Secondary Groundwater Resources Exploited by Traditional Knowledge Systems in a Semiarid Region of Southern Italy

Vincenzo Simeone and Antonio Graziadei

Abstract

Devices used to catch secondary groundwater resources are common in inland southern Italy, though little known to Italian technical literature. They are an interesting example of how the local non-technically-codified knowledge allows for exploiting the water resources. This paper presents the case study of the drainage tunnels (locally called cape d'acqua) of Casino Rago, near the town of Ferrandina, in Basilicata region. Despite its similarities to other underground collection systems that can be found in the region, the device presented here has some unique features within its structure and because it drains water in an area where the dominant outcropping geological formation is silty clay. This tunnel, together with other cape d'acqua and other underground water catchment systems, played a very important role in the development of many agricultural areas in Basilicata. Unfortunately, most of them are no longer in use for their original purpose, so they are slowly undergoing an abandonment process. Recognising the role that structures of this kind have had in the formation of the traditional landscape is the only way to ensure the continuation of a sustainable technique of water management and the transmission of the landscape values to the future.

Keywords

Secondary groundwater resources • Draining tunnels • Traditional knowledge • Traditional landscape

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1 Introduction

Draining tunnels is a generic term that identifies a wide variety of systems for water catchment which allow using groundwater to supply urban and agricultural areas. The tunnels are dug almost horizontally beneath the Earth's surface and can grow to a few metres or several kilometres (Laureano 2001).

These water collection systems can also be found in Italy where, among others, the qanat of Palermo (Todaro 1988) and the Etruscan tunnels (Ravelli and Howarth 1984) are known to be. In Basilicata, examples of them are found in Irsina (Graziadei 2015), where a system of underground tunnels, named Bottini, still collects the groundwater and carries it to the underlying monumental fountain, and onto the near farming areas. In Tricarico (Graziadei 2015) such a structure was identified, though partially damaged and altered in its original function. Other examples of similar structures in Basilicata such as Casino Laudati tunnel are found in the territory of Ferrandina (Graziadei 2015), where they are called "cape d'acqua", and their water production in the past used to support small irrigated areas within more extended olive plantations.

The case study presented here comes from Ferrandina and, for its building characteristics and planimetric design, is an important example of a draining tunnel in the Basilicata region.

2 Geological Characteristics and Groundwater

Geologically the area of Ferrandina, Fig. 1, is part of the Bradanic Foredeep (Galeandro et al. 2013, 2017), a large tectonic trough, filled since the end of Pliocene up to the end of Pleistocene. This shows a significant thick sequence of clayey silts, evolving in the upper part into sands and finally top regressive conglomerates. The sedimentary sequence,

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Fig. 2, going upward, is made by Sub-apennine clays. These contain: silty clays and clayey marly silts, rich of carbonates, up to 40%, characterized by a grey-blue colour. The high content of carbonates makes these clays particularly hard and compact. Within the clay outcrops, the top is characterized by a ochraceous-brown colour, for a thickness ranging between few meters to 10–12 m. The top of the sequence is constituted by regressive sandy conglomerate deposits, like Monte Marano sands and Irsina conglomerate. These deposits constitute the top of the plate on which Ferrandina town is located, where the thickness of this layer is 90 m at most. This plate is the remaining relic of a wider plate, which was progressively disrupted by large landslides. These landslides produced large disarticulated masses, which lay on the right side of river Basento valley close to Ferrandina.

The flank of river Basento valley are strongly disturbed by deep gravitative phenomena, at local and large scale. The slopes are covered by shallow deposits, up to a few meters thick, constituted by silty sands. Along the whole side of the slope, and in particular in the higher part, it is possible to identify large blocks, made of yellowish sands and reddish conglomerates, dipped into the clay mass or as detritus. These constitute the shallow layer of the slope. The clayey over-consolidated masses on the slope are severely disturbed by tectonic and gravitative large phenomena. These affected the slope, originating fractures and dividing those masses into blocks. These clays blocks evolved, due to gravitative phenomena. Along the flanks of the blocks, runoff generated erosion, which is particularly intense where the blocks are steep and poorly permeable. The blocks of the rocks at the top act as rainfall water tanks, which once released infiltrates the poorly cemented layers and then the fractures of the clay. This causes a water circulation, which is very high, if compared with that expected in such poorly permeable terrains.

The investigated site shows several springs, which are drained by some tunnels, located in the higher part of the slope going from the ridge between Ferrandina and Salandra town towards the river Basento. The springs are located close to Casino Rago. The investigated spring is located on a morphological jump, downstream the trench originated by an ancient landslide, constituted by a large mass of closure deposits, i.e. sands and gravels, fallen from the slope. The spring is likely originated by the infiltrated rainfall through the shallow layers of the trench and then drained by the aforementioned large permeable mass. Spring water is rich of calcium carbonate, as shown by the large number of concretions in the draining system. This abundance of carbonates is consistent with the circulation inside calcareous sands and silts and in fissured marly masses, which allow rainfall water to deteriorate the calcium carbonate within the rocks. The flow path is likely long, this is consistent with the high content of carbonates as well as the poor variability of spring discharge during the year.

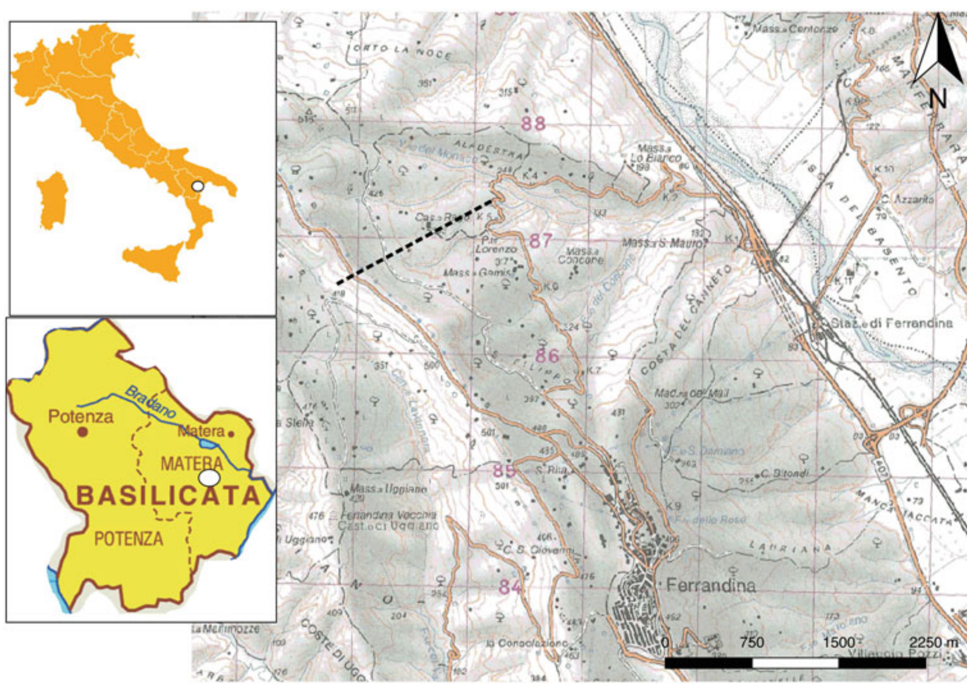

Fig. 1 Study area and track of the geological cross section

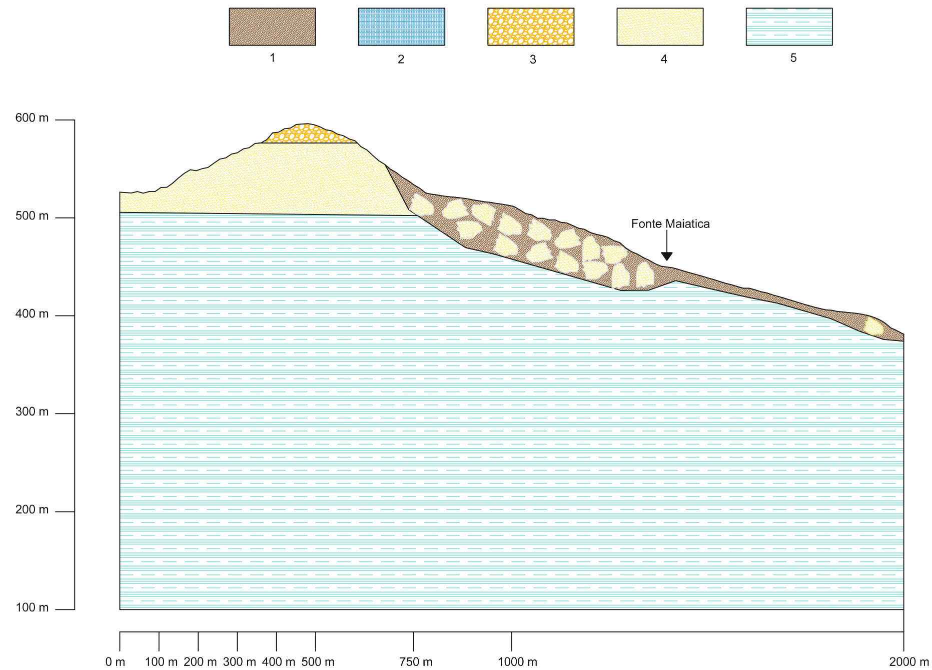

Fig. 2 Geological cross section. 1 Colluvial debris. 2 Alluvial deposits. 3 Irsina conglomerates. 4 Monte Marano Sands and sandstone. 5 Sub-apennine clay and silty clay

3 The System of Draining Tunnels Near the Rago Casino

A short distance from the main building of the estate, a modern rammed earth reservoir collects water in part, by a system of draining tunnels which develops upstream of the water storage. Figure 3 shows the entrance of the tunnel and the surrounding landscape. The catchment system is accessed through a doorway from which, almost perpendicular to each other, the two main tunnels branch out, to the directions east-west and north-south, respectively, Fig. 4.

The tunnel aligned with the entrance (A) penetrates the front side of the hill, so that the distance between the bottom of the structure and the outer surface increases as one moves away from the entrance. The other branch (B), instead, develops roughly in parallel to the contour lines, and depth remains roughly constant with respect to the ground level.

The first tunnel (A), oriented east-west, has a length of about 20 m, Fig. 3a. The path is quite regular, except for a

Fig. 3 Entrance of the tunnel and surrounding landscape

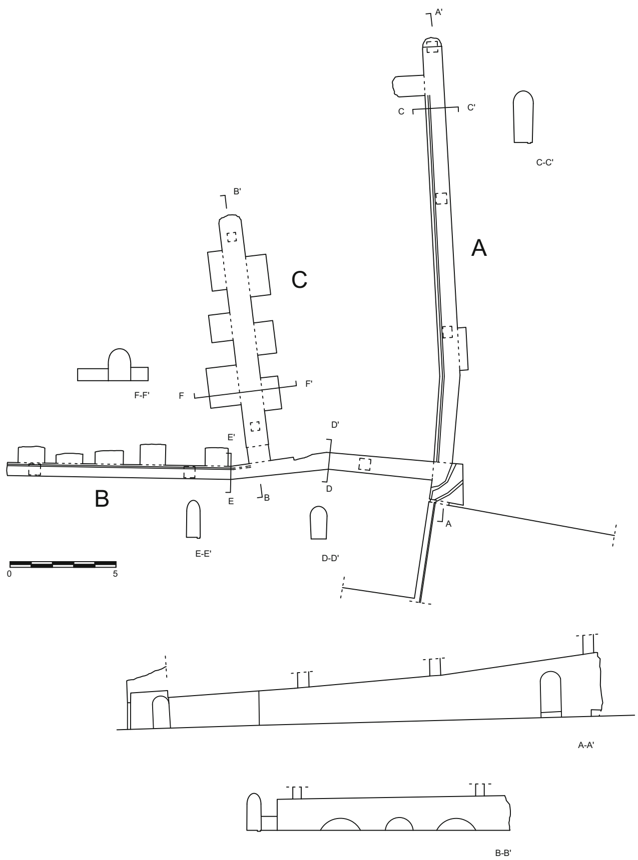

Fig. 4 Survey of the drainage system: plan and cross sections

slight change of direction at about 4.20 m from the entrance. The cross section, except from the height, also remains roughly consistent along the route of the tunnel. The width at 1.50 m from the ground varies between 85 and approximately 105 cm, while it narrows slightly toward the floor, where the measurements are between 80 and 90 cm. This way, the section presents a slight tapering of the side walls up to springer of the vault.

The latter has a profile that varies, depending on the different proportions between the springer width and the rise, from the semi-circular arch to the pointed arch to the elliptic one. In any case, these are slight differences in geometry and the passage from one configuration to another is gradual, so that there are no points of discontinuity. The height of the structure goes from 1.35 m at the entrance to about 2.95 m on the bottom.

Along the same wall, traces of other three arches, now walled up, are visible between the recess bottom of the tunnel and the niche, while a fourth walled arch is between the niche and the mouth of the tunnel. The upstream arch is not completely closed, like the others are, and has, at the bottom, three openings from which water emerges.

At the springing line of the vault, and for all its linear development, there are symmetrical holes evidently functional to the construction of the structure.

The tunnel has three vertical ventilation shafts in communication with the outside, of which, currently, only the most upstream is open, while the others have been intentionally closed with stone slabs, Fig. 5b. The second tunnel (B), oriented north-south, has also an overall length of just over 20 m. The inner profile also in this case is rather constant over the entire length of the tunnel, Fig. 6a. The width varies from 85 cm in the final portion to about 65 cm in the upstream. The tapering towards the inside of the side walls is more evident in the end portion, where the difference between the width from the floor and from the springing line is about 10 cm. The geometry of the vault is similar to that of the first tunnel, mostly elliptical or round arch. The height of the tunnel ranges from around 1.40 at the mouth to 1.75 m upstream.

The executive aspects of this branch appear to be similar to those of the first one. In the left wall there are five arches that define as many functional niches, letting the main duct communicate with other water outcrops. As in the first tunnel, even on the floor of this one there is a draining channel, the same size of the other branch, and currently recognisable only in the innermost portion.

Here too the vault has, at the springing line, holes in sizes and shapes similar to those of the other tunnel, and three vertical shafts. On the left wall a niche gives access to a side branch (C) of the tunnel, Fig. 6b. It runs for about 11 m from east to west, with an almost parallel direction to the first tunnel. Just past the lower connecting arch, the height becomes about 1.50 m, reaching approximately 1.70 m in the inner part. The width of this third tunnel is slightly greater than the other two, and is about 1.05 m along its whole length. Here too, the vault has an elliptical or round profile and the features and executive aspects are very similar to those of the other two tunnels. Even the C branch presents niches, once again formed as small barrel vaults in bricks, opening on both the side walls. The tunnel has two vertical shafts.

4 Some Considerations on Function and Evolution of the System

One of the significant characteristics of the Rago Casino catchment system appears to be the presence of lateral niches to the tunnels. From the analysis of the primary aspects, there seems to be a pretty clear coincidence in time between the building of the tunnel system and the construction of the side arches. The latter may have been made near the major

Fig. 5 **a** The drainage system: branch A. **b** Vertical shaft in the branch A

Fig. 6 **a** The drainage system: branch B. **b** Vertical shaft in the branch B

outflows of water, in order to create a wider area of drainage of the soil, and thus to collect greater amounts of water. The niches in the A tunnel, with the exception of those further upstream on both walls, do not seem to be productive. Their infill can probably be put in relation to static issues that may have affected the tunnel. If the presence of lateral niches and secondary branches can be put in relation to similar features in other systems such as the Bottini of Irsina, the niches of the Rago Casino catchment system have the peculiarity to develop in depth up to constitute, in some cases, small side rooms to the tunnels.

5 Draining Tunnels and Traditional Landscape in Ferrandina

The water caught by the system is no longer used for traditional forms of irrigation or for the original purpose it had during the construction of the draining tunnels. The intensification of olive cultivation on the one hand, the substantial non-use for residential purposes of farms or casini and their service facilities on the other, as well as the disappearance of the agricultural production of family type, has led to a move away of the traditional catchment systems. It so happens that many of the "cape d'acqua" in the area of Ferrandina are no longer repaired, kept efficient or cleaned of debris.

Therefore, it is important to recognise the role that structures of this kind have had in the formation of the traditional landscape, and may still have in its management. This is the only way to ensure the continuation of a sustainable technique of water management and the transmission of the landscape values to the future.

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