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Improving Training In The Hydrogeology Of Volcanic Islands By Visiting The Water Galleries Of The Canary Islands (Spain)

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Abstract

Training in different scientific and technical disciplines has always been supported by the relationship between "theory and practice". This paper focuses on the need to take this fact into consideration once again with greater intensity regarding the current training in mining engineering schools. Subjects related to groundwater and geology on volcanic islands should take advantage of any existing underground hydraulic infrastructures, such as water galleries. In the Canary Islands' archipelago, there is a unique and extensive network of galleries, tunnels and stunning waterways covering thousands of kilometres. There are examples of horizontal drilling of 6,500 m, and vertical wells up to 600 m in depth on the island of Tenerife. Consequently, the Canary Islands are a natural laboratory for the study of earth sciences to be used and exploited in teaching; however, this aspect is hardly taken advantage of in current training programmes. Although the access to such infrastructure entails in some cases safety risks, the fact remains that with adequate planning, selection and adaptation of the best infrastructures and proper evaluation and prevention measures based on the techniques used in mining safety, they could be exploited in teaching at local, national and international level due to their outstanding educational potential.

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1. Introduction: A brief historical reflection

On July 14th 1777, King Carlos III ordered the founding of the first Mining Academy in Spain, just ten years

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after that of Freigerg in Saxony, and only two years after the St. Petersburg one. This new academy was to be built in a village in the Spanish region known as "La Mancha" (home of Don Quixote), far from the Royal Court and from the main academic and university centres of the country. Why build a technical school in such a distant and lonely place? The answer was very logical: the village was Almaden, one of the most promising mining areas in Europe of its time thanks to its cinnabar resources (mercury ore). The Mining Academy (known today as School of Mining and Industrial Engineering of Almaden) was the germ of intense and prolific research and technical innovation in the field of earth sciences; nowadays, we would refer to it as a top level R&D and innovation centre. Obviously, the main pillar of that technical and scientific innovation was the close relationship between theoretical development and the possibility of practical field applications in a direct and immediate way. This close relationship can be seen in the Royal Order of the Academy's founding, whose ultimate goal is (Fernández-Gutiérrez, 2012): *"Teaching young mathematicians, to be summoned from these kingdoms, and from those of the Americas, to be instructed on the theory and practice of underground geometry and mineralogy."*

Today, lost in a welter of educational standards and regulations, we can do nothing but show sincere admiration of the clarity and conciseness of these objectives, which, regardless of subject matter to be taught, clearly declares that teaching should be carried out in both theoretical and practical ways. Where better can geology and mining be taught and learned than next to a mine? Over the years, the increasing complexity and specialization of scientific and technical disciplines added to the need for the geographic concentration of specialist schools in universities has led to this basic principle of common sense being diluted. Therefore, today, we have a clear dissociation between theoretical teaching and practical application in most technical studies. We seem to have forgotten this fundamental principle, so clearly expressed over two hundred years ago: students, researchers and teachers have to be in as close contact as possible with the object of their study, their research, their teaching. Just as health professionals are trained in university hospitals, those professionals dedicated to Earth Sciences, both scientific and technical, must be trained in contact with the earth.

2. Water and hydrogeology studies in volcanic islands

2.1. The best place for it

We now move to the present, a present in which the management of freshwater has become one of the greatest challenges facing humanity. No one can question the critical importance of managing water resources, everyone knows “water is life”, nevertheless, in water-rich areas of the planet that motto is not so well understood as in dry countries. Until now, the management of this valuable resource has been of paramount importance to the economy and development of water-rich countries, but in the short to medium term it is going to be a matter of survival. An obvious example of this problem is found on populated volcanic islands, and, more specifically, in the Canarian archipelago, where water demand is growing fast and whose water resources are limited, with a current delicate balance between aquifer recharge and exploitation. Surface water in the Canary Islands is scarce, almost non-existent, and unevenly distributed, therefore, each island has adopted different methods of underground water exploitation, one of these methods, a very singular one, is the aim of this paper. In order to study these issues, the Canary Islands are a perfect laboratory due to their heterogeneity: each island is different in its hydrogeology and water-demand model, these features alone should be enough to turn the islands into a world reference point regarding research and training management of water resources in all areas. However, this variety is not the only singularity that gives the Canary Islands their quality as an outstanding area for research and teaching in the field of hydrogeology. These islands, especially Tenerife, La Palma and Gran Canaria hold a "secret" regarding underground water exploitation. This secret is none other than the answer to a question, taken from our previous historical reflection. Where is the best place for teaching and studying volcanic geology and hydrology? The answer is obvious, in the bowels of a volcanic island.

2.2. The Canary Islands: a wasted natural classroom

There are more than 3,000 km of drilled galleries and wells in Tenerife alone and hundreds of kilometres in La Palma and Gran Canaria. These galleries and wells constitute a direct access to the heart of these volcanic islands thanks to the efforts of a thirsty population. They are a real luxury for any researcher in earth sciences through

which eminent scientists have been able to unravel and explain, and still do today, the islands' formation processes, make major advances in volcanology, seismic studies, geology, hydrogeology, etc. Anyone would think that with such a natural laboratory available, teaching earth sciences, mining engineering, geology, civil works, hydraulics, etc., would be closely related to traditional Canarian water wells and galleries. Unfortunately, this could not be further from the truth. These days the majority of the Canarian population are not aware of the incredible uniqueness of the place they live in. Even textbooks do not include this marvel, not only from a technical or scientific point of view, but also from a cultural or sociological one. Neither politically nor academically, is there enough awareness about the Canary Islands' underground waterworks great educational potential (Figure 1). It is true that there are outreach initiatives, but clearly insufficient for the magnitude of the opportunity that these infrastructures offer, not only locally but nationally and internationally.

Fig.1. Students inside a water gallery during a class

2.2. Types of Canarian water galleries and wells.

Historically, in the Canary Islands, it has fallen to the private sector to prospect for, exploit and transport water. It has been the communal effort of the Canarian people that have made the impressive network of canals, going around the islands, and the large number of shafts and tunnels that provide water possible. To put it briefly, the excavation of a gallery or a "traditional Canarian Well" has had its origin in the private sector by means of what is generically known as a "Water Community" or "Water Fellowship". Mostly farmers and village people working together to ensure the water supply for their farms and homes by financing the expensive drilling and pipeline works, originally composed these communities. Owning shares in a Water Community grants the right to a certain quantity of water, depending on the number of shares owned. It is precisely this fact that led to the work being performed for the lowest possible budget, with poor safety conditions that make the galleries unsuitable for untrained visitors. The infrastructures of groundwater exploitation in the Canary Islands are, to put it simply, linear excavations with a single exit way. The excavation is horizontal in the case of galleries (Figure 2) and vertical in the case of the wells. The galleries are usually less than 2 m in diameter and with lengths up to 6,600 m; wells have a diameter of 3.5 m and depths up to 600 m (Santamarta et al., 2013a). People and material transportation in the galleries is done by diesel engines and in wells by winches; there are neither spoken communication systems nor interior lighting. The technique used in the construction, ventilation and maintenance of these facilities is purely mining; therefore the regulations that apply to them are those of mining safety.

Figure 2. Inside water galleries in the Canary Islands, on the right is the channel to take out the water. At the bottom of the picture, there are the train rails for transporting material and staff.

3 Challenges and solutions

3.1 Safety

The main problem for teaching within groundwater hydraulic facilities in the Canary Islands is safety, which is conditioned by three main factors (Lario-Bascones, 2013):

- The potentially toxic atmosphere, with significant presence of CO_2 in some cases.
- The absence of underground-surface communication systems.
- Stability of the excavations.

In order to reduce the risks related to the toxicity of the atmosphere and the stability of the excavation, it is necessary to choose facilities that have ventilation systems and a well-maintained stability system. Fortunately, such facilities exist, they have qualified personnel and they successfully pass official inspections and controls. It is essential to have the cooperation of government bodies and inspectors in mining safety to certify whether a particular facility is safe or not and therefore suitable for teaching. These inspectors should carry out the supervision of safety protocols in order to allow non-professional visitors to enter these facilities. The absence of communication is, ironically, the most problematic point. When performing teaching activities within these facilities, it is imperative to install a communication system, which involves an investment that is difficult for gallery owners to make.

3.2 Access

Another practical problem is the difficulty of access to many of the facilities, especially the galleries (Figure 3). The majority of them are located in steep areas of the island, only reachable by 4-wheeled drive vehicles or after a long hike or walk. The adaptation of the access roads is very difficult in cases where the facility is in a protected natural area, where construction of new roads or paths is not permitted.

But these difficulties are solvable, depending on the teaching, facilities with easier access can be chosen, what is more, due to the intense tourism activity in the islands, there are many 4-wheeled drive tour companies that could collaborate.

Fig. 3.Preparing access for students to the water mine for teaching practical classes of hydrology and water management.

3.3 Ignorance and lack of synergy

Of all the problems facing the development of teaching using Canarian wells and galleries, the most important one and the true cause for which this development has not been carried out yet is the ignorance about it and the lack of synergy between the parties involved:

- Facility managers.
- Education sector.
- Technical and inspection bodies.

The lack of synergy and ignorance are complementary problems that hinder the potential routine use of such facilities in educational activities. They are often immediately discarded for safety reasons without any serious study based on existing technical methods to ensure a suitable and safe environment.

However, as can be seen in table 1, obtained from the 2013 updated facility census carried out by the Water Council of Tenerife (BOE, 2013), there is an exhaustive control over the safety of wells and galleries. The figure of 1,046 low-risk galleries indicates that, in these, measures to control the risk of unauthorized access have been taken, in other words, in these galleries, access is available in a safe and controlled way.

Table 1. Risk-based classification of water galleries and wells in Tenerife – 2013

Facility	High risk	Medium risk	Low risk
Galleries	18	190	1046
Wells	11	6	380

Refusal to exploit this potential arises both from facility managers responsible, who do not want any problems and from the education sector, wary of their safety. The solution to reconcile the two positions is the Mining Safety Regulation. That is why to harness this great potential that exists in these training matters in the Canary Islands, collaboration between these actors is needed.

4. Conclusions

Undoubtedly, in the Canary Islands there is untapped potential in the teaching of earth sciences, mining and civil works (Santamarta et al. 2013b). The main reason for its underutilization is ignorance about the state of art in the area of mining safety by the educational community and a lack of collaboration between the different actors involved.

The reality is that in the archipelago, and especially in Tenerife, there are high numbers of easily accessible and

properly maintained galleries in which, with minimal investment, permanent teaching could be safely carried out. As a final comment, we feel it is necessary to highlight the point that two of the three actors involved in this issue, educational authorities and safety control bodies, depend mainly on political power: the Government. Although teaching is carried out privately, the public administration has a great deal of influence in terms of teaching approval and access to these facilities as teaching centres. The political will to promote such activities is essential in order to achieve some success in this endeavour, as it was in the creation of the Almaden Mining Academy. The question that arises today is: Do the current politicians have their ideas on the subject as clear as they had in the eighteenth century?

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