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Aquifer assessment in Alfajayucan (Hidalgo, México) using TDEM

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SUMMARY

Alfajayucan aquifer (central Mexico) is located in a zone with a high demand of fresh water. Nevertheless, resource availability is lower in that area of the country. Therefore, this aquifer needs to be studied in order to understand its dynamic and propose the better area to drill new water supply wells. An integrated assessment was carried out in the area of San Agustin including Time Domain Electromagnetic soundings (TDEM) and a detailed lithological prospection. The fieldwork allowed characterize the different geoelectrical layers in the Alfajayucan aquifer that were correlated with the geological and hydrogeological acquired information. Four main geoelectrical layers were identified: 1) A shallower resistive layer U1 (40-100 ohm-m) that seems to be an unconfined aquifer of granular composition, 2) A high resistive layer U1a (embedded in the unit U1) that serves as recharge zone, 3) A low resistivity layer U2, related with a mixed aquifer, 4) A conductive layer U3, related to an aquitard that confines the upper aquifer in the eastern side. Finally, it was concluded that the area where the unit U2 is shallower, is the best place to drill a water supply well.

Keywords: Aquifer characterization, Time Domain Electromagnetics, Drinking water supply.

INTRODUCTION

The recent increase of the population in central Mexico as well as the agronomic development of the region has substantially increased the demand for fresh water resources. Fresh water scarcity in this area has prompted a series of studies devoted to understanding the dynamics of the aquifers involved as well as potential sources of drinking water in this area.

A multidisciplinary study has been implemented in the zone (San Agustín village) in order to understand the origin and dynamics of the Alfajayucan aquifer system. This study includes a detailed lithological description, hydrogeological and geophysical prospecting. This work is focusing on geophysical characterization that allows us to identify the structures that are potential water reservoirs.

GEOLOGICAL SETTING

San Agustin village is mainly built on volcanic deposits from the Cenozoic age, which are represented by sandy tuffs, lava flows and andesitic-basaltic conglomerates (Aguirre-Díaz and López-Martínez, 2009). Also, there are piroclastic and volcanic deposits ranging from Miocene to Pliocene (Figure 1).

GEOPHYSICAL PROSPECTING

Among different geophysical techniques, we used the time domain electromagnetic method (TDEM), which is appropriated to characterize the electrical resistivity of the subsoil and has proved a valuable tool due its high sensitivity to conductive targets, impressive vertical and lateral resolutions and bigger depth according to array geometry size (Kaufman and Keller, 1983). TDEM physical principle involves the induction of a primary magnetic field through a square coil, which is abruptly interrupted in order to produce eddy currents into the subsurface. These currents will generate a secondary magnetic field, which can be detected by an appropriate receiver coil on the surface. The value and the decay rate of the measured voltage are used to estimate the resistivity distribution using appropriate inversion techniques (Nabighian and Macnae, 1991).

DATA ACQUISITION AND PROCESSING

Data acquisition was performed in two stages; the first one consisted of 26 electromagnetic soundings using coincident loop configuration, 300x300 m by side. This survey was done during November 2008. In the second stage, performed during August 2009, five electromagnetic soundings were acquired using coincident loop configuration, 150x150 m. All measurements were performed using a TerraTem equipment by Alpha Geoscience Co. The transmitting current reached between 7 and 8 amperes.

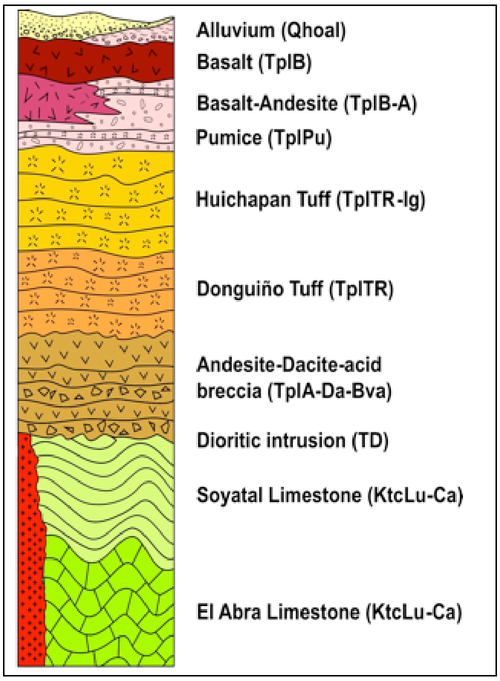

Figure 1. Stratigraphic column of the study area.

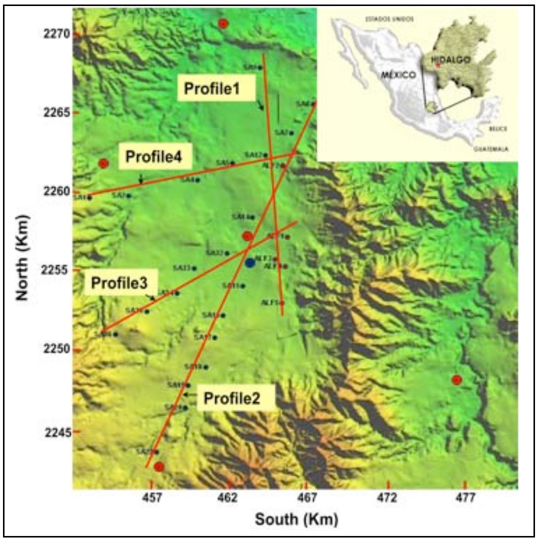

Figure 2. Survey location.

After editing and averaging the decay curves, final apparent resistivity vs. time curves were obtained for each TDEM station. Geoelectrical models were computed using Occam's inversion (Constable *et al.*, 1987). In order to obtain detailed information about the different hydrogeological layers, 4 profiles were EW direction (Profile 4 is shown in Figure 2).

DISCUSSION

Four different geoelectrical layers were inferred from interpreted profiles, which are described below:

- U1: This layer shows medium resistivities between 40 and 100 ohm-m, it could be related to a layer mainly built by sandy tuffs and sand and gravel deposits.
- U1-a: The layer shows high resistivities around 200 ohm-m. These resistivities can be associated to lava flows with andesitic and basaltic composition.
- U2: This horizon has low resistivities between 15 and 40 ohm-m that could be related with piroclastic flows from the Huichapan Tuff.
- U3: This conductive late (between 1 and 5 ohm-m) can be associated with ignimbrites from Huichapan Tuff or clayish material.

Geoelectrical model (Figure 3) show that the greatest potential of water saturation is located in layers U2 and U3. Actually, the already exploited aquifer in the zone is related to the layer U2.

Aquifer characterizacion

Geoelectrical models have been correlated with geological and hydrogeological information acquired in the study zone:

1. High resistivity values from geoelectrical layer U1-a are associated with fractured basaltic and andesitic flows that depict the unsaturated zone. This layer allows infiltration of rainwater into the lower layers, helping with the aquifer recharge.
2. Layer U1 can be an unconfined aquifer with a granular composition. The water table is located between 95 and 110 m depth. Lithological description includes piroclastic deposits of pumice with sand grain size.
3. Low resistivities reported in layer U2 are associated with piroclastic deposits building a mixed aquifer. This aquifer has the greatest potential for groundwater extraction.
4. The lowest resistivity values correspond to layer U3 and are associated to clayish material with low permeability. This layer can be related to an aquitard that confines the upper aquifer in the east and to depth.

CONCLUSIONS

The aim of this study was to characterize the electrical resistivity distribution in order to get a better insight in the hydrogeoelogical configuration of the Alfajayucan aquifer (Hidalgo, México). It was possible to locate the best places to drill an exploitation well to provide drinking water to San Agustín Village. We propose two options, where the unit U2 is shallower according to the geoelctrical model (located at 350 m and 1 km away from town). As it mentioned before, the geoelectrical horizon with the greatest potential is the layer U2, where it is expected find the water table around 110 m. Finally, TDEM provides accurate information about the distribution of electrical resistivities in the subsurface and helped us to establish the complete hydrogeological assessment in the study area.

ACKNOWLEGMENTS

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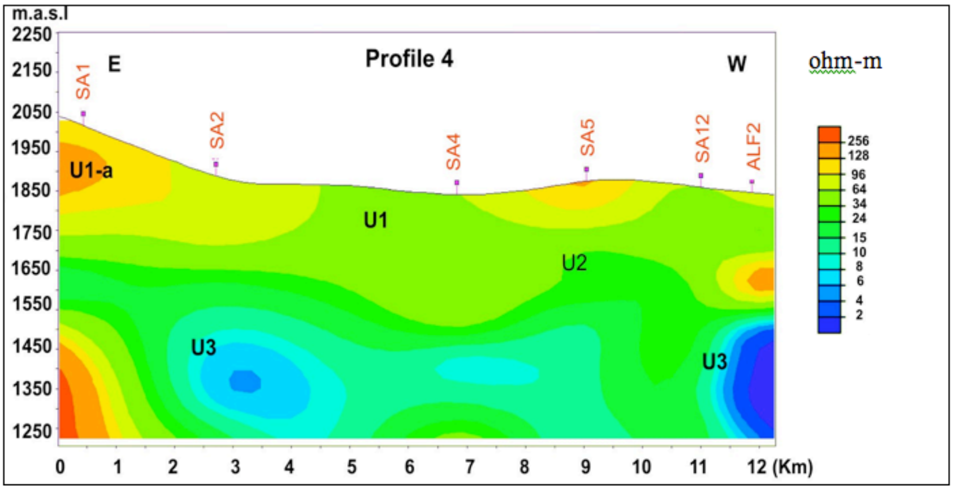

Figure 3. Geoelectrical model.