The applicability of slug tests in fractured-rock formations

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Abstract

Currently slug tests in South Africa are used with two objectives in mind:
- To get a first estimate of the yield of a borehole
- To estimate the K-value (or T-value) of the aquifer near the borehole.

The paper shows that the use of currently available slug-test interpretation methods to analyse slug tests in fractured-rock aquifers to estimate a T or K-value is problematic. The estimated value is dependent on the flow thickness (thickness of the part of the aquifer in which flow occurs due to the slug input). If this thickness of flow is known, the estimated T-value is more representative of that of the fracture zone. By using the total thickness of the formation for the estimation of the K-value in slug-test analysis, the estimated K-value (and thus KD-value) does not represent the T-value of the formation.

Keywords: slug tests, fractured-rock formations

Introduction

In performing a slug test, the static water level in a borehole is suddenly lowered or raised. This is usually done by lowering a closed cylinder into a borehole. The cylinder replaces its own volume of water within the borehole, thus increasing the pressure in the borehole. As the equilibrium in the water level is changed, it will recover or stabilise to its initial level. If the rate of recovery or recession of the water level is measured, the transmissivity or hydraulic conductivity of the borehole can be determined (Kruseman and De Ridder, 1994).

In South Africa slug tests are conducted for the following two reasons:
- To estimate the hydraulic conductivity (K) of the aquifer in the vicinity of the borehole
- To get a first estimate of the yield of a borehole (Vivier et al., 1995).

Vivier et al. (1995) performed slug tests on 32 boreholes, of which the maximum yield was known and they then derived empirically the following formula (there is a 93% correlation between the actual yield and the yield estimated with the formula):

$$Q = 117155.08t^{-0.83} \quad (1)$$

where:
Q = yield of the borehole in ℓ/h and
t = recession time of the slug test in seconds (90% recovery).

Usually the Cooper method (Cooper et al., 1967) or the Bouwer and Rice method (1976) is used to estimate the K-value (or T-value in the case of the Cooper method).

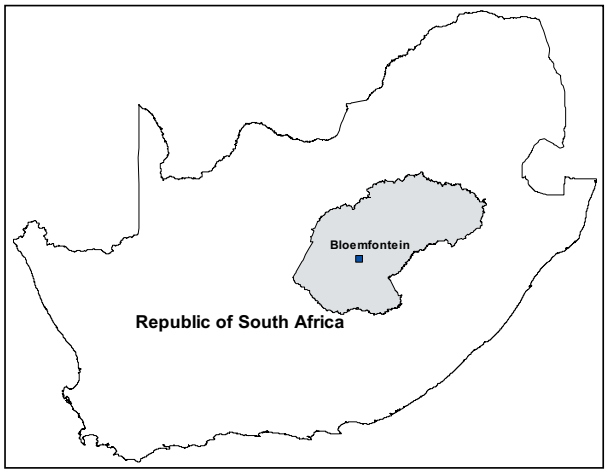

Figure1
Map of the RSA

In the following section slug-test results, as well as pumping and tracer-test results for borehole UO5 on the well-known Campus Site of the University of the Free State, South Africa (Fig. 1) will be discussed to illustrate the problems associated with the interpretation of slug tests in a borehole drilled in a fractured aquifer.

Borehole UO5 on the Campus Site

The Campus Test Site is underlain by a series of mudstones and sandstones from the Adelaide Subgroup of the Beaufort Group of formations in the Karoo Supergroup (Fig. 2). There are three aquifers present on the site. The first, a phreatic aquifer, occurs within the upper mudstone layers on the site. This aquifer is separated from the second and main aquifer, which occurs in a sandstone layer of between 8 and 10 m thick, by a layer of carbonaceous shale with a thickness of 0.5 to 4 m. The third aquifer occurs in the mudstone layers (more than 100 m thick) that underlie the sandstone unit.

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