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The impact of multi-scale geological heterogeneities on geothermal reservoir performance

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Geological heterogeneities in the subsurface are multiscale in nature, sparsely sampled, and hence inherently uncertain, particularly in geothermal reservoirs where the availability of geophysical and geological data is often limited. Yet, these geological heterogeneities influence the convective and conductive transport of heat in a geothermal reservoir and need to be represented adequately in reservoir models. At which scale the heterogeneities must be captured in static and dynamic reservoir models such that reliable forecasts about safe and sustainable heat production become possible remains an open question.

In this study we use the open-source Rapid Reservoir Modelling (RRM) software to design a series of geological scenarios that contain geological heterogeneities at increasingly more detail. To this end, we consider two geothermal reservoirs where production occurs from a geothermal doublet: one is situated in shallow marine deposits and one in deepwater slope channels. The multiscale geological heterogeneities that characterise these reservoirs are represented through a hierarchy of surfaces that represent stratigraphy, facies, and diagenetic bodies. A key advantage of RRM compared to more traditional modelling approaches is that multiscale reservoir models can be constructed in both, a geologically consistent and time effective way, and feedback on the essential static and dynamic reservoir properties is obtained while building the reservoir models.

Using the flow diagnostics capabilities in RRM, we conduct a first screening of the breakthrough times between injection and production well for different well locations, before commencing more detailed and time-consuming full-physics simulations using a commercial geothermal reservoir simulator. These simulations clearly show that forecasts about reservoir performance and heat production become more variable as more geological details are considered: the small-scale (~1m) heterogeneities have significant impact on reservoir connectivity and lead to significantly lower estimates in energy capacity.

Our work demonstrates that it is crucial to design geothermal reservoir models that represent the geometry and connectivity of reservoir heterogeneities in a geologically consistent way to obtain more reliable estimates about reservoir performance and heat production.

Participation

In-Person

References

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