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THE GEOLOGIC IMPORTANCE OF WEST PROGO MOUNTAIN IN THE REFERENCE TO THE NEWLY ESTABLISHED INTERNATIONAL AIRPORT IN WATES, SPECIAL PROVINCE OF YOGYAKARTA, INDONESIA

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Abstract

West Progo Mountain becomes hinterland to the newly developed area as the impact of the establishment of the New International Airport of Yogyakarta. The eastern foot of the mountain is built up by an undulated topography of Sentolo Formation which is underlain by the Quaternary Merapi volcanic deposits forming a large fan. The newly established airport is located in the distal facies at the toe of Merapi fan in the transition to the coastal alluvial deposit in Temon area, Wates. The undulated topography of Sentolo Formation located NW of the airport is an ideal area for urban development. This area covers a distance of about 20 kilometers from the airport to the foot of West Progo Mountain. The The gentle slope of the undulated topography is suitable for the runoff management avoiding the possibility of flash flood. Furthermore, the slope is relatively stable avoiding the possibility of landslides.

Water potentials are readily available in Jonggrangan Formation located at the top of West Progo Mountain (Listyani, 2019). The water resources drain all over the year. The karst topography of Jonggrangan Formation provides space for underground reservoir. Water for industrial porpose might be available from Progo River. In addition some springs are found in the lithologic contact between Old Andesit Formation of West Progo and the younger deposits. Underground water might be found at the alternating layers between limestone and marly sandstone.

Sentolo limestone consisting of hard coral reef and stratified limestone readily provides strong foundation for the development of infrastructure. The thickness of the rock is about 950 meters (Rahardjo, 1995 in Pambudi, 2019). The limestone might also potentials for building materials and cement. In places the limestone quarries are dug by the locals.

Keywords: New International Yogyakarta Airport, hinterland, umdulated topography, water resources, building materials

Introduction

West Progo Mountain is located in West of Kali Progo, Special Province of Yogyakarta. The Mountain is the common border with Central Java Province (Figure 1). Geologically it is known as an *oblong* dome of Kulon Progo introduced by van Bemmelen (1949).

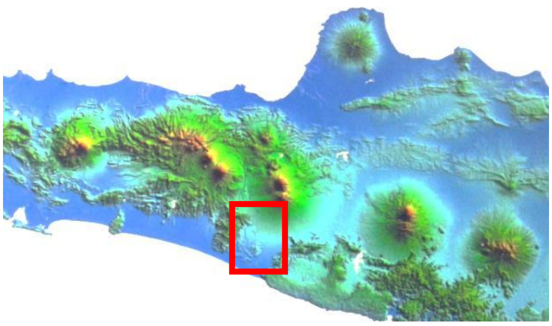

Figure 1. Index map of the investigated area (red square)

It reflects the geomorphologic feature related to the updoming of the mountain based on the undation concept. The forecoming investigators among others Budiadi (2008) referred the elongated shape of the mountain as the result of latteral compression related to the Northward movement of Indo-Australian Tectonic Plate.

Later Listyani (2019) supported the Northward compression based on the fracture analysis in Jongrangan Plateau located at the center of the mountain.

Kali Progo is the main river in the area separating the western portion called Kulon Progo and the Eastern portion which belongs to Yogyakarta plain. In the East it is bordered by Kali Opak Fault Scarp as the sharp end of Gunung Kidul Mountain Range. Geomorphologically Kali Progo represents the West boundary of large fan of volcanic rocks produced by the continuing activity of Merapi Volcano.

In places the volcanic fan left the older topographic surface of Sentolo Formation exposed forming isolated hills. The fan itself spreads over the large area about 50 kilometer distance from the apec in Merapi Volcano to the toe in Wates area in the transition with the coastal alluvial deposit. Volcanologically it belongs to the distal facies.

The newly established International Airport of Yogyakarta is located in Temon subdistrict of Wates District at the border of the volcanic fan and the alluvial deposits, West of Progo River (Figure 2).

Figure 2. International Airport in Kulon Progo

Being the undulated area in the North-Northwest of the newly established airport, the vast undulated topography of Sentolo provides the vafourable space as the hinterland for the upcoming urban development.

The geological characteristics of the area among others the topographic stability, the suitable strength of rock and the provision of water and building materials support the requirement for the urban development.

Geomorphology

The geomorphology of the hinterland of the newly established International Airport as the growth's center might be divided into five zones. It extends from the South to the North, as follows:

1. Gently undulated Zone of Sentolo terrain
2. The large volcanic fan of Merapi
3. The transition topography of Nanggulan
4. The rugged terrain of West Progo Mountain
5. The Jonggrangan Plateau.

The large volcanic fan extended from Merapi Volcano to Wates area. The morphology of the fan is characteriszed by gentle slope about <10^0 to the South. . This condition is vafourable for the runoff to effectively drains and avoids the flash flood . In places the old topography of Sentolo Formation crops out forming the isolated hills. The gentle folding of this formation resulted in the undulating topography (Figure 3).

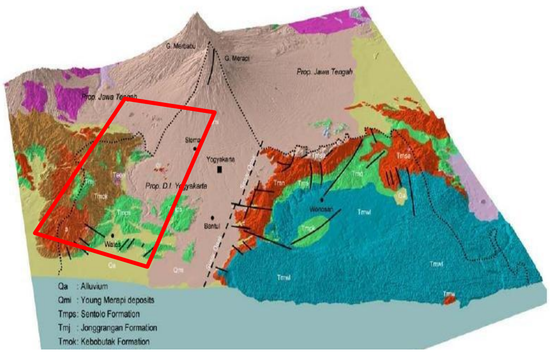

Figure 3. The eye-bird's view to the invetigated area indicated by red quadrangle (Source: Salahuddin et al. 2008)

Sentolo Formation dominantly covers the Western portion of West Progo area. The area extends about 20 kilometers from the airport to the foot of Kulon Progo Mountain. The topography in this area therefore, mostly undulated with a gentle slope

The hills consists of platy limestone and massive coral reefs (Pambudi, 2019). The geomorphologic caharacters provide the vafourable condition for the excessive development.

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In the west, the foot of West Progo Mountain borders the undulated morphology of Sentolo with the elongated talus extending from North to South. The slope of the talus gives the transitonal topography to the rugged terrain of West Progo. Combined with the moderately consolidated breccia dominating the litho;ogy of the area, the tectonic movement produced such a rugged terrain.

The elevation rises about 700 meters, where Jonggrangan Plateau is located. The plateau consists of uplifted limestone of Middle Miocene age. The stratigraphic position of the limestone above breccia of Old Andesite

The karst topography develops in the plateau providing the underground space to store meteoric water. The high elevation and low temperature invites the high rainfall. The springs yield out from the fractures in the limestone and at the contact between the limestone and the underlying breccia (Figure 4).

Figure 4. Underground water at the contact between limestone and the Old Andesite Formation

In Nanggulan area, at the middle of Sentolo undulated terrain, the topography is highly influenced by the upthrusting that brought the underlying Eocene rocks to the surface.

The rocks mainly consistis of clays and fine grains components that easily weathered. This area is known to be vafourable for rice fields supported by the efficient water irrigation drains from water storage at Jongrangan Plateau.

Stratigraphy and tectonics

A. Stratigraphy

West Progo Mountain consists mainly of volcanic products of andesitic composition. It is largely known as part of the Old Andesite Formation with the age around the termination of Oligocene (Rahardjo et al., 1995). The older rocks composed of fine clastic materials, mainly clay which might partly become the basement of the Progo Volcanics (Figure 5).

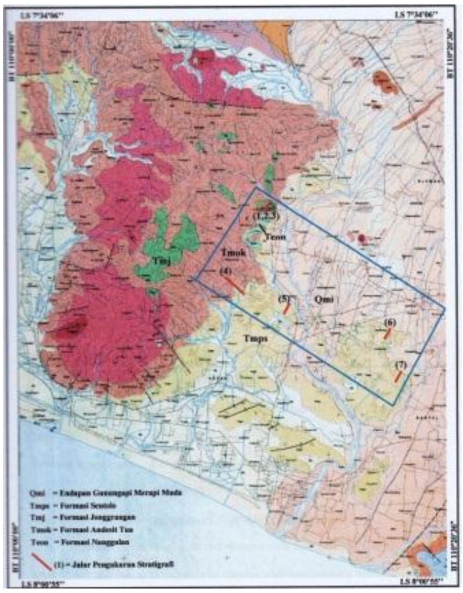

Figure 5. Geologic map of Kulon Progo (Source: Rahardjo et al., 1995)

The age of the basement was assigned Middle to Late Eocene based on fossil contents. Stratigraphc measurements were carried out by Pambudi (2019) and identified three depositional sequences respectively bounded by unconformities. The sequence began with the deposition of sandy grainstone in Late Oligocene to Early Miocene (N1 - N6) in bar and channel of lagoon shelf environment with open circulation.

The sequence also indicated the deposition of coral reef environment. The regression took place after the deposition of sequence during Late Early Miocene (N7-N8) resulting in the uplifting of the entire sequence and produced the unconformity with the overlain sediments

The transgression occurred until Early Middle Miocene (N9) where the younger equence was formed consisting of wackstone with coral reef core and partly the flanks of the reef, and packstone. The squence indicates the depositional environment of local flank and the lee side of the coral reef.

B. Tectonics

The contact between Old Andesite Formation and Nanggulan Formation remains questionable. Budiadi (2008) suspected the tectonic contacts related to regional geology (Figure 6).

The opinion was supported by Listyani (2009) based on the fracture analysis pattern (Figure 7) showing the N-S dominant pressure working in the area. Pambudi (2019) was also in the same opinion by mentioning the syngenetic limestone formation of Jongrangan and Sentolo Formations during the tectonic uplifting of West Progo Mountain which took place from Early Miocene to Late Miocene (N7-N19).

A series of NE-SW faulting was interpreted genetically separating Jongrangan and Sentolo Formations. This interpretation might contribute to the understanding of the underground configuration of Yogyakarta Basin.

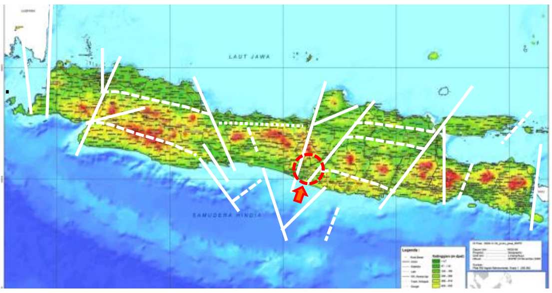

Figure 6. Tectonic block of Java Island

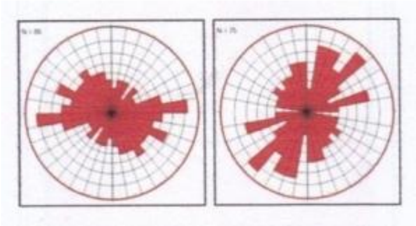

Figure 7. Fracture analysis at Jongrangan Plateau (Listyani, 2019)

Based on the local and regional Bouger Residual Anomalies and the gravity cross section, Winarti et al. (2017) demonstrate the position of Old Andesite and Nanggulan Formations which is side by side. This phenomenon leads to the conclusion that the uprising of Nanggulan Formation might have been controlled by a subsurface upthrusting.

C. Remarks

Based on the observation on the subsurface geological condition, a set of normal and upthrust faultings might locate at the depth. Based on the occurrence of the local erathquake and the recent eartquake of Yogyakarta related to Opak Fault in the East boundary of Yogyakarta Basin, it is suspected that the neotectonics might still taking place.in West Progo area. However the significant earthquake with the magnitude >4 SR have not been recorded in the last 50 years.

Geological resources

The geological resources that might support the development of the hinterkands, can be summarized as follows:

a. Undulated terrain

This type of terrain provides the condition vafourable for large urban development. The gentle slope of the undulated topography of Sentolo Formation is relatively stable. Supported by the massive coral reef and the platy limestone, the slope bocomes more stable. The landslides might be very rare if not absulotely absent.

The undulated terrain provides also the condition for the runoff to drain effectively. The flash flood or local fooding might also very rare.

b. Massive and platy limestone

Sentolo Formation consists of massive and platy limestones which physically hard and strong for the foundation. The thcikness of the formation is about 950 meters (Rahardjo et al., 1995). The rock is evenly distributed in the area West of Kali Progo. In the East portion, volcanic fan of Merapi Volcano covers the rocks which partly expose forming isolated hills.

c. Water resources

Water for domestic use ia available in Jongrangan Plateau storage. Springs yields water from the fracture of the rocks and the underneath contacts with the Old Andesite Formation. The significant water yield was noted in Mudal underground river (Figure 8). The debit exceeds 315 liter per second in rainy season and 237 liters per second n dry season. As many as 40 springs were identified (Listyani, 2019).

Figure 8. Mudal underground River in karst topography of Jongrangan Plateau (Source: Listyani 2019)

At present water is used both for domestic and irrigation. However, in the future the management of water from Jongrangan Plateau might be directed for domestic use. The position of the Jonggrangan reservoir is very ideal at the elevation of more than 700 meters. The springs located in the upper part of West Progo Mountain might be used for irrigation. The up damming in some tributaries is suggested. Water for domestic use by the locals have already been tapped from the dug well.

Kali Progo and many other tributaries might provide sufficient water for industrial purpose. At present in the upper part of Kali Progo water is drained to provide domestic purpose of Yogyakarta city.

The underground water in West Progo area might be available in some aquifers contained in Sentolo Formations. The geophysical surveys to determine the potentials aquifers is needed.

d. Building materials

Building materials is abundace in West Progo area.

(1). *Andesite* is available for quarry in the slope of West Progo Mountain and in the rivers. The andesite rocks of lava flows and intrusions are available in good quaility with an abundant amount.

(2). *Limestone* of Sentolo Formation is largely distributed in West Progo area. The isolated hills with platy and massive limestone might easily be quarried. With a careful management of limestone resources the cement factory might be feasible to build. Clay might be available from places where the Nanggulan Formation exposed. Quartz deposits are available in the Sermo area.

(3). *Clay* and *sand* is available in places at the foot of West Progo Mountain as the weathered rocks and the eroded andesite. The mixture between tuff and volcanic sand is good materials for light brake.

(4) *Others* such as gold and mangan available in places in West Progo Mountain are not included in building materails. Iron sands of beach deposits might not in good position to mine in Yogyakarta area, but in other places the deposit might environmantallly feasible to mine. The iron sand is good for correcting materials of cement factory.

Conclusions and recommendations

The important geological condition of West Progo Area as the hinterland to the newly establihed International Airport in Temon, Wates, can be concluded and recommended as follows:

1. The vast undulated terrain provides the vafourable space for large urban development. The stability of gentle slope and the high strength of massive and platty limestone are suitable for foundation.
2. Water resources in Jongrangan Plateau and the possible underground water in West Progo of Yogyakarta Basin are sufficeiently availablle for domestic use. Progo river might supply water for industrial use.
3. Building materials suchs as andesites, limestone, sand and clay are readily available in Sentolo area and in the foot of West Progo Mountain. A cement factory may be feasible.
4. It is highly recommended to manage the water resources in Jonggranga Plateau to keep the efficient use.
5. It is highly recommended to prepare an early spatial planning taking into account the would be vast and fast urban development in West Progo area in near future.

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References

Budiadi, Ev., 2008, Tectonic Control of the Geomorphology of West Progo Mountain, Dissertation, Padjadjaran University

Listyani, T. R, A., 2019, Geological Control, Hydrochemical and Stable Isotope of Ground Water Flow System at the Center of West Progo Dome, Dissertation, Padjadjaran University, 391 p

Pambudi, Setyo, Sedimentation of Jongrangan and Sentolo Formations based on Qualitative and Quantitative Approaches at the Eastern Part of West Progo Hill, Yogyakarta, Dissertation, Padjadjaran University, 224 p

Rahardjo, W., Sukandarrumidi & Rosidi, H.M.S, 1995, Peta Geologi Lembar Yogyakarta, sekala 1:100.000, Edisi ke dua, Badan Geologi, Bandung

Van Bemmelen, R.W., 1949, The Geology of Indonesia, Martinus Nijhoff, The Hague, 670 p