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STRUCTURAL CONTROL RELATED WITH MEDIUM-TO-VERY HIGH Au GRADE AT PIT B EAST AND B WEST, TUJUH BUKIT MINE, EAST JAVA

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Sari – Tujuh Bukit secara umum disusun oleh batuan vulkanik dan vulkaniklastik Formasi Batuampar berumur Oligosen Akhir sampai Miosen Tengah. Setelah terjadi aktivitas tektonomagmatisme pada Pliosen, satuan tersebut teralterasi dan menjadi *host rock* bagi mineralisasi ekonomis yang juga terbentuk pada Pliosen. Daerah penelitian berada di tambang terbuka Pit B *East* dan B *West*. Kavling yang mencakup kedua pit tersebut memiliki luas ± 700 x 500 m^2, terletak pada koordinat ± 9045100 – 9045600 mU dan ± 174400 – 175100 mT sistem proyeksi koordinat UTM WGS 1984 zona 50S. Penelitian ini membahas tentang kontrol struktur yang berperan dalam pembentukan karakteristik alterasi dan mineralisasi Au sistem epitermal sulfidasi tinggi yang berkembang di Pit B *East* dan B *West*, tambang Tujuh Bukit. Struktur geologi yang dominan berkembang berupa sistem sesar mendatar berumur Pliosen, berarah relatif NW-SE dan N-S, dengan arah tegasan utama NNW-SSE mengikuti model *pure shear*. Terdapat pula sesar normal berarah relatif NW-SE dan sesar naik berarah relatif ENE-WSW. Sesar-sesar tersebut pada skala regional merupakan kompensasi akibat gaya tektonik tekanan (*compressive*) berarah NNW-SSE dalam satu periode tektonik yang sama. Sistem sesar mendatar menghasilkan zona-zona sesar normal dan zona tinggian pada geometri *releasing stepover, releasing bend,* dan *restraining bend*. Sesar-sesar mendatar yang ada di Pit B *East* dan B *West* merupakan sistem sesar *strike-slip* paling kecil pada skala regional Tujuh Bukit. Struktur geologi yang berkembang merepresentasikan tektonik Pulau Jawa saat ini. Terdapat lima satuan alterasi setelah dilakukan integrasi data lapangan, data pengeboran, dan hasil pemindaian ASD, yait
u: satuan kuarsa, kuarsa-alunit, kuarsakaolinit, kaolinit-montmorilonit-klorit, dan kaolinit-montmorilonit. Mineral bijih yang ditemukan berdasarkan observasi di lapangan dan pengamatan mineragrafi berupa pirit, kalkopirit, kovelit, bornit, tetrahedrit, azurit, malakit, hematit, dan goetit. Mineral-mineral tersebut umumnya ditemukan berasosiasi dengan alterasi yang mengalami silisifikasi, seperti satuan kuarsa, kuarsa-alunit, dan kuarsa-kaolinit. Alterasi silisifikasi dan mineralisasi Au kadar menengah hingga sangat tinggi umumnya berada pada zona-zona sesar normal yang diakibatkan oleh pergerakan sesar mendatar pada geometri *releasing bend* (daerah di sepanjang belokan Sesar BE 2 dan Sesar BE 3) dan *releasing stepover* (daerah di antara Sesar BE 1-BE2, di antara Sesar BW 2-BW3, dan di antara sesar BW 6-BW 7-BW 8), serta sesar normal yang sejajar dengan arah tegasan utamanya pada skala regional.

Kata kunci: Sistem sesar mendatar, mineralisasi, epitermal sulfidasi tinggi, Tujuh Bukit.

***Abstract** - Tujuh Bukit generally consists of Late Oligocene – Middle Miocene volcanic and volcaniclastic Batuampar Formation. After tectonomagmatism took place at Pliocene, this stratigraphic unit altered and became a host rock for Pliocene economic mineralization. The research area located in open pit mining at Pit B East and B West. Both pits have an extensive area of ± 700 x 500 m^2, projected on ± 9045100 – 9045600 mN and ± 174400 – 175100 mE UTM WGS 1984 zone 50S coordinate system. This research discusses structural control as the main role of alteration characteristics and Au high sulfidation epithermal mineralization system forming in open pit mining at Pit B East and B West, Tujuh Bukit mine. Main developed structural are Pliocene strike-slip system, relatively NW-SE and N-S orientation, with NNW-SSE principal stress following pure shear model. There is also relatively NW-SE normal fault and ENE-WSW thrust fault. All of these faults in the regional scale are NNW-SSE compressive tectonic compensation within one tectonic period. The strike-slip system resulting in normal fault and ridge zones within releasing stepover, releasing bend, and restraining bend structural geometry. Strike-slip faults in Pit B East and B West are the smallest strike-slip system within Tujuh Bukit regional scale. Developed structural geology representing recent tectonic of Java. Based on the field observation, core drilling, ASD instrument scanning, and petrographic analysis, the alteration unit divided into five, there are quartz, quartz-alunite, quartz-kaolinite, kaolinite-montmorillonite-chlorite, and kaolinite-montmorillonite alteration unit. Based on field and mineragraphic observation, there found ore minerals such as pyrite, chalcopyrite, covellite, bornite, tetrahedrite, azurite, malachite, hematite, and goethite. All* *these minerals generally found associated with silicification alteration, such as quartz, quartz-alunite, and quartz-kaolinite alteration unit. Development of medium to very high-grade mineralization within silicification alteration unit generally took place in normal fault zones caused by the strike-slip system on the releasing bend (can be found on the bending line of BE 2 and BE 3 Fault) and releasing stepover geometry (on the area between BE 1-BE 2 Fault, the area between BW 2-BW 3 Fault, and the area between BW 5-BW 6-BW 7 Fault), and BW 4 normal fault which parallel to the principal stress on a regional scale.*

Keywords*: Strike-slip system, mineralization, high sulfidation epithermal, Tujuh Bukit.*

1. INTRODUCTION

Structural geology plays a crucial role in mineralization as a pathway for hydrothermal fluids going through and deposited an ore within the created open space. The open space created by the structural geology system has an extensive and specific orientation within one or even more particular tectonic periods and can be traced, respectively. Most geologists assumed the forming of an ore mineralization has a special geochemically distinctive feature, but none has been found to prove the useful guide for exploration. Geochemically, the economic mineralized ore-plutonic rocks, and unmineralized plutonic rocks are indistinguishable and will provide the same amounts of their major, minor, and trace elements. This well known as the barren plutons and 'negative' porphyry copper deposits concept (Cloos and Sapiie, 2013).

Mineralization is commonly present on the open space of rock fractures which is often interpreted as a product of hydrothermal fluids pressure itself. This thought is well known as a hydraulic fracturing concept. The rocks are fractured by the hydrothermal fluids high pressure. If so, the mineralization shouldn't have the specific orientation (chaotic fracture) and could occur in any crustal level associated with magmatic fluids. In other words, every magmatic activity should have produced the economic mineralization. But in fact, the economic mineralization does not always take place in every rock which associated with magmatic activity. There should be a specific geological control to create oriented space for hydrothermal fluids deposited an ore in rocks.

The E-W magmatic arc of Java Island (the whole continuous arc well known as Sunda-Banda Arc) started at approximately 25 – 20 million years ago from Indo-Australia Plate subducted beneath the Eurasian Plate and is continuing to the present day. This magmatic arc is formed within Cenozoic and gradually migrated northward. Paleogene and Neogene trace of magmatic arc in southern Java is well known as Old Andesite Formation. The Sunda magmatic arc started at the northwestern tip of Sumatra continuously to the easternmost of Java and Lesser Sunda Island (e.g. Bali, Lombok, Sumbawa) and terminated near the Sumba and replaced by the Banda Arc. Termination of Sunda magmatic arc in the easternmost near Sumba caused by the presence of Timor Through, which Australian continent docking to Timor and lead the polarity reversal of subduction in Inner Banda Arc (Hall and Wilson, 2000).

Most of the Oligocene – Miocene magmatic intrusion along the Sunda arc resulting in the mineralization system. There are found many veins of low sulfidation epithermal system in the western part of this arc, like in Miwah, Sondi, Way Linggo, Ojo Lali, Cibaliung, Pongkor, and Banyumas (Sutarto et al., 2016). Meanwhile, the mineralization system changing in the eastern part of Sunda arc where Cu-Au porphyry system mainly found (Carlile and Mitchell, 1994), like in Batu Hijau, Elang, Tumpang Pitu, and Selogiri (Sutarto et al., 2016; Harrison et al., 2018) (**Figure 1**).

The changing and difference of mineralization system between the western and eastern part of Sunda arc, especially in Java, suspected by the

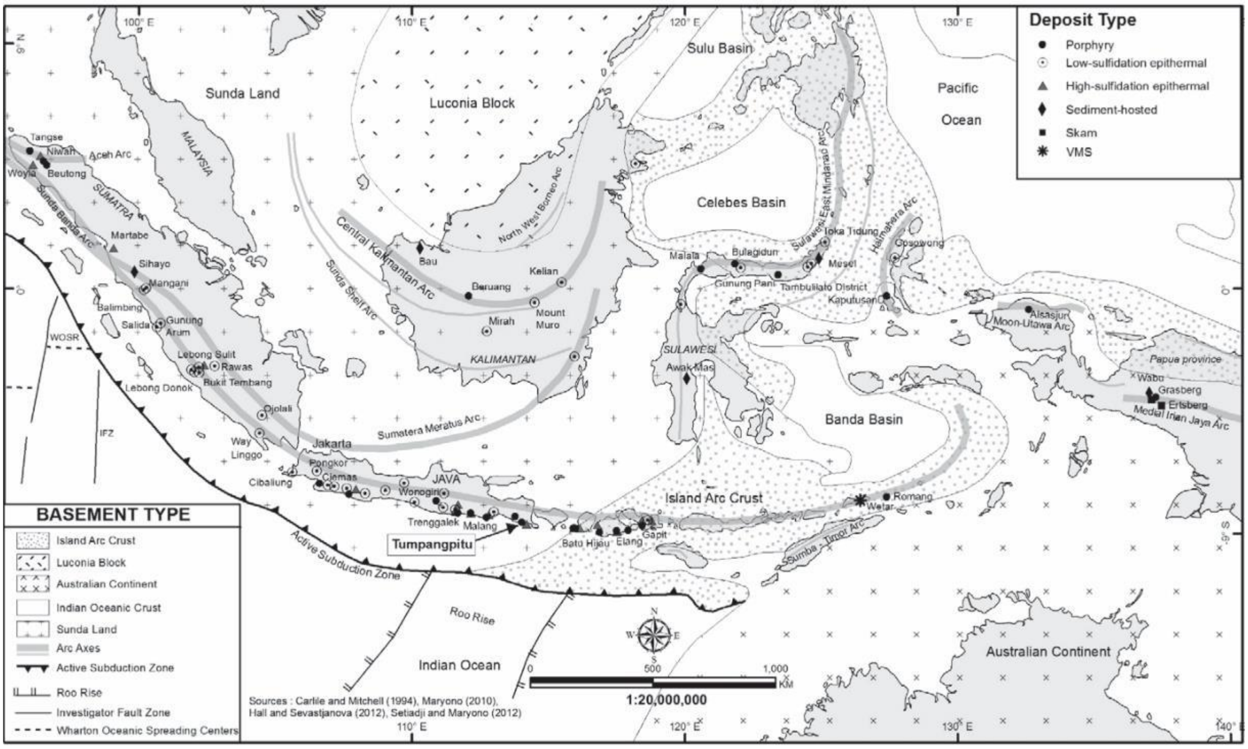

Figure 1. Spatial distribution of the major porphyry and epithermal deposits in Indonesia (Harrison et al., 2018).

different of underlying basement rocks. According to the zircon mineral analysis, western Java was a part of Sundaland at Cretaceous, whereas eastern Java was derived from the Gondwanan microcontinent sliver together with a western arm of Sulawesi (Hall, 2008; Smyth et al., 2008). Sliver collision of the Gondwanan microcontinent to the Sundaland occurred estimated on Middle Cretaceous, approximately 100 million years ago (Satyana, 2016), even though the southeast margin of Sundaland remain unknown. The Early Cenozoic of igneous rocks in Southern Mountain in Java contains Archaean to Cambrian zircons similar to those of Gondwana crust (Smyth et al., 2007; Smyth et al., 2008; Hall, 2012). East Java and the Malino Complex of NW Sulawesi are so far the only parts of Indonesia where Archaean zircons with ages greater than 3 Ga have been found and these strongly suggest a West Australian origin for the basement (Smyth et al., 2007; van Leeuwen et al., 2007; Hall, 2012).

Tujuh Bukit generally consists of Late Oligocene – Middle Miocene volcanic and volcaniclastic Batuampar Formation. It has low-K calc-alkaline andesitic volcanic and interbedded volcaniclastic rock sequence, associated with low-K intermediate intrusions and minor shallow-water marine sedimentary rocks (Harrison, 2012 in Myaing et al., 2018). All of those rocks intruded by the low-K Middle Miocene dioritic-granitic igneous rocks (**Figure 2**). This Middle Miocene intrusion unrelated to economic mineralization mined nowadays. In other words, these intrusions are one of the pre-mineralization phases in Tujuh Bukit. After tectonomagmatism took place at Pliocene, the volcanic and volcaniclastic Batuampar Formation has deformed. The deformation plays a role as a pathway for hydrothermal fluids to going through, making the deformed stratigraphic unit altered and starting to become a host rock for Pliocene economic mineralization.

1.3 Structural Geology Related with Mineralization

The high-pressure hydrothermal fluids always find the lower pressure pathway (as this case is the fractured rocks) to release its pressure to maintain the new chemical equilibrium. One of the complex fracturing/open space rocks could have occurred in a strike-slip system. The strike-slip faulting can create more complex

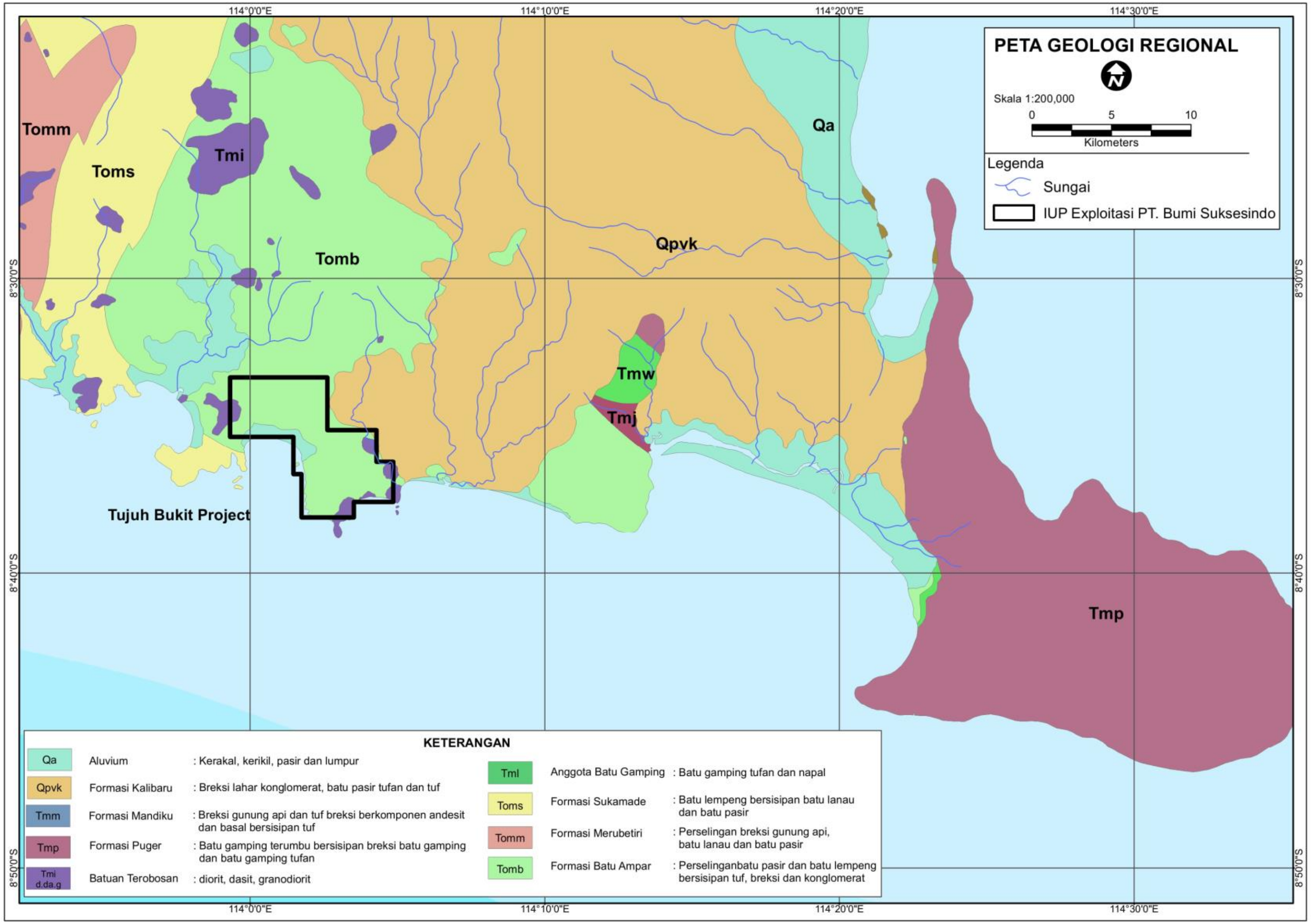

Figure 2. Regional geologic map of Blambangan, East Java with Tujuh Bukit exploitation mining permit (*Izin Usaha Pertambangan*/IUP) on the solid black line of a polygon (modified from Achdan and Bachri, 1993).

subsidiary array faulting within one particular stress and tectonic period. In the case of mineralization forming, hydrothermal fluids can through the fracturing system caused by the intersection of two strike-slip faulting with stepover geometry. In the releasing stepover geometry, a gap between two strike-slip faults can be normal fault zones at once filled by the hydrothermal fluids to deposited an ore. Meanwhile, in the restraining stepover geometry can be the zones of thrust fault and ridges as a consequence of the squeezed in a gap of two strike-slip faulting (**Figure 3**). Mineralization commonly not took place in the restraining stepover geometry.

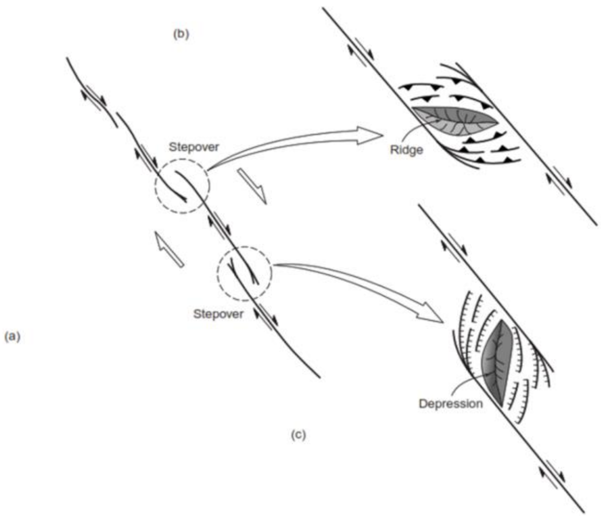

Figure 3. Stepover geometry creates depression and normal fault zones in releasing stepover. On the other side, restraining stepover create ridges and thrust fault zones (van der Pluijm and Marshak, 2004).

2. DATA AND METHODOLOGY

The research area located in Tujuh Bukit open pit mining at Pit B East and B West. Both pits have an extensive area of ± 700 x 500 m^2, projected on ± 9045100 – 9045600 mN and ± 174400 – 175100 mE UTM WGS 1984 zone 50S coordinate system. This research discusses structural control as the main role of alteration characteristics and Au high sulfidation epithermal mineralization system forming in open pit mining at Pit B East and B West, Tujuh Bukit mine. Final purposes are to reveal the orientation and main structural system that control Au mineralization forming, especially medium to very high-grade mineralization.

Field mapping in open pit wall bench at Pit B East and B West is conducted with detail observation in alteration characteristics, mineralization identification, and structural geology features. Then rock samples are brought to microscopic identification to more detailed determining of mineral alteration and ore minerals composition. Analytical Spectral Devices (ASD) instrument used to find out the name of specific minerals from a particular minerals group, especially clay mineral. Atomic Absorption Spectroscopy (AAS) geochemical test is used to determine Au grade in the ppm unit.

Field mapping data including 25 fault planes (including slickensides and brecciation), 49 shear fracture, and 10 gash fracture/vein for structural geology data, 190 points of field observation station for alteration mapping, and 265 channel sampling for Au grade determining (145 and 120 for Pit B East and B West, respectively).

Core drilling also used with the same methodology as field mapping and has the most amount of data compared to the field mapping data. Each drill hole consists of alteration and Au grade. There are 30,763 and 74,594 drill holes for Pit B East and B West, respectively, which contain alteration type and Au grade.

The integration of field mapping and drill core data is the basis for alteration unit classification. Stereographic projection is used to determine the statistical analysis of the fault movement. Due to intense oxidation and brecciation along the fault plane, finding the accompanying structure such as shear fracture and gash fracture/vein are slightly difficult. To support the interpretation of fault movement, Au grade scattering and ore-bearing alteration used instead of accompanying structure stereographic projection analysis.

3. RESULTS

Structural geology, alteration, and Au grade map created after integrated all the data. These main topics discussed with brief stratigraphy

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analysis are described more detail as follows.

3.1 Stratigraphy

There is just one stratigraphy unit consist both Pit B East and B West, the volcanic breccia unit. The unit is polymictic clast supported breccia, has a whitish-gray in a fresh color, locally has a greenish-gray due to chlorite alteration content, reddish-brown in weathered color due to oxidized of sulfide minerals to become hematite and goethite, angular to sub-angular with high sphericity in shape, poorly sorted and permeability, and has a tuff-lapilli matrix. The fragments consist of igneous dacitic, rhyolitic, andesitic, and dioritic rocks, sedimentary rocks, tuff-lapilli, and locally found charcoal fragment. Size of the fragments are diverse, but mostly for igneous rocks up to > 3 m, sedimentary rocks fragment which consists of bedding up to > 7 m, and tuff-lapilli and charcoal mostly not exceed than 25 cm (**Figure 4**).

According to the Blambangan geological regional map (Achdan and Bachri, 1993), the characterization of the volcanic breccia unit is more similar to Late Oligocene – Middle Miocene Batuampar Formation. The Late Oligocene – Middle Miocene volcanic breccia formed in turbidite and gravity flow submarine facies (Achdan and Bachri, 1993). The presence of sedimentary rocks bedding and charcoal as fragments imply in the forming of sedimentary layer pre-date and/or coincidence within the Late Oligocene – Middle Miocene volcanic activity. These sedimentary layer and charcoal are interpreted as a lacustrine deposit by the time volcanic activity create maar. Then magmatic activity took place at this time in which demolished the maar lacustrine sedimentary rocks and blasting the forming pre-date igneous rock to become a fragment. The pyroclastic material becomes a matrix of breccia, locally accreted and becomes fragment. This magmatism is known as a pre-mineralization phase which not ore-bearing fluids deposited. The volcanic breccia unit also well known as one of the "Old Andesite Formation", a terminology refers to Paleogene – Neogene submarine magmatism, lied and create volcanic chain along southern-most of Java.

3.2 Structural Geology

Structural line drawing in the map distinguished into two, which is a solid line and dashed line. Solid line refers to structural with a piece of evidence found in the field, such as slickensides and/or many amounts of accompanying structure data (brecciation, shear fracture, and gash fracture). The dashed line refers to an interpretative structure that has no structural evidence found in the field, a small amount of data, or only vaguely data found.

After the interpretation builds from field data, Pit B East and B West mainly consist of strike-slip faulting which has relatively N-S and NW-SE trends (**Figure 5**). There are ten strike-slip faults and one normal fault deformed a Late Oligocene – Middle Miocene volcanic breccia. The naming of the fault is based on a pit, ascending numerical, and left to right orderly (e.g., BE 1 Fault, BE 2 Fault, BW 1 Fault, and so on).

Slickensides only found in BE 1 point of field observation station in Pit B East. There found one normal fault from slickensides evidence in Pit B West, but the pinpoint location is on the way near to Pit C instead of Pit B West. Nevertheless, the only normal fault interpreted continuously to Pit B West.

Kinematic analysis from BE 1 Fault and BW 4 Fault which have slickensides data are conducted to reveal the main principal stress, respectively (**Figure 6** and **Figure 7**). They have relatively NW-SE fault plane, but with the opposite dip direction. The BE 1 strike-slip fault has relatively NE dip direction, whereas BW 4 normal fault has a relatively SW dip direction. Stereographic projection analysis also conducted to four other faults which have

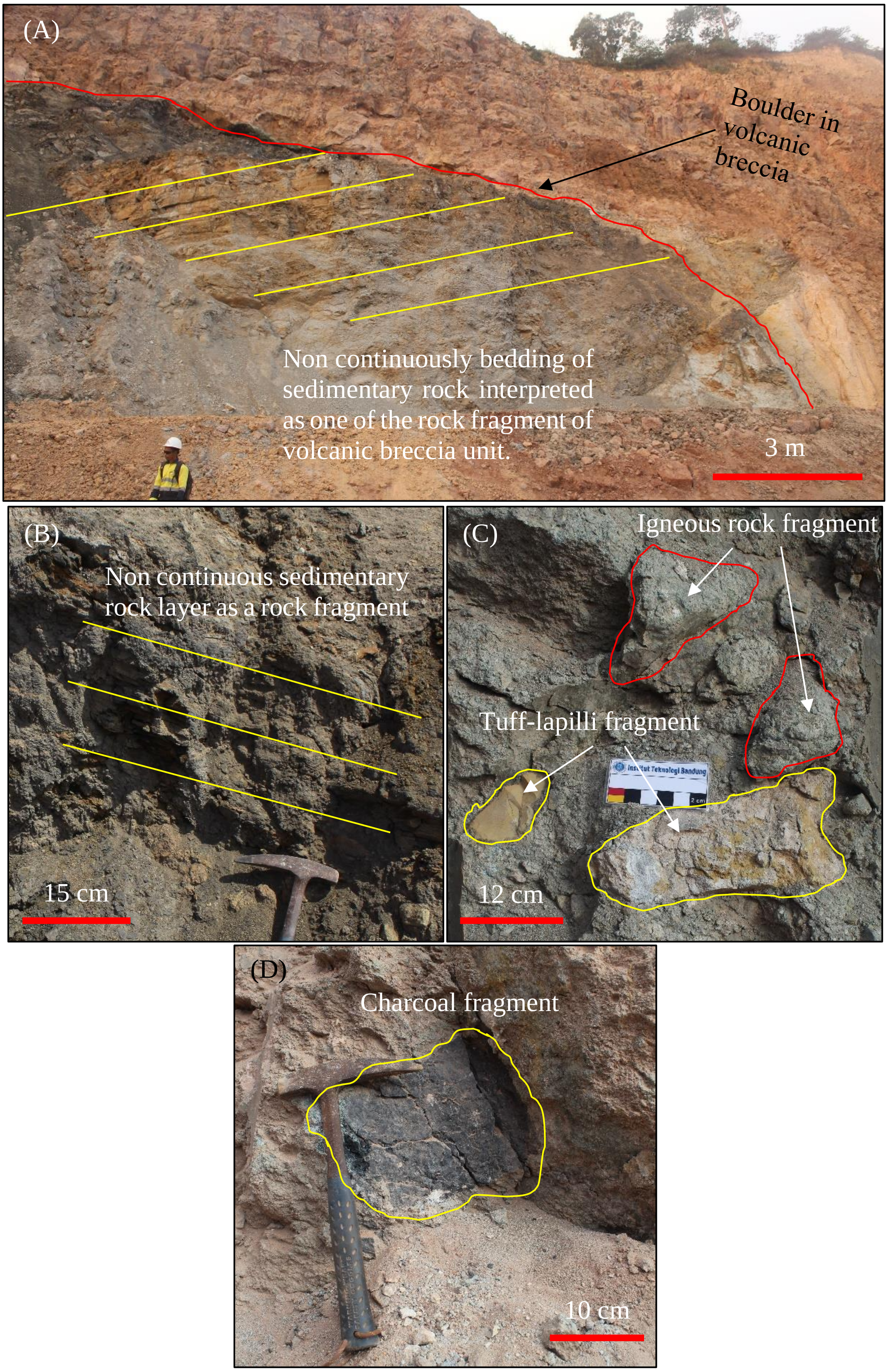

Figure 4. Various fragments of polymictic volcanic breccia with cobble to boulder up to > 7 m in Size with sedimentary layer fragment (A and B); andesite and tuff fragment (C); and charcoal fragment (D).

accompanying structural data such as BE 2 Fault, BE 3 Fault, BW 6 Fault, and BW 7 Fault (**Figure 8**). All of these structural solving from stereographic projection analysis are combined

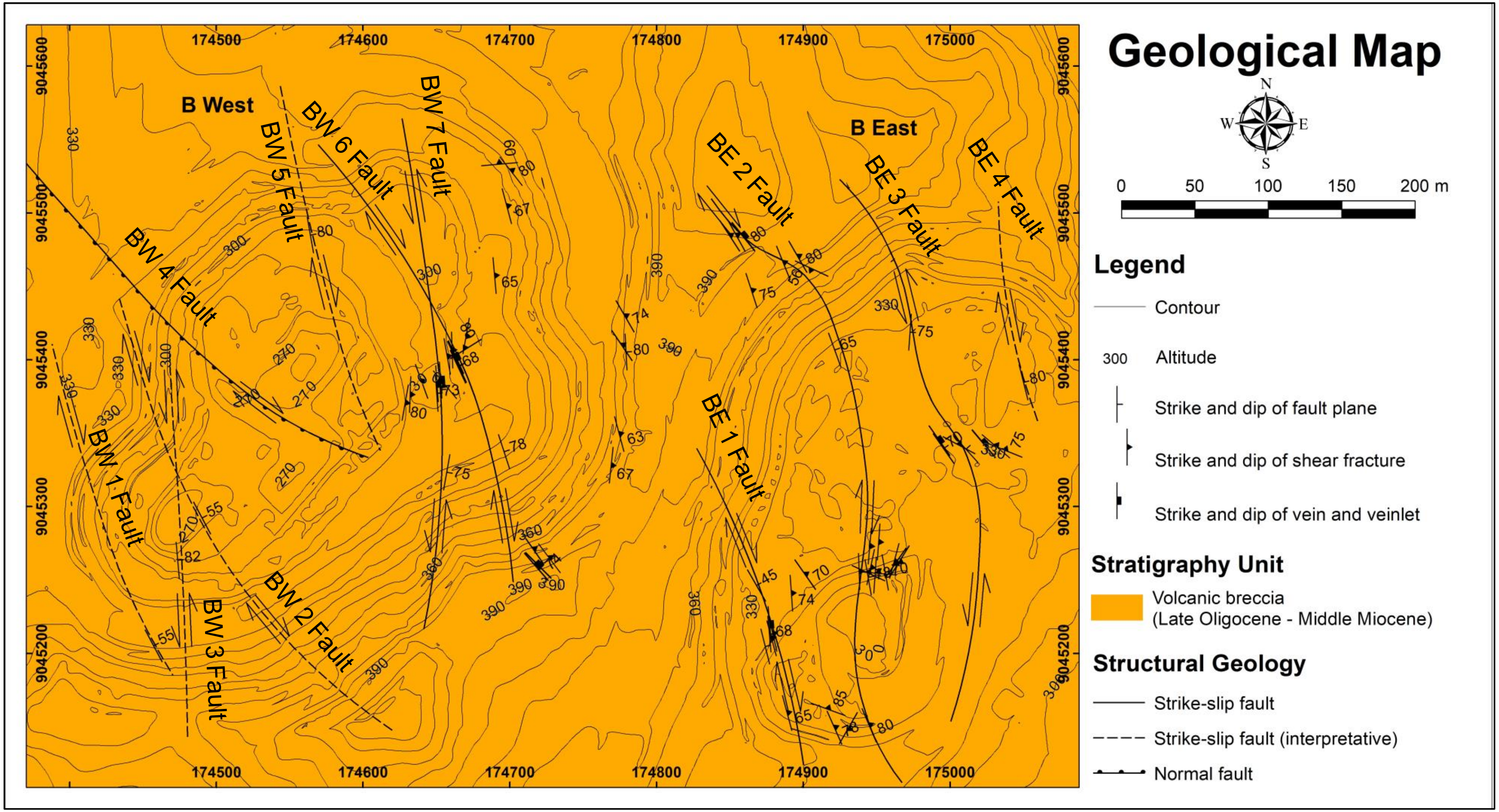

Figure 5. Geological map of Pit B East and West.

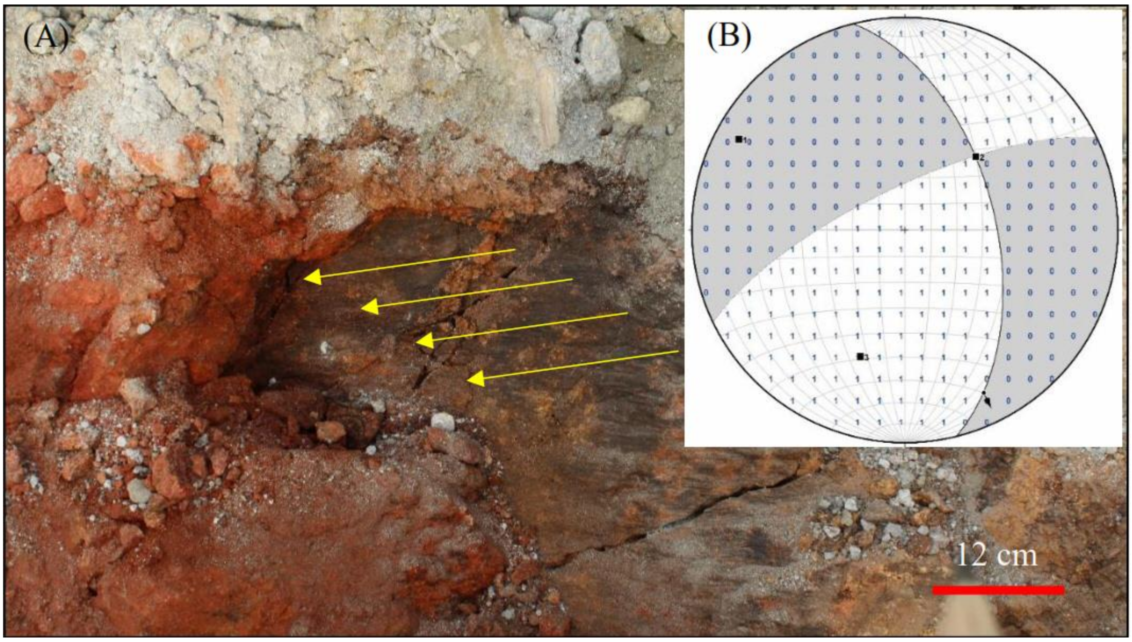

Figure 6. BE 1 Fault shows field evidence of slickensides in a footwall, dextral normal of movement (A) and fault kinematic analysis using stereographic projection (B). Stereographic projection is drawn using FaultKin 8 software (Marrett and Allmendinger, 1990; Allmendinger et al., 2012). It has σ_1 12°, N299°; σ_2 50°, N044°E; and σ_3 37°, N200°E with relatively NW-SE main principal stress.

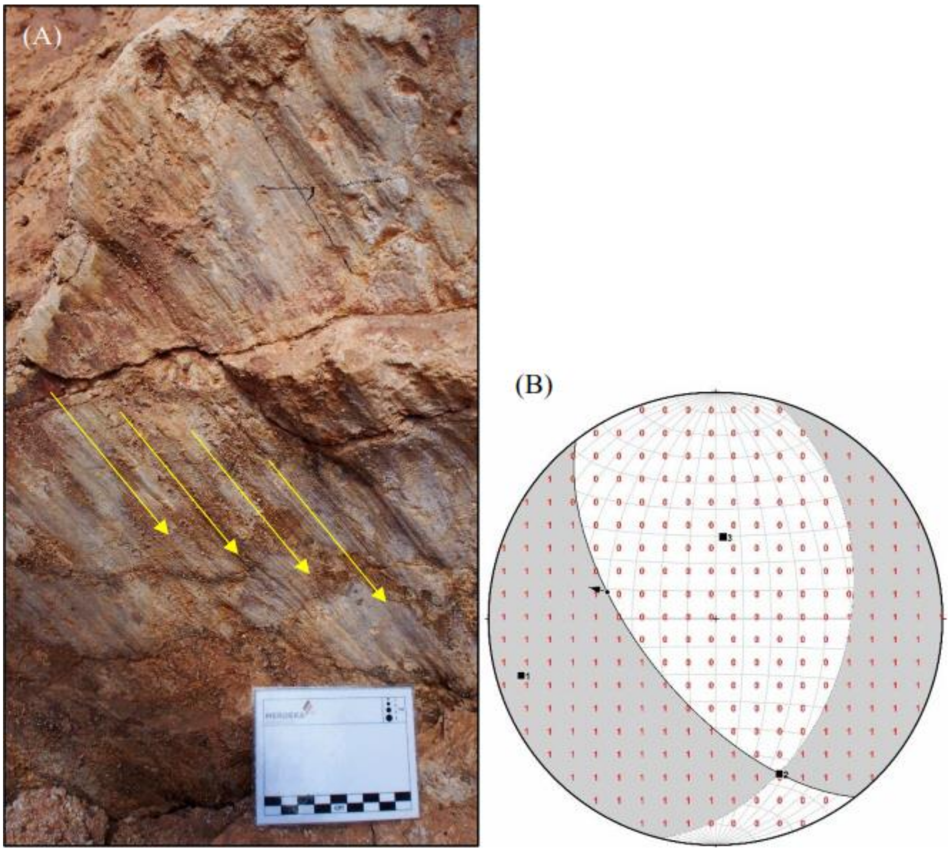

Figure 7. BW 4 Fault shows field evidence of slickensides in the hanging wall, normal dextral of Movement (A) and fault kinematic analysis using stereographic projection (B). Stereographic projection is drawn using FaultKin 8 software (Marrett and Allmendinger, 1990; Allmendinger et al., 2012). It has σ_1 12°, N254°; σ_2 27°, N158°E; and σ_3 60°, N005°E with relatively NW-SE main principal stress.

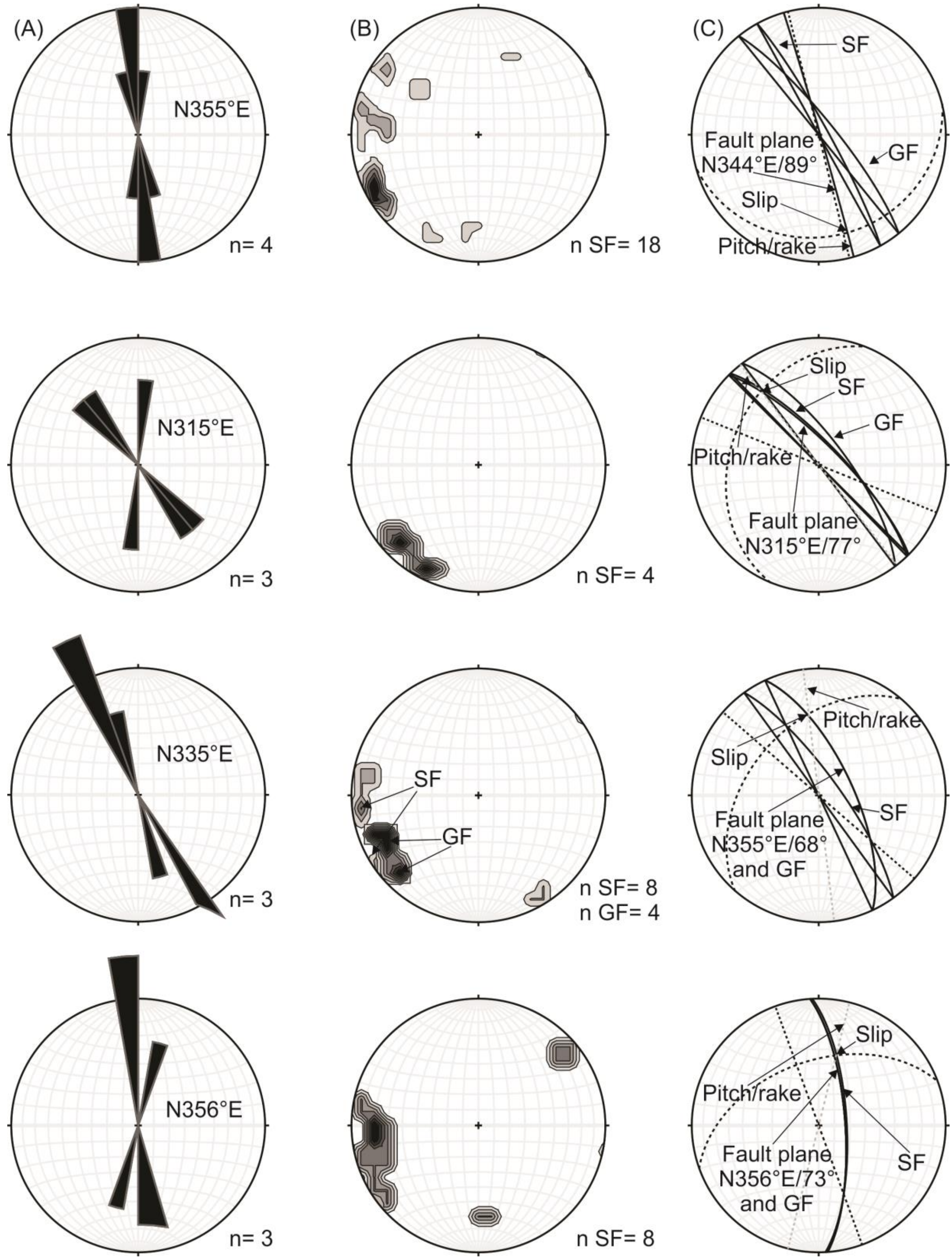

Figure 8. Lower hemisphere stereographic projection analysis for structural geology problem which has only accompanying structure such as brecciations, shear fractures, and gash fractures/veins. From top to bottom: BE 2 Fault, BE 3 Fault, BW 6 Fault, and BW 7 Fault. Rosette diagram of brecciation main orientation (A), contour diagram of shear fractures and/or gash fractures/veins with contour 1% of the area (B), and solving and settlement the statistical analysis of brecciations, shear fractures, and gash fractures (C). All of those stereographic projections are drawn using Stereonet 10 software (Allmendinger et al., 2013; Cardozo and Allmendinger, 2013).

with BE 1 and BW 4 Fault kinematic analysis (**Figure 9**) to reveal the main principal stress tectonic control in the Tujuh Bukit area. It looks the main principal stress has NNW-SSE orientation according to the fault plane and its sense of movement (represented by a small arrow).

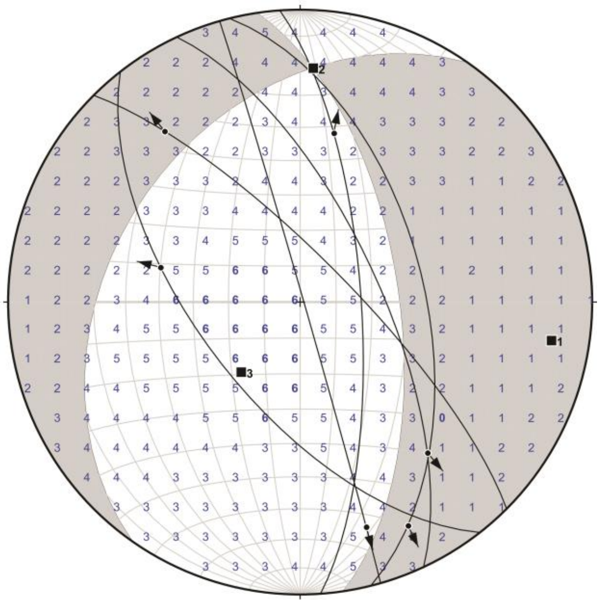

Figure 9. NNW-SSE main principal stress revealed from the kinematic analysis of six faults, including two slickensides data and four data from stereographic projection solving an equation of accompanying structures. Stereographic projection is drawn using FaultKin 8 software (Marrett and Allmendinger, 1990; Allmendinger et al., 2012).

Combining local pit structural data with regional geological map in entire Tujuh Bukit area from early stages of exploration (**Figure 10**) it is interpreted that the main developed structural are Pliocene strike-slip system, relatively NW-SE and N-S orientation, with completely controlled by NNW-SSE principal stress following pure shear model (compare **Figure 5** and **Figure 10**). There also relatively NW-SE normal fault and ENE-WSW thrust fault. All of these faults in the regional scale are NNW-SSE compressive tectonic compensation within one tectonic period. The strike-slip system resulting in normal fault and ridge zones within releasing stepover, releasing bend, and restraining bend structural geometry. Strike-slip faults in Pit B East and B West are the smallest strike-slip system within Tujuh Bukit regional scale. Developed structural geology representing recent tectonic of Java. If alunite alteration took time at 4.38 ± 0.05 Ma (Harrison et al., 2018) and assumed related fluids ore-bearing tectonic occurred just prior to the alteration process in geologic time, then the tectonic and structural geology develop in Pliocene.

Tectonomagmatism in southern Java as Indo-Australian Plate subducted beneath the Eurasian Plate at Pliocene has played the role as the ore-bearing activity. The Late Oligocene – Middle Miocene volcanic breccia deformed and structural pattern developed by the time Pliocene tectonic. Just after the structural system developed, the magmatism which occurred concurrently with structural system development released the hydrothermal fluids through the rocks deformed lane as a pathway for fluids migration. This Pliocene tectonomagmatism activity was an ore-bearing economic mined nowadays, hosted by Late Oligocene – Middle Miocene medium to intense altered volcanic breccia unit.

3.3 Alteration and Au Mineralization

Based on the field observation, core drilling, ASD instrument scanning, and petrographic analysis, the alteration unit divided into five, there are quartz, quartz-alunite, quartz-kaolinite, kaolinite-montmorillonite-chlorite, and kaolinite-montmorillonite alteration unit (**Figure 11**). According to alteration terminology based on the mineral assemblages, all the units are silicification, advanced argillic, and intermediate argillic alteration (Pirajno, 2009). Due to consist of an indistinguishable stratigraphy unit, the geological cross-section only drawn on the alteration map to find out the relationship of structure and alteration unit in the subsurface (**Figure 12**). Silicification alteration (quartz, quartz-alunite, and quartz-kaolinite alteration unit) mainly found as a massive and vuggy quartz (**Figure 13**) with disseminated ore mostly filled in the vugs. Silicification alteration mainly occurred on the structural pathway and vectorially become more clay-rich alteration going outwards as seen on the cross-section,

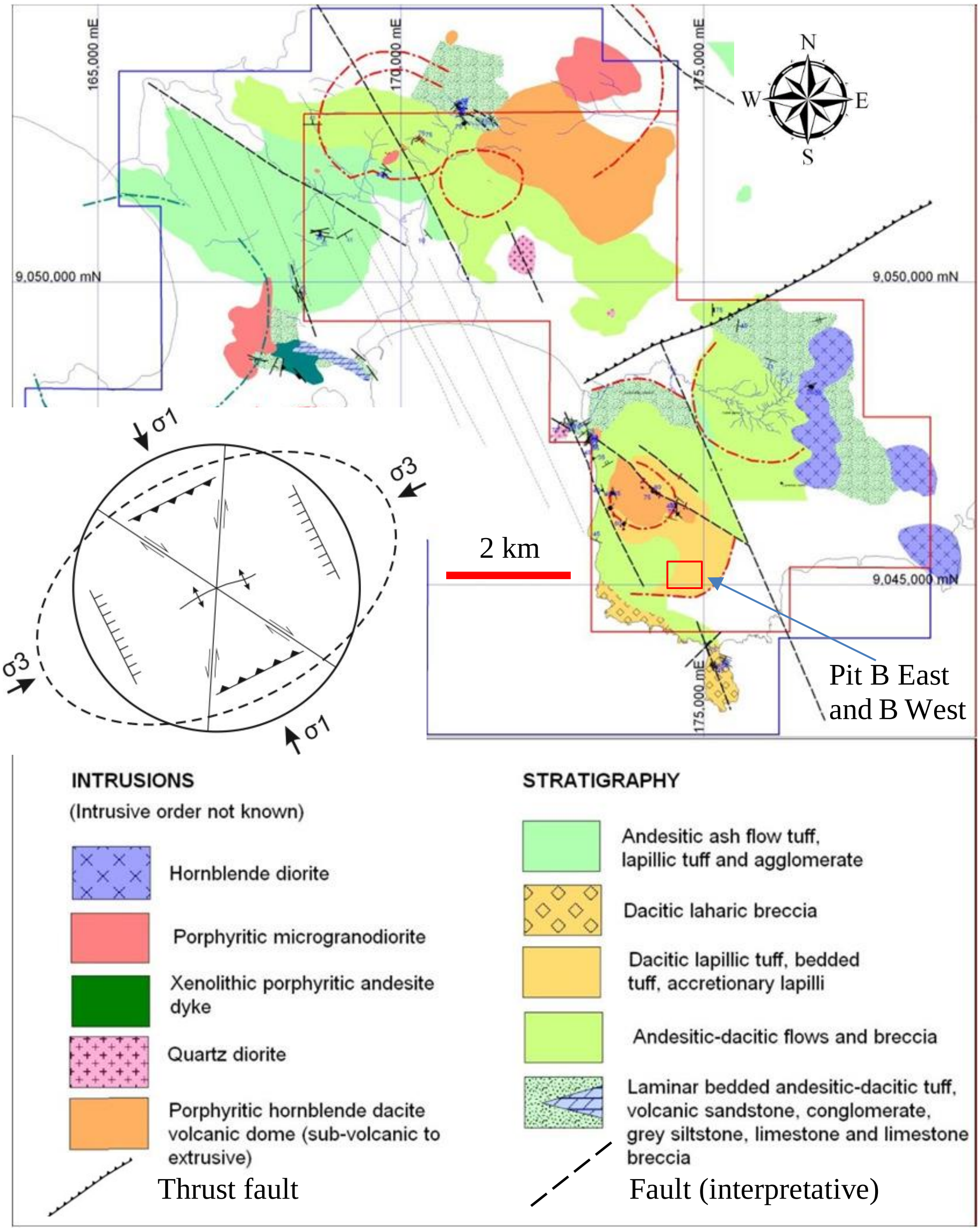

Figure 10. Regional geological map in an entire Tujuh Bukit area from the early stages of exploration (modified from Kavalieris and Khashgerel, 2011).

following the schematic diagram proposed by Arribas Jr. (1995). Geochronological data from $^{40}Ar/^{39}Ar$ dating of alunite defined that the alteration and high sulfidation epithermal mineralization took time at 4.38 ± 0.05 Ma (Harrison et al., 2018), just after the relatively N-S and NW-SE Pliocene strike-slip system developed. The age of mineralization defined by the U-Pb zircon dating revealed that the porphyry system has an age of 5.29 – 3.38 Ma and the epithermal system has an age of 5.29 – 1.91 Ma (Harrison et al., 2018), implying the duration of magmatism up to 3.59 m.y. since 5.29 Ma.

Au grade classified by statistical analysis and divided into five class, there is very low (< 0.25 ppm), low (0.25 – 1 ppm), medium (1 – 3 ppm), high (3 – 5 ppm), and very high grade (> 5 ppm). The value of < 0.25 ppm is cut of grade/lowest net from the company. Silicification alteration generally found on the structural geology lane with strong to intense alteration intensity (Morrison, 1997) and role as host for medium-to-very high Au grade.

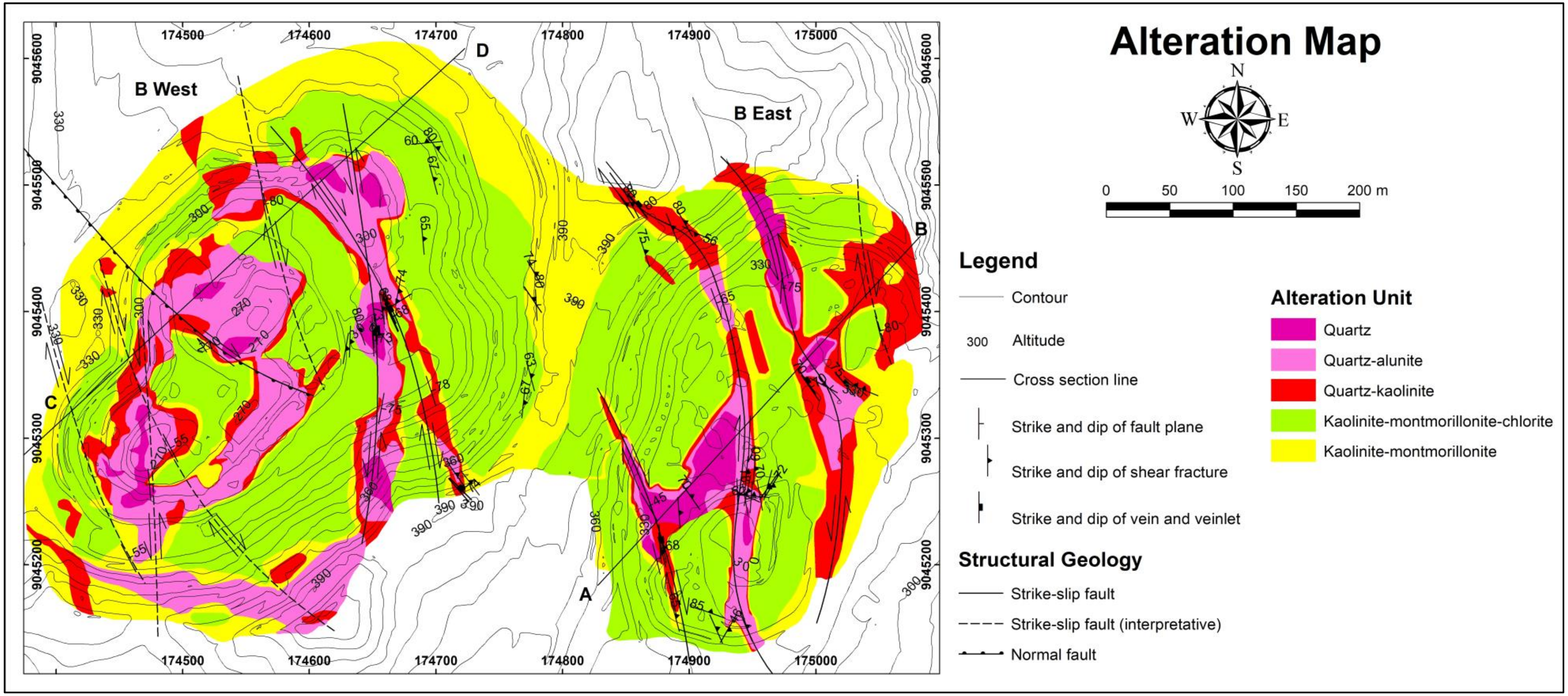

Figure 11. Alteration map of Pit B East and B West after integrating field observation, core drilling, ASD instrument scanning, and petrographic analysis. The alteration map and its topography are following the end of June 2019 mapping and mining activity. It is clear that silicification alteration (contain on quartz, quartz-alunite, and quartz-kaolinite alteration unit) generally following structural pattern, especially in the releasing bend and releasing stepover caused by strike-slip system and normal fault (see text for further explanation).

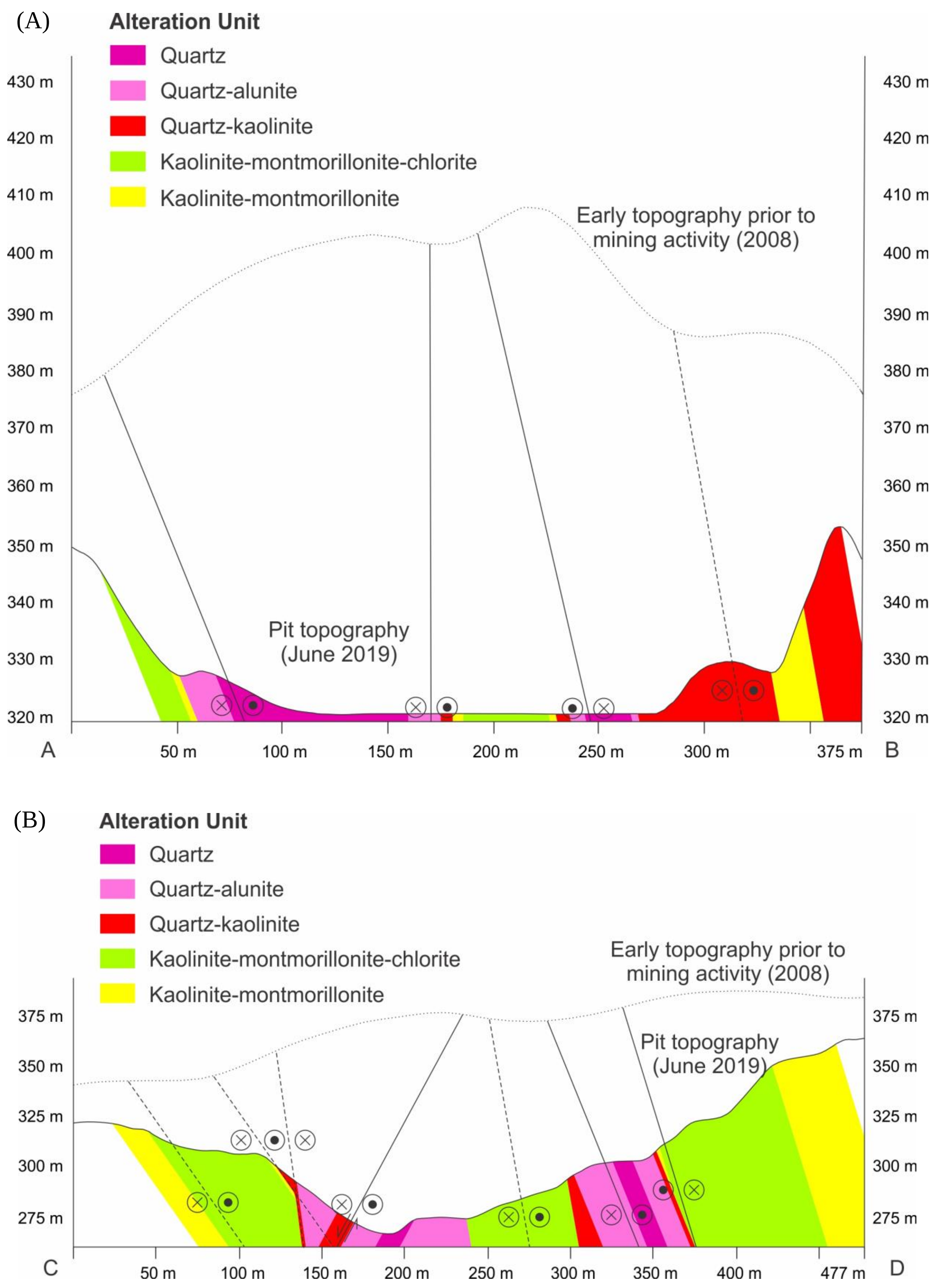

Figure 12. Cross-section of alteration map comparing pit topography (June 2019) to the early topography prior to mining activity in 2008. It is clear that silicification alteration generally formed in a structural pathway and vectorially become more clay-rich rocks going outward of the structure. The A-B is cross-section athwart Pit B East (A) and C-D is Pit B West (B).

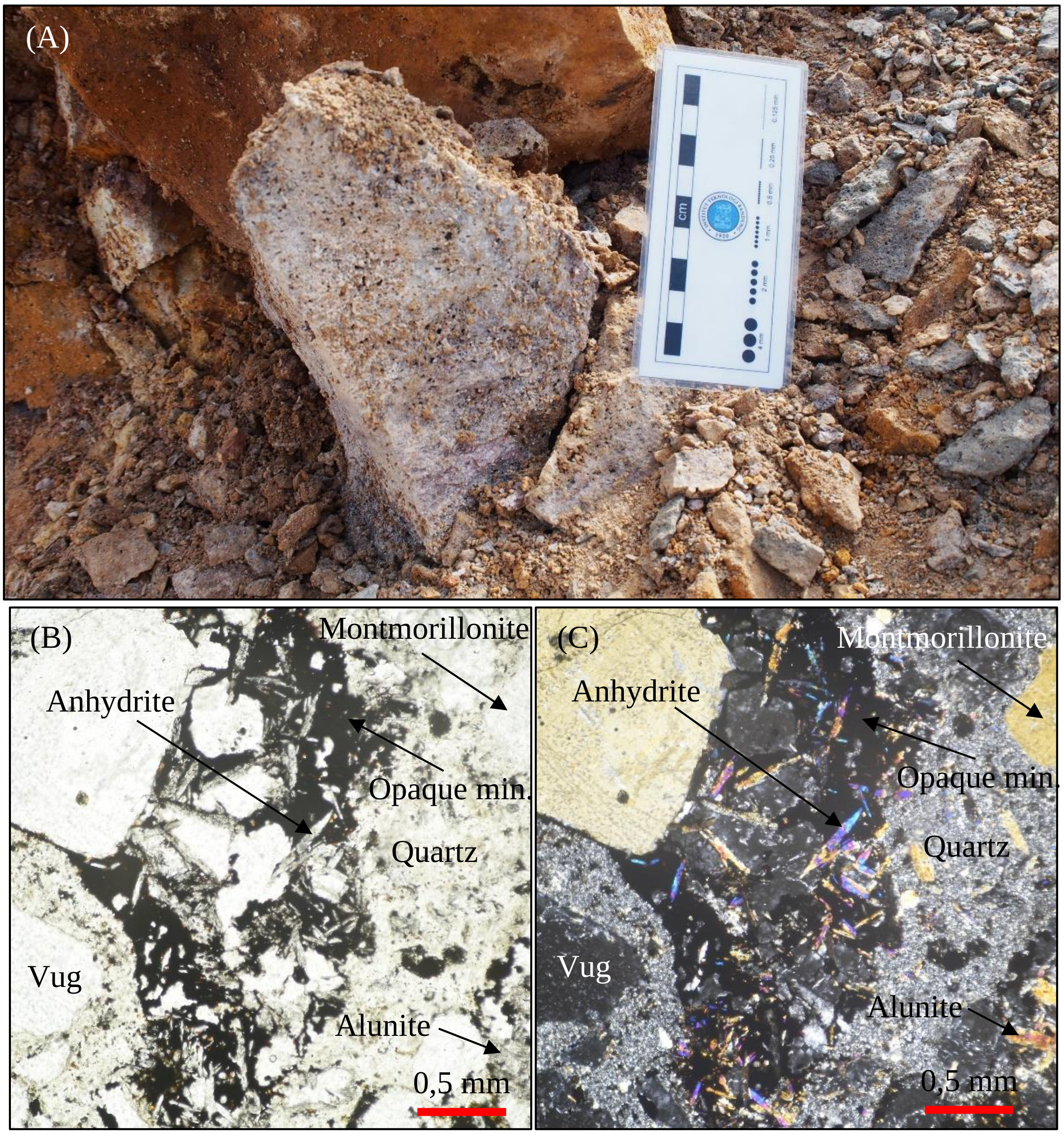

Figure 13. The outcrop of the vuggy quartz alongside with sugary alunite (A) and thin section photomicrograph of an outcrop showing the relative abundance of secondary quartz replacing the groundmass, leaching of phenocryst to become vugs, opaque mineral filling the cavity cracks and locally filling the leached vugs, and typical of high sulfidation epithermal alteration minerals such as alunite and anhydrite under PPL (B) and XPL (C) views.

A structural style that becomes a pathway for medium-to-very high Au grade ore-bearing hydrothermal fluids migration completely controlled by the strike-slip system and normal fault corresponding to the parallel NNW-SSE main principal stress (**Figure 14**). Strike-slip system which has to release stepover on the area between BE 1-BE 2 Fault, the area between BW 2-BW 3 Fault, and the area between BW 5-BW 6-BW 7 Fault resulting deep normal fault zones filled in by medium-to-very high Au grade ore. On the other hand, releasing bend resulting normal fault zones which filled in by ore on the bend geometry can be found on the bending line of BE 2 and BE 3 Fault. The BW 4 normal fault directly corresponding to the parallel NNW-SSE principal stress also host a spread and scattered Au medium-to-very high grade around the fault.

Au/gold present only readable by AAS Au grade determining geochemical test in ppm unit. Gold appearance is unseen in the mineragraphic analysis/micrographic view.

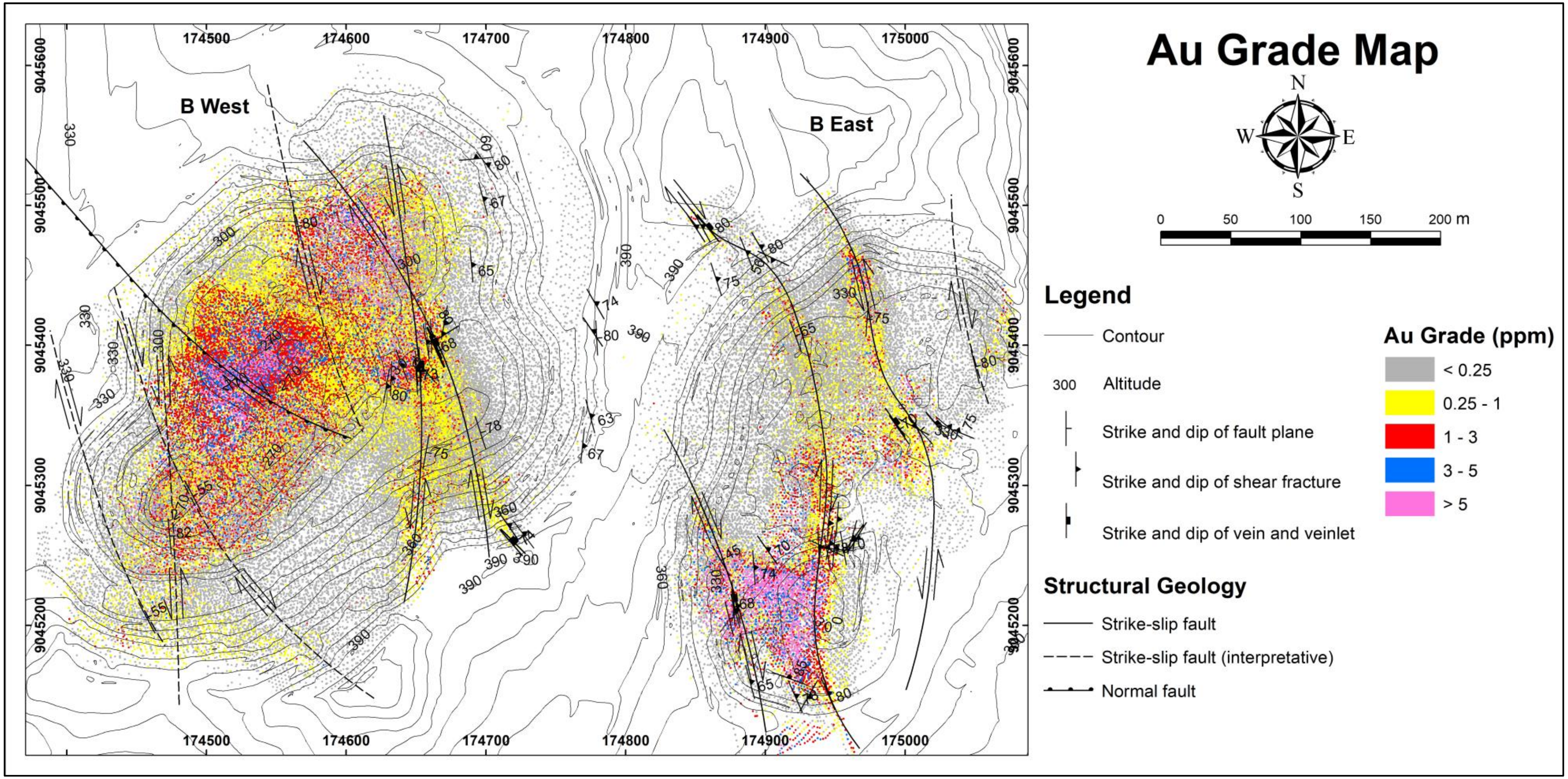

Figure 14. Au grade map showing the spatial distribution of very low (< 0.25 ppm) to very high (> 5 ppm) grade. It is clear that medium to very high Au grade generally following structural pattern, especially in the releasing bend and releasing stepover caused by strike-slip system and normal fault, lied within silicification alteration (see text for further explanation and Figure 12 to compare with alteration map). The Au grade map showed is following the end of June 2019 mapping, core drilling, AAS geochemical grade test, and mining activity.

5. CONCLUSION

Based on the previous analysis, the development of structural geology in Tujuh Bukit predominantly consists of Pliocene strike-slip faulting with relatively NW-SE and N-S orientation, a result of NNW-SSE main principal stress following the pure shear model due to Pliocene tectonomagmatism occurred in southern of Java. Structure, alteration, and mineralization which contain economic values and mined nowadays regionally controlled by the Indo-Australian Plate subducted beneath the Eurasian Plate at Pliocene. This tectonic activity also creates magmatism. The high sulfidation epithermal ore-bearing magmatism has a duration of up to 3.59 m.y. since 5.29 Ma.

Five alteration units concluded after data integration from the field, drilling, and ASD scanning, there are quartz, quartz-alunite, quartz-kaolinite, kaolinite-montmorillonite-chlorite, and kaolinite-montmorillonite alteration unit. Based on field and mineragraphic observation, there found ore minerals such as pyrite, chalcopyrite, covellite, bornite, tetrahedrite, azurite, malachite, hematite, and goethite. All these minerals generally found associated with silicification alteration, such as quartz, quartz-alunite, and quartz-kaolinite alteration unit. The Au present by mineragraphic view is unseen, however, Au associated with secondary quartz and other Cu-bearing minerals found in the high sulfidation epithermal realm. Development of medium to very high-grade mineralization within these alteration units generally took place in normal fault zones caused by the strike-slip system on the releasing bend (can be found on the bending line of BE 2 and BE 3 Fault) and releasing stepover geometry (on the area between BE 1-BE 2 Fault, the area between BW 2-BW 3 Fault, and the area between BW 5-BW 6-BW 7 Fault), and BW 4 normal fault which parallel to the principal stress on a regional scale.

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