenhaus des Kloster Prüfening, in: *Wasser, Lebensquelle und Bedeutungsträger 1999* 136–141.

*Goll – Knapp 2008* J. Goll – U. Knapp: Zisterziensische Leistenziegel: Mutanten im Technologiewandel. Ziegelei-Museum 25 (2008) 53–61.

*Grewe 1991a* K. Grewe: Wasserversorgung und -entsorgung im Mittelalter. Ein technikgeschichtlicher Überblick, in: *Wasserversorgung im Mittelalter 1991* 11–86.

*Grewe 1991b* K. Grewe: Der Wasserversorgungsplan des Klosters Christchurch in Canterbury (12. Jahrhundert), in: *Wasserversorgung im Mittelalter 1991* 229–236.

*Holl 2000* I. Holl: Funde aus dem Zisterzienserkloster von Pilis. VAH 11. Budapest 2000.

*Kinder 1995* T. N. Kinder: Les installations hydrauliques dans l'abbaye cistercienne de Fontfroide (Aude). Bulletin de la Société nationale des Antiquaires de France (1995) [1997] 107–115.

*Kolláth 2021* Á. Kolláth: Székesfehérvár vízellátása a középkorban és a kora újkorban. [The water supply of Székesfehérvár in the Middle Ages and the Early Modern Period], in: B. Weisz – I. Kádas (eds): Határon innen és túl. Gazdaságtörténeti tanulmányok a magyar középkorról [Inside and beyond the borders. Studies on the economical history of medieval Hungary]. Budapest 2021, 351–378.

*Kosch 1991* C. Kosch: Wasserbaueinrichtungen in hochmittelalterlichen Konventanlagen Mitteleuropas, in: *Wasserversorgung im Mittelalter 1991* 89–146.

*Kovalovszki 1992* J. Kovalovszki: A pálos remeték Szent Kereszt-kolostora (Méri István ásatása Klastrompusztán) (Das Kloster zum Heiligen Kreuz der Paulianer Einsiedler [Ausgrabungen von István Méri in Klastrompuszta]). CommArchHung (1992) 173–207.

*Kruse 2014* K. B. Kruse: Bischof Bernward von Hildesheim und die Ziegelherstellung um 1000. Ziegelei-Museum 31 (2014) 55–65.

*Laszlovszky et al. 2014* J. Laszlovszky – D. Mérai – B. Szabó – M. Vargha: The "Glass Church" in the Pilis Mountains. The long and complex history of an Árpád period village church. Hungarian Archaeology E-Journal (2014/4) 1–10.

*Laszlovszky – Stark 2017* J. Laszlovszky – K. Stark: Medieval Glass Production at Pomáz-Nagykovácsi: The Finds and Heritage Interpretation of an Archaeological Site. Annual of Medieval Studies at CEU 23 (2017) 239–264.

*Liebert 2015* Th. Liebert: Die historische Wasserführung der Zisterzienserabtei Eberbach im Rheingau. Bodenfunde, Baubestand und Schriftquellen als Spiegel der Wasserbaukunst des Ordens. Arbeitshefte des Landesamtes für Denkmalpfl ege Hessen 26. Darmstadt 2015.

*Lillich 1982* M. P. Lillich: Cleanliness with Godliness: A Discussion of Medieval Monastic Plumbing, in: B. Chauvin (ed.): Mèlanges à la mémoire du père Anselme Dimier V. Ordre, fuilles. Arbois 1982, 123–149.

*Morel 2009* J. Morel: Hohlziegel der Zisterzienser von Bonmont. Ziegelei-Museum 26 (2009) 40–56.

*Nagy – Čurný 2011* P. Nagy – M. Čurný: Stredoveké a novoveké keramické potrubia zo Slovenska (Mediaeval and modern-age ceramic piping in Slovakia). AH 36/2 (2011) 541–555.

*Raynaud – Wabont 1998* Ch. Raynaud – M. Wabont: Réseaux hydrauliques de l'abbaye cistercienne de Royaumont (Asnières-sur-Oise, Val d'Oise), in: L'innovation technique au Moyen Âge. Actes du VIe Congrès international d'Archéologie Médiévale (1-5 Octobre 1996, Dijon – Mont Beuvray – Chenôve – Le Creusot – Montbard). Caen 1998, 71–72.

*Regensburg 1995* M. Angerer (Hrsg.): Regensburg im Mittelalter. Katalog der Abteilung Mittelalter im Museum der Stadt Regensburg. Regensburg 1995.

*Reidel 1999* H. Reidel: Die Wasserleitung des Abtes Peringer II. (1177–1201) von St. Emmeram zu Regensburg, in: *Wasser, Lebensquelle und Bedeutungsträger 1999* 142–145.

*Renaud 1999* C. Renaud: L'abbaye cistercienne en France. Moisenay 1999.

*Rüffer 2017* J. Rüffer: Funktionalität und Spiritualität. Die Wasserversorgung bei den Zisterziensern, in: G. Huber-Rebenich – Ch. Rohr – M. Stolz (Hrsg.): Wasser in der mittelalterlichen Kultur / Water in Medieval Culture: Gebrauch – Wahrnehmung – Symbolik / Uses, Perceptions, and Symbolism. Berlin 2017, 243–254. https://doi.org/10.1515/9783110437430-017

*Schich 1980* W. Schich: Die Wirtschaftstätigkeit der Zisterzienser im Mittelalter: Handel und Gewerbe, in: K. Elm – P. Joerißen – H. J. Roth (Hrsg.): Die Zisterzienser. Ordensleben zwischen Ideal und Wirklichkeit. Eine Ausstellung des Landschaftsverbandes Rheinland. Rheinisches Museumsamt, Brauweiler. Aachen, Krönungssaal des Rathauses 3. Juli – 28. September 1980. Bonn 1980, 217–236.

*Schich 1999* W. Schich: Klosteranlage und Wasserversorgung bei den Zisterziensern, in: P. Rückert – D. Planck (Hrsg.): Anfänge der Zisterzienser in Südwestdeutschland. Politik, Kunst und Liturgie im Umfeld des Klosters Maulbronn. Oberrheinische Studien 16. Stuttgart 1999, 25–41.

*Seidenspinner 1989* W. Seidenspinner: Das Maulbronner Wassersystem – Relikte zisterziensischer Agrarwirtschaft und Wasserbautechnik im heutigen Landschaftsbild. DBW 18/4 (1989) 181–191.

*Seidenspinner 2010* W. Seidenspinner: Das Denkmal und seine Gefährdung. Zur Konkurrenz von Entwicklung und Schutzgedanken im Blick auf das Maulbronner Wassersystem. AnalCis 60 (2010) 17–30.

*Siklósi 2003* Gy. Siklósi: Die Wasserversorgung und das Kanalsystem im mittelalterlichen Székesfehérvár (Stuhlweissenburg). Antaeus 26 (2003) 225–228.

*Simon 1997* H. M. Simon: Zur Entwicklung und Bedeutung der Brunnerhäuser innerhalb der mittelalterlichen Sakralbaukunst deutscher und österreichischer Territorien. Frankfurt am Main – Berlin – Bern – New York – Paris – Wien 1997.

*Sümegi – Jakab – Benkő 2021* P. Sümegi – G. Jakab – E. Benkő: A pilisi királyi erdő a középkorban (The Pilis royal forest in the medieval period), in: E. Benkő – Cs. Zatykó (eds): A Kárpát-medence környezettörténete a középkorban és a kora újkorban / Enviromental History of the Medieval and Early Modern Carpathian Basin. Budapest 2021, 249–330.

*Takács 1992* I. Takács: Egy 13. századi kút töredékei a pilisi ciszterci monostorból (Fragments of a 13th-century fountain from the cistercian monastery of Pilis). MŰÉ (1992) 1–19.

*Takács 1994* I. Takács: A pilisi ciszterci apátság [The cistercian monastery of Pilis], in: Á. Mikó – I. Takács (eds): Pannonia Regia. Művészet a Dunántúlon, 1000–1541. Budapest 1994, 236–247.

*Takács 2007* I. Takács: A pilisi apátság művészeti emlékei [Works of art from the Pilis Monastery], in: L. F. Hervay – E. Benkő – I. Takács: Ciszterci apátság Pilisszentkereszten. Budapest 2007, 29–44.

*Végh 2011* A. Végh: Kutak, vízművek. Kiegészítés Buda város helyrajzához [Fountains and waterworks. Supplement to the topography of Buda], in: K. Kővári – Zs. Miklós (eds): Fél évszázad terepen. Tanulmánykötet Torma István tiszteletére 70. születésnapja alkalmából [Half a century in the Field. A volume of essays in honour of István Torma on his 70th birthday]. Budapest 2011, 327–332.

*Wasser, Lebensquelle und Bedeutungsträger 1999* Wasser, Lebensquelle und Bedeutungsträger. Wasserversorgung in Vergan genheit und Gegenwart. Beiträge des Regensburger Herbstsymposions zur Kunstgeschichte und Denkmalpflege vom 20.-23. November 1997. Regensburger Herbstsymposion zur Kunstgeschichte und Denkmalpflege 4. Regensburg 1999.

*Wasserversorgung im Mittelalter 1991* K. Grewe (Hrsg.): Die Wasserversorgung im Mittelalter. Geschichte der Wasserversorgung 4. Mainz 1991.

*Wild 1992* D. Wild: Die mittelalterliche Tonrohr-Wasserleitung in das Areal der Dominikaner von Zürich. Ziegelei-Museum 9 (1992) 5–25.

*Zäschke 1981* W. Zäschke: Keramische Werkstoffe in der Geschichte der Wasser- und Abwassertechnik. Schriftenreihe der Frontinus-Gesellschaft 4. Köln 1981, 9–29.

*Zólyomi – Précsényi 1985* B. Zólyomi – I. Précsényi: Pollenstatistische Analyse der Teichablagerungen des mittelalterlichen Klosters bei Pilisszentkereszt. Vergleich mit dem Grundprofil des Balaton. ActaArchHung 37 (1985) 153–158.

ANTÆUS