

# LOCATION AND COLLECTION OF SUBMARINE KARSTIC SPRINGS

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## **Abstract:**

*More and more often, decision makers are considering using brackish water for agricultural, industrial and domestic purposes. The main reason for that is that it is a good alternative to plain desalination. But also, when people really need water they are now ready to pay a higher price. On the other hand, the cost per m<sup>3</sup> has dropped considerably due to new technological developments (inverse osmosis and membranes) combined with a reduction in manufacturing costs. A reputed utility such as the "Groupe des Eaux de Marseille" (SEM) could not stay indifferent to this new trend, specially since the Mediterranean area and the Middle East are good grounds for the application of such techniques. In the short run, SEM's objective is to master these techniques and to strengthen its know-how in the operation of saltwater and brackish water processing units. It is in this context that SEM has sought, for some 20 years, to widen its knowledge in the use of such resources. Its initial approach involved the study of the improvement of a resurgence close to Marseilles, the resurgence of Port Miou. The first part of this presentation summarises the approach that was adopted. The second part details the methodology that is currently being implemented. Based on an innovative approach and bringing together a full panel of environmental specialists, the current approach aims to apply new processes, methods and equipment to the development and efficient use of the resource.*

**Key term:** Resurgence, Brackish, desalination.

## **THE CASE OF PORT MIOU**

Cassis is a delightful seaside resort of 8000 inhabitants located 20 kilometers to the east of Marseilles (1 million inhabitants). Between the two cities there is a limestone massif that ends in cliffs on the seaward side, interspersed by the "calanques" or creeks for which Marseilles is well known. These creeks constitute a site that attracts large numbers of recreational boaters, walkers and rock climbers.

The Cosquer cave was discovered in 1985 at the base of one of these cliffs. Although the entrance to the cave is now submerged under 40 metres of water, it would have been accessible without so much as wetting one's feet 27000 years ago. Its occupants have left primitive paintings that are of great interest to palaeontologists.

Two major submarine resurgences are also to be found on this site, those of Port Miou and Bestouan. These resurgences have been known since the dawn of time, as the Greek navigator and geographer Pytheas mentioned them 2600 years ago. It is true that, on a clear day, when the flow rate is only about 7 m<sup>3</sup>/s, it takes a sharp eye to spot the fresh water currents going out to sea. Nevertheless, after periods of rain, one can't miss the enormous muddy plume that emerges from Port Miou with a flow rate 10 or 20 times greater.

However, until the 20th century, the site was only known as a local curiosity with no use whatsoever, as the water of both springs was brackish. Since the beginning of the century, it started to interest a certain number of specialists:

- The invention of the self-contained underwater breathing apparatus (SCUBA) allowed to explore the galleries. The divers were rapidly aware of the hardship of exploring more than three kilometres upstream of the Bestouan resurgence because of many low points and obstruction by rockfall that cannot be cleared safely. Conversely, the Port

Miou resurgence appeared to have a large cross section and a bell-shaped chamber 500 metres from its mouth.

- During the Second World War, the Germans contemplated to use this chamber, referred to as Bell 500, to shelter a submarine base. They dug a pit 45 metres deep to gain access to the chamber from the surface, but never had the time to go further before the end of the war.
- Hydrogeology has become a speciality of its own and has developed technologies that have allowed increasingly advanced investigations in this field.
- As speleology became accessible to a broader public, many amateurs became interested in Port Miou and so remain. Their explorations have gone further and further and have helped to understand the way the resurgence works. Their last attempt allowed them to go as far as 2200 meters upstream from the seaward outlet and to discover a submerged chasm 150 metres deep.

SEM showed interest in the Port Miou resurgence as early as 1970. This utility was created in 1960 to confront the serious problems that plagued the water supply of Marseilles at the time. Indeed, as SEM was already designing a canal to bring 17 m<sup>3</sup>/s from the Alpine snow, the Port Miou resurgence was of limited use in terms of improving the conditions of water supply of the region.

However, as SEM subsequently turned towards overseas consultancy and assistance to water thirsty countries, it rapidly became aware that this site was an ideal field of experimentation. Therefore, it created the “Syndicat des Recherches de Port Miou” along with BRGM with the aim of developing new technologies applicable to water deficient countries .

Together, the two companies decided to use Bell 500 as a working base. They equipped it with a lift to simplify access and fitted flow gauges and salinity sensors. As early as 1972, having detected the ingress of saltwater up to this point at low flow, they designed and constructed a first dam made of cement grout lightened by detergent bubbles, as it was necessary to set the dam down on soft sediment with little load-bearing capacity. In this way, they hoped to cut off the lower salty section and to recover the fresh water by forcing it to overflow above the dam. The dam limited the intrusion of saltwater, but the upstream water remained salty.

Having continued their measurements to monitor the evolution of the situation, they decided in 1975 - 76 to raise the dam so as to create slight backpressure upstream. On completion of the work, the residual salinity decreased slightly, without going below 3 g/l, possibly making it almost suitable for watering reforestation programmes but not fit for drinking.

For some time, it was thought that the residual salinity could originate from the leaching of continental saline deposits. However, following the discovery made by speleologists of the deep chasm mentioned above, thinking changed and measurements were carried out to verify whether marine contamination occurred there at depth.

Since that time, several experts have studied the question and, more generally, the dynamics of karstic networks in Provence. The article that Eric Gilly published in October 2001 provides a useful summary of current knowledge of the problem. He demonstrated that the resurgences in Cassis have an excess flow rate relative to their impluvium, but that their flow rate corresponds approximately to the shortfall in that of lower Provence taken as a whole. This led him to imagine an immense karst at depth, extending over the entire surface area of the region at a depth of less than 300 metres. The karst would include two major systems, that of Vaucluse to the north and that of Port Miou to the south, the communication of which remained to be verified.

The operation of the systems would have been substantially modified by the rise in the level of the Mediterranean Sea. The clearest evidence of this is that stalagmites can be seen in Port Miou at a depth of 20 metres. Similarly, in the Fontaine de Vaucluse chasm, the bottom of which now lies at a depth of 200 metres below sea level, shapes that resemble channelling are to be seen in the walls.

His conclusion is that, to understand the way the resurgences in Cassis function, it is necessary to undertake a major multi-disciplinary investigation, which would include structural, speleological, hygrometric, climatological and, of course, palaeo-geographic considerations.

## **New orientations**

This broadening of the hydrogeological horizons coincides with SEM's position, which is taking increasing interest in the new techniques on the market, such as:

- Collection of fresh water as it exits to the sea,
- New forms of transportation by sea (big bags),
- New forms of brackish water treatment derived from desalination.

SEM therefore wishes to take all these new parameters into consideration to enlarge its approach. To this end, it has created a joint venture with IFREMER and BRGM.

The purpose of the joint venture will be the development of a new methodology for the research, characterisation and exploitation of coastal karstic resurgences, in association with specialists from a variety of disciplines.

To begin with, it will work to overcome the difficulties of determining the physical-chemical characteristics of waters, by using not only water chemistry and isotopic characterisation, but also hydrodynamic characterisation.

It also wants to develop hydrodynamic flow simulation models and new instrumentation for the physical parameters of the resurgence (salinity, temperature and flow rate), required to calibrate the models.

Furthermore, recent membrane technology for the treatment of drinking water or agricultural applications will be used. The full spectrum of treatment technologies will be implemented and developed, ranging from suitable instrumentation (sensors to measure turbidity, conductivity, flow rate...) to the supervision of the catchment and treatment processes, in a field that is to be mastered.

Finally, the reduction in the cost of producing drinking water using membrane processes favours their increased use in conventional management. Logically, the application of such methods to coastal karstic or marine resources should therefore allow realistic production costs to be achieved. The costs of locating and characterising the resource to be treated should remain minor in comparison to the installation of the treatment plants.

From the point of view of methodology, several phases are planned. Initially, detection campaigns are carried out at sea in order to locate the presence of a resurgence. The parameters of the plume of the resource (geometry, salinity and temperature) are then gathered, along with an analysis of the catchment areas concerned. The data gathered make it possible to draw up a computerised model of the overall system. Once the resurgence has been characterised in this way, a technical and economic feasibility study is carried out to assess whether catchment and production levels are suitable. In parallel, an environmental impact study is undertaken. Depending on the results of the feasibility study, the location of the catchment point is determined with the help of the model (inland, on the shoreline or at sea), along with land-based measurement (bore-holes) if required, and the treatment process is deployed. By using the most advanced instrumentation and data transmission technologies to monitor the points at which the

parameters of the water to be treated are measured, it is possible to adapt the treatment to fluctuations in the resource. This innovative methodology will be applied to the Port Miou resurgence near Marseilles.

Apart from the pooling of skills in hydrology, knowledge of marine environments, karstology and water treatment, the project briefly described above should enable the use of the most recent and most efficient instrumentation, monitoring and operating technologies. It will also be the vector of pragmatic research into pertinent solutions that aim to enhance knowledge and management of the resource, which is often lacking in a long-term perspective.

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