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Geology, Structure, Metamorphism and Deformation of Botechaur-Chaurjhari Area of Western Nepal

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ABSTRACT

The Lesser Himalayan unit of the Nepal Himalaya, especially the western and central parts comprise numerous metamorphic crystalline thrust sheets occupying the cores of large synclinorium. Despite having complex geological settings, some areas in western parts of Nepal lack detailed geological mapping with credible information. This study aims to explore one least explored section; with emphasis on lithostratigraphy, structural setting, deformation, metamorphism, and magmatism. Detailed geological mapping along the Botechaur-Chaurjhari section revealed three tectonostratigraphic units separated by the Main Boundary Thrust (MBT) and the Mahabharat Thrust (MT); the Siwaliks (Middle Siwalik), autochthonous units of the Lesser Himalaya (Dandagaon Phyllite, Nourpul Formation and Dhading Dolomite) and the Lesser Himalayan Crystalline units (Kalagaon Formation and Chaurjhari Formation) from south to north respectively. From the microstructural analysis and measurements of shear sense indicators, the MT shows a top-to-the-south sense of shear indicated by asymmetric boudins, parasitic folds, and thrusting indications in blasto-mylonitic augen gneiss and asymmetric porphyroblast of garnet and the shearing in the garnet. The area also displays an inversion of metamorphism, supporting the development and existence of thrust. The metamorphic grade ranges from chlorite grade to kyanite grade having metamorphic facies assemblage of zeolite to amphibolite facies. Five phases of deformation (D_1 to D_5) are prevalent within the area, two of which (D_1 and D_2) belong to the pre-Himalayan (pre-Tertiary) orogeny and the rest of the deformation syn-to post-Himalayan.

Keywords**:** Thrust sheet, Metamorphism, Facies, Lesser Himalaya, Western Nepal.

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INTRODUCTION

Among four tectonostratigraphic units of the Himalayas, the fold-and-thrust belt, Lesser Himalayan belt is structurally very complex. It is characterized by several tight to overturned folds, mostly north dipping but also some south dipping imbricate faults and detached outliers. Practically the entire Lesser Himalayan sequence was previously concealed under the Higher Himalayan crystalline thrust sheets (Paudyal and Paudel, 2013; Dhital, 2015). The thrust sheets moved over the Lesser Himalayan sequence which was deformed to yield various folds and faults in this process. The Himalayan sequence of different regions was also passively twisted out of normal shape and extension at some stages of Himalayan deformation. In west Nepal, the Lesser Himalayan sequence is about 100 km wide and extends in the northwest-southeast direction for about 300 km. The complex interplay among thrusting, erosion, and folding of the Lesser Himalayan sequence has created a complex pattern of tectonic windows, nappes and klippen along western Nepal (Dhital, 2015); some of which are the Jajarkot Nappe and Karnali Nappe. In the region of west Nepal, mainly two thrust sheets (or nappes) are overriding each other; the uppermost nappe represented by the Greater Himalayan Crystalline forming the hanging wall of the MCT, and the Lesser Himalayan Nappe is resting over the phyllites, quartzites, carbonates, and slates belonging to the Lesser Himalayan sedimentary succession comprised of intensely deformed and faulted rocks.

From the very beginning, there has always been a controversy about stratigraphic setup and structural interpretation from researchers to researchers investigating in different parts of the Himalayas. Fuchs and Frank (1970) divided the metamorphic rocks into the Chail Nappes and the overlying Crystalline Nappes; and mapped the present area under Chail Nappe series. The Chail Nappe series is roughly comparable with the Lesser Himalayan thrust sheet and upper Crystalline Nappes with the Greater Himalayan Nappe. While Hagen (1969) has designated the area under Hiunchuli Nappe and Hashimoto et al. (1973) included them within the Baragaon Zone.

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Despite the controversy, structural and stratigraphic complexity, many geologists (e.g., Adhikari and Sharma 1983; Kansakar and Chitrakar 1984; Fuchs and Frank 1970) have published geological maps of western Nepal in a wider range with vague stratigraphic and structural controls. However, these maps lack credible information on tectonics and the spatial distribution of various rock successions. The same applies to the study area (Fig. 1), which will be somehow overcome by the present investigation. An attempt to investigate the tectonic implications of the area at the micro-structural level followed by detailed large-scale mapping within the area will certainly contribute to the proper interpretation of tectonic events within the complex belt of western Nepal.

published literature and unpublished reports was reviewed thoroughly in the first phase and in the second phase for the proper route delineation for a better approach to all the presented stratigraphic succession. Extensive desk study during the preparation phase was followed by a detailed field investigation, which included delineation of lithological and structural boundaries, structural measurement, and systematic sampling. Furthermore, petrographic analysis of systematic samples collected during field investigations was performed under a high-resolution petrographic microscope for the validation of lithological descriptions, stratigraphic set-up, and studies on deformation and metamorphism. The combined effort was made, in the end, to compile data from a

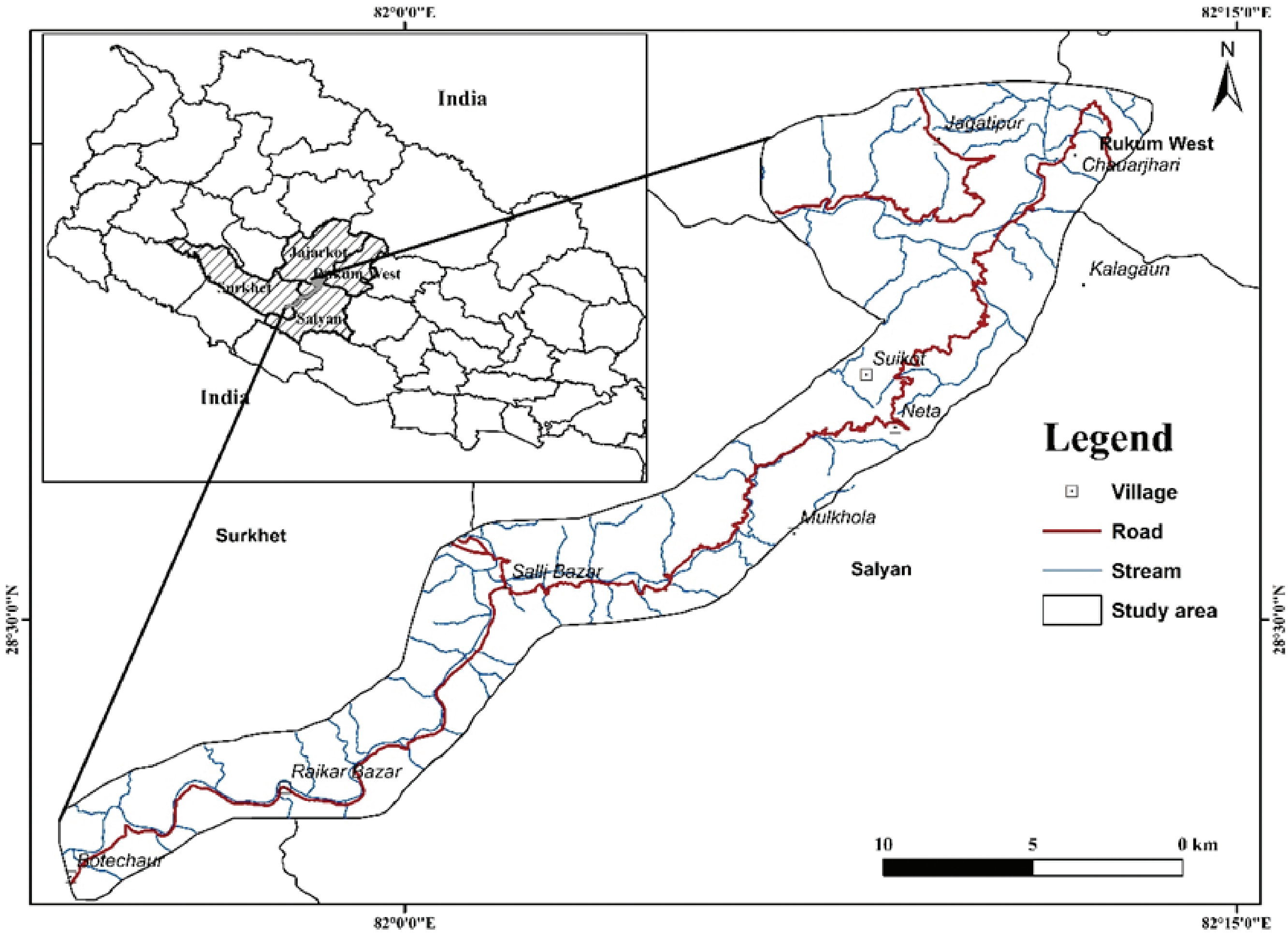

Fig. 1: Location map of the study area.

METHODOLOGY

The present research followed wide range of methodologies from desk study to detailed field investigations, systematic sampling and laboratory analysis of the representative rock samples. To find the proper research gap, an extensive desk study of

detailed geological survey and laboratory analysis to prepare a geological map as accurately as possible and to analyze the metamorphism and deformation history of the area. Moreover, the present research is followed and complemented by the previous work of authors in the nearby section (the Chheda-Saureni section) of the Surkhet and Jajarkot district (Shahi et al. 2022).

RESULTS

The area under the present investigation comprises non-metamorphosed sedimentary molasses in the southern part towards Botechaur to incipiently metamorphosed rocks in the northern section, as the grade of metamorphism increases gradually towards the north. As the rocks in general dip towards the north, the area apparently displays an inverse of metamorphism, a well-recognized phenomenon within the Himalayas. Based on lithological characters, stratigraphic set-up, and structural and tectonic features, the rocks of the study area can be divided into several distinct lithological sequences within three broad tectonostratigraphic units (Table 1, Fig. 2).

Tectono-stratigraphy

Detailed geological mapping from Botechaur to Chaurjhari revealed three litho-tectonic units; the Siwaliks, the Lesser Himalayan metasediments, and the Lesser Himalayan Crystalline sequence (Fig. 2). These three units have distinct lithological characteristics, metamorphism, magmatism and deformation history; so, can be divided into a number of rock formations, which have their stratigraphic successions well established within the limits of their tectonic boundaries (Table 1, Fig. 2). However, a complete stratigraphic scheme for the study area cannot be established at the present state of the investigation due to the absence of reliable age indicators like fossil evidence in most formations,

Table 1: Litho-tectonic succession along the route from Botechaur to Chaurjhari

Tectonic Unit	Rock Formation	Lithology
Lesser Himalayan Crystalline MT	Chaurjhari Formation	Kyanite-schist, garnet-mica schist, micaceous quartzite, feldspathic schist, and garnetiferous, calcareous schist
	Kalagaon Formation	Micaceous quartzite, muscovite-biotite schist, garnet-mica schist with occasional graphitic schist band.
Lesser Himalaya MBT	Dhading Dolomite	Very thick bedded bluish grey, laminated, stromatolitic cherty dolomites
	Nourpul Formation	Thick-to-very thick beds of medium to coarse-grained, pink, grey, and white quartzites with pink to grey metasandstones and purple shale. Basic intrusions are frequent. Parallel-laminated, pale grey, yellow or white quartzite intercalated with schists and phyllites; have frequent meta-basic intrusions.
	Dandagaon Phyllite	Dark grey to blue green phyllites and schists.
Siwaliks	Middle Siwalik	Fine to medium-grained sandstone, sometimes with pepper-and-sand appearance and variegated mudstones

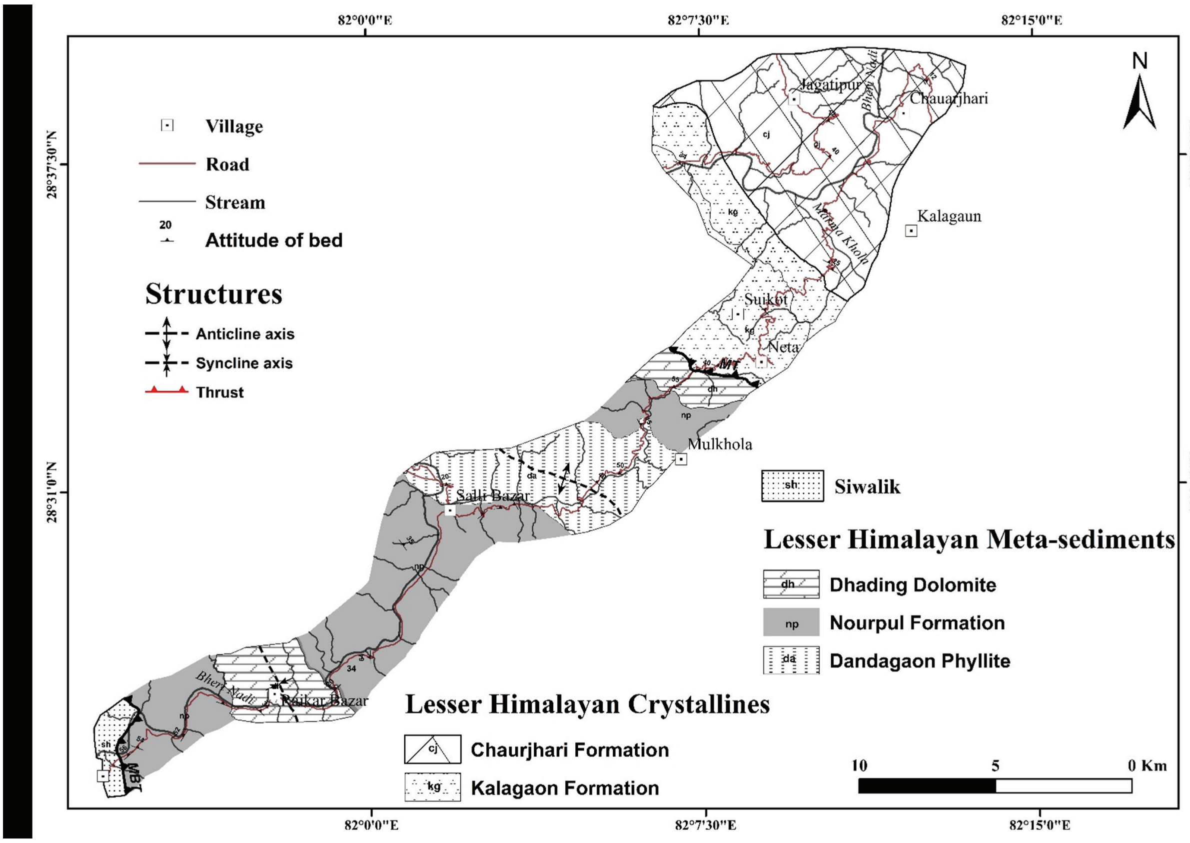

Fig. 2: Geological route map from Botechaur to Chaurjhari.

which is further complicated by a complex tectonic process that has been operated during the formation of thrust sheets. Although, most possible accurate attempt to identify litho-stratigraphy and structural boundary based on field evidence and petrographic analysis has been made here.

Lesser Himalayan Crystalline Rocks

The Lesser Himalayan Crystalline rocks of this section have been coined as the Golyachaur-Chaurjhari Nappe by Sharma and Adhikari (1983); after well-known places.

in Jajarkot district. This uppermost tectonic unit of the area is classified as the Lesser Himalayan Crystalline unit due to documentation of multiple deformational features showing a top-to-the-south sense of shear and the presence of metamorphic inversion in addition to higher metamorphic grade. This tectonic unit is comprised of medium to high-grade metamorphic rocks; mica-schist, garnet-mica-schists, and micaceous quartzite with some graphitic schist bands, which can be further subdivided into two lithological units as mentioned below:

Kalagaon Formation (kg)

The name of this rock succession was first introduced by Adhikai and Sharma (1983) and has been retained for rock sequences of similar nature. Along the Botechaur-Chaurjhari section, this succession extends around Neta and Suikot villages, while the northern contact is south to the Marma Khola. It consists of medium to thickly bedded, yellow tanned, parallel laminated, lineated, and white to grey, micaceous quartzites, coarse-grained metasandstone, greenish garnet-mica-schist (with garnet porphyroblasts of up to 4 mm diameter) and occasional thin interbeds of graphitic schists. The basal part of this litho-unit contains a meta-conglomerate, just south of Neta, which eventually disappears throughout the succession (Fig. 4a).

The mica schist is coarse-grained and contains

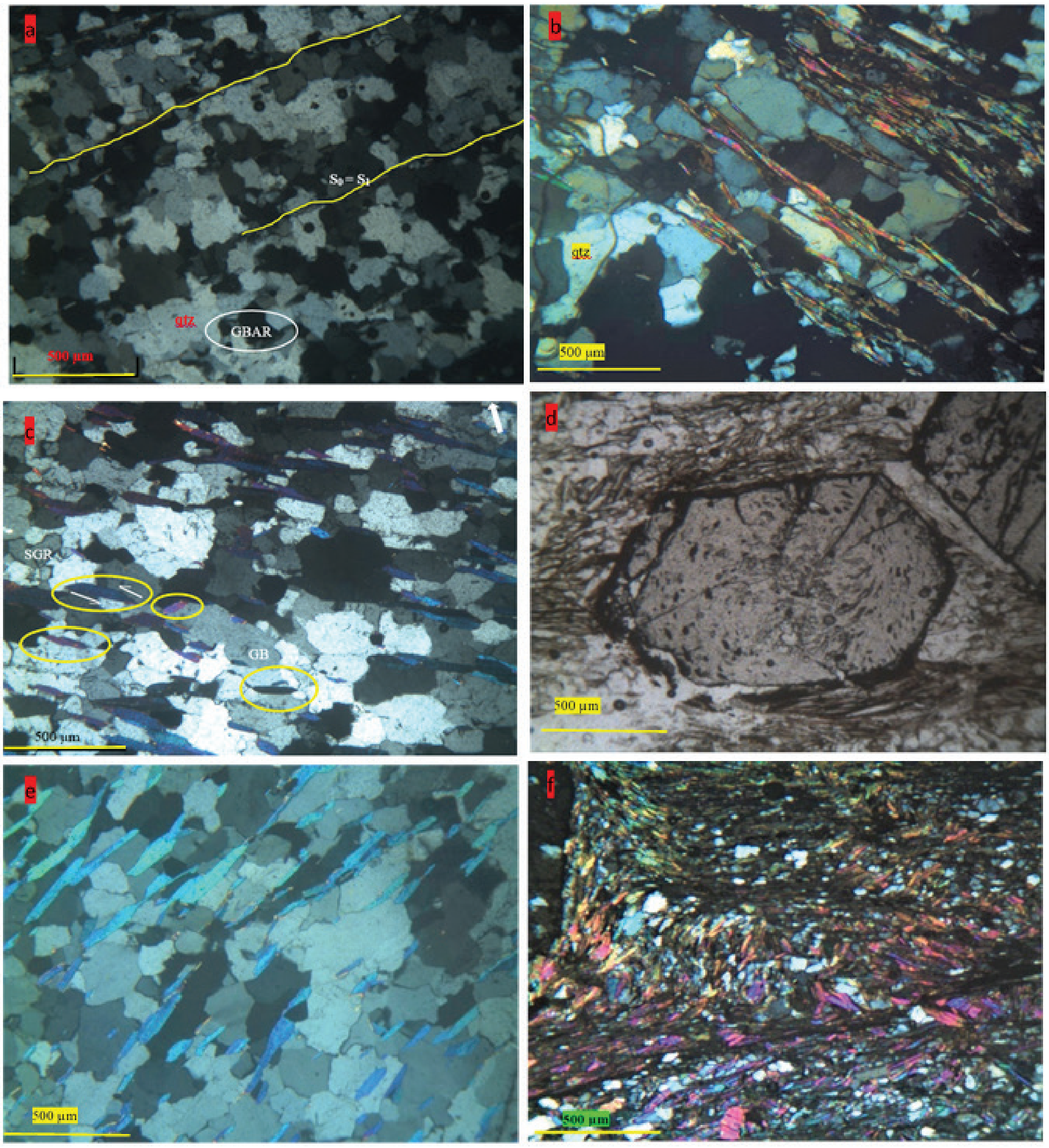

Fig. 3:Photomicrographic reference of representative rock samples showing composition and deformation: a) Quartz crystals flattened by intracrystalline deformation, polycrystalline quartz dynamically recrystallized by GBM and SGR and statically by GBAR, b) micaceous quartzite showing bedding parallel foliation, c) Pssamatic schist showing mica fish (within circle) indicating topo-to-the-south movement and evidence of static and dynamic recrystallization; at the top of Chaurjhari Bazar, d) UPPL image of snowball garnet showing inclusions of quartz within garnet-schist succession e) flattened quartz crystals in micaceous quartzite showing bedding parallel foliations and e) photomicrographic reference showing s-c fabric and strain shadows in garnetiferous schist.

Fig. 4: a) An outcrop of meta-conglomerate having clasts stretched along foliation observed at the base of the Kalagaon Formation, b) an outcrop of crenulated pelitic schist with conjugate boudins within the Chaurjhari Formation formed by stretching.

tabular flakes of sub-parallelly oriented muscovite and biotite alternating with anhedral and elongated quartz layers. The coarse-grained micaceous quartzite contains anhedral, elongated, and flattened quartz grains and tabular flakes of subparallel-oriented micas (Fig. 3b). The quartz grains have undergone static and dynamic recrystallization in the form of GBAR, SGR, and GBM respectively (Fig. 3a and 3c). The mica minerals present are altered to chlorite and sericite and quartz grains show strain shadow indicating the retrogression effect of the MT.

Chaurjhari Formation (ch)

This unit was named after the type locality, Chaurjhari by Adhikari and Sharma (1983) and has been retained in the present research for similar lithological succession. The Chaurjhari Formation is transitionally underlined by the Kalagaon Formation and is extended around Chaurjhari from the south of the Marma Khola section.

It is composed of up to meso-grade pelitic and psammitic sequences as medium-grained, crenulated, crystalline garnet-two-mica schist (Fig. 3d and 4b) interbedded with gray micaceous quartzite (Fig. 3b) and black graphitic schists at places. Kyanite grade schists have been reported from the top of Chaurjhari Bazar, at the quarry side. Under a microscope, the quartzite shows fine-to coarse-grained anhedral quartz intergrown into a granoblastic texture (Fig. 3e).

Lesser Himalayan Metasediments

The autochthonous unit: non-crystalline Lesser Himalayan metasediments reported along the section has been dissected, deformed, and metamorphosed to a bit due to the folding and thrusting of the rock sequence. The following rock sequence of the Lesser Himalaya has been encountered along the route during geological route mapping along the section; namely the Dandagaon Phyllite, Nourpul Formation, and Dhading Dolomite from older to younger stratigraphy. The name of these rock successions was first introduced by Stöcklin and Bhattarai (1977) in central Nepal and has been retained for the similar rock succession in this section.

Dandagaon Phyllite (da)

The rocks of the Dandagaon Phyllite, containing rather uniform argillaceous to finely quarzitic phyllites of dark grey to greenish grey color are well exposed in the Salli Bazar section. The Dandagaon succession of this area has been pervasively folded forming the core of the anticline; due to which the non-calcareous argillaceous dark phyllite with some quartzitic phyllite with a ratio of 3:1, has been deformed and metamorphosed to crenulated schist (figure 6c, 6d, 6e) at the core of the anticline near Salli Bazar (Fig. 5a, 5b). Along this section, the Dandagaon Phyllite is underlaid by the stratigraphically younger Nourpul Formation with a transitional contact both at the top and bottom part.

Nourpul Formation (np)

The rocks of the Nourpul Formation are well exposed in the southern part of the section above the Siwalik rocks and are well documented in between the north of Botechaur to a few distance south of the Raikar Bazar.

Fig. 5: Some field reference of lithological descriptions: a) an outcrop of the Dandagaon Phyllite displaying weathering color, b) deformed schist of the Dandagaon at the core of anticline, c) metabasites within the Nourpul Formation and d) an outcrop of quartzite from the Nourpul Formation.

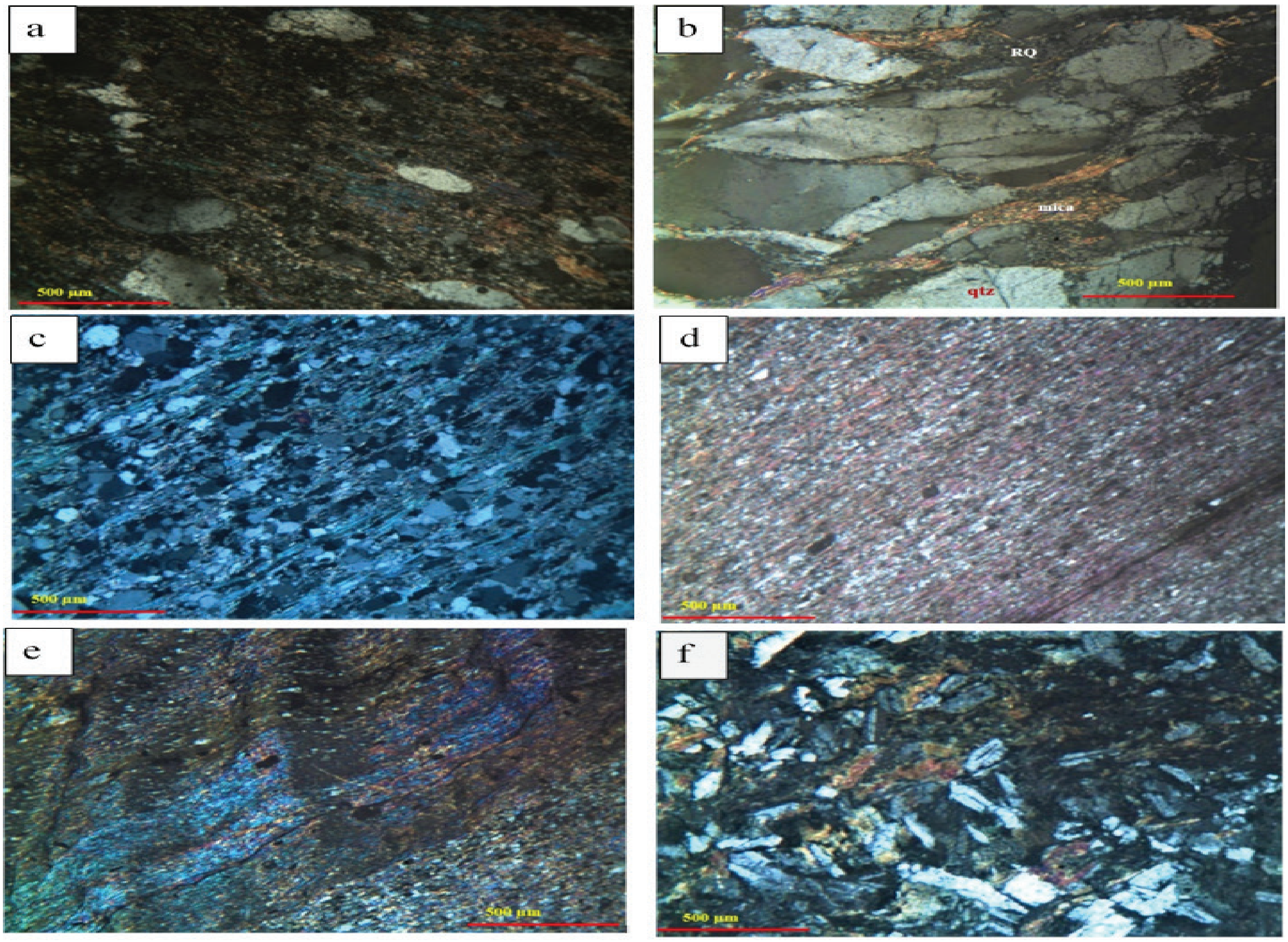

Fig. 6: Some photomicrographic references of the rocks from the Lesser Himalayan metasedimentary sequence; a) low-grade mylonite within the Nourpul Formation derived from phyllite, b) medium-grade mylonite derived from micaceous quartzite. RQ= recrystallized quartz, c) and d) schists and phyllite from the Dandagaon Phyllite, e) crenulated phyllite from anticline sequence of the Dandagaon Phyllite and f) metabasic rocks within the Nourpul Formation.

Apart from these areas, it is exposed around Mulkhola and Salli Bazar areas and is comprised of very thick to thickly bedded medium to coarse-grained, parallel laminated, rippled, dense, pink, yellow, gray, or white quartzites interbedded with green-gray phyllites, mica-schists, purple slates, and, medium-grained, pink meta-sandstones (Fig 5c, 5d). Phyllite partings and sporadic amphibolite bands (Figure 6f) are very frequent within this formation. Quartzite and phyllite of this unit have deformed and crystallized to form medium grade mylonites (Fig. 6a and 6b).

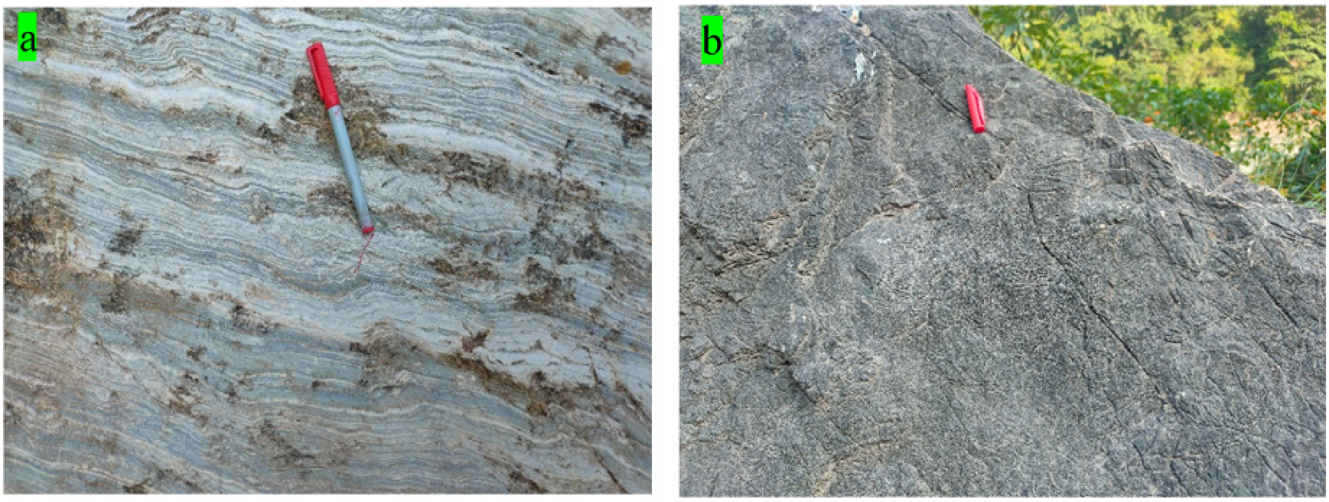

Fig. 7 a) folded lamina present in the dolomite of the Dhading Dolomite succession around Raikar Bazar, b) field photograph of columnar stromatolites in the dolomites.

Dhading Dolomite (dh)

The bluish-grey, cherty, siliceous, stromatolitic dolomites of the Dhading Dolomite unit are well exposed along the Raikar Bazar occupying the position of a northern limb of the fold to the north of Mulkhola village. It comprises thin-to-thickly bedded, bluish-grey, siliceous, brecciated, laminated, stromatolitic (Fig. 7b) dolomites intercalated with dark gray phyllite (Fig. 7a). Dolomites of this succession are characterized by fine crystalline or dense; light blue/blueish grey with splintery fracture.

Siwaliks (sh)

The name (in the form of Siwaliks) was first introduced in India by Medlicott (1864) and has been used for similar rock succession comprising molasses-type sediments. In the present area, sedimentary molasses of the Siwalik Group especially the Middle Siwalik rocks comprising fine-to-medium-grained paper-and-salt textured sandstones and mottled mudstones has been reported from section south to Botechaur (Fig. 2)). Rocks of the Siwaliks are crushed, deformed, and weathered in several places; at most of the places it has been concealed by the alluvial deposit of Bheri River.

Geological Structures

Structures of various scale; megascopic structures like the MBT and the MT along with an anticline fold with an axis passing through Salli Bazar and a syncline fold with an axis passing through Raikar Bazar has been reported in this section (Fig 2). The MBT is placed at the base of the Lesser Himalaya above the sedimentary molasses of the Siwaliks and is well-exposed in Botechaur area. Whereas the MT demarcates the boundary between the Lesser Himalayan Crystalline rocks and the rocks of an autochthonous unit of the Lesser Himalaya.

For the present observation, the MT is demarcated based on brittle deformation structures like the shear zone and some ductile structures like the folded vein, which has a top-to-the-south sense of shear as indicated by the grain scale deformation and shearing (Fig. 8a -8d).

There is less sharp structural discontinuity that separates the autochthonous Lesser Himalayan Sequence and the Lesser Himalayan Crystalline. Brittle shear zones, outcrop scale folds (Fig. 8c), folded quartz veins, intense deformation in microscopic scale (Fig. 8c), and inversion of metamorphism were prevalent in field and laboratory studies. Moreover, the equal angle lower hemispheric projection of the bedding and

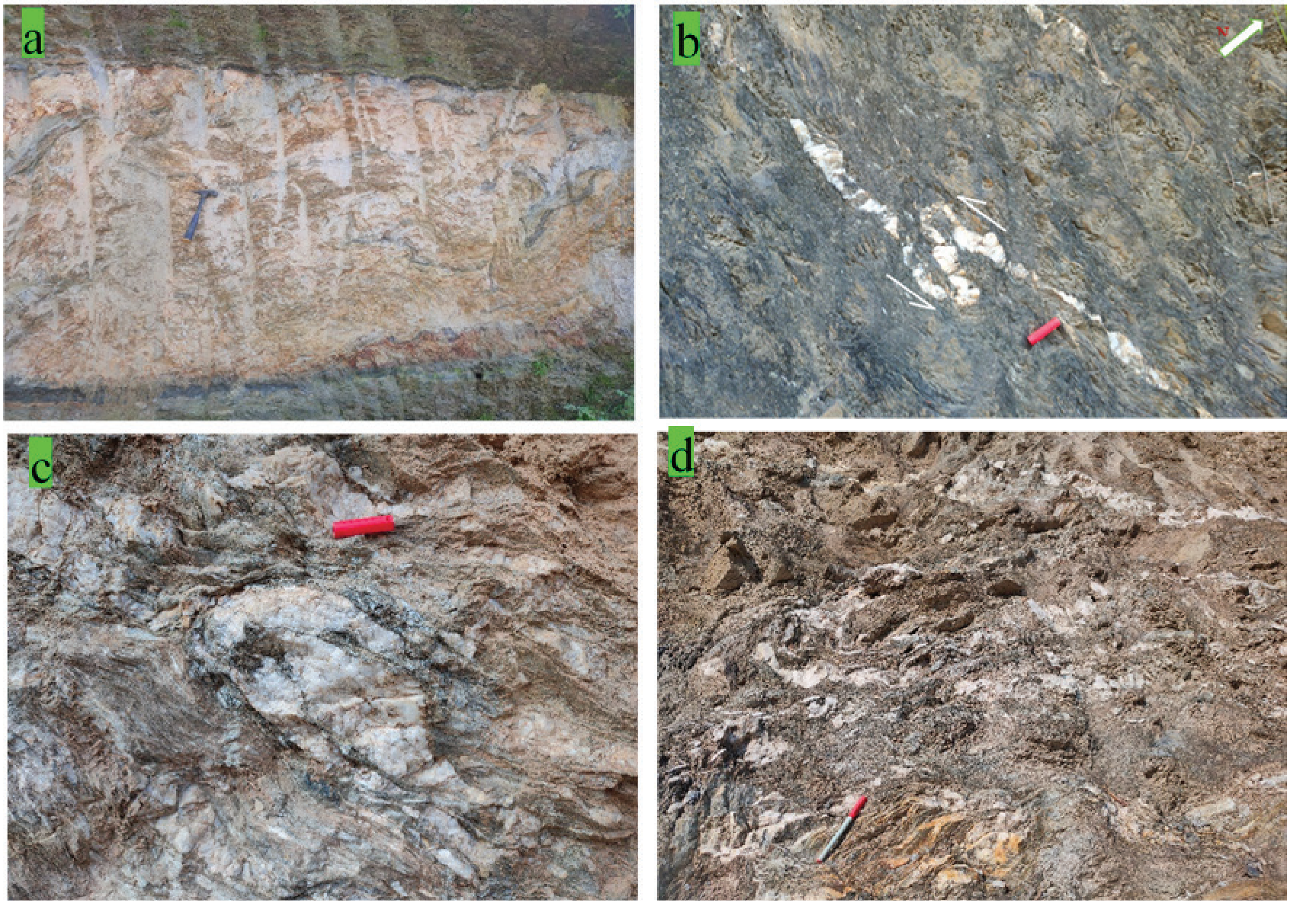

Fig. 8: Some photographic evidence of outcrop scale deformation structures showing indications of thrust; a) Flexural fold present within the Chaurjhari Formation observed along Chaurjhari- Karkigaun road section, b) S-type fold developed in the vein showing a top-to-the south sense of shear; along Charjhari-Karkigaun road section, c) an asymmetric boudin showing top-to-the-south sense of shear; note: tip of marker points towards north and d) deformed quartz vein on the schist.

foliation measurements shows that the fold is a non-cylindrical plunging fold with a trend and plunge of the axis as 261°/10° (Fig. 9).

Metamorphism and Magmatism

The area along Botechaur to Chaurjhari has a variety of rocks ranging from the un-metamorphosed

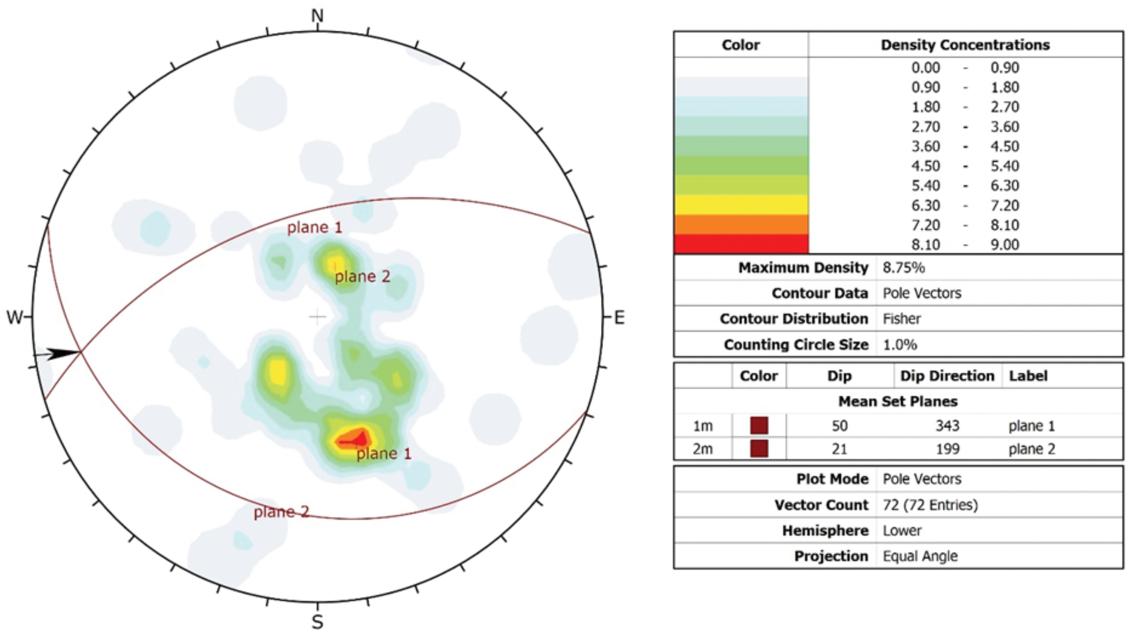

Fig. 9: Equal area lower hemispheric projection of the foliation data along Salli Bazar section; showing the anticline fold plot; measurement of axes; 343°/50° and 199°/21°; fold axis, 261°/10°.

sedimentary succession of the Siwalik Group to the kyanite-grade rocks of the Lesser Himalayan Crystalline. The overall rock succession is biotite to garnet grade, while the kyanite-grade rocks are observed in the Chaurjhari Formation rocks at the top of Chaurjhari in the rock quarry site.

Retrograde metamorphism from kyanite to muscovite is well preserved in schists. Mainly four equivalent facies of regional scale are well preserved within the area, zeolite facies, greenschist facies, amphibolite facies, and granulite facies.

There are two types of magmatic bodies in the area: granitic and basic and are well-metamorphosed in the present condition. Metabasites are abundant in the rock successions of the Nourpul Formation (Fig. 5c). Medium-to coarse-grained amphibolite bodies within quartzites of two geological units are mapped (Fig. 2). Granitoid intrusions, which have metamorphosed to augen gneiss and have undergone intense shearing are observed at the basal part of the Chaurjhari Formation along the Marma Khola section (Fig. 10c).

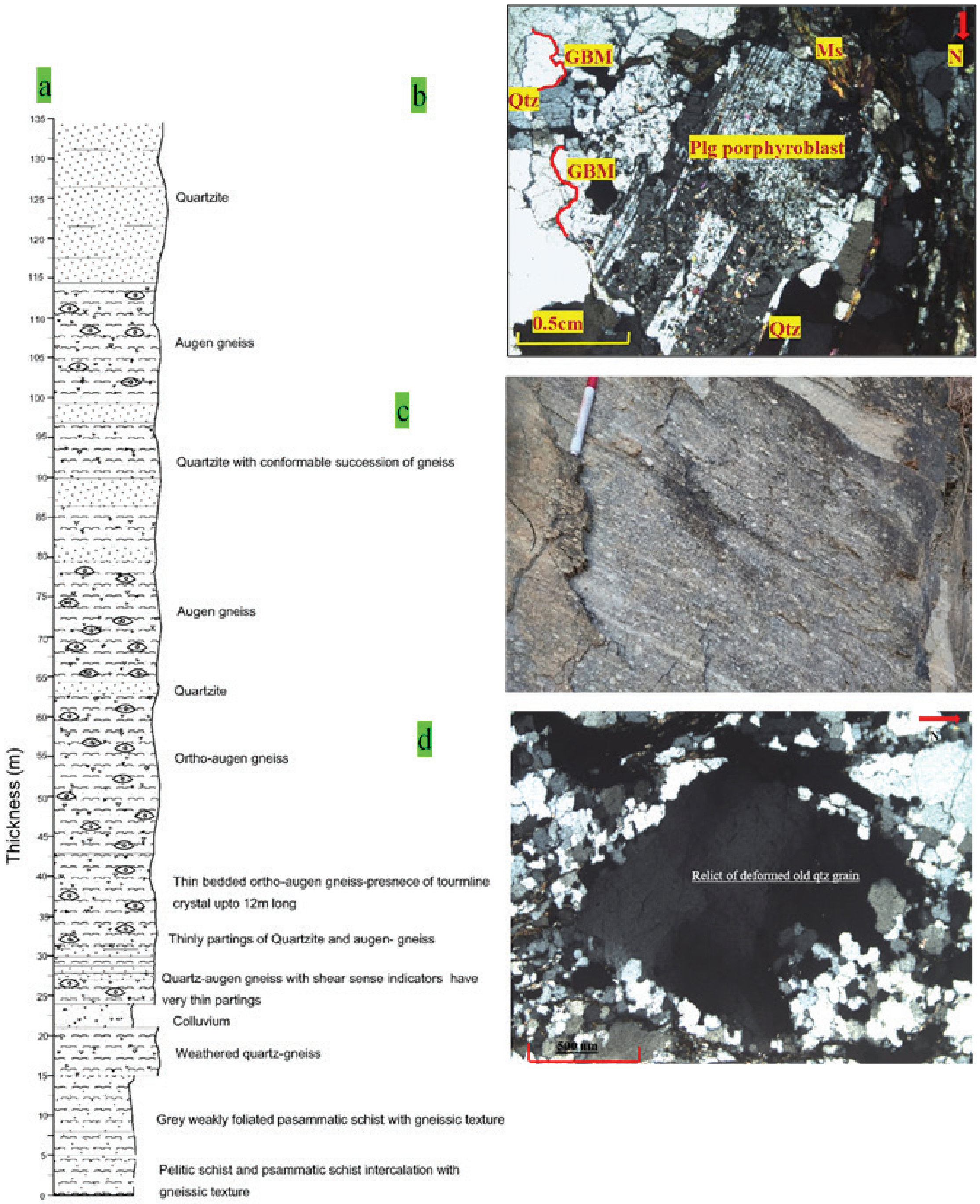

Fig. 10: Evidence of the granitoid intrusions; a) Columnar section showing granitoid intrusion at the base of the Chaurjhari Formation, b) photomicrograph of the granitic augen gneiss showing plagioclase porphyroblast and GBM in quartz and c) an outcrop of granitic augen gneiss observed at the basal part of the Chaurjhari Formation and d) photomicrographic reference of deformation along thrust) Polycrystalline quartz aggregate developed predominantly by SGR and GABR. Transitions exist between grains surrounded by high-angle boundaries and sub-grains. (plg = plagioclase, qtz = quartz, ms = muscovite; adopted from Whitney and Evans 2010)

Under high-resolution petrographic microscopes, augen-shaped, porphyroblast of K- feldspar are associated with biotite, muscovite, and sericite, which define gneissosity. Moreover, the mica flakes that have deformed into mica fish and intercrystallite deformation of quartz grains as GBM, SGR, and GBAR are well observed in psammitic sequences (Fig. 10d).

DEFORMATION HISTORY

The structures (various fabrics, growth sequence of minerals, lineation, folds, joints, and faults) in the rocks of the autochthons of the Lesser Himalaya and Lesser Himalayan crystalline of the Botechaur-Chaurjhari section show the polyphase deformation. Five deformational phases have been recognized in the study area, which are labeled as D_1, D_2, D_3, D_4, and D_5.

Among the five deformation phases, the first two (D_1 and D_2) are supposed to be of pre-Himalayan (pre-Tertiary) and the later three (D_3, D_4, and D_5) are related to the Himalayan orogeny (Paudel and Arita 2000; Paudyal and Paudel, 2013; Paudyal 2014). Both the rocks of the Lesser Himalaya and the Lesser Himalayan Crystalline have suffered from five deformational events (D_1-D_5). For the delineation of the deformation history, structures having the same geometric style in all the tectonic units are assigned to the same deformational event. However, it does not imply that they were synchronous in all tectonic units, and thus the correlation of the deformation events (Table 2) should be regarded as very tentative.

Table 2: Deformational events and related structures in the Lesser Himalaya of western Nepal along the Botechaur-Chaurjhari section.

Tectonic unit	Pre-Himalayan Phase		Himalayan Phase		
	D_1	D_2	D_3	D_4	D_5
Lesser Himalaya and Lesser Himalayan Crystalline	Bedding parallel foliation (S_o=S_1)	N-S trending isoclinal folds, drag folds	S-C fabric and NNE-SSW trending stretching lineation	Fracture cleavages, E-W trending crenulations.	Small-scale brittle faults and shear zones

Pre-Himalayan Phase

Pre-deformational compositional layering (S_0) that has deformed to foliation is preserved throughout the Lesser Himalayan Sequence and Lesser Himalayan Crystalline (Fig. 11b). The first deformational event (D_1) is marked by the dominant bedding-parallel foliation (S_1) within Lesser Himalaya (Fig 7a). The D_1 was most probably due to the flattening of beds due to vertical load. The D_2 event corresponds to the deformation of the S_0 and S_1 producing isoclinal and drag folds with N-S trends (Chaudhry and Ghazanfar, 1989; Baig et al. 1988). In the study area, both the events are well-documented.

Himalayan Phase

The Himalayan deformation phase can be considered as a single continuous phase of deformation. Despite

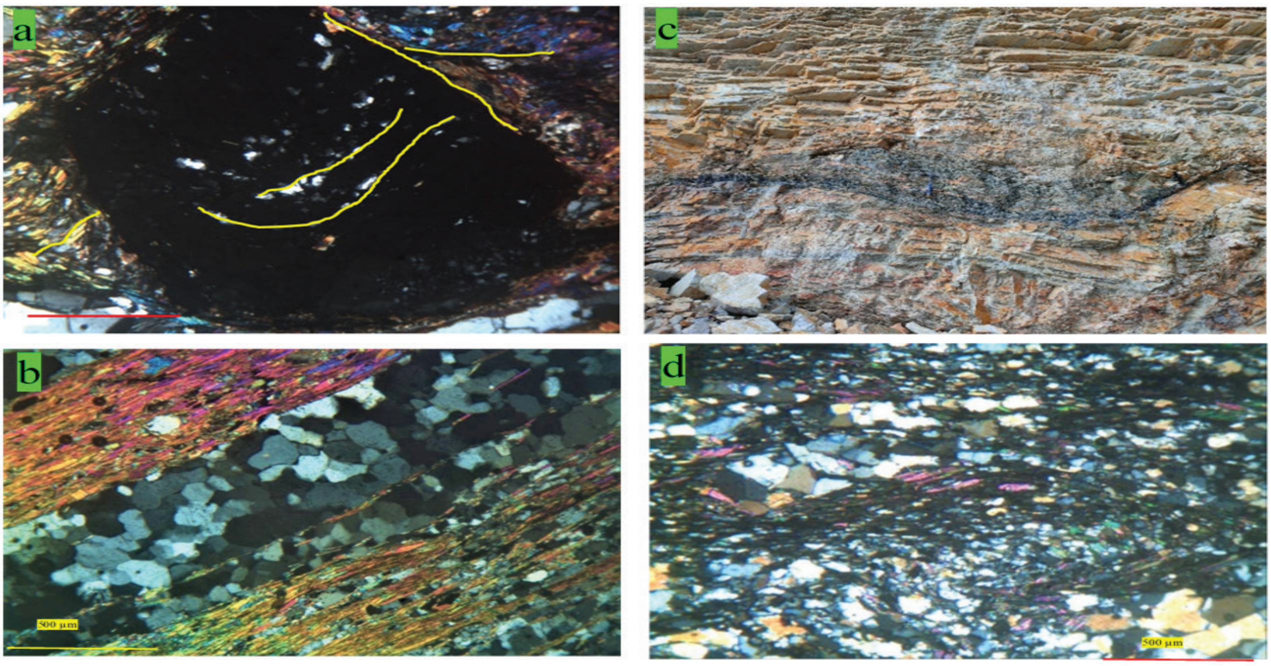

Fig. 11: a) Photomicrograph of the gneiss from the Lesser Himalayan Crystalline showing trigonal contact and bedding parallel foliation. b) Photomicrograph showing garnet porphyroblast with sigmoidal inclusion trail and two sets of foliations, c) Photograph showing brittle shear zones d) Photomicrograph of the schist from the Lesser Himalayan Crystalline showing S-C fabric and two sets of foliations.

this fact, it can be divided into three phases based on the difference in structural style during different stages of deformation (Schelling 1989; Paudel and Arita 2000).

The D_3 is characterized by intense ductile shearing parallel to S_0 and S_1. The D_3 was the main deformation event during the placement of the rocks of the Lesser Himalayan Crystalline which produced dominant mylonitic foliation (including both the S- and C-planes) and stretching and mineral lineation. The mylonitic foliation represents well-developed S-C fabric in some places (Fig. 11d). This phase of deformation is prominent in the rocks of all three tectonic units. Most of the major and minor folds with axes trending from WNW to ESE and vergence to the south were formed during D_4 (Paudel and Arita 2000). Brittle fractures, axial plane cleavage, and crenulation folds characterize the rock of the Lesser Himalaya. E-W trending crenulation folds (Fig. 4e) along with the crenulation cleavages are abundant within the pelitic rock layers.

The D_5 is usually characterized by small-scale brittle faulting throughout the area (Fig. 11c)). The brittle faults crosscut all the previous structures (Fig. 11d). This structure representing one of the stages of the Himalayan deformation is observed within all three tectonic units.

DISCUSSIONS AND CONCLUSIONS

The geological investigation along the Botechaur-Chaurjhari section included a detailed field survey to draw the overall idea of geology, metamorphism, deformation, and magmatism with a major focus on structural settings, which was later verified by petrographic analysis. The section under study revealed three tectonostratigraphic successions: the Siwaliks, the Lesser Himalaya, and the Lesser Himalayan Crystalline, separated by two major thrusts; the MBT, and the MT from south to north respectively; most of which have their own well-defined litho-stratigraphic successions. The litho-stratigraphic subdivision of these three rock sequences from present research can be correlated with the work of Kansakar and Chitrakar (1984) and Dhital (2015), who have worked within, nearby, or in similar tectonic settings (Table 3).

On the contrary, the outcome of this research is not in agreement with the recently published map of the Department of Mines and Geology, Nepal, in terms of structural boundaries and litho-stratigraphy.

Within the present area, the MBT (which is equivalent to Botechaur Thrust of Dhital (2015)), overrides the rocks of the Lesser Himalaya over the rocks of the Middle Siwalik and the MT (the MCT, according to Dhital (2015)) has placed the rocks of the Lesser Himalayan Crystalline Nappe over the Dhading Dolomite (autochthonous succession of the Lesser Himalaya). The Meso and microstructural observations, as well as measurements of asymmetrical boudins, projection of lineation data, and axis measurement of small parasitic folds, revealed top-to-the-south movement throughout the area, indicating southward propagation of the crystalline rocks along the MT. During the evolution and transportation of thrust sheets within the area, the area has undergone five phases of pervasive deformation (D_1 to D_5). Moreover, based on thermos-barometric reference structures given by Passchier and Trouw (2005), the petrographic analysis of the rock sample revealed a deformation temperature of 500°-700°C shown by the dominancy of the GBM and GBAR crystallization in quartz and feldspar.

Alongside, deformation, the area displays an interesting history of magmatism (both acidic and basic magmatic intrusions) and metamorphism (both prograde and retrograde metamorphism with metamorphic inversion along the thrust sheets). The granitic intrusions at the base of the crystalline thrust sheet have metamorphosed to blasto-mylonitic augen gneiss due to the transportation of rock sequence above the MT. Although the area displays

Table 3: Lithostratigraphic correlation of the present study with other researchers.

Kansakar and Chitrakar (1984)	Dhital (2015)	Present study
Chaurjhari Formation		Chaurjhari Formation
Kalagaon Formation MT		Kalagaon Formation
	Stromatolitic Dolomites	Dhading Dolomite
	Pink Quartzites	Nourpul Formation
Simta Phyllites MBT	Simta Phyllites	Dandagaon Phyllite
	Ranimatta Formation	
	Siwalik	Siwalik

quite an interesting deformational history, there are no studies addressing detailed metamorphism and deformation history, it is yet to be explored; which is addressed in this research.

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