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Doubly Thrust Fault and Superposed Fold at Rondonom-Girisono Region, East Jiwo Hill, Bayat Central Java, Indonesia

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Abstract. The trending of Rondonom trust fault zone can be traced on three locations, namely the NE –SW trust fault trend in Rondonom, the NE – SW trend in Padasan village and Grabahan hill, and the NE – SW trend in Konang hill. Girisono fault zone was firstly mentioned as Girisono thrust fault on Regional Geoheritage Conference 2019, show evidence for two successive structure episodes. The first generation (D1) is deformation in northern part of Jokotuwo hill to the Rondonom hill. This zone is manifested by a variety of structures for well-developed mylonite foliations and mostly associated with recumbent minor, chevron, and superposed fold. The second generation (D2) of deformation is in southern part of Jokotuwo – Rondonom hills to southern part of Semangu hill. This zone is manifested by shearing structure for foliation cataclasite flow and associated with swelly or scalyclay structure, and sometime with chevron fold. The earliest structures in the Eastern Jiwo hill was generally showed that D1 structures are rotational and non-coaxial in semi-ductile character. The deformation was dextral thrusting involving NW shortening with a significant component of thrust-parallel slip movement that continued into the Pra-Tertiary Orogeny. The D2 was dextral thrusting compression involving E-W shortening with significant of thrust-parallel slip movement that continued into Late Eosen or Paleogen Orogeny.

Keyword: Doubly Thrust Fault, Superposed Fold, Deformation

INTRODUCTION

Jiwo Hills (Bayat) is one of three places where the pra-Tertiary and Paleogen rocks in Java Island uncovered. The other locations are Ciletuh, located at the southeastpart of Pelabuhan Ratu, West Java and Karangsambung, the northpart of Kebumen, Central Java. Many geologist has done doing research at Bayat area, such as [3], who made stratigraphy column of Jiwo Hills and also proposed the name of Wungkal Formation and Gamping Formation which aged Eosen; [17], researching in more detail the geology of East Jiwo Hills, study of biostratigraphy is ever conducted by [18, 14 and 19], researching volcanic stone in Java Island, consists of age of many stones with radiometric method (Isotrophic K/Ar dating method) some igneous stones at Bayat and surrounding areas; [16], researching about nomenclature of crystalline rock at West Jiwo Hills; [13], researching about paleostress of geological structures at Jiwo Hills; [11], researching the stratigraphy analysis associated with probability of ancient high at Jiwo Hills.

GEOLOGY OF EASTERN JIWO HILL

Jiwo Hills Lithostratigraphically can be divided into three rock units [3, 13] namely (1) Pra-Tertiary metamorphic rocks, (2) Gamping – Wungkal Formation and (3) Oyo Formation. (**FIGURE 1**). Base on SSI (1996) nomenclature [16], suggested the crystalline rock at West Jiwo Hills to be Bayat Phyllite Lithodemic, Bayat Gabbro

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Lithodemic and Bayat Basalt Lithodemic. Phyllite Lithodemic consists of phyllite, schist, serpentinite, and marble. Phyllite is the most important metamorphic rock at Jiwo hills, that has been exposed at Konang hills and Semangu hills. Schist is exposed at Padasan hills at East Jiwo, although it is not wide, and marble is the lense of phyllite, it is exposed at Jokotuo hills. In phyllite lithodemic, there is no fossil appeared, so the certain age of phyllite is unknown, because tertiary-aged formation covered phyllite, the age of phyllite is set on pre-Tertiary.

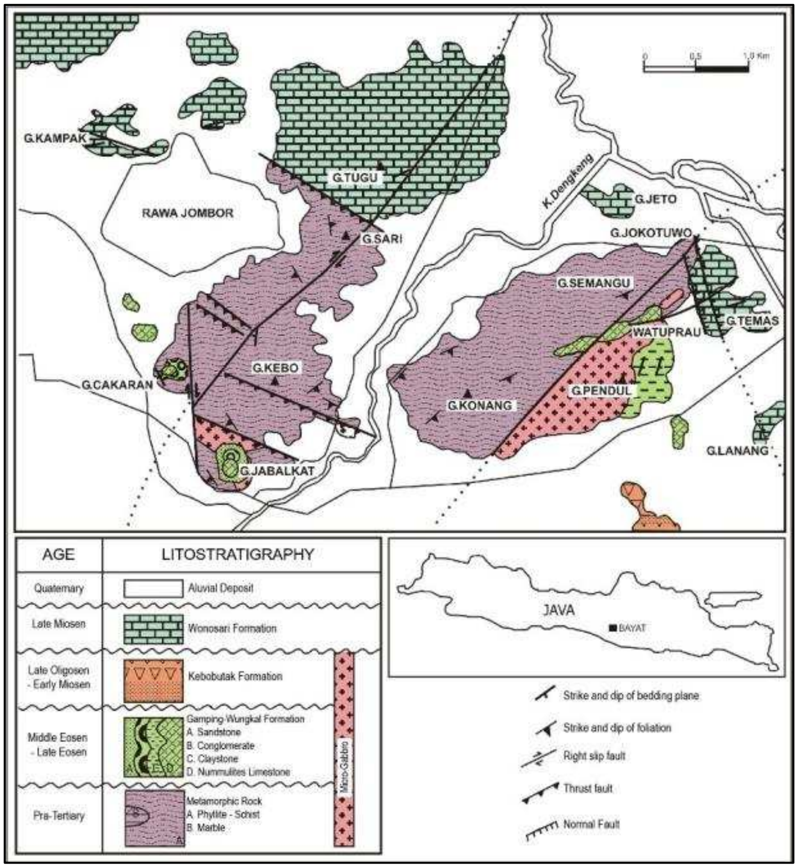


FIGURE 1. Geological Map of Jiwo Hill, Bayat, Klaten [13].

Both of Wungkal Formation and Gamping Formation [3], represent Eosen-aged rock formation. Wungkal Formation consists of polymictic conglomerate, quartz sandstone, claystone and large foraminifera (*Assilina* and *Camerina*) limestone that show Early Eosen Age (Ta). This rocks unit is exposed at West Jiwo Hills, Wungkal Hills, Sekarbolo Village. This rocks unit is location type that is suggested by [3]. Gamping Formation consists of large foraminifera (*Camerina* and *Discocyclina*) limestone which is Late Eosen aged (Tb), sandstone and claystone. There is nonconformity above metamorphic rock group, exposed around Pendul hills and Watuprahu (East Jiwo Hills) is located at Gamping Village, and it is the location type.

Gabbro lithodemic consists of many basaltic dykes (Winong, Brumbung, Bukit Merak, Pager Jurang, etc) and gabbroic stock (Bendungan Village, Pendul hills, and Kebo hills). Those gabbroic rocks with earlier researcher are called diorite, but based on a chemical analysis and rock texture showing the rock is gabbro rather than diorite. At Temas Hill and Bendungan Village, Eocene-aged rock formation is covered with nonconformity by reef limestone of Oyo Formation. Radiometric dating with isotropic Potassium-Argon method showing that the gabbro at East Jiwo Hills is 31,3 Ma or Early Oligocen [19]. Oyo Formation consists of calcarenite and marl layered, that has Middle Miosen age (N11 – N13), well exposed at Temas and Lanang Hills, this unit rock covered unconformity with phyllite and gabbro lithodemic.

Geological structures that has been observed at East Jiwo are fault that cut Jokotuwo Marble hills. Fault evidences are fault plane with slickenlines, fault breccia and also sistematic joint, which is caused by its fault. Folliation structure can be observed at phyllite rock and schist rock (Jokotuwo) and layered bed rock at Gamping

Formation around Watuprau Village. Fault breccia is located at Konang Hills, and also there is fault evidence appeared at Temas Hills.

METHODOLOGY

This research is mainly a field-based research. Fieldwork was conducted in two methods. The first method is Detail Mapping at scale 1 : 500., and the second method is used grid systematic structural analysis have focused on small localized selected areas. Structural orientational data were analysed by means of manual stereographic plot hemisphere projection and software DIPS Version 3.7., and Paleostress Version 3.11.

Petrographic study under microscope was carried out to unravel the more detail information on identity of rocks based on mineralogical composition, texture, structure and petrogenesis. An investigation of the cleavage types and others related fabrics, and metamorphic petrogenesis was accomplished by thin section studies.The relationship between So, S1, and S2, relationship on crenulation cleavage, relationship to fold and cleavage, relationship fold to fold on superposed, relationship internal and external structure on porphyroclast or porphyroblast have comparable to overprinting relationships, structural vergences, tectonic transport directions and stratigraphic relationship in field investigation

EVIDENCE FOR DOUBLY THRUSTING DEFORMATION

The fault zone of Rondonom-Girisono area show evidence for two successive dynamo metamorphic structure episodes (**FIGURE 2**).

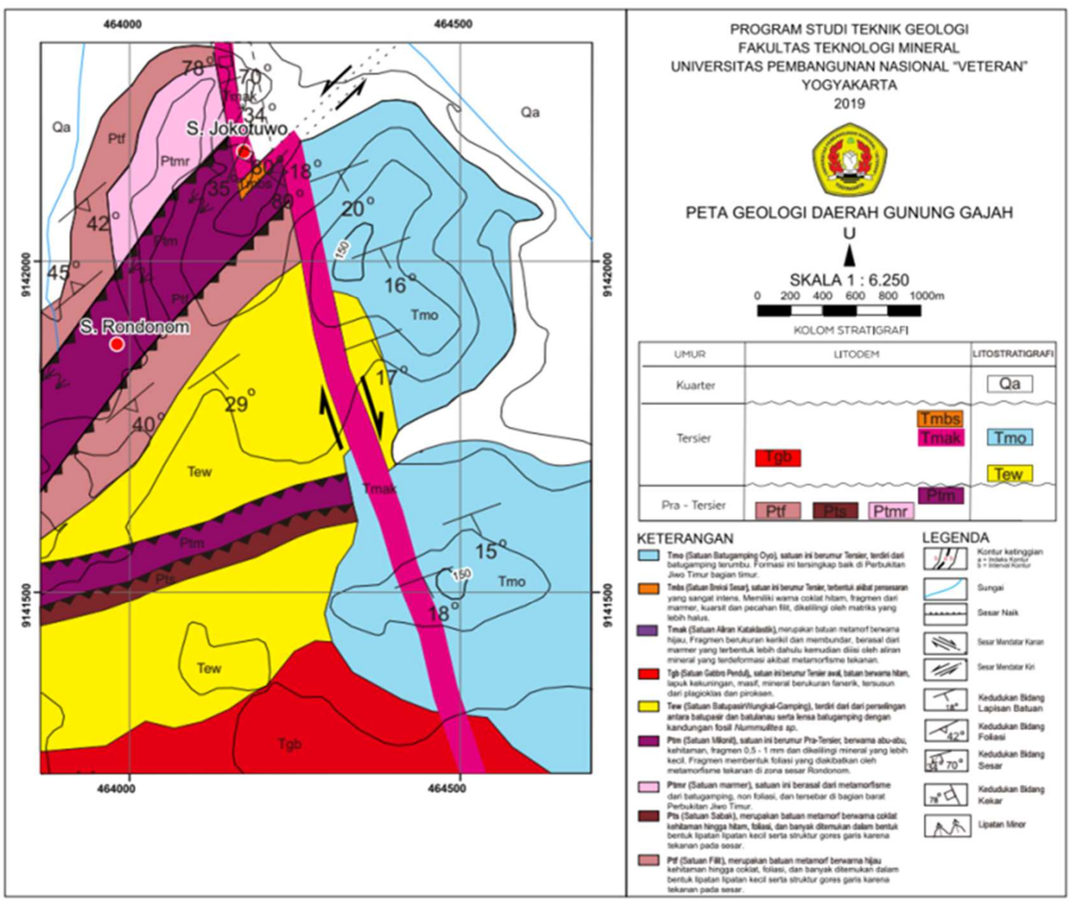


FIGURE 2. Geological Map of Gunung Gajah Region, Bayat [12].

The first generation structures (S_1) Rondonom episode

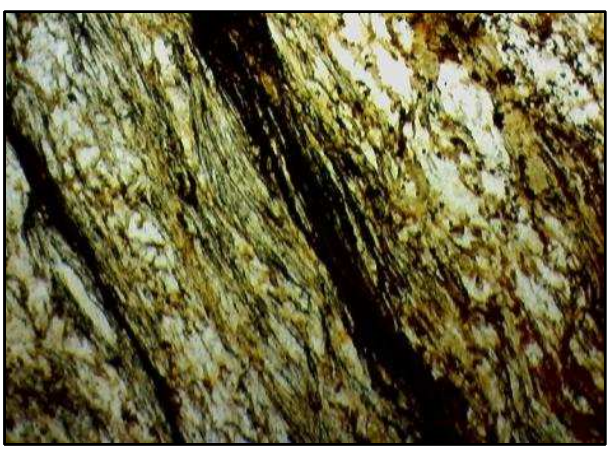
Fieldwork was show varies of mylonite foliated fold structures, those are recumbent to overturned folds,with fold axes generally gently plunging to the NE or SW (**FIGURE 3a**). Their axial surfaces ranging from low to horizontaly dipping and commonly associated with bedding parallel cleavage (C_1), crenulation, superposed and chevron folds. Most of the cleavage transects not only the axial surface but also the fold hinge. The NNW cleavage trend cut off by the NW cleavage. The cleavage cuts counterclockwise relative to roughly synchronous fold hinges, indicates component of dextral thrusting. (**FIGURE 3b**)

(a)

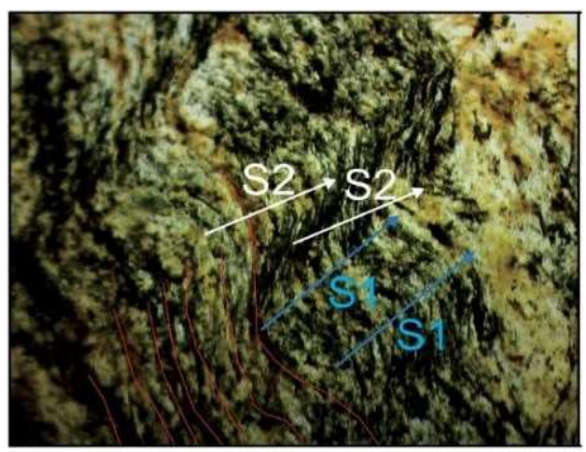
(b)

FIGURE 3. (a) Mylonite foliated fold structures, those are recumbent to overturned folds, Their axial surfaces ranging from low to horizontaly dipping. (b) bedding parallel cleavage (C_1), crenulation, superposed and chevron folds.

Petrographic study show varies of mylonite foliated structures of Rondonom – Girisono, those are parallel bedding and recumbent to overturned folds, Parallel bedding foliated have greenish to grayish colour, formed by a series of mineral serisite, chlorite, and little graphite, encompassing elongated quartz grains. (**FIGURE 4**).



(a)



(b)

FIGURE 4. (a) Mineral serisite, chlorite, and little graphite, encompassing elongated quartz grains. (b) Most of the cleavage transected cuts counterclockwise relative to roughly synchronous fold hinges.

The recumbent to overturned folds have grayish colour, formed by a series of minerals serite, muscovite, quartz, chlorite and small graphite. Their axial surfaces ranging from low to horizontaly dipping and commonly associated with bedding parallel cleavage (C_1), superposed and chevron folds (**FIGURE 5**). Most of the cleavage transected cuts counterclockwise relative to roughly synchronous fold hinges, indicates component of dextral lateral thrusting. (**FIGURE 6**). Transposition of layering during the first deformation (D_1) is not uncommon and the occurences of high-strain zone of thrust faults suggest that the D_1 deformation were derived from intense NW-SE compression with significant shouthern block thrusting of Jiwo Hill has undergone NW oblique deformation (**FIGURE 7**).

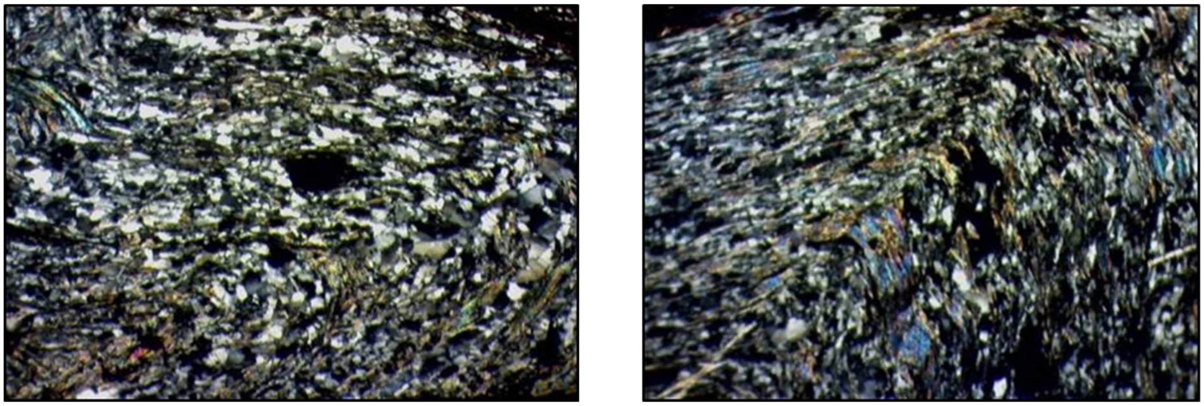
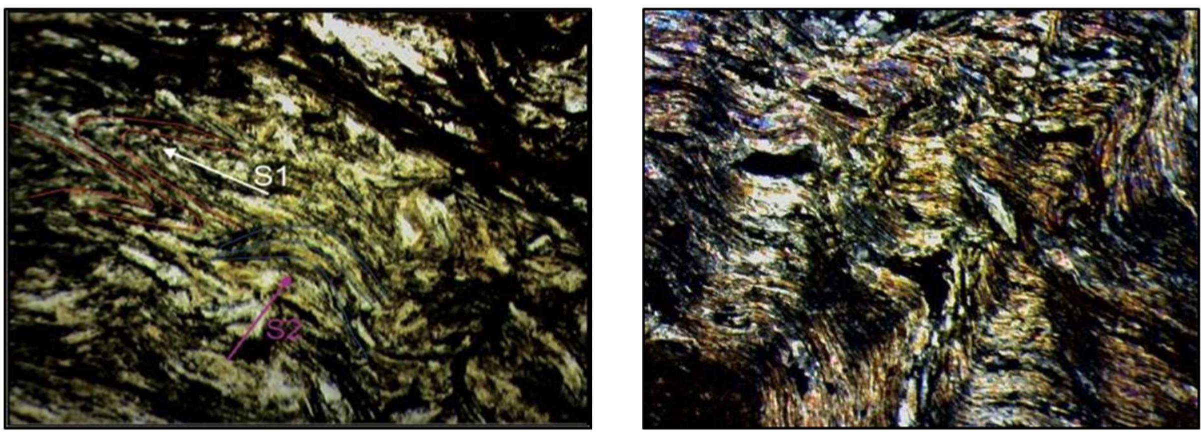


FIGURE 5. Milonite foliated recumbent fold composed by serisite, chlorite, muscovite, quartz and little graphite.



(a) (b)

FIGURE 6. (a) Superposed fold from Recumbent fold (S1) and isoclinal fold (S2) (b) Superposed fold from recumbent fold and crenulation.

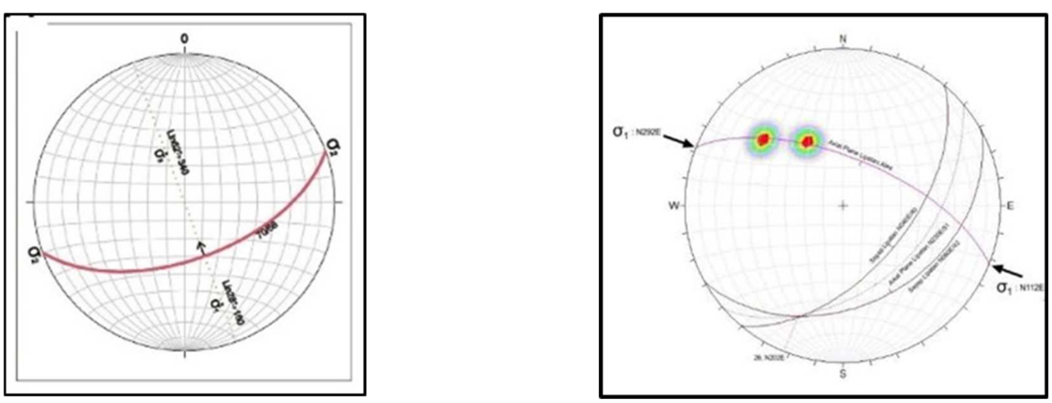


FIGURE 7. DIPS stereometric analysis of thrust fault and recumbent fold on thrust fault zone

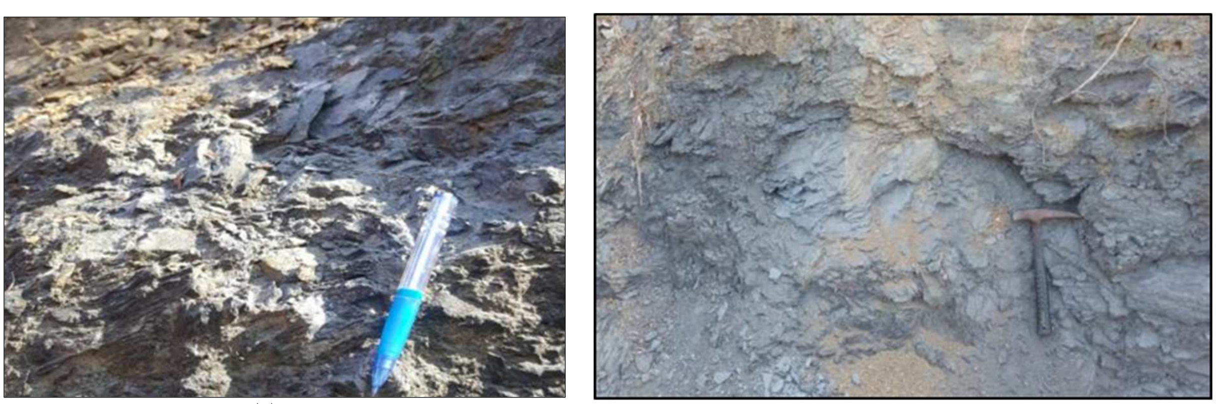
The Second generation structures (S_2) Girisono episode

The second generation structures (S_2) that grow within a synshearing structures zone during deformation are generally called growth structures, they include isocline folds (F_2) and E - W Larger Foraminifera orientation. Fieldwork show varies of cataclasite foliated fold structures, those are isocline to asymmetrical folds,with fold axes generally low plunging to horizontally plunging to the East or West (**FIGURE 8a**). Their axial surfaces ranging from high to verticaly dipping and commonly associated with xenoblast parallel orientation of pinch and swell structure and anastomosing structure. (**FIGURE 8b**)

(a) (b)

FIGURE 8. (a) Isocline to asymmetrical folds,with fold axes generally low plunging to horizontally plunging (b) Limestone xenoblast parallel orientation of pinch and swell structure.

In graphite slate or phyllite with strong bedding-plane foliation was formed crenulation cleavage (**FIGURE 9a**). It is typically an S_2 foliation that has been superimposed on an earlier (S_1) foliation. These evidence suggests that the D_2 deformation was dextral lateral thrusting. The predominance of Larger Foraminifera Limestone Blast orientation asymmetric pinch and swell structure as well as asymmetric boudinages and the non-coaxial superposition of S_2 cleavages. (**FIGURE 9b**) Dextral lateral thrusting deformation of D_2 produced zones of high flattening strain and E-W-striking fault zones. The deformation orientation of D_2 is N-S, and different with the first deformation (D_1). (**FIGURE 10**).



(a) (b)

FIGURE 9. (a) Graphite slate with strong bedding-plane foliation that formed crenulation cleavage. (b) Phylite xenoblast orientation asymmetric pinch and swell structure as well as asymmetric boudinages.

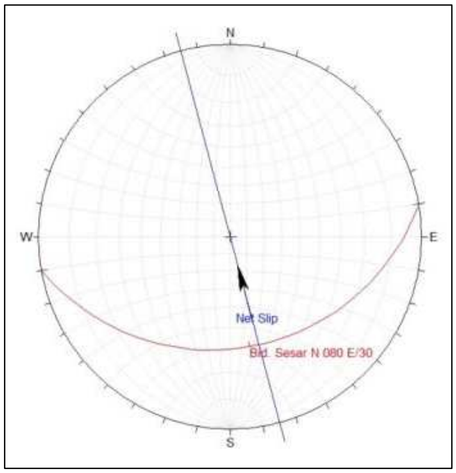
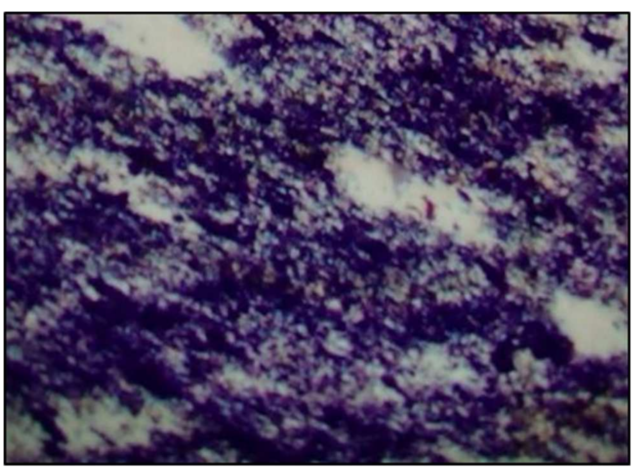


FIGURE 10. DIPS stereometric analysis of thrust fault with shouthern block of Jiwo hill has undergone to Nothern direction.

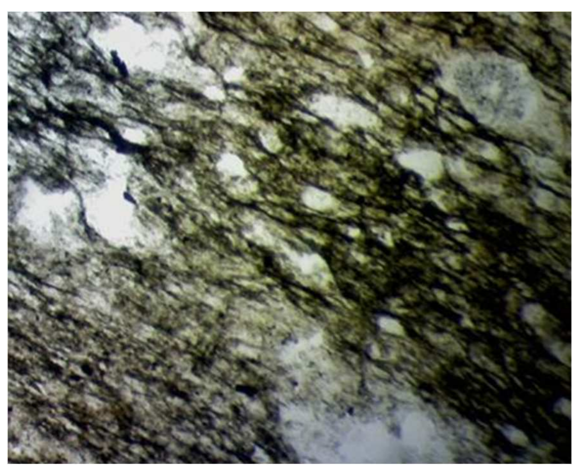
In Girisono area, petrography show varies of mylonite foliated structures, those are parallel bedding and isocline to asymmetric folds, Parallel bedding foliated have greenish to grayish colour, formed by a series of mineral serisite, graphite, quartz and little muscovite, encompassing elongated quartz grains. (**FIGURE 11**). The isocline to asymmetric folds have grayish colour, formed by a series of minerals serite, graphite, quartz, and little muscovite and commonly associated with bedding parallel cleavage (C_1), xenoblast orientation asymmetric pinch and swell structure as well as asymmetric boudinages **(FIGURE 12**).

THE AGE OF DYNAMO METAMORPHIC

The timing of deformation is difficult to constrain due to lack of paleontological data. However, based on the unconformable relationship between Gamping Formation and the pra-Tertiary phylitic metamorphic lithodem. The first deformations (D_1) typically from ductile to semi-ductile behavior of low grade mylonite metamorphic facies. Both phylite and mylonite developed at the same depth and time. It could be inferred that the age of D_1 was pra-Tertiery. Synshearing or growth fault structures on Late Eocene Foraminifera Limestone have suggested that the age of D_2 was similar with Late Eocene to Oligocene Foraminifera limestone, but Girisono thrust fault was not cut Oligocene gabbro, it have suggested that the age was Late Eocene.

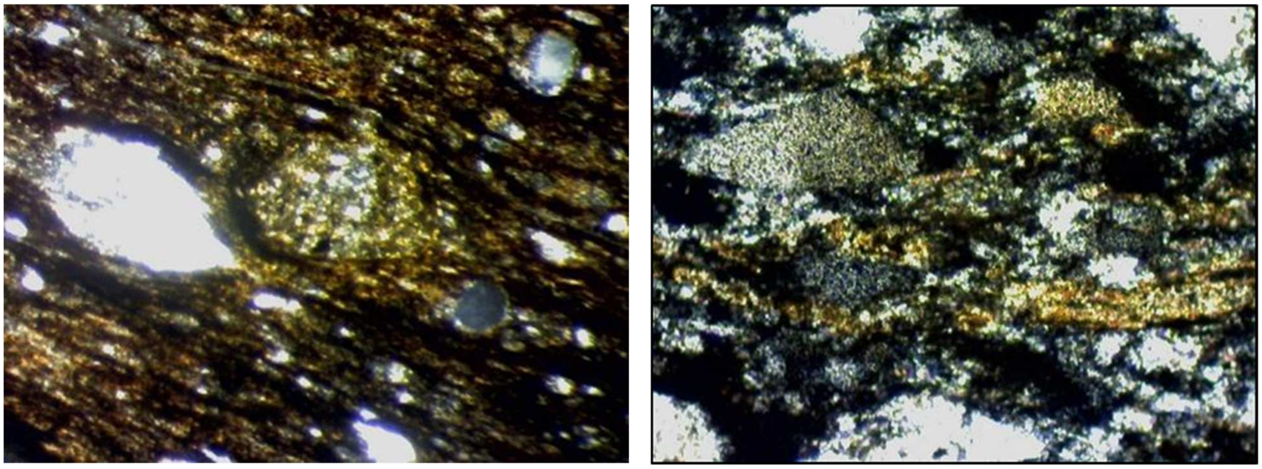


(a)



(b)

FIGURE 11. (a) Graphite slate with strong bedding-plane foliation by graphite, serisit and quartz. (b) Cataclasite foliated with parallel xenoblast orientation structure.



(a) (b)

FIGURE 12. (a) Serisite, chlorite, graphite, encompassing elongated xenoblast grains. (b) Pinch and swell structure on petrography thin section.

CONCLUSION AND TECTONIC HISTORY

The earliest deformations of Eatern Jiwo Hill was NW compression involving NE-shortening with a semi–ductile significant component of thrusting movement during late Mesozoic to that continued into the early Tertiay East Java micro continent Orogeny. The growth of the thrust fault zone mainly controlled by coaxial refolding and reactivation dextral thrust zone. Based on the type of superposed fold that the semi-ductile fault zone showed at least two deformation periods (D_1 and D_2). The semi-ductile deformation of Eastern Jiwo Hill (D_2) was NNW compression involving ENE-shortening during Late Eocene post collision East Java micro continent Orogeny, before the Oligocene Gabbroic intrusion and Oligocene-Miocene volcanic subducted activity.

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