Regional Distribution of Hydraulic Properties of the Palaeozoic Wajid Sandstone Group Southwestern Saudi Arabia*

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Abstract

In the frame of aquifer studies in Saudi Arabia, we measured porosity and permeability of sandstones of the Palaeozoic Wajid Sandstone in order to get a database for a regional groundwater model. The Wajid sandstone is subdivided into five formations, which differ in their dominant depositional environment. From the base to the top these are: (i) Dibsiyah Formation representing a shallow-marine clastic shelf, (ii) Sanamah Formation containing glacial to proglacial sediments most of them deposited in tunnel valleys, (iii) Qusaibah Formation characterized by highstand shales, (iv) Khusayyayn Formation showing large-scale tabular cross-bedded tidal sands, and the (v) Juwayl Formation again containing glacial to proglacial sediments mostly deposited in tunnel valleys and overlain by shallow-marine tidal beds.

Altogether 380 samples were taken in the outcrop area most of them along sedimentological logs to correlate poroperm properties with sedimentary facies and/or diagenetic features. From oriented samples, cylindric plugs were drilled. With a minipermeameter, all three directions were measured to analyse anisotropy. A column permeameter was used to measure intrinsic permeability under controlled conditions in a sealed cell. In general, both, porosity and permeability are high for all formations with values typically between 0.5 to 5 Darcy and 20-30%, respectively. Nevertheless, permeability varies about several orders of magnitude among samples or between vertical and horizontal permeability within one sample. This anisotropy can be well explained by varying sedimentary facies and cementation. To better predict poroperm properties in the subsurface, we measured gamma ray and analyzed selected samples with polarization and raster electron microscopy (REM). The data obtained enhance the quality of the hydraulic interpretations of this aquifer system.
Introduction

The Sandstones of the Palaeozoic Wajid Sandstone Group are the most important groundwater reservoirs in the southern part of the Kingdom of Saudi Arabia. Although investigated by Mott and Newbould (1950), a detailed reservoir characterization was still missing.

The aim of this study was to deliver a reservoir characterization and a depositional basin model for the Wajid Group. This includes the interpretation of the depositional processes and environments in terms of palaeo-geography and palaeo-oceanography and the evaluation of the aquifer systems in terms of hydraulic parameters. The results are presented in terms of palaeo-geography, palaeo-oceanography, subsurface stratigraphic architecture, petrophysical parameters, and reservoir engineering aspects. We will discuss here the hydraulic parameters obtained from this study. For the first time, porosity and permeability of the Wajid Group were investigated. Furthermore, hydraulic parameters were determined for each formation. Facies shifts and dimensions of sedimentary features are the key to equivalent characterization of each formation.

Motivation

Saudi Arabia does not have renewable water sources. But the country has fossil water bodies stored in large regional aquifers system. The available water volume, and the yield of the aquifer depend on porosity and permeability of the formations, which were not known in details before this study. The aim of this study is to determine these parameters for the Wajid Sandstone Group, which is one of the most important aquifer system in the country. It is a thick sandstone succession, more than 1000 meters thick.

Materials and methods

140 samples were oriented and collected along the sedimentological logs in the study area. The samples were drilled to get cylindrical plugs.

The hydraulic properties were measured in the lab, by a special method, to get a clear picture about the relation between the hydraulic properties and the different sedimentary facies of the aquifer.

Field & Laboratory Work

The Wajid outcrops are located south of Wadi Ad Dawair. During the field campaign, more than 16 sections (~ 600 m) have been logged on a scale, covering all formations of Wajid Group in the study area. Samples for porosity and permeability measurements were taken at 6 locations. The an extensive field work to collect samples from the main formations of Wajid Group.

A determination of the porosity and permeabilities in lab experiments.

*Establishing correlations between the different formations and important parameters for water resources estimation.

Field Sites

<table>
<thead>
<tr>
<th>Formations</th>
<th>Logged and sampled</th>
<th>Logged and studied</th>
<th>Wajid Outcrop Belt</th>
<th>Study Area</th>
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Conclusions

• In general the Palaeozoic Wajid sandstone shows very high porosities (20 - 31 %) and permeabilities (500 - 7000 mD).

• The effective volume is close to unconsolidated Quaternary deposits.

• Poro - Perm properties can be closely linked to sedimentary facies.

• Glacial sediments (Sanamah, Juwayl) show high heterogeneities, whereas shallow marine sediments are quite homogeneous (Dibsiyah, Khusayyayn).

• Better sorting in the Khusayyayn Fm. leads to higher permeabilities compared to Dibsiyah Fm.

In glacial deposits permeabilities cannot be predicted without knowledge of sedimentary facies. Samples for water storage in the Wajid sandstone. To account for permeabilities, sedimentary heterogeneities have to be

References


