

Groundwater flow analysis in variable-density formation waters – a comparison of common approximations

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ABSTRACT

Calculating the direction and magnitude of groundwater flow from freshwater hydraulic heads is a common approach, yet decreasingly accurate with increasing density-variations of groundwater in sloping aquifers. The density of groundwater can vary significantly both laterally as well as vertically with increasing depths due to e.g. total dissolved solids, fluid temperature, fluid compressibility, and gravity. Aquifers are not always situated horizontally but can dip at certain angles and vary in thickness. Thus, buoyancy from density-variations and potential forces from pressure and elevation differences can play a major role in determining flow of formation waters (Bachu 1995)

Being confronted with the task of determining the direction of groundwater flow in a sedimentary rock basin with a surface area of app. 1220km², consisting of sloping saline and fresh water aquifers, we use this opportunity to quantify the components of the flow-driving forces. Despite the fact that common knowledge apparently suggests to re-calculate heads to a reference, defining this reference is not trivial in aquifers with great density variations. In this study we review and compare the most common approximations to calculate groundwater flow in variable-density formation waters (Davies 1987; Bachu and Michael 2002; Alkalali and Rostron 2003). We rely hereby on a great number of measured data, which were available from groundwater monitoring bores in the form of fluid-level measurements, pressure data measurements, and/or chemical analyses.

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