International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 7; Issue 4(J); April 2018; Page No. 11994-11997
DOI: http://dx.doi.org/10.24327/ijcar.2018.11997.2097

Research Article

CLAY MINERAL ANALYSIS AND DIAGENETIC ENVIRONMENT OF THE TERTIARY ROCKS OF CHANGKIKONG RANGE, MOKOKCHUNG DISTRICT, NAGALAND, NORTHEAST INDIA

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A R T I C L E I N F O

Article History:

Received 17th January, 2018
Received in revised form 26th February, 2018 Accepted 9th March, 2018
Published online 28th April, 2018

Key words:

Clay minerals, Diagenetic environment, Belt of Schuppen, Changkikong Range, Naga Hills

A B S T R A C T

The Tertiary rocks of Changkikong range constitute a part of belt of Schuppen - a most prominent morphotectonic unit of Naga Hills stretching along the western margin of Nagaland State. The Barail Group (Tikak Parbat Formation), Changki Formation and Tipam Group (Tipam Sandstone Formation) have been studied for their clay mineral content, ultrastructure of sand grain surfaces and pores as well as diagenetic changes. Presence of illite, chlorite, montmorillonite, and kaolinite in the sediments of the study area has been documented. A deep burial diagenetic environment has been envisaged for the Tertiary sediments of Changkikong range, Mokokchung district, Nagaland.

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INTRODUCTION

Changkikong range is one of the majestic hill ranges in the Mokokchung district of Nagaland. It is named after Changki, a resident of Changki village in the district. To the west of Changkikong range there lays a parallel range named Japukong range. These ranges are manifestations of thrust slices in the Belt of Schuppen - the western most morpho-tectonic unit of NE – SW trending Naga Hills (Fig. 1). In addition, Naga Hills comprises of two more morpho-tectonic units namely, Inner Fold Belt and the Ophiolite Belt that occupy the central and eastern most parts respectively. The present study is an attempt to analyse the clay minerals besides diagenetic features to understand the tectono – sedimentary milieu of the Tertiary rocks of Changkikong range, Mokokchung District, Nagaland.

Study Area

The study area forms a part of Belt of Schuppen and covers nearly 125 square kilometres bounded between North parallels of 94⁰ 20' and 94⁰ 30' East meridians of 26⁰ 24' and 26⁰ 30' of the Topographic Sheet No.83 G/7 of Survey of India. It includes areas lying near Changki, Longnak, Chungliyimsen, Atuphu, Mangkolemba and Mongchen Villages of Changkikong Range in the Mokokchung District, Nagaland (Fig.1). The area can be approached from Mariani in Assam, the nearest railhead of NF-Railway on Guwahati-Dimapur-Dibrugarh rail route.

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The NH 39 passes through the study area connecting Mariani and Mokokchung via Changki.

The Tertiary succession (Evans, 1932; 1964) of the study area preserves well developed cyclic pattern and normal stratigraphic succession except along the western face of the Changkikong range where the thrusted contact between the successive litho-units has been recorded. The succession comprises of coal bearing Tikak Parbat Formation of the Barail Group (Oligocene), the Changki Formation and Tipam sandstone Formation of the Tipam Group (Miocene). The Tipam sandstone Formation in turn is overlain by Dihing Formation.

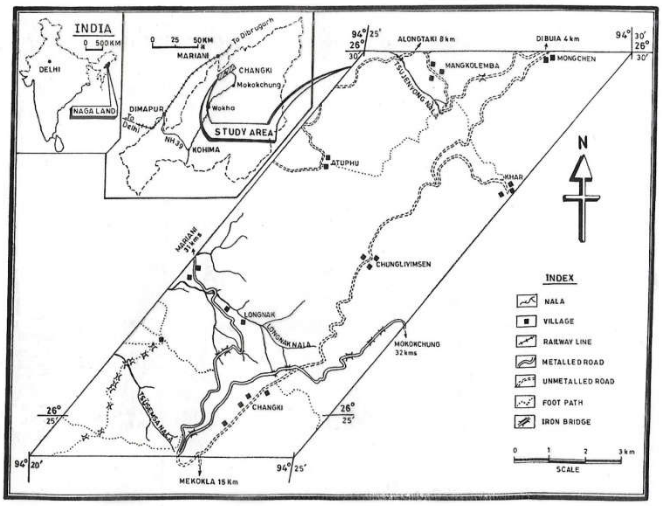


Fig 1 Location map of the study area

Clay Mineral Analysis

More than 25 suitable rock samples were examined thoroughly by X- Ray Diffraction techniques at the Wadia Institute of Himalayan Geology, Dehradun. The relative amounts of clay minerals in the Tertiary sandstones and shales including Barail coal of the Changkikong range are presented in Table – 1.

Table - 1: Clay Minerals (%) in Tertiary Sediments of Changkikong Range

SAMPLE NO.	ROCK TYPE	ILLITE	CHLORITE	MONTMO-RILLONITE	KAOLINITE
Tikak Parbat Formation					
R 92/11	Shale	5.10	3.35	3.60	0.00
R 92/27	Shale	11.80	8.20	6.60	0.00
R 92/40	Shale	2.50	3.60	0.00	0.00
R 92/41	Coal	15.00	9.50	0.00	0.00
R 94/386	Clay & carb. shale	4.60	2.60	0.00	0.00
R 94/390	Shale	2.10	1.70	1.40	1.80
R 94/394	Sandstone	0.90	0.00	1.70	0.00
Changki Formation					
R 92/3	Sandstone	0.60	0.70	1.00	0.70
R 94/292	Granular sandstone	1.10	0.00	1.40	0.00
R 94/300	Granular sandstone	0.80	0.00	0.00	1.60
R 94/304	Granular sandstone	0.90	0.60	0.00	0.00
R 94/308	Granular sandstone	0.00	1.50	0.00	0.00
R 94/309	Granular sandstone	0.00	0.00	0.00	0.00
R 94/331	Granular sandstone	1.40	1.70	0.00	0.00
R 94/379	Sandstone	2.10	0.00	2.60	0.00
R 94/384	Sandstone	1.50	0.00	2.10	0.00
Tipam Sandstone Formation					
R 92/18	Shale	6.30	7.50	0.00	0.00
R 94/275	Sandstone	0.00	5.50	0.00	0.00
R 94/278	Sandstone	2.00	0.00	0.00	0.00
R 94/282	Sandstone	1.90	0.00	1.90	1.60
R 94/332	Calcareous sandstone	1.60	2.30	0.00	0.00
R 94/333	Sandstone	1.90	1.70	2.50	0.00
R 94/334	Calcareous sandstone	1.60	2.40	0.00	0.00
R 94/335	Calcareous sandstone	1.60	0.00	2.30	0.00
R 94/374	Calcareous sandstone	2.90	0.00	3.30	0.00

A brief description of clay minerals is as follows:

Illite

It is the major clay- mineral constituent in all the Tertiary Formations studied. Invariably illite dominates the shale and display wide variation in relative quantity within sands. The Changki Formation records minimum amount of illite (average sandstones 0.86% and shales 2.1%) relative to Barails (average sandstones 0.9% and shales 3.6%) and Tipam Sandstone Formation (average sandstones 1.7% and shales 6.3%). During transportation mechanical fractionation of detrital illite (Bucke Jr. *et al*., 1971) may be considered the logical mechanism controlling distribution. The same holds good in the case of coal and associated clays, where illite content is as high as 15% and nearly 12% respectively.

Chlorite

Although all chlorite is recorded as clay size, it was found through thin-section examination to be present in the clay matrix. This might be one of the reasons for relatively small and inconsistent variation in chlorite quantity among samples of different textures. The sandstone samples of Tikak Parbat Formation, Changki Formation and Tipam Sandstone Formation contain 2.85%, nil and 7.5% chlorite, where as it is nil, 0.69% and 1.5% for shales respectively. The size-fractionation during transportation does not seem to be that effective as compared to illite. In Barail coal and associated clays, the chlorite content may be averaged to 9.5% and 8.2% respectively.

Montmorillonite

The abundance of montmorillonite in sandstones and shale samples from different litho-units (average sandstones 1.7%, 0.50%, 1.25%; shales 1.25%, 2.6% and nil from Barails, Changki and Tipam Sandstone Formations respectively) appears to relate to the source rock having similar distribution trend as that of illite.

Kaolinite

It is the least in abundance among all the clay minerals present, that too with an unequal distribution. This indicates that kaolinite might have been formed due to reconstruction of some detrital clay materials during post-depositional diagenetic processes.

Ultrastructures of Sand Grain Surfaces and Pores

Surface textures of sand grains, as revealed by Scanning Electron Microscope (SEM), have been extensively used in recent years for interpreting the depositional and diagenetic environments of sands and sandstones (Krinsley and Doornkamp, 1973; Pittman, 1972 ; Ingersoll, 1974; Marzolf, 1976 and Hurst ,1981).

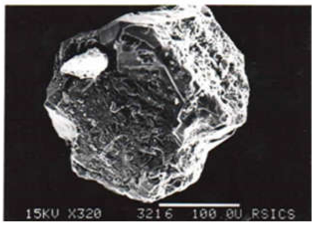
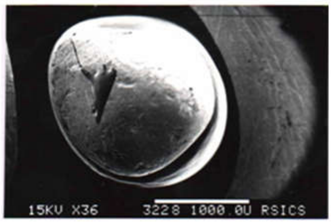


Fig. 2



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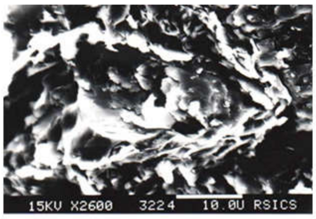

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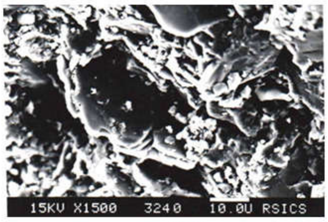

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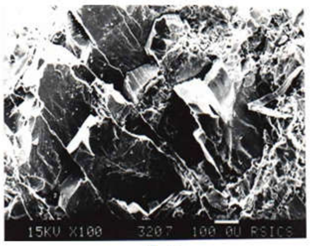

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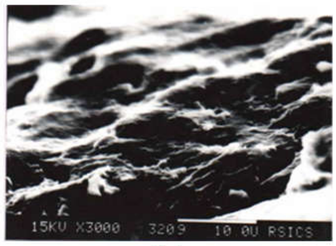

Fig. 7

In the present investigation nearly 10 sand grains and 12 freshly fractured surfaces of sandstones and shale were examined through SEM at Regional Sophisticated Instrumentation Centre (RSIC), North Eastern Hill University, Shillong. The surface textures of quartz grains from Tikak Parbat, Changki and Tipam Sandstone Formations reveal rhombic-shaped plastered and incipient crystal overgrowths; shiny, polished well rounded surfaces with V-shaped patterns; and highly fractured abraded grains displaying edge modification features (Fig. 2 & 3) respectively. In Changki and Tipam Sandstone Formations rounding of overgrowths together with chemical etching along the enlargement plane indicate effect of pressure solution during compaction of sand grains (Pittman, 1972; Hurst, 1981). Further, the study of pore spaces and secondary overgrowths on quartz grains indicate the presence of mixed layer illite- smectite and dissolution effects due to pressure solution at the time of lithification of the rocks (Wilson and Pittman, 1977). The abundance of illite is further attested by the dominance of confused – rosettes with short lath-like degitate edges (Fig. 4). Worms of vermicular chlorite (Blatt, *et al*. 1980, Fig . 8.4) in Tipam Sandstones is remarkable (Fig. 5). Incipient quartz overgrowth together with calcium carbonate precipitation and vermicular chlorite suggests an early stage of diagenesis under marine conditions (Burley, *et al*. 1985). The SEM examination of coal samples reveal the presence of crushed structureless vitrinite and inertinite resulting in extensive solution pits (Fig. 6 &7).

Sources of Cement

The Iron – oxide, silica and calcium carbonate cements occur as interstitial pore filling cements within Tertiary rocks of the study area. The following observations in regards to the sources of different types of cement may be made as follows:

Silica Cement

1. Due to the pressure solution some amount of silica might have been generated (Weyl. 1959 ; Dapples, 1979) as most of the quartz grains display sutured as well as concavo-convex contacts.
2. Alteration of unstable minerals like feldspars and also the clay-matrix (Towe, 1962) might have served as the source for silica.

Calcite Cement

1. Oxidation of methane into bicarbonate ion, under the influence of bacteria (Martens and Berner, 1974), and after combination with calcium might have precipitated calcium cement in coal bearing Barail sediments (Tikak Parbat Formation).
2. Dissolution of limestone rock fragments by pressure solution followed by subsequent migration and redistribution of carbonate saturated waters which might have ultimately precipitated as calcite cement (Dapples, 1972) in Barail as well as Tipam sediments.
3. In Tipam sediments calcite cement occurs as a replacement of quartz. It is quite likely that replacement of quartz and precipitation of calcite might have occurred near the upper contact of sandstone bodies with shale (Friedman, 1978).

Iron-Oxide Cement

The most likely source for iron-oxide cement is the alteration of ferromagnesian minerals present in the mafic and ultramafic rock fragments. Possibly of iron-oxide solution from ophiolite suite of rocks can also not be ruled out.

Diagenetic Features

The diagenetic features of Tertiary rocks of Changkikong range comprise a series of alteration in mineralogical composition and texture. These features may be conveniently grouped into early and post–diagenetic (i.e. deep burial diagenesis and incipient metamorphism, as suggested by Borak and Friedman, 1981) changes. The early diagenetic changes include precipitation and deposition of silica or epitaxial growths of micas (phyllomorphic stage of diagenesis) around detrital quartz grains and rarely on feldspar and chert fragments. Such silica overgrowths are conspicuously less developed especially in Barails and Tipam Sandstone Formation where quartz grains are mostly held together by simple bond of illite – clay or sericite matrix (Fig. 8 & 9).

The clay matrix appears to have acted as a barrier for the secondary silica solution to reach the quartz grains and formed overgrowths. (Heald & Larese, 1974). Further, at places association of authigenic illite – clay and chlorite with quartz overgrowths is followed by carbonate and iron-oxide precipitation displaying the typical order of cementation (Burley, *et al*., 1985). The carbonate is rarely present as a passive pore filling cement rather it has partially replaced detrital quartz grains and the clay matrix (Fig. 10). In few instances, near complete replacement of quartz by calcite cement has resulted in irregular island quartz grains. Such a common antipathic relationship between calcite and quartz has been attribute to the inverse relationship of their solubilities with increasing pH (Correns, 1950; Bucke Jr. *et al*., 1971)Of the depositional environments . In Tikak Parbat and Changki Formations, the most common diagenetic features include alteration of K-feldspar grains and reconstituted detrital illite or sericite – chert matrix (Fig. 11). The post depositional alteration of feldspar is attested by its association with the pseudomatrix.

Fig. 8

Fig. 9

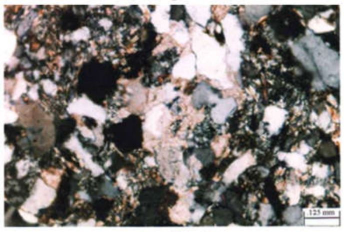

Fig. 10

Fig. 11

With increasing depth of burial, the diagenetic changes as suggested by Sen Gupta (1994), record fracturing, crushing and squashing of detrital grains and warpping of mica flakes around quartz grains (Fig. 12). Further, the solution of solid clastic grains at their contacts, due to the effect of pressure – solution causes modification of grain contacts from tangential to sutured through concavo-convex. Among other signatures of deep burial diagenesis, recrystallization and reconstitution of matrix, in general and conversion of illite into biotite in particular, corrosive reaction between quartz and matrix plus bending of chlorite flakes in response to compaction (Fig. 13) were recorded from the Tertiary sediments of the study area.

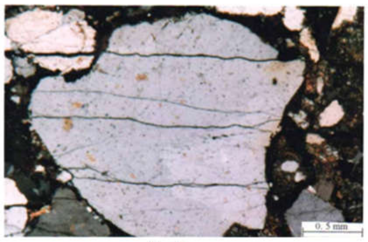

Fig. 12

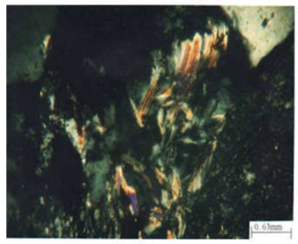

Fig. 13

CONCLUSION

Based on the above observations it may be inferred that the Tertiary sediments of Changkikong range have undergone deep burial diagenetic changes. With increasing depth of burial, the constituent lithologies responded in terms of fracturing, crushing and squashing of detrital grains and warpping of mica flakes around quartz grains besides modification of grain contacts from tangential to sutured through concavo-convex. Conversion of illite into biotite and corrosive reaction between quartz and matrix further substantiates deep burial diagenetic model.

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How to cite this article:

Ralimongla and Pandey N (2018) 'Clay Mineral Analysis And Diagenetic Environment of the Tertiary Rocks of Changkikong Range, Mokokchung District, Nagaland, Northeast India', *International Journal of Current Advanced Research,* 07(4), pp. 11994-11997. DOI: http://dx.doi.org/10.24327/ijcar.2018.11997.2097

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