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Matching tracer selection to georeservoir typology – A note on geothermal reservoir classification

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Thermal-lifetime prediction is a traditional endeavor of inter-well tracer tests conducted in geothermal reservoirs. Early tracer test signals (detectable within the first few years of operation) are expected to correlate with late-time production temperature drop (so-called 'thermal breakthrough', supposed to not occur before some decades of operation) of a geothermal reservoir.

Whenever a geothermal reservoir can be described as a single-fracture system, its thermal lifetime will, ideally, be determined by two parameters, whose inversion from conservative-tracer test signals is straightforward and non-ambiguous (provided that the tracer tests, and their interpretation, are performed in accordance to the rules of the art).

However, as soon as just few more fractures are considered, this clear-cut correlation is broken. A given geothermal reservoir can simultaneously exhibit a single-fracture behavior, in terms of heat transport, and a multiple-fracture behavior, in terms of solute tracer transport (or vice-versa), whose effective values of fracture apertures, spacings, and porosities are essentially uncorrelated between heat and solute tracers. Solute transport parameters derived from conservative-tracer tests will no longer characterize the heat transport processes (and thus temperature evolutions) taking place in the same reservoir. Parameters determining its thermal lifetime will remain invisible to conservative tracers in inter-well tests.

Non-conservative tracers, in particular sorptive and thermo-sensitive compounds, can be used to overcome this gap between heat and tracer transport. However, significant differences exist, w. r. to tracer functionality, between different geothermal systems:

- (I) hot natural aquifers (with predominantly 'porous media' character),
- (II) aquifer-based EGS,
- (III) petrothermally-based EGS,
- (IV) naturally-fractured systems.

Conservative tracers are indispensable to characterizing any of (I) – (IV), but their residence time distribution (with mean residence time MRT) correlates differently with thermal lifetime: the more pronounced the petrothermal character (with effective aperture w), the more the quadratic term (proportional to D_{th}*MRT^2/w^2) will prevail within thermal lifetime. It therefore turns out that thermo-sensitive tracers are less useful (roughly speaking) in petrothermal, than in aquifer-based reservoirs; whereas sorptive tracers prove more useful in petrothermally-dominated, than in aquifer-based reservoirs.

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