

## *Hydrogeochemistry of an ancient groundwater system (Sete Fontes, Braga, Northern Portugal)*

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### **Introduction**

Water supply systems and morphology of ancient cities suggest a strongly constrain between urban development and water sources. The availability and location of water resources are mainly associated to a possible transport to the populations.

The ancient drinking water supply system from Sete Fontes (Braga, northern Portugal) was built in the middle-eighteen century, overlaying a much older system with probable Roman origin (Martins et al., 2011), and was used as the main supply system of the city until 1913 (Vieira et al., 2016). Although with some uncertainty, the Sete Fontes area is considered by some authors (e.g., Martins et al., 2011; Martins and Ribeiro, 2012) as part of the main source area of water for the Roman city of Bracara Augusta.

The system is composed of several underground galleries (eleven of them are still active) collecting spring waters, stone aqueduct channels with about 3500 m long for water transportation, cisterns for water storage, waterspouts and fountains for public water distribution (Vieira et al., 2016). The water sources of this system are located in a valley with a NE-SW trend and with altitudes ranging between 250 and 300 m, with the main reservoir (water storage and distribution) in a topographic elevation of approximately 194 m. The geomorphology of the area causes a favorable declivity to water gravity transport into the city.

Geologically, the Sete Fontes aquifer is characterized by the contact of Silurian metasediment's (essentially biotite micaschist's) with Variscan granites (Braga granite and Sameiro granite). The area presents two main fracturation trends - ENE-WSW e NW-SE - which partially controls the groundwater movement.

In the last decades, the economic and demographic growth of Braga lead to the increasing need of

prospection of other water resources. Nowadays, the city is supplied by water abstracted from Cávado River. However, most of city fountains and waterspouts are still supplied the Sete Fontes water source system, with an estimated daily productivity of 500 m<sup>3</sup> (Vieira et al., 2016).

Groundwater geochemistry characterization was performed between 2011-2012 (Costa, 2012). Water hydrogeochemistry results revealed a mineralized water, with an electrical conductivity of 102 µS/cm, total mineralization of 85.1 mg/L, neutral feature (pH=6.8) and an alkalinity of 12.69 mg/L CaCO<sub>3</sub>. The water has a dominant sodium (average = 11.61mg/L) - bicarbonate (average = 15.48mg/L) facies. Water geochemistry from Sete Fontes is mainly controlled by water-rock interaction, associated with a maritime influence (e.g., Mg, Na e Cl<sup>-</sup>) and a local agricultural and human contribution (e.g., NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup> (Costa, 2012).

### **Conclusion**

Groundwater from Sete Fontes water system preserves both the original memorial role and its operational function, so its preservation and valorization is a key urban asset of the city of Braga. The classification as a national monument was declared on the 25<sup>th</sup> March 2011.

According to its cultural significance, bearing on its authenticity and integrity, the Sete Fontes water system receives an important historical value as a national heritage (Vieira et al., 2016). The historical importance from the Sete Fontes aquifer is also enlarged if considered that during the Roman period this area was probably the main source of water for the city (Martins et al., 2011), delivering the much-needed water for the roman public baths.