 DOI: https://doi.org/10.7494/geotour.2024.3-4(78-79).83

# Geotourism along the Annapurna Mountain Range

**Nawaraj Parajuli*, Durga Khatiwada**

*Prithvi Narayan Campus, Department of Geology, Tribhuvan University, Pokhara, Nepal*
*nawaraj.parajuli@prnc.tu.edu.np; durga.khatiwada@prnc.tu.edu.np*

* Corresponding Author


Article history:
Received: 29 September 2024
Accepted: 15 April 2025
Available online: July 2025



**Abstract:** *Nepal is more explained by its natural beauty of mountain, which have been formed due to continental collision during geological past of approx. 22 million years ago. The Mountain Range of Nepal holds a huge geological history and are rich in geological units of Higher Himalayan Crystalline and Tibetan Tethys Sedimentary Sequence. Each year tourists from different countries visit Nepal for the glorious high hill peak trekking and mountaineering. Tourists are more curious about the minerals, gemstones and rocks of Nepal Himalaya. This paper presents the geology along the Annapurna Mountain Range, so that the tourist can visualize the geological evolution during geological time period. Literature review holds a major part in this research work. Various geological information was collected and used to finalize this research work. Maps, cross sections, and photographs are the main output of this paper.*

**Keywords:** *Annapurna Mountain Range, tourist, Higher Himalayan Crystalline, Tibetan Tethys Sedimentary Sequence, MCT*

## Introduction

The Himalayan Ranges of Nepal represent a distinctive natural region of immense beauty and ecological significance, serving as the source of major river systems. Among these remarkable mountain ranges, the Annapurna Mountain Range stands out as a notable example (Fig. 1). This range plays a significant role in Nepal's ecology, economy, culture, recreation, and overall living environment.

In Nepal, trekking has been practiced for decades. Following the ascent of Mount Everest (Sagarmatha), the number of tourists has surged. The current trend is that visitors from all over the world visit the range not just to climb mountains but also to explore other locations for hiking through picturesque valleys, and take in the sights of highland meadows, pasture land, and glaciers. Since the early 1960s, geologists have also shown a great deal of interest in the Nepal Himalaya. The Annapurna Mountain Conservation Area, Gandaki Province, Nepal is one of the most popular tourist destinations for foreign visitors among the several sites. 75,673 tourists made visits to the Annapurna Conservation Area in 2022 (Bajracharya *et al.*, 2020). Beautiful valleys, glaciers and high hill meadows lies within this range. The amazing views of this range can be explored from Gandruk, Badaldanda, Dhampus Kori, Pokhara Valley and from different highlands to south as well. The Annapurna Mountain Range falls under Annapurna Conservation Area and as a result of diverse relief (Fig. 2), geographical position, geological feature, land formation, hydrological network and climatic condition, it shows a large diversity of natural habitats, including: forests of rhododendron, pine, and other different high trees, beautiful pastures and valleys, steep slope sites of karst topography.

There are different geological formations of Tethys and Higher Himalaya consisted in the Annapurna Mountain Range. In the upper portions of the Annapurna Range, the Palaeozoic-Mesozoic rocks of the Tibetan Tethys Zone, referred to as the Tibetan-Tethys

Sedimentary Series and Tethys Himalayan Sequence, are well exposed. These rocks include limestone, dolomite, shale, slate, quartzite, sandstone, marble and calcsilicates rocks. Fossils abound in the Tethys deposits (Fig. 3). According to Arita (1983) and Colchen *et al*. (1986) the Higher Himalaya is made up of migmatites of amphibolite facies containing kyanite and sillimanite, granitic orthogneisses, and pelitic, psammitic, and calcareous paragneisses. According

 eISSN 2353-3641 | ISSN 1731-0830

to Gansser (1964) the Higher Himalayan rocks are thought to constitute the Proterozoic Indian Shield's reactivated basement rocks. The Formation I consists of banded gneisses with an arenaceous to pelitic origin. The Formation II is primarily made up of marble and calc-gneisses that contain pyroxene and amphibole.

The coarse-grained augen gneiss of igneous origin is comprised in the Formation III. Local and international tourists who venture into mountainous terrain not only immerse themselves in beautiful landscapes but also witness first-hand dynamic processes that shape these majestic landforms over millions of years of geologic past. Understanding the geology of mountains enriches the tourism experience. This paper aims to provide the geological information in maps, cross section and sketches that will serve as a valuable resource to enhance geotourists to understand geology during trekking along different sections of the Annapurna Mountain Range.

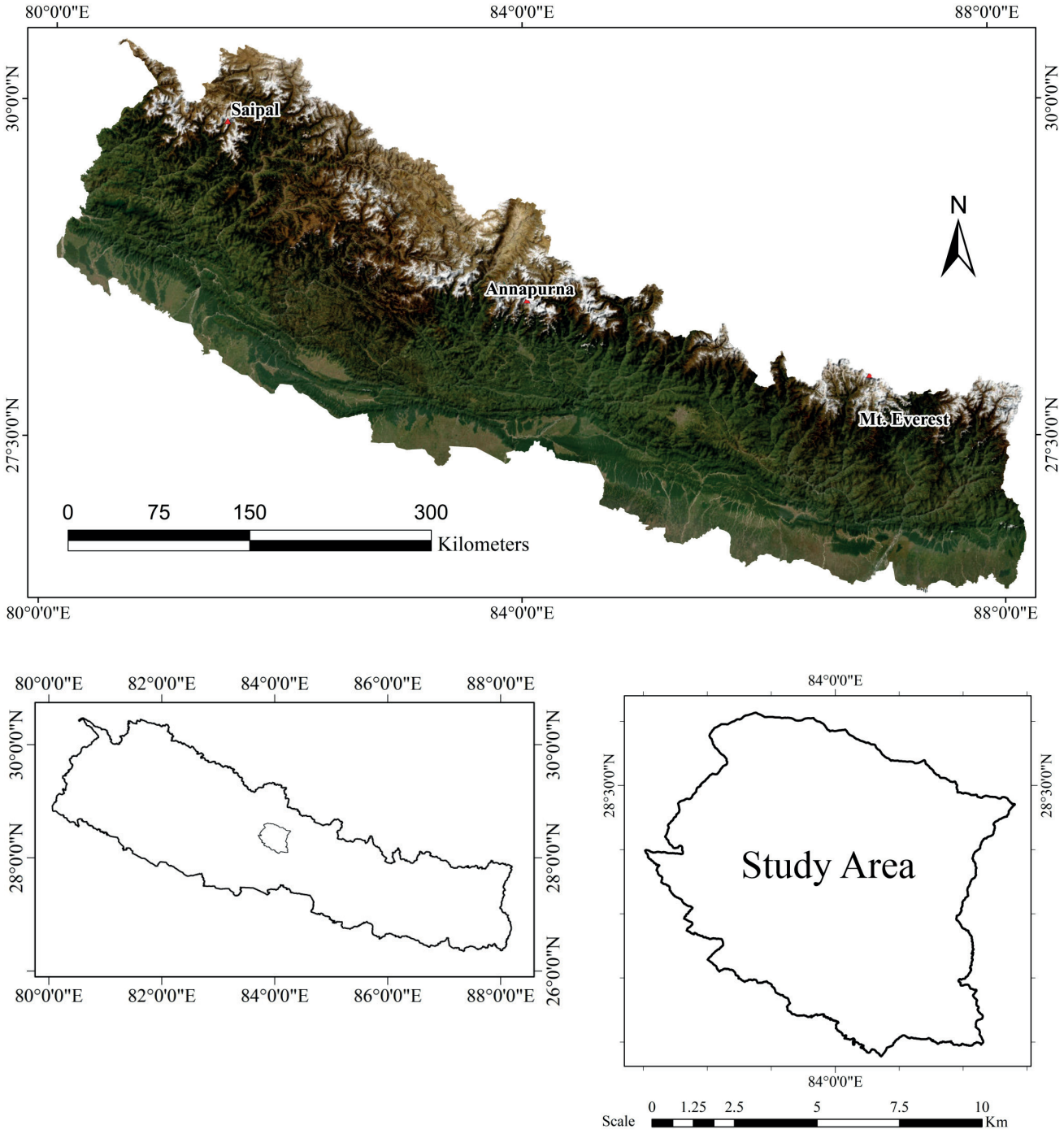


Fig. 1. Satellite image of Nepal showing the location of Annapurna Mountain Range (Google Earth Image)

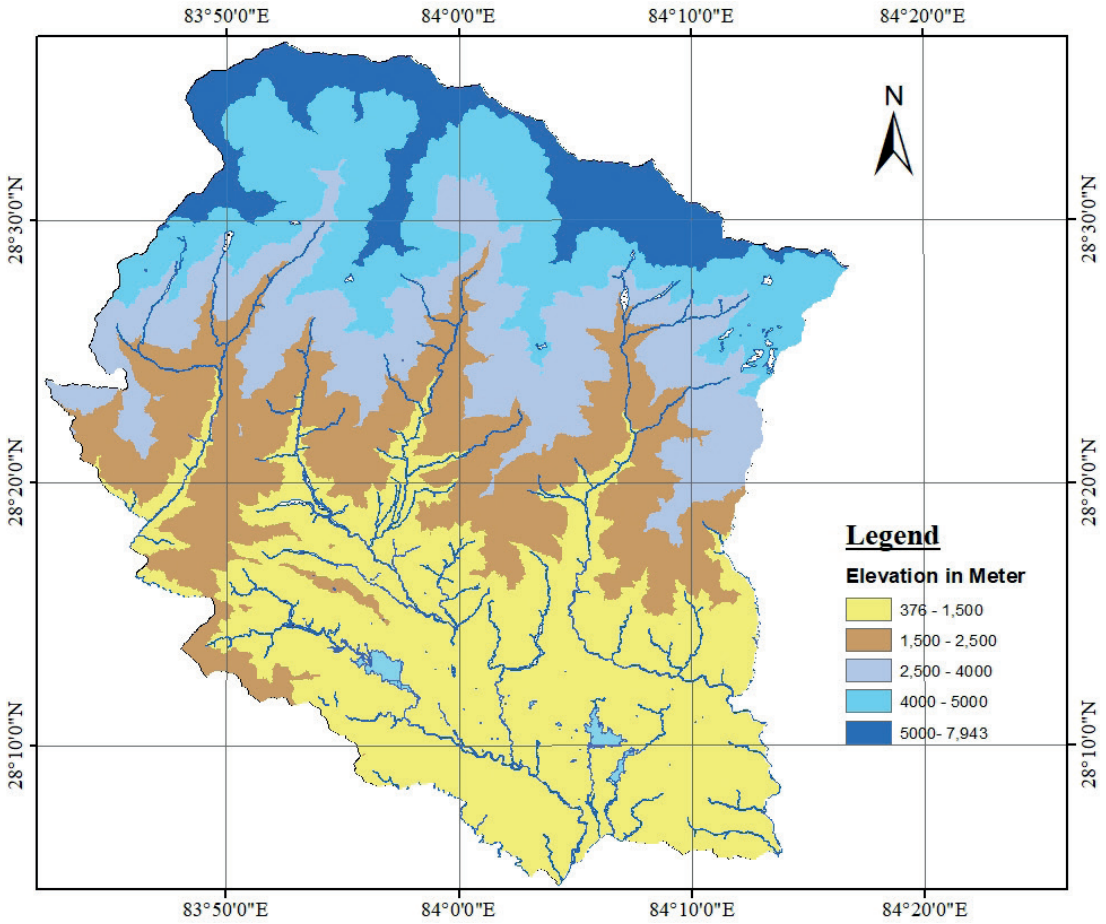


Fig. 2. Digital elevation model of the study region showing the variation in elevation as one moves towards North

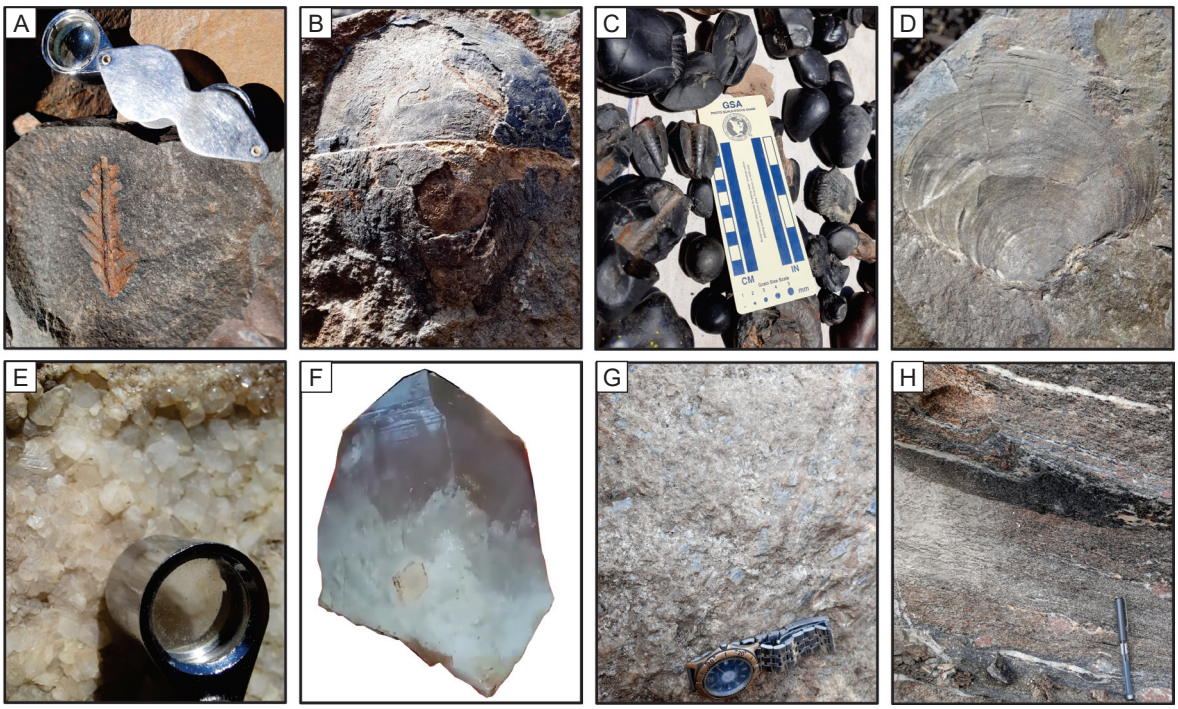


Fig. 3. Geotouristic objects that can be observed while trekking in Tethyan Sedimentary Sequence (TSS) and Higher Himalayan Crystalline (HHC): A – plant fossils found in TSS; B–D – animal fossils found in TSS; E – calcite grains as a vein in TSS; F – quartz crystal; G – kyanite gneiss of HHC; H – garnet gneiss of HHC with slightly rotated augen

## Geotrekking sites

The geotrekking sites of Annapurna Mountain Range consist of rock units ranging their age from Paleoproterozoic to Mesozoic (Colchen *et al*., 1986). In the southern sections, the geological units are primarily composed of Lesser Himalayan rocks. These are structurally separated from the Higher Himalayan Crystalline units to the north by the Main Central Thrust (MCT) (Fig. 4). On moving further north, the Tethyan Sedimentary Sequence rests over the Higher Himalayan Metamorphosed rock units. The Tethyan Sedimentary Sequence was once deposited in a Tethys Ocean and due to tectonic collision between Indian and Tibetian Plates, the sedimentary rocks along with the fossils present in them are now at the top of the Annapurna Mountain Range (Fig. 3).

The Paleoproterozoic phyllites, metasandstones, and schists with a few bands of quartzite mark the beginning of the Lesser Himalayan Sequence. There are also few granite bodies and many small intrusions.

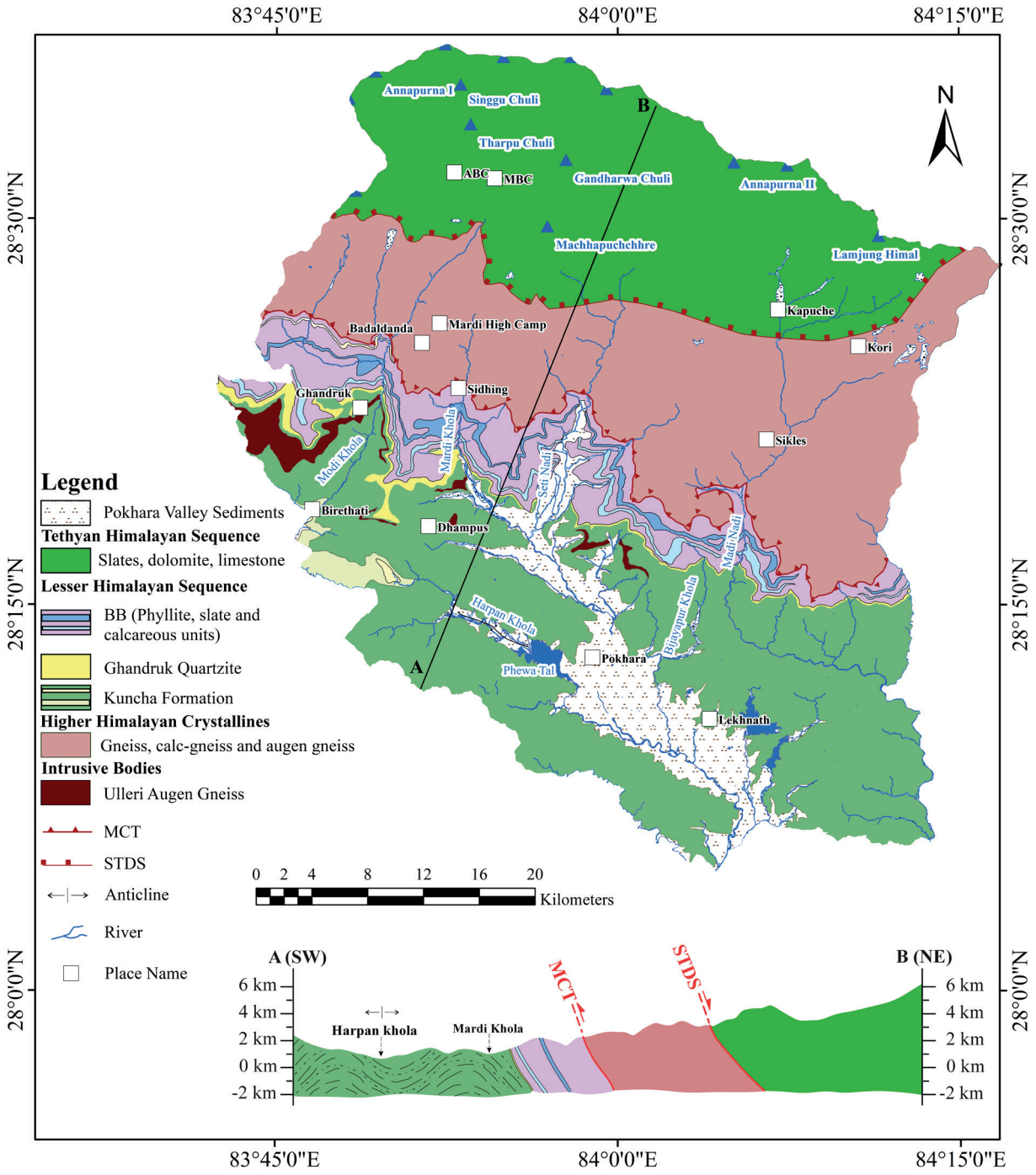


Fig. 4. Geological map of the study area and generalized cross-section along A–B (compiled and modified after Colchen *et al*., 1986 and Dhital, 2015)

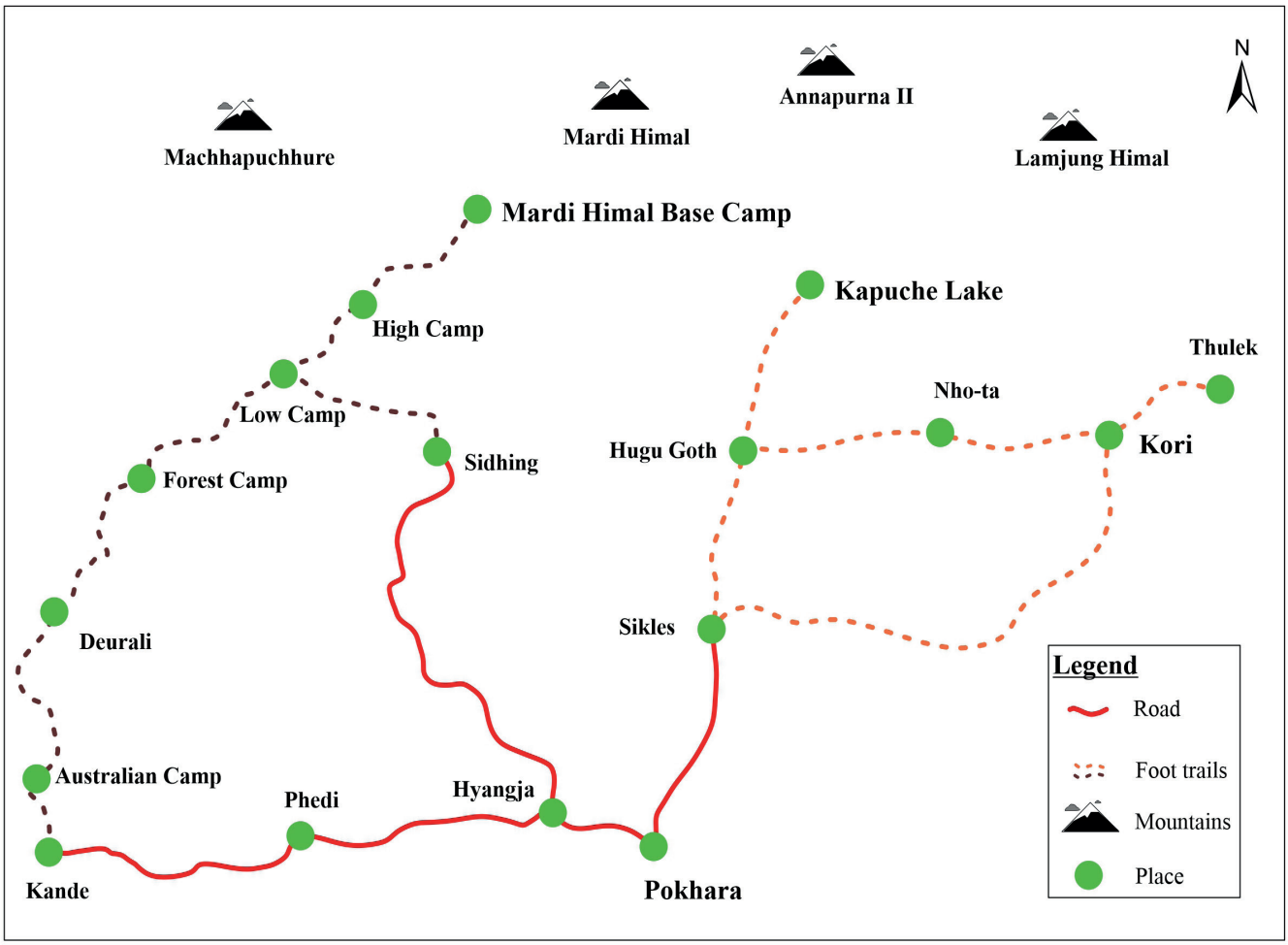


Fig. 5. Geotouristic trekking route along Mardi Himal Base Camp, Kapuche and Kori

These are named as Kuncha Formation and is followed upwards by resistant quartzite bands of light yellow and grey-coloured Ghandruk Quartzite, and they are alternating with grey-green phyllites and psammitic schists. Graphitic schists, thinly laminated quartzites, carbonate bands and garnet schists overlies the Ghandruk Quartzite. In the vicinity of the MCT, there is a noticeable but discontinuous quartzite band (Fig. 4). The Higher Himalayan Crystallines at sections to the trekking route displays beautiful outcrops of gneisses, calc-gneisses and migmatites as well. The rocks of the Tethyans Sedimentary Sequence rest at the peaks within Annapurna Mountain Range. These rocks are brought to the valleys and rivers by rock and snow avalanches in the mountains by which the fossils and minerals are visible to the trekkers along the route such as in Kapuche, Seti Nadi and Mardi Khola (Fig. 5). *Khola* and *Nadi* refers to river in Nepali language.

### *Sikles – Kapuche Lake and Kori trek*

The first excursion takes us to view the Paleozoic sedimentary rock formations towards the north of Pokhara Valley. These Paleozoic Sedimentary rocks lie over the Precambrian metamorphosed rock formations (Fig. 4).

The highway road exits in the Pokhara valley and merges into the country road to Sikles villages (Fig. 5). Travelling towards the newly constructed road, the Precambrian rocks of Lesser Himalayan Sequence are well exposed (Figs 4 and 6). This area is known for its natural beauty of mountains view. Before reaching Sikles Villages, the road passes by Main Central Thrust leading us to the rock formations of Higher Himalayan Crystalline (Fig. 4). Then the trail journey starts with a beautiful landscapes and geology leading towards the Kapuche Lake (Figs 4 and 5). The Annapurna area has the breath-taking high-altitude lake known as Kapuche Lake. At a 2,546 meters above sea level, it is the nation's lowest glacier lake.

The Kapuche Lake is a popular destination for both local and international trekkers. Trekkers typically start their journey in the village of Sikles, which is located about 20 km from Pokhara (Fig. 7A). Avalanches, erosion, surges, retreat and advance of the glaciers created the lake. The Kapuchu valley has been left with a deposit of broken rocks and ice blocks that have accumulated from the steep slope in the form of avalanches or rock falls (Fig. 7B). The lake is filled with moraine deposits.

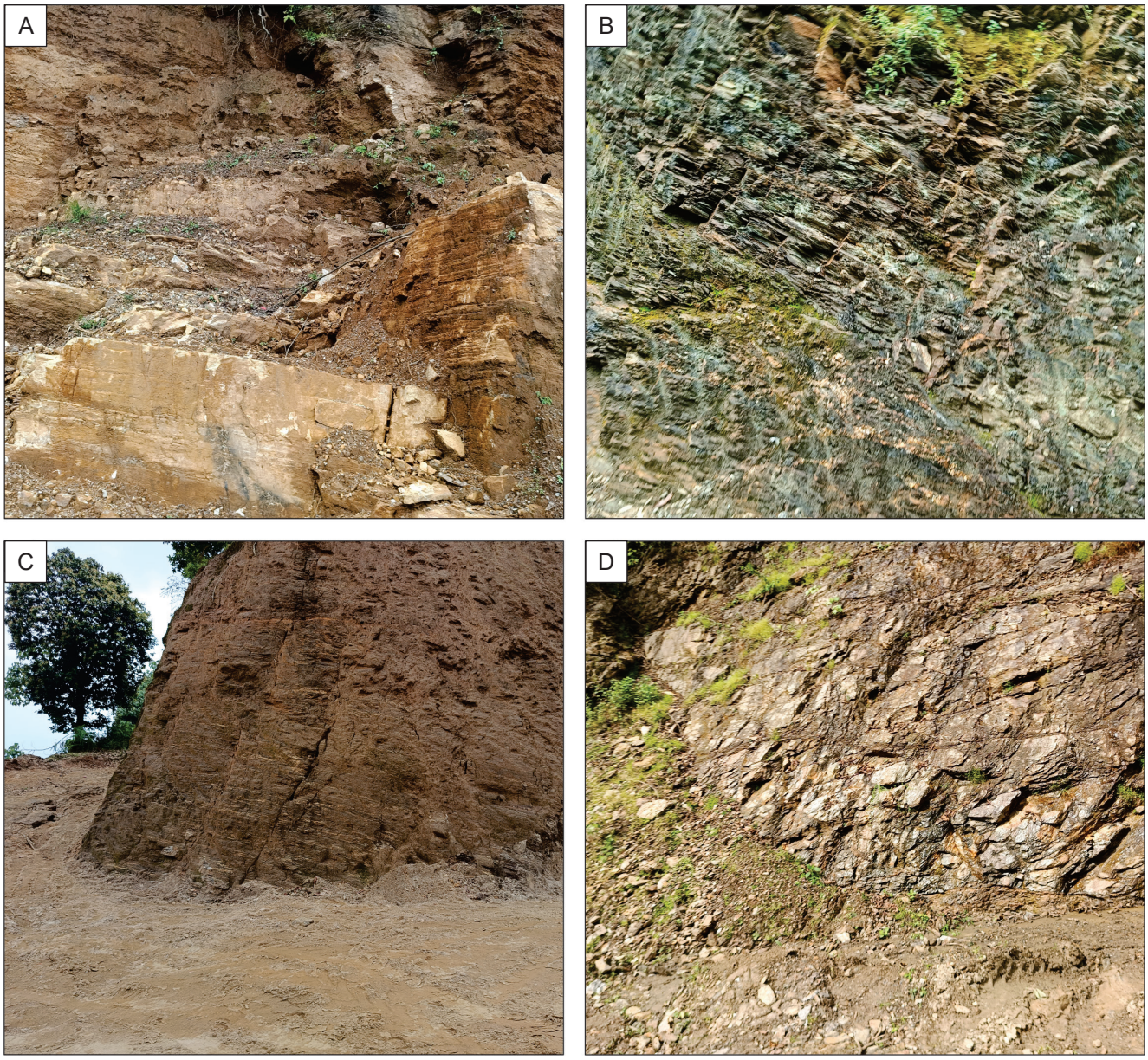


Fig. 6. Lesser Himalayan Sequence outcrops observed on a route to Sikles (the photographs A–D represent respectively from South to North on a road to Sikles): A – limestone observed on a road cut to Sikles (the white colour limestone interbeds with light grey to dark grey phyllite); B – interbedding of thin grey, brown metasandstone with green, grey phyllite; C – augen gneiss observed on a loop towards Sikles on a newly constructed road (the augen gneiss in most of the road cuts have been highly weathered); D – grey schist near the Main Central Thrust (MCT)

The origin of the Kapuche Lake is the outcome of the water dissipating in such a deposit. The lake provides a reasonably accessible opportunity for visitors to take in the splendour of the Himalayas, encircled by verdant woods and snow-capped peaks. The trek to the lake takes around two days. The journey does not stop here, leading us to another climb to the beautiful pasture land named as Kori (Fig. 7C).

The highest crystalline formations form the foundation of the Annapurna Summit I (Figs 8 and 9). The tallest peaks of the main range are all constructed by sedimentary rocks, extending from the Annapurna I in an east-southeast direction. The Machhapuchare alone is made of crystallines from Higher Himalaya. Typically, tectonics involves crystallization as well for the highest Kathmandu nappes.

This is clearly visible in the Machhapuchare (Fig. 8) and on the ridge that runs between the south peak and Annapurna I. This location appears to have provided more room for tectonic activity between the Kathmandu nappes and the Tibetan marginal synclinorium, which has a variety of folding in both normal and reverse sense, and the Kathmandu nappes' uniformly dipping roots (Hagen, 1968).


Fig. 7. Geotouristic sites along the Sikles-Kapuche-Kori Site: A – Sikles Village with Annapurna Mountain Range in its background; B – Kapuche Lake with debris brought by ice and rock avalanche from the mountain above it; C – Kori with meadows and beautiful Himalaya view just north of it (view towards north); D – view of Pokhara valley from Kori with Modi Khola, as a main tributary and the background villages just on the right is Sikles, left is Tangting and the Pokhara valley at the top of the photo

The beautiful mountains with rocks dipping North of various geological age and covered with snows provides all the human reaching there a heavenly happiness. This journey, which is located inside the inner Annapurna conservation buffer zone, takes us into Nepal's pristine environment.

Within the framework of the Kori Trek, Kori Danda's visual splendour is a standout highlight, providing an incredible panoramic perspective. Views of the majestic Annapurna II (7,937 m), the enchanting Lamjung Himal (6,988 m), the imposing Manaslu Himal (8,156 m), and the famous Machhapuchare Mount Fishtail (6,993 m) can all be seen from this vantage point (Fig. 8). The sight of these soaring peaks etch themselves permanently in one's memory. The Kori trip, which is primarily a tent camping experience, offers an unmatched chance to fully immerse oneself in the unspoiled and wild grandeur of the Annapurna Region. For those who are fortunate enough to see these magnificent vistas, the trip promises to be a visual feast that will leave them with lasting memories.

The road leading from Pokhara Valley to Sikles (Fig. 5) after crossing the Bijayapur Khola leads towards the outcrops of the Lesser Himalayan Sequence which can easily be noticed on a fresh road cut. The stratigraphic sequence continues from bottom phyllite and metasandstone followed by grey, green quartzite and metasandstone. The metasandstone on moving towards north gets followed by calcareous units (Fig. 6A) along with the phyllites. The phyllites of dark grey and green colour also interebeds with metasandstones (Fig. 6B). The augen gneiss (Fig. 6C) is easily visible in the section just above the calcareous and phyllites units. At nearly towards the MCT, the grey to dark grey schists (Fig. 6D) can be noticed. The road than continues towards Sikles with few outcrops of gneiss of Higher Himalayan Crystalline.

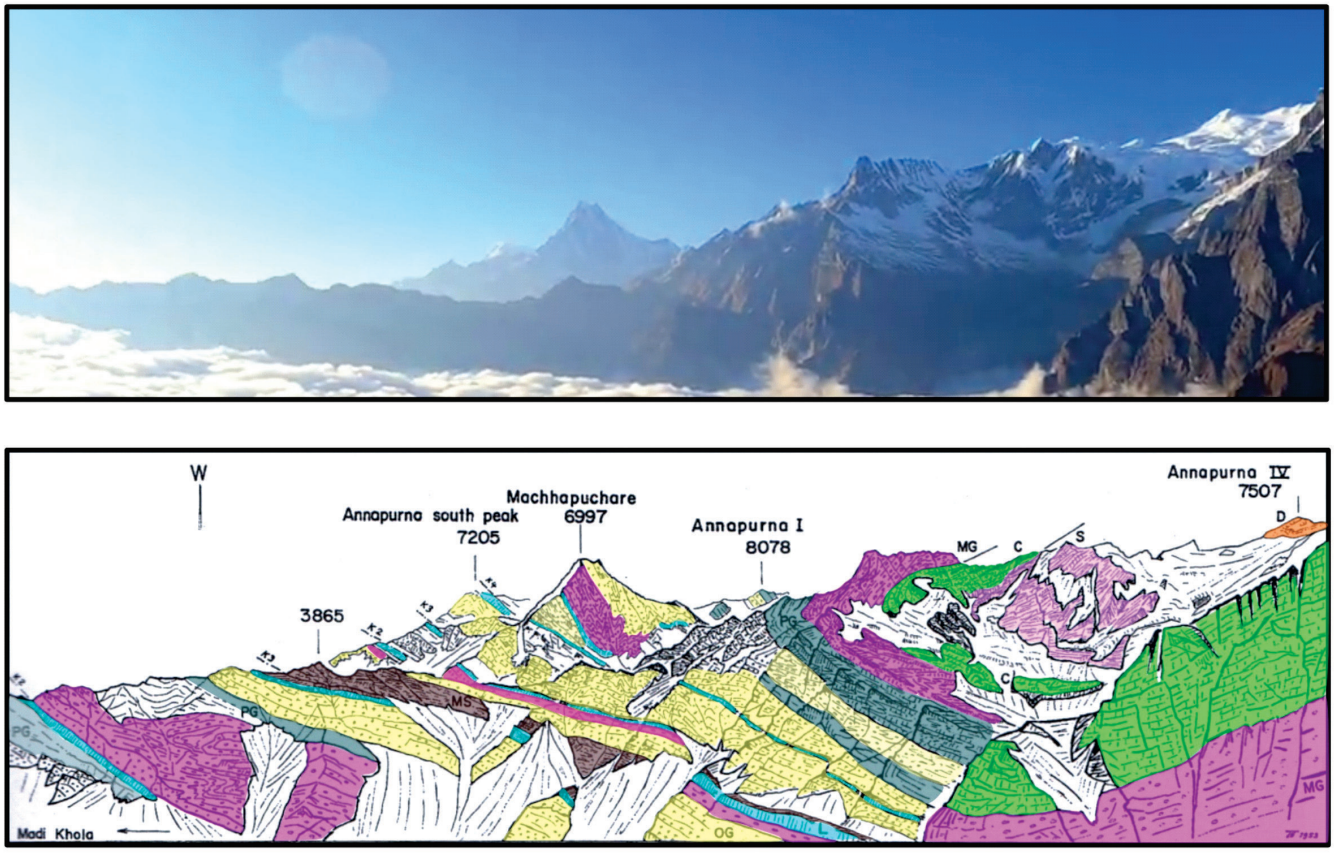


Fig. 8. Geological profile of Annapurna range seen from southeast. Rocks with calc-silicates and various gneisses make up the lowest portion. The sediments that make up the higher portion are reversely folded. The right half of the picture shows the western dip of the well-bedded formations due to the axial rise of the Manang synclinorium towards east, which shows the same mountain from the southwest (modified after Hagen, 1968)

### *Mardi High Camp trek*

The Mardi Camp excursion takes us to view the metamorphic rock formations towards the north of Pokhara Valley. These metamorphic rock formations underlie the Precambrian metamorphosed rocks formations of Higher Himalayan Crystallines. The Machhapuchare consist of the folded, but generally northern dipping granite-gneisses of Kathmandu nappe. The western flank of Annapurna IV gives a good cross section through the reverse folded sediment covers of the Kathmandu Nappe (Fig. 9). The gneiss rock sequences have also been involved in the folding.

With a duration of just over a week, this trek is an ideal introduction to Nepal's highlands for people with limited time. The highway road exits the Pokhara Valley and merges into the country road towards Badaldanda. The Precambrian rocks of Lesser Himalayan Sequence are well exposed in road cuts along the road before reaching Siding Village. The foot trails journey takes us up through old rhododendron forests before Badaldanda. The Main Central Thrust passes in between the Sinding Village and Badaldanda (Fig. 4). The foot trails continue through beautiful pasture lands on the ridge, exposing rocks of Precambrian age of Higher Himalayan Crystalline composed mainly of gneiss, calc-gneisses and migmatites (Fig. 9), to Mardi High Camp (Figs 10A and B).

The Mardi Himal trip is a hidden jewel, located just east of the Annapurna Base Camp.

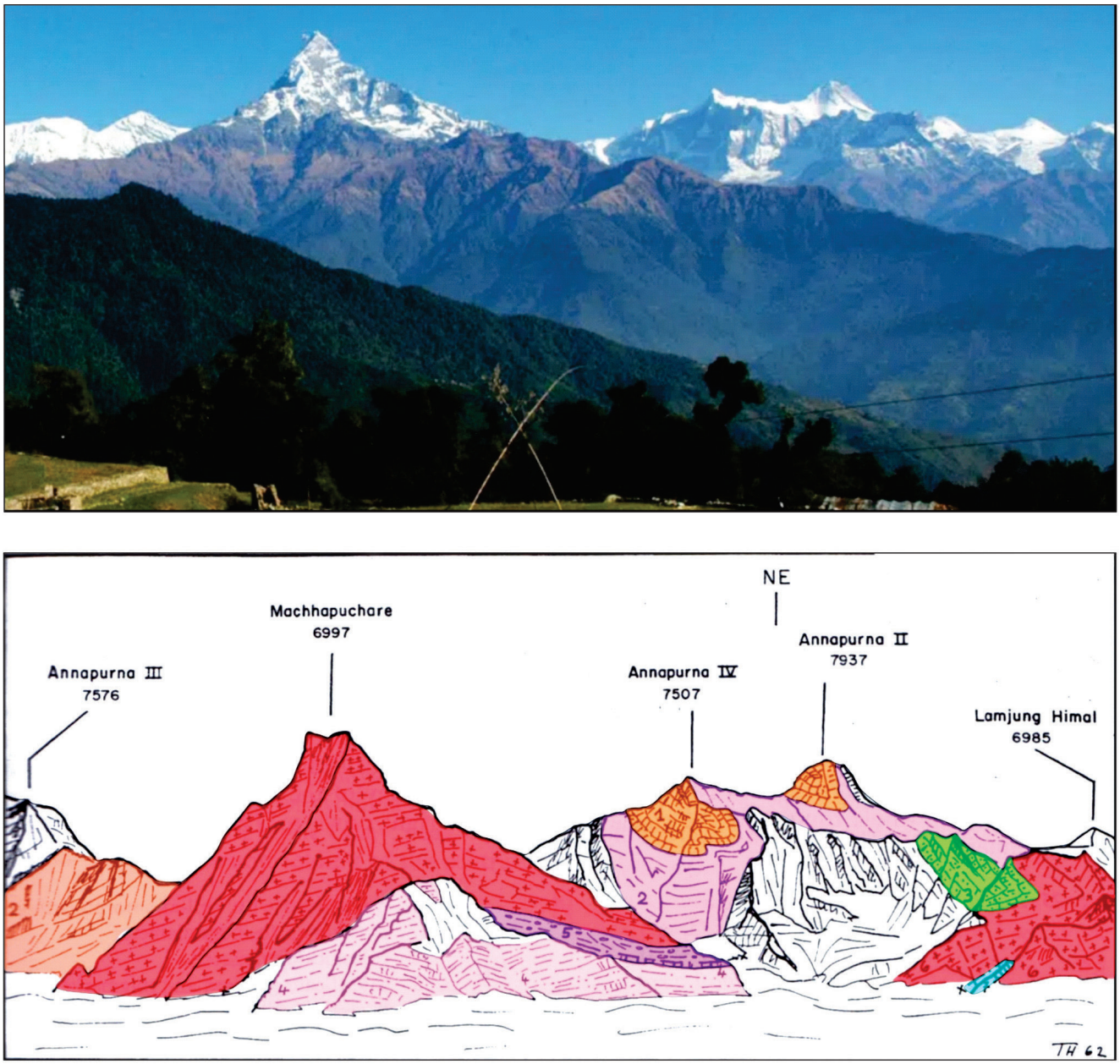


Fig. 9. Geological profile of Annapurna Range seen from south (modified after Hagen, 1968)

Not many trekkers visit Mardi Himal's High Camp, which is magnificently positioned at the foot of Mardi Himal and the stunning and majestic Machhapuchare or Fishtail (Figs 10C and D). The trail meanders through old-growth rhododendron forests on narrow trails, culminating in a rise of around 3,300 meters. With breath-taking views of the Mardi Himal, Machhapuchare, Annapurna South, and Hiunchuli, the scenery changes pretty dramatically at this point. One may ascend to Mardi Himal Base Camp, which provides breath-taking up-close views of the entire Annapurna Range, in roughly three to four hours from High Camp (3,580 m). Another fantastic vantage point is around two hours' drive from High Camp.

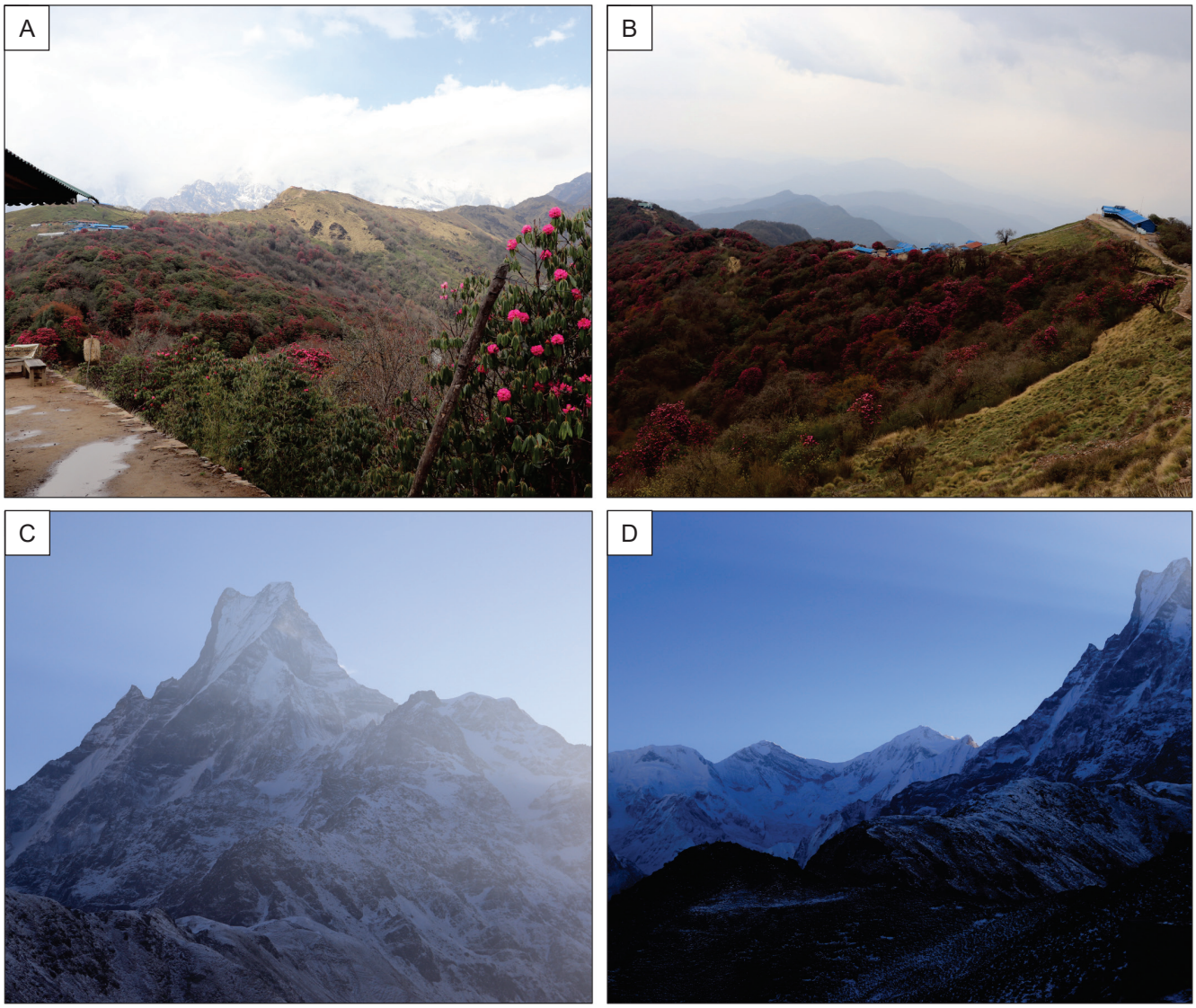


Fig. 10. Geotouristic trekking route along Mardi Himal High Camp: A – Badaldanda on the background along which the foot trail to Mardi Himal High Camp continues (view towards northwest); B – thick Rhododendron Forest on the eastern edge of the ridge leading towards Mardi Himal High Camp (view towards south); C – view of Fishtail shape at the summit of Machhapuchare observed from Mardi High Camp and thus named in Nepali as Fishtail Mountain; D – Machhapuchare along with Annapurna III just on the left side of Machhapuchare

## Discussion

### *Geotourism value*

The Paleozoic, Mesozoic succession and Precambrian rocks of the Annapurna Mountain Range has educational value to structural and mining geologists. The thrust that separates the two different rock units exposed in different sections of the research area can provide information regarding the upliftment of Nepal Himalaya and its orogenic history. The gneiss and migmatites that are well exposed in different locations of the Annapurna Range can lead us to exploration works for various gemstones and other important mineral resources. Palaeontologists will be impressed with the fossils of Tethyan Sedimentary rocks sequence from Annapurna Mountain Range and specialists will be interested in the remains of the oldest microfossils derived from land and oceanic plants. Low-lying glaciers such as Kapuche Glacier is a fascinating and significant area of scientific inquiry because of its enormous geological significance and its special characteristics and the important information as it may provide about the dynamic processes of Earth. Geologists can investigate these glaciers in order to understand the region's geological past, track the effects of climate change, and reduce any possible risks related to glacial dynamics.

### *Geotourism infrastructure*

Geotourist lovers consider Pokhara, a modern city with a strong infrastructure, to be a top destination. Offering a variety of chain hotels and dining establishments, it offers a cosy starting point for visitors keen to see the area's natural

treasures. Pokhara International Airport connects the city to major airport hubs nearby, making it an ideal starting point for travel. Exploring the trekking routes that go to Kapuche and Mardi provides a wide variety of lodging choices. In contrast to the relatively recent activity along the Sikles-Kori route in last few years, the Mardi High Camp trek route was developed a decade ago.

In spite of the geological importance of these locations, there is a conspicuous lack of tourist infrastructure, educational signage, and pamphlets. Geotourists can enhance their sense of adventure by using foot trails and 4-wheel drive vehicles to access certain spots. Fortunately, the exposed outcrops and straightforward local structural geology make exploration accessible.

While local grocery stores offer basic essentials like cold drinks, geotourists are recommended to bring enough of drinking water. Warm clothing is required due to the cool midday temperatures on the trekking trails. Furthermore, extended exposure to the sun emphasizes how crucial it is to take the appropriate protective measures against the sun. A journey to the Annapurna Mountain Range is incredibly gratifying, even beyond its geological marvels.

The trip reveals the intricate details of traditional Nepali culture, including farming methods, scenic locales, and colourful regional clothing. Gourmets can enjoy Nepali food at authentic eateries, which enhances the overall geotourism experience with a delicious element.

## Conclusions

Annapurna Mountain Range of Nepal has strong potential for geotourism. There are excellent geological sites that are well exposed and easily accessed. The Higher Himalayan Crystallines and Tethyans Sedimentary Sequence are among the most important geological units in terms of natural resources. Their educational value to geoscience students and specialists ranks highly because they contain unique fossil and mineral occurrences that give us a new perspective on the evolution of land plants and marine microorganisms. The stratigraphic units and thrust exposed in different sections of the Annapurna Mountain Range can be used to explain the history of the Nepal Himalaya Evolution.

### *Acknowledgements*

We thank Dr Michał Krobicki, professors Megh Raj Dhital, Lalu Paudel, Kabiraj Paudyal and the journal editors for offering constructive comments on the manuscript.

## References

Arita K., 1983. Origin of the inverted metamorphism of the lower Himalayas, central Nepal. *Tectonophysics*, 95(1–2): 43–60. https://doi.org/10.1016/0040-1951(83)90258-5.

Bajracharya S.B., Sherchan B. & Pun S. (eds), 2020. *NTNC Annual Report 2020*. National Trust for Nature Conservation, Khumaltar, Lalitpur. https://www.ntnc.org.np/sites/default/files/doc_publication/2021-09/annual-report-2020_print-final.pdf

Colchen M., Le Fort P. & Pêcher A., 1986. *Annapurna–Manaslu–Ganesh Himal*. Centre National de la Recherche Scientifique, Paris (Special publication with a geological map, 1:200,000).

Dhital M.R., 2015. *Geology of the Nepal Himalaya: Regional Perspective of the Classic Collided Orogen*. Springer Cham. https://doi.org/10.1007/978-3-319-02496-7.

Gansser A., 1964. *Geology of the Himalayas*. Interscience, New York.

Hagen T., 1969. *Report on the Geological Survey of Nepal*. Vol. 1: *Preliminary Reconnaissance* (with a geological map). Orell Füssli, Zürich. "Denkschiiften der Schweizerischen Naturforschenden Gesellschaft", bd. 86/1.