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Slugtests in fractured aquifers – advantages and caveats

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The hydraulic characterisation of fractured aquifers is a challenge due to the large contrast between conductive fractures and a relative low conductive rock matrix. Depending on the type of problem, spanning from water resources issues at catchment scale to contaminant transport at local, borehole scale, different methodological approaches are required.
The employment of slugtests as a characterisation method has a major advantage above classical pumping tests since they provide information also for the lower end of the permeability spectrum and are less logistically demanding. However, the volume of investigation of slugtests is generally small and limited to the immediate borehole area.
The application of slug tests to fractured systems was investigated by Barker and Black (1983); Dougherty and Babu (1984) and Karasaki et al. (1988). Barker and Black (1983) pointed out the non-uniqueness of type curves with re¬spect to determining reservoir parameters, apart from hydraulic conductivity and sto¬rage coefficients. The unknowns in¬clude fissure densities, apertures and the hy¬draulic parameters of the rock matrix. They found that the Cooper method syste¬matically overestimates aquifer transmis-sivities by a factor of up to three. This figure however applies to a fairly homogeneously fissured aquifer such as the English Chalk. Dougherty and Babu (1984) examined in detail the effects of partial penetration, dif¬ferent skin factors and mass exchange coef-ficients in a double porosity system. They did however not present any parameter estimation solu¬tion. Karasaki et al. (1988) developed type curves for heterogeneous aquifer systems and came to the conclusion that "slug tests suffer problems of non-uniqueness to a greater ex¬tent than other well tests".
In this paper, this aspect of non-uniqueness is addressed in detail, based on slugtest data in a fractured and karstified aquifer from the Swabian Alb in the SW of Germany, explanations and models of interpretation are provided and assessed with respect to their relative importance.