

Hydrogeochemical processes and isotopes analysis. Study case: “La Línea Tunnel”, Colombia

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Hydrogeochemical and stable isotopes analyses have been widely used to identify recharge and discharge zones, flowpaths, type, origin and age of water, chemical processes between minerals and groundwater as well as effects caused by anthropogenic or natural pollution. In this paper we analyze the interactions between groundwater and surface water using as laboratory the tunnels located at the La Línea Massif in the Cordillera Central of the Colombian Andes. The massif is formed by two igneous-metamorphic fractured complexes (Cajamarca and Quebradagrande group) plus andesitic porphyry rocks from the tertiary period. There, eight main fault zones related to surface creeks were identified and main inflows inside the tunnels were reported. 60 water samples were collected in surface and inside the tunnel in fault zones in two different years, 2010 and 2015. To classify water samples, a multivariate statistical analysis combining Factor Analysis (FA) with Hierarchical Cluster Analysis (HCA) was performed. Then, analyses of the major chemical elements and water isotopes (^{18}O , ^2H and ^3H) were used to define the origin of dissolved components and to analyse the evolution in time. Most samples were classified as bicarbonate calcite water or bicarbonate magnesium water type. Isotopic analyses show a characteristic behavior for east and west watershed and each geologic group. According to the FA and HCA, obtained factors and clusters are first related to the location of the samples (surface or tunnel samples) followed by the geology. Surface samples behave according to the Colombian meteoric line as inflows related to permeable faults while less permeable faults show hydrothermal processes. Finally, water evolution in time shows a decrease of pH, conductivity and Mg^{2+} related to silicate weathering or precipitation/dissolution processes that affect the spacing in fractures and consequently, the hydraulic properties.