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Wormhole Growth in Dissolving Limestones: Insights from 4D Tomography

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Dissolution of porous media introduces a positive feedback between fluid transport and chemical reactions at mineral surfaces leading to the formation of pronounced wormhole-like channels. While the impact of flow rate and reaction rate on the shapes of the wormholes is now well understood, much less is known about the dynamics of their propagation. In this study we capture the evolution of wormholes and their effects on flow patterns by in-situ X-ray microCT imaging of dissolving limestone cores. 4D tomography allows us in particular to correlate the permeability changes in a dissolving core with the advancement of the tip position of the wormhole. Surprisingly, we find that the relation between the two is highly nonlinear, with extensive periods of relatively fast growth of the wormhole which is nevertheless not reflected in any significant change in the overall permeability. We hypothesize that this is caused by the presence of highly cemented regions in the core which act as permeability barriers for the flow. The presence of such regions is confirmed by a detailed analysis of the pore geometry based on the tomographic data. The results demonstrate that the analysis of the wormhole dynamics in 4d tomography can be used to probe the internal structure of the rock.