Hydrostratigraphic Assessment of Groundwater Flow System in Slopes of the Volcanic Mt. Talang, West Sumatera

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Abstract

Mount Talang is one of the active volcanos in Indonesia, it located at Kayu Aro District, Solok Regency, West Sumatera, Indonesia, and Mount Talang is part of Barisan Mountain and lies at Sumami segment which is part of the active Sumatera Fault. In groundwater flow, a fault zone can act as a sink, or as a barrier, when the fault zone highly permeable in relation to the host rock and the fault zone must trend so as to maximize its effects, preferably parallel with general trend of the groundwater flow. Six explorations well identified at the North West Slope of Mount Talang and only two explorations well productive to be converted as exploitation well, while the others dry. Base on the geological setting, the hypothesis is faults play the role for groundwater flow. Fault occurrence analyzed from the lithology of the Bore Log each well by developed 2D hydrostratigraphic model.

Keywords: Groundwater, Hydrostratigraphy, Borehole, Volcanic.

Introduction

Mount Talang is one of the active volcanos in Indonesia, it located at Kayu Aro District, Solok Regency, West Sumatera, Indonesia (fig.1). Mount Talang is part of Barisan Mountain and lies at Sumami segment (Natawidjaja & Triyoso 2007) which is part of the active Sumatera Fault. Active fault impacted groundwater flow, fault slip increased the permeability, and the size of the resulting slip plane. In groundwater flow, a fault zone can act as a sink, or as a barrier, when the fault zone highly permeable in relation to the host rock and the fault zone must trend so as to maximize its effects, preferably parallel with general trend of the groundwater flow (Gudmundsson 2000) (Singhal & Gupta 1999) and fault affect fluid flow patterns in groundwater aquifer (Mayer 2007) (Singhal & Gupta 2010). Author identified six explorations well at the North West Slope of Mount Talang and only two explorations well productive to be converted as exploitation well, while the others dry. Base on that fact, motivated a research of active fault impacted groundwater flow by using cutting data from the Drill Log of each exploration well and analyze it with 2D hydrostratigraphic model, at the North West Slope of Mount Talang, Solok District, West Sumatera, Indonesia.

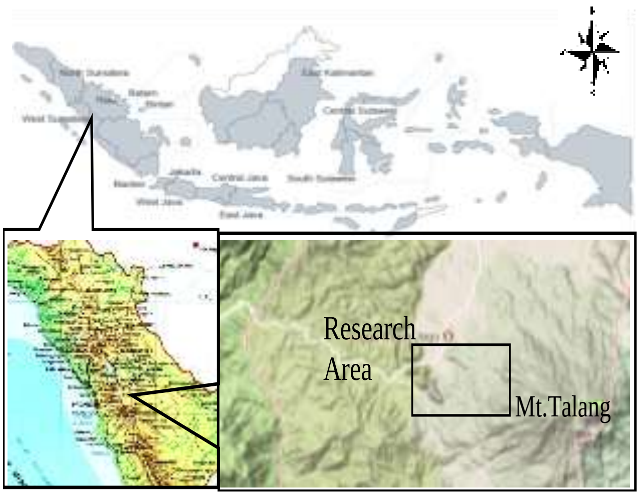

Figure 1. Research Area.

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Regional Geology Setting.

Sumatera Fault consists of 20 segment and strike NW-NE (Tjia 1978). Extending 1900 km in NW-SE along the western part of the island (Sieh & Natawidjaja 2000). The research area lies at Sumami segment of Sumatera Fault (fig. 2). The Sumatran Fault system is a complex of dextral strike-slip faults running from NW to SE through the center of the Barisan Mountains, which form grabens along the line of the fault system (Barber & Crow 2005) (Curray 1989). The Geology Regional (Hendrayana & Putra 2010). describe as:

a. Undifferentiated Volcanic Products (Qtau): This group is composed by old lava deposits from Mount Talang, fanglomerat and sediment colluviums.
b. Welded Tuff (Qtwt): According to the geological map sheets of Solok (fig.2), there is a welded tuff that does fingering with volcanic material which was separated.
c. Andesite of Gunung Talang (Qatg): This unit consists of breccia, laharic deposits, lava flows, lapili, tuff, mostly from the eruption of Mount Talang andesite. This unit is Quaternary age
d. Fan Group Alluvium (QF): This group is the destruction of alluvial fan deposits result of volcanic eruptions that have been there before. This group consists of boulder-sized material, gravel, sand from andesite and tuff materials.

The regional stratigraphy of Solok sheet belongs to Bukit Barisan Mountain Range. In this area there have been several times magmatism phase and deposition of sediment repeatedly. From the oldest to the youngest, sequence stratigraphy in the study area are as figure 2.

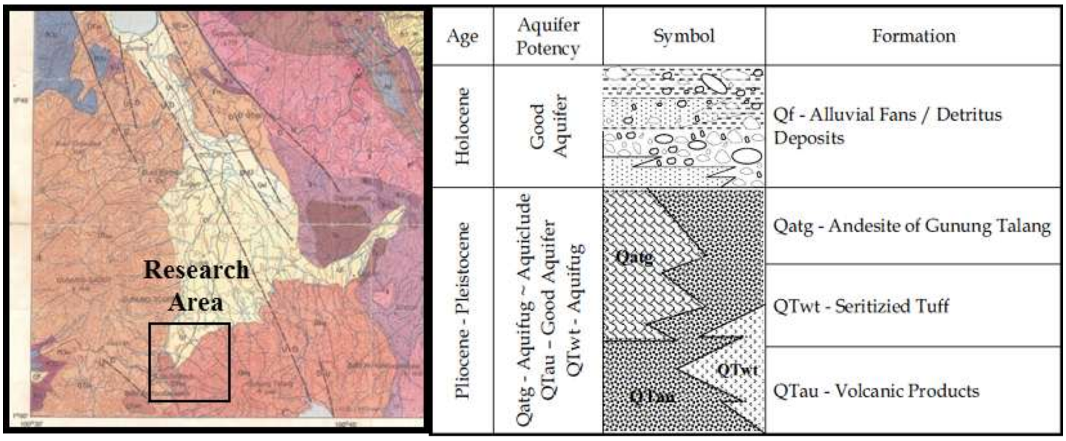

Figure.2. Geology Map Solok (Silitonga & Kastowo 1995) and Regional stratigraphy and the surrounding area of Solok (Hendrayana & Putra 2010)

Methodology.

This research is using data from Regional geological setting, Bore log from five exploration borehole, one production well that will to develop Hydro stratigraphic.

Hydrostratigraphic unit is bodies of rock with considerable lateral extent that compose a geologic framework for a reasonably distinct hydrologic system (Maxey 1964). Main criteria that use to defined hidrostratigraphic are litology characteristic and hydraulic characteristic (Seaber 1988). The step in defined Hydrostratigraphy is by defining from the bore log result the lithology is an aquifer, aquiclude, aquifuge or aquitard Base on those result conceptual 2 dimension section developed (2D).

Borehole Data.

There were eight spring identified in this research, five exploration borehole (BE1, BE2, BE3, BE4 and DW4) and one production well (DW2) as describe on figure 3. And borehole coordinate include borehole depth as on table 1. The most important data in this research is Bore log data which contained lithology correlated with the depth for each borehole. As described on figure 4, the bore log data is simplified.

BE1 is artesian well with capacity 1 l/s while BE2, BE3, BE4 and DW4 are dry. The Production well DW2 is pumped well with capacity 12 l/s.

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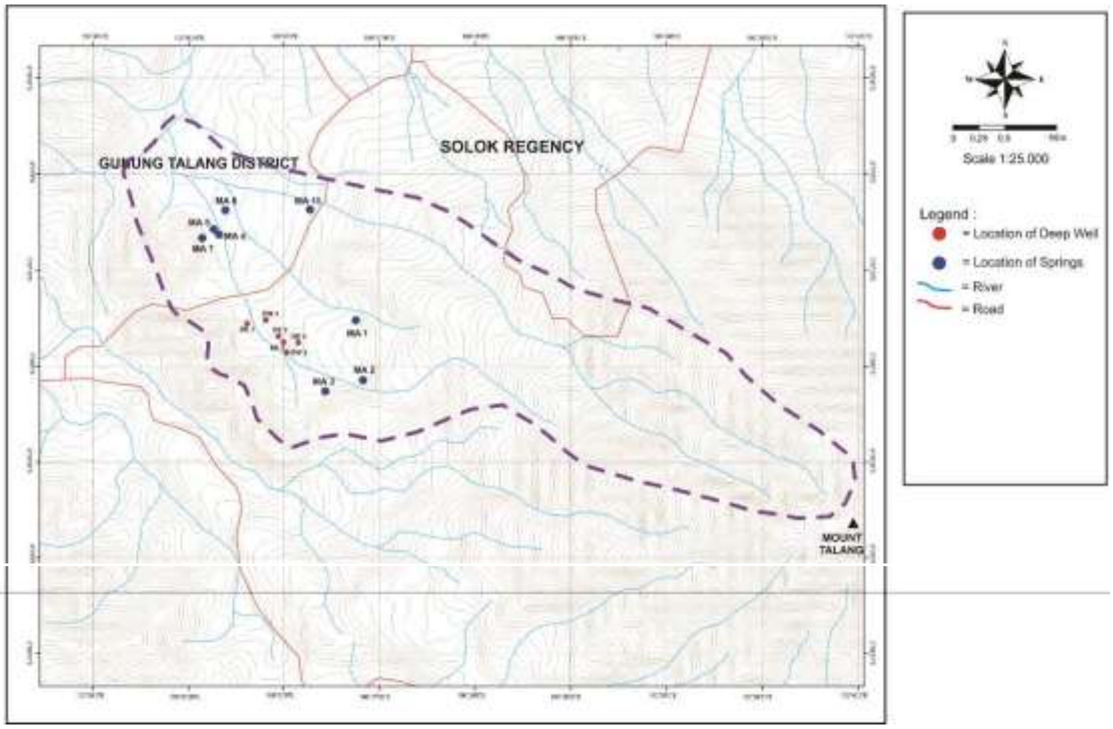

Figure 3. Research Area. Borehole Location and Spring Occurrence

Tabel 1. Borehole Location & Depth

Borehole No	Latitude	Longitude	Depth (m)
BE-1	00^0 58' 25.5"	100^0 37' 33.6"	100
BE-2	00^0 58' 31.0"	100^0 37' 12.3"	100
BE-3	00^0 58' 39.0"	100^0 37' 23.8"	100
BE-4	00^0 58' 06.8"	100^0 37' 36.3"	78
DW-04	00^0 57' 51.03"	100^0 37' 1.16"	119
DW-02	00^0 58' 03.2"	100^0 37' 09.2"	75

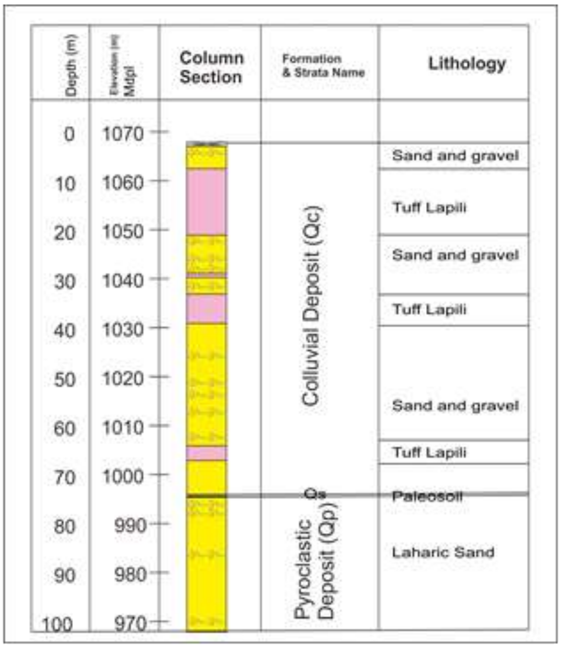

Figure 4. Simplified Bore log of BE2

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Result & Analysis

The lithology on exploration borehole BE1, DW4, BE2, BE3, BE4 as described on Hydrostratigraphic figure 5 has similar geology setting, Sand and gravel, Laharic, Andesitic pebble, Clay – Sand and loose, tuff and tuff lapili, tuff breccia, Welded tuffs ad Paleo-soil.

From the bore log a thin Paleo-soil layer found in different depth of each Borehole (fig. 5) the paleo-soil have different depth, BE1 to Dw4 the paleosoil depth different is 30m with distance 155m North East of BE1. Borehole DW4 and BE2 the paleosoil depth different is 20m with distance 225m South East of DW4. Borehole BE2 and BE4 paleosoil depth different is 50m with distance 150m South West of BE2.

On Borehole DW2 the paleosoil layer not found. In Borehole DW2 the lithology found as Sand and Gravel, Andesitic Lava and Andesitic breccia. The hydrostratigraphic different lithology's compare to other all exploration well.

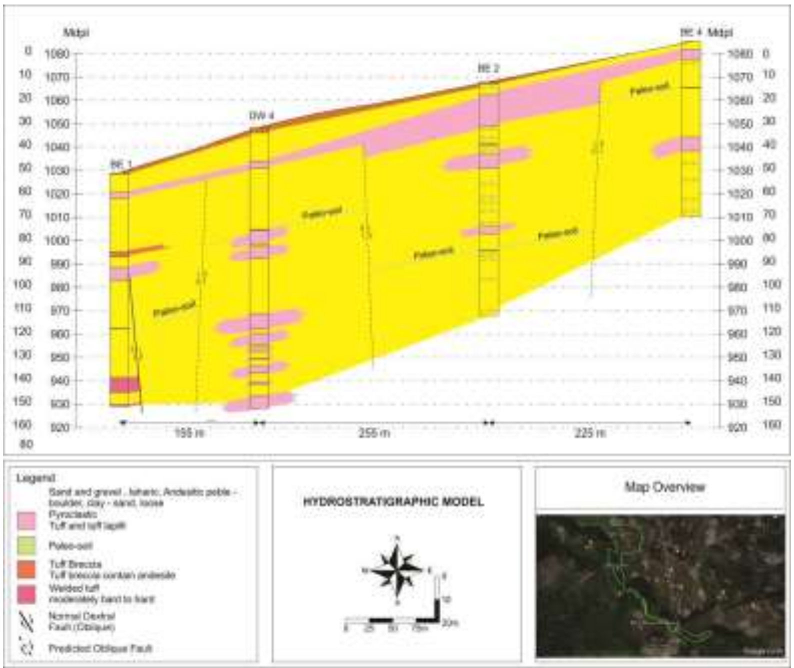

Figure 5. Hydrostartigraphic - Conceptual 2D cross section BE1 – DW4 – BE2 – BE4

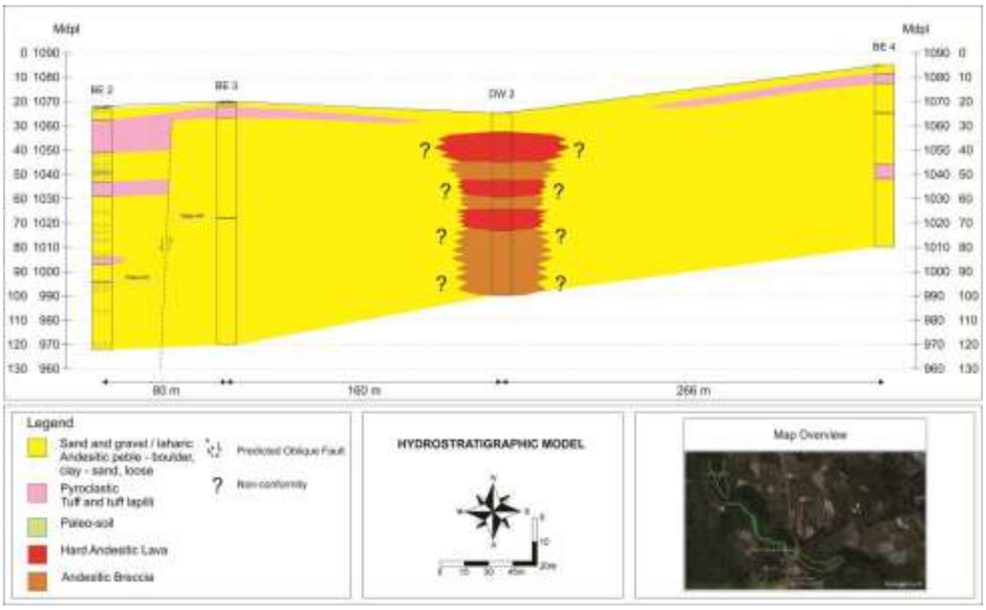

Figure 6. Hydrostartigraphic - Conceptual 2D cross section BE2 – BE3- DW2 –BE4

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Conclusion and Recommendation.

The different depth of Paleosoil layer which is found on the bore log from the upstream to downstream, BE4-BE2-DW4-BE1, interpreted as fault.

Between Borehole BE1 and Borehole DW4 interpreted as Normal Dextral Fault (Oblique), between borehole DW4 and borehole BE2 interpreted as Normal Sinistral Fault (Oblique), between borehole BE2 and borehole BE4 interpreted as Normal Dextral Fault (Oblique) (Fig.7).

Those interpreted Fault is continuity of the Putuik Hill graben at South West of the borehole (Fig.8).

From the hydrostratigraphic model no Fault found between borehole DW2 and borehole BE4 most probably the location of DW2 and BE4 is inter finger or geological border between Mount Talang and Putuik Hill. Those explain the reason that the groundwater occurred in borehole DW4 but not in borehole BE4, BE3, BE2 and DW4. Groundwater occurred in borehole BE1 most probably is different water facies from borehole DW2 due to three fault identified between DW2 and BE1 .

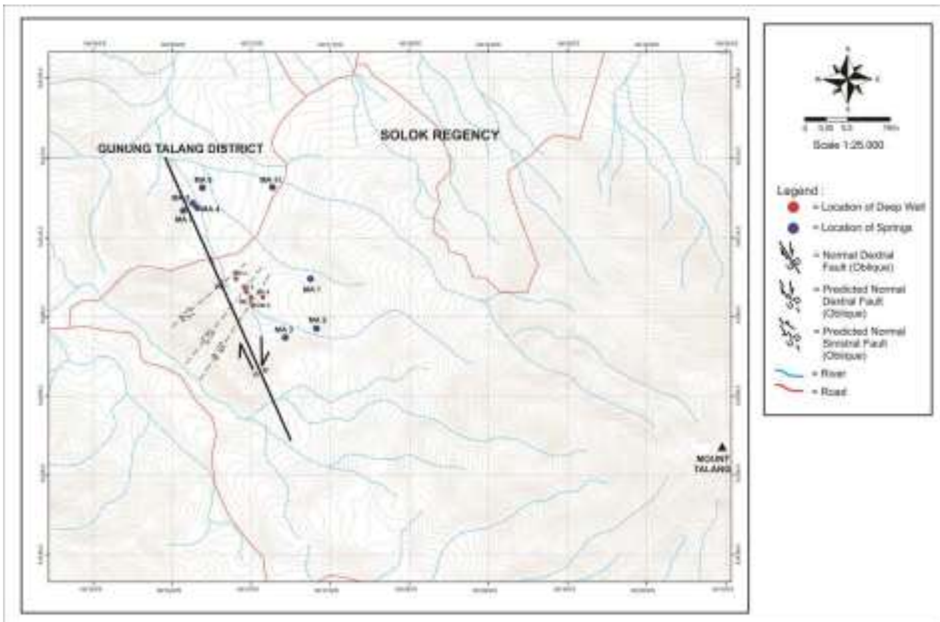

Figure 7. Interpreted Oblique Fault

Figure 8. Putuik Hill Horst and Graben

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but need to investigate more by hydrochemistry assessment. And the aquifer at DW2 identified as Andesite Breccia while BE1 as Laharic.

The 2D Hydrostratigrapic model shows that the faults works as barrier for the borehole BE3, BE2 and DW4 and works as conduit for BE1.

Recommendation for further study and validate this result is to do geophysics study for understanding the distribution and direction of the Lava flow and laharic product and to do hydrochemistry study for understanding groundwater facies and validate the groundwater flow.

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