

## Chapter 2 Occurrence of GW

- where and how GW exists
- subsurface distribution
- geology formation (water-holding, water yielding capabilities)

### 2.1 origin and age of GW

Meteoric (surface and atmospheric) waters

Connate water (fossil interstitial water)

Magmatic water (water from magma, plutonic)

Volcanic water (shallow water 3-5 km)

Oceanic water

Juvenile water (new water)

Metamorphic water (water with rocks)

→ Fig 2.1.1

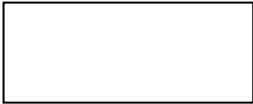
Residence time of water underground (isotope)

→ Equation 2.1.1

(e.g., hydrogen-3, carbon-14, tritium, O14 (for young water))

### 2.2 Rock Properties

→ aquifer = groundwater reservoir / water bearing formation

aquiclude	}	(saturated, clay)	
aquifuge		(impermeable, granite)	
aquitard		(saturated, sandy clay)	

Porosity

effective porosity : space available for fluid flow

primary / secondary porosity

granular sedimentary deposited → Porosity

Eq. 2.2.1, 2.2.2

shape, arrangement of individual particles

distribution by size , degree of compaction , cementation

Fig 2.2.1

Table 2.2.1

sample

Soil Classification

- particle size
- uniformity coeff.
- Specific surface ( $m^2/g$ )
- Area per unit weight

Uniformity coefficient

Table 2.2.2

Fig 2.2.3, 2.2.4 (representative)

Surface area (Table 2.2.3)

Sample

### 2.3 Vertical Distribution

Fig 2.3.1 divisions of subsurface water

(saturation, unsaturation, vadose, gw)

### 2.4 Zone of aeration

Soil water zone

Capillary zone

Water content measurement

- Available water
- Field capacity
- wilting pt

Specific retention  $(S_r) = \frac{W_r}{V}$

Specific yield  $S_y = \frac{W_y}{V}$

Total 2.5

Well pumping

## 2.5 Zone of saturation

Specific retention

Specific yield (Table 2.5.1)

## 2.6 Geologic Formation as aquifers

Alluvial deposits

- water courses
- abandoned or buried valleys
- plains

intermontane valleys

Limestone

Volcanic

Sandstone

Igneous

Clay

(see Thailand hydrogeologic map)

## 2.7 Types of Aquifer

Unsaturated aquifer

Confined aquifer

Leaky aquifer

Idealized aquifer

Fig 2.7.1

## 2.8 Storage coefficient

Volume of water that an aquifer releases or takes into storage per unity surface area of aquifer per unit change through a confined aquifer (see Fig 2.8.1 a)

Values fall in the range of 0.00005 – 0.005

Rule-of-thumb relationship for a confined aquifer

$$S = 3 \times 10^{-6} b \quad (2.8.1)$$

Storage coefficient for an unconfined aquifer  
(Fig 2.8.1 b)

### 2.9 groundwater basin

Hydrogeologic unit containing one large aquifer of several connected and interrelated aquifer.  
(Fig 2.9.1) Thailand case

### 2.10 Springs

A concentrated discharge of groundwater appearing at the ground surface as a current of flowing water.  
(different from seepage areas).

5 types (Fig 2.10.1)

Classification by discharge (Table 2.10.1)

Sample of gaining/losing streams by dye tracers or water balance.

### 2.11 Hydrothermal phenomena

Thermal springs (warm or hot springs, geyser)

Geothermal Energy springs

(dry, wet, low temperature, dry rock)

### 2.12 Groundwater in permafrost regions

Perennially frozen ground (unconsolidated deposits or bedrock that continuously have had a temperature below 0 degree C for two years to thousands of years.

Creates an impermeable layer --- acts as a confining layer.

### 2.13 Groundwater in US

Productive aquifer, withdrawals from the wells in the US  
Aerial distribution of groundwater in the US

## 2.14 Groundwater in Thailand

(Ms. Somkid's presentation)

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