

Hydrogeochemical study of thermo-mineral waters in Lisbon region (Portugal): contributions for hydrogeological conceptual models

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In the Lisbon region, Portugal, existing thermo-mineral waters have been historically exploited in balneological centers. However, currently, the majority is abandoned or is dilapidated (Acciaiuoli, 1952; Lopo-Mendonça et al., 2004; Ramalho e Lourenço, 2006). Physical-chemical composition of these thermo-mineral waters have been briefly characterized by previous studies (Andrade, 1932; Acciaiuoli, 1952; Almeida, 1952), showing a complex diversity of hydrochemical facies ($\text{HCO}_3\text{-Na}$, $\text{HCO}_3\text{-Ca}$, $\text{SO}_4\text{-Ca}$ and Cl-Na) and mineralization contents (between 0.5 and 6 g/L). These characteristics have been firstly correlated to different aquifer lithologies, recharge conditions and local vs regional flowpaths (Almeida et al., 1991; Lopo-Mendonça et al., 2004; Ferreira et al., 2011; Carvalho et al., 2013). Some of these thermo-mineral waters are probably related to deep circulation through sedimentary aquifers of limestone and sandstone formations, which are lacking a hydrogeological conceptual model, except for the Estoril thermal water (Lopo-Mendonça et al., 2004).

The main objective of this study was to identify and quantify the processes related to the hydrochemical and mineralization complexity of these thermo-mineral waters in order to define or update their hydrogeological conceptual models. In this work we present new physical-chemical and isotopic data (stable and radioactive) from 20 thermal and/or mineral waters sampled (15 wells, 3 springs and 1 borehole) in the Lisbon region between March and June and November to December of 2013. The results obtained show that mineralization is mainly controlled by water-rock interaction processes, as well as by mixing process with saline waters from different origins (seawater, ancient groundwater, etc.). A significant positive correlation between sodium and chloride concentrations and salinity parameters has also been identified. Stable isotopes signatures show a meteoric origin and in some cases a minor fractionation signature related to seawater mixing, calcite precipitation and/or gypsum dissolution.

Keywords: thermo-mineral waters, hydrogeological conceptual model, Lisbon, aquifer.

References

- Acciaiuoli, L. (1952): "Le Portugal Hydromineral". Direction Générale des Mines e des Services Géologiques. V.I, 284 pp.
- Andrade, C.F. (1933). "A tectónica do estuário do Tejo e dos vales submarinos ao largo da costa da Caparica, e a sua relação com as nascentes termo-medicinais de Lisboa (Considerações Preliminares)". Separata do tomo **XIX** das Comunicações dos Serviços Geológicos de Portugal, 21 pp.

- Almeida, A. (1952): "Lisboa, Capital das Águas". Revista Municipal. Separata dos nºs **49 e 50**, 27 pp.
- Almeida, C., Carvalho, M.R., Almeida, S. (1991): "Modelação de Processos Hidrogeoquímicos Ocorrentes nos Aquíferos Carbonatados da Região de Lisboa-Cascais-Sintra". Hidrogeologia y Recursos Hidráulicos, t. **XVIII**, 289-304.
- Carvalho, M.R., Ferreira, F., Silva, C., Almeida, C. (2013). "Origin of dissolved carbon in groundwaters from carbonated aquifers in Lisbon-Cascais region (Portugal) using $\delta^{13}\text{C}$ ". AIG10, Budapest, Hungria, 22-27 Setembro.
- Ferreira, F., Carvalho, M.R., Silva, C., Almeida, C. (2011). "Variabilidade hidrogeoquímica nos aquíferos carbonatados entre Lisboa e Cascais". 8ºSeminário sobre águas subterrâneas, Lisboa, 10-11 de Março.
- Lopo-Mendonça, J., Oliveira da Silva, M., Bahir, M. (2004). "Considerations concerning the origin of the Estoril (Portugal) thermal water". Estudios Geológicos, **60**, 153-159.
- Ramalho, E.C., Lourenço, M.C. (2006). "As águas de Alfama – a riqueza esquecida da cidade de Lisboa". Edição Especial Boletim de Minas, **40** (1), pp. 5-24.