Journal of Nepal Geological Society, 2024, Vol. 67, pp. 163–175
https://doi.org/10.3126/jngs.v67i1.74587

Mineralogy and texture of the eastern part of the Palung Granite, Lesser Himalaya, central Nepal

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ABSTRACT

Geological mapping of the granite body along the Kulekhani-Palung area was carried out and the geological boundary of the granite body was well-traced out in 1:25,000 scales. This study investigates the mineralogical and textural characteristics of the Palung Granite, located in the Lesser Himalaya region of central Nepal, with the primary objective of classifying the granitic massif. Field observations, hand sample analysis, binocular observation of individual grains and thin section studies were carried out to assess the mineralogy and texture of the rocks. The Palung massif reveals four distinct types of granites, each showing diverse mineralogical compositions and textures. These granites contain various minerals, including quartz, orthoclase, plagioclase, muscovite, biotite, and tourmaline. Through mineralogical analysis, the granites within the Palung massif were identified as coarse-to-medium-grained quartz-rich granite and pegmatites, coarse-grained feldspar-rich granite with biotite and tourmaline, coarse-to-medium-grained muscovite-tourmaline granite, and coarse-grained biotite-tourmaline granite with a porphyritic texture. Classification according to the QAP system of the International Union of Geological Sciences (IUGS) categorizes these granites into quartz-rich granitoid, monzogranite, granodiorite, tonalite, and quartz monzodiorite. The contact between the granite and surrounding country rocks varies from sharp to irregular.

Keywords: Petrography; Texture; Mineralogy; Palung Granite; Central Nepal

Received: 13 May 2024 **Accepted:** 29 August 2024

INTRODUCTION

The Nepal Himalaya, located in the central segment of the greater Himalayan range, stretches approximately 800 kilometres in length. Within Nepal's Lesser Himalayan region, an array of granitic bodies of varying sizes is scattered, with the Palung Granite being a notable example. Although some past studies have been conducted by both Nepalese and international geologists, these granites have only been partially explored. Various geoscientists have researched different aspects of the Lesser Himalayan granites, as demonstrated by the works of Kaphle (1991, 1992, 1994), Joshi (1978), Bashyal (1981, 1986), Le Fort (1983), Stöcklin and Bhattarai (1977), Stöcklin (1980), Sharma (1993), Mitchell et al. (1973, 1977), Agrawal et al. (1972), Karantha et al. (1977), and Thakur (1983). However, despite these endeavours, a comprehensive mapping of the Palung Granite, particularly concerning its mineralogical composition and textural characteristics, remains incomplete. This study aims to address this gap by conducting an in-depth investigation of the eastern part of the Palung Granite, with a particular emphasis on its mineralogy and texture. The occurrence of Lesser Himalayan granites has been well-documented across various regions within the Nepal Lesser Himalayas. Significant granitic batholiths are observed within the Bhimphedi Group, where they exhibit clear cross-cutting relationships with the surrounding country rocks. However, it is noteworthy that such granitic rocks have not been reported from the Kahun Klippe, situated immediately west of the Kathmandu Nappe, despite the lithological equivalence of these rocks to the Bhimphedi Group (Paudyal and Paudel, 2013). Conversely, recent studies have confirmed the presence of granitic rocks within the Jajarkot Thrust Sheet, further contributing to the understanding of granitic distributions in the region (Lamsal et al., 2023).

Mineralogical and textural analyses are fundamental aspects of understanding the evolutionary history of granite formations. These analyses provide valuable information into the crystallization processes, thermal history, and chemical evolution of granitic bodies, which in turn aid in correlating distinct granitic bodies across the region. By examining the mineral assemblages and textural features, such as grain size, shape, and orientation, a more detailed understanding of the genesis and post-emplacement history of granites can be achieved.

The study area lies in the Thaha Municipality of Makwanpur district, central Nepal, offering a convenient access within approximately three hours of jeep drive from Kathmandu. Covering a significant portion of the topographic maps: 2785-05A (TISTUN-PALUN), 2785-05B (THANKOT), 2785-05C (BHAISE), and 2785-05D (BHIMPHEDI), issued by the Department of Survey, Government of Nepal, the study area encompasses coordinates between longitude 85°00'00"E to 85°11'00"E and latitude 27°31'00" N to 27°40'00" N (Fig. 1).

METHODOLOGY

The study utilized a multi-step approach encompassing desk research, fieldwork, hand sample analysis, laboratory investigation, data analysis, and interpretation. Several geological traverses were conducted along roads, foot trails, and riverbanks to observe lithological properties, mineralogy, textural arrangements, rock orientations, and both primary and secondary structures in the rock bodies. Attitudes of host rocks were measured, and geological boundaries were delineated wherever the traverses were possible.

Fieldwork included zonation mapping of the granite massif, based on dominant mineralogy. Systematic sampling was performed within each demarcated zone. Mineral identification in coarse- to very coarse-grained textures was carried out using hand lenses during field observation. For weathered or fragile samples, binocular microscopy was employed in the lab. Medium- and fine-grained samples were analyzed under thin sections, followed by mineralogical and textural studies under petrologic microscopes. Over one hundred representative samples were collected for such mineralogical as well as textural studies.

Classification of granitic rocks was made based on textural and mineralogical criteria. Visual inspection was performed in the field, while binocular microscopy proved especially useful for fragile, weathered, and fine-grained granites in the lab. Thin sections were utilized for detailed mineralogical analysis of fine-grained samples. The QAP diagram was employed for the classification of each sample. Thin section preparation and analysis were carried out in the laboratory of the Central Department of Geology, Tribhuvan University, Kathmandu. The overall methodological workflow is illustrated in Fig. 2.

RESULTS

A geological map of the study area was produced using a topographical base map at a scale of 1:25,000. Additionally, several cross-sections were constructed to examine the contact relationships between the granitic body and the surrounding rock formations. The geological map reveals that the granitic body exhibits cross-cutting relationships with the adjacent lithological units, including the Kalitar Formation, Chisapani Quartzite, Kulekhani Formation, Markhu Formation, and Tistung Formation (Fig. 3). These lithological unit names follow the nomenclature established by Stöcklin and Bhattarai (1977) and Stöcklin (1980). The geological survey also identified significant evidence of contact metamorphism at the boundary between the granitic body and the surrounding country rocks. Several types of hornfels have developed, with their characteristics depending on the composition and texture of the host rocks in the region. Based on the texture and dominant visible minerals, the granitic pluton has been categorized into four distinct textural-mineralogical classifications (Fig. 3).

Nature of granite boundary and field relation with surrounding rocks

The Palung Granite intrudes various geological units, including quartzite, schists, and marble, primarily as dykes that crosscut the surrounding rock formations. At the contact with schists, garnet-grade metamorphism has developed in several locations, while quartzites and marbles have darkened due to the influx of igneous minerals, particularly tourmaline. Numerous pegmatitic veins, some of which align with the orientations of the host rocks, are also present. The granite is composed predominantly of quartz, feldspar, muscovite, biotite, tourmaline, and other unidentified opaque minerals. In the northern part of the region, the contact between the granite and the host rocks is sharp, whereas in the southern part, particularly around the Lamidada area, the contact becomes

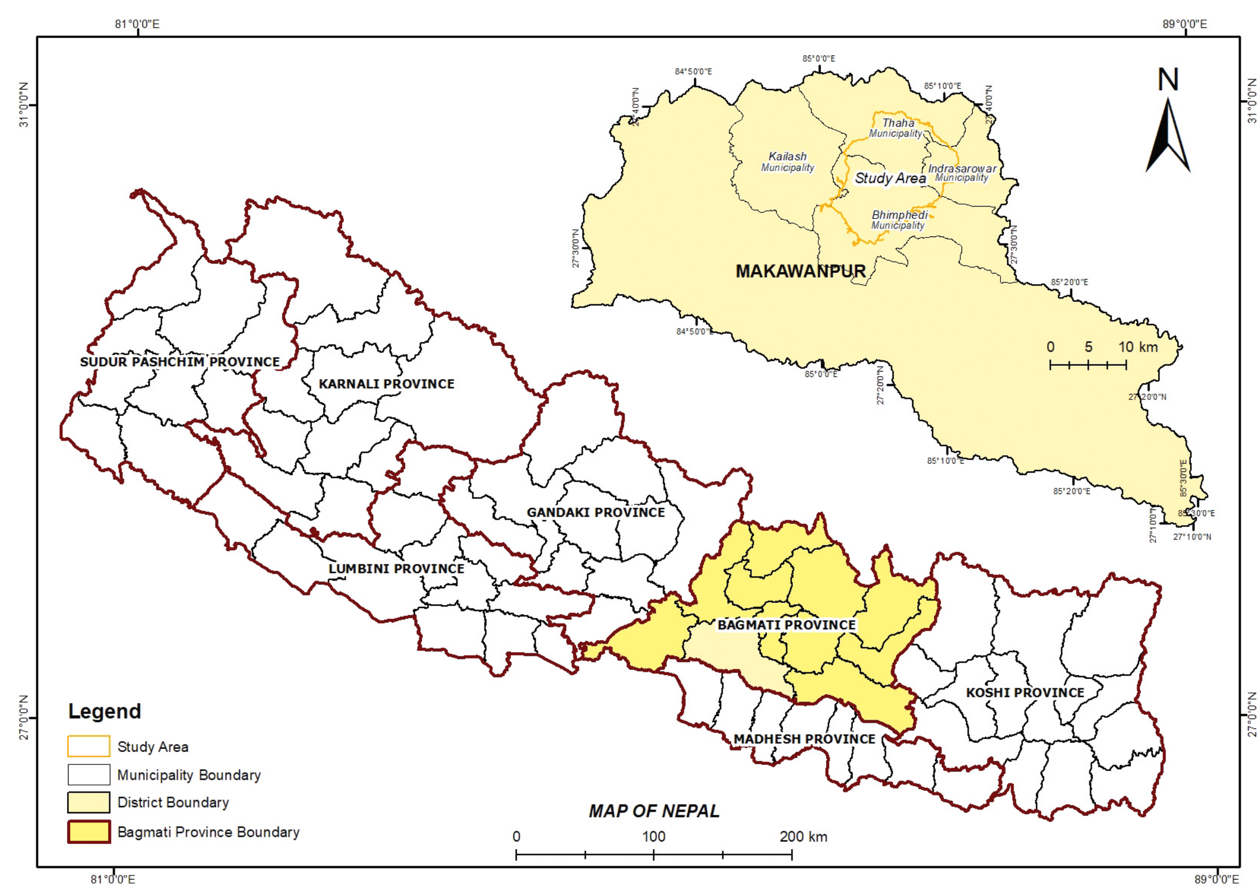

Fig. 1: Location map of the study area.

more irregular (Fig. 3, 4, and 5). The peripheral zones of the granite are characterized by higher quartz content (Fig. 3, Fig. 6a), while the core regions are enriched with feldspar and biotite (Fig. 6b and 6c). The central core of the granite contains large muscovite "books", marked by significantly larger muscovite crystals (Fig. 6d). Xenoliths of the country rock are frequently found within the granite body (Fig. 6e). Additionally, several pockets of leucogranites and pegmatites (plagioclase-rich granites with crystals larger than 1 cm) have been identified in the contact regions (Fig. 6f). Gently dipping granite bodies having irregular contacts with the host formations have been observed in the Chau Khola, Jurikhet Khola, and Mandu Khola areas.

Classification of granite based on texture and structure

The Palung Granite can be separated into several zones depending on mineralogical constitution such as quartz, feldspar, biotite, muscovite, tourmaline, and texture. Based on the mineralogy and grain size, Palung Granite can be divided into coarse-to-medium-grained quartz-rich granite and pegmatites, coarse-grained feldspar-rich biotite tourmaline granite, coarse-to-medium-grained muscovite tourmaline rich granite, and coarse-grained biotite tourmaline rich granite with porphyritic texture (Fig. 3, Fig. 4, and Fig. 5). By texture, the whole body of granite has very-coarse to medium-grained in nature. Each of these mineralogical-textural classification of granites is briefly described in the following sections:

Coarse to medium-grained quartz-rich granite and pegmatites

The dominant mineral in the Palung Granite is quartz, constituting approximately 35-45% of the rock, primarily in the form of smoky and grey quartz. The quartz grains exhibit an anhedral to subhedral morphology, with sizes ranging from 0.1 to 0.7 cm. Plagioclase feldspar is the second most abundant mineral, comprising 15-25% of the granite, with grain sizes varying from 0.2 cm to 3 cm. Tourmaline is present in smaller amounts, accounting for 5-10% of the composition, with grain sizes between 0.1 and 0.2 cm. Biotite, making up 4-6% of the granite, has a maximum grain size of 0.2 cm. Alkali feldspars occur in minimal proportions. This felsic granitoid lacks mafic minerals and forms a broad zone in the peripheral areas of the granite body (Fig. 3).

Coarse-grained feldspar-rich biotite tourmaline granite

This granite exhibits a greyish to white colour and possesses a medium- to coarse-grained texture. It contains varying proportions of quartz, plagioclase feldspar, biotite, muscovite, and tourmaline (Fig. 3, 7 and 8). Predominantly, the granite is characterized by porphyritic crystals of feldspar, primarily plagioclase, which can reach sizes up to 2.5 cm and account for 40-50% of the granite mass. Quartz, another essential mineral, occupies approximately 30-35% of the rock mass, with grain sizes ranging from 0.2 mm to 5 mm, while alkali feldspar is present in fine-grained size and constitutes less than 10% of the granite. Accessory minerals such as tourmaline, biotite, and muscovite are also prevalent. Tourmaline, appearing black, comprises about 5-10% of the composition and exhibits elongated needles ranging in size from a few mm to 1.0 cm. Sheets of transparent muscovite flakes and dark grey biotite occupy about 10-15% of the granite, with sizes varying from 0.1 mm to 10 mm. This granite zone undergoes significant weathering and exhibits alteration to kaolin-type clay minerals.

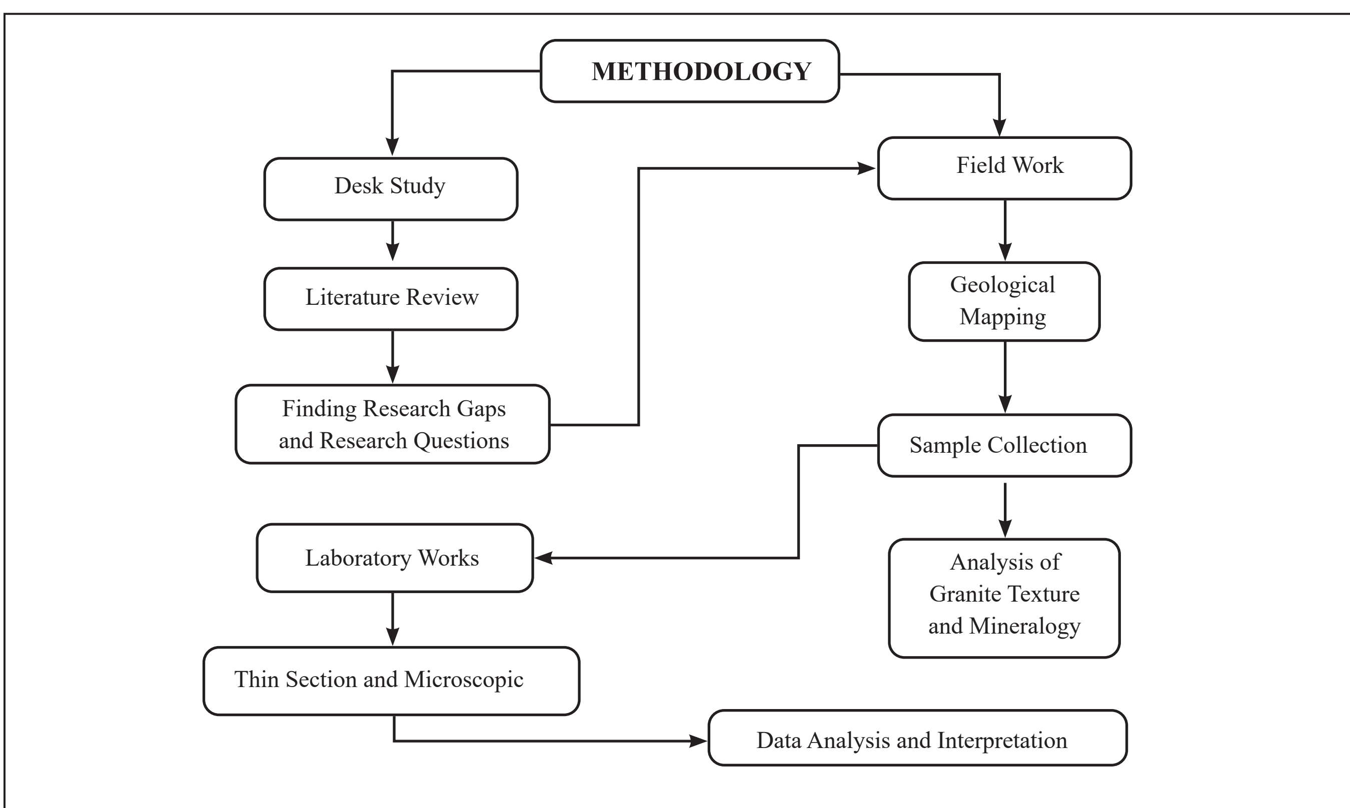

Fig. 2: Flow chart of the methodology adopted in the study.

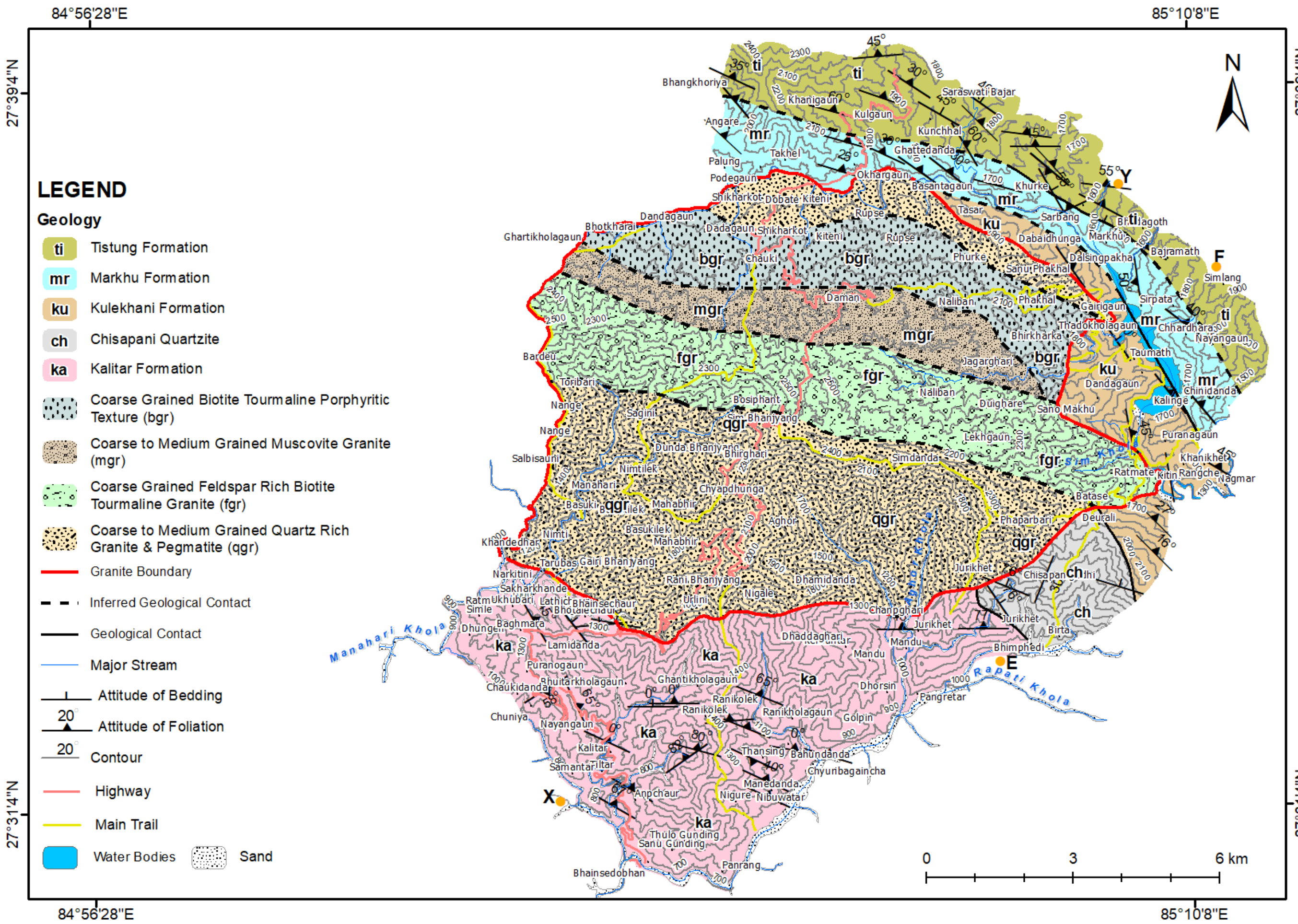

Fig. 3: Geological map of the Palung Granite showing textural-mineralogical zonation. The red line inside the map borders the granitic body.

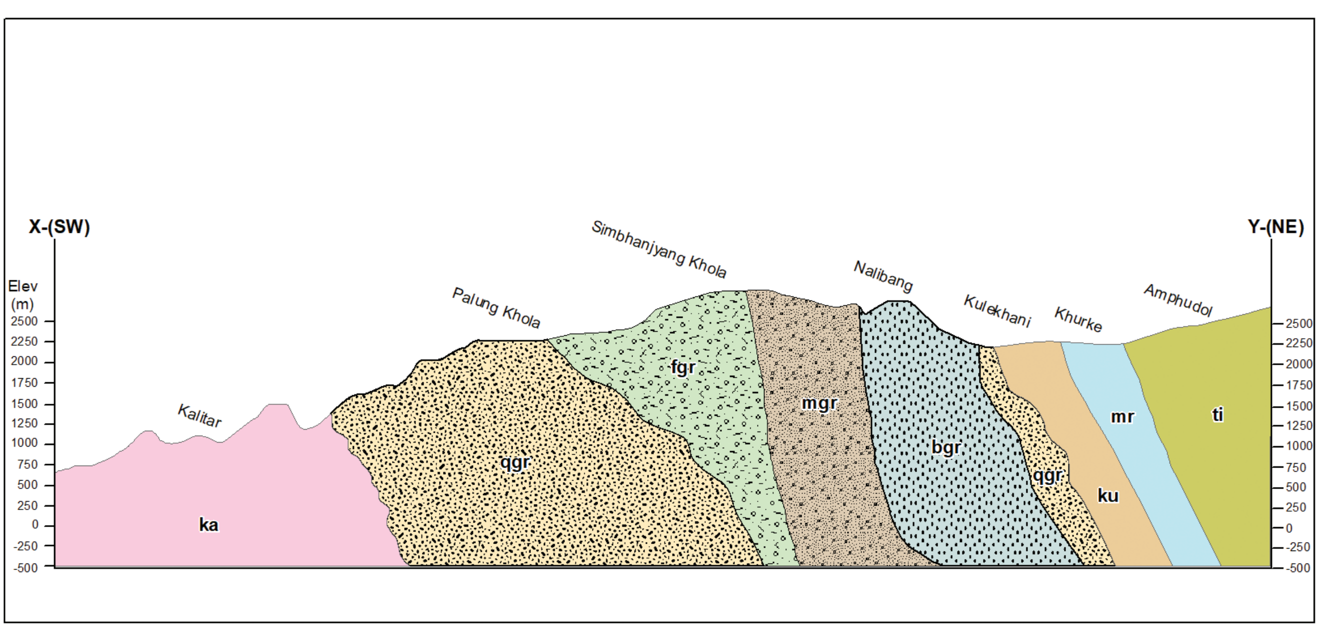

Fig. 4: Geological cross section along X and Y. Four zones of the granitic body are shown through this section.

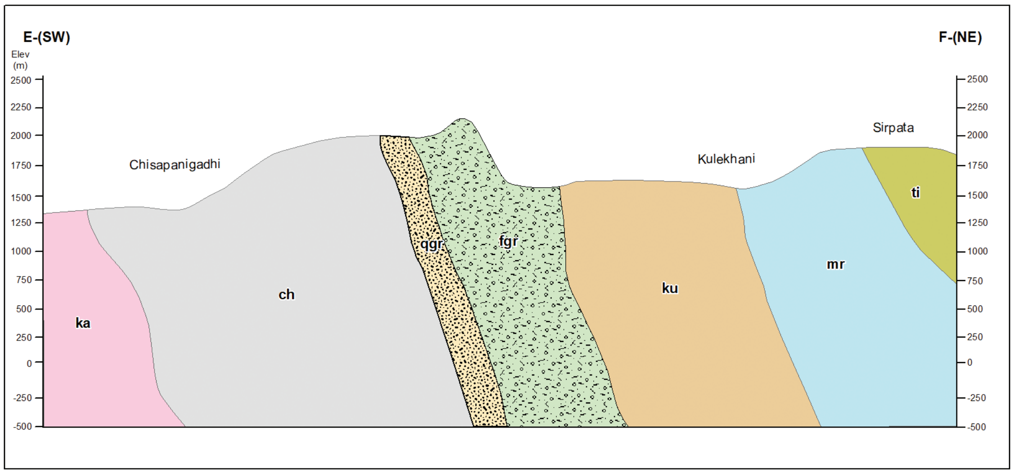

Fig. 5: Geological cross-section along E and F. Two zones of the granite body are distinct in this section.

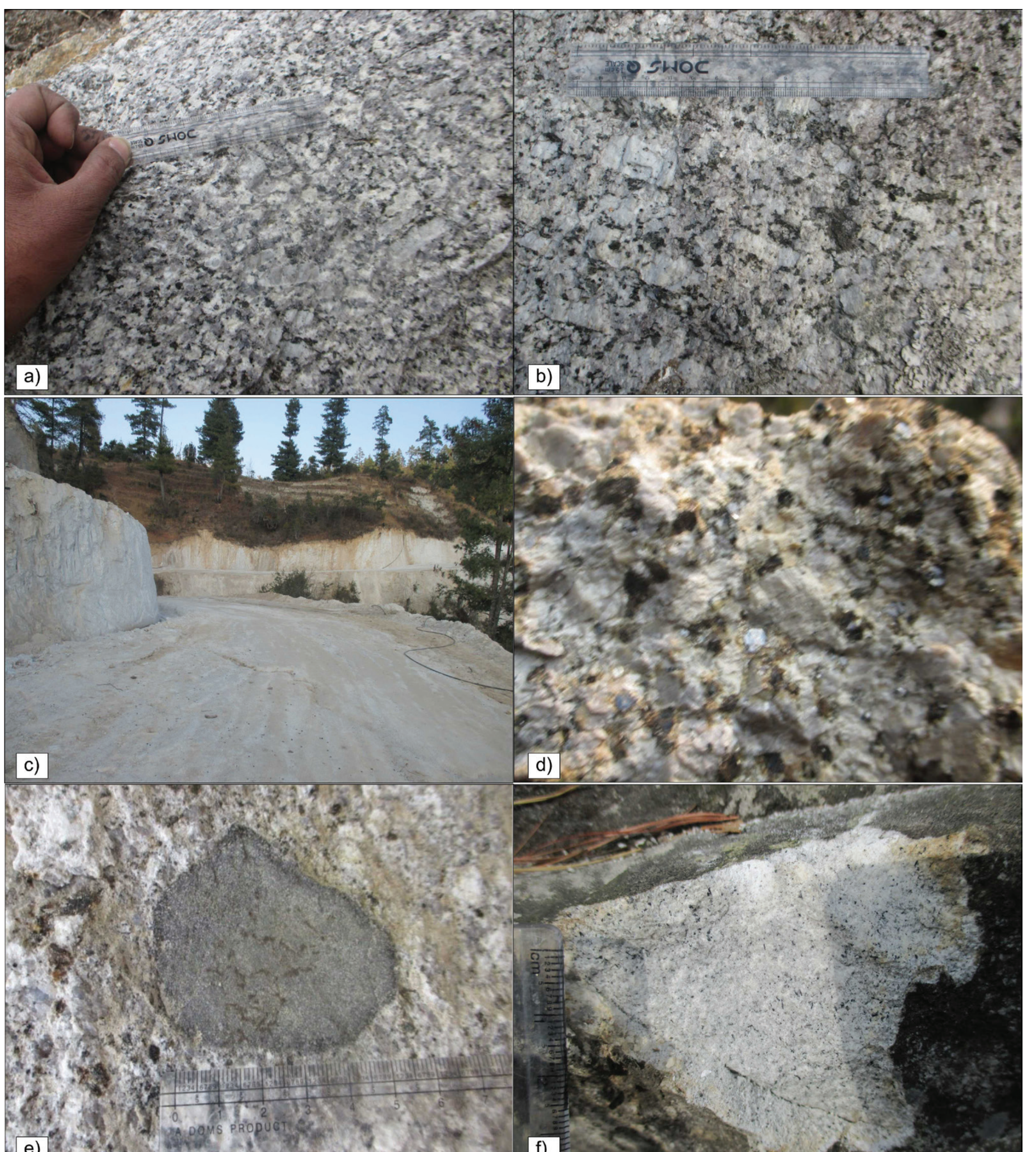

Fig. 6: (a) field photograph showing quartz-rich granite at the Mahabhir area, (b) photograph showing feldspar granite (granodiorite) at Simbhanjyang, (c) photograph showing feldspar granite (~tonalite) at Simbhanjyang, (d) photograph showing coarse-medium grained muscovite tourmaline granites at Daman (e) photograph showing metasandstone inclusion found in granite at Dhamidanda, and (f) photograph showing leucogranite at Jurikhet area.

Coarse- to medium-grained tourmaline-bearing muscovite-granite

The granite found along the Shangkhamul Khola section is characterized by a medium-to-coarse-grained texture and exhibits hues ranging from brownish to greyish. It contains a combination of quartz, feldspar, muscovite, and tourmaline. The Plagioclase feldspar crystals are typically white to brown, with sizes ranging from 0.2 to 0.4 cm, constituting approximately 40 to 50% of the granite's composition. Quartz crystals, appearing brownish and white, are transparent and can reach sizes of up to 1 cm, accounting for 35 to 50% of the granite mass. Tourmaline, observed as black, opaque, and needle-shaped, comprises approximately 7-10% of the granite's composition, Muscovite, exhibiting hues from brownish to white and transparent, occurs in the form of flakes up to 0.3 cm in size, representing 15-20% of the granite's composition and other minerals are opaques. The presence of dominant muscovite is taken as the basis of zonation mapping.

Coarse-grained tourmaline-bearing biotite-granite with porphyritic texture

Biotite is taken as the dominant mineral for the classification. Porphyritic granite displays a grayish to white hue and a medium-to-coarse-grained structure, comprising quartz, feldspar, biotite, and tourmaline. The feldspar crystals, measuring up to 2.5 cm, constitute 40-50% of the composition, while smoky quartz accounts for 30-40%. Biotite crystals, ranging from dark brown to black and sized at 0.5 cm, make up 10-20% of the rock. Tourmaline, appearing as small black needles, comprises 5-10% of the composition, and muscovite, ranging from white to brown, represents 3-5% (Fig.3).

Classification of granite based on mineralogy

The QAP diagram serves as a tool for classifying igneous rocks based on their mineralogy. It utilizes three mineral groups: Q (quartz), A (alkali feldspar), and P (plagioclase), with their percentages recalculated to sum up to 100%. The triangular plot of minerals revealed five predominant types of granites present within the surveyed areas: quartz-rich granitoid (~granite), monzogranite, granodiorite, tonalite, and quartz monzodiorite. An attempt was made to map these five types of acidic rocks over the geological map. However, due to the limited extent of monzo-granite, and quartz monzodiorite, only three major zonations were used for the map preparation (compare Fig. 7 and Fig. 8).

Petrography

Thin sections of representative samples from each granite type as fine-grained as possible were selected for the petrography (Fig. 9). Quartz-rich granite has larger porphyritic grains of plagioclase feldspars (Fig. 9a). The percentage of minerals

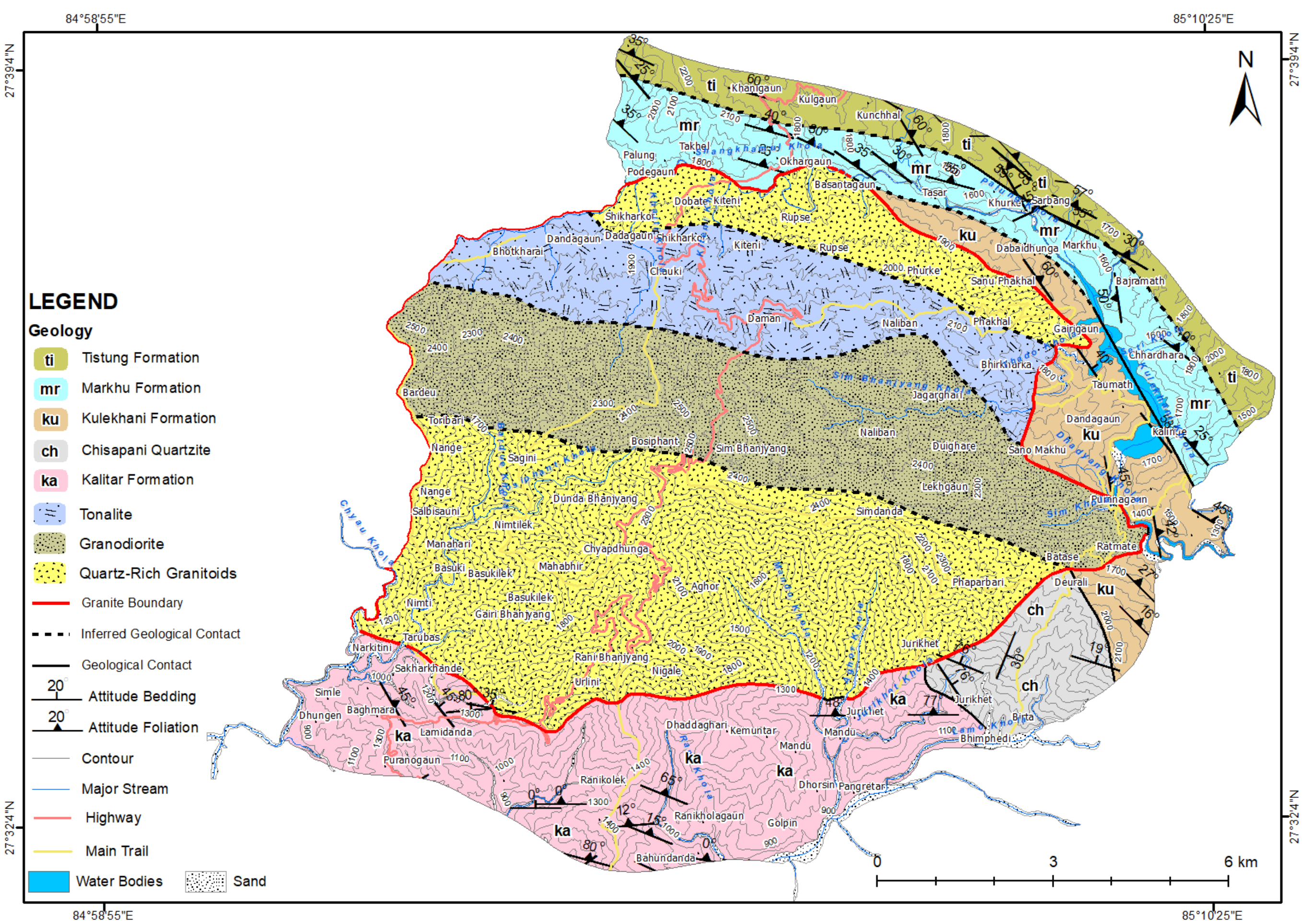

Fig. 7: Map showing the different granite zones following the IUGS classification.

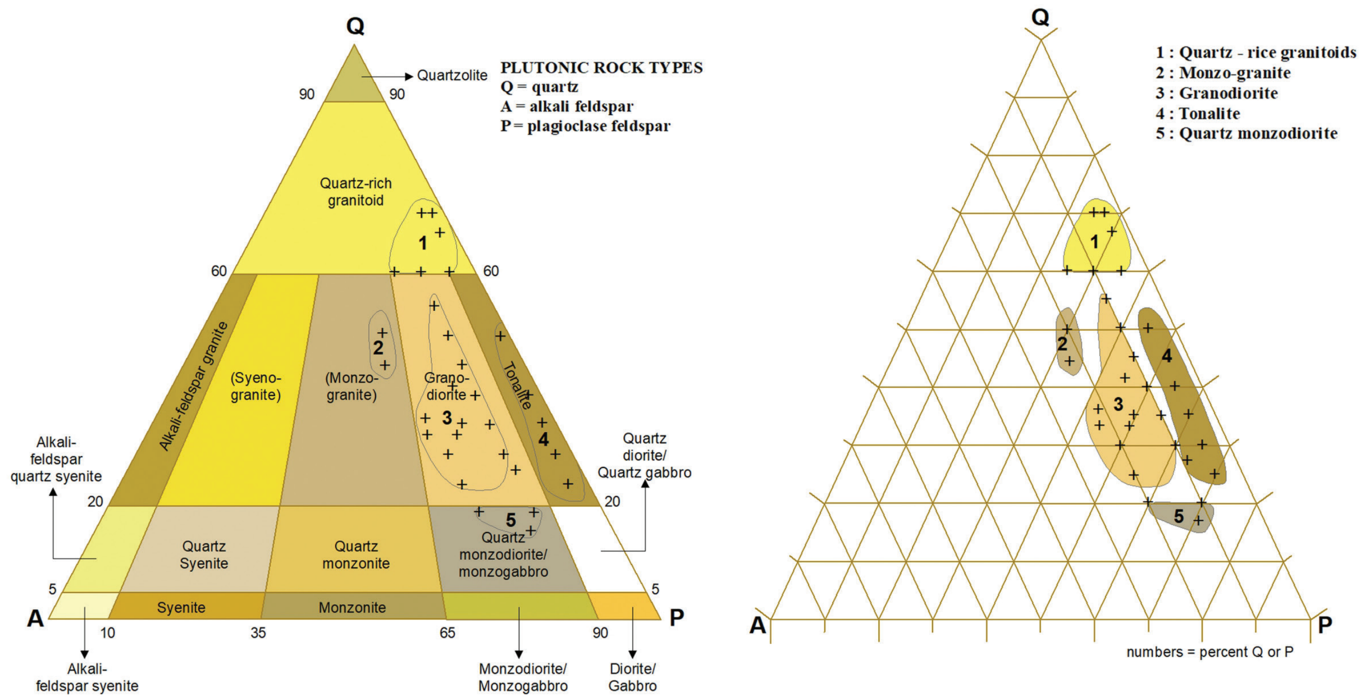

Fig. 8: QAP diagram showing the sub-classes of the Palung Granite based on an essential mineral percentage (the left figure is the standard classification proposed by Streckeisen, 1973, and the right one is the present work). See supplementary tables used for the classification in Annex 1, Tables 1-3.

visually estimated as ~40% quartz, ~30% plagioclase, ~10% tourmaline, ~15% muscovite with minor proportion of biotite and ~5% opaques. Porphyritic texture indicates the two-cooling history of the magma during crystallization. The early formed crystals were sufficiently larger with sufficient time and nucleation rates. However, later the rock could have been cooled faster. Another sample taken from the feldspar-rich zone consists of dominancy of both plagioclase (~25%) and orthoclase (~20%) feldspars along with the well-developed biotite (~25%), tourmaline (~10%) and quartz (~20%) (Fig. 9b). Orthoclase has developed some secondary minerals (alteration product) like sericite inside it. Another sample taken from the tourmaline-muscovite-containing granite shows abundant quartz (~30%), and muscovite (~20%) in addition to the tourmalines (~30%), plagioclase (~10%) and other unidentified opaques (~10%) ((Fig. 9c). tourmaline-biotite containing granite was also studied under the thin section (Fig. 9d). This type of granite has ~25% quartz, ~25% plagioclase, ~25% tourmaline and ~25% micaceous minerals dominantly biotite. The grain size of minerals ranges from 1.0 mm to 1.5 cm. In the case of very coarse-grained samples, the single grain covers the whole field of vision of the microscope. Therefore, fine-grained samples were used for the petrography analysis under thin section. For coarser samples, binocular observation was made for the mineralogy and grain size determination.

DISCUSSIONS AND CONCLUSIONS

The evolution of granite, tonalite, monzogranite, and quartz monzodiorite involves a series of geological processes primarily related to the cooling and crystallization of magma deep within the Earth's crust. Granite forms from the slow cooling and solidification of magma deep within the Earth's crust. It is primarily composed of quartz, feldspar, and mica minerals. Granite typically forms in large, intrusive bodies called plutons. Over time, as the magma cools, minerals crystallize, and granite structures can become exposed through erosion or tectonic activity (Winter, 2012). Tonalite is a granitic rock like granite but with a higher proportion of plagioclase feldspar relative to alkali feldspar. It forms through the crystallization of magma in the lower to middle crust (Best, 1986). Tonalite tends to have a lighter colour compared to granite due to its higher plagioclase content. Monzogranite is a granitic rock that contains roughly equal amounts of alkali feldspar and plagioclase feldspar, along with quartz and typically some mica. It forms from the crystallization of magma with intermediate silica content (between granitic and dioritic compositions). Monzogranite often occurs in association with other granitic rocks in plutons and batholiths (Winter, 2012). Quartz monzonite is a plutonic igneous rock that contains more quartz and alkali feldspar than plagioclase feldspar. It is like monzogranite but has a higher proportion of quartz. Quartz monzodiorite forms through the slow cooling of magma within the Earth's crust, typically in large intrusive bodies. It often has a speckled appearance due to the presence of quartz and feldspar crystals. The Palung Granite is a large batholith whose area is about 170km^2, however, the present study area represents only the Eastern part of Palung Granite, and it is about~143 km^2. The magmatic event for the development of the Palung Granite, as it is a part of the Lesser Himalayan granite, is still controversial and needs more studies in terms of geochronology and petrology (Mitchell et al. 1973,

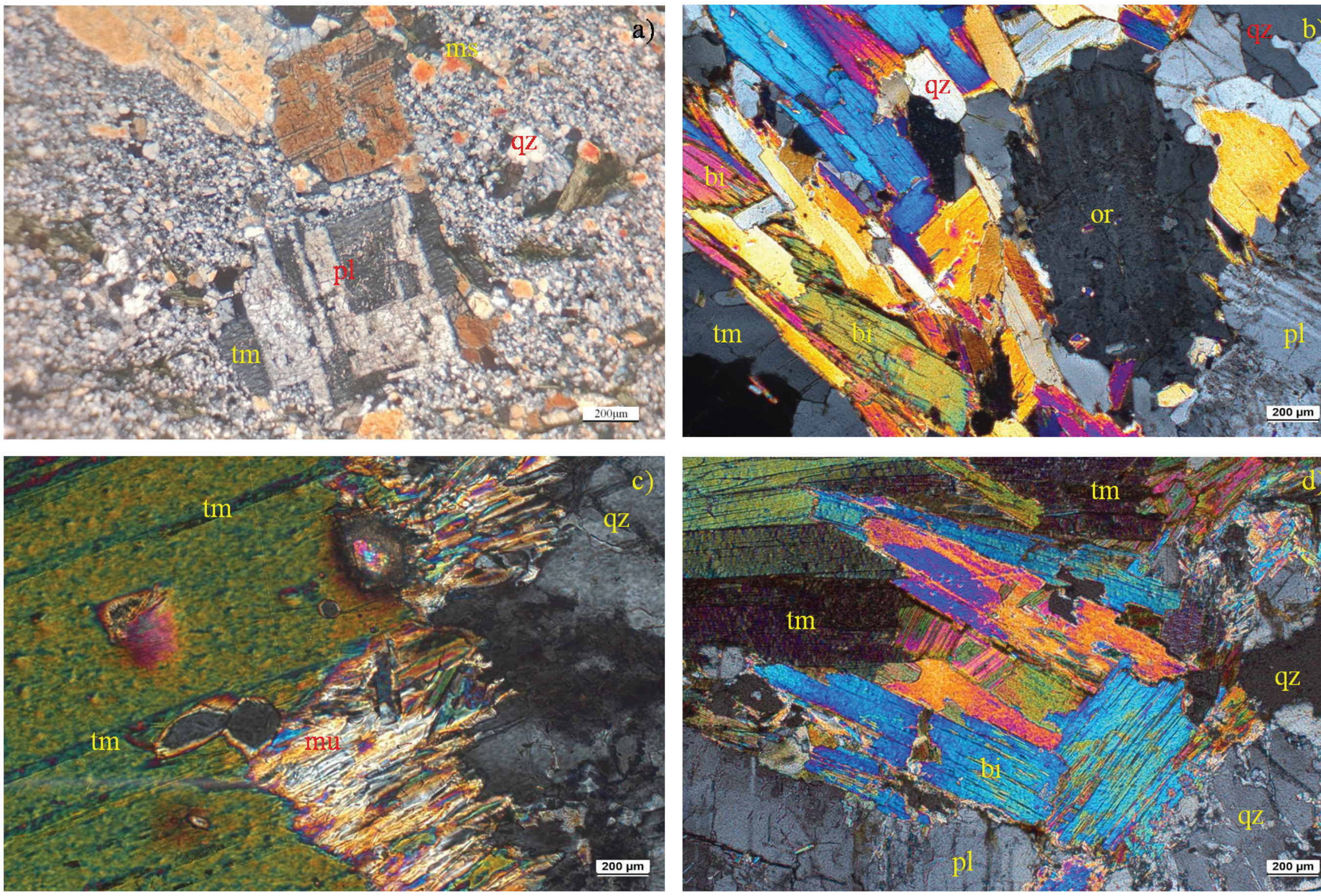

Fig. 9: Photomicrographs of (a) porphyritic granite taken from the Mandu Khola section, near Nigale; (b) feldspar-rich granite taken from the Sim Khola section, near Ratmate; c) granite with abundant tourmaline and muscovite, sample taken from Daman; and d) microphotograph showing abundant tourmaline and biotite, sample taken from Chauki. For the names of these places see the geological map at Fig. 3.

1977; Islam et. al, 2005). In the present case, due to the deep weathering of the granitic body, the mineralogical study is very difficult. It is a granitoid, not perfect granite in nature. To verify the type of granite, many granite samples were taken from different sections and were analyzed systematically. The study showed that the granitic body can be categorized under five different classes. These are the quartz-rich granite, monzogranite, granodiorite, tonalite, and quartz monzodiorite. Among these classes of acidic rocks, monzogranite and quartz-monzodiorite have very limited extensions in the field. Therefore, only three zones have been shown on the map for the eastern part of the Palung Granite. The most noteworthy is the presence of quartz-rich granite at the peripheral part of the pluton and feldspar-rich granite, biotite-rich granite, and muscovite-rich granite at the central part of the granite body. Tourmaline's occurrence, generally in the later stages, suggests the role of volatile-rich fluids in the granite's evolution, while biotite minerals as the earlier crystallization point to medium-temperature conditions during the initial cooling of the magma. By principle, biotite usually crystallizes before tourmaline due to its higher crystallization temperature. Tourmaline, being more dependent on the availability of boron and other volatiles, forms later. The presence of fluids rich in volatiles such as boron is crucial for tourmaline formation. These fluids can also influence the growth of biotite, particularly in the later stages of crystallization when the magma is more evolved. In the present case, the zonation of minerals indicates the perfect differentiation of magma during crystallization in the case of Palung Granite.

Additionally, the quartz-rich granite at the marginal part may be the result of the assimilation of granite with the host rocks. The boundary of the batholith with the country rocks is discordant, and irregular with corrosive boundaries in several places and sharp in several places. Contact metamorphism is significant in the contact zones with the host rocks. Several types of hornfels are reported at the contact zones. These hornfelsic zones are developed in rock units like the Chisapani Quartzite, Kulekhani Formation, Markhu Formation in several places. The geology and metamorphism related to the Palung Granite are not detailed in this paper; the research is underway for this part. The xenoliths of the country rocks show the magmatic assimilation during its emplacement. Evidence of magmatic assimilation in xenoliths includes textural changes, mineral alterations, and corrosive boundaries at the contact. The granitic body was formed due to the slow cooling of the acidic magma relatively at a greater depth as justified by the coarse-grained texture. The bimodal distribution of minerals in the rock mass also indicates at least two cooling histories during the solidification process. Sometimes, three modal sizes are also observed in the rocks. However, such rocks are isolated as pockets.

In conclusion, it can be said that the whole pluton of granite was well-differentiated forming the four distinct mineral and texture-based zones. These are the quartz-rich granites, feldspar-rich granites, and tourmaline granites with muscovite-rich and biotite-rich phases. These granitoids as per the IUGS system, can be classified under five types of distinct classes: quartz-rich granites, monzo-granite, granodiorite, tonalite and quartz monzodiorite. The mafic composition of these granitoids is minimal and negligible for the classification. The remaining part of the Palung Granite located in the western section of the present location is under study.

ACKNOWLEDGEMENT

The authors express sincere gratitude to the Central Department of Geology, Tribhuvan University, Kirtipur, Kathmandu for the facilities provided for the petrographic laboratory. We are thankful to Bipin Adhikari for his support in thin section preparation, and field data analysis and to Sunil Lamsal and Ashok Dhakal for computer settings.

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Supplementary Tables

Table 1: Table showing the results of the QAP plot for Granodiorite field.

S.N.	Location		Recalculated % of minerals			Rock type according to QAP plot
	Northing	Easting	Quartz	Alkali Feldspar	Plagioclase Feldspar	
1	3056698	608164	36	21	43	
2	3056320	6103365	30	10	60	
3	3056101	610905	35	15	50	
4	3054824	608011	40	10	50	
5	3053598	607418	30	20	50	
6	3050827	606402	37	12	40	
7	3051156	613224	50	10	40	Granodiorite
8	3053868	606484	40	10	50	
9	606314	3053863	30	10	60	
10	3053836	606130	30	10	60	
11	3054833	605803	30	10	60	
12	3055225	608808	40	10	50	
13	3055216	6088849	30	10	60	
14	3055132	608898	40	10	50	
15	3055172	608928	40	10	50	
16	3055160	609108	30	10	60	
17	3055215	609194	30	10	60	
18	3055291	609191	40	10	50	
19	3055426	609504	40	10	50	
20	3055577	609850	30	20	50	
21	3055408	609986	30	10	60	
22	3055214	610248	40	10	50	
23	3055156	610415	30	10	60	
24	3055023	610886	30	10	60	
25	3055012	611165	30	10	60	Granodiorite
26	3054979	611266	40	10	50	
27	3054809	611944	30	20	50	
28	3054871	611902	40	10	50	
29	3055090	611593	30	10	60	
30	3055152	611571	35	15	50	
31	3055397	611587	40	10	50	
32	3054711	611951	30	10	60	
33	3054551	611929	40	10	50	
34	3054495	611920	40	10	50	
35	3054393	612186	30	10	60	
36	3054368	612278	40	10	50	
37	3054314	612457	30	10	70	
38	3054286	612503	40	10	50	
39	3052245	614171	40	10	50	
40	3052129	614206	50	10	40	
41	3052070	614299	30	10	60	

S.N.	Location		Recalculated % of minerals			Rock type according to QAP plot
	Northing	Easting	Quartz	Alkali Feldspar	Plagioclase Feldspar	
42	3052052	614279	50	10	40	Granodiorite
43	3051469	614398	50	10	40	
44	3051301	614204	30	15	45	
45	3051266	614242	35	10	55	
46	3051152	614182	30	20	50	
47	3051084	614097	40	10	50	
48	3051291	613554	50	10	40	
49	3051130	613503	50	10	40	
50	3049404	611386	40	10	50	
51	3049274	611327	30	10	60	
52	3049261	611262	50	10	40	
53	3049283	611087	30	10	60	
54	3049318	610833	30	20	40	
55	3049402	610583	30	20	50	
56	3049380	610466	30	10	60	
57	3049415	610361	35	10	55	
58	3049371	610076	50	10	40	Granodiorite
59	3049223	609880	40	10	50	
60	3048585	603839	30	20	50	
61	3048571	603904	30	20	40	
62	3048704	604010	40	10	50	
63	3048729	604099	50	10	40	
64	3048630	604210	40	10	50	
65	3048539	604138	30	20	40	
66	3051319	605758	50	10	40	
67	3050883	605371	30	10	60	
68	3050787	605270	25	20	55	
69	3050803	604951	40	10	50	
70	3050817	604925	45	10	45	
71	3050862	604889	50	10	40	
72	3051059	604584	30	10	60	
73	3051128	604521	20	20	60	
74	3051154	604427	40	10	50	
75	3050975	604565	30	10	60	
76	3050518	604725	30	10	60	
77	3050004	604735	30	10	60	
78	3050143	604942	40	10	50	
79	3049269	605823	30	10	60	
80	3049683	606048	40	10	50	
81	3049620	606424	30	10	60	
82	3049546	606748	40	10	50	
83	3049339	607141	50	10	40	
84	3057581	610264	50	10	40	

S.N.	Location		Recalculated % of minerals			Rock type according to QAP plot
	Northing	Easting	Quartz	Alkali Feldspar	Plagioclase Feldspar	
85	3053152	607335	30	10	60	Granodiorite
86	3053836	606130	40	10	50	
87	3056818	608261	50	10	40	
88	3056364	609385	40	10	50	
89	3056429	610109	40	10	50	
90	3054422	610434	30	10	60	
91	3056396	610647	30	20	50	
92	3056512	610945	30	10	60	
93	3054526	612134	30	10	60	
94	3054236	612873	30	10	60	
95	3048039	604531	40	10	50	
96	3049662	606097	40	10	50	
97	3049019	607457	40	10	50	
98	3049008	607276	30	10	60	
99	3053264	607169	55	10	35	

Table 2: Table showing QAP result in quartz-rich granitoid.

S.N.	Location		Recalculated % of minerals			Rock type according to QAP plot
	Northing	Easting	Quartz	A. Feldspar	P.Feldspar	
1	3050948	611791	60	5	35	Quartz rich granitoid
2	3050888	611415	70	5	25	
3	3053152	607335	60	3	27	
4	3053388	607119	60	5	35	
5	3053461	607060	70	3	27	
6	3053673	606892	60	10	30	
7	3053764	606641	60	10	30	
8	3053803	606050	60	10	30	
9	3053687	605976	60	15	25	
10	3053638	605951	70	5	25	
11	3053671	605904	60	10	30	
12	3053685	605912	60	10	30	
13	3053926	605609	70	5	25	
14	3054130	605526	60	10	30	
15	3054232	605543	70	5	25	
16	3054311	605559	60	10	30	
17	3054359	605582	60	10	30	
18	3054581	605641	70	5	25	
19	3055557	609724	70	5	25	
20	3052132	614274	60	10	30	
21	3052085	614321	60	5	35	
22	3052115	614265	60	10	30	
23	3051996	614244	60	10	30	
24	3051928	614262	70	5	25	
25	3051879	614276	60	10	30	

S.N.	Location		Recalculated % of minerals			Rock type according to QAP plot
	Northing	Easting	Quartz	A. Feldspar	P.Feldspar	
26	3049475	610215	60	10	30	Quartz rich granitoid
27	3049351	610046	60	10	30	
28	3048933	604239	60	5	35	
29	3051176	605665	60	10	30	
30	3050835	605011	60	10	30	
31	350256	604738	60	10	30	
32	3049345	605911	60	5	35	
33	3049264	607455	60	10	30	
34	3049344	607683	60	10	30	
35	3049414	608125	70	5	25	
36	3049211	608529	60	10	30	
37	3057366	610160	60	10	30	
38	3056897	609906	60	5	35	
39	3056798	607219	60	10	30	

Table 3: Table showing QAP results in tonalite

S.N.	Location		Recalculated % of minerals			Rock type according to QAP plot
	Northing	Easting	Quartz	A. Feldspar	P.Feldspar	
1	3055292	608762	30	5	65	Tonalite
2	3055456	609202	30	5	65	
3	3055168	610118	30	5	65	
4	3055036	610610	40	5	55	
5	3055035	611079	40	5	55	
6	3055095	611498	30	5	65	
7	3054258	612551	30	5	65	
8	3054121	612818	30	5	65	
9	3052431	614109	30	5	65	
10	3048880	604253	50	5	45	
11	3050105	604759	40	5	55	
12	3053372	607118	35	5	60	
13	3053809	606574	40	5	55	
14	3056610	608470	35	5	60	
15	3054350	612435	40	5	55	
16	3049425	605915	35	5	60	
17	3048818	605760	25	5	70	
18	3055077	610592	30	5	65	