Transboundary Aquifer of Northern Thailand

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Abstract

Detailed hydrogeology of the Chiang Rai and Pha Yao Provinces in northern Thailand was studied by the Department of Groundwater Resources, aiming for a proper groundwater management. Conjunctive use of surface water and groundwater is planned as a part of a green society development project. The area covers 11,000 square kilometers of alternating hills and plains that is divided into five basins, namely Mae Sai, Chiang Rai, Mae Suai, Wiang Pa Pao, and Phan–Pha Yao basins. The Mae Sai and Chiang Rai basins are located in the northernmost part of Thailand and is hydraulically connected to Mekong River and the adjacent areas of Myanmar and Lao PDR. The aquifers in the basins are characterized by both hard rocks and unconsolidated sediments. Included are granite, sandstone, limestone, and volcanic rock aquifers at the depth of 20-80 meters with a yield of up to 30 m^3/hr, and the sand-gravel aquifers that may reach the depth of 250 meters with a yield of up to 50 m^3/hr. Groundwater quality is generally characterized by high iron content, and in some places, by high manganese and fluoride contents. Groundwater flow direction, aquifer hydraulic properties, groundwater potential and groundwater uses are also assessed.

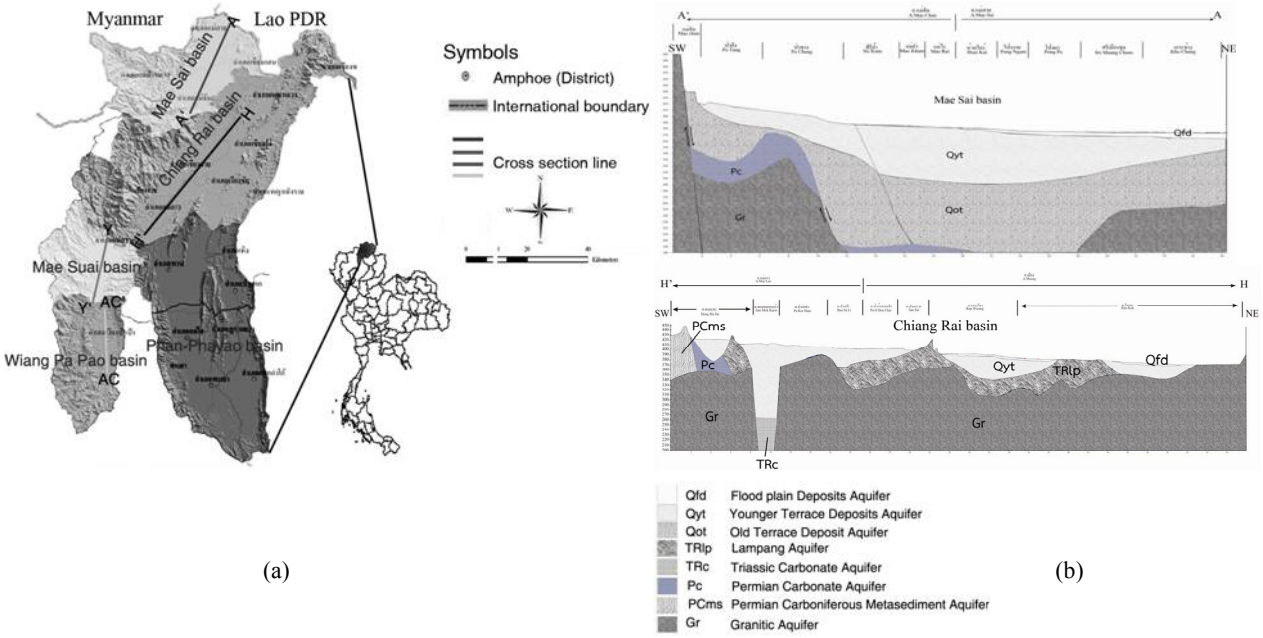
This study provides a basic knowledge that benefits the Mekong River Commission (MRC) countries and also Dialogue Partners of the MRC, i.e. Cambodia, Lao PDR, Vietnam, Thailand, China and Myanmar. Joint management of their shared water and related resources would form a strong foundation for sustainable development and poverty alleviation in the Greater Mekong Subregion.

Keywords: Transboundary Aquifer, Northern Thailand, Mae Sai Basin, Chiang Rai Basin, Mekong River

1. INTRODUCTION

Detailed hydrogeology of the Chiang Rai and Pha Yao Provinces in northern Thailand was studied by the Department of Groundwater Resources, aiming for a proper groundwater management. The area covers 11,000 square kilometers of alternating hills and plains, characteristics of a basin and range topography, and is divided into five basins, namely Mae Sai, Chiang Rai, Mae Suai, Wiang Pa Pao, and Phan-Pha Yao basins (Fig.1). Towards the north, northeast, and east of the area are Myanmar and Lao PDR. The Mae Sai river marks the border between Thailand with Myanmar while the Mekong river marks the border between Thailand, Myanmar and Lao PDR. The oldest rocks in the area are Precambrian high-grade metamorphic rocks, and the youngest is unconsolidated sediments of Quaternary period (Department of Mineral Resources, 2005). The geological structures of northern Thailand are characterized by folded Paleozoic-Mesozoic sediments and metamorphics superimposed by a series of Cenozoic extensional basins. The tectonic model explaining the formation of these intermontane basins is ascribed either as pull-apart basins associated with strike-slip faulting or extension and changing stress system related to the Tertiary-aged escape tectonics of Southeast Asia (Morley,2002).

The study aims to assess the groundwater potential of the area for a proper groundwater management. Conjunctive use of surface water and groundwater is planned as a part of a green society development project. This paper focuses on Mae Sai and Chiang Rai basins, which are hydraulically connected to Mekong river and areas of Myanmar and Lao PDR.



(a) (b)

Fig.1 (a) The Mae Sai, Chiang Rai, Mae Suai, Wiang Pa Pao, and Phan –Pha Yao basins in the northern Thailand, and (b) geologic cross-sections of the Mae Sai and Chiang Rai basins.

2. METHODS

To collect information used for assessing the groundwater potential of the study area, the following activities were performed:

1. Collection of available existing data on hydrogeology of the area, such as groundwater maps, well locations with well information and tests.
2. Resistivity surveys across the basins with Schlumberger and dipole-dipole configuration, with a maximum depth of about 200 meters.
3. Borehole drilling in 10 differences consolidated and unconsolidated aquifers. Core samples and cuttings were collected. Geophysical loggings were performed.
4. Setting up the composite monitoring wells with one test well and two observation wells at each site.
5. Pumping tests of 12 and 72 hours pumping period with a constant rate were performed in wells perforated in targeted aquifers, with a number of 100 wells and 16 wells, respectively. Data were analyzed using Aquifer Test v 2.57
6. Water level measurements and water samplings for complete chemical analyses.
7. Installation of piezometers in monitoring wells.

3. AQUIFERS AND HYDRAULIC PROPERTIES

The Mae Sai basin covers an area of 2,300 square kilometers. The recharge areas are located along the basin margin. The aquifers in the basin are both hard rocks and unconsolidated sediments. Included are carbonate aquifer at the depth of 20-80 meters with a yield of up to 30 m^3/hour, and the sand-gravel aquifers reaching the depth of 250 meters at the basin center, with a yield of up to 50 m^3/hr. The unconsolidated aquifers can be divided into (1) floodplain aquifer, 20-30 meters thick, composed of fine to medium sands, with a yield of 5-10 m^3/hr. (2) young terrace aquifer, 30-65 meters thick, composed of sands and gravels with interbedded clays, with a yield of 10-20 m^3/hr, and (3) old terrace aquifer, more than 150 meters thick, composed of sands and gravels with interbedded clays, with a yield of over 50 m^3/hr. Well drilled at Ban Hong Hae School, located near the center of the basin, yields flowing artesian water about 1.5 meters above ground surface (Fig.2).

The Chiang Rai basin covers an area of 2,500 square kilometers**,** with the recharge area and bedrock outcrops around basin periphery. The aquifers of the Chiang Rai basin are both hard rocks and unconsolidated sediments. Hard rock aquifers include granite, sandstone, limestone, and volcanic rock, at the depth of 30-80 meters with a yield of less than 2 m^3/hour. Sand and gravel aquifers may reach the depth of 50 meters near the basin center, with a yield of 10-20 m^3/hr.

The NE-SW cross-sections of the Mae Sai and Chiang Rai basins are shown in figure 1. The hydraulic properties of aquifers resulted from pumping test analyses are shown in table 1.

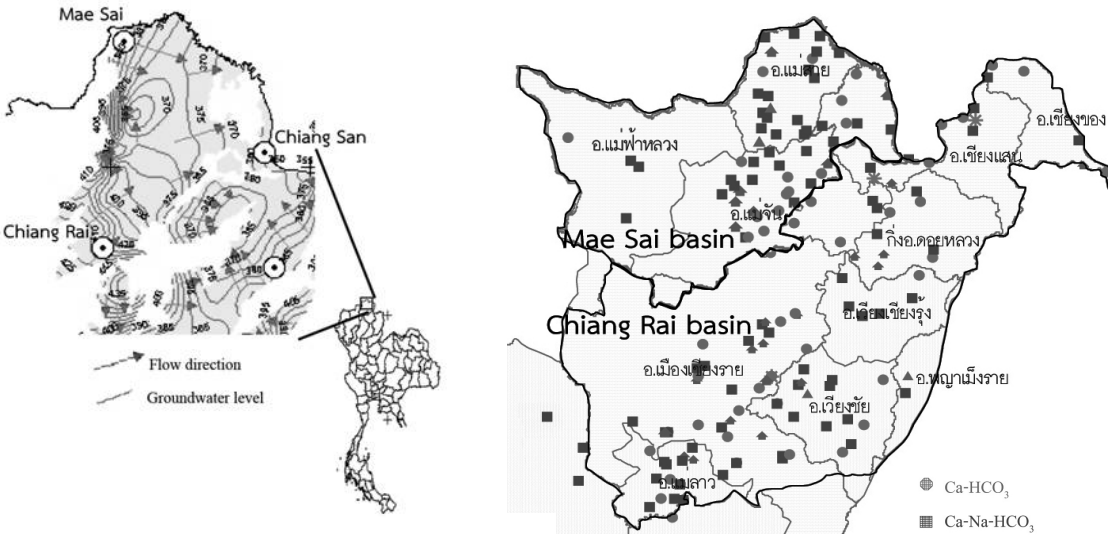
Table 1 Hydraulic properties of difference unconsolidated aquifers (Department of Groundwater Resources, 2009).

Aquifers	Transmissivity (m^2/d)	Hydraulic conductivity (m/d)
Floodplain (Qfd)	1.18 - 2,956.00	0.19 - 493.00
Young Terrace (Qyt)	0.50 - 569.33	0.08 - 189.73
Old Terrace (Qot)	0.24 - 698.00	0.02 - 42.88

Fig.2 Flowing artesian well in Mae Sai basin, depth of 200 meters with 50-60 m^3/hour.

4. FLOW DIRECTION AND QUALITY

Groundwater level of inventory wells in the Mae Sai and Chiang Rai basins were measured and plotted as the flow net diagram to assess the flow directions. In the Mae Sai basin, the flow directions are from west to east and from south to north. The flow direction in the Chaing Rai basin is from southwest to northeast (Fig.3). Groundwater samples were also taken for physical and chemical analyses twice a year, one in January (winter) and another in April (summer). The plots in Piper diagram show slight variation for both sampling periods. The major cations are calcium and in some places calcium and sodium while the major anions are bicarbonate. The typical hydrochemical facies of three different types of unconsolidated aquifers are calcium-bicarbonate, and calcium-sodium-bicarbonate (Fig.3). Groundwater quality is characterized by high iron content, and in some places, by high manganese and fluoride contents.



(a) (b)

Fig.3 Groundwater flow direction (a) and hydrochemical facies (b) of the Mae Sai and Chiang Rai basins.

5. CONCLUSIONS

The preliminary data reported here do not constitute a complete assessment of the transboundary aquifers in this region. However, the results reveal several key indicators to support the existence of the Mae Sai and Chiang Rai transboundary aquifers: (a) the thickness of unconsolidated sediments with a high yield of flowing artesian water, (b) geologic cross-sections showing the extent of aquifers beyond the borders of Thailand, Myanmar, and Lao PDR, and (c) groundwater flow of north and northeast directions toward the Mekong river.

This study provides a basic knowledge that benefits the Mekong River Commission (MRC) countries and also Dialogue Partners of the MRC, i.e. Cambodia, Lao PDR, Vietnam, Thailand, China and Myanmar. Joint management of their shared water and related resources would form a strong foundation for sustainable development and poverty alleviation in the Greater Mekong Subregion.

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REFERENCES

Department of Groundwater Resources (2009): *Groundwater potential assessment of Kok watershed (Chiang Rai and Pha Yao Basin*). Bangkok, Thailand.

Department of Mineral Resources (2005): *Geologic map of northern Thailand (digital version, scale 1:250,000 and 1:50,000)*. Bangkok, Thailand.

Morley, C.K. (2002): A tectonic model for the Tertiary evolution of strike-slip faults and rift basins in Southeast Asia. *Teconophysics*, 347: 189-215.