DEFORMATION CHARACTERS ALONG THE SAGAING FAULT ZONE BETWEEN INDAW AND SINGU TOWNSHIP, CENTRAL MYANMAR

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Abstract

The study area is situated along the dextral Sagaing Fault zone, about 208 km long, between Indaw Township in Sagaing Region and Singu Township in Mandalay Region, in central Myanmar. It is demarcated by Latitude 22° 30′ N to 24° 20′ N and Longitude 95° 50′ E to 96° 10′ E. In this area, on the basis of the right stepover (releasing step) pattern; the Sagaing Fault can be subdivided into two segments – the northern Indaw-Peinnegon segment (52 km+) and the southern Peinnegon-Singu segment (156 km). There are four types of structural deformation which are determined from both the mesoscopic and microscopic characters of the oriented samples. These are ductile extensional deformation, brittle-ductile extensional deformation, semibrittle extensional deformation, and brittle extensional deformation. The former three types are especially present in the metamorphic rocks exposed between Chaunggyi and Thabeikkyin, and Katha. The brittle extensional deformation is especially present in the sandstones and conglomerates of Male Formation, Irrawaddy sandstones and Singu basalt along the southern and northern parts of the Sagaing Fault zone in the area. Rock units of the study area show distinctive structural deformation characters related to the progressive deformation processes due to the dextral shearing of the Sagaing Fault.

Keywords: Sagaing Fault zone, Indaw-Peinnegon segment, Peinnegon-Singusegment, structural deformation and progressive deformation processes

Introduction

Location

The study area is situated between Indaw and Sigu Townships, Sagaing and Mandalay Regions, in central Myanmar. The area is demarcated by Latitude 22° 30′ N to 24° 20′ N and Longitude 95° 50′ E to 96° 10′ E (Figure 1).

Objective

The study of the structural deformation along the Sagaing Fault zone is focused as the principal objective.

Method of study

The topographic maps, satellite images and aerial photographs are used for preliminary work. This is supported by later field observations and microscopic investigations in order to get the structural deformation in the study area.

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Segmentation of Sagaing Fault

On the basis of the right stepover (releasing step) pattern, Sagaing Fault in the study area can be subdivided into two structural segments (Figure 2). These are as follows:

Northern segment: (Indaw-Peinnegon segment, between lat. 24° 00′ and 24° 20′ N).

Southern segment: (Peinnegon-Singu segment, between lat. 22° 30′ and 24° 00′ N).

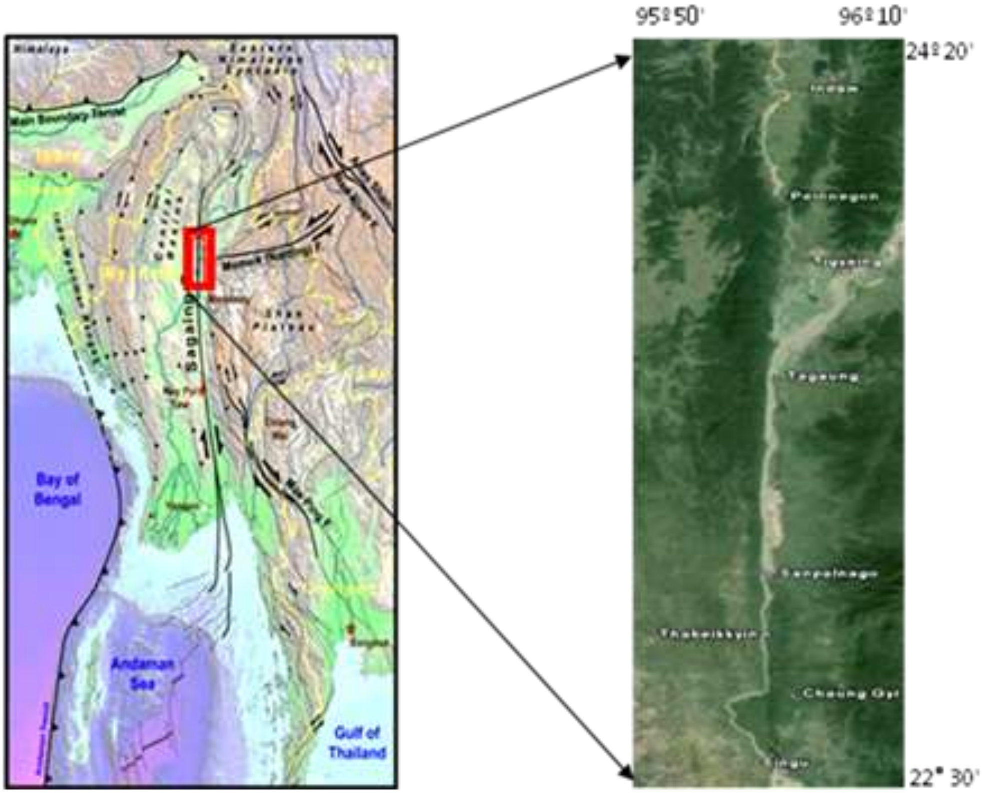


Figure 1 Location map of the study area.

Deformation Characters

Rock units of the study area show distinctive structural characters related to the progressive deformation processes along the Sagaing Fault. These evidences are studied in mesoscopic structures from outcrop investigations and microscopic textures from petrographic examination. On the basis of these studies, structural deformation in the study area can be classified as ductile extensional deformation, brittle-ductile extensional deformation, semibrittle extensional deformation and brittle extensional deformation.

Field Evidence of Structural Deformation

(1) Ductile extensional deformation

The mesoscopic characters of ductile deformation consist of foliation and stretching mineral lineation. Evidences for ductile deformation in Thabeikkyin area are represented by foliation and fold which are observed in hornblend-biotite schist of Mogok metamorphics (Figure 3a, b). In Chaunggyi, mylonite and gneiss of Mogok metamorphics are evidences of ductile deformation (Figure 3c, d).

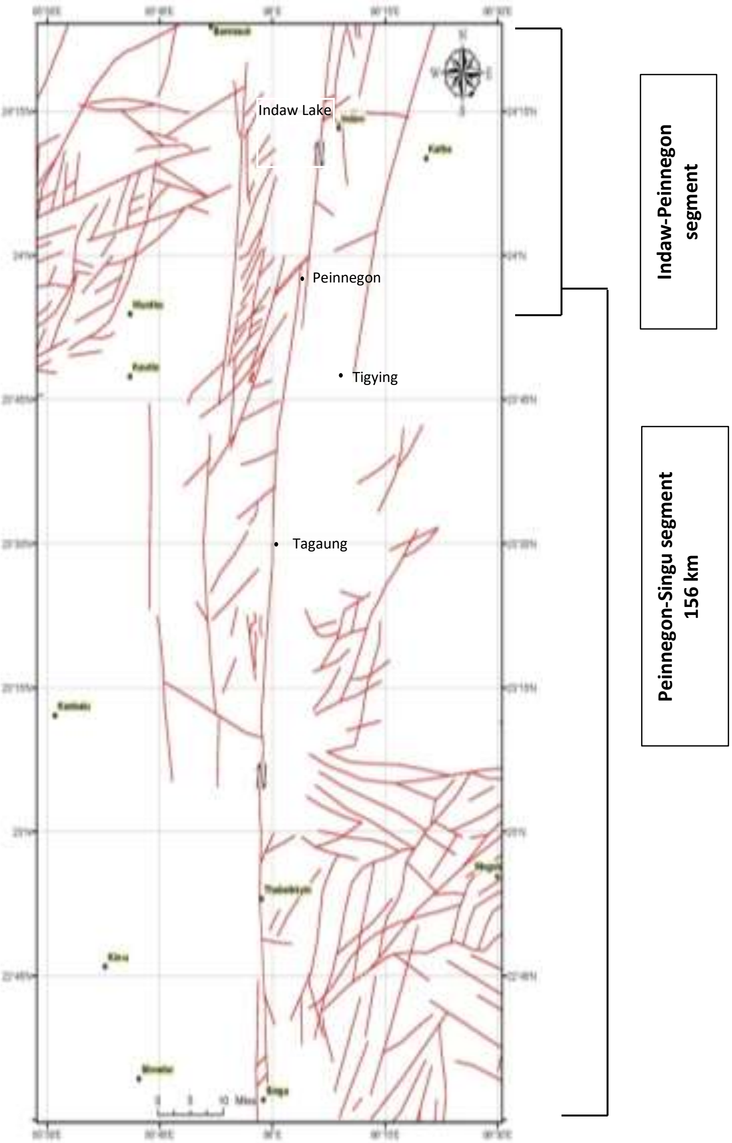


Figure 2 Two structural segments of the Sagaing Fault in the study area.

(2) Brittle- ductile extensional deformation

Rock deformation is dominated by both brittle and ductile mechanisms. Many brittle-ductile deformations contain boudins, rock fragments, and porphyroclasts of the more brittle minerals and rock types, all floating in a tectonite matrix of more easily deformed minerals and rocks. Cataclasite in thabeikkyin area and blastomylonite in Chaunggyi area are evidences for brittle-ductile extensional deformation (Figure 4a, b).

(3) Semibrittle extensional deformation

It is dominated by brittle deformation mechanisms (fracturing and cataclastic flow), but some ductile aspects are well remarkable. *En echelon* veins, *en echelon* joints and *en echelon* stylolites are evidences of this deformation. Evidence for this deoformation in Chaunggyi is represented by *en echelon* quartz veins which are observed in gneiss of Mogok metamorphics (Figure 5).

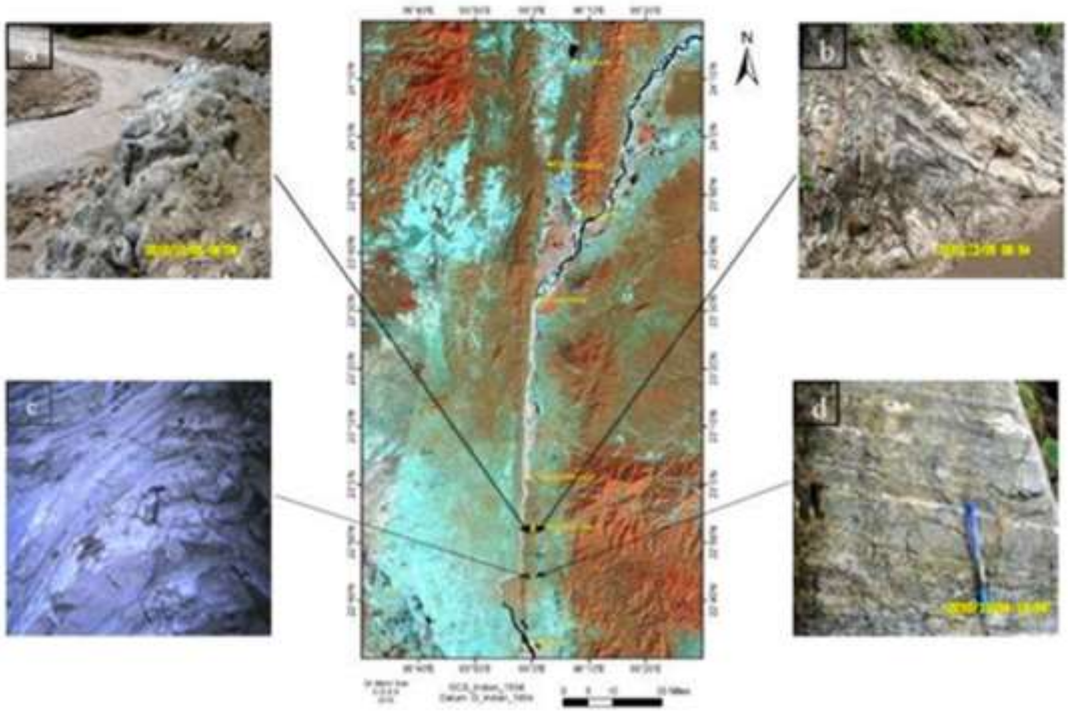


Figure 3 Ductile extentional deformation character. (a) foliation in hornblend-biotite schist of Mogok metamorphics in Thabeikgyin area, (b) fold in hornblend-biotite schist of Mogok metamorphics in Thabeikgyin area, (c) mylonite in Chaunggyi area, and (d) gneiss of Mogok metamorphics in Chaunggyi area.

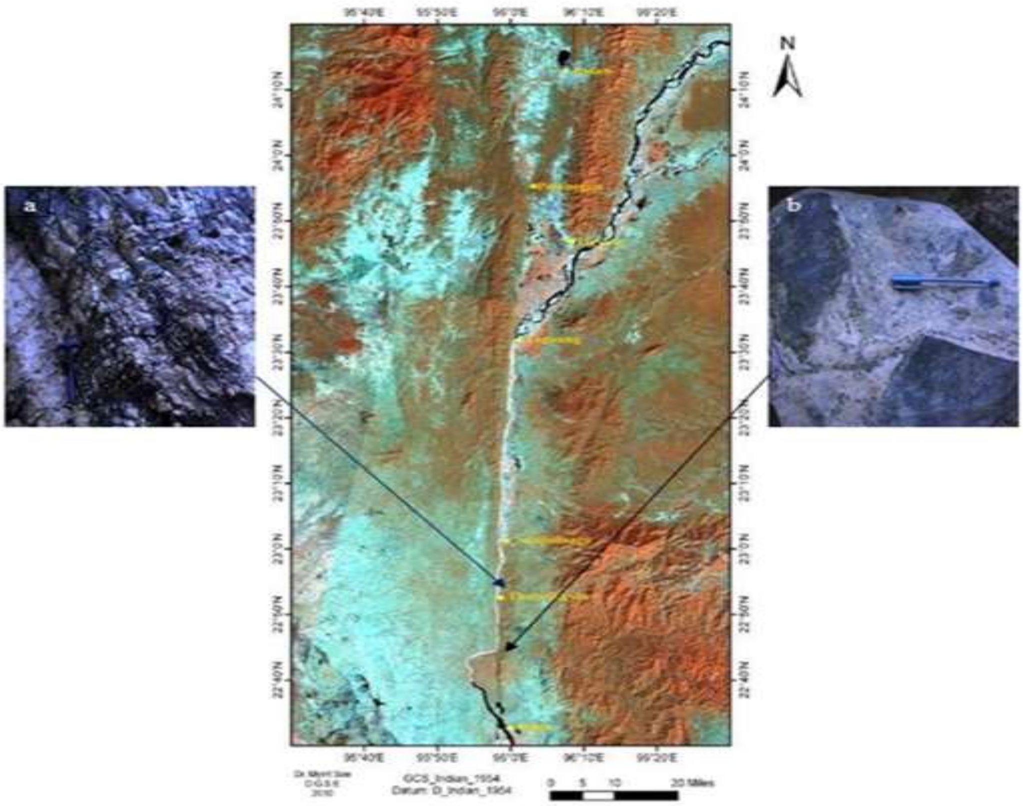


Figure 4 Brittle-ductile extentional deformation character. (a) Cataclasite in Thabeikkyin area and (b) blastomylonite in Chaunggyi area.

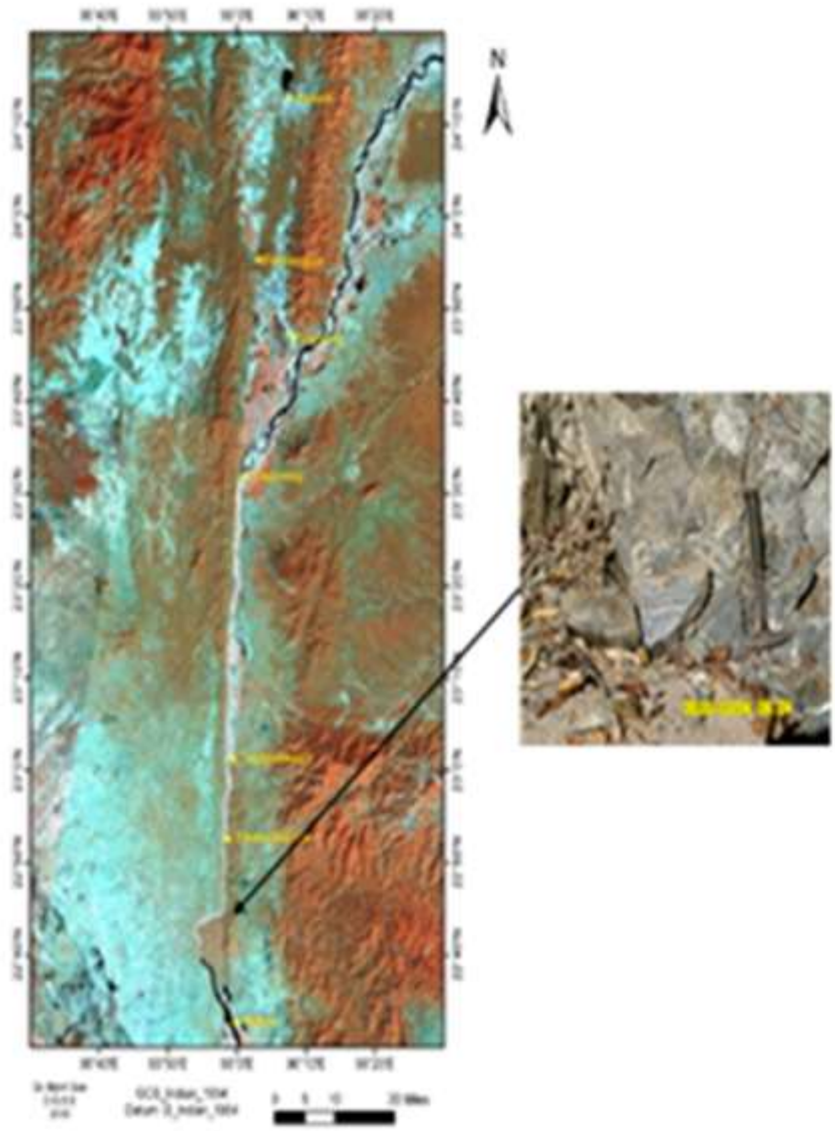


Figure 5 Semibrittle extentional deformation character. (a) En echelon quartz veins in gneiss of Mogok metamorphics in Chaunggyi area.

(4) Brittle extensional deformation

Brittle extensional deformation operates in the shallow part of the earth curst generally within the 5-10 km level of the earth surface, where deformation is dominated by brittle mechanisms, such as fracturing and brecciation. In the study area, brittle shear planes, fault gouge and breccias are evidences for this deformation (Figure 6). Evidences for this deformation in Thetkekyin area (Indaw) are mainly represented by brittle shear plane and fault gouge which are observed in sandstone of Irrawaddy Formation (Figure 6a, b). In Peinnegon area, brittle shear planes are observed in sandstone of Male Formation (Figure 6c, d). In the northwestern part of Zethaung area, normal fault plane is observed in limestone unit (Figure 6e). In Thabeikkyin area, normal fault plane is observed in calc-silicate rock of Mogok metamorphics (Figure 6f). Evidences for this deformation in Singu area are mainly represented by shear fault plane, fault gouge and fault breccias are observed in Singu olivine basalt (Figure 6g-j).

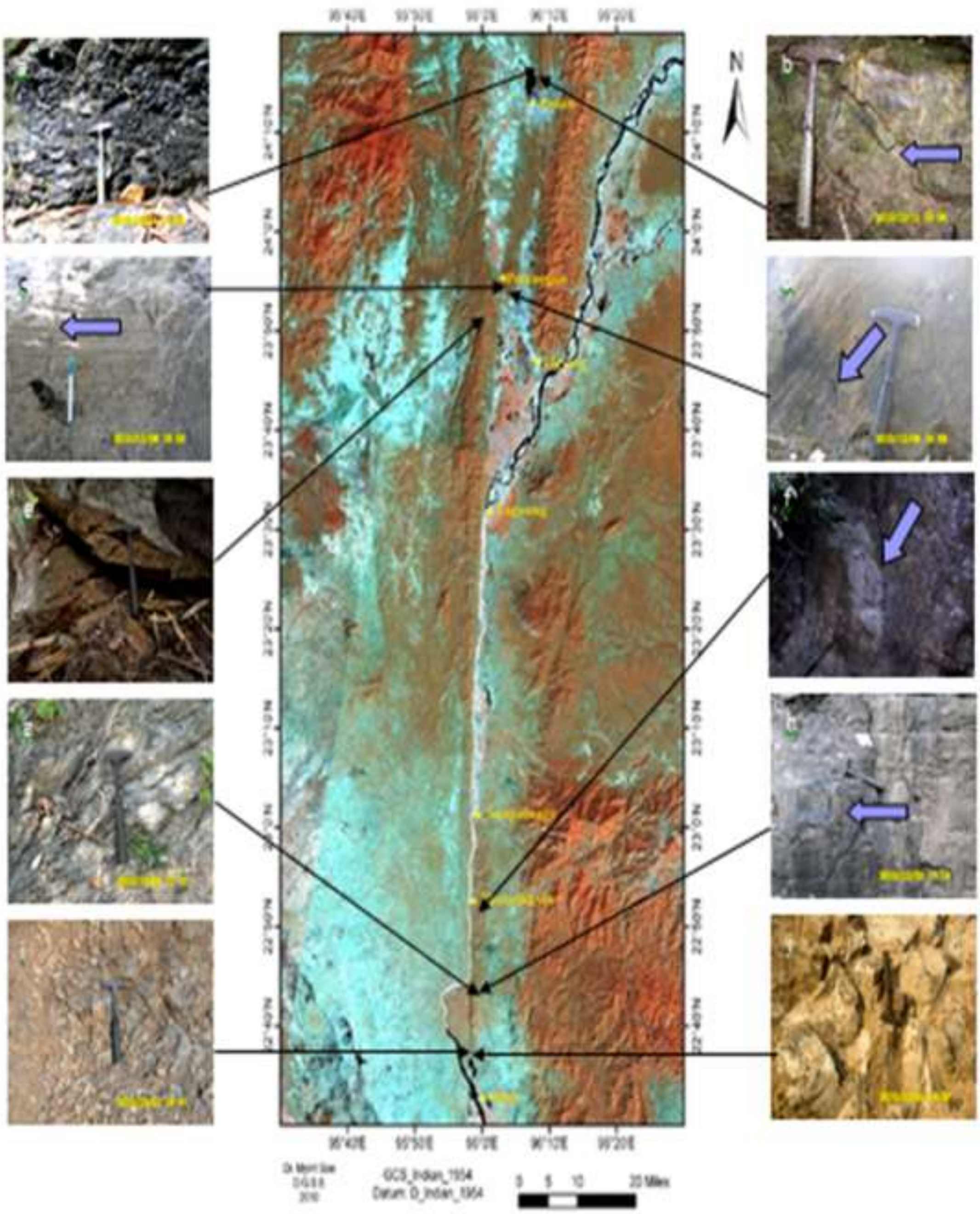


Figure 6 Brittle extentional deformation character. (a) Fault gouge in sandstone of Irrawaddy Formation in Thetkekyin area (Indaw), (b) Dextral strike-slip fault plane in sandstone of Irrawaddy Formation in Thetkekyin area (Indaw), (c) Dextral strike-slip fault plane in sandstone of Male Formation in Peinnegon area, (d) Oblique normal strike-slip fault plane in sandstone of Male Formation in Peinnegon area, (e) Normal fault plane in limestone in Zethaung area, (f) Normal fault plane in calc-silicate rock of Mogok metamorphics in Thabeikkyin area, (g) Fault gouge in Singu olivine basalt in Singu area, (h) Dextral strike-slip fault plane in Singu olivine basalt in Singu area, (i) Fault breccias in Singu olivine basalt in Singu area and (j) Fault breccias in Singu olivine basalt in Singu area.

Microscopic Evidence of Structural Deformation

(1) Ductile extensional deformation

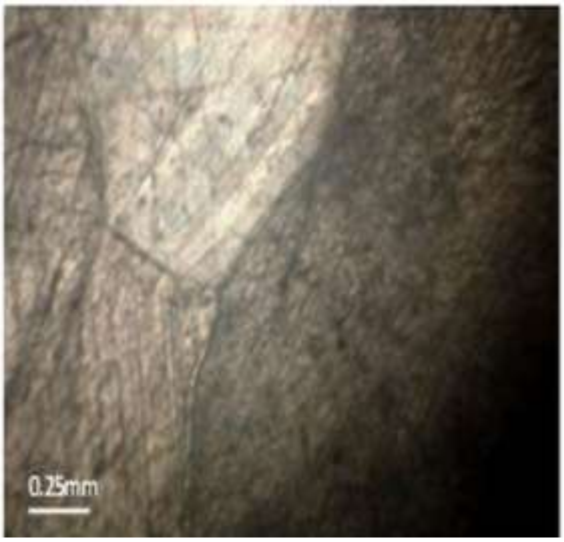
Microscopic characters of ductile extensional deformation are composed of deformation twin, undulose extinction, sub-grain development and grain-boundary migration.

Deformation twins are formed by crystal growth during structural deformation. Conjugate set of deformation twin is observed in calcite crystals of marble of Mogok metamorphics (Figure 7). The occurrence of deformation twining suggests extensive recrystallization process involving grain-boundary migration and intercrystalline slip as the dominant mechanism during ductile shear deformation (Barker, 1998).

Undulose extinction is a strain shadow effect. It is formed by deformation or distortion of crystal lattic. It is observed in quartz of quartz schist of Mogok metamorphics (Figure 8). It represents the process of intracrystal dislocation, and intracrystalline deformation during ductile shearing.

In quartz schist of Katha metamorphics, ductile deformation can be represented sub-grain development (Figure 9). It is observed at crystal boundary. It is one of the dynamic recrystallization processes in ductile deformation (Davis and Renolds, 1996).

Grain-boundary migration shows irregular, serrated grain boundaries (Figure 10). It caused boundary-migration recrystallization. The controlling factors are temperature, lattice-orientation and minor constituents or impurities within the aggregate of grains (Barker, 1998).



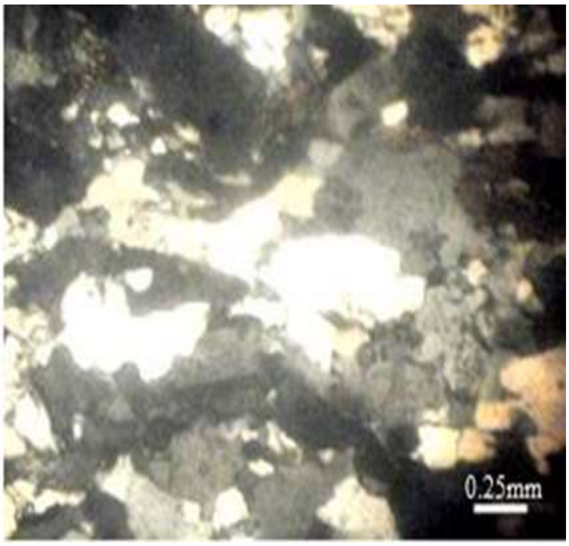


Figure 7 Conjugate set of deformation twin in marble of Mogok metamorphics. Loc. 22° 52. 178′ N and 95° 59. 203′ E, between XN.

Figure 8 Undulose extinction of quartz in quartz schist of Mogok metamorphics. Loc. 22° 44. 085′ N and 95˚ 59. 256′ E, between XN.

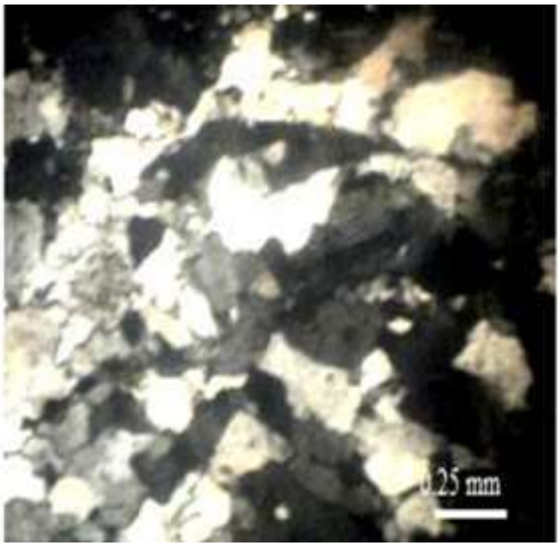


Figure 9 Sub-grain development in quartz schist of Katha metamorphics. Loc. 23° 45. 550′ N and 96° 09. 102′ E, between XN.

Figure10 Grain-boundary migration in quartz schist of Mogok metamorphics). Loc. 22° 44. 085′ N and 95° 59. 430′ E, between XN.

(2) Brittle-ductile extensional deformation

Microscopic characters of brittle-ductile deformation are well recorded in gneiss of the Mogok metamorphics. In gneiss, this deformation is expressed by grain fragmentation which associated with stretching quartz and sweeping undulatory extinction (Figure 11).

Figure 11 Grain fragmentation associated with stretching quartz and undulatory extinction in gneiss of Mogok metamorphics. Loc. 22° 53. 700′ N and 95° 59.612′ E, between XN.

(3) Semibrittle extensional deformation

Microscopic characters of semibrittle extensional deformation are well documented within the marble and limestone. Calcite crystals in marble of Mogok metamouphics show small scale dislocation in calcite twins (Figure 12). Conjugate set of calcite veins in limestone reflects the semibrittle deformation (Figure 13).

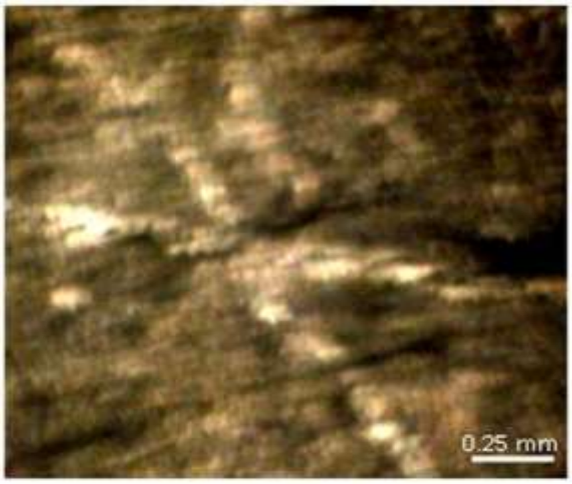
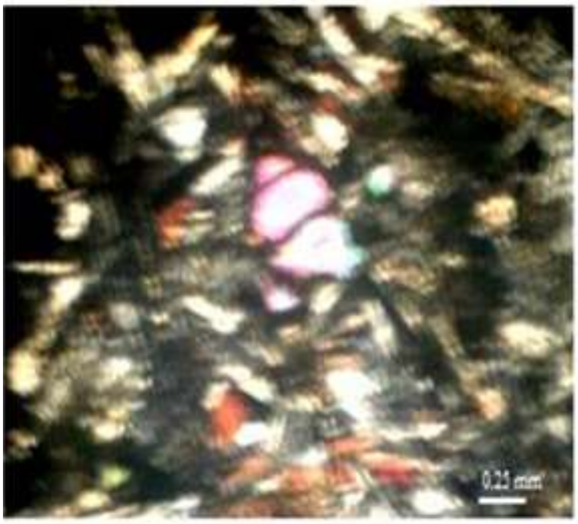


Figure 12 Small scale dislocation of calcite twins in marble (Mogok metamorphics). Loc. 22° 52. 142′ N and 95° 59. 265′ E, between XN.

Figure 13 Conjugate set of calcite veins in limestone. Loc. 23° 51.342′ N and 96° 05.021′E, between XN.

(4) Brittle extensional deformation

Microscopic characters of this deformation are fracturing of olivine in Singu olivine basalt, grain fragmentation in conglomerate and microbrecciation in sandstone of Male Formation (Figure 14, 15, 16).



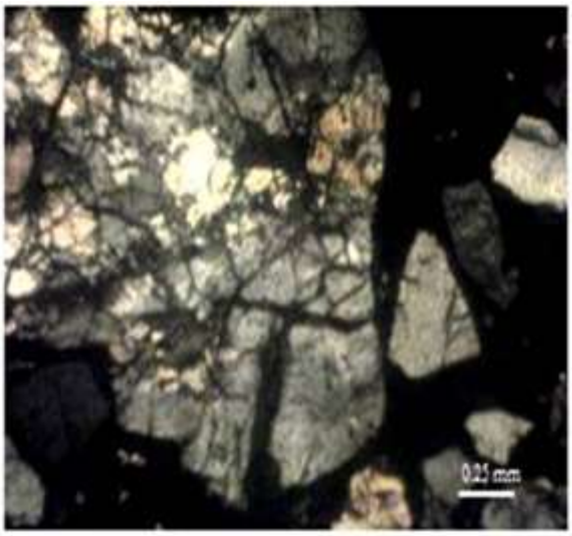


Figure 14 Fracturing of olivine in Singu olivine basalt. Loc. 22°40.135′N and 95° 58.990′E, between XN.

Figure 15 Grain fragmentation in conglomerate (Male Formation). Loc. 23° 05. 435′ N and 95° 59.501′ E, between XN.

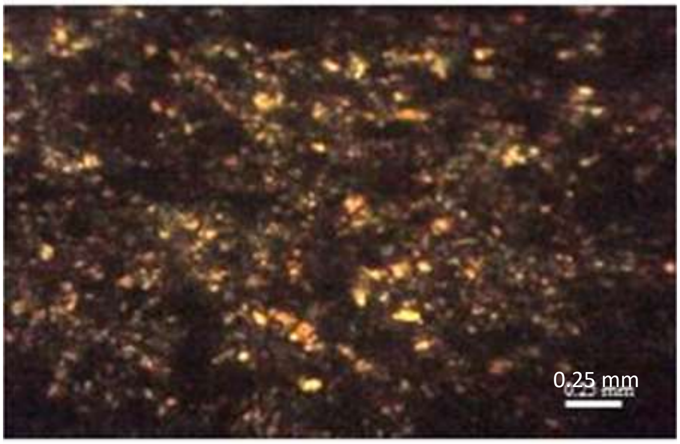


Figure 16 Microbrecciation in sandstone (Male Formation). Loc. 23° 55. 728′N and 96° 02.693′E, between XN.

Conclusion

There are four types of structural deformation which are determined from both the mesoscopic and microscopic characters of the oriented samples from eleven different localities along or near the Sagaing Fault zone in the study area. These are ductile extensional deformation, brittle-ductile extensional deformation, semibrittle extensional deformation and brittle extensional deformation. The former three types are especially present in the metamorphic rock types exposed between Chaunggyi and Thabeikkyin, and Katha. The brittle extensional deformation is especially present in the sandstones and conglomerates of Male Formation, Irrawaddy sandstones and Singu basalt along the southern and northern parts of the Sagaing Fault zone in the area. Rock units of the study area show distinctive structural deformation characters related to the progressive deformation processes along dextral shearing of the Sagaing fault. Brittle deformation forms in the shallow parts of the crust, generally within 5-10 km of the Earth’ surface. Ductile deformation is formed by shearing under ductile condition, generally in the middle to lower crust and in the asthenosphere. Brittle versus ductile character may change along a shear zone as it encounters rocks of contrasting mechanical properties. Some rock types affected by the shear zone may respond brittlely, whereas others respond by ductile flow. In other cases, a shear zone may operate under progressively changing physical condition, from ductile to brittle. Alternatively, a shear zone may be reactivated under physical condition totally different from those under which it first formed. All these situations can produce a shear zone that is neither strictly brittle nor strictly ductile.

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