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# Single-well tracer push-pull test sensitivity w. r. to fracture aperture and spacing

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Dealing with a parallel-fracture system of infinite lateral extension, four characteristic regimes of tracer signal sensitivity w. r. to fracture aperture and w. r. to fracture spacing $s$ (whose reciprocal defines fracture density, or the fluid-rock interface area per volume) can be identified during the pull phase of a single-well push-pull test, also depending upon the ratio between push-phase duration $T_{push}$ and a characteristic time scale $T_s$ (defined by $s^2$ / $D$ = $T_s$ , with $D$ denoting the tracer's effective diffusion coefficient):

- early-time regime: tracer signals are sensitive w. r. to fracture aperture, but insensitive w. r. to fracture spacing; sensitivity w. r. to fracture aperture first increases, then decreases with $T_{push}$ / $T_s$ (thus there will be an optimum in terms of to $T_{push}$ / $T_s$ , at early pull times);
- mid-time regime: tracer signals are sensitive w. r. to fracture spacing, but insensitive w. r. to fracture aperture; sensitivity w. r. to fracture spacing increases with $T_{push}$ / $T_s$ ;
- late-time regime: with increasing pull duration, tracer signals become increasingly insensitive w. r. to fracture spacing, while regaining sensitivity w. r. to fracture aperture;
- 'very late'-time regime: sensitivity w. r. to fracture aperture becomes independent upon $T_{push}$ / $T_s$ .

From these different regimes, some recommendations can be derived regarding the design and dimensioning of dual-tracer single-well push-pull tests for the specific purposes of geothermal reservoir characterization, using conservative solutes and heat as tracers.

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