

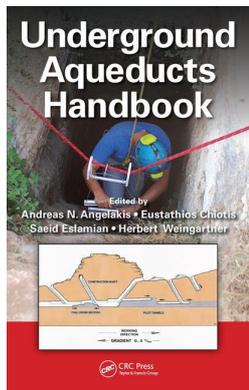
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## Underground Aqueducts Handbook

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### Roman Underground Aqueducts in Germany

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# 3 Roman Underground Aqueducts in Germany

*Constantin Canavas*

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## 3.1 ROMAN UNDERGROUND AQUEDUCTS IN GERMANY

Aqueducts dating from the imperial Roman period were constructed in the territory of present-day Germany since the first century AD. Some of them—at least partially—were constructed as underground channels. The underground character enabled a better protection of the water transfer from weather influences, as well as from destructive human interventions (Hodge 1992).

In general, underground Roman aqueducts have been much less studied than the spectacular overground ones (Leveau 2008, 145, 2015, 166). During the recent years, both kinds of sources, archaeological excavations (e.g., in France and in Germany) and new assessments of the historical records, have shifted the focus of research toward underground water networks.

Two major controversially discussed issues should be mentioned at the beginning of the present overview. One is related to the terminology—especially to the criteria of characterizing an underground channel as a *qanāt* or a *qanāt*-like aqueduct. Major features of the *qanāt* are the perpendicular manhole shafts in regular distances to each other (e.g., 10–15 m), which permit the descending from the ground surface to the underground channel between the mother well and the outlet—some hundred meters or several kilometers away from the mother well, which guarantees the water supply. The debate involves the re-assessment of the historical record (mainly the *History* by Polyvius, who, in book *Antiochus the Great In Media*, Chapter 28, describes campaigns in Media, Minor Asia in 209/208 BC and refers to underground water-carrying constructions dating back to the Achaemenid period) and the different translations provided by philologists and historians for the terms concerning these constructions. Several issues and criteria for defining or recognizing a *qanāt*, a *hyponomos*, or other old type of underground channel (such as the Etruscan *cuniculus*) have been analyzed critically and discussed, for example, during the colloquium on irrigation and drainage in the antiquity held in Collège de France (Briant 2001). Since major researchers define these constructions differently, later channels such as the Roman underground aqueducts in Italy, Gaul, and Rhineland are eventually described on the basis of different terms—depending also on the author’s assumptions concerning typology and construction technique. Thus, Goblot recognizes a *qanāt* as a water-capturing technique that follows mining tradition and experience (Goblot 1979); according to those recognition patterns,

underground aqueducts gathering water from superficial sources should not be called *qanāt*. Grewe distinguishes further between *qanāt* and tunnels constructed by the counter-excavation technique (Grewe 2008, 322–323). For the *qanāt* technique, he refers to an Arabic text by an Iranian mathematician of the eleventh century AD, al-Karajī, in which geometrical survey of constructing *qanāt* is described both theoretically and practically. Grewe summarizes the *qanāt* procedure as follows: “The planned route of the tunnel is laid across any intervening elevation in a line that allows the shafts to be as shallow as possible. [...] Next the shafts were staked out and sunk. After reaching a precisely calculated depth below found, a straight connection was driven between the central shaft and the two adjoining shafts. The excavated spoil was transported to the surface in leather bags or baskets lifted by winches” (Grewe 2008, 323). According to Grewe, the counter-excavation technique should have appeared by the sixth century BC: “In this procedure the tunnel is driven from two sides in an attempt to meet in the middle of the mountain to be perforated” (Grewe 2008, 323). This also includes the option to dig from two adjacent shafts, with the attempt to meet in the middle of the distance separating them. From textual reports, it may be deduced that both techniques were applied in constructing Roman underground tunnels (Grewe 2005, 11). In his critical commentary, Leveau underlines the fact that this distinction is mainly based on certain assumptions concerning the transmission of ancient Greek treatises on applied geometry and survey, for example, *Dioptra* by Heron of Alexandria, first century AD, and indicates possible misunderstandings in the transmission and the perception of Heron’s text (Leveau 2015, 171–176). He makes the point that such distinctions eventually overestimate text-based transmission of scientific knowhow in relation to archaeological evidence (Leveau 2015, 168–170).

The other major debate concerns the origin and the diffusion of the *qanāt* pattern—or its independent development at several geographical regions. Generally, the term would be attributed to the Asian (Iranian) pattern. Grewe considers the Iranian *qanāt* as a model for the Roman underground tunnels (Grewe 1998, 2005, 9, 17; Briant 2001; Leveau 2008, 144, 2015, 154), and others are more critical with respect to the Iranian origin and the diffusionist hypothesis—especially when questionable and scarce historical sources or questionable transmission lines and interpretations of scientific treatises are used to fill the lacunae of the archaeological evidence.

Typical Roman underground aqueducts in Germany with well-established archaeological record are the Eifel aqueduct conceived for the water supply of Colonia (Cologne/Köln), the aqueduct of Mogontiacum (Mainz), the tunnel at the Drove Mountain (“Heiliger Pütz”), and the aqueduct in the Ruwer valley near Waldrach used for supplying the Roman Colonia Augusta Treverorum (Trier) with water. Further, two aqueducts in the Moselle region, at Mehring and Pölich, and tunnels located at Brey (Koblenz), Retterich (Mayen), and Miesenheim (Mayen) should be mentioned. In 2005, an underground aqueduct tunnel was excavated in Alt-Inden/Düren in Rhineland.

### 3.2 THE EIFEL AQUEDUCT

The Eifel aqueduct in its latest phase was perhaps the longest one in the north regions of the Roman Empire. Archaeological evidence has revealed some 100 km of mostly underground channels bringing water from sources in the Eifel region to the urban area of Colonia Claudia Ara Agrippinensium (present-day Cologne/Köln). Considering some additional springs, the total length of channels could reach 130 km. Field survey and excavation research have revealed aqueduct parts that correspond to use in several periods. The oldest one should be the waterline A in the Hürther valley, dating from the first century AD. As a whole, it should have been in use from the first up to the fifth century AD. The dating has been established on the basis of a few coins, which imply that a part of the aqueduct in the first century AD already existed. The poor ceramic finds only imply that another part was constructed in the second century (Haberey 1971, 99). Among the constructions revealed by archaeological research, there are shafts (entrances to the tunnel system used for cleaning and repairing), several elaborate intermediate basins for water cleaning, and bridges for the overground

channels over valleys. In a later period of use, a second channel was constructed in a less depth, parallel to some parts of the older one. The water provided by the aqueduct has been estimated between 10,000 m<sup>3</sup>/d and 20,000 m<sup>3</sup>/d. Detailed documentation is provided by W. Haberey (1971) and K. Grewe (1986, 2004, 74–81).

### 3.3 THE AQUEDUCT OF MAINZ (MOGONTIACUM)

The aqueduct of Mainz dates from the second half of the first century AD and was presumably built to provide the Roman legions in Mainz (Mogontiacum) with water, estimated up to 7000 m<sup>3</sup>/d, from the springs of Finten (Fontanetum). Its length was 9 km, with 6 km underground channels and 3 km on arches. The remains of these arches (58 pillars) are known as “Römersteine” (Roman stones). Further foundations of the aqueduct are still visible and accessible for visit at some places, but most of the structures are lost—presumably, they were reused as building material during the Middle Ages (Lamberth 1983; Frontinus-Gesellschaft 1988; Dolata 2007).

### 3.4 HEILIGER PÜTZ (DROVE MOUNTAIN, DÜREN IN NORTH RHINELAND)

The underground tunnel between the water source Heiliger Pütz at the Drove Mountain near Düren (North Rhineland) and Soller is the longest tunnel north of the Alps. The tunnel has a length of 1660 m and is constructed in the rocks of the Drove Mountain at a maximal depth of 26 m. The vertical shafts are not in a straight line; moreover, the distance between them varies: the ones at the beginning and at the end of the tunnel are considerably closer to each other than the shafts in the middle part of the tunnel. The plausible explanation provided by Grewe implies that the ancient surveyor suggested to the builders to use the calculated horizontal distance between the shafts as a measure for their depth (Grewe 2004, 81–86). Thus, the depth of the tunnel and the distance between two shafts increase from the ends toward the central part of the tunnel from 8 m to 26 m. Grewe underlines the current assumption that the elaborate underground structure was presumably used to supply just a small Roman settlement (*villa rustica*) with water (Grewe 2008, 328).

### 3.5 FURTHER UNDERGROUND AQUEDUCTS

Further tunnels are located at Brey near Koblenz, at Retterich near Mayen, and at Miesenheim (Mayen).

Some shafts of the tunnel at Brey were reported as “devil’s holes” already in 1885. During World War II, parts of the tunnel were used as refuge by civilians. The excavated length is 75 m. Six vertical shafts in a distance of 5–10 m from each other have been traced. Today, the bed of the tunnel is 4.0–4.5 m below the ground surface. Its quadratic cross section measures approximately 1.2 × 1.2 m to 2.0 × 2.0 m (Grewe 1998; Haberey 1971, 148). Parts of the tunnel can be visited.

A similar, but deeper, tunnel (9 m deep vertical shaft) has been found at Retterich near Mayen. Traces of small niches for the lamps have been found on the walls of the tunnel (Haberey 1971, 146).

Another underground tunnel was discovered in an old mine at Miesenheim (Mayen); because of mining activities in modern times, several parts of the underground aqueduct have been destroyed (Haberey 1971, 146; Bemann 1988).

### 3.6 ROMAN QANĀTS

Some Roman aqueducts in Germany are described by scholars explicitly as *qanāts* or *qanāt*-like tunnels. These include two underground aqueducts in the Moselle region (Trier-Saarburg), one at Mehring and another one at Pölich, as well as an underground aqueduct excavated at Alt-Inden (Düren, North Rhineland) in 2005.

In the cases of Mehring and Pölich, B. Kremer assumes that the Romans have developed the *qanāt* technique further by transforming it into the counter-excavation technique. Without further argumentation, he assumes the latter technique as having been applied in Mehring and Pölich and uses the term *qanāt* for the tunnel, apparently because of the existence of the vertical shafts (Kremer 1999, 2005). The first (modern) report on the tunnel at Pölich dates from 1888. After several excavation campaigns, the tunnel has been studied in a length of 430 m. Twelve round vertical shafts—including the mother well (shaft)—with a diameter of 1.2–1.8 m have been traced up to now. The tunnel has a height of 1.2 m and a width of 0.55 m. Timber used as support in the tunnel was dated through dendrochronology back to 206 AD (Päffgen 2006, 140 n. 11). Parts of the tunnel can be visited (Gilles 2008).

The other Roman *qanāt* in the Moselle valley is in the north of Mehring. It was used for the water supply of a Roman *villa rustica* in the second to third century AD, as in the case of “Heiliger Pütz.” The tunnel was first mentioned in 1855. Up to now, some 106 m of the tunnel have been excavated—including 10 vertical shafts. The height is 1.20 m and the width is between 50 cm and 60 cm (Kremer 1999).

A further *qanāt*-like underground aqueduct was traced in 2005 in conjunction with the excavation of a Roman *villa rustica* at Alt-Inden (Düren, North Rhineland). The aqueduct has a length of 500 m, from which 300 m are underground. Beside the mother well, some 27 vertical shafts with a diameter of 2 m, in a distance of 5–17 m from each other (mostly 10 m), have been traced up to now. Four further prospection shafts have also been found near the mother well. The water-capturing part of the tunnel extended up to 20 m from the mother well. In the subsequent water-carrying part of the aqueduct, clay tubes with a diameter of 15 cm, as well as their fittings, have been found. Timber supports and covering were also used. There is no mention in the literature whether these elements were introduced from the beginning into the underground aqueduct (Päffgen 2006, 135–142).

### 3.7 THE AQUEDUCT IN THE RUWER VALLEY (TRIER)

The aqueduct in the Ruwer valley near Waldrach was used for supplying the Roman town Colonia Augusta Treverorum (present-day Trier) with water. The aqueduct has a length of 13 km and dates from the second century AD. It was fed by the river Ruwer and ran mostly underground in the Ruwer valley, bringing water to Colonia Treverorum, with a flow rate up to 25,000 m<sup>3</sup>/d. When deep valleys had to be crossed, the channel was continued on bridge constructions. The underground channel is not a tunnel but a stone water channel built from square sandstone blocks to a width of 74 cm and a height of 96 cm. From traces on the sidewalls, an average water level of 60 cm can be deduced (Frontinus-Gesellschaft 1988, 79). Many parts of the water channel are freely accessible and serve today as exhibition of Roman water technology ([www.ruwer.eu](http://www.ruwer.eu)).

### 3.8 THE UNDERGROUND WATERLINE OF VIENNA

A Roman aqueduct construction in Central Europe that could be compared to the aqueduct of the Ruwer valley is the waterline of Vienna. The aqueduct was constructed of sandstone in a small depth under the earth surface and had a length of 17 km. Actually, the goal of the aqueduct was to bring spring water from the Vienna Woods into what was to become the Roman legionary garrison Vindobona—a place that in the second century AD should have offered living place, urban infrastructure (e.g., water supply), and services to a total of c. 30,000 persons, including c. 6000 legionaries. The waterline was first uncovered and studied at the beginning of the twentieth century (Kubitschek et al. 1908). It consists mainly of a U-form stone construction with an inner waterproof cement-like layer and stone cover. The height of the channel is 60 cm and its width is 50 cm. The estimated average flow rate should have been c. 4300 m<sup>3</sup>/d. Several wooden or stone wells in the

settlement area have been discovered; some of these wells, as well as parts of the waterline, are accessible for touristic visits (Saki-Oberthaler and Ranseder 2009, 15–19).

### 3.9 CONCLUSIONS

Underground aqueducts constructed in Germany during the imperial Roman period have been found at several places, typically in the regions of Eifel, Moselle, and Rhineland. Some of them were used for the water supply of large towns, such as Colonia (present-day Cologne/Köln), Mogontiacum (present-day Mainz), and Colonia Augusta Treverorum (present-day Trier). Others were presumably used for supplying small Roman *villae rusticatae* with water. The spectrum of construction type varies from underground tunnels (some of them are comparable to *qanāt*) to covered water channels, constructed by using stone plates just under the ground surface. Parts of these aqueducts have been arranged accordingly (including supply of information tables on site) and are today accessible to the public ([www.romanaqueducts.info/index.html](http://www.romanaqueducts.info/index.html)).

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