



Discriminating the source of elements in travertine and tufa deposits: new perspectives from trace elements and isotopes

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Calcitic or aragonitic travertine and tufa deposits (CATT) are frequently associated to former limestone dissolution in epigeal or hypogean hydrogeological reservoirs. However, a large variety of other rocks can also occur as substratum and potential source of elements building these continental carbonates. In modern and recent environments, many studies have suggested that igneous rocks (basalts, rhyolites, carbonatites, ultramafics, syenites, granites) and other sedimentary rocks (dolomites, evaporites) may constitute “exotic” sources for calcium and other elements. Unfortunately in drilled fossil CATT, a wide array of rocks forming palaeo-hydrogeological reservoirs are generally unknown. Because CATT microfacies bring only little information to this issue, a geochemical database has been established by compiling major, minor, trace elements and stable isotopes. This database includes data from published literature and a new data acquired as part of an on-going research work. The later includes analyzed Modern and Recent non-marine CATT from the Ligurian Ophiolites (Italy), the Chaîne des Puys (France), the Limagne graben (France), the Paris Basin (France) and the Reunion Island (Indian Ocean). Each of these case studies is located on a relatively well-constrained hydrogeological reservoir.

Among the geochemical tracers investigated in this dataset, particular emphasis is placed on (1) barium and strontium concentrations and (2) stable isotopes ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$). Barium and strontium concentrations allow the definition of three distinct geochemical fields. The first field is characterized by Ba and Sr concentrations respectively below 80 and 500 ppm, and corresponds to CATT associated with epigeal karst system in limestone. The second field, in which CATT exhibits high Ba concentration (>80 ppm) but consistently low Sr content, is indicative of either ultramafic reservoirs or epigeal reservoirs with a mixture of dolomite, evaporite and limestone. The third field is composed of Sr-rich CATT (>500 ppm) and relates to igneous reservoirs, excluding ultramafics. Within this field, high barium content (>1000 ppm) is associated to carbonatite reservoir whereas low Ba content (<40 ppm) to aragonite-rich CATT derived from pure volcanic reservoirs.

In most cases $\delta^{13}\text{C}$ - $\delta^{18}\text{O}$ values alone do not permit to discriminate the lithology of the hydrologic reservoirs. However, a few instances of specifically distinct $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values do exist. For instance, $\delta^{13}\text{C}$ values < -13‰ PDB are only found in CATT originated from ultramafic reservoirs. Also, in agreement with prior studies, CATT with $\delta^{13}\text{C}$ > -1‰ PDB and $\delta^{18}\text{O}$ < -4‰ mainly correspond to hypogean CATT, independently of their lithological reservoir. Most lacustrine CAAT, with or without hydrothermal inputs, have positive $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ above -9‰, regardless of the catchment rock lithology.

The definition of compositional fields for actively-forming or recently-formed CAAT is clearly influenced by many factors such as: water composition, water temperature, dissolved gas composition and concentration, biological activity, position among the sedimentary body and early diagenesis. However, the results of this preliminary work suggest that, despite the many factors, the combined use of Ba, Sr, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ may be useful to discriminate the lithology of their hydrogeological or palaeo-hydrogeological reservoirs. Further investigation along this line of research is under way.