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# Petrography and diagenesis of sandstones from renji formation in and around Phiphima, Dimapur, Nagaland, India

**S. K. Srivastava* and Tiamenba Longshir**
**Department of Geology**
**Nagaland University**
**Kohima Campus, Meriema-797004**
Email-*sanjaikohima@yahoo.co.in

## Abstract

Renji Formation, the youngest unit of Barail Group, is characterized by massive, hard, thicklybedded and ferruginous sandstones intercalated with minor shales. Sedimentary structures observed are load cast; ripple marks, plane and fine cross laminations.Petrographic compositions of the studied sandstones suggest their derivation from a mixed provenance having contributions from all possible sources dominated by a sedimentary provenance. Sediments of the study area have undergone both early and late stages of diagenesis and are influence by chemistry of sea water, and increasing depth. Diagenetic features preserved in the siliciclastics of the study area suggest a depth range of 1.5 to 2.5 km and a temperature above 100°C.

**Keywords-** Petrography, Provenance, Belt of Schuppen, Diagenesis

## Introduction

The Assam-Arakan Basin is morpho-tectonically divisible into three parts corresponding closely to geological units. The eastern limit is defined by the Naga - Lushai - Patkai hill ranges which are described geologically under three different belts-

a. The Outer Belt or the Schuppen Belt
b. The Inner Fold Belt
c. The Ophiolite Belt

Evans (1932) was the first to describe the geology of the region which had provided the basis for later workers. Following Evans (1932) many workers have attempted the stratigraphy, structure and tectonic framework of the region ( Mathur and Evans,1964; Raju,1968; Bhandari *et al.,*1973; Desikachar,1974; Dasgupta,1977; Banerjee,1979; Agarwal and Murthy, 1983; Ganju and Khar,1985;Saikia *et al*.,1987; Acharyya ,1986,1991 and 2007; Naik *et al.,*1991).

According to Brunnschwiller (1996), Indo-Burma ranges (IBR) were made mainly of Cretaceous to Eocene pelagic strata overlain by thick Eocene to Oligocene turbidites and upper Miocene to Pleistocene Molasses. Much later, many author including Sengupta *et al*. (1990) described Indo-Burma ranges (IBR) as a trench deposit containing OphioliteMelanges Scraped off the Subducting Indian Plate. Oblique collision and tectonic wedge model has been proposed by Naik (1993) to describe the stratigraphic inconsistencies of the area. Recently, Srivastava (2002) and Srivastava *et al*. (2004) identified a well-developed transition zone between Disang and Barail Groups named Disang-Barail Transitional Sequences (DBTS).In recent years, attention has been paid towards the study of Northeast Indian sedimentary Basin in the light of plate tectonic (Biswas *et al.,* 1993).

## Materials and methods

### Study Area

The study area is a part of the Schuppen Belt (Fig.-1) which has been defined as a narrow linear belt of imbricate thrust slices which follows the boundary of Assam Valley alluvium for the distance of 350 Km along the flank of the Naga–Patkai hill range. It is postulated that this belt comprise eight or possibly more over thrusts along which the Naga hills has moved north-westward relative to the foreland spur. The total horizontal movement of all the thrust together is estimated to be over 200 Km. The Schuppen Belt is delineated on the east by the Halflong-Disang thrust which has an echelon deposition. Sediments ranging in age between Upper Eocene-Oligocene and Plio-Pleistocene along with total absence of Disang rocks together characterize the Schuppen Belt. Renji Formation, the uppermost unit of Barail Group in the Belt of Schuppen, is characterized by a thick succession of ferruginous sandstone. The thickness of Renji Formation in the different tectonic slices of Schuppen Belt varies widely due to changes in the depositional environment and unconformable overlap of Surma rocks. Rocks of the study area had undergone tremendous stress which is reflected in the vertical beds with a dip nearly of $90^0$.Present study has been carried out with the objective to interpret the provenance and the diagenetic history of the sediments throughpetrographic analysis.

## Petrography

Petrographic analysis is an important tool in identification and understanding of the provenance. The mineralogy of the detrital particles in siliciclastic sedimentary rocks provides the primary evidence of lithology of parent rocks in the source area. Our understanding of the vanished mountain systems of the past basically rest upon the analysis of framework mineralogy of detrital sediments. In addition, it also provides evidences for interpreting tectonic settings and to a limited extent paleoclimate as source rock lithology is linked fundamentally with tectonic settings and climatic conditions for selective destruction of minerals.

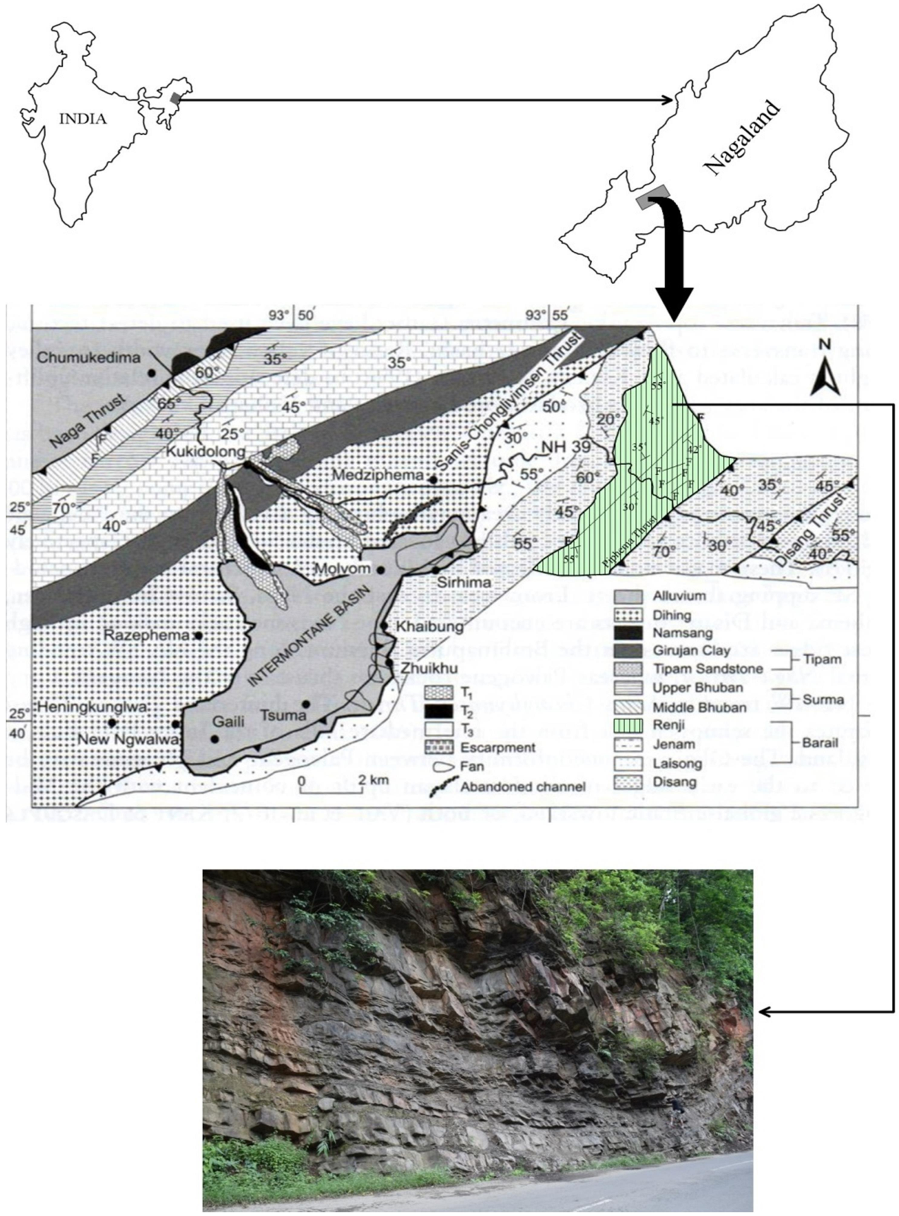


Fig.1 Location and Geological map (Aier *et al.*2011) of the study area with field photographs

The grains are poorly sorted, angular to sub-angular and ranges in size from medium to coarse sand.Among the framework grains, quartz is the most abundant constituent showing the presence of angular, sub angular to sub-rounded monocrystalline non undulatory and undulatory as well as polycrystalline quartz. Some of the quartz grains also show inclusions. At places corroded quartz boundary is also seen. Rock fragments rank second after quartz and include volcanic glasses, chert, siltstones and schists. Sedimentary rock fragmentsincludechert and siltstone; volcanic glass represents igneous rock fragment whereas schists characterize the metamorphic category. Albitized feldspar and plagioclase feldspar were also observed. In addition a few mica and chlorite flakes have also been noticed. The cementing material is mostly of silica though some patches of iron cement were also noticed. Some very well rounded zircon and tourmaline grains have been noticed as accessory minerals (Figure-2a, b, c, d, e, and f).

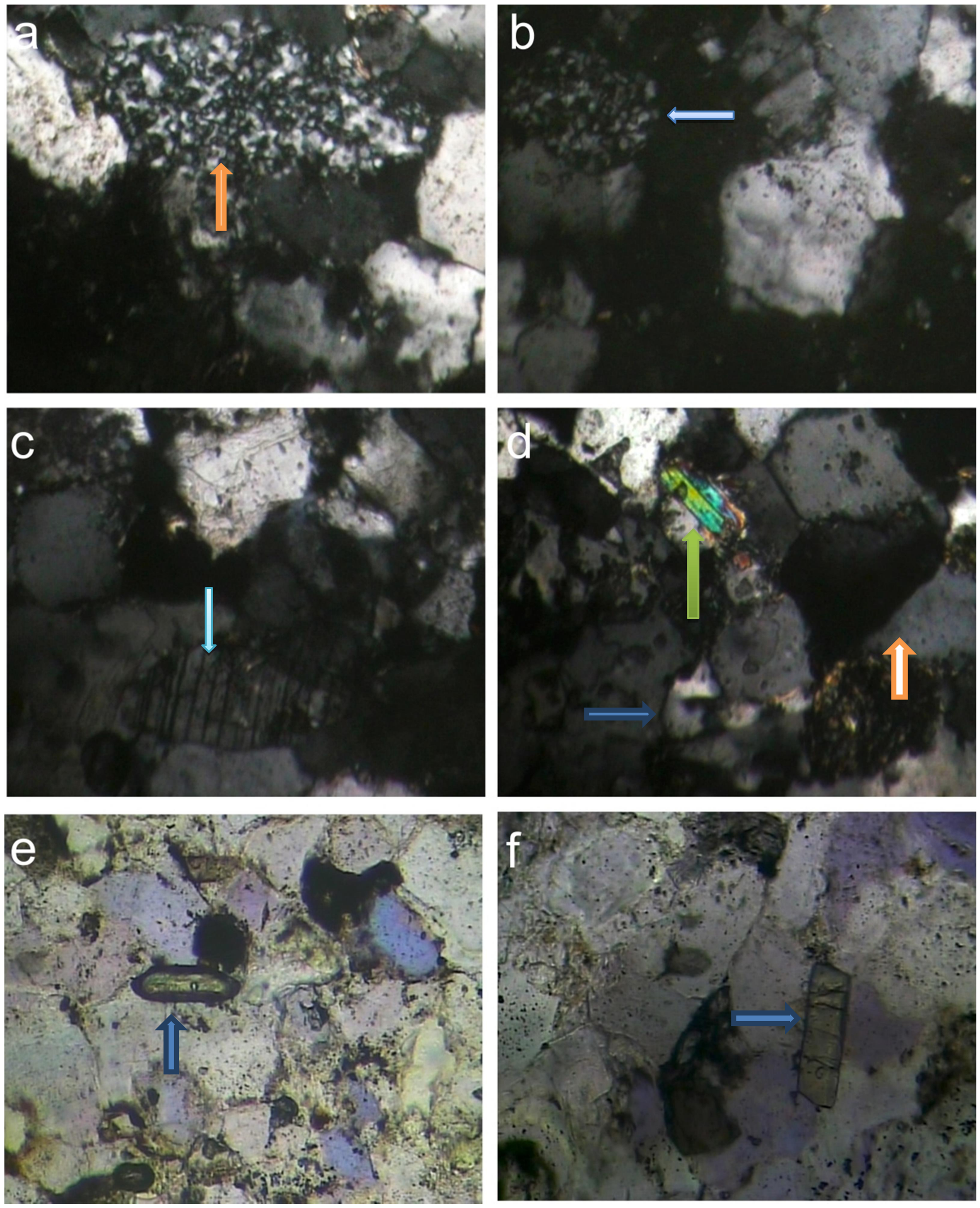


**Figure-2:** Photomicrographs showing a) Chert, b) Siltstone rock fragment c) Plageoclase feldspar d) Monocrystalline (undulatory, orange arrow), polycrystalline quartz (blue arrow) and Chlorite (Green arrow) e) Euhedral zircon f) Tourmaline

## Diagenesis

Early studies of diagenesis focused on petrographic examination of thin sections and the evidence of compaction, cementation, dissolution, and so on; that could be read from petrographic study. Petrographic examination remains the main stay of diagenetic study; however, it has been increasingly supplemented since the 1960s by use of electron microscope, cathodoluminescence petrography, XRD, electron microprobe analysis etc. In present study petrographic examination of thin sections has been used for the purpose. The siliciclastics of the study area shows various diagenetic effects which include compaction, authigenesis and cementation. Diagenetic signatures preserved in these sediments can be grouped into two categories of early and late diagenesis. Early diagenesis includes precipitation of silica and growth of mica around quartz grains. Diagenetic features such as fracturing, crushing, bending and warping of micaceous minerals around detrital quartz indicate the increasing depth of burial.

**Compaction-** Compaction refers to a decrease in the bulk volume of the sediments due to reduction in porosity. The important evidence of compaction owing to compressional stress can be seen in deformation of flaky minerals and grain to grain contacts.

**Nature of contacts-** All possible types of contacts have been encountered in the Renji sandstones of the study area. The high proportion of the interpenetrative contacts suggests towards high degree of compaction. It also indicates a low porosity for these sandstones. Compaction has also resulted in bending of flaky minerals. Floating contacts have also been encountered. The straight contacts can be developed due to various factors including the original grain packing where the detrital grains have adjusted their boundaries against other grains due to slight increase in pressure. More pressure in such cases may result in the development of concavo-convex and sutured contacts. Such modifications in the sandstone can only be accomplished at greater depth with high pressure (Srivastava, 2013).

**Authigenesis-** It includes all the physico-chemical processes leading to development of new mineral species in situ. Quartz overgrowth, neo quartz, albitization, reconstituted mica are the signatures of authigenesis preserved in these sandstones.

**Quartz overgrowth**-Quartz overgrowth is a very common and important evidence of authigenesis. Where the grains are free from any coating it occurs as syntaxial overgrowth on detrital quartz. Such overgrowths are least developed where quartz grains are held together by clay as such coatings act as barrier for silica solution to reach the detrital grain boundaries. At places it appears to have covered the clay coatings. Rimming of quartz by silica is determined by the space available and rate of silica precipitation. Presence of authigenetic quartz in the siliciclastics may be considered as an indication of early diagenetic changes under eogenetic (shallow depth) marine conditions.

**Neo-quartz-**These are new, small and sharply polyhedral aggregates of quartz crystal resembling metamorphic quartz. These are developed at the stress points under early diageneticconditions.

**Albitization**-It is a special kind of diagenetic process that involves replacement of calcic plagioclase or K-feldspar with albite. Albitized feldspar is identified by their cloudy appearance and presence of small blebs. Twinning is indistinct and diffused. Some albitized feldspar has vague, irregular twin lamella which does not pass through entire grain. Fractures and cleavage traces provide the space through which fluids could penetrate the crystal for albitization processes.

**Cementation-**The cementation proceeds through various inter-related diagenetic processes including dissolution, precipitation, recrystallization etc. Silica cement is the dominant cementing material in the studiedsiliciclastics though ferruginous cement has also been observed.Neomorphic quartz and epitaxial as well syntexial silica over growth has been encountered. Enlargement of quartz grains due to silica precipitation and thick rims of silica cement around detrital quartz grains are common.

**Source of silica cements-** Tracing the source and the route for silica rich solution is a great puzzle. The chemical material forming the siliceous cement of many sedimentary rocks has been the subject of intensive study in recent years (McBride, 1989). Origin of cementing material is often a problem of considerable magnitude and many of the theories offered have been unable to account for a supply of silica in the amounts dictated by the petrologic evidence (Towe, 1962). The mechanism advocated for the source of silica cement in one area may not be applicable to another area. In clastic sedimentary rocks, authigenic quartz cement is the most abundant form of diagenetic cement. Despite this, there are many unknowns relating to source of silica for cementation. However, there could be three possible sources for silica cement in case of the rocks of the study area. Though, their contributions in terms of percentage can be a matter of debate.

a) Pressure solution
b) Transformation of clay minerals
c) Associated shale and siltstones

Most of the workers dealing with silica cement have attributed pressure solution as a major source of silica cement. These are a prime source of silica cementation in sandstones (Berner, *et al.*1971, 1996). Increasing pressure at the contact of quartz grains also increases the liberation of silica which precipitates along the detrital grain boundaries.But studies on pressure solution show that this process yields about one third of the silica needed for cementation (Prothero *et.al* 2000). The post-depositional transformation of montmorillonite and/or mixed-layer illite-montmorillonite, andillite is suggested as a source of silica cement in some sedimentary rocks. Depth of burial appears to be an important factor in effecting this change, though supporting data are lacking (Towe, 1962). Presence of iaugenetic plagioclase not only indicates deeper burial but also temperature in excess of 100°C. K-feldspar, mafic minerals and volcanic glass on reaction with water also release silica along with the formation of clay minerals including illite (Einsele, 2000). Silica for cement comes from shale and sandstone beds within the depositional basin, including possibly deeply buried rocks undergoing low-grade metamorphism, but the relative importance of potential sources remains controversial and likely differs for different formations (McBride, 1989). Underlying shale, siltstone as well as fine grained sandstones on compaction due to loading of the sediments can also supply silica solution which can move upwards through water as in many sedimentary basins several solute transport systems operate simultaneously in conjugation with pressure solution processes (Einsele, 2000). All possible types of grain contacts have been observed. Low percentage of floating grains, high percentage of interpenetrative contacts, high contact index, bending of flaky minerals point towards the high degree of compaction indicating deep burial conditions. Presence of authegenic plagioclase also suggests a great depth and high temperatures. If the composition of the adjacent particles is different, one of them usually maintains its shape at the expense of the other; however, pressure solution does not occur between deformable clay particles (Figure-3 a, b, c, d, e, and f).

## Conclusions

Petrographic compositions of the Renji sandstones suggest their derivation from a mixed provenance having contributions from all possible sources dominated by a sedimentary provenance. Sediments of the study area have undergone both early and late stages of diagenesis and are influence by chemistry of sea water, and increasing depth. Subsidence of the basin owing to accumulation of sediments has resulted in reduction of porosity and also modifying the grain contacts from straight to sutured through concavo convex contacts; indicating a progressive diagenetic regime. Liberation of silica, which has precipitated as chert and neomorphic quartz later, is the result ofcompaction which wasresponsible for increased pressure at grain contacts. This also suggests that the circulating waters were supersaturated with silica at shallower depth under early diagenetic conditions. Albitization is the result of solution activities along the fractures or the plane of weakness of the crystals. Diagenetic features preserved in the siliciclastics of the study area suggest a depth range of 1.5 to 2.5 km and a temperature above 100°C.

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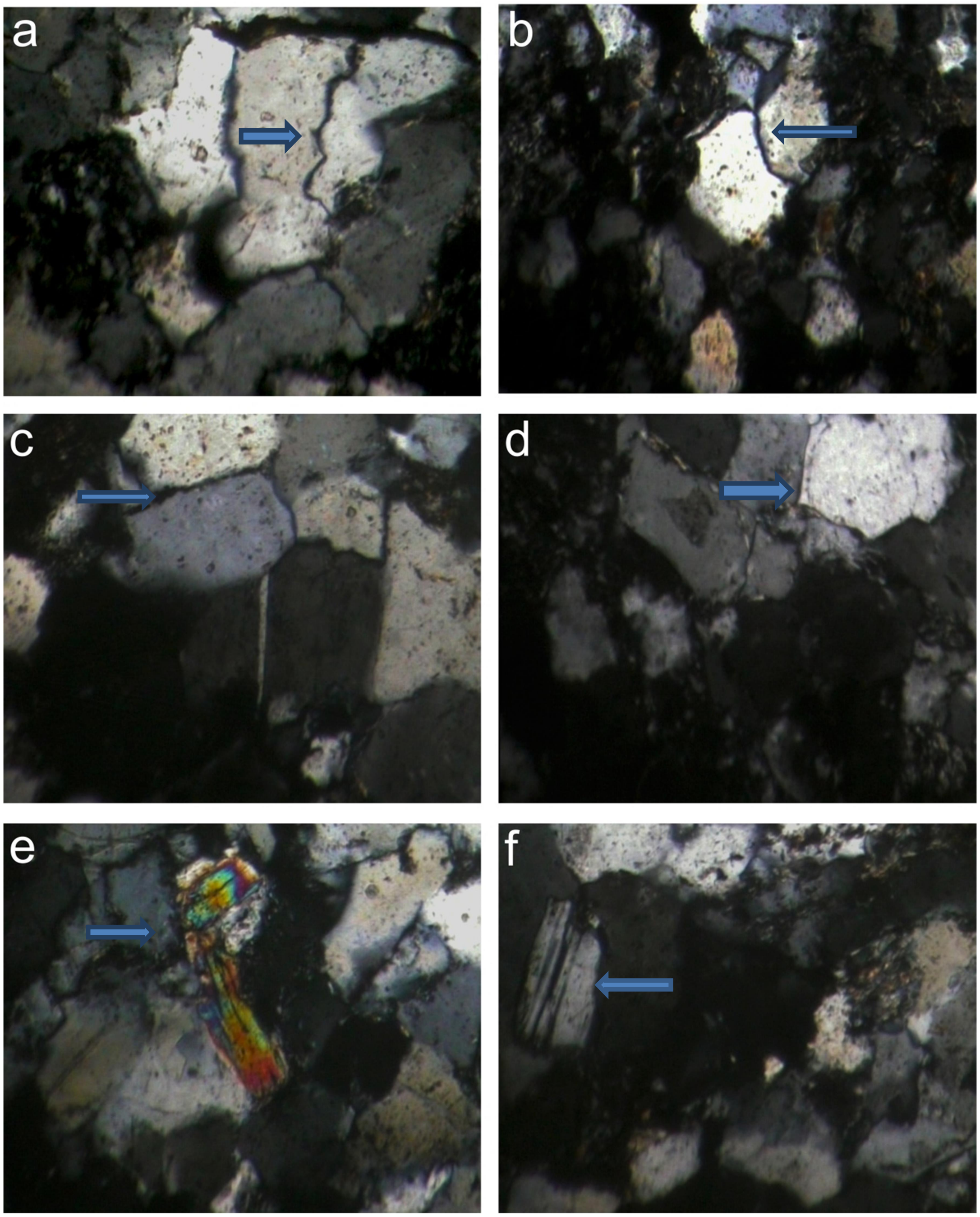


**Figure-3** Photomicrographs showing a) Sutured contacts b) Cocavo-convex contacts c) Straight contacts d) Siliceous growth e) Bent mica f) Albitized feldspar

## References

1. Acharya, S.K. (1986). Cenozoic plate motion creating the eastern Himalayas and Indo-Burmese Ranges around the northern corner of India.Ophiolites ND Indian Plate Margin, (Eds) by Ghose, N.C and vardarajan, Spp.146-161.

2. Acharya, S.K. (1991). Late Mesozoic-early Tertiary basin evolution along the Indo-Burmese range anAndman island arc.In S.K. Tandon, Charu, C.Pant and S.M.Casshyap (Eds), Sedimentary basins of India: Tectonic Context. 104-130 p,GyanodayaPrakashan,Nainita,India
3. Acharya, S.K. (2007). Evolution of the Himalayan Palaeogene foreland basins, influence of its litho-packet on the formation of thrust related domes and windows in the Eastern Himalayas-A review.Jour.Asian Earth Sci.,31:1-17.
4. Aier, I., Luirei, K., Bhakuni, S. S., Thong, G. T. and Kothyari, G. C., (2011).Geomorphic evolution of Medziphema intermontane basin and Quarternary deformation in the Schuppen Belt, Nagaland, NE India: Zeitschrift fur Geomorphologie, Stuttgart, 22 (2):247-265.
5. Banerjee, R, K., (1979). DisangShale,itsStratigraphy,Sedimentation History and Basin configuration in North eastern India Burma, Q. Jour. Geol. Min. Metal. Soc.India, 51:144-152
6. Berner, R. A.(1971) . Principles of Chemical Sedimentology*:* McGraw-Hill, New York
7. Bhandari, L.L., Fluoria, R.andSastry,V.V.(1979).Stratigraphyof Assam Valley, India:Bull.Am Assoc.Geol.57(4):642-650.
8. Biswas, S.K., (1993). Classification of Indian sedimentary basin in the framework of plate tectonics. Proc.Second seminar on petroliferous basins of India.1:1-46.
9. Brunnschwiller, R.P., (1966). On the geology of the Indo-Burman ranges. Jour. Geol. Soc. Australia, 15:137-194.
10. Desikachar, S.V., (1974). A review of the tectonic and geologic history of eastern India in terms of plate tectonic theory. Jour. Geol. Soc. India, 15 (2):137-149
11. Dasgupta, A.B., (1977). Geology of Assam- Arakan Region. Quart. Jour. Geol. Min. Met. Soc. Ind., 49 (1/2):1-54.
12. Einsele, G., (2000). Sedimentary basins; Evolution Facies, and Sediment Budget, Springer, (2nd edition), 792p.
13. Evans, P., (1932). Tertiary succession in Assam. Trans. Min. Geol. Inst. India, 37, 155-188.
14. Evans, P., and Mathur L.P. (1964). The tectonic framework of Assam. Jour. Geol. Inst. India.5: 80-96.
15. Ganju, J.L., and Khar, B.M., (1985). Structure, tectonics and hydrocarbon prospects of Naga Hill based on integrated remotely sensed data. Petrol.Asia Jour.,8 (2):142-151.
16. McBride, G.H., (1989). Diagenetic processes that effect provenance determination in sandstones. In: G.C. Zuffa (Ed), Provenance of arenites. Reidel, Dordrecht, pp95-113.
17. Naik,G.C., Padhi, P.K. and Mishra,J.(1991).Hudrocarbon exploration and related geoscientific problems in Northeast India. Proc. Regional Symp. On hydrocarbon deposits in Northeast India, Gauhati, Assam.pp 22-38.
18. Naik, G.C. (1994). Subsurface geology and tectono-sedimentary evolution of of Pre-Miocene sediments of Upper Assam,India,Ph.D thesis (Unpublished), ISM, Dhanbad.

19. Prothero, Donald, R., and Schwab, Fred. (2000). Sedimentary Geology; An introduction to sedimentary rocks and stratigraphy, W.H. Freeman and Company, New York, (2nd edition), 557p.
20. Raju, A.T.R. (1968). Geological evolution of Assam and Cambay Tertiary basins of India, Bull. Am.Asso.Pet.Geol., 51(12):2422-2437.
21. Himanshu, K. S and Ghosh, S. K. (1996). Fluid inclusion study of the Neoproterozoic Nagthat Siliciclastic sediments, NW of Kumaon Lesser Himalaya: Implication to quartz cementation history. Jour. Geol. Soc.India, 47,107–114(eds.), aspects of of diagenesis: SEPM special Publication, 26, pp227-242.
22. Saikia, M.M., Kotoky, P. and Duarah, R. (1987). A zone of plate convergence with associated seismic activity-the Indo-Burman arc.Tectronophysics,134:45-152
23. Sengupta, S.M., Ray, K.K., Acharyya, S.K., De-Smith, J.B., (1990): Nature of Ophiolite occurrence along the eastern margin of Indian plate and their tectonic significance. Geology, 18: 439-442.
24. Srivastava, S.K.**(**2002). Facies Architecture and Depositional model for PalaeogeneDisang- Barail Transition, North West of Kohima, Nagaland. (Unpublished Ph.D thesis), Nagaland University, Kohima.
25. Srivastava, S.K., (2013). Source of silica cement for the siliciclastics at Disang-Barail Transition, North-West of Kohima, Nagaland, India. International Journal of Earth Sciences and Engineering, 06 (02): 386-391.
26. Srivastava, S.K., Pandey, N. and Srivastava,V. (2004). Tectono-sedimentary evolution of Disang-Barail Transition, North West of Kohima, Nagaland, India. Himalayan Geology, 25(02):121-128.
27. Towe, K.M., (1962). Clay mineral diagenesis as a possible source of silica cement in sedimentary rocks. Journal of Sedimentary Petrology, 32 (01):26-28.

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