Near Surface Geology using Seismic and Resistivity Tomography

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Summary

In arid regions the main source of water is the groundwater aquifers, which are recharged only through rains. Efficient use of groundwater aquifers for drinking or agriculture is important. To utilize the groundwater in an optimum way we need to understand the aquifer's geology, depth, thickness, and the rate of recharge.

To characterize the subsurface geology of Wadi Qudaid, western side of Saudi Arabi, we collected 2D seismic and 2D resistivity data sets. Then, both data sets are inverted to get the final results.

Seismic and resistivity result show the existence of 3 subsurface layers (1) a surface layer consists of sand-silt-gravel, (2) a layer of consolidated sand with some gravel, and (3) a clay layer.

Introduction

Geophysical methods have been used for groundwater management for a long time. Such methods are very efficient in solving groundwater-related problems such as; find groundwater aquifers (Inverarity et al., 2011), seawater intrusions (Allen, et al., 2002), managing groundwater aquifers (Skokan and Munoz, 2010; Abraham et al., 2010), monitoring aquifers (Eigenberg and Woodbury, 2012), track flow paths (Kofoed et al., 2011), etc. Kirsch (2009) presents a good review of different geophysical methods and how we can use it in groundwater applications.

In this work we show the results of a preliminary study made at Wadi Qudaid area, 80 km north of Jeddah, KSA. The main purpose of this study is to characterize the subsurface aquifer for better groundwater management and use.

The area of study is known as Wadi Qudaid and is located at the western side of Saudi Arabia at the Red sea. Wadi Qudaid is located around 80 km north of Jedah, KSA, and 25 km east of Thuwal, KSA. Wadi Qudaid is one of the longest valleys in the area, hence it is an important source of groundwater at that region for both drinking and agriculture activities. There are about 200 water wells in the valley; however, the aquifer dimension and size are almost unknown. Uncontrolled groundwater pumping by locals may affect the quantity of the water stored in the aquifer since the aquifer characteristics, including size and water volume, are unknown.

In this study we collected 2D seismic resistivity profiles to investigate the subsurface geology and aquifer characteristic in the area of interest.

Data Acquisition and Interpretation

The seismic data set contains 117 shot (200 lb weight drop) gathers each has 117 receiver. The shot intervals and the receiver intervals are 2.0 m. Each common shot gather (CSG) was recorded with a sampling interval of 1.0 ms for 0.25 s and 10 to 15 stacks at each shot location. The first arrival traveltimes of the recorded seismic data is picked and then inverted to generate the traveltime tomogram (Figure 1a).

The resistivity data set is collected using 64 nodes at 4 m interval between each two nodes. A schlumberger-Wenner array is used to measure the apparent resistivity values, and then these values are inverted to create the true resistivity tomogram shown in Figure (1b).

From both seismic and resistivity tomograms we can observe three subsurface layers as follow

1. First layer has a P-wave velocity of 400-800 m/s and resistivity of 3000-4000 Ohm.m, which is corresponding to a dry silt-sand-gravel layer.

2. The second layer has a P-wave velocity of 1200-1600 m/s and resistivity of 3 – 500 Ohm.m, which is corresponding to a clay layer with some gravel. Its thickness is 5-10 m on the seismic section and 4 – 8 m in the resistivity section.
3. The third layer has a p-wave velocity >2000 m/s resistivity > 4000 Ohm.m, which is corresponding to limestone.

Comparing the seismic and resistivity section we note differences in the left hand side of the tomograms. In the seismic tomogram the first layer is thicker, which is also reflected on the second layer. To resolve this contradictory result, more data is required, which will be done in a future study.

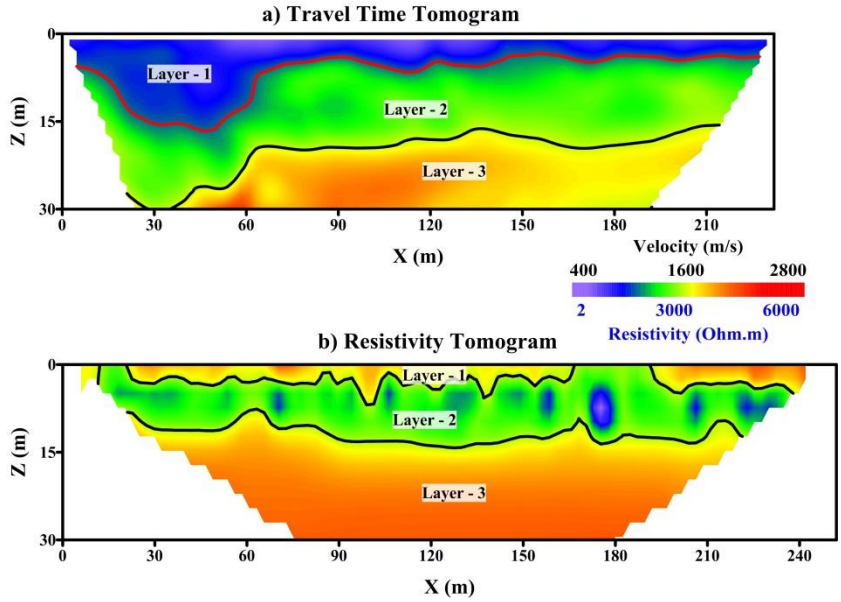

Figure 1: a) The refraction tomogram generated by inverting the first arrival traveltimes. B) The resistivity tomogram. Both seismic and resistivity data sets were collected along the same location at Wadi Qudaid, Saudi Arabia.

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