GEOLOGICAL STRUCTURE CONTROL TO GEOMETRY OF GROUNDWATER BASIN IN THE NON-BASIN AREA OF GROUNDWATER, DISTRICT NGLIPAR AND GEDANGSARI DISTRICT GUNUNGKIDUL, SPECIAL REGIONS OF YOGYAKARTA

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Abstract

Nglipar and Gedangsari Districts are located ± 18 km to the east of Yogyakarta city, administratively located in Gedangsari and Nglipar Districts of Gunungkidul Regency, Special Region of Yogyakarta, covered in Geology Map of Surakarta-Giritontro sheet, Java, map number 1408-3 and 1407-6 with scale 1: 100.000 magnification 1: 20.000 with research area ± 70 km^2. Groundwater is water moving in the soil or rocks that exist in the space between grains of soil, which seep into the soil and combine to form a soil layer called the aquifer. The formation of groundwater influenced by several factors among others, is the nature of the rock in this case as the primary porosity and geological structure that can become secondary porosity formed in the zone of geological structure due to impermeable layer. The groundwater system at the study site can be determined by correlation of surface data in the form of rock lithology, geological structure, and subsurface data in the form of geophysical measurement data of geoelectric and well logging methods, aquifer system obtained in the form of aquifers between grains and fracture aquifers. The fracture aquifer is formed by the presence of stocky and caesarean that has a role as a groundwater store, in other words as an aquifer, And as a place to drain groundwater from surface to below surface and vice versa that characterized by the presence of springs. The geological structure that develops in the location of the research is the position of rock layers, the fracture structures that have four direction patterns of north-east, west-east, northeast-southwest and north-south, and fault structures with three fault patterns ie north-south, northeast-southwest and south-western, The geological structure is very influential in the ground water system at the study site.

***Keywords**: geological structure, groundwater, lithology*

INTRODUCTION

Groundwater is one of natural resources that serves to support life and development activities. Until now, groundwater in the Gunungkidul area is still the main source to meet the needs of raw water for the population, both for drinking water, households, irrigation water and industrial water, so that ground water is a natural wealth that fulfills the livelihood of many people.

The important role of ground water, when over-exploited exceeds the available potential, will have a negative impact on the quantity and quality of the groundwater itself and the environment.

The groundwater basin, naturally constrained by hydraulic boundaries controlled by local geological and hydrogeological conditions. The northern Gunungkidul area is classified as a Non Groundwater Basin area (Hendri Setiadi, 2008), controlled by rock layers of ancient volcanic products which have been solid and unfavorable as primary pore aquifers. Therefore, it is necessary to have a research of geological structure as a discourse of secondary porosity to determine the limits of

groundwater zone that can be used in the region as a supporting tool for the region and the community in the framework of groundwater management. Therefore, the authors conduct geological and hydrological research to techn structure ically determine the boundaries of groundwater zone in the northern Gunungkidul region, either strike sliply or vertically by determining in detail the hydrogeological configuration of the groundwater zone.

The location of the research area of Geological Structure Control to Geometry of Groundwater Basin in the Non-Basin Area of Ground Water is administratively located in Gunungkidul Regency North, Yogyakarta Special Region. The research location is ± 17 km to the east of the city of Yogyakarta and is located in the northern part of Wonosari town of Gunungkidul Regency. Research location can be reached by using two-wheeled vehicles for ± 1 hour from the city of Yogyakarta with a relatively good road conditions to the location of the study and continued on foot to reach the location of the research detailed trajectory.

RESEARCH METHOD

To carry out the research and to achieve the result of this research, the method used is descriptive analysis qualitative and quantitative, such as by doing the job phasing, that is preparation stage, field orientation and planning stage, field work step, data evaluation stage and continued with step Discussion and reporting. Data collection includes secondary and instantiated data, as well as primary data taken directly in a field survey.

RESULT

Geomorphology

The basis for the distribution of land form in the telitian area is based on aspects of geomorphology. According to Verstappen (1985), there are four main aspects in the analysis of Geomorphological Mapping:

1. Morphology
2. Morphogenesis
3. Morphochronology
4. Morphokonservasi

Based on the above aspects obtained the form of origin and land form telitian area which is then classified in 2 forms of land that is Homoklin Hills and The Karst Plain has been eroded.

Stratigraphy

The geological condition of Gunungkidul Regency north zone (along Baturagung mountains), geologically is a series of andesite mountain formation (Mount Wungkal, Wuni, Semilir, Nglanggeran and Mandalika). Physically this area consists of the Oyo River valley and the Baturagung Mountains. Based on the results of geological mapping of stratigraphic cross-sectional measurements, stratigraphic sequence analysis and confirmed and compared with previous research results, the stratigraphy of research areas from old to young include, (Figure 1):

1. Kebo-Butak Formation

The Kebo-Butak Formation is spread over northern Baturagung Subzona that forms hills with elevations of 500 - 600 meters above sea level. This unit consists of the dominance of lithology in the form of volcanic sandstones. At the bottom of this unit is massive sandstone entanglement, claystone and siltstone with polymic breccia inserts, carbonate sandstones. Gradually upward the unit is dominated by coarse-grained volcanic sandstone, breccia sandstone and breccia with cobble size to granule with batter inserts and local rocks. Based on petrographic observations, the mud content present represents more than 15% indicating that the unit lithology is composed of wacke sandstones with small primary

pores. The thickness of this unit is estimated to be over 650 meters.

2. Semilir Formation

Northern Semitir Formation is spread out on the Baturagung Mountains Subgen (van Bemmelen, 1949) which forms the morphology of the hills of Patuk, Nglipar and Gedangsari sub-districts with elevations between 600 and 800 meters above sea level. This unit consists of tuff and lapilistone lithology and insertions of tuff sandstones and volcanic rocks. Petrographic observations indicate that mineralogical contents of volcanic rocks in the Semilir Formation consist of very dominant muds, and thus the compact and primary porosity (inter grains) in this unit are very small. The thickness of this unit is estimated to be over 460 meters.

3. Nglanggeran Formation

The Nglanggran Formation is spread out on the Baturagung Mountains Subgen (van Bemmelen, 1949) which forms the southern hilly morphology of the Baturagung Mountains in Patuk, Nglipar and Gedangsari sub-districts with elevations between 400 and 600 meters above sea level. This unit consists of breccia dominance. At the bottom of this unit is dominated by breccia and volcanic sandstone and tuff inserts. While at the top is dominated by volcanic sandstones, breccia sandstones and breccias. Petrographic observation showed that mineralogic contents of volcanic rocks of Nglanggeran Formation consisted of very dominating mud, so that the compact and primary porosity (inter grains) in this unit is very small.

While the breccia of this unit dominance shows the presence of grains that dominate (grain supported) so it does not allow stored water on the lithology. The thickness of this unit is estimated at 530 meters.

4. Sambipitu Formation

This unit is composed by well-laid volcanic sandstone lithology, many showing the structure of the animal traces (burrow) and hummocky cross stratification, as evidence of settling in a quiet neritik environment with no volcanic activity. Surface water flow patterns generally show a fault trallis pattern.

Chemically this unit shows a type of sandy silicate sandstone with a carbonate content of between 30% - 35% with compact physical properties, intercellular porosity (primary) between 5% - 20%, and secondary porosity (derived from the burrow and dissolution structure) between 10% - 20%. In general at the bottom consists of volcanic sandstone and volcanic clay, while in the middle and top consists of a sandstone loop Fossilized gossip, and and fossiped gossip, The observation of volcanic sandstone clusters at the bottom shows the type of volcanic wacke sandstone composed by andesite and feldspar lytic fragments, with a 20% - 40% matrix that also acts as cement, compact, blue day analysis showing porosity Primary are very small, ranging from 1,0 – 2,5%. In the middle and top shows arkitic sandstone, Composed by feldspar and quartz fragments, slightly lit, the percentage of the matrix between 4% - 6%, cemented by sparry calcite (carbonate). Blue day fluid analysis shows porosity ranges from 10% - 20%. Some other features of this unit are dispersed with a relatively strike slip layer slope with a slope of 10° - 15°, At the bottom in some places shows the structure of the crossbeding, while in the middle and top generally shows the structure of the traces of the animals are interconnected to be able to form the strike slip alleys that are interconnected to follow the pattern of the plane. The thickness of this unit is estimated at more than 170 meters. The stratigraphy has a corresponding relationship with the Nglanggeran Formation at the bottom and is inconsistent with the Oyo Formation Tuff Unit at the top. Petrogenesis of Sambipitu sandstones gives an idea that sedimentation is derived from volcanic sedimentation, estimated volcanic development (post-

volcanic), and mixed with coral reefs in shallow marine environments.

5. Oyo Formation

Oyo formation is spread around the Oyo river valley between the Stage Ridge and the Baturagung Mountains and between the hills of Nglanggeran and the Wonosari ridge. Administratively include the Nglipar and Patuk District, at an elevation of approximately 150 meters above sea level. The unit lithology is composed of alternating tuffs of sandstone with volcanic-limestone of silt size of the central and upper carbonate clay inserts, while at the bottom of the limestone insertion. In general the content of carbonate in this unit is more than 70% with high carbonate slurry content. The petrographic incision shows the type of volcanic sandy limestone, primarily composed by fossil shell fragments, slight lithic peculiarities and feldspar, generally matrix supported in the form of microns in an amount of between 30% - 45%. Primary porosity is very small between 1% - 2%, while the secondary porosity results in the dissolution of fossil and vugy skeleton between 10% - 20%. Thus, the growing porosity belongs to the secondary porosity due to dissolution, usually much dissolving is formed between the layers of the rock layers. Matrix dominance in sandy limestone is closely related to the pattern of its distribution which always associates with cesarean and mixing or landslides indicated by slumping and chaotic breccia structures that are contested of cesarean section. The thickness of this unit is estimated to be more than 140 meters which overlap in a harmonious manner above the Semilir Formation.

Geological Structure

A. Fracture

In the research area, stocky can be found scattered in several places and in every lithology in the research area. A more robust stocky appearance is the shear fracture and gash fracture, where the dimensions of the stocky shack are very clear for identification. From the results of rosette diagram analysis of the measurements done in several observation locations, there are four fracture direction patterns (compress) fractures, ie:

1. Patterns of Direction of Fracture of Southeast-Southeast Fracture
2. Pattern of Confirmation Directions of Western-East Fracture
3. Pattern of Northeastern-Southwest Fracture Direction
4. North-South Fracture Direction Pattern

B. Faulting

In the study area, there were several cesarean pattern pattern, from field analysis and studio analysis by observing cesarean characteristics and other geological symptoms in the study area. Studio analysis performed using stereographic projection analysis, obtained from the analysis of the three patterns of direction of the fault, the pattern of North-South direction, Northeast-south direction pattern and the south-east direction pattern.

a) North-South Fault Direction Pattern

1. Ngalang Strike slip Fault
2. Tegalrejo-Katongan Strike slip Fault
3. Cepek Strike slip Fault

b) North-east Fault Direction Direction

1. Mertelu Strike slip Fault
2. Krinjing Strike slip Fault
3. Jurangjero Normal Fault
4. Watusigar Trush Fault
5. Hargosari Strike slip Fault
6. Gambarsari Strike slip Fault
7. Prengguk Trush Fault

c) West-southeast fault pattern

1. Banjarejo Strike slip Fault
2. Pace Strike slip Fault
3. Karang Strike slip Fault
4. Kaliwuluh Strike slip Fault
5. Gayam Strike slip Fault
6. Katongan Strike slip Fault

C. Folds

1. Anticline Watusigar

Watusigar Antiklin is located in Watusigar Village with dimension 1,2 km. These anticlines are observed on the basis of the layers of rock present in the lithology of tuffs of the Semilir Formation and the Oyo Formation batugamping.

2. Syncline Grojokan

Sinklin Grojokan is in the southeast of Grojokan and Beji Area with dimensions of 2,5 km. This syncline is observed on the basis of the existing layers of rock in the Oyo's limestone tubes.

DISCUSSION

Hydrogeology

A. Type of Spring

Field observations indicate that there are three types of springs developing in the study area, including: (a) depression springs, (b) contact springs and (c) fracture springs, (Figure 2):

a. Depression springs, a spring that develops due to the intersection between the topographic pattern of the watertable, spreads along the valleys of the northern and southern Baturagung Hills. Generally springs in the study area precisely on the topography of the hills included into this spring.
b. Contact spring, a spring that develops due to two layers of rock that pass water against impermeable layer/waterproof. The results showed that the contact springs were spread over the southeastern lolate of observation on the limestone lithology of the sandstone to the carbonate claystone, forming a springs parallel to the sloping field of rock layers.
c. Fracture springs, are non-gravitational springs generated from cracks or fractures and the zone as groundwater channels on the exit due to pressure differences. These springs are scattered along the fault zone of either the north-east and south-south trending fault groups. The potential of fracture springs in the research area is Gayam Tirto area (Gayam Tirto springs) reaches 3 liters/dt discharge that has been permanently utilized through permanent pipes and used by 2 villages around Natah and Pilangrejo Village, Nglipar District.

B. Groundwater level

Groundwater levels are measured based on groundwater level measurements existing on dug wells and springs as free groundwater. Measurements are made based on elevation of observation points on the height/depth of the groundwater level. Groundwater itself is controlled by topography as well as differences in hydraulic conductivity or influenced by pressure differentials. Soil water level analysis produces groundwater and groundwater flow maps.

Groundwater level in the research area based on measurement of dug wells ranging from 2-13 meters including into shallow ground water depth (<7 meters) to medium (7-15 meters), in Baturagung Hills difficult to find the location of dug wells, only Based on existing springs in effluent rivers, based on the withdrawal of the groundwater contours of the hilly area including into the deep groundwater class (> 15 meters).

Ground water flow is obtained based on the contamination of groundwater level by flowline. The direction of groundwater flow is divided into 2 systems namely the flow of ground water in hilly areas and terrain areas. The direction of groundwater flow in the plains to the southeast to the Oyo River (influent) that runs down to the Opak River or can be called the Opak-Oyo Watershed. While on the hill, flow to the north and south to the valleys in the upper river Juwet on Krinjing Area, Papah River at Guyangan Area, Kedunglaban River on Jurangjero Area and Ngalang River Ngalang Area. Groundwater flow in this hilly area leads to effluent rivers which are heavily controlled

by northeast-southwest, northwest-northsouth and south-north faults.

Indications of control of the geological structure of faults against groundwater are characterized by the emergence of springs in the vicinity of geological structures which indicate that the geological structure as a channel where groundwater flows to the surface. This is influenced by the pressure difference around the fault zone characterized by low hydraulic conductivity values so that the groundwater level will be close to the topography. The control of the geological structure of groundwater flow controlling underground groundwater flow is characterized by subsurface flow that does not follow the growing river pattern.

C. Regional Aquifer System Research

The aquifer system of the research area can be divided into 3 types of aquifers based on aquifer composition influenced by lithology and geological structures, aquifer systems and groundwater systems such as: (a) aquifer system between grains and fracture, (b) fracture aquifer systems, and (c) Non aquifer/aquiclude.

1. Aquifer System Between Grains and Fracture

   The aquifer system between grains and fractures is composed of carbonate sandstones with siltstone inserts and claystone, Oyo limestones in the form of limestone and sandstone conjoinings. The fracture system formed on this aquifer system is a systematic/tectonic fracture that cuts rock bedding and fracture system results from dissolution of the rock bedding with a medium fracture intensity. The aquifer system is a fracture aquifer with porosity and primary permeability between grains and secondary due to dissolution and fracture, medium graduation. The basic rocks of this aquifer are Tertiary volcanic rocks namely Nglanggeran Formation breccia and tuff Semilir Formation. Type of flow in the form of seepage flow either through soil results of weathering or grain and fractures. Groundwater faces shallow and interconnected.
2. Fracture Aquifer System

   The fracture aquifer system is composed of volcanic rocks of the Kebo-Butak Formation and the tuff of the Selimir Formation of volcanic sandstone, tuff, siltstone and claystone with breccia insertions. The fracture system is a systematic/tectonic fracture of the developmental results of major faults that form minor faults and fracture zones along the fault lines. The aquifer system is a fracture aquifer with porosity and secondary permeability due to fracture, medium graduation. These aquifer rocks are older volcanic rocks. The type of flow is a local seepage flow through soil weathering results and fractures. Groundwater face and shallow and non-interconnected depending on the height variation of the topography.
3. Non Aquifer/Aquiclude

   Non aquifer/ aquiclude is composed of volcanic rocks of Kebo-Butak Formation, tuff of Semilir Formation and Nglanggeran Formation of Tertiary volcanic rocks of tuff, lapilistone and breccia rocks with low fracture/low fracture development with moderate to strong level of wethering Which forms a layer of soil at the top as a shallow free aquifer (10-15 meters).

   These non aquifer systems have small porosity and permeability due to the lithology of volcanic rocks rich in mud and low fracture intensity, in some lithologies such as breccia having high graduation but not having the ability to store water. This type of flow is a seepage flow in soil caused by weathering. Groundwater face in, in some places with soil thick shallow free water surface.

CONCLUSION

- Stratigraphy of research area into some formations of rock from old to young: Kebo-Butak Formation, Semilir Formation, Nglanggeran Formation, Sambipitu Formation and Oyo Formation.
- Geological structures developed in the research area in the form of fracture and fault structures, with fracture patterns encountered in northwest-southeast, west-east, northeast-southwest and north-south directions, and directionally fault pattern north-south, north-east -baratdaya and northwest-southeast.
- There are three types of springs that develop in the research area of the depression springs, contact springs and fracture springs.
- Ground water flow is obtained based on the contamination of groundwater level by flowline. The direction of groundwater flow is divided into 2 systems namely the flow of groundwater in hilly areas and terrain areas
- The aquifer system of the study area can be divided into 3 types of aquifers based on aquifer composition influenced by lithology and geological structure, namely: aquifer system between grains and fracture, fracture aquifer system, and non aquifer/aquiclude.

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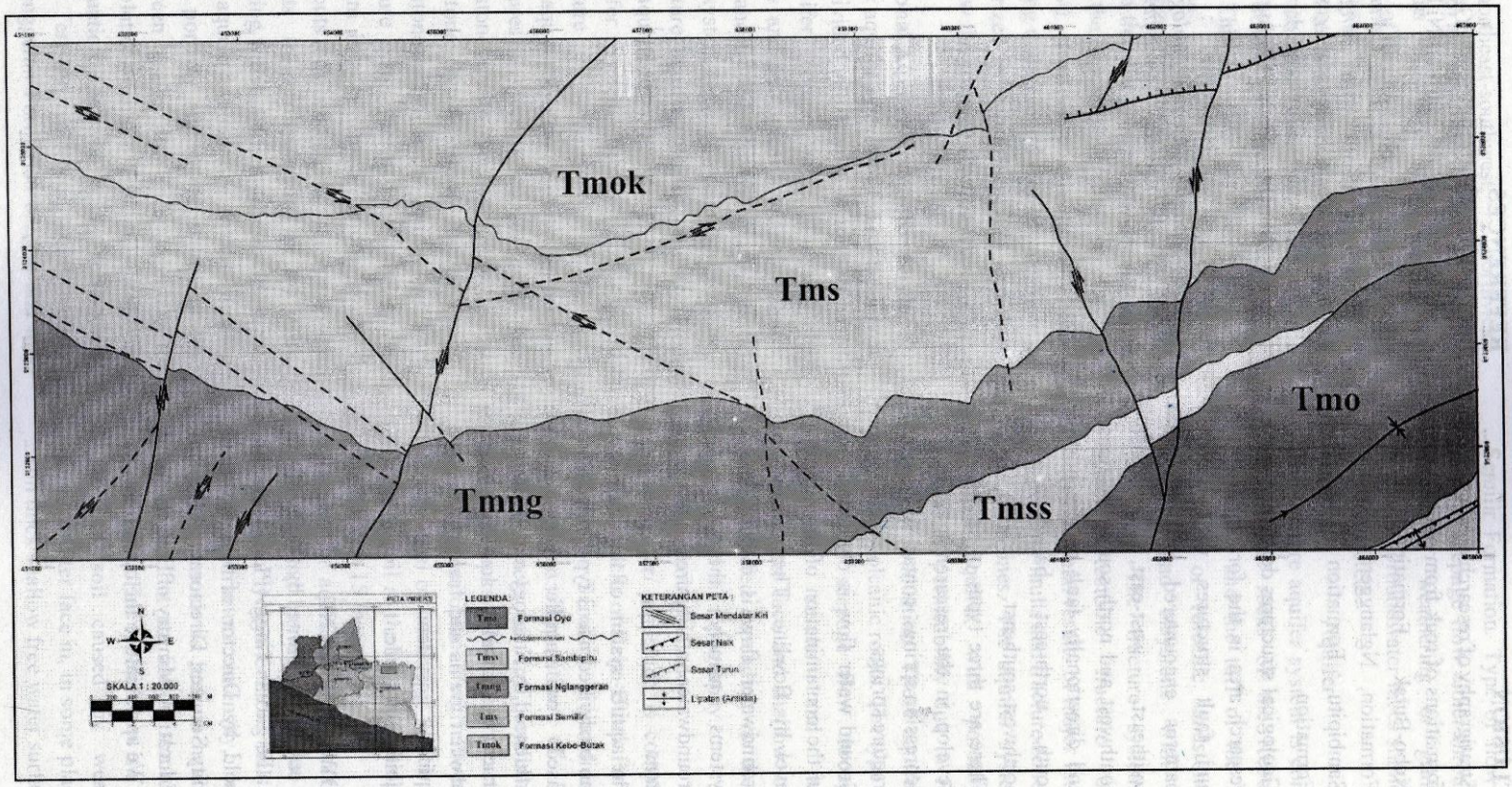

Figure 1. Geological Maps of Research Areas

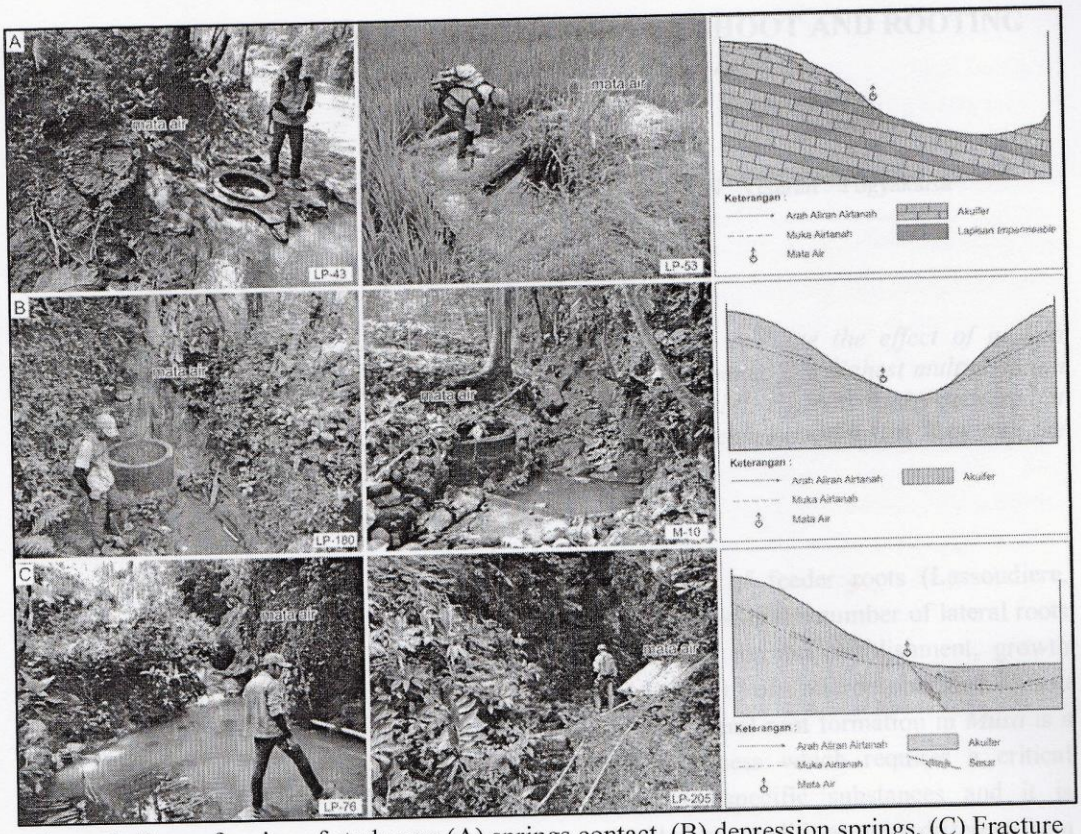

Figure 2. Type of spring of study are: (A) springs contact, (B) depression springs, (C) Fracture springs