Roman Irrigation Aqueduct in Aosta/Italy

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Summary

One of the most impressive roman buildings of the Aosta-valley is the 2007 years old bridge of Pont d'Ael (Pondel) as a part of a 6 km long water-conduit, which is crossing the gorge of Grand Eyvia near Aymaville in a height of 66 m above ground. Beside the aqueduct, which was originally a three-staged bridge, some other particular parts are a channel, which was cut out of the solid rock as a half-shut gallery, several terraced buildings and a short tunnel. The buildings out of the year 3 B.C. are retained in good quality and have been totally surveyed and indicated first in 1996 by the author. The ancient water-conduit supplied an irrigation-area and some rural settlements.

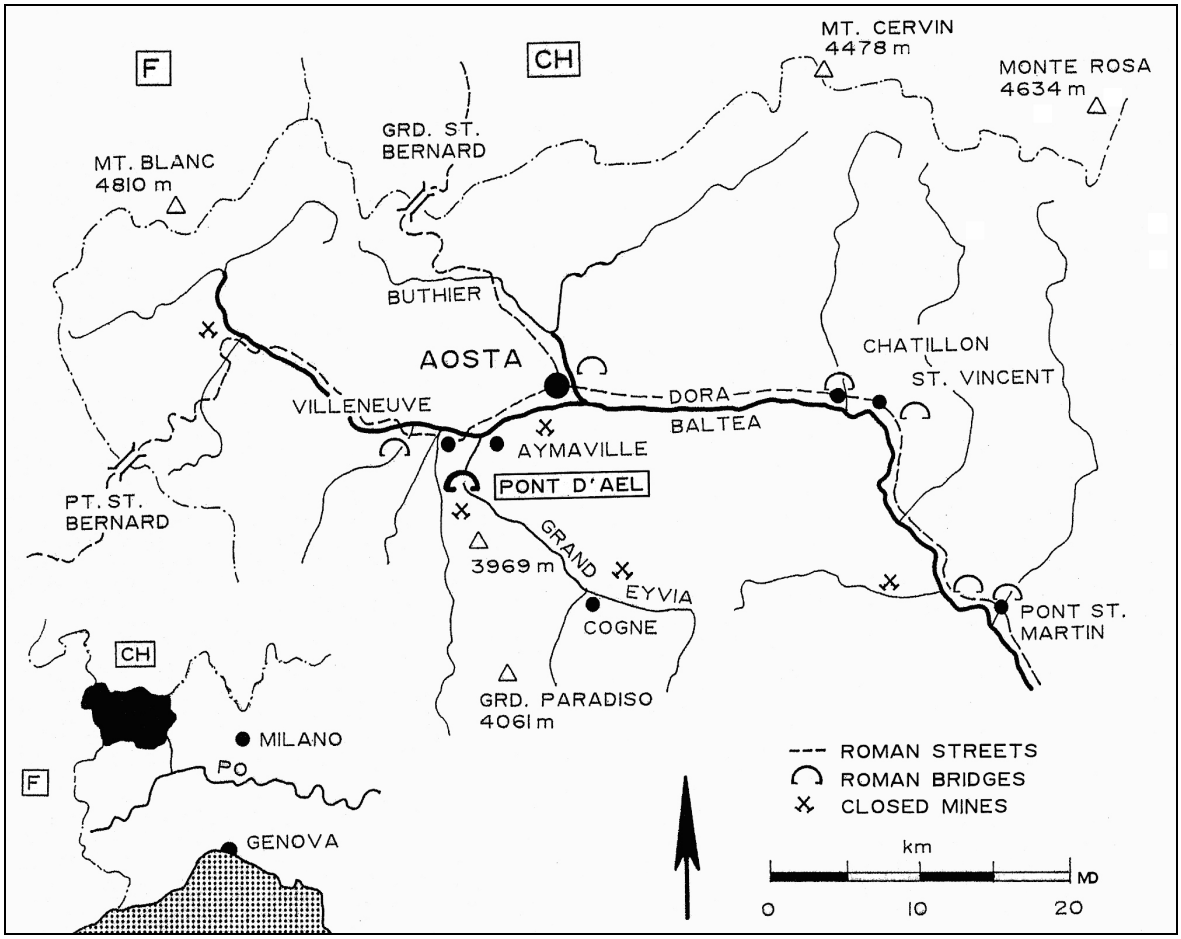

Fig. 1: The Valley of Aosta, general view.

1. The Romans at the Aosta valley

There are just a few regions in the Alps, which are full of Roman constructions. The Aosta valley is one of them. It is especially rich of antic technical constructions. In the narrow gorge valleys and on the passes many suspension bridges and retaining walls testify for military and trade movings over the Alpis Graia later called the little and the Alpis Poenina the big St. Bernard pass (Fig. 1).

The Antic constructions are mainly found in Aosta, established as Augusta Praetoria in 24 B.C: the almost completely remained 2,5 kilometres Roman city wall with the impressive Porta Praetoria (the East Entrance gate to the city), the triumphal arch of Augustus, the back wall of the Roman theatre, 22 metres high, pieces of the amphitheatre and especially the Forum, which underground vault halls represent the former importance of the city. Just in a few years Aosta was growing to a nationwide trading Centrum with more than 20.000 inhabitants. It was the starting point of all military and product transports in the Helvetic, Germanic and middle Gallic area.

The water supply for the area was not a big problem: three short underground water pipes and a branched irrigation system supplied by spring water and the Buthier river guaranteed the water for the rural settlement. The disposal has been done over an extensive sewerage system.

Just the rapid growth of the city and therefore the supply situation with agricultural products seemed to be a problem. They had to develop an area close to the city and orientated to the south with good soil conditions, which had to be irrigated in the dry summer month (there is today only 405 mm rainfall a year, mainly in the winter) Suitable seemed to be an area with a size of 200 hectare, 600 to 750 metres above sea level close to today's Aymaville, 6 kilometres to the west. Currently it is still intensively used for agriculture. Unfortunately the Dora Baltea River couldn't provide the area with water because it was located 50 to 150 metres lower.

2. The Roman aqueduct of Pont d´Ael

There was only one supply possibility which could be taken into consideration: the irrigation canal from the nearby Cogne valley. There existed the Grand Eyvia River, best possible water supplier. In the main vegetation period between April and September the river carries a lot of water from melted snow and ice from the Gran-Paradiso area. Close to the area, which had to be irrigated, the river flows in a deep unapproachable gorge. Therefore the water had to be lead way back in the valley along the gorge to the upper slope area.

Grand Eyvia

Catchment area	239 km²
with glacier	35 km²
average high of water flow	1400 mm
average volume of water flow (summer)	10,6 m³/s

Water conduit of Pont d`Ael

Overall length ca	6 km
Length to Pont d´Ael	2,9 km
on the rocks	0,65 km
on the hillside	2,25 km
width of the cross section in the rock	1,20 m
estimated height of fall	6 ‰
average volume of the water flow	200 l/s

The irrigation system is planned so that the water is always flowing on the surface. That is the reason why the height of fall had to be constant over the overall length. A possibility for a location route existed only at a height of 900 meters. Therefore the water conduit had

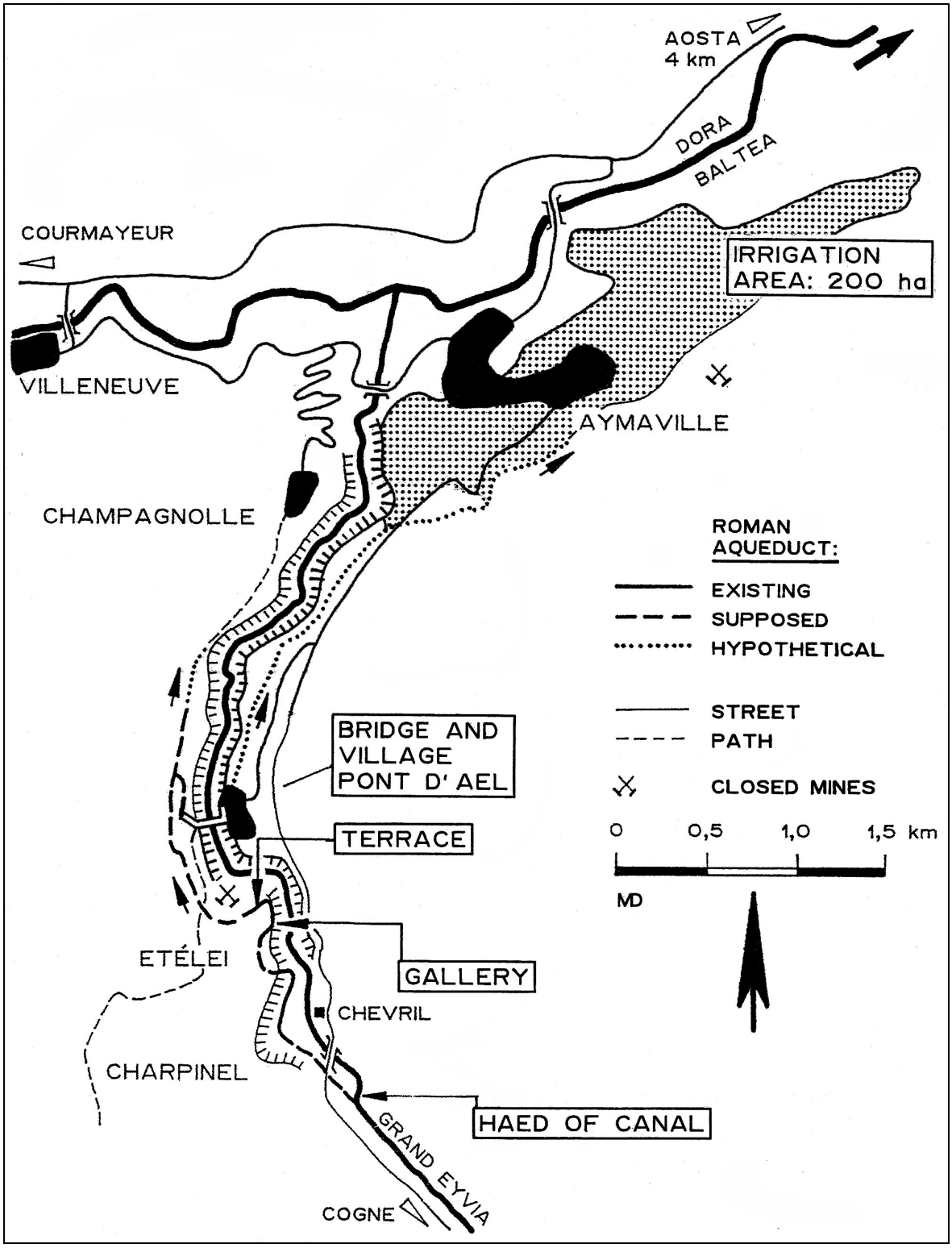

Fig. 2: The roman aqueduct of Pont d'Ael, buildings and irrigation area.

to be twice as long as planned originally (Fig. 2). Even at this place there has been just a small passage way between the rocks and the gorges. Only a measurement master-piece could result in such a sophisticated line into the wild changing and broken area. The water conduit, the aqueduct, has been created. The later developed village called Pondel got its name after that aqueduct.

It was out of question to build tunnels through the rocks. The drive through the hard stone would have been maximum 2 to 3 cm a day. So it had taken them more than 20 years to complete the water conduit. Also the construction method of Qanat, the tunnel construction with many intermediate pits, couldn't be realized because of soil cover from 60 to 120 m.
In the short still existing water pipe pieces nobody could reconstruct a clear height of fall or the high of the water in there. The average volume of the water flow can just be estimated. The irrigated area of 200 hectare can be split into 30 % green land (average irrigation of 8 mm = 80 m³/ha), 50 % farmland (6 mm) and 20 % viniculture (2,5 mm). With irrigation cycle of 4 days a volume of 150 to 200 l/s had to flow towards the irrigation area in a rectangular cross section. It follows that the height of fall was 20 to 25 cm. The rural settlement also used the way over the aqueduct. In comparison with the irrigation it has been a small amount of water supply and can be ignored in the calculation.

3. Gallery and terrace constructions

The water conduit starts about 200 meters above the bridge of Chevril (Fig. 2). The usually build constructions to dam the water with a weir could not be realized because it could have not hold the wild Grand Eyvia river. The big water flow in the summer month did not make the weir necessary. Probably they started the conduit with a normal trench and corrected the water line with replaceable stones. The input building is damaged because of the strength of the river which can move away really heavy stone cubes.

On the straight way through the rock wall of Charpinel the conduit is at first visible after 500 meters. There it is carved into the rock in a form of a half gallery or build in with stone blocks erected high terraces. Rockfall and frost damaged the conduit nearly completely, that now just a few unreachable pieces exist.

Aqueduct gallery Etêlei

Length		250 m
Still existed		75 m
Height of fall (unsafe)		± 0
Width (mostly)		1,20 m
Cleft depth	hill side	< 6 m
	valley side	< 3 m

The most impressive part of the aqueduct could be found near by Etêlei (Fig. 2). There it changes from the hang zone into the rock zone and crosses over a length of 250 metres the whole west edge of the gorge. This happens right over the 120 metres high walls (Fig. 3, 4).

The rectangular channel is continuously 1,20 m wide and has an even bottom. It cuts on the hill side up to 6 metres in the rock and on the valley side up to 3 metres. The side walls are almost vertical; sometimes they become narrow to the top up to a few centimetres. An obvious height of fall could not be established, but if there is one it has to be less than 1 ‰. This construction as mixtures of tunnel and channel is rarely found in the Roman hydraulic engineering. The most well-known example is the aqueduct gallery of Side /Turkey.

North of the gorge of Etêlei the region becomes more even but still with a rocky character. To prevent the cut into the gneiss in that region they built terraces with a width of two to four metres and a height up to five metres

Fig. 3: Aqueduct gallery of Etélei.

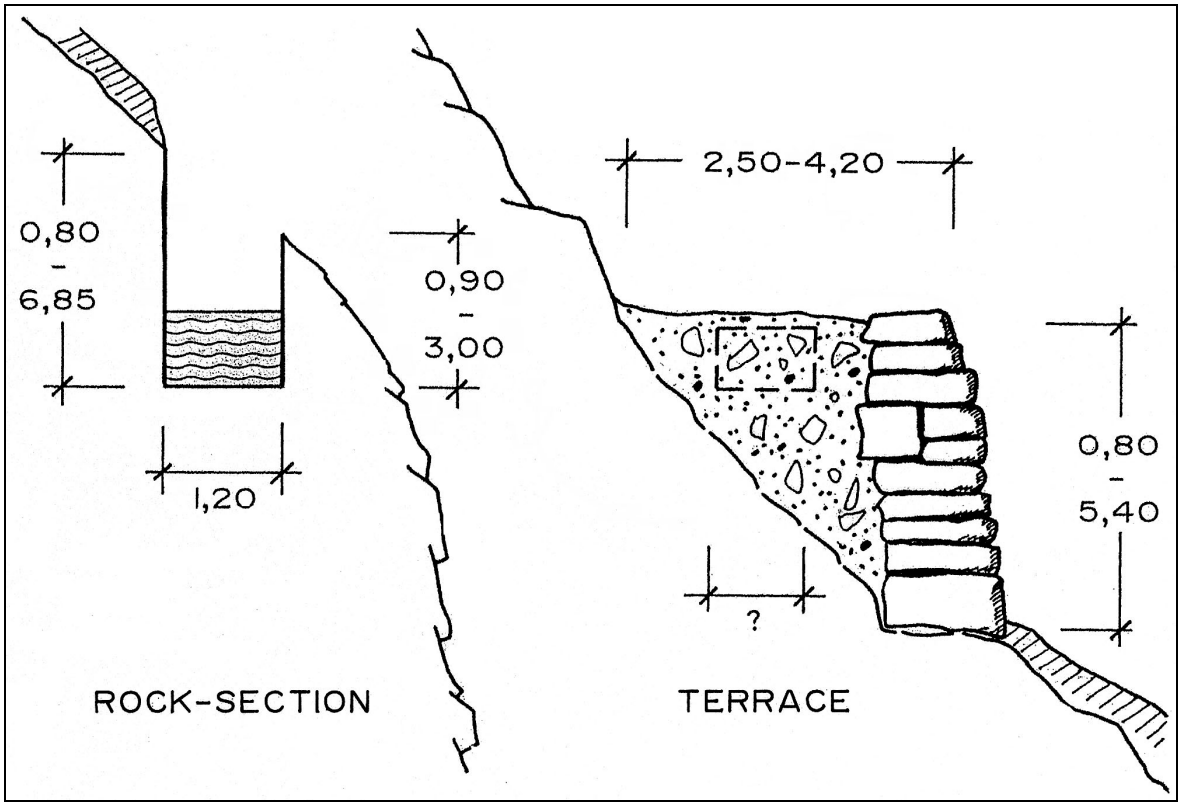

Fig. 4: Cross-sections of the aqueduct.

where the mains have been lowered into (Fig. 4). The water channel itself does not exists anymore. It must be a rectangular channel with stone walls sealed with plaster which was probably covered up at some places. The terraces have been supported by dry walls.
After that part the trace is lost into an unclear area which is full of dense vegetation. The antic walls had probably rebuilt to erect terraces for the later agriculture. With a good eye some stones with one flat side can be discovered. It is possible that they are pieces of the old aqueduct. Such stones are more often used in the horizontal corridor. Therefore they mark the upper located main route.

4. Pont d´Ael aqueduct

What used to be a three-floor bridge could be found at the only possible crossing over the gorge of Grand Eyvia between Chevril and Aymaville, which has a length of over 4 km and a depth up to 150 m, (Fig. 2). The upper edges are not only at the same high, they have also just a distance of 12 m. The construction is 2,26 m wide, 60 m long and spans the gorge in just one bow with a width of 14,24 m. (Fig. 5, 6, 8). Today there is a path over the bridge.

The travel journal of the antique dealer Pingone [1] is the first known report which mentioned the Pont d`Ael aqueduct in the year of 1550. It also included a sketch and the speculation of Pingone, that the bridge is an aqueduct with lead pipes. In the 19th century sketches of Baron De Malzen [2] (1826) and Aubert [3] (1860) indicate the bridge in the shape it has today.

The first partly site measuring was produced by Promis [4] in 1864 and has been comple-

Fig. 5: The aqueduct bridge from north.

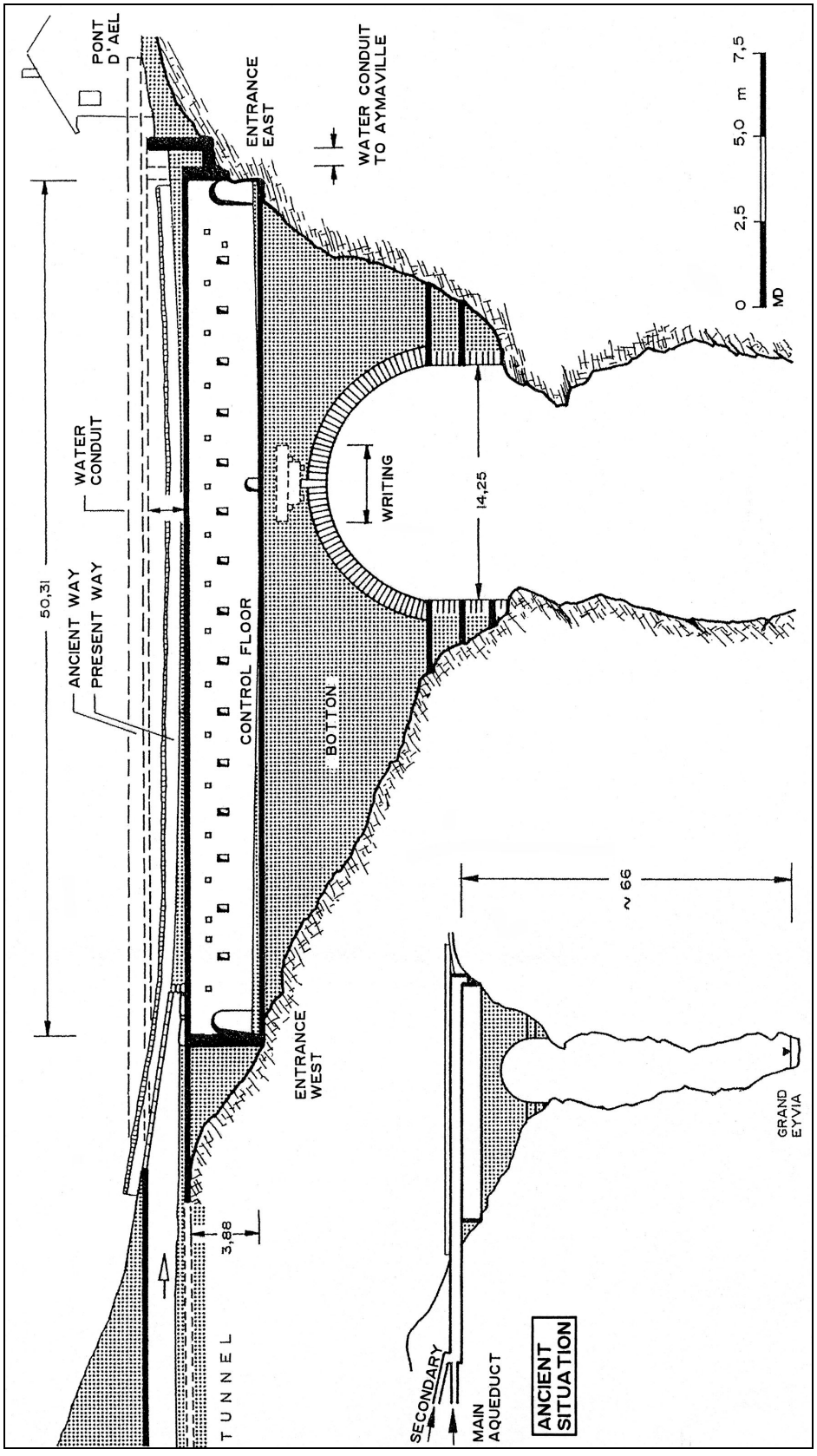

Fig. 6: Long-section of the aqueduct bridge.

Fig. 7: Control-floor in the interior of the bridge-

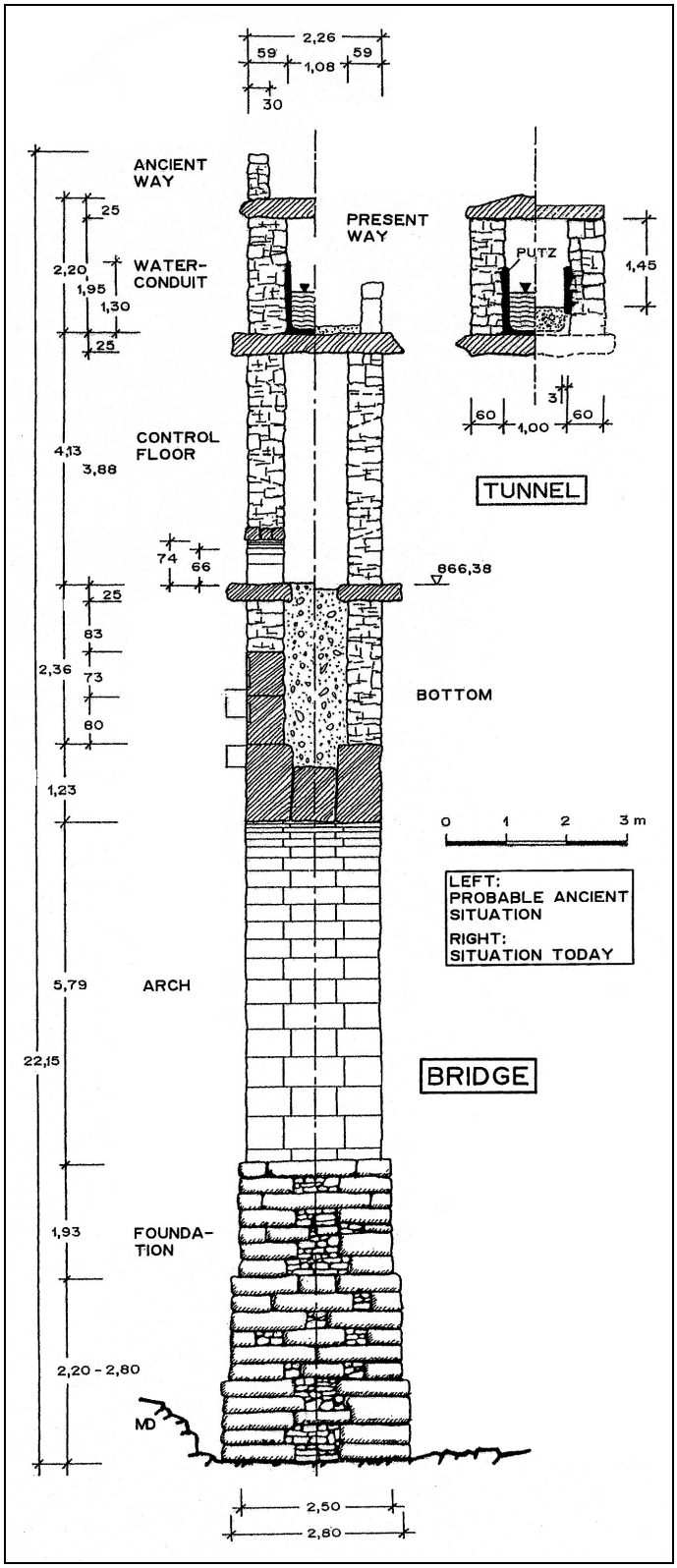

Fig. 8: Cross-section of the bridge.

mented by Barocelli [5] in 1930 after excavation at the east end of the bridge. The two last-named contradicted the aqueduct theory. They only did suppose a footbridge.

A hypothesis which has been taken unproved by almost all following reporters until the hidden gallery, the conduit terraces as well as the short tunnel, connected with the bridge at the west, have been discovered in this century.

The tunnel with the length of 50 m is build from stone. The walls are sealed with plaster up to a high of 1,30 m. It is constructed in an open excavation and covered with smoothed out stone plates afterwards.

The Bridge of Pont d´Ael

Length	60,46 m
Width	2,26 m
High above foundation level	22,15 m
High above valley level	66,00 m
Span of the vault	14,24 m
Length of the control floor	50,35 m

In the inside of the bridge a still passable floor with a high of 3,88 m and a width of 1,08 m is connecting both valley sides. This gangway is also covered with careful worked stone slabs (Fig. 6, 7, 8). On the basis of the position and route of the tunnel and some still existing wall pieces is it possible to reconstruct the way and size of the water conduit. It is proved that there has been a water conduit at the level of today's path, 1,90 m high and 1 m wide. It is out of question that they have been sealed with plaster in several layers in the traditional building method.

Like every hydraulic engineering building the most important part are the permeability tests. Water in the bridge would have damaged the walls rapidly. The gangway under the water conduit has been a control way for the bridge-guard. That is the reason for the two rows of windows on top of each other on both sides. The lower ones brought light on the way and the upper ones lightened the ceiling so that humid places could be detected quickly (**Fig. 7**).

If the aqueduct included a public path in the antic (what is supposed) it had its route above the water conduit. The way today is placed in the old gangway of the water conduit. There is a fragment of the way at the south east edge of the bridge. An inscription above the north bow allows the conclusion to the construction builder, Gaius Avillius Caimus of Padua, and the completion year, 3 B.C.

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