FRACTURES CONTROL OF GROUNDWATER AQUIFER CONFIGURATION AT BATURAGUNG VOLCANIC RANGE, A POTENTIAL NEW GEOSITE OF GUNUNG SEWU GEOPARK

by Puji Pratiknyo

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ABSTRACT

The residual of the natural rock erosion in the Baturagung range area of Gunung Kidul exhibit a cuesta of volcanic sedimentary rock is incredible. In preliminary studies indicate that the remains cuesta has a close relationship with the local faults pattern and major fault structure in the ENE-WSW trending which has been named as Dukuh and Mertelu faults by Lestanto Budiman (1990), and Sudarno (1997). The presence of so many major, meso and minor faults in the cuesta , it shows that this minor and meso faults in the major fault system that has developed imbricated graben and horst in a relatively long period. This study used detailed research methodology with detailed data acquisition along the cuesta. As expected found sufficient data for analysis fault zone and faulted rock. In this detailed trajectory represented 3 blocks of detailed observations. Field observations, resistivity geo-electrical, and Pole-dipole geo-electric method show that not at all region have same faults pattern in the cuesta. In each block region observation, they usually have several combinations of minor, meso and major faults variation. The first block, varies from minor, meso, major and nothing fractures with fault plane generally steeply dipping to the SSE. Their fault plane ranging from steeply to very steeply dipping and commonly associated with E-W half graben faults. The second block varies from meso, minor and nothing fractures with fault plane generally steeply dipping to the north or south. They are commonly called synthetic-antitethic normal fault, and parallel with major fault. Transposition of layering during deformation is not uncommon and the occurences of high-strain zone of horst fault suggest that the deformation were derived from intense NNW-SSE tention. The third block, always follow system of NNW-SSE tention fault and commonly associated with steeply dipping ENE-WSW half graben. The varies structures in the all blocks is produced by ***footwall collapse on half grabens system***. Baturagung groundwater basin are compiled by some rock formations and also fractures which is as a controller of recharge and discharge areas. There are three rock formations that have properties permeability rock with unfavorable ie Kebobutak Formation, Semilir Formation and Nglanggran Formation. Fracture patterns that develops relatively leads North-South and East-West, which is where the pattern of North-South is controllers of a recharge area while the fracture pattern with alignment relative direction West-East is a fracture pattern which controls a discharge area.

The physical dimension of the mountain range, the geological history of the structures and the aesthetic beauty of panoramic landscape it produced make the Baturagung miosen volcanic range a unique cuesta geoheritage resources not only to Indonesia but also in the world especially for tropical countries where intense weathering will rapidly transform rocks into thick soil in very short time.

INTRODUCTION

Baturagung range is a top cuesta mountain of Miosen volcanic residual erosion at Gunungkidul, with the Main Range which is well endowed with lush green tropical rainforest and green valley. Silhoueted by these forests, on the north-northwestern border of the city protruded an amazing great cuesta of Gunungkidul. The Baturagung

Range, named by Bemmelen (1949) after the Geology of Indonesia published in which this range belonged to. (Figure 1). Often mistaken with synclinal structure for its cuesta-like morphological features, this 24 km long (up to 9 km wide and 750 m tall) cuesta is almost entirely made of Miosen volcanic clastic, hence a giant volcanic cuesta. The physical dimension of the cuesta, the geological history of the cuesta and the aesthetic beauty of panoramic landscape it produced make the Baturagung groundwater basin a unique geosite resources not only to Gunung Sewu Geopark, Indonesia but also in the world especially for tropical countries where intense weathering will rapidly transform rocks into thick soil in very short time.

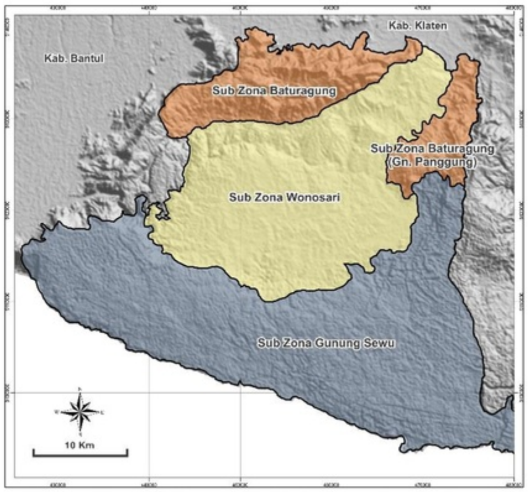

Figure 1: Physiographic region of Gunungkidul area, show the physical and dimension of the Baturagung cuesta Range.
(Modivication from Bemmelen, 1949)

THE GEOLOGY OF GUNUNGKIDUL

The geology of Gunungkidul and its surrounding area is mainly made up of Lower Miosen Kebobutak-Semilir volcanic sandstone and Nglanggran volcanic breccia and the Late Lower Miosen Sambipitu volcanic calcareous sandstone Formation which all were intruded by the Late Miosen Tegalrejo Basaltis (Mahfi, 2003). Structurally, Gunungkidul area was affected by a series of major post-volcanic cuesta implacement's half graben faulting (Figure 2) known as Baturagung Fault Zone (Bemmelen, 1949; Lestanto Budiman, 1990; and Sudarno 1997). The low lying areas was covered by thick Quarternary alluvial deposits at northern part and thick Late Miosen Oyo tuffaceous limestone Formation.

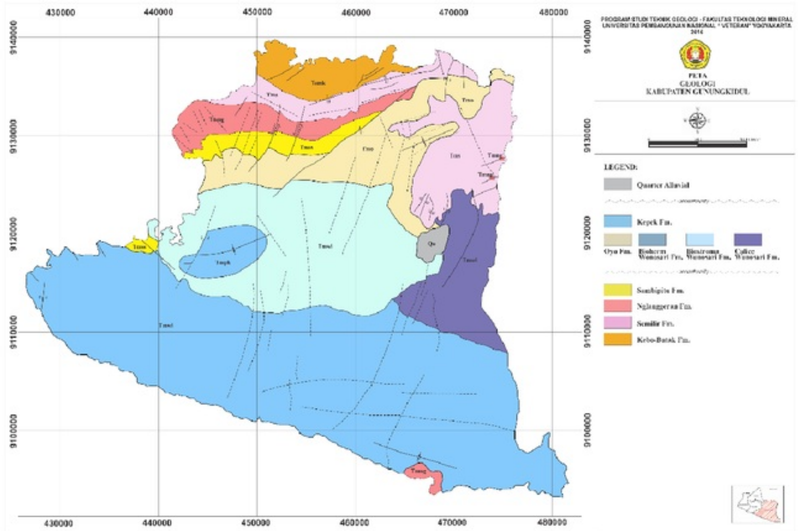

Figure 2: Geogical Map of Gunungkidul area (Modivication from Rodhi, et al, 2016)

THE BATURAGUNG CUESTA RANGE

Baturagung volcanic cuesta range is an elongated body extended to about 14 km in E – W direction exposing more than 9 km of volcanic of different lithological characteristics. It is mainly located in gunung Semilir-Baturagung, Kecamatan Gedangsari, extended a little into gunung Nglanggran, Kecamatan Patuk, Gunungkidul. The cuesta is undulated forming several hills with Bukit Baturagung (827m) as it highest peak rising up to 500m above the Wonosari plain. The width of the cuesta is ranges from 1km-3km. The cuesta geomorphology is unique with its nearly valley (to surrounding hills in places) ghostly green sea with giant ship resembling volcanic foot hill geomorphology (Sudarno, 1997). Tog the south-southwest lies the bustling Wonosari City with Gunung Sewu Geopark and to the north-northeast is the serene artificial lake of Rawa Jombor, Bayat where a narrow gap in which Dengkeng River flows through along northern of Tegalrejo escarpment.

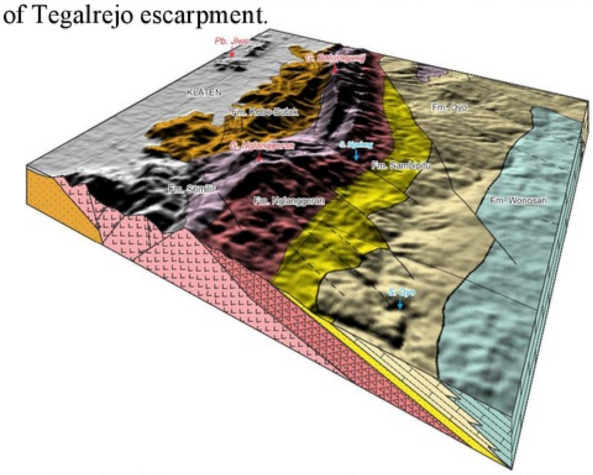

Figure 3: Diagram Block of Baturagung area, show geomorphology the cuesta control by lithology and fractures (Source : Rodhi et al. 2016)

Petrology

Baturagung cuesta is not a simple single giant-sized cuesta as it was often misunderstood. Instead it is a combination of several types and generations of volcanic layers with different lithology, texture and fractures associations. In general it is intercalation volcanic sandstone and tuff with volcanic breccia and calcareous volcanicsandstone. There are three variations of volcanic unit lithology. The first variation varies sandstone in thick from 5cm to 20cm thick, generally show distal turbidite structure with parallel lamination structures, sometimes brecciated and associated with quartz-zeolite tuff. The second variation is mostly major volcanic sandstone with proximal turbidite structure showing thickening up-ward sometimes breccia and associated with lapilli tuff and vitric tuff, while the third variation is generally volcanic breccia major to moderate thick layers with debrise to grain flow structure showing thinning up-ward , and most commonly associated with andesite and basalt fragmens. All lithology variations show matrik supported with porosity range 1%-2%. (Figure 4).

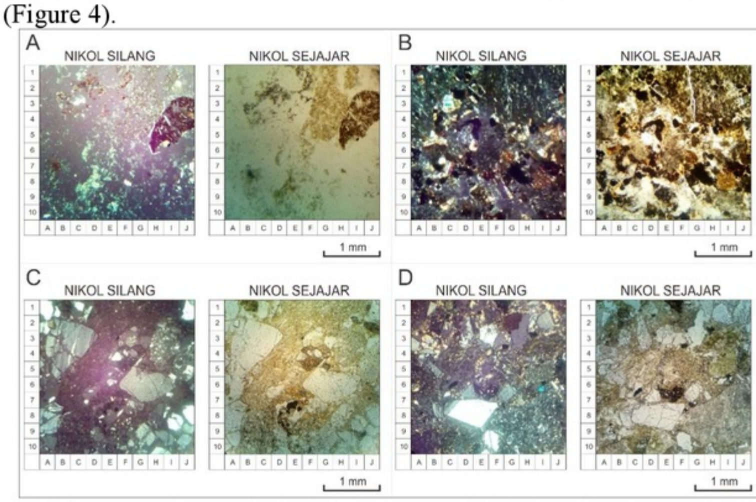

Figure 4: Petrographic analysis thin section with blueday liquid porosity analysis. (A) Left-upper show vitric tuff, with porosity 2%. (B) Right-upper show matrix supported of breccia withporosity 1%. (C) Left-lower show matrix supported of volcanic wacke with porosity 1%. And (D) Right-lower show matrix supported of volcanic wacke with porosity 1%.

Structure and tectonic

Baturagung Cuesta is part of the Baturagung graben fault system that cut all volcanic rocks in Gunungkidul area, hence interpreted to have been formed after the final emplacement of the Miosen volcanic. Based on the radiometric age by Mahfi et all (2003) and Suryaatmadja, et al (1993) age of the Bayat-Gunungkidul volcanic is 26 - 33 million years ago (Late Oligocene-Early Miocene age). Rodhi et al. (2016) believed that the Baturagung cuesta fault zone was active from Early Miocene to Middle Miocene, while Sudarno (1997) assumed that fault movement ended in Early Miocene. This is evidence from the presence of various types of deformation to the earlier volcanic foothill environment and half graben cuesta. At least three different generations of half graben were identified forming at different dip directions, angles and attitudes. The first generation is develop Kebo-Butak domino system, second develop Semilir horst complex, and the last Semilir half graben. (Figure 5).

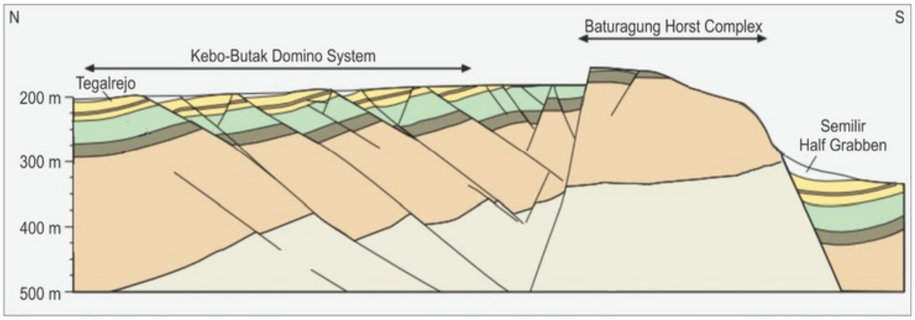

Figure 5: Ideal section Baturagung cuesta show half graben system which Kebo-Butak Domino System in northern part, Baturagung Horst in central part and Semilir half graben in southern part. (modivication from Fossen, 2010)

From prominent strike modes of fracture lineaments it can be interpreted that Baturagung half graben cuesta has been produced .by horizontal tentional acting along 172^{o} - 352^{o} that were responsible for the Middle Miocene orogeny, and were still active for quite sometimes after the emplacement of the volcanic cuesta (Figure 6).

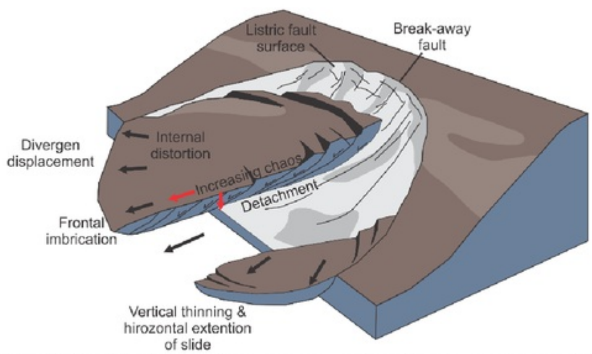

Figure 6: Ideal Model half graben show Footwall collapse controlled by the presence of weak layer from Wungkal Formation. (Rodhi et al, 2016, modivication from Fossen, 2010)

Hydrogeology

Field observations, resistivity geo-electrical, and Pole-dipole geo-electric method show that not at all region have same faults pattern in the cuesta. In each block region observation, they usually have several combinations of minor, meso and major faults variation. (Figure 7). The first block, varies from minor, meso, major and nothing fractures with fault plane generally steeply dipping to the SSE. Their fault plane ranging from steeply to very steeply dipping and commonly associated with E-W half graben faults. The second block varies from meso, minor and nothing fractures with fault plane generally steeply dipping to the north or south. They are commonly called synthetic-antitethic normal fault, and parallel with major fault. Transposition of layering during deformation is not uncommon and the occurences of high-strain zone of horst fault suggest that the deformation were derived from intense NNW-SSE tention. The third block, always follow system of NNW-SSE tention fault and commonly associated with steeply dipping ENE-WSW half graben.

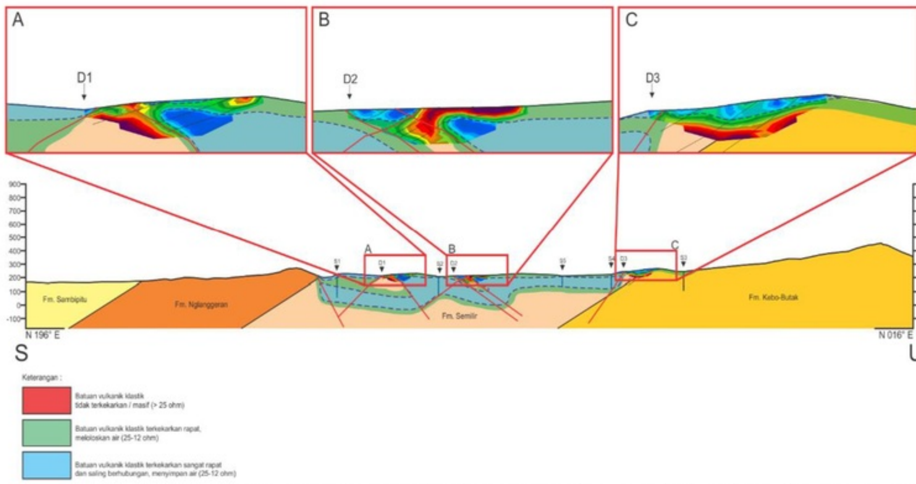

Figure 8 : Field and geo-electrical method analysis shows relationship the structural patterns and three block of the cuesta range. (Source : Rodhi et al. 2016).

The pattern of east-west trending is a pattern structure in one direction with a stance rock and forming normal fault. The pattern of these structures shows that the groundwater many trapped and stored in the valleys between the hills of homoklin-cuesta discharge, many found the springs in the valleys of the structure, acting as a path (channel) groundwater flow from the hills as recharge (Figure 8).

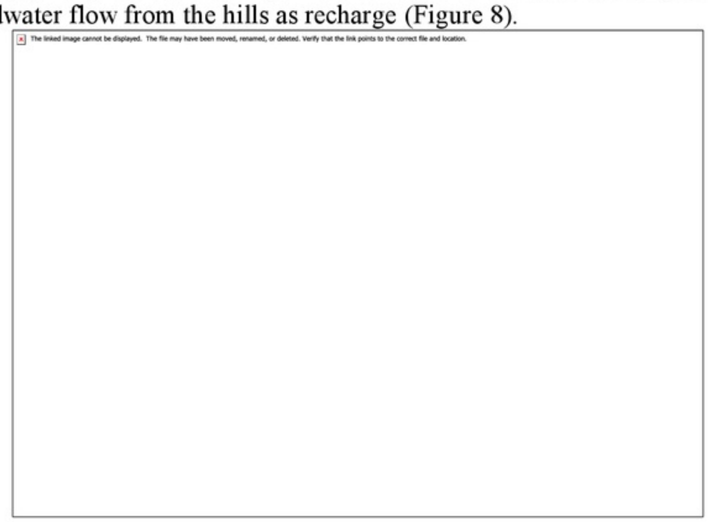

Figure 8 : Hydrogeology and sub-surface groundwater flows countur map show the structural patterns, lithology and topographic combination are forming groundwater aquifer trap

Landform and landscape

Differential weathering has been responsible in producing an undulating vertical cuesta stood proudly above the background made of insitu volcanic sandstone soil with both slopes are formed by collovium where volcanic sandstone soils and fractured are mixed porosity together (Rodhi et al.,2016). That is a good secondary porosity and it was a good aquifer, too. (Figure 8)

Figure 9: Sriten pond at southern slope of the top Baturagung cuesta an a good porosity sample. Tog the south-southwest lies the bustling Wonosari City with Gunung Sewu Geopark

The undulating nature of the cuesta is due to the formation of weak zone by later faults that form several gaps including those cut by two main valley that are surrounding Bukit Semilir, Bukit Baturagung and Bukit Nglanggran. At larger scale, the various peaks of these landforms formed different morphological features such as dome, cuesta, half-conical and hogback, (Figure 10)

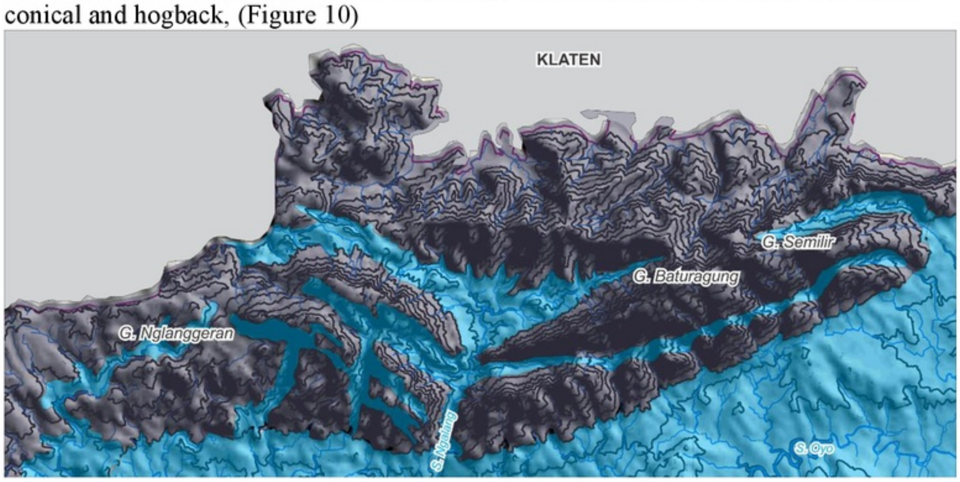

Figure 10: The various peaks of these landforms formed different morphological features such as dome, cuesta, half-conical and hogback

Heritage value and conservation

Rodhi et al., (2016) have pointed out several scientific, aesthetic and recreational values for this cuesta and have propose it to be established as a geological monument, reservoir and recreational reserves. At this moment part of this cuesta is located under the Forestry Department Act as a State Park for conservation of rare wildlife and flora associated with the volcanic cuesta. At present, the Gunungkidul State Government with supports from various federal government agencies and academia have put their conserted efforts in nominating this unique geoheritage site to the new geosite List..

SUMMARY

The Baturagung cuesta range is the longest visible volcanic cuesta in Indonesia and one of the longest in the world. It is part of the half graben Baturagung Fault zone, made up of a single cuesta with multiple fractures at volcanic lithology representing various stage of the fault development. The formation of the entire cuesta represents a special event in geological history where tectonic forces continue to take place long after the suturing of two major plates. Deep tropical weathering exposed the cuesta to create a majestic landscape and groundwater basin at the background of Wonosari city, Gunungkidul. Its unique geomorphological features resembles cuesta landscape is a special feature of tropical weathering. This volcanic cuesta should be preserved for its scientific (geological) and aesthetic values as well as for its ecological values.

ACKNOWLEDGEMENT

The authors wish to thank ESDM Yogyakarta for financing the field expenses and all Geology structural laboratory staff of the Geology Department,

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