Journal of Advances and Scholarly Researches in Allied Education
Vol. 12, Issue No. 2, January-2017, ISSN 2230-7540

Petrography of the Nahan Formation Exposed in the Type Area Nahan and Adjoining Regions in Northwestern Himalaya, India

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Abstract – The petrography of the Middle Miocene Nahan Formation of the type area, northwestern Himalaya, India has been analyzed to understand the paleoclimatic and paleotectonic conditions in the frontal Himalayan terrain. 250 thin sections of rocks collected from Lower Siwalik Nahan Formation exposed in the selected and measured three sections (Shambhuwala – Nahan section, Renuka – Nahan section and Sataun – Rajban section) of the northwestern Himalaya were subjected to petrographical and mineralogical investigations. Various petrological units distinguished in the Lower Siwalik Formation include lithic arenite ferruginous cement, quartz wacke, lithic arenite siliceous cement, quartz arenite, siltstone/clays/shales. The detrital grains are angular to subangular and have moderate sorting.

Key words – Petrography, Nahan Formation.

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INTRODUCTION

The Siwalik group extends in a linear fashion along the Himalayan foothills for about 2400 km. The Lower Siwalik subgroup (13 Ma to 9.2 Ma) is very well exposed in the type area Nahan and surrounding region. Lithologically the Nahan Formation is composed of an alternating sequence of sandstones and clays. The sandstones are fine grained and shows dominantly purple and grayish purple color in the lower part while in upper part grayish purple colour is dominant. The clays are dominantly maroon in colour. The Siwalik sediments have been studied by Chaudhri (1971a, 1971b and 1991).

This paper deals with the petrography of the rock samples from the Lower Siwalik, Nahan Formation of the type area. Lithologically the Formation consists of alternating sequences of sandstone and clays. The sandstones are fine grained and show dominantly purple and grayish- purple colour in the lower part while in upper part grayish- purple colour is dominant.

GEOLOGICAL SETTING

The Siwalik group of northwestern Himalaya in India is very well exposed in a linear fashion along the Himalayan foothills for a distance of about 2400 km from near Jammu in West to near Tripura in the East. It represents a huge thickness of sediments ranging from 3300m to 6300m which were deposited in a foredeep. The Siwalik group is further divided into three sub-groups, The Lower Siwalik (Middle Miocene), Middle Siwalik (Late Miocene- Early Pliocene) and The Upper Siwalik (Late Pliocene-Early Pleistocene).

The Lower Siwalik is also known as Nahan Formation. The age ranges from 13 Ma to 9.2 Ma. During the 9.2 Ma – 10.7 Ma the maximum erosion take place and from 11.5 Ma – 12.5 Ma upliftment took place (Gautam and Wolfgang, 1999). The Middle Siwalik ranges from 9.2 Ma to 5 Ma and The Upper Siwalik ranges from 5 Ma to 0.8 Ma. Chaudhri (2000) observed that the Siwalik group of the western Himalaya is a product of two coarsening up mega cycle.

The first mega cycle is represented by the Lower Siwalik / Nahan Formation which is characterized by a slow pace of erosion and sedimentation and stable palaeotectonic conditions. The second mega cycle comprising the Middle and Upper Siwalik Formation is marked by coarsening of the sediments which eventually indicates a fast rate of degradation process.

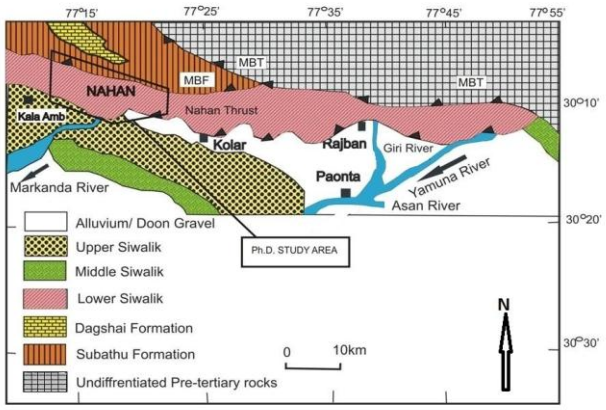


Fig. Geological map of Nahan and surrounding regions (*modified after Rohtash et al*., 2002)

MATERIALS AND METHODS

250 rock samples were collected using selective sampling strategy along the geological traverse route. Three sections are selected by using tape and brunton survey. These three sections are Shambhuwala – Nahan section (SNR), Renuka – Nahan section (RNR) and Sataun – Rajban section (SRR) which are exposed in the type area along the road.

Thin sections have been prepared by cutting, grinding and polishing. So first the samples is cut into a chip form and then grind and polish one face of the rock chip. Grinding method was done with carborundom powder no. 100 and then with carborundom powder no.400 on grinding machine. The carborundum powder used is depending on the thickness of the rock sample. So one face of the sample was polished and then fix it on glass slide with the help of mounting material such as araldite or canadabalsam. Dry the slide overnight and again grinding and polishing process was followed. The thickness of the rock sample should be 30 micron meter. As the samples of the Nahan Formation are soft and fragile so these are not directly cutted and grinded. So all samples were backed in solution of broza and xylene for about one hour on a hot plate. Than thic sections are prepared.

These were analyzed by using a polarizing microscope. Petrographic study was carried out to determine texture, matrix, cement, packing density, contact type and composition of the sandstones. Mineralogical composition of the sandstones was determined by modal analysis of about 500 grains using a point counter.

PETROGRAPHIC DESCRIPTION

The various rock types identified in the Nahan Formation of the type area Nahan and adjoining regions include quartz arenite, lithic arenite ferruginous cement, lithic wacke , quartz wacke, siltstones and clays.

Quartz arenite-

Quartz arenite is composed of greater than 90% detrital quartz with limited amounts of other framework grains (feldspar, lithic fragments) and matrix. In thin sections grains are sub-angular to sub – rounded. These medium to fine grained sediments show moderate degree of sorting.

Quartz and chert form 45.4 % to 50% of the modal rock composition. Monocrystalline quartz and polycrystalline quartz both are present. Orthoclase and plagioclase feldspar vary from 1.5 % to 3.5% of the total modal composition. Rock fragments make up 10 % to 12% of the modal composition. Sedimentary and metamorphic rock fragments contribute near equal amount of the total lithic rock fragment count. Fragments are sandstone, siltstones of sedimentary rock source and schist and gneiss represents the metamorphic rock source.

Minor mineralogical constituents comprises 4%to 6% of total modal compositions are presented by garnet, zircon, staurolite and chlorite/chloritoid.

Wacke –

Wacke is characterized by hardness , dark colour and poorly sorted angular grains of quartz, feldspar and lithic fragments. This exhibits moderate degree of sorting.

Quartz and chert constitute 44.2% to 55.4% of the total modal composition. A significance proportion of quartz grains exhibits undulatory extinction. Feldspar constitute 1.2% to 2.5% of the modal composition. Rock fragments constitute 12% to 15% of the total modal composition. Almost equal amount of rock fragments i.e. sedimentary and metamorphic rocks are present. Minor mineralogical constituents 2.6% to 5.8% of the total modal composition.

Lithic arenite ferruginous cement -

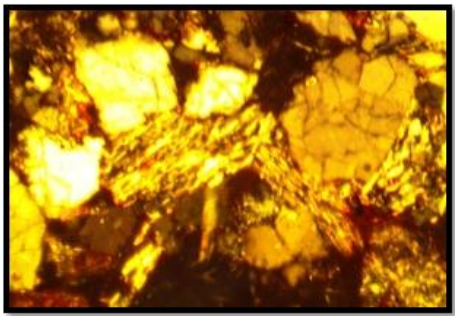
These rocks have sub-angular to sub - rounded detrital grains which have normal to partly disrupted framework. Medium to fine grained sediments show moderate degree of sorting. Quartz and chert make a 46.4% to 52.3% of the modal rock composition. Monocrystalline grains dominate over the polycrystalline variety. Significant proportion of the quartz grains exhibits undulatory extension. Felspars constitute 3.2% to 5.4% of the mineral composition. Orthoclase constitute 2.4% to 5.8% of the modal composition. Rock fragments constitute 12.2% to 17.4% of the modal composition. Sedimentary fragments are represented by sandsones, siltstones while the metamorphic fragments are represented by shists and gneiss. Minor mineralogical constituents form 2.5% to 5.4%. The grains are set in argillaceous matrix which is heavily impregnated in ferruginous matter.

Clay/Siltstone –

The siltstone and sandy clays of the Nahan Formation are poorly indurated and exhibits maroon and chocolate colour. The fine grained sandy clays/siltstones show normal to partly disrupted framework. The angular to sub-angular detrital grains exhibit poor degree of sorting.

INTERPRETATION OF THE RESULT

Various petrological units identified in the Lower Siwalik Formation include quartz arenite, lithic arenite ferruginous cement, lithic wacke , quartz wacke, siltstones and clays. The detrital grains are angular to subangular and have moderate sorting. A significant proportion of the quartz grains show undulatory extinction. Some of the quartz grains bear minute dark inclusions. Incipient development of minute flakes of micaceous minerals is also noticed. Some of the flakes show a parallel linear arrangement. At places mica flakes are seen bent along non flaky constituents. The rock fragments make up 30 to 35 percent of the modal composition and represent such parent rocks as sandstones, siltstones, clays, chlorite schist, biotite schists and gneissose rocks. Presence of fragments of polycrystalline quartz is rather significant. The more important minor mineralogical components having a bearing on the sediments include garnet, staurolite , chloritoid/chlorite and biotite.



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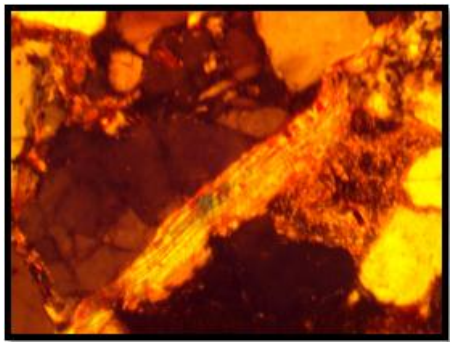

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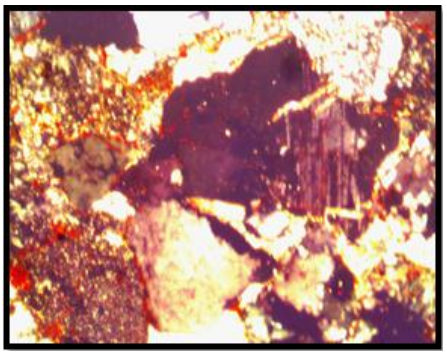

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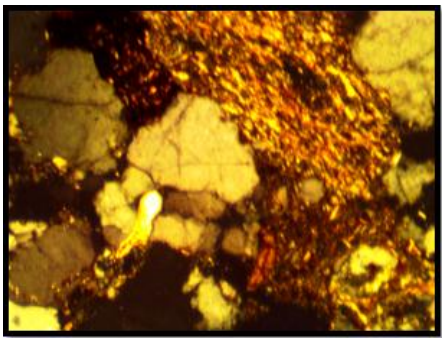

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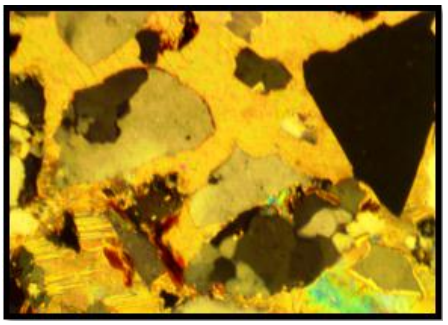

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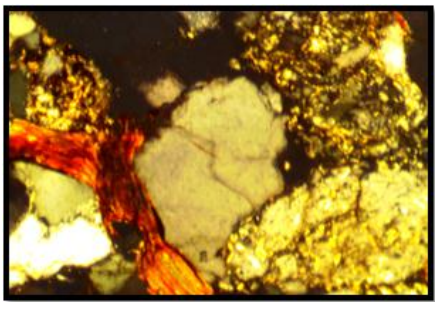

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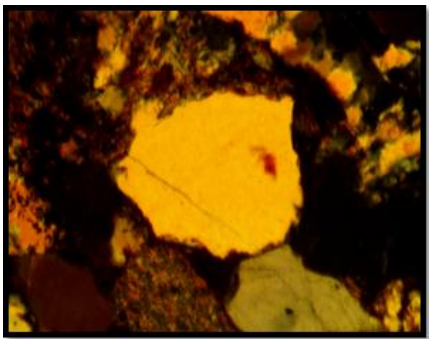

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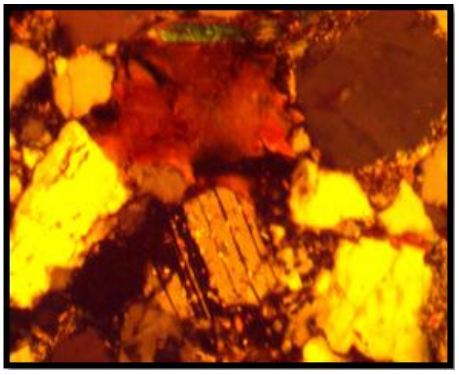
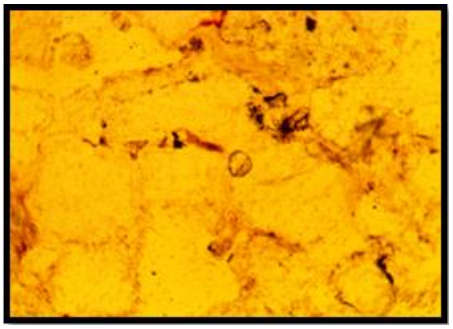


(h)

Photomicrographs of this section showing (a) metamorphic rock fragment, (b) muscovite mica flake, (c) sedimentary rock fragment and feldspar, (d) metamorphic rock fragment, (e) angular quartz grains, (f) muscovite grain, (g) subangular quartz grain and (h) feldspar grain.



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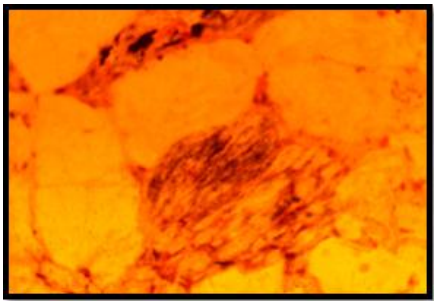

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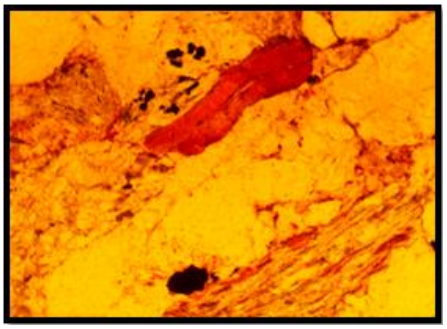

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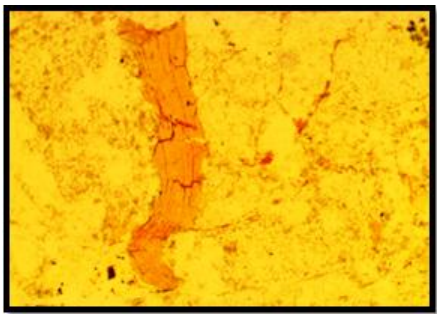

(d)

Photomicrographs of thin sections of the Nahan formation under crossed Nichols showing (a) garnet , (b) schist rock fragment, (c) biotite grain and (d) muscovite grain

CONCLUSIONS

The rock types identified in the Nahan Formation of the type area Nahan and adjoining regions include quartz wacke, quartz arenite ferruginous matter, lithic wacke, and clay/siltstones. The modal percentage of quartz and chert in these rock types ,low maturity indices , incomplete disintegration of the source rocks and the appreciable percentage of rock fragments of sedimentary and metamorphic nature reflect the tectonically active paleotectonic regime and suggest a relative short distance of transport of the detritus. Presence of monocrystalline quartz in excess over the polycrystalline variety suggests the derivation of sediments comprising the Nahan Formation from crystalline and metamorphic rocks. According to Friedman and Sanders (1978). Majority of the monocrystalline quartz is contributed by granites as compared to schists and gneisses. Bokman (1952) regarded metamorphic rocks as the source of polycrystalline quartz. Conolly (1965) suggested that the abundance of polycrystalline quartz in a clastic sediments is directly proportional to the grain size. Majority of the detrital grains show undulatory extinction. Grains showing undulatory extinction on more than 5 degree rotation of the microscope stage dominate over the grains which show undulatory extinction on less than 5 degree rotation of the stage. This suggests that a major portion of the sediments have been derived from metamorphic rocks with a slightly lesser contribution from crystalline/ plutonic rocks. Quartz grains showing non-undulatory

extinction appears to have been derived from sedimentary rocks and may also is of multicyclic nature. Majority of the quartz grains bear an acicular, irregular and dusky inclusions. Chaudhri and Grewal (1988b) recorded that acicular inclusions are more frequently observed in quartz grains derived from metamorphic rocks than from plutonic rocks. The sediments of the Nahan Formation appear to have been derived from metamorphic and plutonic rocks. The inclusion free quartz grains reflect their multi-cyclic nature and their derivation from pre-existing sedimentary rocks. The overall texture and mineralogy of the minor mineralogical constituents suggest that the major proportion of the detritus was driven from crystalline and metamorphic rocks. Sedimentary rocks also contributed a part of sediments. Cameron and Blatt (1971) observed that rock fragments of schist get disintegrated on more than 25 km. of fluvial transport. The presence of rock fragments and their dominance suggests that the source rock were near the basin of sedimentation.

The modal analysis reveals relatively low feldspar content in different lithological unit of the Nahan Formation. This suggests that a major proportion of the sediments was derived from sedimentary and metamorphic rocks as these rocks are usually poor in their feldspar content (Pettijhon, 1957).

ACHKNOWLEDGEMENT

The author wish to record his sincere gratitude to Prof. Dr. A. R. Chaudhri for his constant support and guidance. The work was carried out at Department of Geology, Kurukshetra University, and Kurukshetra.

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