

# The Study on Groundwater Development in Central Cambodia

## Final Report

### Main Report

LOCATION MAP

EXCHANGE RATE AND LIST OF ABBREVIATION

EXECUTIVE SUMMARY

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## CHAPTER 4

### GROUNDWATER INVESTIGATION



## CHAPTER 4 GROUNDWATER INVESTIGATION

### 4.1 Topography and Geology

The results of investigation are presented in the **topographical map** and the **hydrogeological map**. The following explanation is based on these maps.

#### 4.1.1 Kg. Chhnang Province

##### A. Topography

In the western area of Kg.Chhnang, the eastern end of Cardamom Massif is extending. The highest point is 1,550m. In the eastern half of this Province, on the other hand, low wetlands formed by Tonle Sap river are widely distributed (present flood area falls the area lower than 10 meters in elevation). Between the above mentioned two areas, gentle slopes with 1/3,000~1/4,500 in inclination are widely distributed lower than 100m in elevation (these slopes are covered by thick sand and poor in vegetation showing scenery like desert).

Many isolated hills outstanding in low wetlands and gentle slopes with less than 200m in relative height are unique landform in this Province. Such isolated hills are called “Phnom” and most of them have a temple at its top. The isolated hills outstanding on both sides of Thonle Sap River near Kg. Chhnang City are large in scale and the highest point is 429m.

##### B. Geology

In Cardamom Massif and many isolated hills, hard sedimentary, metamorphic and igneous rocks formed in Paleozoic and Mesozoic Eras are distributed. These rocks compose basement rocks all together.

In low wetlands of Tonle Sap River, unconsolidated sand and mud formed in recent age (Alluvium) is widely distributed. On the gentle slopes between Cardamom Massif and Tonle Sap River, geological outcrops are scarce due to thick cover of sand derived from the basement rocks. However, synthesizing the results of electric sounding and test drilling, it is deduced that the basement rocks are widely distributed shallower than 30m under the ground surface (see geological cross section).

The unconsolidated sediments covering the basement rocks is characterized by sand layers

containing well sorted quartz grains and a turmeric yellow clay layer. Evidence showing its sedimentary environment and geological age are not found yet, however, it is deduced that this layer was deposited in fresh water areas in Pleistocene.

In Kg. Chhnang Province, many rivers are seasonal and many existing dug wells dry up in dry season. Therefore, many villages are lacking of drinking water in dry season.

According to the results of test drilling, groundwater was not obtained from the unconsolidated sedimentary layers but only from fissure zone of basement rocks. Horizontal electric sounding survey should be carried out to investigate groundwater in the basement rocks since vertical electric sounding is not effective to find fissure zones in the basement rocks. At R035G, fissure zone was found by horizontal electric sounding and enough groundwater was obtained.

The buried valley carving the basement rocks is worth to notice in the geological structure of Kg. Chhnang. This buried valley extends from NNW to SSE direction along the rise of the basement rocks distributing along National Road No.5. According to the results of electric sounding survey, the deepest part of this buried valley is more than 50m in depth. It is supposed that thick Quaternary sediments are deposited within this buried valley, and important aquifer might be found though it was not confirmed in the test drilling survey.

#### **4.1.2 Kg. Cham Province**

##### **A. Topography**

Mekong River changes its flow from EW to NS in direction and the width of its river bed (lower than 10m in elevation) is narrow in the northern area of this Province. On the other hand, various size of sandbanks and wide wetlands are found in the southern area because the width of river bed becomes wide and the flow speed down.

Rivers and streams in this Province are classified into the following five systems.

- 1) the river system directly flowing into the trunk of Mekon River from the eastern side
- 2) the river system directly flowing into the trunk of Mekon River from the western side
- 3) the river system flowing northward and join to Steung Chimit River, the branch of Tonle Sap River
- 4) the river system flowing southward and join to Song Vam Co Dong River, the branch of Basak River
- 5) the river system flowing southward and join to Chhlong River, the branch of Mekong

## River

The almost part of the divide are plateaus with flat top. Plateau units are discriminated as six in the western area and seven in the eastern area. Each plateau unit has nearly elliptical shape with long axis of 10~20km and short axis of 5~15km. The relative height is 20~120m. Old explosion vent, volcanic crater or volcanic cone are often accompanied with these plateau.

## B. Geology

Basaltic rocks consisting plateaus with flat top characterize and make complicate geology of Kg. Cham Province. These basaltic rocks are members of plateau basalt distributed widely in the southern Indochina Peninsula. According to the existing data, the eruption age of such basalt is 2.60Ma~1.77Ma (late Pliocene~early Pleistocene).

At some test drilling sites, unconsolidated sediments which is similar to the one in Kg. Chhnnag Province are found beneath this basalt layer. At the other test drilling sites, however, the similar sediments are also found in the upper horizon of this basalt layer.

Though the maximum thickness of the basalt layer confirmed by test drilling was 32m, total thickness of it is estimated as 90~160m when the elevation of top and bottom were compared by unit plateau. But, it is possible that the basalt layer does not consist of a single lava but plural lava intercalating unconsolidated sediments.

This basalt is deduced as lava or pyroclastics erupted in the terrestrial environment. On the basalt plateaus covered by thick laterite (red soil), vast rubber plantations are developed and vegetation is also rich. Pepper and coffee field, orchard and etc. are developing.

The unconsolidated sediments beneath the basalt layer might be formed in Pliocene because the age of the basalt is early Pleistocene. Though the basalt consists of plural beds of lava or pyroclastics intercalating unconsolidated sediments, it was represented by a single basalt layer in the hydrogeological map.

At some test drilling sites, basement rocks are confirmed under the above mentioned unconsolidated sediments (mainly black sandstone). Such basement rocks crop out in the limited area of isolated hills or river bed lower than 60m in elevation.

It is difficult to distinguish basalt from the basement rocks based on the electric resistivity value and to draw the contour lines representing the upper surface of the basement rocks

because basalt layers widely lie in Kg. Cham Province with various depth.

#### **4.1.3 Geological Unit**

Based on the geological investigations of the Study and some related literatures, geologic units in the Study area are summarized as shown in Table 4.1.1.1.

Alluvial deposits consists of gravel, sand, clay and silt. The gravel and sandy layers form aquifer, but silt and clayey layers form aquitards or aquicludes.

Basalts of Quaternary and Plio-Pleistocene age, which occurs in Kg.Cham province, are classified as aquifers. It was confirmed by test well drilling in the Study. Sand and gravel layers of upper and lower Pleistocene unconsolidated sediments also form aquifers. The rocks of Mesozoic to Paleozoic are mainly composed of sandstone, granite and rhyolite They are called basement rocks. Generally those fresh bedrocks are solid, massive and compact so that they are treated as an impermeable basement or a hydrogeologic basement. However, weathered rocks and fractured rocks can be classified as aquifers when they yield significant quantities of water to wells and springs.

#### **4.1.4 Hydrogeologic Structures**

The main hydrogeologic structure in the Study area is the top surface of basement rocks. To estimate basement rocks depths at different places, geophysical survey was carried out by the Study. The Wenner's electrode configuration was employed for the resistivity sounding (See **Supporting Report**).

In the hydrogeological map of Kg.Chhnang, the estimated basement rocks depth based on the results of resistivity sounding and test well drilling is presented. The contour lines of depth to basement rock were drawn considering the bedrock exposures in and around the Study area. These contour lines suggest that a buried valley carved on the basement rocks runs side by side with the chain of the isolated hills along National Road No.5. This buried valley extends from NNW-SSE direction with about 10km in width and more than 50m in depth.

In Kg. Cham Province, the basement rocks crop out in limited areas, but it was confirmed at some test drilling hole in Memot District. Electric resistivity data also suggest that the basement rocks distribute in a shallow depth in plateau areas. However, it is difficult to draw the contour lines representing the surface of the basement rocks in this Province since basalt also shows high resistivity as well as the basement rocks.

**Table 4.1.1.1 (1/2) Geological Units Applied to This Study****Kg. Chhnang Province**

<b>Geologic Age</b>	<b>Facies</b>	<b>Sedimentation Environment</b>	<b>Thickness (m)</b>	<b>Distribution</b>		<b>Related Topography</b>
				<b>Area</b>	<b>Elevation</b>	
Holocene	Alluvial sand	Recent river bed	less than 10m	riverbed of Tonle Sap River and its tributaries	lower than 10m	Alluvial plain
	Alluvial clay	Recent lake and marsh				
	Residual sand	foot of a mountain / hill	less than 100m	<ul style="list-style-type: none"> <li>- eastern foot of Cardamom Massif</li> <li>- foot around the hills near Kg. Chhnang City</li> <li>- foot around the hills in Kg. Leng District</li> </ul>	higher than 50m  higher than 20m  higher than 20m	talus slope
Pleistocene (including Pliocene)	Sand and clay - coarse to medium sand rich in quartz grains - turmeric yellow colored clay	Pleistocene fresh water area	less than 20m (more than 100m in the buried valley)	gentle slopes spreading out from the foot of Cardamom Massif to Tonle Sap River	higher than 10m (except in the buried valley)	gentle slope (pediment) buried valley
Pre-Tertiary	Basement rocks (Sandstone, Granite, Rhyolite etc.)			isolated hills		isolated hills buried pediments shallower than 30m under GL

**Kg. Cham Province**

Geologic Age	Facies	Sedimentation Environment	Thickness (m)	Distribution		Related Topography
				Area	Elevation	
Holocene	Alluvial sand	Recent river bed	unknown	river bed of Mekong River and its tributaries	lower than 10m	Alluvial plain
	Alluvial clay	Recent lake and marsh				
	Laterite	terrestrial environment	less than 40m	uppermost part of plateaus formed by basaltic lavas	higher than 50m	flat top of plateau
Pleistocene	Basaltic lava with sediments	terrestrial environment	90 ~ 160m (including laterite and intercalating sediments)	plateaus (unit ~ )	highest point : 218m (including laterite) lowest level : -12m (R214M)	plateau
Pliocene (including Pleistocene )	Sand and clay Coarse sand is rich in quartz grains. Red or brown sticky clay is often intercalated.	Pliocene fresh water area	more than 80m	widely in the Study area	lower than 100m	flat plain around the foot of a plateau
Pre-Tertiary	Basement rocks (mainly sandstone)					