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Characterization of aquifers in the Vientiane Basin, Laos, using Magnetic Resonance Sounding and Vertical Electrical Sounding

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ABSTRACT

The aim of this study is to define and characterize water bearing geological formation and to test the possibility of using geophysical techniques to determine the hydrogeological parameters in three areas in the Vientiane basin, Laos. The investigated areas are part of the Khorat Plateau where halite is naturally occurring at depths as shallow as 50 m in the Thangon Formation. Magnetic Resonance Sounding (MRS) has been used in combination with Vertical Electrical Sounding (VES) in different geological environments. In total, 46 sites have been investigated and the MRS and VES recognized the stratigraphic unit N_2Q_{1-3}, consisting of alluvial unconsolidated sediments, as the main water bearing unit. The aquifer thickness varies usually between 10 and 40 m and the depth to the main aquifer range from 5 to 15 m. The free water content is here up to 30%, and the decay times vary between 100 and 400 ms, suggesting a mean pore size equivalent to fine sand to gravel. The resistivity is highly variable, but usually around 10–1500 Ω-m, except for some sites in areas 1 and 2, where the aquifer is of low resistivity, probably related to salt water. Hydraulic and storage-related parameters such as transmissivity, hydraulic column, have been estimated from the MRS. The MRS together with VES has been shown to be a useful and important tool for identifying and distinguishing freshwater from possible salt-affected water as well as the salt-related clay layer of the Thangon Formation. This clay layer is characterized by very low free water content and a resistivity lower than 5 Ω-m and can be found in all 3 areas at depths from 15 to 50 m.

1. Introduction

Lao People's Democratic Republic (Laos) is located in the middle of south-east Asia bordering on Thailand, China, Burma (Myanmar), Vietnam and Cambodia (Fig. 1a).

Laos possesses great water resources as it has been estimated that 35% of all water in the Mekong River originates from watersheds in Laos, where 80% of the precipitation falls in the rainy season. The two most important socio-economic sectors to take advantage of this natural resource are irrigation and hydropower (STEA, 2001). The annual renewable fresh water supply per capita amounts to 54,000 m^3/person, compared to the current demand of 228 m^3/person. This makes Laos the richest country in Asia for renewable freshwater per capita. Still, only 60% of the urban and 51% of the rural population had direct access to a water supply in 1998 (STEA, 2001). The Vientiane Basin is located in the central part of Laos on the outer edge of the Khorat Plateau. In the basin, natural salt layers are found in the Thangon Formation. This affects the groundwater quality in some deep wells (JICA, 2000). Salinity problems are common in central Laos and central-eastern Thailand and have been studied by among others Srisuk et al. (1999), Wannakomol (2005), and Williamson et al. (1989).

Most Lao people live in the countryside and are heavily dependent on dug wells as their main water source, but also deep wells, river water and rainwater are used (Medlicott, 2001). Dug wells usually dry out during the dry period and in addition, water-borne diseases caused by the infiltration of domestic waste and excreta from farm animals, has led to a high morbidity rate (JICA, 1993; Medlicott, 2001). Deep groundwater has many advantages compared to surface water and shallow groundwater, since it demands little or no treatment and access is secured against temporary droughts. However, for exploration the small topography difference in the Vientiane Basin makes it difficult to evaluate the groundwater potential from the visible physical environment. Deep wells are expensive and unprofitable if drilling is made without knowing the groundwater potential and the location of salt-affected groundwater. Therefore, basic information that can guide drilling is essential.

One aim of this study is to investigate the efficiency of using Magnetic Resonance Sounding (MRS) to define and characterize water bearing geological formations according to their hydraulic and storage

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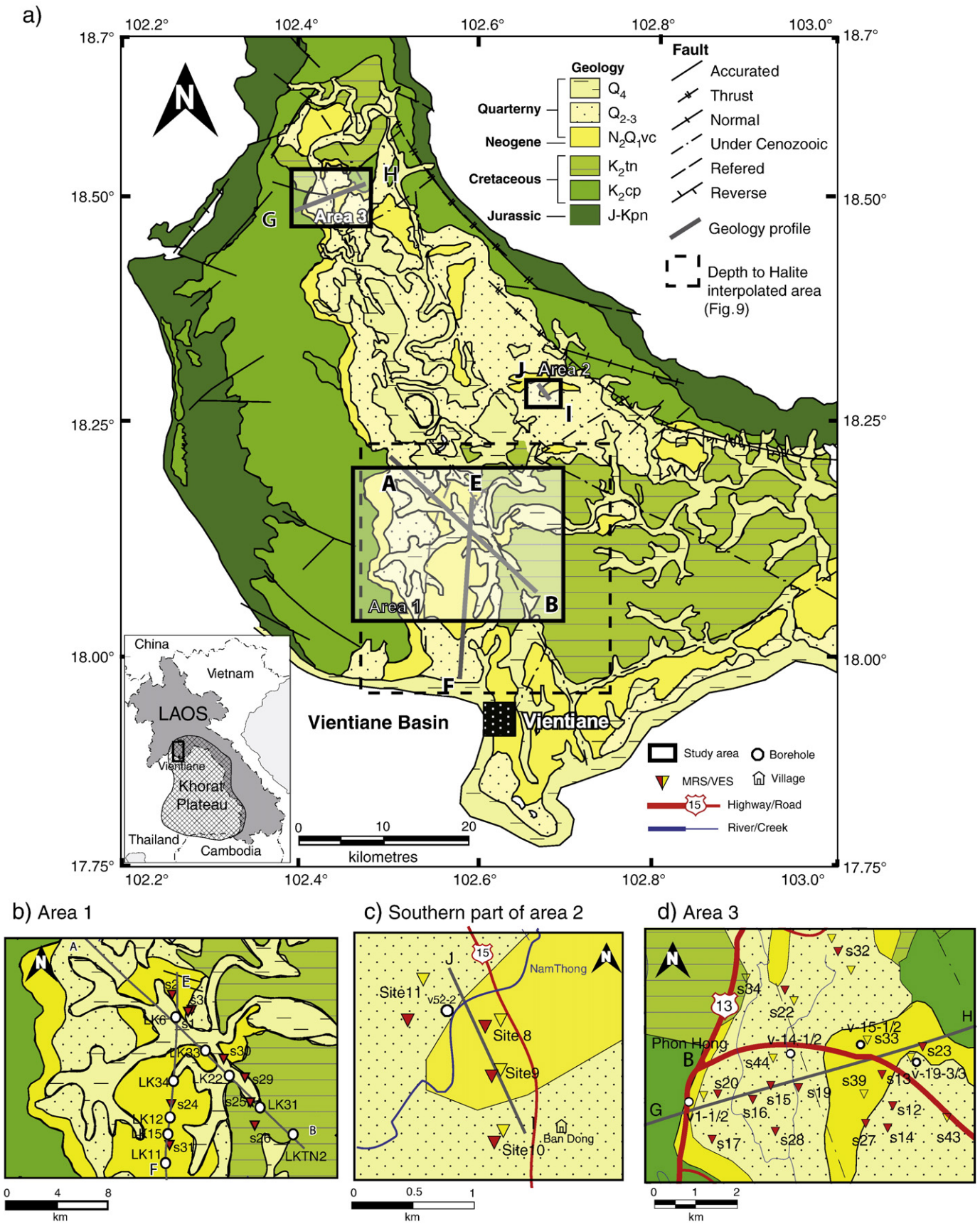

Fig. 1. a) Overview map inlet, showing the extent of the Khorat Plateau after El Tabakh et al. (1999) together with the Geology of the Vientiane province after Long et al. (1986). The hatched rectangle defines the area where halite depths have been determined from the borehole data in Fig. 9. A and B, E and F, G and H and I and J define profiles along which geophysical and geological data are presented. Three study areas are defined with rectangles and are shown in b) area 1, c) area 2 and d) area 3.