Abstract
A study has been carried out on the development of microstructures in the Neogene sedimentary rocks of lower part West Kameng District, Arunachal Pradesh. The study consists of oriented field sampling and microscopic analysis of the rocks thin sections. The study revealed numerous -grain scaled quasi-plastic deformations, e.g. undulatory extinction, deformational bands and lamellae in quartz grains, sub-grain formation, inter-granular indentation, and grain-boundary migration, kink band, cataclastic flow etc. The study suggested that the rocks of the study had experienced a syn-depositional, regional scale compression-extensional thin-skin thrust-fold tectonic regime. The rocks have also exhibited brittle to ductile regime of orogenic development, dominant in the shale bed near fault zones and siliceous rock fragments oriented parallel to the flow direction. Microstructural asymmetric fold verge towards the flow direction and the sense is generally top to the south or top to the south east sinistral. The study concluded that the area is affected by the active Himalayan tectonics and the deformational structures resulted from this affect is persistent up to microscopic level.

Key words: microstructure, quasi-plastic, kink bands, cataclastic flow, shearing.

INTRODUCTION
The study is carried out in southern part of the West Kameng District of Arunachal Pradesh, India. Area lies between 27°00'- 27°10'N and 92°30'-92°40'E in Siwalik Range of Arunachal Himalaya (Figure 1). Siwalik basin is also a Peripheral (Pro) foreland basin bounded by two major Himalayan structural identities namely MBT in the north and HFT in the south.

The mountain front along the HFT is suggested to be tectonically active because of south ward progression of deformation of the Himalayan deformation orogeny [2]. In the NW and the Central Himalayan sectors the rate of uplift of the Siwalik Mountains along the HFT has been computed to be the order of 10-15 mm/year [4,5,11]. The Siwalik basin was formed about 18.3Ma ago [6]. The rocks of the Siwalik Group were deposited from the Mid-Miocene to the Pliocene. The general setup is the result of the flexural subsidence of the Indian lithospheric plate due to continued thrust loading which leads to the creation of a
foreland basin in front of the Himalayan metamorphic belt[7]. The hinterland thrust loaded thickening and the tapered Siwalik wedge creates an isostatic imbalance and the equilibrium is maintained probably by southward extension of the mountain front[8].

**Figure 1**: Location map of the study area.

**METHODOLOGY**
In the present study, systematic sampling in 500m interval was taken along the road and stream section between Tipi and Elephant Flat. Few cross traverses were also made towards NW from road side along Tipi and Pinjoli fall. Field structures and mapping was carried out using GPS traverse. For petrographical and microstructural investigation, thin sections are prepared and studied in the laboratory under petrological microscope.

**RESULTS AND DISCUSSIONS**
Petrographical and microstructural investigations of Dafla Sandstone suggest both polycrystalline and monocrystalline variety of quartz constitute the primary composition of the sandstone. Many grains show fractures through which matrix materials intrude the grains. Some stained quartz grains are also observed (Figure 3.C) Fracture pattern of the grains respond to the locally developed stress field are oriented (Figure 2.D) and indicates that release of the strain through the development of fractures as well as grain granulation is achieved in the brittle or frictional regime. Feldspar occur in very small amount
(less than 10%), mica mainly occur as Muscovites particularly developed along the boundaries of the quartz grains mainly as diagenetic product. Development of kink bands in the mica grains is specially observed in Dafla sandstone and involves slip on the basal plane. Sharp hinged kinking observed (Figure 2.B) is strongly dependent on layer parallel compression affecting a multilayered sequence under very thick overburden. Due to layer parallel movement the migration of the hinge line of the kink bands are very prominent (Figure 2.B). Quartz grains within the mica layers have shown granulation in its tail parts. Fractured grain showing sigmoidal pattern can also be seen in the photograph (Figure 2.C). Formation of sub-grains due to release of stress by the parent quartz grains are observed in some sections. They deposits in the areas of least stress (Figure 3.D). This happens only if dislocations are relatively free to climb from one lattice plane to another. They

Figure 2: Deformational microstructures observed in Dafla Sandstone. (A) Quasi-plastic deformation of mica, (B) Kink bands in mica, (C) Sigmoidal sense of deformation in quartz grain in the centre, (D) Synthetic fracture in quartz grain verging dextral to the mica plane, (E) Microthrusting in muscovite, (F) Grain boundary indantation by quartz grains.
are indicative of dynamic recrystallization. Another important structure shown by the rocks is micro-faulting by quartz. Due to anisotropic stress field the fracture in the quartz grains developed in such a way that they can represent the stress field. Further propagation through such planes creates some gliding planes inside the minerals through which further movements takes placed (Figure 3.B, 2.F). Indentation of one grain by another (as shown by quartz) is also shown by the rocks (Figure 2.F). This is due to the gradual forceful intrudation of one grain by another takes place mainly in the high ductile regime.

Figure 3: Deformational structures in Dalla Sandstone. (A) Brittle deformation in mica grain, (B) Micro-faulting in quartz grain, (C) Deformational lamellae in D.F, (D) Subgrain formation at the boundary of the quartz grain.

Some parts of the rock sections show cataclastic flow. It is essentially a brittle process that is achieved by mechanical fragmentation of rocks and subsequent sliding and rotation of the fragments. Cataclastic flow usually occurs at non to low-grade metamorphic conditions and at relatively high strain rates. The condition also depends on the typical mineral involved and on fluid pressure. The presence of pressure solution in some section is also observed (Figure 2.C), which is defined as dissolution of grains at the boundaries of grains under high normal stress and precipitation in low stress sites. The process operates at moderately shallow levels of the crust at around 200°C-300°C. They are localized
where the grains are in contact along surface at a high angle to the instantaneous shortening angle and where stress in the grains is high.

Cement content of the Dafla Sandstone is small in amount and mainly silicic in nature. In few samples ferruginous cement also occur in the quartz supported framework (Figure 3.D). The Subansiri Formation is dominated by monocrystalline quartz grains. These are characterized by salt and pepper textured coarse to medium grained grey, micaceous, soft, thick bedded massive sandstones. Some of the grains are fractured due to mechanical forces. Feldspars are observed in some samples. Muscovites formed by recrystallization during diagenesis of clays are present in the rocks. The matrix is mainly of clays and the cement content is small in amount. Deformation features are less developed in Subansiri Formation than the Dafla Formation mainly due to less overburden on the Subansiri rocks and hence less load pressure.

CONCLUSIONS

The zone between MBT and HFT consist of imbricate faulted slices of Dafla, Subansiri and Kimin Formation along the Kameng River section of Arunachal Pradesh. Large scale ramp and flats are observed as regional structural pattern. The manifestation of the large scale geometry in the mesoscopic scale consist thrust imbrications, formation of duplex, fault propagation fold and fault band folds.

Deformation in the grain scale is quasi plastic to frictional type; evidenced by undulatory extinction, deformational bands and lamellae in quartz grains, subgrain formation, intergranular indentation, and grain boundary migration in Dafla Formation. Kink band development under intense horizontal compression and strong load pressure is indicative of quasi-plastic deformation. However, the elastico-frictional deformation follows and overprints the quasi-plastic deformation which can be seen as bent or kinked mica fractured along the axial planes. The slip along those fractures produces both compression and extension related micro-faults. Cataclastic flow is dominant in the shale bed near fault zone and siliceous rock fragments are oriented parallel to the flow direction. Microstructural asymmetric fold verge towards the flow direction and the sense is generally top to the south or top to the south east.

REFERENCES

5. Gogoi M. P. 2011. Estimation of rock strength parameters for middle Siwalik, West Kameng District,


*Manuscript accepted: 11/11/2012*