Geophysical Techniques for Hydrogeological Targets in the Semi-Desert Area in Southern Vietnam

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INTRODUCTION

The Binhthuan-Ninhthuan coastal area in southern Vietnam has an extensive red sand dune area about 90 kilometers long and 12 kilometers wide, extending from Ham Tan to Phan Rang. This is a typical semi-desert region. The Bac Binh study area in this sand dune area is located between north latitude $11^0$00' and $11^0$05'and east longitude $108^0$15' and $108^0$25' and is the driest area of the semi-desert region. Geophysical investigations were conducted to determine the hydrogeological conditions for locating groundwater aquifers. The geophysical methods used were geoelectric resistivity, electromagnetic soundings, and seismic prospecting.

Two local aquifers were determined from the geophysical data. One was a shallow aquifer with limited water-bearing potential and the other was a deeper aquifer, between depths of 40 and 90 meters, with good water-bearing potential. Two monitoring wells with depths of 63 and 71 meters and two test wells with depths of 95 and 110 meters confirmed the interpreted geophysical data. The water in these wells was good quality.

OVERVIEW OF RELIEF AND GEOLOGY OF THE STUDY AREA

The Bac Binh area is mainly a plain, though there are some hills that extend westward from the coast (Figure 1). The area's sedimentary units are mainly Pleistocene eolian, alluvial, and marine sediments. These sediments overlie igneous and metamorphic rocks, including dacite-rhyodacite, that have low potential as aquifers.

GEOPHYSICAL INVESTIGATIONS

Since the study area had a rainy season and a dry season, the geoelectric survey was done in the rainy season, this providing good contact of electrodes with the soil, and the seismic and electromagnetic surveys were done in the dry season.

The electric resistivity survey was vertical electric sounding. The Schlumberger configuration was used for this, with current electrodes AB=1000 meters, potential electrodes MN=100 meters maximum, and electrical profiling with AB=400 meters.

The seismic survey was a refraction survey. Four lines were surveyed, totaling 8200 meters. Lines had five shot points with 115-meter spacing. Geophone spacing was 2.5 and 5 meters.

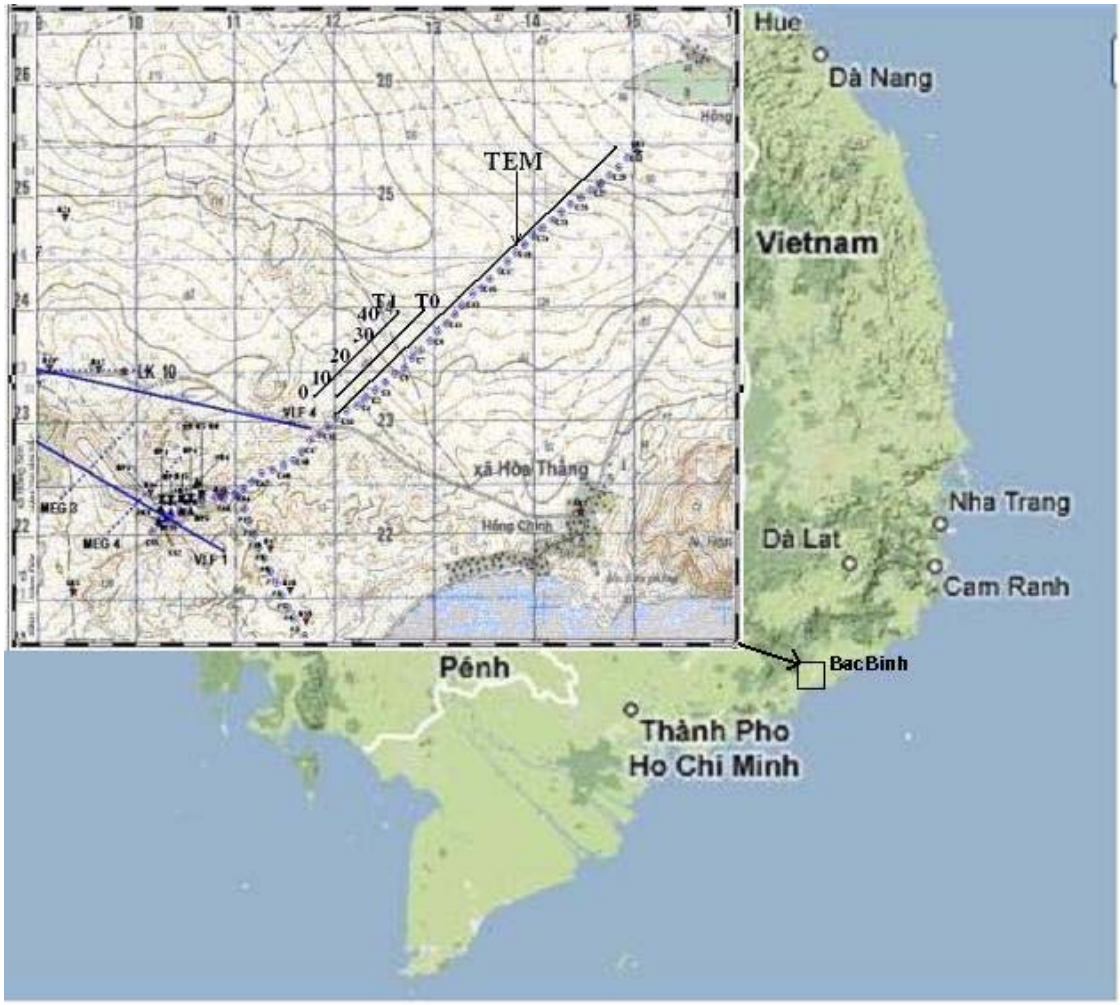

Figure 1. Location of study area and geophysical survey lines.

The electromagnetic methods used were magnetic resonance sounding, transient electromagnetic sounding, very low frequency electromagnetics, and ground penetrating radar. These methods investigated local geological structure and assessed the groundwater potential of study area.

The vertical electric sounding survey consisted of 126 stations along 12 profiles. A pragmatic approach was used for data interpretation. This allowed resistivity values of every layer of the model to be modified instantaneously by various steps from 0.1 to 1000 ohm-meters; similarly so for thickness values. This procedure allowed seeing the influence of each layer and, thus, to choose the most suitable model for the hydrogeological problem. The interpreted groundwater aquifer was at depths of 35 to 60 meters. The calculated resistivity values of the aquifer were about 20 ohm-meters, indicating that the groundwater is fresh water.

The four refraction lines shot indicate, on the basis of velocities, three zones above a basement bedrock. These are a surface layer with velocities from 400 to 800 meters per second and thickness up to 20 meters, a second layer with velocities from 800 to 1500 meters per second and thickness from 30 to 40 meters, and a third layer with seismic velocities from 1500 to 2800 meters per second and thickness from 50 to 60 meters. The basement bedrock has velocities over 3000 meters per second and is at depths of 60 to 140 meters. The time-distance curve and seismic refraction section of line T1 are shown in Figure 2. Line T1 is oriented northeast-southwest.

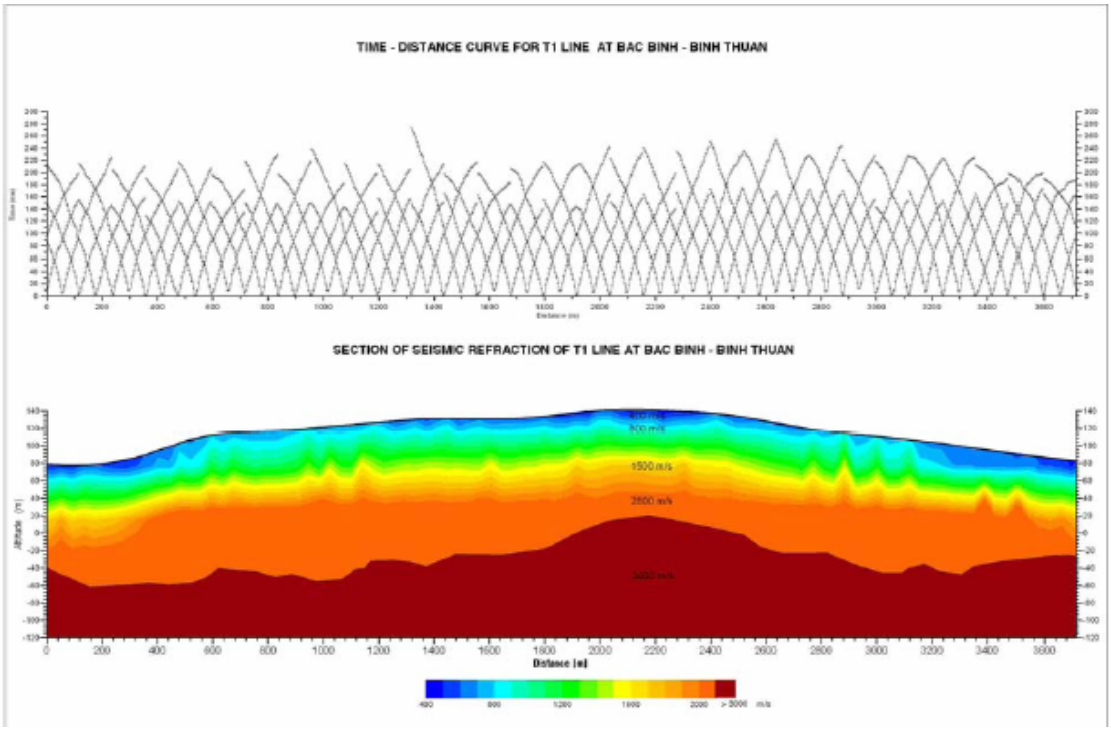

Figure. 2. Bac Binh seismic refraction line T1; velocity is meters per second

Magnetic resonance sounding and transient electromagnetic sounding were made along profiles T0, T1, and TEM (Figure 1). A geophysical datum always has of two elements, the measurement itself, the signal, and the uncertainty of the measurement, the noise. Electromagnetic background noise originates from various sources: the power supply, related man-made electrical installations, and lightning. Tests measurements were used to reduce the noise and increase the signal for choosing optimum configuration. Data sets were processed and interpreted by a modeling program for investigation of the hydrogeological condition, as well as for the layering structure and aquifers (Figure 3). Data interpretation indicated two groundwater aquifers (Figures 4 and 5). The shallow aquifer is at depths of 20 to 40 meters and has poor groundwater potential. The other aquifer is at depths of 60 to 90 meters and has good groundwater potential. The complex interpretation of

electromagnetic data shows that the magnetic resonance sounding and transient electromagnetic sounding are good correlation methods for locating and assessing aquifers in the sand dune study area. These electromagnetic data can be used to select locations for drilling ground water wells.

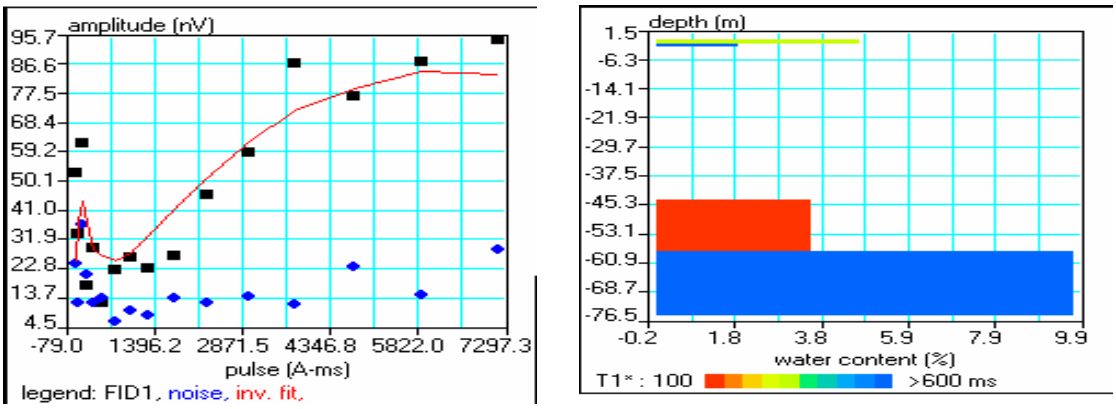

Figure 3. Interpretation of magnetic resonance sounding profile at point 10 of profile T1.

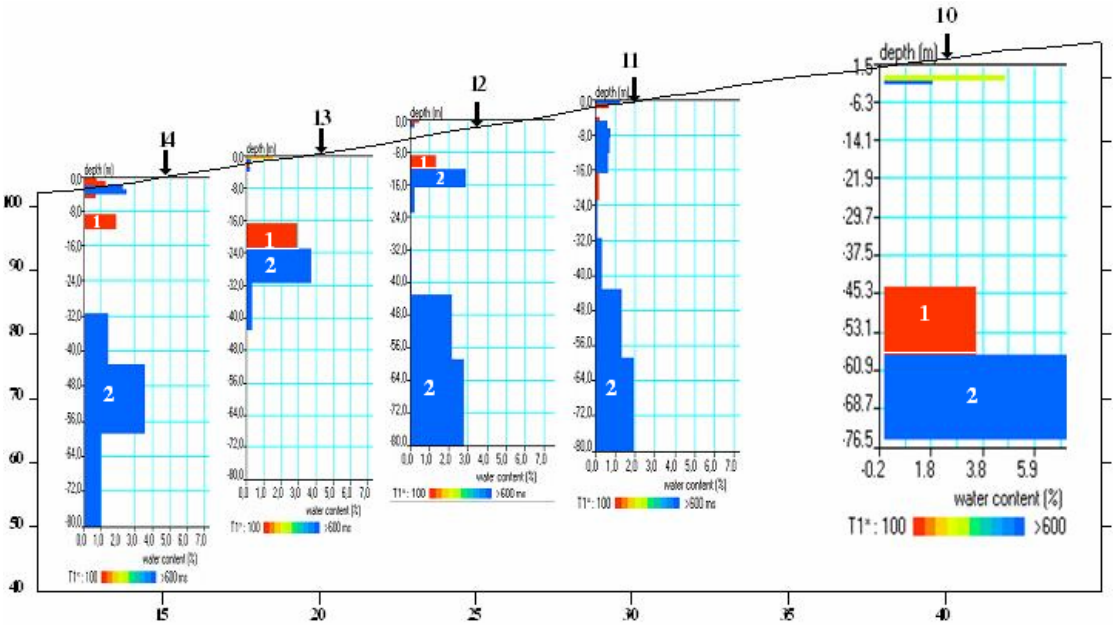

Figure 4. Results of interpretation for profile T1 by magnetic resonance sounding data; 1 is fine sand layer; 2 is coarse sand layer.

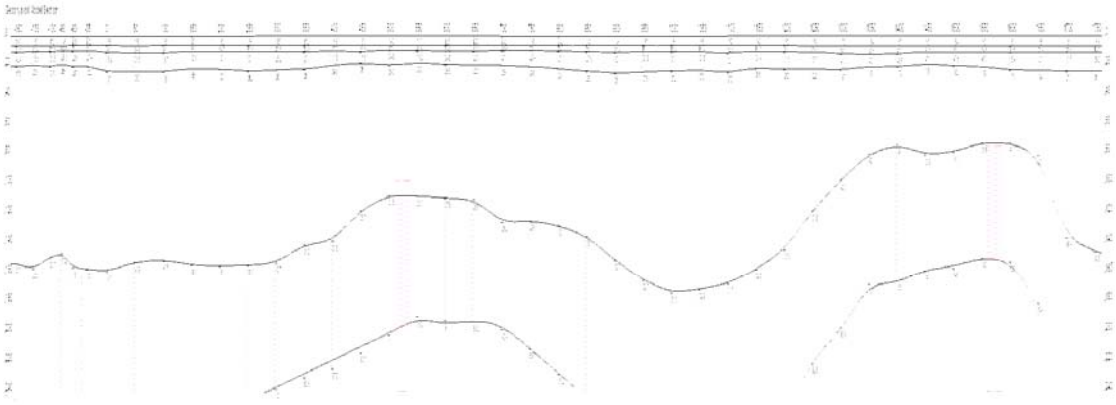

Figure 5. Geological structure of profile TEM by transient elecctromagnetic sounding data; section is 175 meters long; violet color indicates two aquifers.

The interpretation of the magnetic resonance sounding section indicates a 25- to 30-meter thick aquifer. The transient electromagnetic sounding investigation showed four layers, the third of which is an aquifer.

The aim of the use of multiple geophysical survey methods was the appraisal of the study area's hydrogeological potential by delineating the subsurface distribution of groundwater. In addition to this result, the relationships between parameters of surface and subsurface layers were determined and shown to be useful in identifying new sites that are suitable for monitoring and exploiting ground water.

The distribution of basement in the study area is shown in Figure 6. This distribution was confirmed by two monitoring wells with the depths of 63 and 71meters and by two test wells with the depths of 95 and 110 meters.

Aquifer testing began on 27 May 2005 and ended on 5 November 2005. Total time duration of pumping was 162 days. During this time, 33,598.8 cubic meters of groundwater were extracted.

CONCLUSIONS

The multiple geophysical survey techniques used successfully identified hydrogeological targets in the semi-desert Bac Binh area. These techniques delineated basement bedrock and the overlying sequence. The depth of basement mostly ranges from 60 to 150 meters but is 15 to 20 meters beneath hills. There are three sediment layers above the basement. One is the surface- near surface sand layer. The second and third layers are aquifers. The interfaces of these layers are defined by contrasting velocity values. The basement velocity is over 3000 meters per second and the velocity of the

overlying sediments ranges from 400 to 1500 meters per second. The third layer aquifer is saturated or semi-saturated sand. This aquifer does not underlie the entire Bac Binh area. Its top is 25 to 70 meters below the surface and its base is 80 t0 100 meters below the surface.

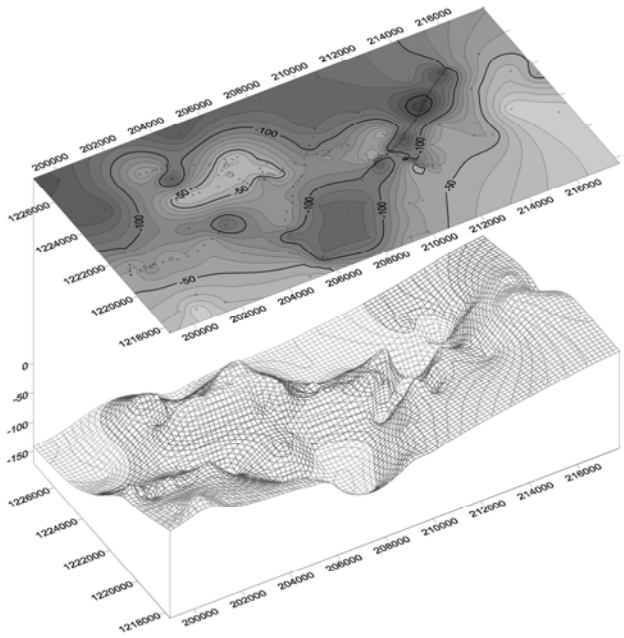

Figure 6. Distribution of study area basement, based on data from multiple geophysical survey methods.

The hydrogeological potential for increasing groundwater supply can be determined using multiple geophysical survey methods. These methods include resistiviity sounding, refraction seismic, very low frequency magnetics, ground penetrating radar, magnetic resonance sounding, and transient electromagnetic sounding. Interpretation of data from these various surveys can identify new sites that are suitable for monitoring and exploiting ground water.

ACKNOWLEDGMENT

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