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Geological and Structural Framework of Lansdowne, Garhwal Himalaya, Uttarakhand India

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Abstract : This study examines the geological features of the Lansdowne area in the Garhwal Lesser Himalaya. Age of the rocks are Precambrian to Paleozoic. The Lansdowne region showcases intricate geological features, encompassing various stages of deformation, and notable compositional changes from granite-to-granite gneiss and augen gneiss. Detailed field analyses of the rock formations and geological structures suggest significant tectonic movements which are marked by the presence of fault, joint sets, and fault gouge zones. The lithological variation in the rocks to understand the different tectonic activities and metamorphism in the area. Thecentral part of Lansdowne, which is characterized by porphyritic granite, shows less intense deformation. This study highlights the importance of geological structure of the thrust area. The shear sense indicators determine NW-SE direction of the rocks and transportation of the area along SE direction along the Lansdowne thrust.

Keywords: Lansdowne granite and gneiss, Garhwal Himalaya, fault, joint sets and shear sense indicator.

1. INTRODUCTION

The Himalayas, situated on the southern edge of the Tibetan Plateau, are the youngest mountain range in the world, extending approximately 2,500 kilometers from west to east. This arc-shaped range, convex to the south, features syntaxial bends at both its western and eastern extremities. The formation of the Himalayas is attributed to the collision between the Indian and Eurasian tectonic plates, a process that continues today and results in the uplift of the highest mountain range on Earth. The range spans from Nanga Parbat, at 8,138 meters in the northwest, to Namcha Barwa, which rises to 7,756 meters in the northeast. Its width varies significantly, measuring around 350 kilometers in the west (Kashmir) and narrowing to about 150 kilometers in the east (Arunachal Pradesh). This continental convergence has led to substantial crustal shortening, facilitated by southward-directed tectonic deformation, which has transported thrust sheets along the Himalayas. The study area lies in the Lesser Himalaya.

This region is composed of Precambrian and Cambrian rock formations, including the Jaunsar-Garhwal, and Mussoorie Groups of rocks [1] The area consists of the Lansdowne formation of the Almora group of the rocks. lithological the area consists of granite, granite gneiss and augen gneiss with metasedimentary rocks of the Amri member. The granitic rocks show the contact with metasedimentary depicts the thrust called Lansdowne thrust. In the field some structures are observed such as thrust, fault, joint sets, gouges, folds, and shear sense indicators. Tectonic sub division of the Himalaya shown in the figure 1.

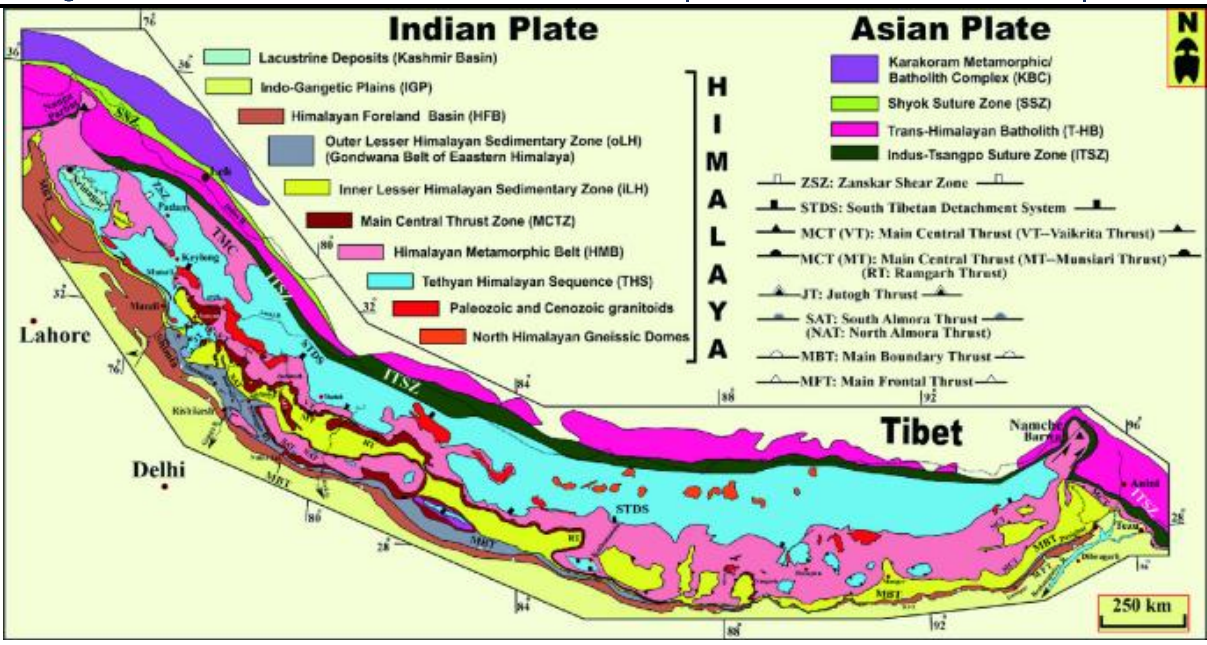

Fig. 1 Tectonic subdivision of the Himalaya.

2.GEOLOGICAL SETTING

The Garhwal Himalaya forms part of the Lesser Himalayas, bounded by the Main Boundary Thrust (MBT) to the south and the Main Central Thrust (MCT) to the north [2]. Lansdowne, a town in the Pauri Garhwal district of Uttarakhand, lies within this region. The Lansdowne granitic gneisses are part of the Amri tectonic unit of the Garhwal nappe [3], and the area is marked by a tectonic contact between these granite gneisses and the underlying Lansdowne metamorphites [4]. These metamorphic rocks have undergone polyphase progressive regional metamorphism, reflected in three distinct deformational and folding events [5]. The region hosts a unique mineral assemblage, including chloritoid, staurolite, kyanite, andalusite, and quartz. The granitic rocks have been transformed into augen gneiss, mylonites, and phyllonites, indicating significant deformation [4]. Geochemical alterations, such as muscovitization, tourmalinization, and greisenization, further highlight the effects of these tectonic processes. The textural and geochemical changes in the rocks are directly tied to the deformational and folding events that have shaped the Lansdowne area. The granitic gneisses in the region are well foliated, extending northwest to Bhayansu on the steep slopes of Lansdowne Hill. They occupy the core of the Lansdowne synform. The litho-tectonic succession of the Lansdowne area is depicted in the figure 2 and the geological map of the region in the figure 3.

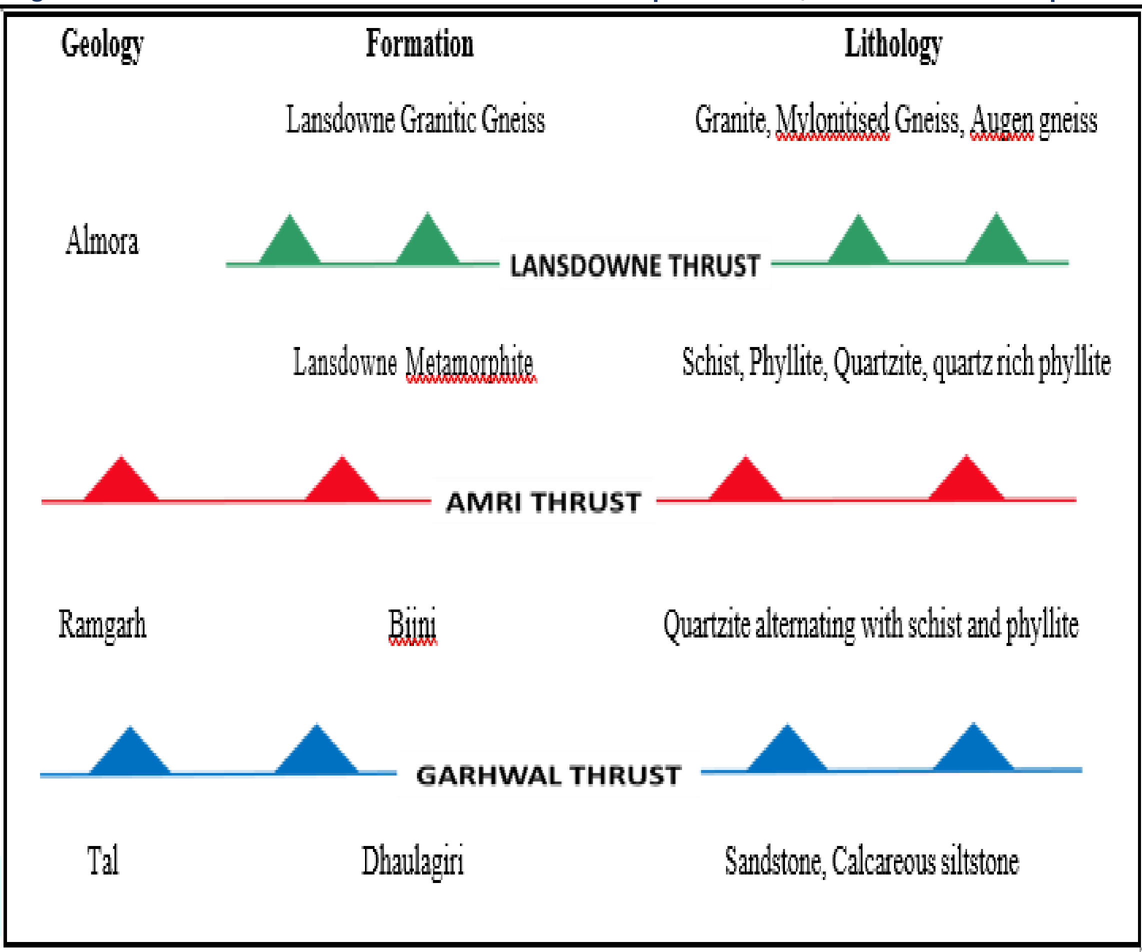

Fig.2 Litho tectonic subdivision of the study area [10]

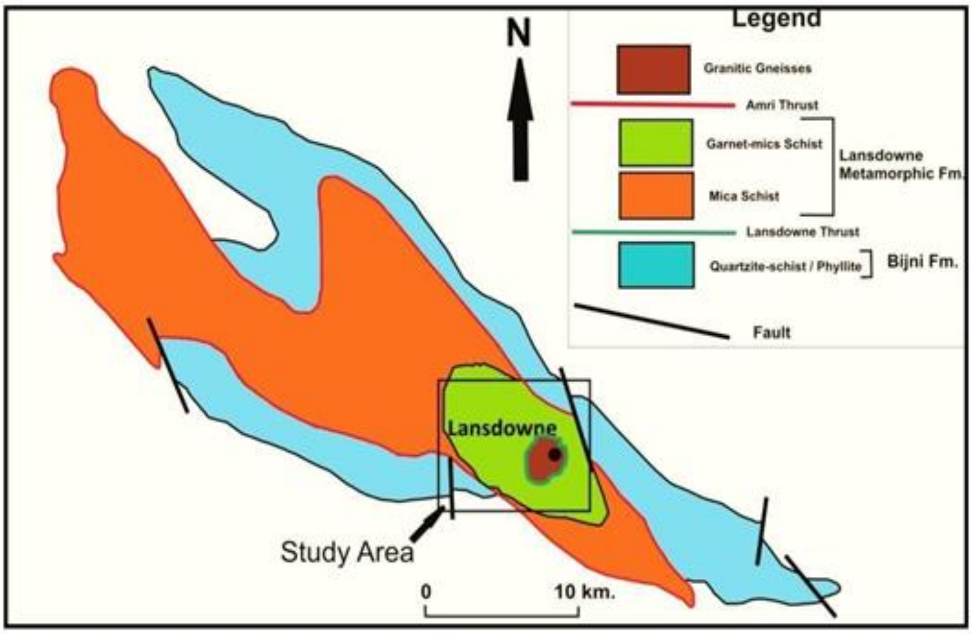

Fig. 3 Geological map of Lansdowne area (after Fuchs and Sinha, 1978)

3. MATERIAL AND METHOD

This research involved extensive fieldwork to gather data on the geological structures, compositional variations, and lithological changes in the Lansdowne area. Potential study sites were first identified using topographic and geological maps, with a focus on both accessibility and geological significance. At each site, a Global Positioning System (GPS) was used to record the latitude and longitude, with the coordinates and site identification numbers noted in a field notebook. The foliation trends of rock outcrops were measured using a Brunton compass, with multiple readings taken at each location to ensure accuracy. A 10x hand lens was employed to closely examine mineral compositions, allowing for detailed identification of key minerals and their relationships. Representative outcrops were selected based on geological maps, and their GPS coordinates were logged for precise location tracking. Rock samples were collected from these marked locations, and detailed observations on the changes in rock types were recorded.

4. RESULTS AND DISCUSSION

Field investigations and petrographic analyses revealed significant variations in the structural and lithological features of the Lansdowne region in the Garhwal Himalayas. The primary findings are outlined below:

4.1 Lithological Variation

In the central part of Lansdowne town, a significant lithological transition is observed, marked by a shift from granite to augen gneiss. This transitional zone exhibits a gradual fading of the foliated structure characteristic of the gneiss, as the composition shifts towards a more granitic nature. Augen gneiss, distinguished by its large feldspar crystals (or "augen"), indicates a high degree of metamorphism and deformation. The transition to granite suggests a reduction in the intensity of these processes, potentially indicating varying stages of magmatic intrusion and cooling. The granite composition includes quartz, alkali feldspar, plagioclase, muscovite, biotite, and tourmaline. This transition could either represent a diminishing influence of deformation and metamorphism towards the core of the region or reflect a separate phase of magmatic activity. Figures 4 depict the granite and granite gneiss.

Fig. 4. Showing granite and granite gneiss.

4.1.1 Fault

Faults are fractures in the Earth's crust where significant displacement occurs along the fracture plane or fault surface. A fracture forms when rock breaks under stress, dividing it into two or more segments [7]. In the Lansdowne region, small-scale faulting is evident in local quartz veins displacement indicating localized tectonic activity. A prominent reverse fault was observed in the study area, characterized by the upward movement of the hanging wall block relative to the footwall block (Fig. 5). The presence of such faults suggests that the Himalayas have undergone multiple episodes of deformation, highlighting the region's dynamic and evolving tectonic environment.

Fig. 5. Showing fault in granite

4.1.2 Gouges

Fault gouges are fine-grained materials that form near the Earth's surface as a result of rock pulverization during faulting [8]. In the study area, fragments of finely crushed rock and clay minerals were identified along the fault planes, signifying the presence of gouge material (Fig. 6). These gouges are clear evidence of intense brittle deformation and significant fault movement. Additionally, their presence suggests fluid-assisted alteration processes likely occurred during the faulting events, further contributing to the area complex geological history.

Fig. 6. Showing fault gouge

4.1.3 Joint Sets

Joints are fractures or cracks in rocks where no displacement has occurred [7]. A joint set refers to a group of parallel fractures that share a common origin [9]. In the Lansdowne region, three distinct joint sets were identified (Fig. 7). The orientations of these joint sets indicate that the area has experienced different stress regimes over time, aligning with the area ongoing tectonic activity. This pattern of joint sets provides further insight into the complex deformation processes in the geological landscape.

Fig. 7. Showing joint sets

4.1.4 Shear sense

Some micro-structure observed in quartz and feldspar grains indicate different phase of deformation. These indicators are observed in the granite gneiss and augen gneiss. The shear sense indicators directed towards in the NW-SE direction (Fig. 8). These indicators suggest the Lansdowne thrust transported towards SE direction during the thrusting on the area.

Fig. 8. Showing shear sense

5. CONCLUSION

This geological study of the Lansdowne region in the Garhwal Himalayas revealed the area has complex geological framework, characterized by multiple phases of deformation, faulting, and compositional transitions from granite to augen gneiss to. A notable tectonic contact Lansdowne thrust exists between the Lansdowne granite gneiss and the underlying metamorphites. The identification of faults, joint sets, and gouge zones highlights significant tectonic activity in the region. The transition from the highly deformed augen gneiss to the more uniform granite towards the core of Lansdowne suggests varying tectonic and metamorphic conditions. The relatively undeformed granite core indicates less intense deformation and metamorphism compared to the surrounding areas dominated by augen gneiss. The shear sense indicators determine NW-SE direction of the rocks and transportation of the area along SE direction along thrust.

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