

Structural Interpretation of the Jonggol Mount Area, Kulon Progo, Yogyakarta, Using Gravity Inversion Modelling

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ABSTRACT

The Mount Jonggol region in Kulon Progo, Yogyakarta, constitutes an important segment of the Sunda–Banda magmatic arc system; however, its subsurface structural configuration remains insufficiently understood. This study aims to interpret subsurface structures and lithological boundaries through derivative analysis and three-dimensional gravity inversion modelling. The gravity dataset was obtained from the Global Gravity Model Plus (GGMplus), which provides absolute gravity acceleration measurements with high spatial resolution. The data were processed using sequential corrections, including normal gravity, free-air, simple Bouguer, and terrain corrections, to generate the Complete Bouguer Anomaly (CBA). The resulting CBA data were analyzed using the First and Second Horizontal Derivative (FHD and SHD) methods to delineate structural discontinuities, fault planes, and density contrasts. Furthermore, three-dimensional inversion modelling was conducted to visualize subsurface density variations to a depth of approximately 3.5 km. The results indicate that Mount Jonggol is situated at the tectono-lithological boundary between the low-density Jonggrangan Formation (2.0–2.4 g/cc) and the high-density Old Andesite Formation (2.7–3.0 g/cc). The gravity anomaly pattern reveals a northwest–southeast-oriented magmatic corridor controlled by thrust and strike-slip fault systems, providing important insights into the tectono-magmatic evolution and uplift mechanisms of southern Central Java.

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1. INTRODUCTION

The Jonggol Mount area, located in the Kulon Progo region of Yogyakarta, Central Java, represents a significant geological site within the southern Sunda–Banda magmatic arc system. The majority of this area is underlain by the Jonggrangan Formation, which comprises volcanic breccia, tuffaceous sandstone, and conglomerate derived from reworked Late Miocene volcanic materials. This formation is interpreted to have developed in a volcano–sedimentary environment that emerged following the principal volcanic activity of the Menoreh Mountains volcanic complex (Scotese et al., 2025; Setijadji et al., 2006). Mount Jonggol is not an active volcano; rather, it constitutes the eroded remnants of an ancient volcanic structure that has undergone significant denudation and weathering over time (Hall, 2012; Smyth et al., 2005).

The rock formations surrounding Jonggol, including the Andesite Formation and Old Volcanic Deposits, indicate that this area was formerly part of an extensive Miocene volcanic region in Central Java (Clements et al., 2009; Scotese et al., 2025). These lithologies document volcanic and subvolcanic processes associated with andesitic to dacitic magmatism, characteristic of continental arc environments within the Sunda–Banda subduction system (Hall, 2012; Hamilton, 1979). At present, Mount Jonggol represents an eroded remnant of ancient andesitic intrusions or lava flows, reflecting the vestiges of a magmatic system that was uplifted and exposed by subsequent tectonic activity (Hall, 2012; Hall et al., 2007).

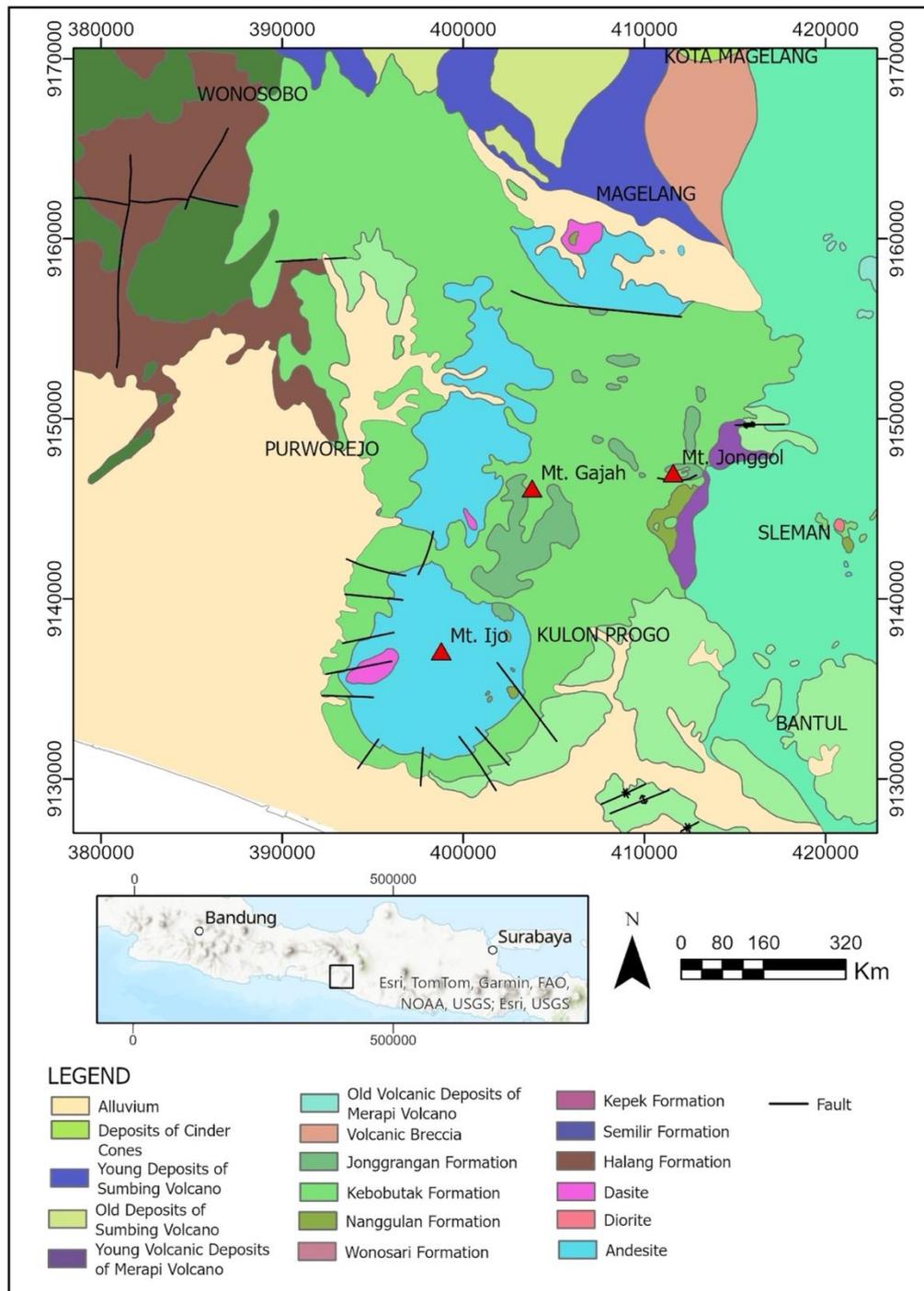


Figure 1. Geological map of Jonggol Mount (Rahardjo et al., 2012).

Multiple fault systems traverse the study area, demonstrating that tectonic processes have significantly influenced both the distribution of exposed rocks and the uplift of the volcanic zone. The predominant northwest–southeast (NW–SE) fault orientation aligns with the regional stress regime in southern Java, which is governed by the oblique convergence of the Indo-Australian and Eurasian plates (Katili, 1967; Simandjuntak & Barber, 1996). This structural pattern is consistent with the formation of transpressional and strike-slip faults that control the morphology and exposure of the Menoreh–Kulon Progo highlands (Clements et al., 2009; Smyth et al., 2005). Consequently, tectonic uplift and fault reactivation are regarded as the principal factors shaping the landforms and rock exposures in the Jonggol area (Hall, 2012; Setijadji et al., 2006).

Despite the considerable geological significance of the Jonggol region, few detailed structural and geophysical investigations have been conducted. Most research in Central Java has concentrated on major Quaternary volcanoes such as Merapi, Lawu, and Dieng, leaving Miocene volcanic remnants like Mount Jonggol poorly understood in terms of subsurface structure, deformation, and tectonic history (Hall, 2012; Smyth et al., 2005). Addressing these knowledge gaps is essential for reconstructing the tectonic and volcanic evolution of Central Java following the Miocene, particularly along the northern margin of the Sunda–Banda subduction system (Clements et al., 2009; Setijadji et al., 2006). Understanding the interactions among volcanism, sedimentation, and tectonic uplift in this area is also critical for elucidating the crustal processes that have shaped Java’s geology (Hall, 2012; Smyth et al., 2005).

This study investigates the Jonggol Mount area using derivative analysis and inversion modelling of gravity data to delineate structural and lithological boundaries. These geophysical methods provide effective tools for delineating fault geometries, density contrasts, and magnetic susceptibility variations, thereby offering valuable insights into the subsurface configuration of the Jonggrangan Formation (Blakely, 1996; Nabighian et al., 2005). From a broader geodynamic perspective, the results of this study are anticipated to enhance knowledge of the structural evolution of southern Central Java and to have significant implications for geohazard assessment, mineral exploration, and basin analysis in ancient volcanic terrains (Clements et al., 2009; Hall & Smyth, 2008; Scotese et al., 2025).

Gravity derivative and inversion modelling were selected as the primary analytical methods to evaluate these geological processes. Inversion modelling of gravity anomalies enables quantitative reconstruction of subsurface geometry, including the depth and continuity of high-density intrusions associated with Miocene magmatic systems (Pirttijarvi, 2014). Compared with resistivity methods, which are constrained by limited depth penetration and groundwater influence, gravity inversion offers a more reliable approach for imaging deep-seated structures within the back-arc lithosphere. Consequently, this study applies derivative filtering and three-dimensional gravity inversion to delineate the subsurface structural and lithological framework of the Jonggol area, with the objective of clarifying the tectonic evolution of the Kulonprogo back-arc uplift. The regional geological setting of the study area is presented in Figure 1, which illustrates the distribution of the Jonggrangan Formation, Old Andesite Formation, and associated structural features (Rahardjo et al., 2012).

2. METHOD

2.1 Gravity Data and Anomaly Processing

This research employs data from the Global Gravity Model Plus (GGMplus) dataset, a joint initiative created by Curtin University and the Technical University of Munich. GGMplus is distinguished for its elevated spatial resolution, characterized by a grid spacing of roughly 200 meters, rendering it especially appropriate for geophysical studies at both local and regional levels. The GGMplus dataset utilized in this study includes gravity acceleration (absolute) measurements, as opposed to free-air gravity anomalies. Therefore, a sequence of adjustments is necessary to mitigate the influences of terrain and adjacent mass at the observation stations to get precise gravity anomaly measurements.

The GGMplus data underwent multiple correction procedures to derive the Free-Air Anomaly (FAA), Simple Bouguer Anomaly (SBA), and Complete Bouguer Anomaly (CBA). The corrections

encompass the Theoretical Normal Gravity Correction, Free-Air Correction, Simple Bouguer Correction, and Terrain Correction. Each correction step aims to progressively isolate subsurface density fluctuations by removing the gravitational effects of elevation and surface mass distribution (Hirt et al., 2013, 2016; Pascaning Setiahadwibowo et al., 2025).

Precise gravity anomaly data were generated using these sequential correction procedures, which underpin the comprehension of underlying geological structures and density distribution in the studied area. This procedure, along with established techniques in prospective field geophysics, ensures that the resultant anomalies genuinely represent subsurface mass fluctuations rather than surface influences (Blakely, 1996; Telford et al., 1990) by (equation 1).

$$FAA = (g_{obs} - g_n) - (-0,3085672 h) = g + 0,3085672 h \quad (1)$$

The observed gravity field is referred to as g_{obs} , whereas the normal gravity field on the reference spheroid is designated as g_n . Where g represents the observed gravitational acceleration (absolute gravity acceleration measurements from GGMplus), and h denotes the topographic elevation at each measurement location. Thereafter, topographic corrections were implemented, encompassing both the simple Bouguer correction and terrain correction. The Simple Bouguer Anomaly (SBA) was derived by subtracting the Free-Air Anomaly (FAA) from the Bouguer correction (Hinze et al., 2013).

$$SBA = FAA - (0.04192 h) \quad (2)$$

Utilizing the Simple Bouguer Anomaly data obtained from the Digital Elevation Model – Earth Residual Terrain Model 2160 (DEM ERTM 2160), the terrain correction value (δg_{TC}) at each gravity measurement location was calculated employing the terrain-correction method via the Hammer chart approach (Hammer S) (Hammer, 1982) by equation 3:

$$CBA = SBA + [0.04192 (HN - h)] \quad (3)$$

The variable HN signifies the standard or reference height utilized in the GGMplus dataset, while h indicates the actual topographic elevation at the observation site. The gravity anomalies were next processed by projecting them onto a planar surface, dividing the field into regional and residual components, and analyzing the First Horizontal Derivative (FHD) and Second Horizontal Derivative (SHD). A block model was subsequently developed to optimize the subsurface configuration utilizing Occam inversion and Singular Value Decomposition (SVD) techniques. SVD inversion is a matrix factorization technique reliant on singular values, wherein the conventional SVD method calculates the inverse of the Jacobian sensitivity matrix. The Occam inversion, conversely, amalgamates neighboring minor block values and reduces the discrepancy between the observed and computed data, thus enhancing their correlation (Pirttijarvi, 2014).

2.2 Horizontal Derivative Analysis (Horizontal Gradient)

The horizontal derivative in gravity anomaly data is defined as the rate of change in gravitational field values between two places at a specified distance apart. Horizontal derivative analysis may be conducted with either the first horizontal derivative (FHD) or the second horizontal derivative (SHD). This technique is advantageous for distinguishing both shallow and deep subterranean formations. Equations 4 and 5 were utilized in the computation of FHD and SHD (Hinze et al., 2012).

$$FHD = \frac{\partial \Delta g}{\partial r} = \sqrt{\left(\frac{\partial \Delta g}{\partial x}\right)^2 + \left(\frac{\partial \Delta g}{\partial y}\right)^2} \quad (4)$$

$$SHD = \frac{\partial^2 \Delta g}{\partial r^2} = \sqrt{\left(\frac{\partial^2 \Delta g}{\partial x^2}\right)^2 + \left(\frac{\partial^2 \Delta g}{\partial y^2}\right)^2} \quad (5)$$

Figure 2 presents the behavior of gravity anomalies across an extended vertical geological contact defined by contrasting density values. The First Horizontal Derivative (FHD) displays maximum or minimum values, while the Second Horizontal Derivative (SHD) is zero at the position of the density contrast, thereby facilitating the identification of geological boundaries (Hinze et al., 2012). Lithological

boundaries can be characterized by maximum values of the First Horizontal Derivative (FHD) and zero crossings of the Second Horizontal Derivative (SHD), which indicate sharp density contrasts.

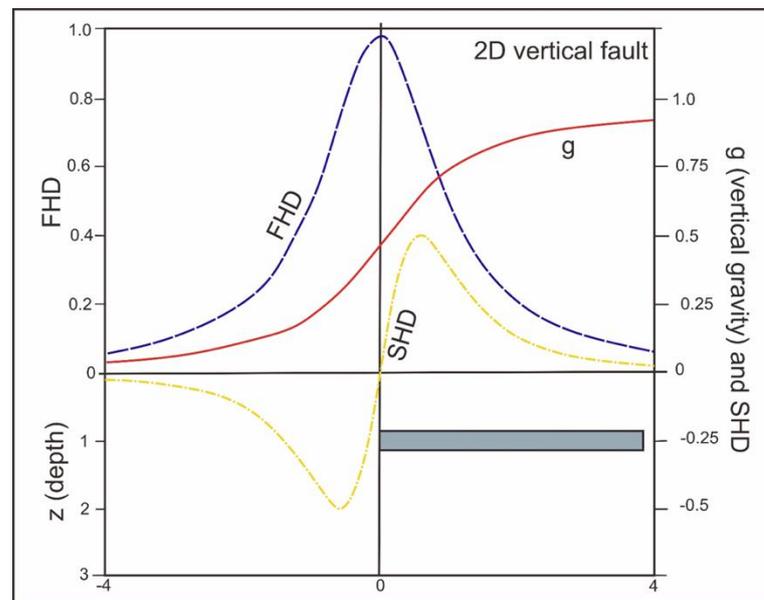


Figure 2. Illustration of gravity anomaly (g), SHD, and FHD at a density contact (Hinze et al., 2013).

2.3 Inversion Modelling

Following the acquisition of regional and residual gravity anomalies, an initial modelling phase was implemented to characterize subsurface structures. The residual anomaly specifically informed the modelling of shallow subsurface features. The process commenced with the construction of a block model constrained by geological parameters (Figure 2), using (Pirttijarvi, 2014) and Bloxer Grablox (Pirttijarvi, 2012) software. Physical parameters, including density values and block coordinates (x , y , z), were assigned to the model. Subsequently, the geometry and presence of subsurface structures were refined through inversion processes employing Singular Value Decomposition (SVD) and Occam inversion techniques. The SVD-based inversion encompassed basic, density, and height inversions, while the Occam inversion included Occam d (density inversion), Occam h (height inversion), and a combined Occam $h + d$ inversion (Pirttijarvi, 2014).

3. RESULTS AND DISCUSSION

3.1 Complete Bouguer Anomaly Map (CBA) Interpretation

The Complete Bouguer Anomaly (CBA) map (Figure 3) presents the spatial distribution of gravity variations across the Kulon Progo region and adjacent areas, with anomaly values ranging from 93.9 to 175.3 mGal. Elevated anomaly values, depicted in red to purple shades, are concentrated in the central to western sectors, particularly around Mount Gajah, Mount Ijo, and Mount Jonggol. In contrast, lower anomalies, shown in blue to green shades, are found in the northern areas such as Magelang and Wonosobo. Geophysically, the pronounced gravity highs in central Kulon Progo indicate the presence of dense subsurface materials, most likely related to intrusive igneous bodies and andesitic–basaltic lava flows that form the Kulon Progo Hills. Conversely, gravity lows in the northern to eastern sectors (Magelang–Sleman) reflect lower-density formations, which correspond to Quaternary volcanic sediments and alluvial deposits at the base of the volcanic arc.

The Kulon Progo region is geologically underlain by the Old Andesite Complex, which consists of breccia, lava, and andesitic–dioritic intrusions of Oligocene–Miocene age (Rahardjo et al., 2012). To the west and north, these rocks are overlain by the Jonggrangan and Sentolo Formations, which comprise Middle to Late Miocene limestone and marl units. The elevated Bouguer anomaly values observed around Mount Gajah indicate the presence of a dense igneous core, interpreted as an intrusive dome that

forms the structural nucleus of the Kulon Progo Hills. The formation of this intrusive body is inferred to have contributed to local uplift and deformation of the surrounding morphology, a process genetically linked to post-subduction magmatic activity along the southern Java arc (Hall, 2012; Nugraha & Hall, 2018).

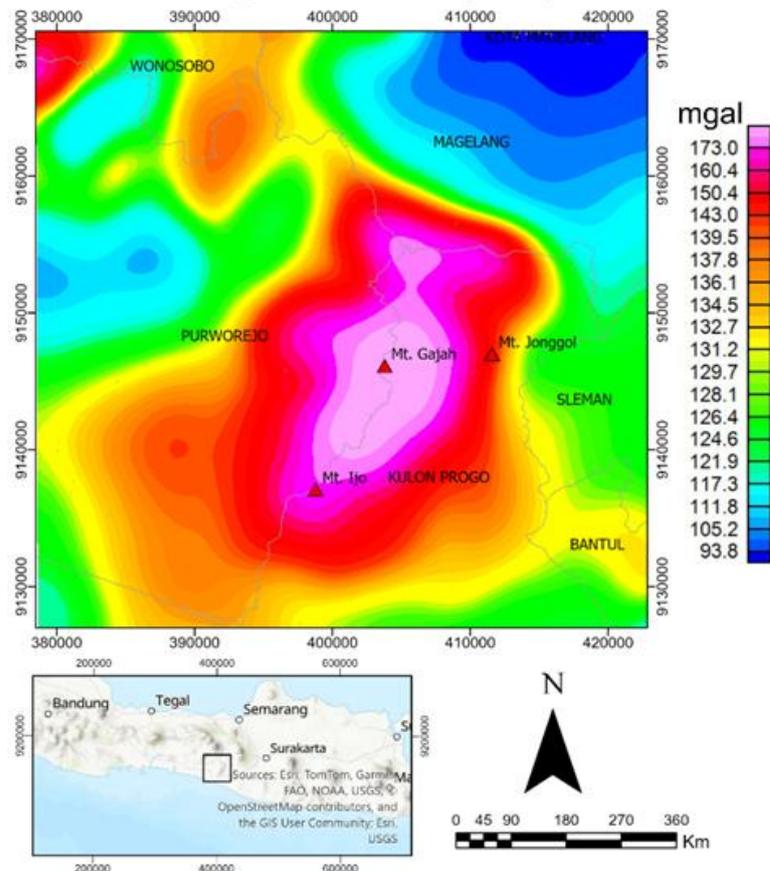


Figure 3. Complete Bouguer Anomaly (CBA) map.

The regional gravity anomaly map (Figure 3) shows a clear high-gravity belt (150–173 mGal) running southwest to northeast from Mount Ijo through Mount Gajah to Mount Jonggol. This pattern marks a linear magmatic and structural corridor with dense rocks, likely andesitic to dioritic intrusions that make up the deeper crustal roots of the Miocene Kulon Progo volcanic complex (Setijadji et al., 2006; Smyth et al., 2005). The gravity high at Mount Ijo matches the oldest volcanic center in Kulon Progo, which is the main Miocene magmatic core of the area. Gravity values gradually decrease to the northeast (down to 125–140 mGal near Mount Jonggol), showing thinning and erosion of volcanic deposits and intrusions (Clements et al., 2009; Hall, 2012). These results suggest a genetic link among Mount Ijo, Mount Gajah, and Mount Jonggol, which are all parts of the same magmatic system that developed during the Late Miocene (Hamilton, 1979; Scotese et al., 2025). The CBA map highlights a regional high-gravity corridor trending northwest–southeast, indicating deep-seated dense intrusive bodies.

The residual anomaly map (Figure 4) gives a more detailed view of near-surface density changes. Clear positive anomalies (2.0–4.9 mGal) around Mount Ijo and Mount Gajah point to shallow subvolcanic intrusions or dense lava flows. Smaller positive anomalies near Mount Jonggol (1.5–2.5 mGal) suggest buried intrusive bodies or feeder dikes along the same northwest to southeast structural line. Negative anomalies (–2.0 to –3.5 mGal) around these highs likely show volcanoclastic and sedimentary cover rocks from the Jonggrangan Formation, which have lower densities (Blakely, 1996; Telford et al., 1990). The pattern of these anomalies matches the tectonic structure of southern Java, shaped by oblique convergence and faulting between the Indo-Australian and Eurasian plates (Hall &

Smyth, 2008; Nugraha & Hall, 2018; Simandjuntak & Barber, 1996). This structure supports the idea that both Mount Gajah and Mount Jonggol were uplifted along fault blocks, which fits with regional changes during the post-Miocene uplift of the Menoreh–Kulon Progo highlands (Koulali et al., 2016).

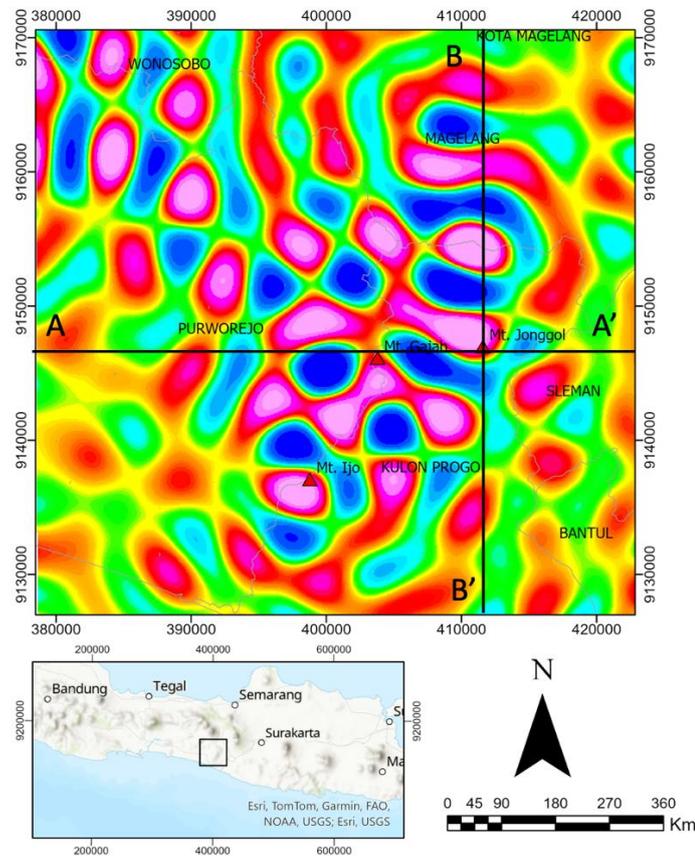


Figure 4. Residual anomaly map.

Combining both datasets, the Jonggol–Gajah–Ijo alignment can be interpreted as a Miocene–Pliocene magmatic chain formed by Looking at both datasets together, the Jonggol–Gajah–Ijo alignment appears to be a Miocene–Pliocene magmatic chain formed by subvolcanic intrusions along reactivated basement faults. Mount Ijo, the oldest volcano, is the magmatic center of this chain. Mount Gajah is an intermediate subvolcanic dome, and Mount Jonggol is the northeastern erosional remnant of the same system. The continuous gravity highs show a persistent dense zone underground that links all three, likely the solidified root of an ancient volcanic arc. This matches regional studies that say the Kulon Progo uplift comes from arc–trench coupling and backarc shortening after Miocene volcanism ended (Hall, 2012; Katili, 1967; Pubellier et al., 2003). These results help refine the subsurface model of Kulon Progo and show that the Jonggol–Gajah–Ijo complex is important for understanding arc crust evolution, exhumation, and possible mineralization in Java’s Miocene volcanic belt (Verdiansyah, 2019; Widagdo et al., 2018). The residual anomaly map enhances shallow density contrasts and delineates local structural discontinuities associated with fault-controlled volcanic remnants.

The three-dimensional gravity inversion model (Figure 5) reveals significant variations in subsurface density distribution from the surface (0 km) to approximately 3.5 km depth. Density values range from 1.8 to 3.0 g/cc, represented by a color gradient from blue–green (indicating low density) to orange–red (indicating high density). The low-density zone (1.8–2.3 g/cc), which dominates the shallow layer (0–1.5 km), corresponds to clastic and tuffaceous volcanic rocks of the Jonggrangan Formation, extensively exposed around Mount Jonggol. These rocks consist of pyroclastic debris and sedimentary volcanic deposits formed during Late Miocene volcanic activity. At depths exceeding 2 km, a high-density zone (2.7–3.0 g/cc) emerges beneath the Mount Jonggol area toward the southwest. This zone

is interpreted as andesitic–dioritic intrusive rocks of the Old Andesite Formation, which constitute the subvolcanic basement beneath the Jonggrangan Unit. The 3D inversion model (Figure 5) reveals the vertical continuity of high-density bodies (2.7–3.0 g/cc), interpreted as subvolcanic intrusive roots extending to depths of 3.5 km.

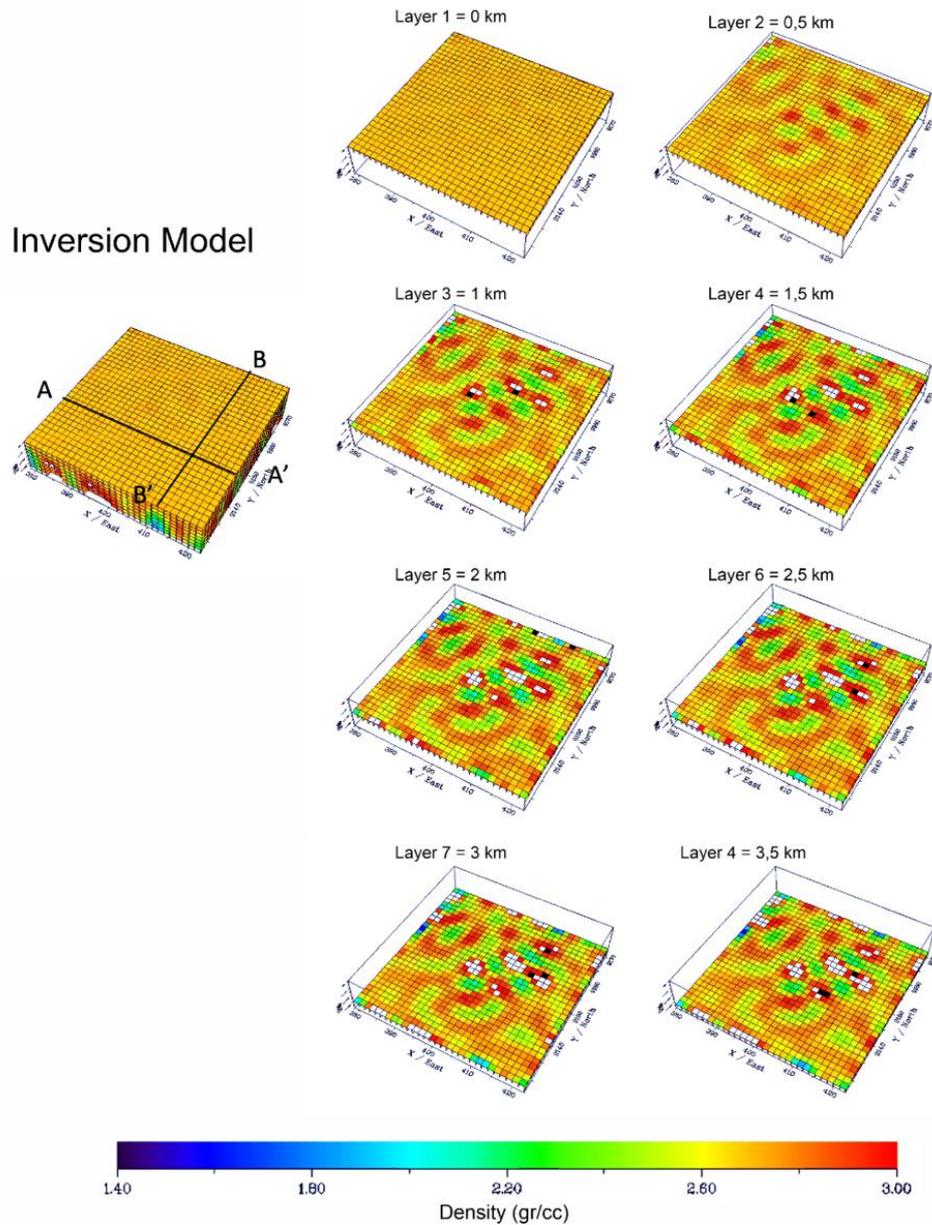


Figure 5. Result model 3D inversion.

These findings indicate that Mount Jonggol is situated directly on the tectono-lithological contact zone between older volcanic rocks (Old Andesite). Laterally, the inversion model demonstrates the continuity of high-density bodies from 1.5 to 3.5 km depth, suggesting the presence of a magma conduit (feeder system) or subvolcanic intrusive root associated with the Miocene magmatic system that formed the Kulon Progo Complex. This high-density zone (orange–red) most likely represents the remnant of a solidified magmatic intrusion emplaced along a northwest–southeast trending fault line, consistent with the regional stress regime of southern Java. The observed increase in density toward the southwest indicates that Mount Jonggol forms part of the eroded northern slope of a larger magmatic–structural complex, with centers of activity located near Mount Gajah and Mount Ijo. The results of this

three-dimensional inversion support the interpretation that Mount Jonggol is positioned directly above the boundary between the low-density Jonggrangan Formation and the high-density Old Andesite Formation, both of which experienced post-Miocene tectonic reactivation within the Kulon Progo volcanic arc zone.

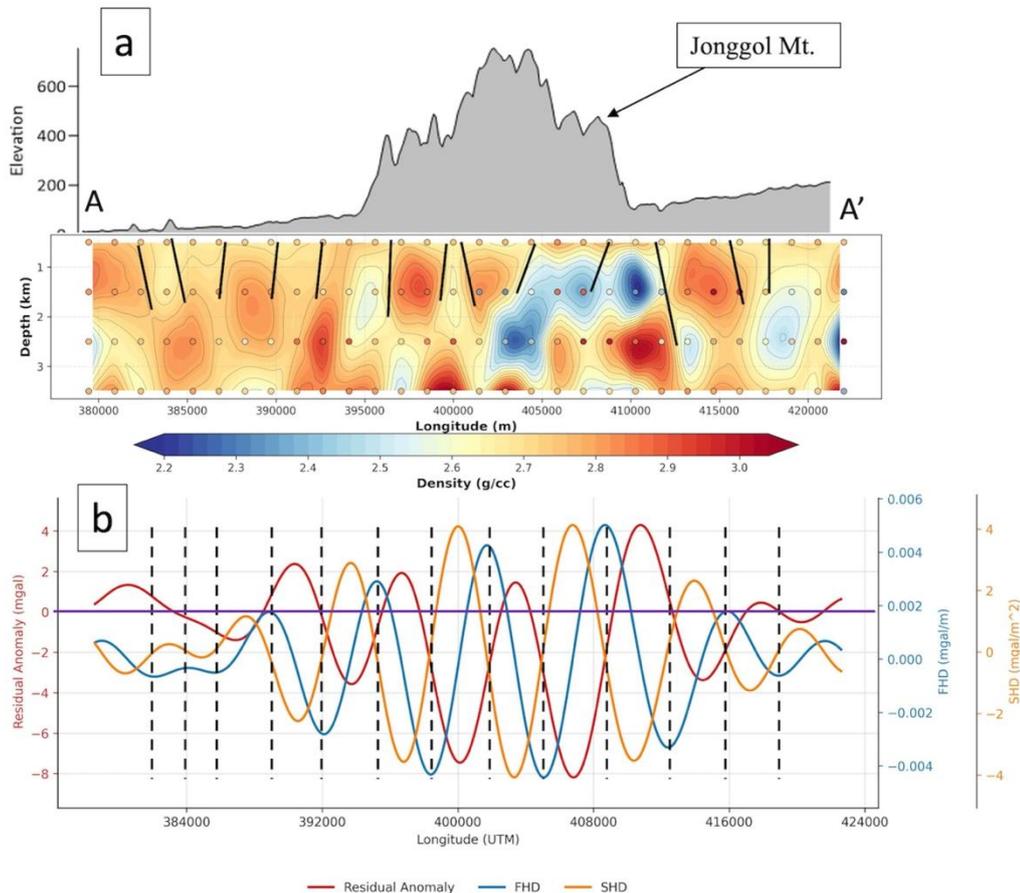


Figure 6. (a) Model inversion result horizontal of Jonggol Mount, (b) derivative gravity profiles.

The inversion (Figure 6a) and derivative gravity profiles (Figure 6b) delineate the structural configuration and lithological density contrasts along a horizontal transect across Mount Jonggol and adjacent formations. The central density model panel displays color-coded density variations from 2.2 to 3.0 g/cc. Red to dark-orange zones (2.8–3.0 g/cc) correspond to the Old Andesite Formation, while blue to light-cyan zones (2.2–2.4 g/cc) indicate the Jonggrangan Formation (Kusuma et al., 2019; Pambudi et al., 2017). The boundary between these formations is defined by a steep density gradient beneath Mount Jonggol. The highest density contrast occurs between longitudes approximately 400,000 and 410,000 m, where the topographic peak of Jonggol aligns with the transition from dense volcanic to less dense volcano-sedimentary rocks. These observations indicate that Mount Jonggol is situated at a significant lithological and structural boundary, likely governed by faulting or shear zones associated with post-Miocene tectonic reactivation (Clements et al., 2009; Simandjuntak & Barber, 1996; Verdiansyah, 2019).

The black solid lines in the density section indicate fault and fracture zones trending predominantly northwest–southeast, which aligns with the regional stress regime of southern Java (Koulali et al., 2016; Simandjuntak & Barber, 1996). These structures serve as lithological boundaries, separating the dense Old Andesite units from the more porous Jonggrangan volcanic-sedimentary deposits. The alternating high- and low-density blocks observed are indicative of horst–graben or tilted fault-block geometries, characteristic of extensional to transpressional deformation within the Kulon Progo uplift. Vertical displacement of density interfaces implies that the Old Andesite Formation has

been uplifted and exposed along fault scarps, whereas the Jonggrangan Formation occupies the downthrown basin-side blocks. This structural compartmentalization is corroborated by field evidence of sheared and brecciated andesite along fault zones near Mount Jonggol and Mount Gajah. The bottom-derivative gravity profile, which presents the First Horizontal Derivative (FHD) and Second Horizontal Derivative (SHD) curves, provides additional support for the structural interpretation.

Sharp FHD peaks (blue) and SHD inflections (orange) align with the black dashed vertical lines (Figure 6b), marking the locations of major fault zones that separate contrasting density domains. The most significant derivative peaks are located beneath Mount Jonggol, confirming its position at the intersection of high-density Old Andesite and low-density Jonggrangan units. This density transition likely corresponds to an ancient volcanic conduit or intrusive contact zone that functioned as a magma feeder during Miocene volcanism and was subsequently exhumed by uplift and erosion. The strong correlation between FHD/SHD peaks and mapped density boundaries substantiates the presence of steep, fault-controlled contacts rather than gradual lithological transitions. Collectively, the structural and density patterns indicate that Mount Jonggol is a tectonically uplifted boundary zone, where remnants of Miocene andesitic intrusions of the Old Andesite Formation are juxtaposed with tuffaceous and volcanoclastic deposits of the Jonggrangan Formation (Blakely, 1996; Telford et al., 1990). Overall, Figure 6 provides important evidence of the lateral structural configuration beneath Mount Jonggol, clearly illustrating the sharp density contrast between the Old Andesite and Jonggrangan Formations and confirming the presence of fault-controlled lithological boundaries. The strong correspondence between inversion density contrasts and FHD–SHD peaks demonstrates that the subsurface contact is structurally controlled rather than gradational, highlighting the tectonic significance of Mount Jonggol as a reactivated boundary zone within the Kulon Progo uplift.

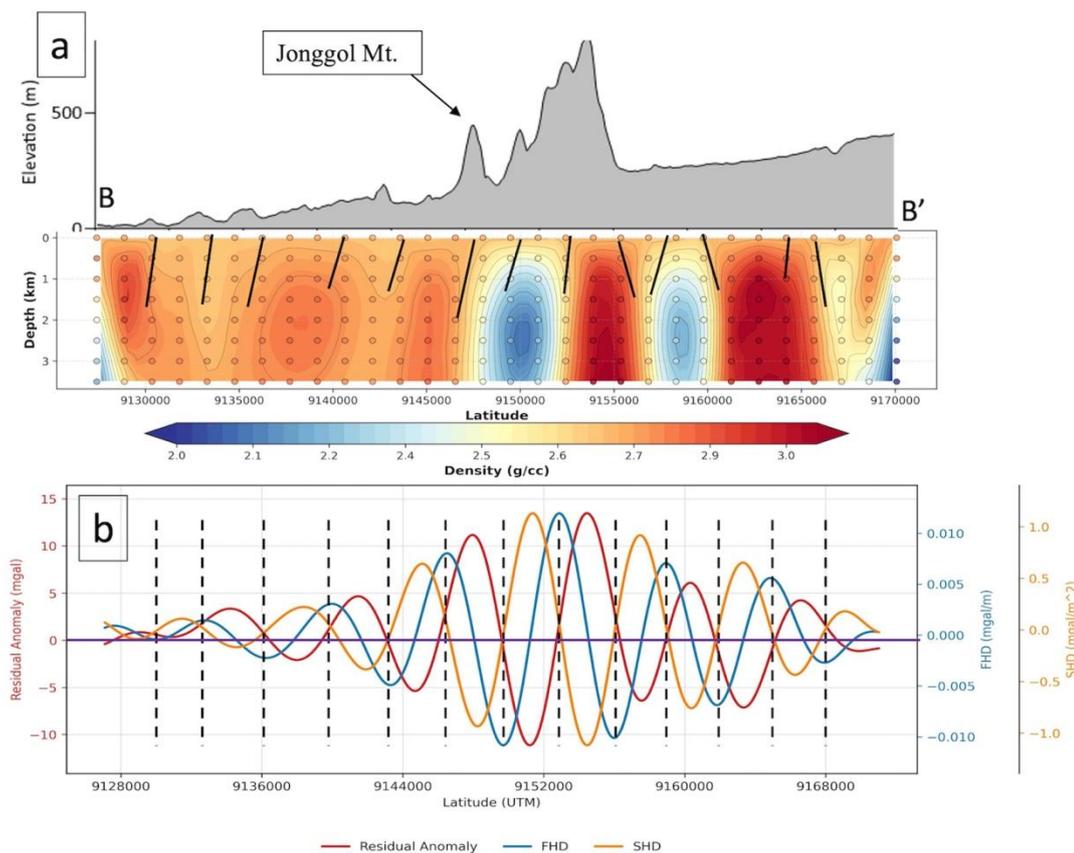


Figure 7. (a) Model inversion result vertical of Jonggol Mount, (b) derivative gravity profiles.

The inversion density cross-section (middle panel) displays a pronounced vertical and lateral contrast in subsurface densities, ranging from 2.0 to 3.0 g/cc (Figure 7a). This contrast delineates the

compositional boundary between the low-density volcanic–sedimentary rocks of the Jonggrangan Formation (blue zones, 2.0–2.4 g/cc) and the high-density andesitic intrusive or lava flow units of the Old Andesite Formation (orange–red zones, 2.7–3.0 g/cc). The Jonggrangan Formation is a limestone unit (Bondan et al., 2019; Nurfiyanto & Pandita, 2017). The contact between these formations is observed beneath Mount Jonggol (latitude 9145000–9150000), where the topographic peak coincides with a steep density boundary (Figure 7b). This transition zone is interpreted as a fault-bounded lithological contact, formed during post-Miocene tectonic uplift and reactivation of pre-existing volcanic structures within the Kulon Progo uplift. The geometry of the density contrast indicates that Mount Jonggol is situated within a structural boundary zone, where dense andesitic materials of the Old Andesite Formation are juxtaposed against the lighter volcanoclastic deposits of the Jonggrangan Formation.

The black solid lines (Figure 7a) on the density inversion model represent interpreted fault zones that dip alternately eastward and westward, forming a series of horst–graben or tilted fault blocks. These structures create an alternating pattern of uplifted and downthrown blocks, which aligns with the gravity derivative signature. The red to orange density zones (2.7–3.0 g/cc) indicate uplifted fault-bounded blocks dominated by andesitic intrusions or lava remnants, whereas the blue density zones (2.0–2.4 g/cc) correspond to basinward depressions filled with reworked tuffaceous–volcanoclastic materials of the Jonggrangan Formation. The highest-density domains (~3.0 g/cc) are concentrated at latitudes 9,155,000–9,165,000, suggesting the presence of subvolcanic intrusions or feeder systems that extend to the deeper magmatic roots beneath Kulon Progo (Clements et al., 2009; Smyth et al., 2005). The proximity of these dense anomalies to Mount Jonggol suggests that the area constitutes an erosional window exposing the upper part of an ancient magmatic conduit.

The derivative gravity profile (Figure 7b) provides quantitative evidence supporting these interpretations. The First Horizontal Derivative (FHD, blue curve) delineates sharp lateral density contrasts, while the Second Horizontal Derivative (SHD, orange curve) highlights the vertical intensity of subsurface density changes. Peaks in both derivatives closely correspond with the vertical black dashed lines, which indicate the locations of major structural discontinuities. The highest positive FHD–SHD amplitudes are observed directly beneath Mount Jonggol, coinciding with the density transition (2.4–2.9 g/cc) between the Jonggrangan and Old Andesite formations. This observation confirms that Mount Jonggol is situated on a principal fault-controlled contact zone, interpreted as a Miocene boundary fault system that facilitated the emplacement of intermediate magmas and governed subsequent uplift. The periodic oscillation of FHD and SHD values toward the south (latitude 9155000–9165000) indicates the presence of multiple fault strands and repeated deformation events, potentially associated with the transpressional tectonics of southern Java (Koulali et al., 2016; Simandjuntak & Barber, 1996). Figure 7 provides critical insight into the vertical structural architecture of the study area, revealing the depth extent and geometric relationship of high-density intrusive bodies and low-density volcanic–sedimentary units. The alignment between derivative peaks and steep density gradients confirms the existence of a major fault-controlled tectono-lithological boundary beneath Mount Jonggol. This image is particularly important in demonstrating the vertical continuity of subvolcanic intrusions and their structural association with Miocene magmatic emplacement and subsequent tectonic reactivation.

4. CONCLUSION

The research indicates that Mount Jonggol in Kulon Progo represents a primary structural contact zone formed by the interaction between high-density volcanic rocks (Old Andesite Formation, 2.7–3.0 g/cc) and low-density volcanoclastic rocks (Jonggrangan Formation, 2.0–2.4 g/cc). Inversion modeling and gravity-derivative analysis reveal a pattern of elongated high anomalies oriented northwest-southeast, which indicates the presence of an ancient magmatic corridor and associated fault structures within the transpressional tectonic regime of southern Java. This evidence suggests that Mount Jonggol, together with Mount Gajah and Mount Ijo, forms part of a Miocene volcanic system that was uplifted and exposed by post-Miocene tectonic activity. These findings contribute to a deeper

understanding of the subsurface configuration, tectono-magmatic evolution, and uplift mechanisms of the old volcanic arc area in Central Java, and have implications for geological hazard assessment and resource exploration in similar environments. The integrated derivative and inversion gravity modelling confirms that Mount Jonggol represents a tectonically controlled lithological boundary within the Kulon Progo uplift. The northwest–southeast alignment of high-density anomalies indicates a reactivated Miocene magmatic corridor. These results provide new insights into the tectono-magmatic evolution of southern Central Java and support future geohazard and mineral exploration studies in ancient volcanic arc systems.

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