Wormhole dynamics, competition for the flow and changes in transport behavior: an intermediate-scale experiment

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Salt flats (Salar) are complex evaporitic systems of economic interest and environmental value. On the one hand, these aquifers are usually exploited for variety of minerals, including dissolved species (e.g. Lithium and Potassium) extracted from the brines. On the other hand, the genesis of salares favors that they are surrounded by uncommon ecosystems, which must be protected. In this context, it is feared that brine pumping might favor the development of dissolution channels (Wormholes) that could connect the Salar nucleus with the environmental sensitive surroundings. Thus, a full understanding of the conditions and processes involved in wormhole formation and evolution has to be achieved. The hydraulic and geochemical conditions for conduits growth have been widely discussed in carbonate environments, while little has been done in halitic and gypsum environments. But we unkowledge experimental works aimed at understanding wormhole dynamics and the mechanism of competition for the flow that influence dissolution pattern evolution.

In this study, we want to improve the understanding of multiple wormholes growth in the context of wormhole competition and consequent changes in transport behaviors. For that purpose, we designed and performed a laboratory intermediate-scale tank experiment under controlled conditions. Halite in the form of granular medium is used to reproduce the aquifer. Hydrodynamics and geochemical conditions are set as to reproduce a dominant wormhole dissolution regime. Several coloured tracer tests are carried out to characterize the medium before, during and after the dissolution experiment. Tracer concentration, hydrogeochemical and flow parameters, as well as tank images are continuously recorded. In particular, the use of fluorescent tracer jointly with image processing analysis highlights wormholes growth, shape and propagation through the medium at different times. Experimental results allow visualizing and analyzing several features related to wormhole competition, e.g. wormhole growth rate and density evolution, as well the redistribution of the flow towards areas where dominant wormholes are developing. Results are compared to available numerical and analytical solutions. Lastly, the interpretation of BTCs allows to understand changes in flow and transport behavior and related processes, given the developing dissolution pattern.