

Fault analysis to Determine Deformation History of Kubang Pasu Formation at South of UniMAP Stadium Hill, Ulu Pauh, Perlis, Malaysia

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Abstract

The Kubang Pasu Formation at South of UniMap Stadium Hill has suffered deformation that produced fault with various types and orientations. First deformation (ST1) is southeast – northwest were resulted normal, reverse, dextral and sinistral fault. At station 32, Reverse fault (N94°E/48°) from ST1 was cut by reverse fault (N48°E/40°) result of second deformation (ST2). Another cross cutting fault found at station 108, third deformation (ST3) with stress direction from northeast – southwest that produced reverse fault with strike direction N134°E and 68° of dip angle was cutting the reverse fault (N87°E/66°) from second deformation. The youngest deformation (ST4) has stress from east – west. At station 110, normal fault (N90°E/30°) is representing the youngest deformation was cutting the reverse fault (N154°E/52°) from third deformation.

Keywords: Deformation, reverse fault, normal fault, dextral fault, sinistral fault, cross cutting.

1. Introduction

The study area is located at Bukit Stadium of UniMAP's sport complex, Ulu pauh, Perlis. The area is bounded by latitude 06° 28.246' N to 06° 28.273' N and longitude 100° 20.923'E to 100° 21.087' E (Figure 1). The outcrop is hill-cut at south of Bukit Stadium with extensive approximately 320 m². This area was mapped as Kubang Pasu Formation that consist of clastic sedimentary rock (Gobbet, 1973 and Jones, 1981). History of deformation can be determined by observation of tectonic structure. Study about tectonic structure was carried by Zaiton Harun et al. (1999), Gobbet (1973), and Abdul Hadi et al. (1999) at Kubang Pasu Formation. Relationship between structures can be used to determine the relative age of deformation. Cross cutting law is one of many methods to determine the relative age.

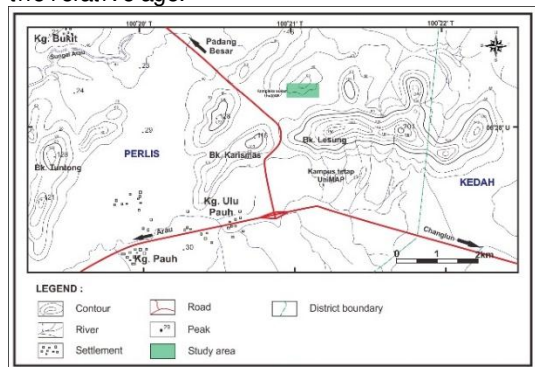


Fig 1. Map of the study area

2. General Geology and Stratigraphy

Based on geological map of Peninsular Malaysia show that study area is located at Kubang Pasu Formation. The Kubang Pasu Formation is exposed well at north and center of Perlis and extended to north of Kedah (Basir Jasin et al., 2003). Kubang Pasu and Singa Formation at north of Peninsular Malaysia is same age, the typical characteristic of Kubang Pasu is consist of thick quartz sandstone and interbedded with mudstone (Gobbet, 1973). Thickness of Kubang Pasu Formation is more than 1500 m that consist of sandstone and mudstone (Foo, 1983). At Bukit Temiang, there are passage beds from clastic rock of Kubang Pasu Formation become limestone of Chuping Formation. Hassan and Lee (2002) said, sometimes there are pebble and cobble at mudstone and shale layers. The age of Kubang Pasu Formation is determined by fossil that found. Trilobite *Cyrtosymbole (Waribole)* was found at red and grey shale at Gunung Hutan Aji together with bellerophonitide, pelecypode, baculitide, brachiopode and crinoid stem. All those fossil represent at Late Devonian till Early Carbon (Kobayashi and Hamada, 1973).

Complete sequence of Kubang Pasu Formation exposed at ex-quarry Ladang Cheong Chong Kaw, south of Kampong Panchor and at Kampong Belukar. Bottom part of this formation consist of dark mudstone and dark grey of chert. These layer overlay by interbedded of thin sandstone and thick mudstone. Interbedded of sand stone and mudstone with same thickness is the upper part of Kubang

Pasu Formation (Zaiton Harun and Basir Jasin, 1999). At Kaki Bukit and Gunung Hutan Aji, lower Paleozoic unit (Setul Formation) and upper Paleozoic unit (Kubang Pasu Formation) is exposed adjacent. There is no clear evidence that show unconformity between Paleozoic unit and Devonian unit.

Lithostratigraphy of study area are divided into the facies association, they are interbedded of sandstone which is the bottommost sequence, followed by fossiliferous thick mudstone and massive sandstone at the uppermost of the sequence.

3. Structure of Study Area

North part of Peninsular Malaysia is associated with Bok Bak mega fault. Bok Bak fault at Bukit Jabi

was discussed by Zaiton Harun and Basir Jasin (1999), Mahang formation overlay the Kubang Pasu Formation that younger than it. The boundary between those formations is a mylonite zone result of thrust fault caused by Bok Bak fault.

Structure geology of study area is show at figure 2. The bedding in this area has two dominants direction that are east – west and northeast – southwest. The dip ranging from 10° - 80° toward south and southeast. Furthermore, the dominant structure in the study area is fault. The fault identified in the field are reverse fault, normal fault, sinistral fault and dextral fault. The fault can be identified by presence of mylonite, fault breccias, slickenside, and displacement figure 3.

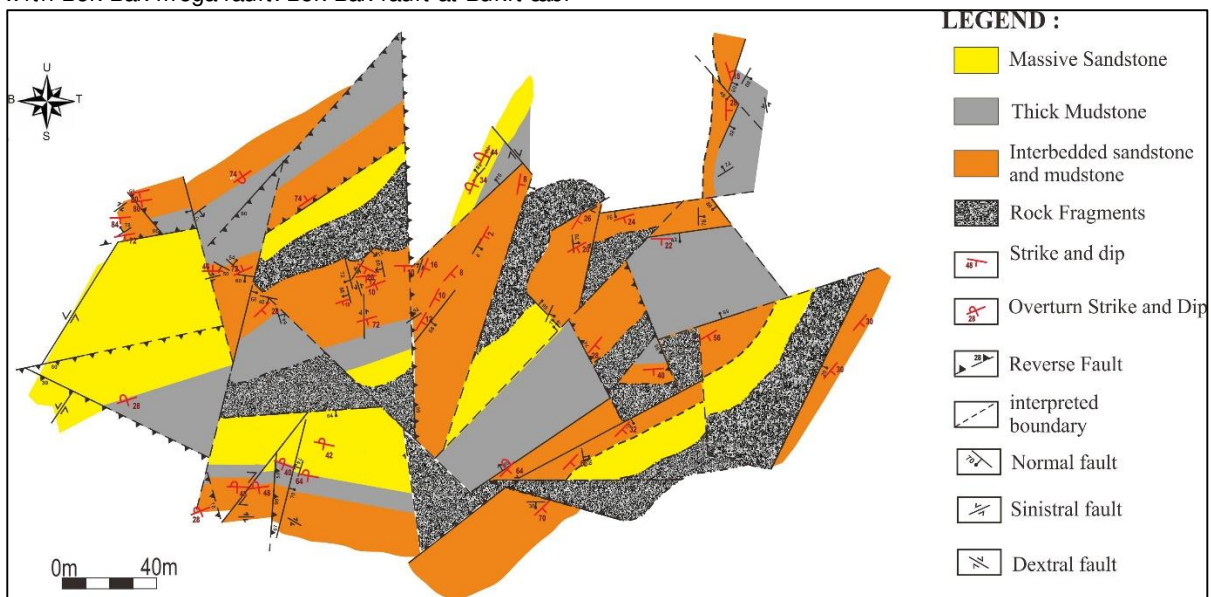


Fig 2. Geological structure map of study area

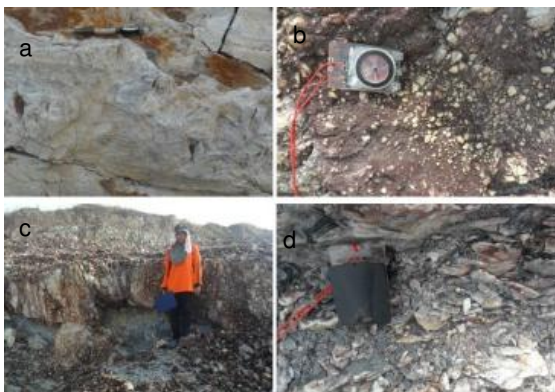


Fig 3. Indication of fault; a. slickenside; b. fault breccia; c. displacement; d. mylonite

3.1 Reverse Fault

34 strike and dip data of reverse fault was taken from the field. All the data plotted to stereonet to get the major reverse fault and the result shown that there are 4 major reverse faults named as Ss1, Ss2, Ss3 and Ss4 (figure 4). All those faults interpreted as pure reverse fault. Besides that, also there is reverse sinistral fault with pitch toward $N76^{\circ}E$ named as SsG. Result of reverse fault analysis represent at Table 1. The result show that there are 4 main stress (compressional stress) which are east-west (Ss1 and Ss4), southeast-northwest (Ss2), north-south (Ss3) and northeast-southwest (SsG).

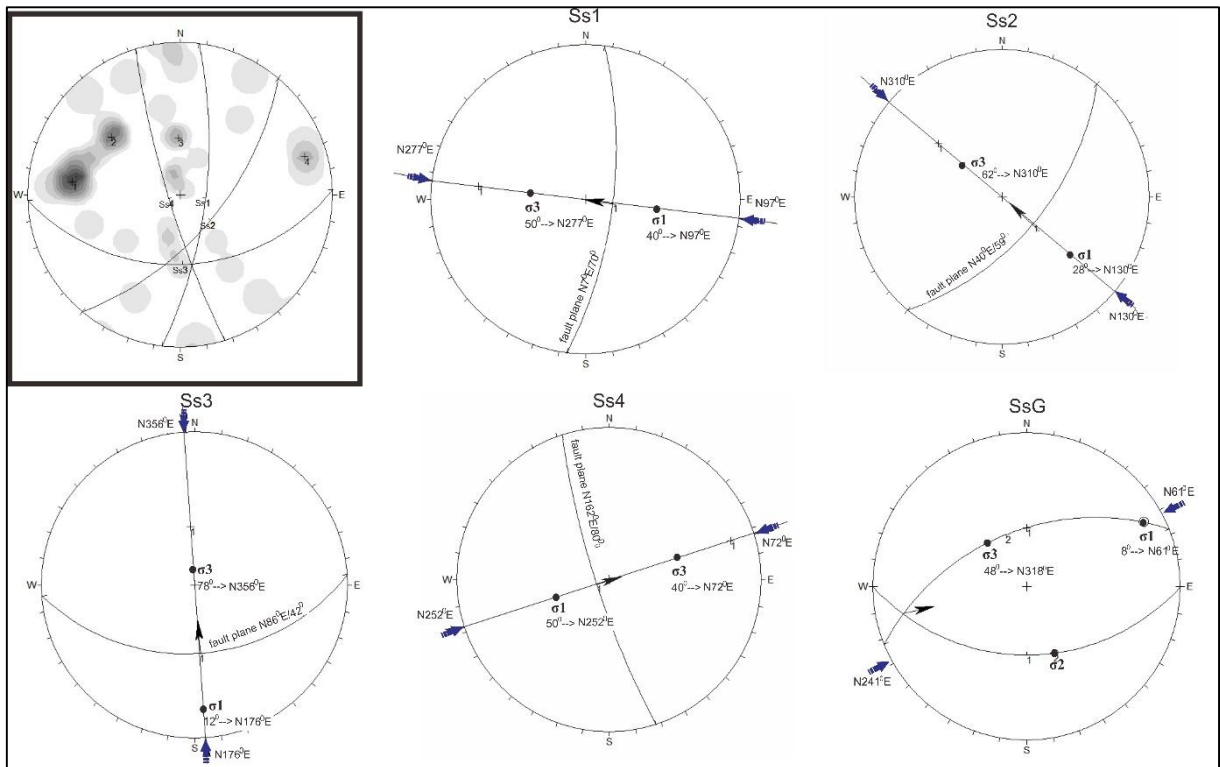


Fig 4. Sterionet analysis of reverse fault

Table 1. Stress analysis result of reverse fault

Fault plane	Strike and dip	Pitch direction	Compressional stress σ_1	Stress direction
Ss1	N7°E/70°	-	N97°E – N277°E	East-West
Ss2	N40°E/59°	-	N130°E – N310°E	Southeast-northwest
Ss3	N86°E/42°	-	N176°E – N356°E	North-South
Ss4	N162°E/80°	-	N252°E – N72°E	East-West
SsG	N90°E/42°	N76°E	N318°E – N138°E	Northeast-south west

3.2 Normal Fault

From 47 strike and dip data of normal fault was taken 4 major normal fault labeled as Sn1, Sn2, Sn3 and Sn4 (figure 5). Aside from all those pure normal fault, there are 2 another normal faults found at field. They are normal dextral fault with pitch toward N240°E (SnG1) and normal sinistral fault with pitch toward N6°E (SnG2). The result of normal fault analysis (Table 2) show that there are 4 extensional stress which are north-south (Sn1), northwest-southeast (Sn2), east-west (Sn3) and northeast-southwest (Sn4, SnG1 and SnG2).

3.3 Dextral Fault

5 major dextral fault plane was got from plotting 18 strike and dip data from field observation. 5 major dextral fault interpreted as pure dextral fault that labeled as Ska1, Ska2, Ska3, Ska4 and Ska5 (figure 6). Data and results of analysis of dextral fault show at Table 3. There are 3 main stress (compressional stress) that generate all of those faults at study area, they are stress from northeast-southwest (Ska1), north-south (Ska2 and Ska3) and northwest-southeast (Ska4 and Ska5).

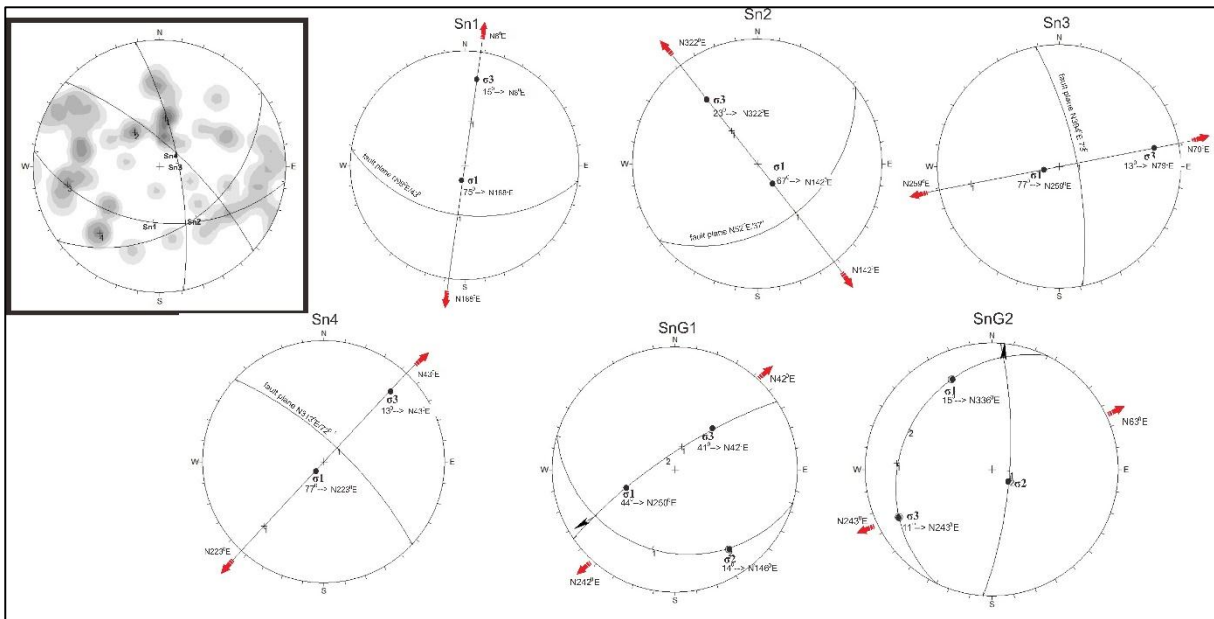


Fig. 5 Serionet analysis of normal fault

Table 2. Stress analysis result of normal fault

Fault plane	Strike and dip	Pitch direction	Extensional stress σ_3	Stress direction
Sn1	N98°E/43°	-	N8°E – N188°E	North-south
Sn2	N52°E/37°	-	N142°E – N322°E	Northwest-southeast
Sn3	N349°E/73°	-	N79°E – N259°E	East-west
Sn4	N313°E/72°	-	N43°E – N223°E	Northeast-southwest
SnG1	N106°E/22°	N240°E	N42°E – N222°E	Northeast-southwest
SnG2	N4°E/74°	N6°E	N243°E – N63°E	Northeast-southwest

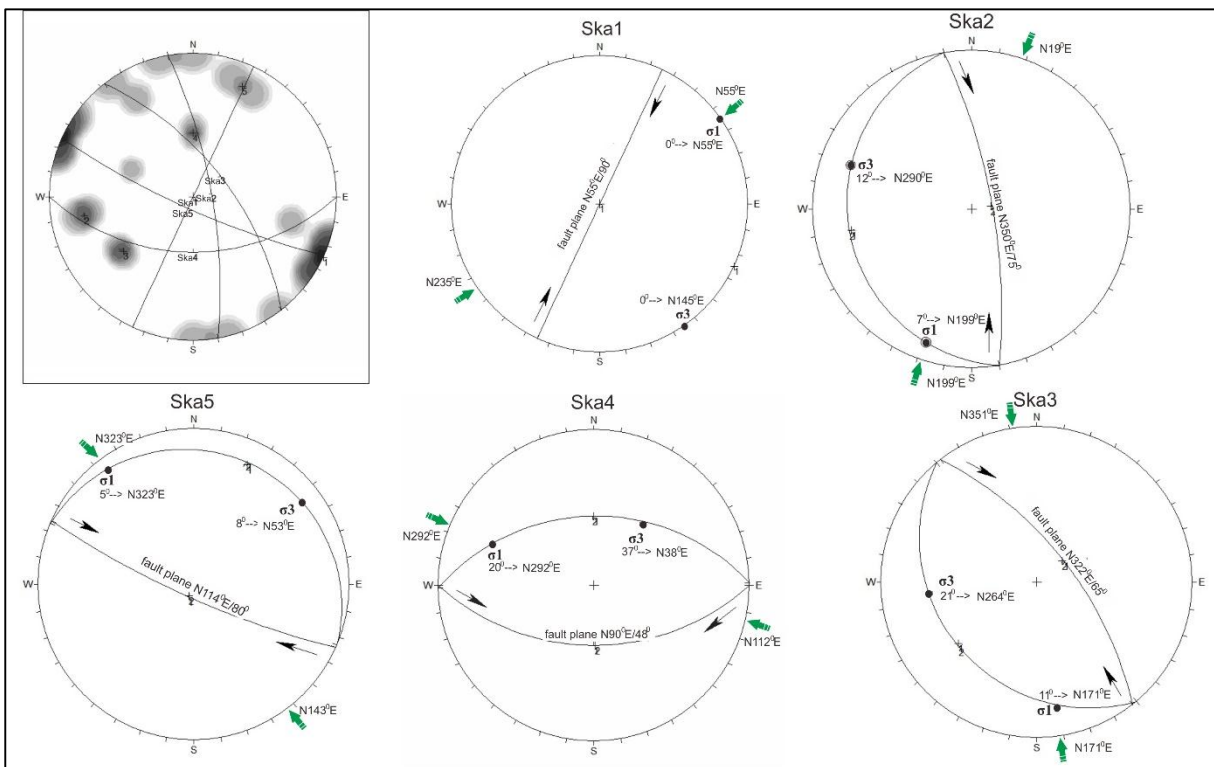


Fig 6. Stress analysis result of dextral fault

Table 3. Stress analysis result of dextral fault

Fault plane	Strike and dip	Compressional stress σ_1	Stress direction
Ska1	N205°E/90°	N55°E – N235°E	Northeast-southwest
Ska2	N350°E/70°	N199°E – N19°E	North-south
Ska3	N322°E/65°	N177°E – N357°E	North-south
Ska4	N90°E/48°	N292°E – N112°E	Northwest-southeast
Ska5	N114°E/80°	N325°E – N145°E	Northwest-southeast

3.4 Sinistral Fault

From 12 strike and dip data of sinistral fault was taken 3 major sinistral fault labeled as Ski1, Ski2 and Ski3 (figure 7). All of them interpreted as pure sinistral fault. Based on analysis of sinistral fault (Table 4), there are 3 main stresses which are north-south (Ski1), northwest-southeast (Ski2) and northeast-southwest (Ski3).

Table 4. Stress analysis result of sinistral fault

Fault plane	Strike and dip	Compressional stress σ_1	Stress direction
Ski1	N27°E/90°	N358°E – N178°E	North-south
Ski2	N177°E/88°	N150°E – N330°E	Southeast-northwest
Ski3	N81°E/61°	N55°E – N235°E	Northeast-southwest

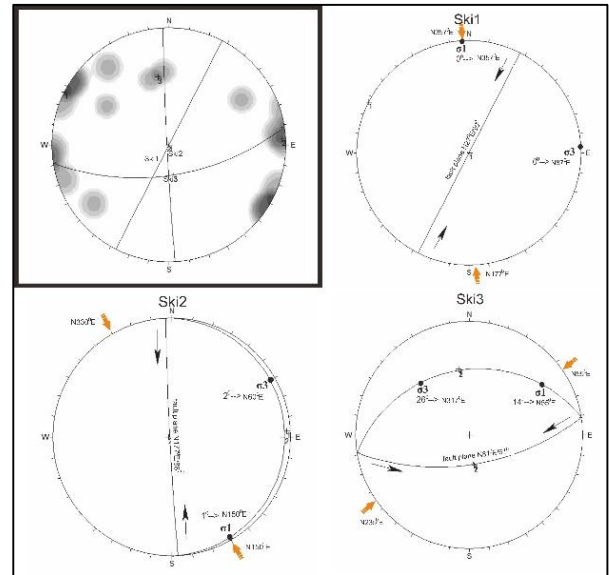


Fig 7. Stress analysis result of sinistral fault

4. Discussion

On the whole, there are 4 main stress that generate fault at study area. All of them are northwest-southeast (ST1), north-south (ST2), northeast-southwest (ST3) and east-west (ST4). Stress from northwest-southeast (ST1) were generated some structures such as Ss2, Sn4, SnG1, SnG2, Ska4, Ska5 and Ski2. Another structure which are Ss3, Sn3, Ska2, Ska3 and Ski1 were generated by stress from north-south (ST2). For stress from northeast-southwest (ST3) were resulted Ss4, SsG, Sn2, Ska1 and Ski3 while stress from east-west (ST4) were caused form Ss1 and Sn1 (Table 5).

To determine relative age of all of main stress, cross cutting law was used. At field, cross cutting

between faults were found. At station 32, ST1 that represented by reverse fault with strike N48°E and dip 30° was cut by reverse fault N94°E/48° from ST2. That mean ST1 is older than ST2 because it was cut by ST2. Meanwhile at station 108, reverse fault N134°E/68° that represent ST3 was cutting reverse fault N87°E/66° that generated by ST2. In other hand, ST 4 that generated normal fault N90°E/30° at station 110 was cutting 2 reverse fault N154°E/52° and N160°E/36° that result of ST3. Based on cross cutting between fault that found at field, the relative age of main stress was determined where the oldest stress is from northwest-southeast (ST1), following by north-south (ST2) and northeast-southwest (ST3). Whilst stress from east-west is the youngest stress at study area (Table 5).

Table 5. History of deformation at study area based on analysis of fault

Relative age	Main Stress	Compressional Stress (σ_1)	Extensional stress (σ_3)	Structures formed
Oldest	ST 1	Southeast-northwest	Northeast-southwest	Ss2, Ska4, Ska5, Ski2, Sn4, SnG1 and SnG2
↓	ST 2	North-south	East-west	Ss3, Ska2, Ska3, Ski1 and Sn3.
↓	ST 3	Northeast-southwest	Southeast-northwest	Ss4, SsG, Ska1, Ski3 and Sn2
Youngest	ST 4	East-west	North-south	Ss1 and Sn1

5. Conclusion

4 type of fault which are reverse fault, normal fault, dextral fault and sinistral fault were identified by indication of slickenside, fault breccias, displacement and presence of mylonite. Analysis of

fault indicate that there are 4 main stresses were controlled the deformation at study area. The relative age of main stress was determined by cross cutting evidence between faults that found during observation at field. The oldest main stress is ST1 with the direction from northwest-southeast. The

second main stress is from north-south (ST2) and following by third main stress from northeast-southwest (ST3). Meanwhile, the youngest main stress is ST4 with direction from east-west. All the main stresses were represented the history of deformation at study area.

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