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Geotectonic Configuration of Kulon Progo Area, Yogyakarta

Konfigurasi Tektonik Daerah Kulon Progo, Yogyakarta

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Abstract

Kulon Progo Mountain, located west of Yogyakarta, is known as a unique morphological expression of an elongated dome frequently called "oblong dome". The structural elements occurring in Kulon Progo Mountain were predominated by a radial pattern. Applying a quantitative method to measure various morphometric elements however, revealed that the regional geotectonic pattern apparently controlled the development of Kulon Progo Mountain. A general picture of the tectonics showed that the mountain building of Kulon Progo was not solely predominated by a vertical undation force; instead it was closely related to the general geotectonics operating in the area. The macro morphological analysis using various types of satellite imageries augmented with field visits unraveled three regional tectonic stages controlled the development of Kulon Progo Mountain. Those are Meratus, Sunda, and Java trends, operating in SW-NE, NNW-SSE, and E-W directions respectively.

Keywords: oblong dome, undation theory, regional tectonic pattern, mountain building, Kulon Progo

Abstrak

Pegunungan Kulon Progo yang terletak di sebelah barat Yogyakarta, sejauh ini dikenal sebagai suatu bentuk morfologi yang khas yang disebut "kubah oblong". Terminologi ini seolah-olah melekat pada Pegunungan Kulon Progo. Berdasarkan teori undasi, Pegunungan Kulon Progo ini dibentuk oleh tenaga endogen vertikal yang mengangkat pegunungan itu menjadi "kubah" seperti sekarang ini. Sebagai konsekuensinya, maka pola-pola struktur memancar mendominasi Pegunungan Kulon Progo. Dengan menggunakan metode kuantitatif atas pelbagai unsur morfometri, terungkap bahwa tiga pola tektonik regional telah mengendalikan pembentukan Pegunungan Kulon Progo. Pola termaksud adalah Pola Sunda, Meratus, dan Jawa dengan arah masing-masing utara barat laut-selatan tenggara, barat daya-timur laut, dan barat-timur.

Kata kunci: *kubah oblong, teori undasi, pola tektonik regional, pembentukan pegunungan, Kulon Progo*

Introduction

Kulon Progo Mountain is located in Central Java about 30 km to the west of Yogyakarta (Figure 1). This mountain is very unique. First, because morphologically it differs from the general trend of the Southern Mountain where it belongs to. Second, because the morphology of the mountain forms an elliptical-shape with its elevated core and radially sloping. This particular configuration of the mountain has led van Bemmelen (1949) to define the Kulon Progo Mountain as an oblong dome originated due to the undation process. He pointed out that Kulon Progo was an ideal example of the mountain building caused by undation mechanism. In this particular case a micro tumor was built up (Figure 2).

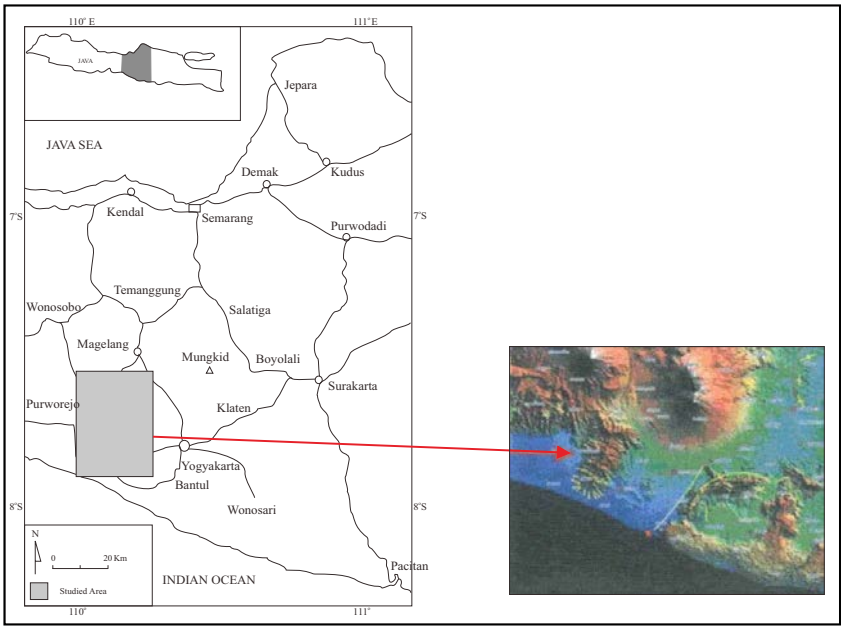

Figure 1. Map and satellite imagery show the location of the investigated area. A twin volcanoes Merapi and Merbabu are located at the center of northern part of the satellite imagery, whilst Kulon Progo Mountain is expressed in a rugged topography SW of those volcanoes or W of Yogyakarta City.

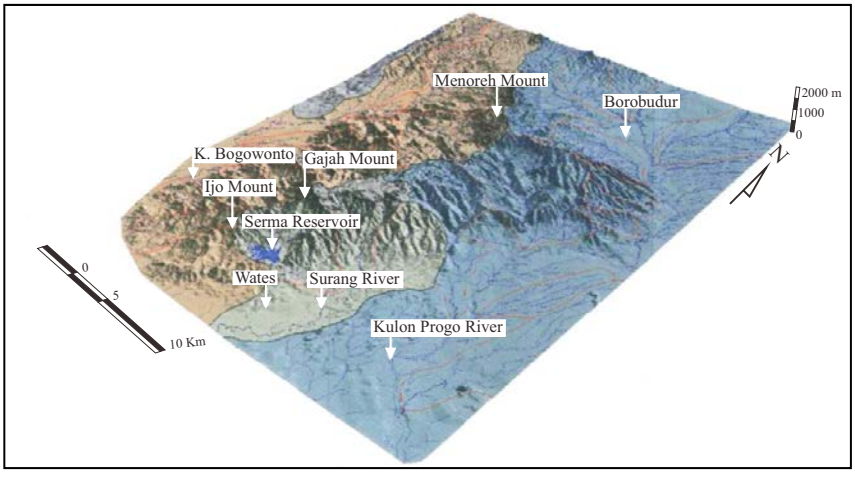

Figure 2. Bird view satellite imagery shows the morphologic configuration of Kulon Progo Mountain. An elongated shape of the mountain was one of the evidences of the tumor genesis suggested by van Bemmelen (1949). However the present investigation revealed that the regional tectonics operating in the area controlled the formation of Kulon Progo Mountain. Ijo and Gajah volcanic centers and important geographic names are indicated in this image (Note: different colors represent drainage basins).

The undation theory was first introduced by Haarman (1930). The concept put forward the vertical endogen forces that generated mountain building. The opinion was not in line with the general trend of the thought. Based on the geological phenomena observed in Alps, almost all earth scientists believed that the horizontal stress movement was the prevailing force in the formation of a mountain.

Van Bemmelen (1949) intensively applied the concept in the analysis of the geology of Indonesian

Archipelago and its surroundings. The mega undation was introduced covering the western part of Kalimantan and Sumatra. This mega tumor is the central of the development of mountains in western part of Indonesia. The mountain range in Java, East Kalimantan, and Sulawesi were the impact of the mountain building at this mega undation. Locally, a smaller size tumor was also introduced, among others Batak Tumor in Toba area with meso size and Kulon Progo of micro size.

The present investigation attempted to re-study the formation of Kulon Progo Mountain particularly in the light of plate tectonic theory. Satellite imageries analysis and measurement in the field of various morphometric elements had been carried out. It is expected that the unique morphological expression of the mountain can be better explained as viewed from another angle.

Methodology

The quantitative method was intensively applied in this investigation. The morphometric elements were measured in details to reveal the prevailing tectonic control in the area. Those elements consist of drainage density, river bifurcation, height and width ratio of a river profile, azimuth, length and density of the lineaments, drainage pattern, and sinusoidal morphometry. A statistical analysis applying regression-correlation Hotteling method and one way ANOVA method were carried out.

The remote sensing analysis was also focused to this particular subject. The images were Landsat-7 ETM+ taken in 1995 and panchromatic aerial photographs. The image interpretation was the combination between manual method and the application of computer digital processin

Results of Investigation

The Kulon Progo Mountain is composed of volcanic rocks presumably of Oligocene age based on the age determination of the underlying Eocene sediments containing fossils. The volcanic rocks are dominated by clastic materials and locally effusives. The basaltic andesite intrusions presumably representing the late phase magmatic activities were observed. The mineralization was also observed in the intrusions.

The clastic rocks consist mainly of breccia intercalated with sand and lapilli deposits. The rocks were most probably subaerially deposited. The clastic materials in the southern part, in general, were dominated by breccia, whereas to the north in the Menoreh Mountain, the clastic materials consist mainly of sand and tuff. At the same time, the finer materials were deposited in the subaqueous environment represented by glassy tuff found in Sentolo area. Finally, the whole succession was overlain by sandy tuff and limestone of Jonggrangan Formation. The age determination of the formation reveals Middle Miocene (Te5 - Tf1). Morphologically, the position of the formation is presently at the top of Kulon Progo Mountain forming a plateau. The geologic map of Kulon Progo is presented in Figure 3.

The updoming process and the intensive erosion uncovered the root of the volcano. The batholiths can be observed at the core of the mountain. Two volcanic centres were observed namely Gajah and Ijo Volcanoes supposedly the centres of the activities in the past. The transition between the magmatic rocks and the clastic materials could also be observed. Based on the evidences, van Bemmelen (1949) concluded that the updoming process has brought the mountain to build. Hence the radial pattern of the faulting and fracturing features were due to this mechanism. The patterns of river segments lineaments and structural alignment of Progo Mountain areas have a very close relationship. The correlation between these two phenomena have a 95% confident level.

Based on the river segments lineaments and structural alignments, three systems are detected. System I comprises 12 pairs of alignment direction (cross the Nanggulan Formation); System II A consists of 107 pairs of alignment direction (cross the Kaligesing-Hamlet Formation); System II B (cross Sentolo - Jonggorangan Formations) is composed of 34 pairs of direction straightness, and System III (cross Quaternary Deposit) consists of 70 pairs of alignment direction.

Based on the detailed measurements of various morphometric elements as outlined above, the present study however comes into a conclusion that the regional tectonics controlled the development of Kulon Progo Mountain. Those regional tectonics are Meratus trend presumably of Eocene age (Asikin, 1974), Sunda or Sumatra trend (Pulunggono and Martojoyo, 1994) much probably Late Miocene, and

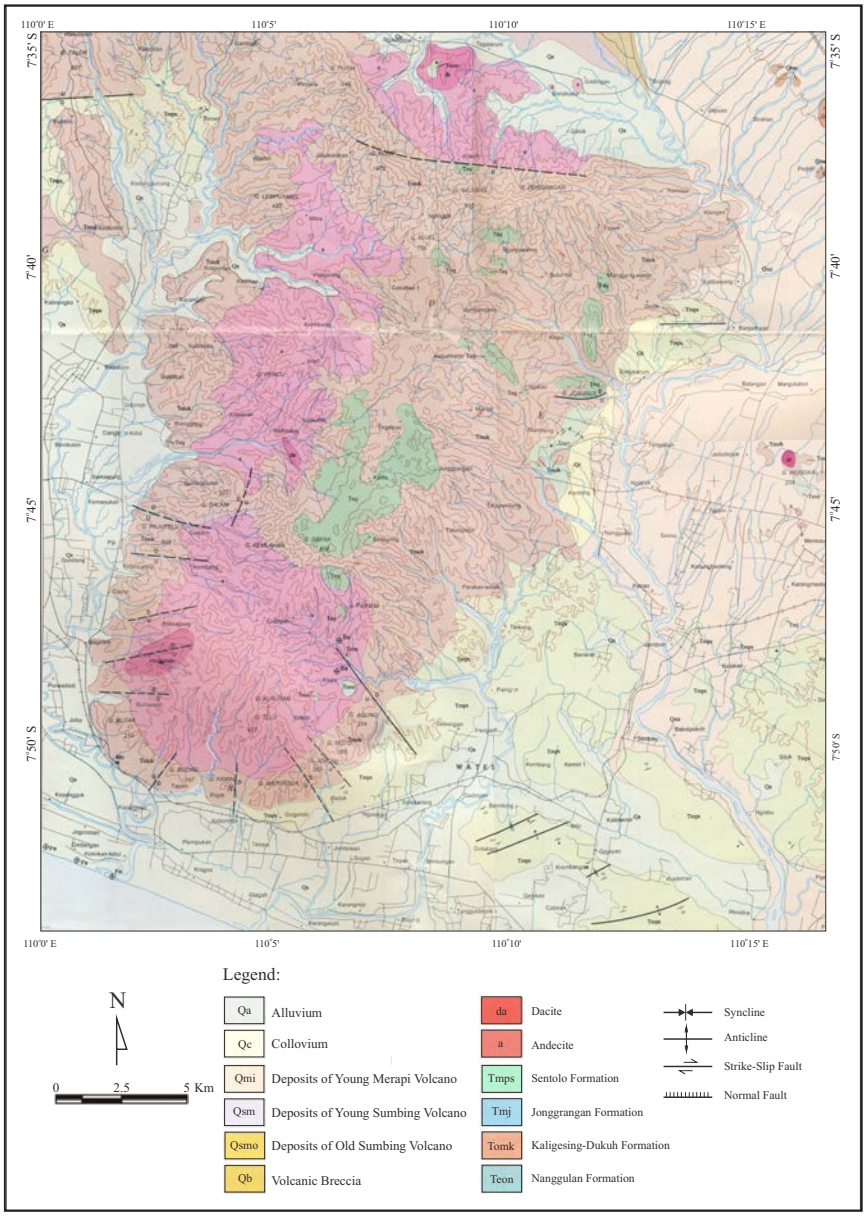

Figure 3. Geologic map of Kulon Progo Mountain, Yogyakarta (Rahardjo *et al.*, 1995).

finally the Java trend (Pulunggono and Martojoyo, 1994; Soeria-Atmadja *et al.*, 1998) with the age of Pliocene to Present. The directions of those trends are SW-NE, NNW-SSE, and E-W respectively.

Discussion

The measurement of various elements of morphometry reveals the tectonic analysis as viewed from different angle. Quantitative method has provided the information confirming the hypothesis that Kulon Progo Mountain was formed under a regional tectonic pattern. The evidence is very significant taking into account that the mountain building in Indonesian Island Arc is highly controlled by the movement of the Indian-Australian Oceanic Plate in collision with the Eurasian Continental crust.

The unique morphologic expression of Kulon Progo Mountain trending SSW-NNE might be

explained by the general pattern of the faulting occurrence in Java Island. The orientation of deep seated faults producing low and high strutures can be observed from the geophysical evidences presented among others by Untung and Wiriosudarmo (2005), and the structural analysis by Satyana and Purwaningsih (2002), as well as by Widiyanto, 2013, in prep; Figure 4). The orientation of Kulon Progo Mountain is very much in line with the general faulting block system of Java Island.

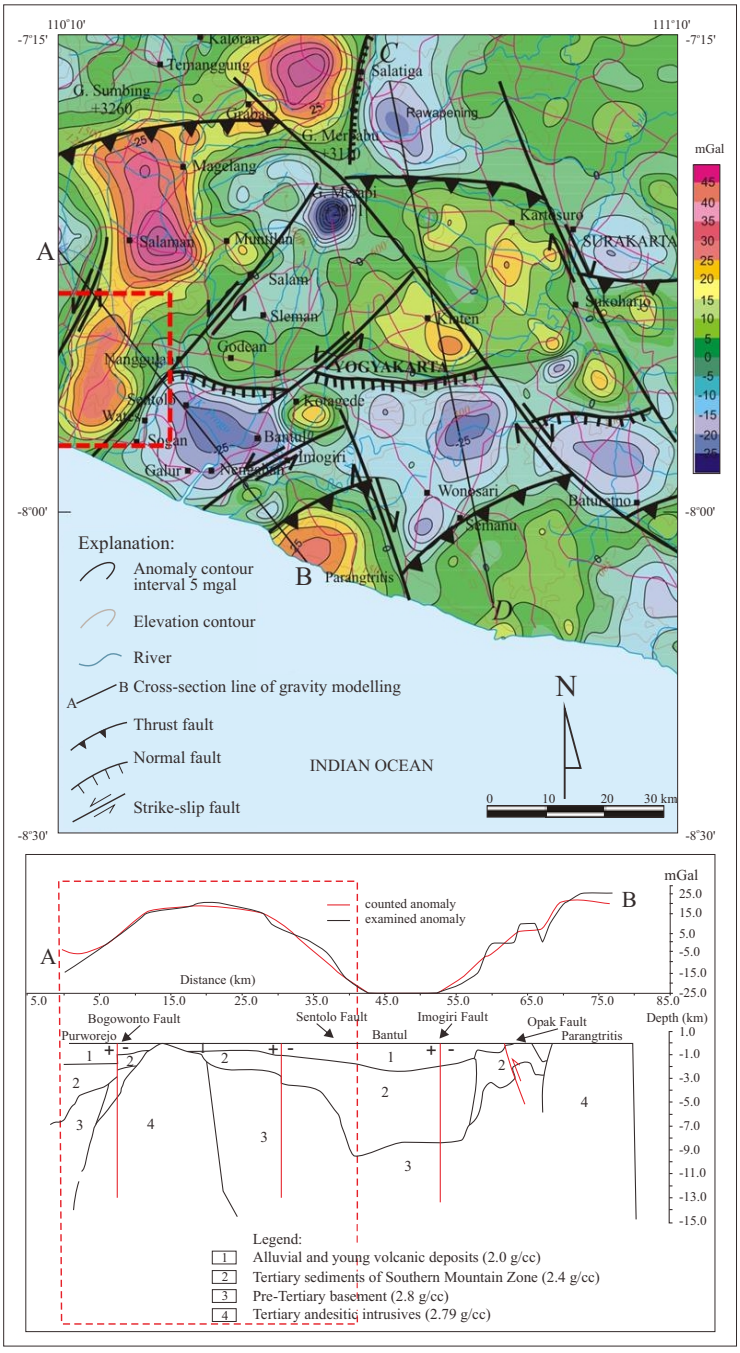

Figure 4. Bouguer - Residual anomalies modelling map of Kulon Progo Mountain and surrounding areas showing the basement configuration and lithology variation (Widiyanto, 2013).

Conclusion and Recommendation

The unique morphological expression of Kulon Progo Mountain is due to the general trend of the tectonics which has been operating in Java Island since Eocene time. The elliptical morphologic form of the mountain is very much likely controlled by the general trend of the basement structure of Java Island as the results of the above mentioned geotectonic pattern. The configuration of the dynamics operating in Kulon Progo Mountain seems to follow the general tectonics rather than to the undation mechanism. It is therefore very strongly recommended to revise the terminology "oblong dome" frequently applied to Kulon Progo Mountain to avoid misleading in view of the geotectonic mechanism.

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