TRANS-HIMADRI THRUST AND DOMAL UPWARPS IMMEDIATELY SOUTH OF COLLISION ZONE AND TECTONIC IMPLICATIONS

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ABSTRACT

A deep thrust-fault is recognized north of the Great Himalaya (= Himadri) encompassing the Zanskar, NandaDevi-PanchChuli, Dhaulagiri-Annapurna and Sagarmatha (Everest) ranges. Stretching over 1600 km from Ladakh to Sikkim, the Trans-Himadri Thrust (T-HT) sharply severes the Precambrian basement complex of high-grade metamorphics of the Great Himalayan subprovince from the late Proterozoic-to-Upper Cretaceous/Eocene sedimentaries of the Tethyan domain. It is a lag thrust that has attenuated, truncated and regionally eliminated the lower units of the Tethyan succession including the Cambrian. It has caused spectacular back-folding and back-faulting in the sedimentaries, and mylonitized and considerably sheared the basement metamorphics and granites intruding them. The T-HT developed in the continental margin of the northward advancing Indian plate following the blocking of movement along the zone of collision of the Indian and Asian crustal plates.

The leading edge of the Indian crust between Ladakh and northcentral Nepal exhibits very conspicuous domal upwarps immediately south of the line of collision. These upwarps imply great resistance encountered by the Indian crust and resultant folding up of its front. These anticlinal structures and the attendant breaking up of the crust along the T-HT indicate that the Indian plate was too buoyant to underthrust significantly under the Tibetan (Asian) crust. The fact that not much of the Tethyan sedimentary prism has been lost in the subduction rules out large-scale underthrusting of the Indian plate under the Asian crust.

INTRODUCTION

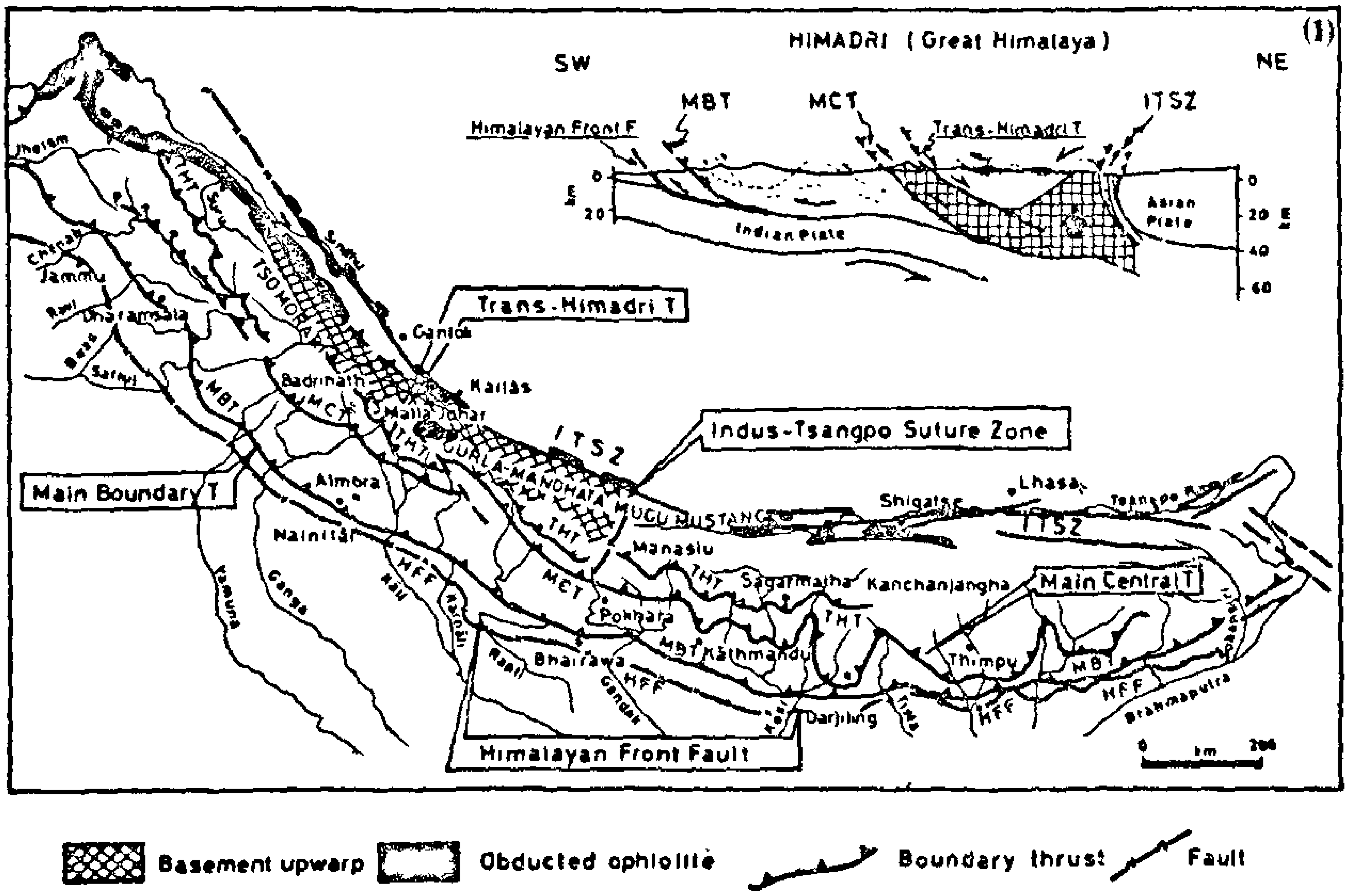
The ruggedly youthful Great Himalaya (= Himadri) constituted of Precambrian high-grade metamorphics are succeeded by a very thick succession of Late Proterozoic-to-Upper Cretaceous/Eocene sedimentaries of the Tethyan domain, representing the shelf on the continental margin of the Indian shield. It is widely, if not universally, believed that the Great Himalayan metamorphics transitionally grade upwards into the Tethyan sediments. Metamorphism related to the principal phase of Himalayan orogeny and attendant widespread invasion of mid-Tertiary (28–20 m.y.) anatectic granite ($^{87}Sr/^{86}Sr > 0.7478$) coupled with apparent concordance of structures in earlier studied sections are responsible for this assumption. Investigations by the author in the Kumaun Himalaya and analysis of literature demonstrate that the Great Himalayan lithotectonic subprovince is separated from the Tethyan sediments by a lag thrust of regional dimension extending perhaps discontinuously from the Sindhu valley in Ladakh to northern Sikkim. This thrust, designated as the Trans-Himadri Thrust (T-HT), is geodynamically as important as the Main Central Thrust (MCT), Main Boundary Thrust (MBT) and Himalayan Front Fault (HFF) that subdivide the Himalayan province into five latitudinal subprovinces (figure 1).

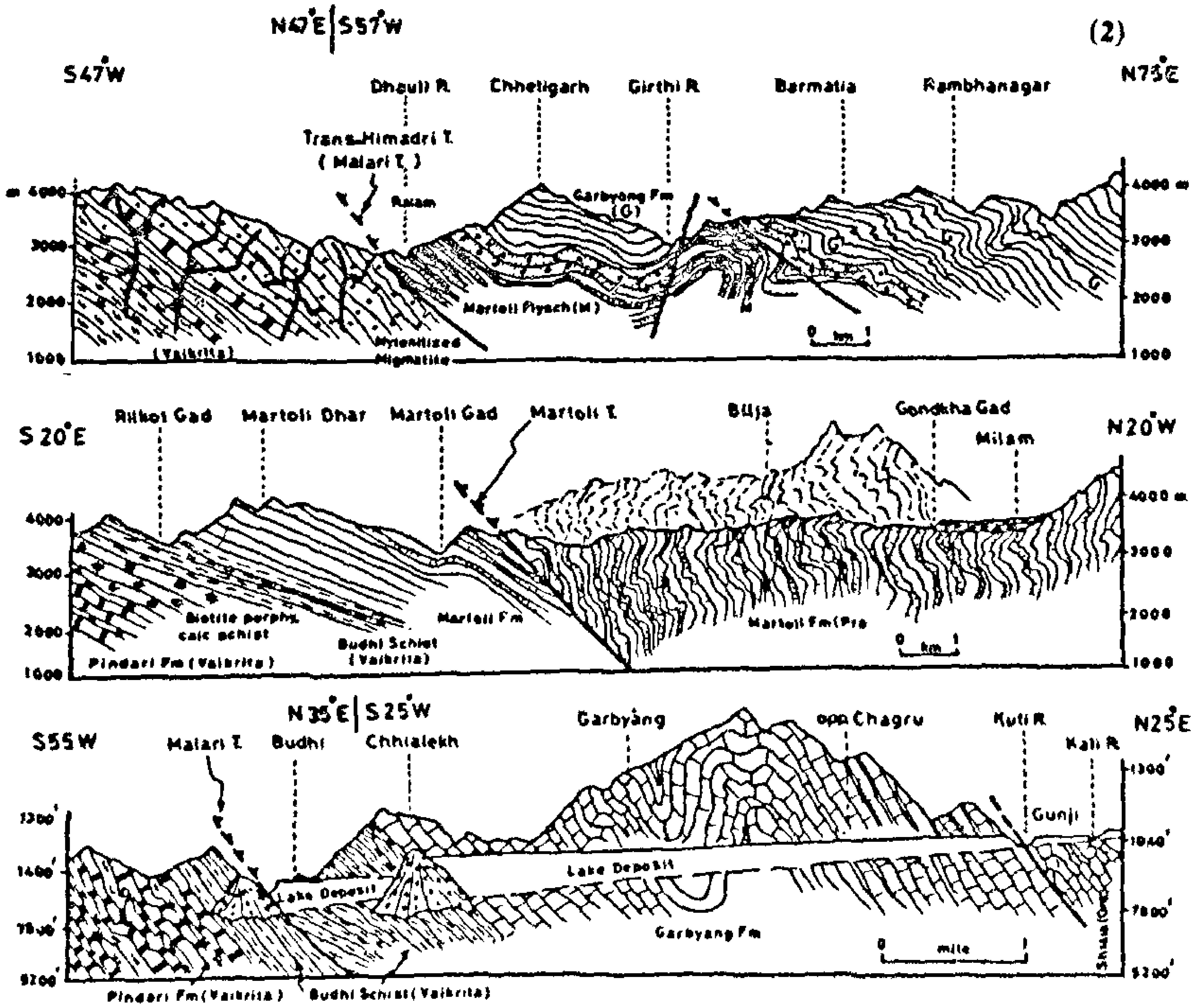
FAULT DELIMITING NORTHERN BOUNDARY OF GREAT HIMALAYA

It was in northeastern Kumaun Himalaya in the

Figure 1. The Himalayan Front Fault (HFF), Main Boundary Thrust (MBT), Main Central Thrust (MCT) and Trans-Himadri Thrust (T-HT) subdivide the Himalayan province into four lithotectonic subprovinces. Note the basement upwarps immediately south of the Indus-Tsangpo Suture (ITSZ) – the zone of collision of the Indian and Asian plates.

Figure 2. The high-grade Vaikrita metamorphics intruded by mid-Tertiary granites are sharply truncated by the T-HT against the backfolded Tethyan sedimentaries beginning with upper Proterozoic flysch in northern Kumaun.


(1)
HIMADRI (Great Himalaya)
SW
NE
MBT
MCT
ITSZ
Himalayan Front F
Trans-Himadri T
Indian Plate
Asian Plate
Trans-Himadri T
Indus-Tsangpo Suture Zone
Main Boundary T
Main Central T
Himalayan Front Fault
Jhelum
Chenab
Jammu
Ravi
Dharamsala
Beas
Satluj
TSOMORIRI
Gartok
Kailas
Badrinath
Malla Johar
GURLA-MANDHATA
MUGU MUSTANG
Almora
Nainital
Yamuna
Ganga
Manasiu
Sagarmatha
Kanchanjangha
Pokhara
Kathmandu
Bhairawa
Gandak
Darjiling
Thimpu
Shigatse
Lhasa
Brahmaputra
MBT
MCT
THT
HFF
ITSZ
Basement upwarp
Obducted ophiolite
Boundary thrust
Fault


(2)
N47°E | S57°W
S47°W
N75°E
Dhauli R.
Chhetigarh
Girthi R.
Barmatia
Rambhanagar
Trans-Himadri T.
(Malari T.)
Garbyang Fm
(G)
Martoli Flysch (M)
Mylonitized Migmatite
(Vaikrita)
S 20°E
N 20°W
Rilkot Gad
Martoli Dhar
Martoli Gad
Martoli T.
Bilja
Gonkha Gad
Milam
Biotite porph. calc schist
Budhi Schist (Vaikrita)
Pindari Fm (Vaikrita)
Martoli Fm
N35°E | S25°W
S55W
N25°E
Malari T.
Budhi
Chhialekh
Garbyang
opp Chagru
Kuti R
Kali R
Gunji
Lake Deposit
Garbyang Fm
Pindari Fm (Vaikrita)
Budhi Schist (Vaikrita)

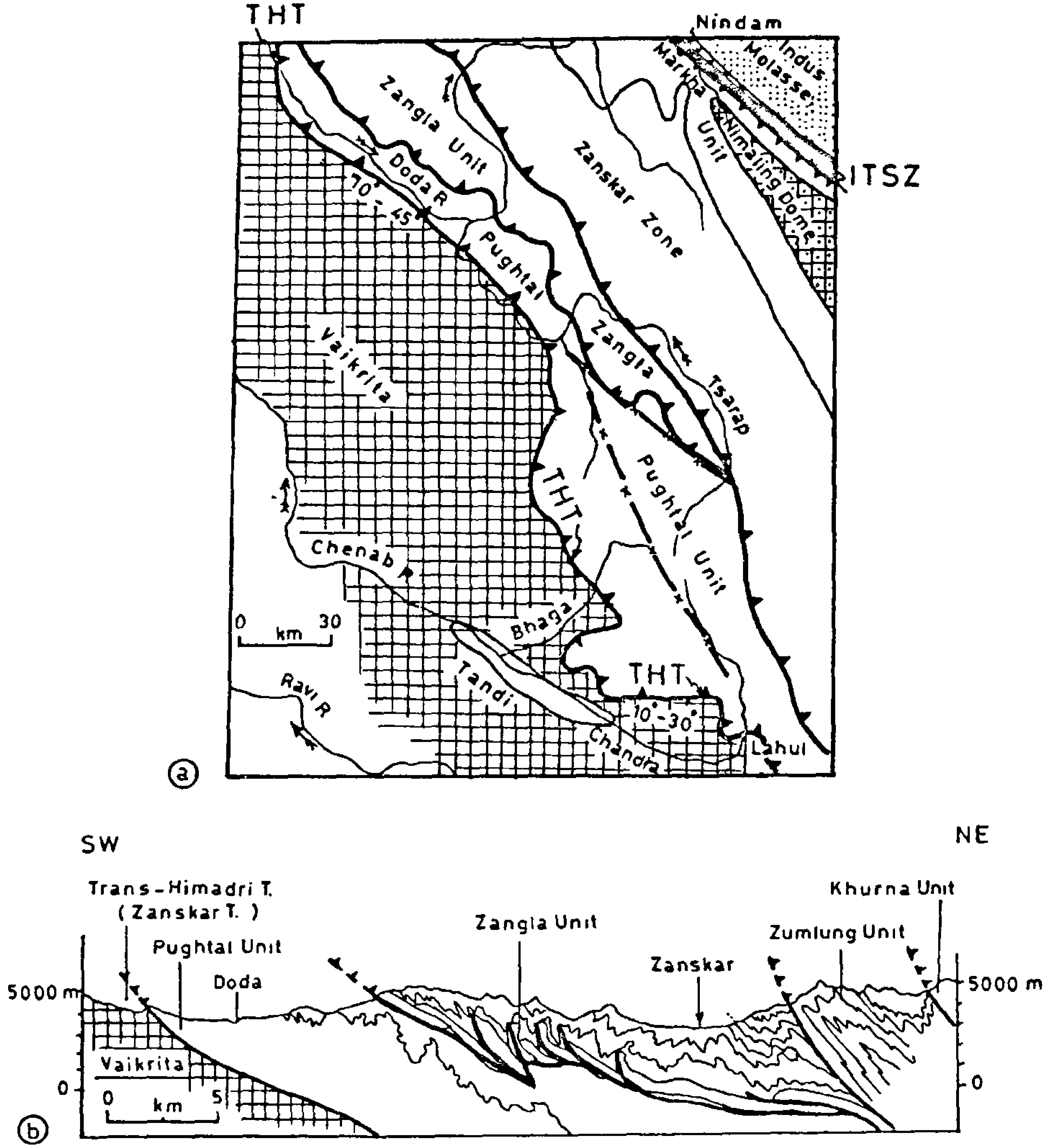
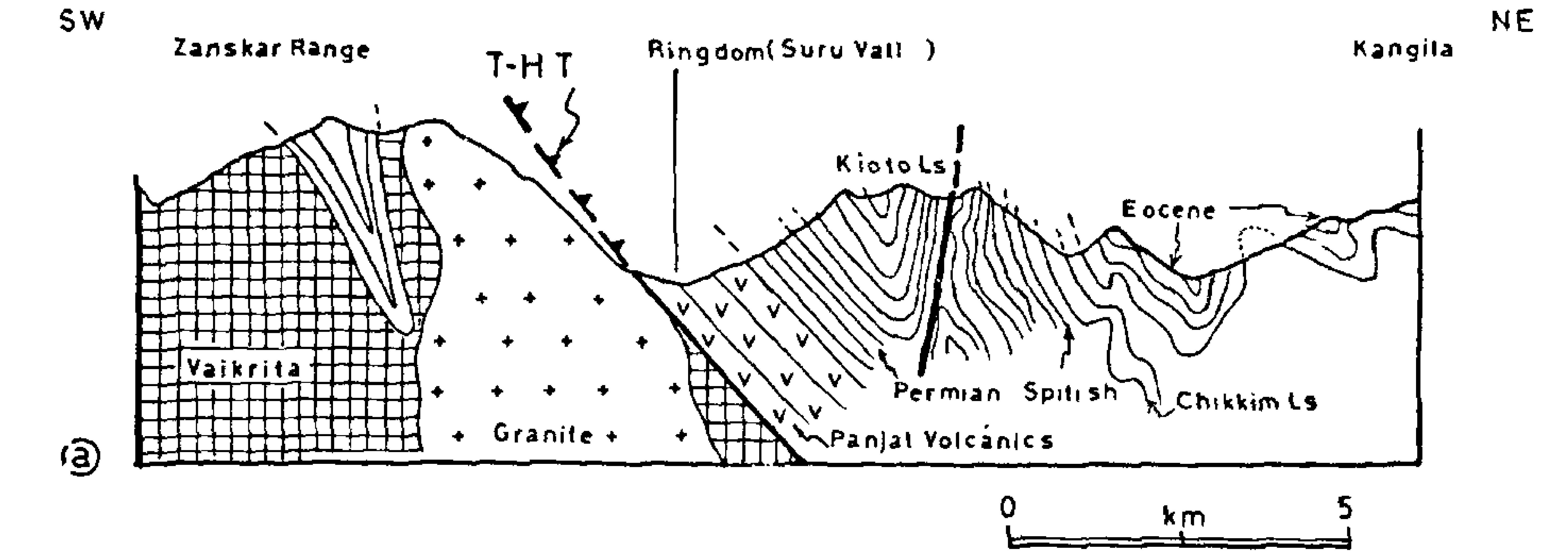


Figure 3. The map and section[6] of the Ladakh area showing faulted contact of the Vaikrita metamorphics of the Zanskar Range against the Tethyan sediments. Note the progressive steepening of the T-HT northwest-wards.



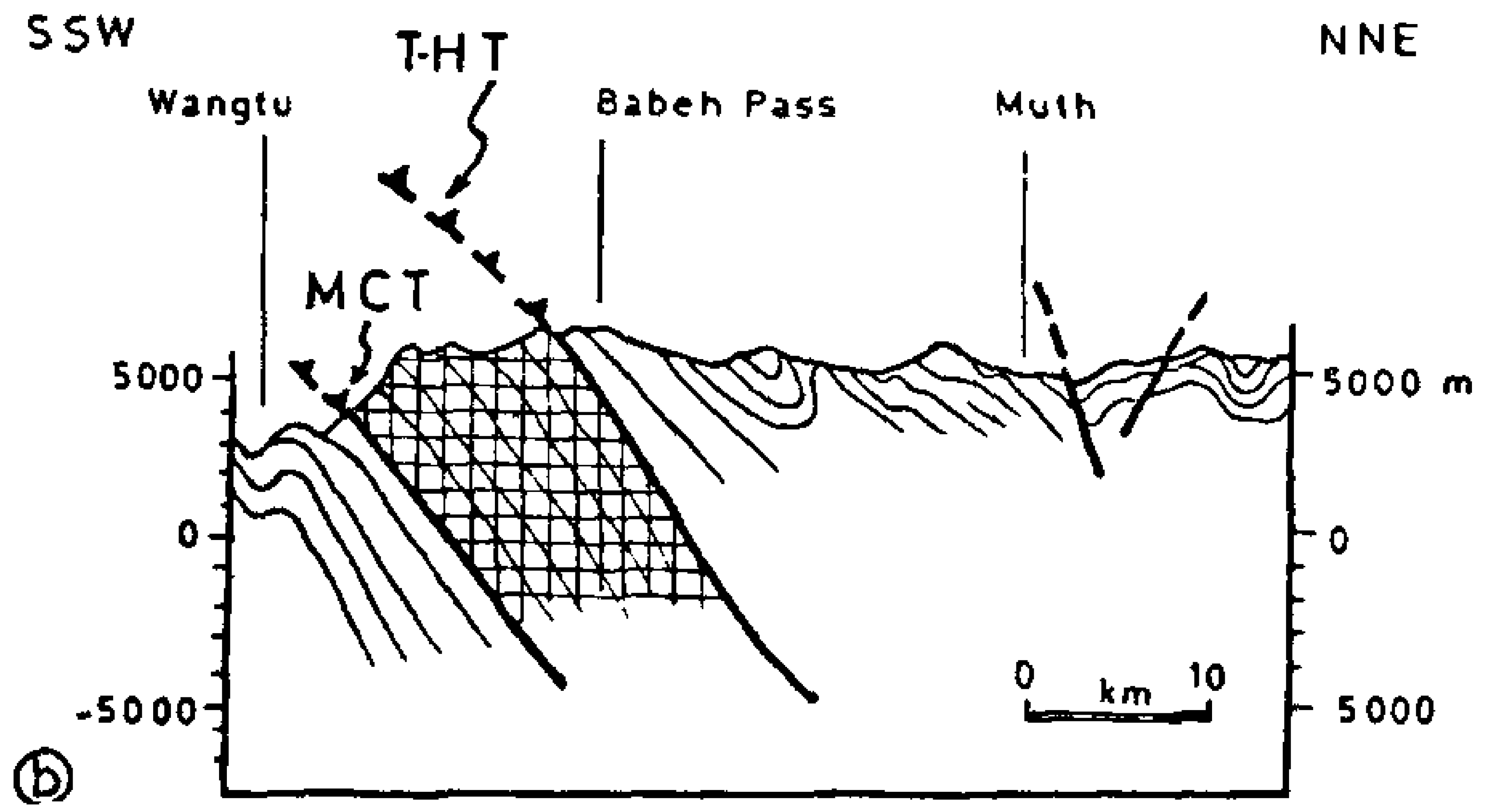


Figure 4a – b. **a.** In the Suru valley the upper Palaeozoic-Triassic Panjal Volcanics abut against the granite-injected Zanskar (Vaikrita) crystallines[7] — the whole of Proterozoic and much of Palaeozoic missing; **b.** In the Spiti valley a thrust of trivial magnitude[4] separates the Vaikrita from the Haimanta sedimentaries.

upper reaches of the Dhauli, Gori and Kali rivers (figure 2) where the T-HT was first recognized and described as the Malari Thrust[1–3,23]. The Malari Thrust has profoundly sheared and mylonitized the metamorphics, migmatites and mid-Tertiary granites of the Vaikrita Group, and considerably attenuated the Late Proterozoic Martoli flysch and Ralam conglomerate in the Dhauli and Gori valleys and eliminated the upper part of the Budhi Schist (Vaikrita) and wholly the Ralam conglomerate in the Kali valley (figure 2).

To the northwest in the Spiti valley a trivial thrust separates the Vaikrita metamorphics from the Tethyan Haimanta[4] (figure 4b). The intensity of deformation progressively increases northwestwards. The thrust between the Vaikrita crystallines of the Zanskar and Late Proterozoic Phe flysch (figure 3) dips 10–30° in the Bhaga valley in Lahaul, increasing to 45–75° in the upper Doda valley[5,6]. In the Suru valley it is the Upper Palaeozoic-to-Triassic Panjal Volcanics that is thrust against the granite-intruded Vaikrita metamorphics[7]—the entire Proterozoic and most of the Palaeozoic having been altogether eliminated (figure 4a). Further north the T-HT striking almost N-S is abruptly truncated obliquely by the WSW-ENE, E-W, WNW-ESE trending faults of the Indus Tsangpo Suture Zone (ITSZ) (figure 8). Not only the basement rocks and the synclinorium of the cover sediments, but also the TsoMorari-Nimaling dome are obliquely cut. There is no suggestion of flexing or bending down of the rock formations, rather the plunging folds and thrusts are sharply cut down and eliminated.

Turning southeast in the Kali Gandaki Valley in west-central Nepal, disharmonic folding of incompetent beds disrupt the continuity of succession[8] (figure 5) or the strongly lineated (NNE-SSW) Vaikrita metamorphics characterized by complex isoclinal folds give way abruptly to Tethyan sediments without these structures but exhibiting spectacular backfolds (figures 5b,c) and backfaults[9,10]. Further east in the Sagarmatha (Everest) massif the Chomolungma Thrust[11] or Main North Himalayan Thrust[12] separates the Ordovician fossil-bearing limestones from the Great Himalayan hornfelsed pelitic schists intruded by granites. The metamorphics are strongly mylonitized (figure 6). In the adjoining part of Sikkim, the Trans-Axial Thrust[13] cuts the Great Himalayan Tongshi-Chekha schists from the Tethyan Everest Pelites-Everest Limestone succession. It is noticed that throughout Kumaun and Nepal the Cambrian sediments are missing in the Tethyan column—obviously eliminated by the T-HT.

UPWARPS AT THE LEADING EDGE OF INDIAN CRUST

The pronounced domal upwarp at the northern edge of the Indian crust in the proximity of the ITSZ (figures 1 and 7) has brought up the basement metamorphics against the obducted material in the Gurla Mandhata-Mansarovar area[14,15]. The upper part of the doubly plunging TsoMorari-Nimaling anticline in Ladakh (figures 7b and 8) is constituted of anatectic granite-injected high-grade Vaikrita metamorphics and metamorphosed sedimentary cover involved in imbricate thrusting[4,16,17]. The Nanga Parbat massif in northwestern Kashmir possibly represents a tight anticlinal structure caught in the loop of the ITSZ and delimited to the west by a N-S trending tear fault.

To the southeast, in northwestern Nepal, "strong axial rise" has brought up the crystalline basement above the sedimentary cover between Manangobhot

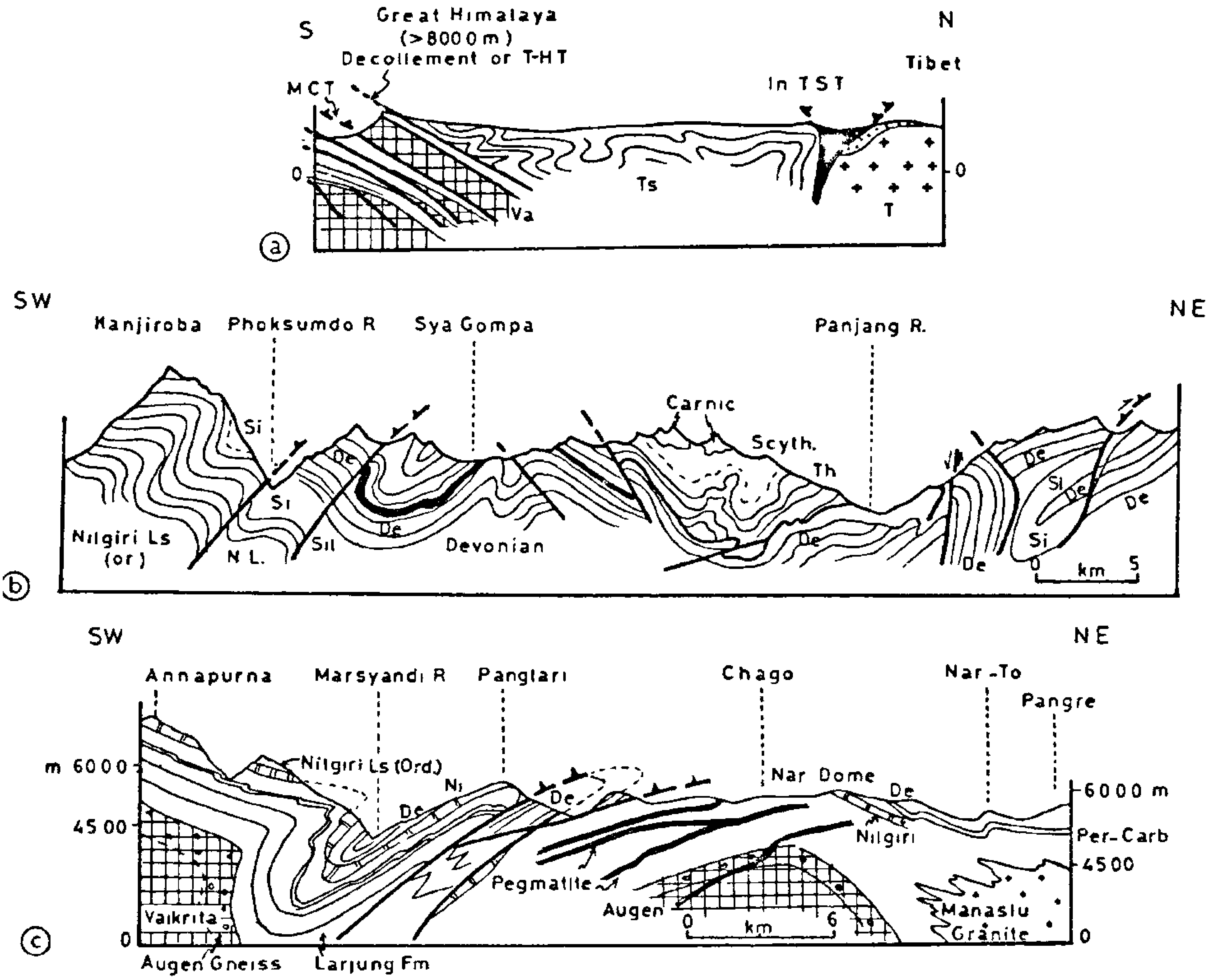


Figure 5a–c. **a.** In western Nepal the contact of the basement crystallines-sedimentary cover is marked by decollement and disharmonic folding[8]; **b.** North of Kanjiroba — Dhaulagiri massifs the sedimentary cover is backfolded due to gravity gliding[10]; **c.** A huge dome is developed north of Annapurna[9].

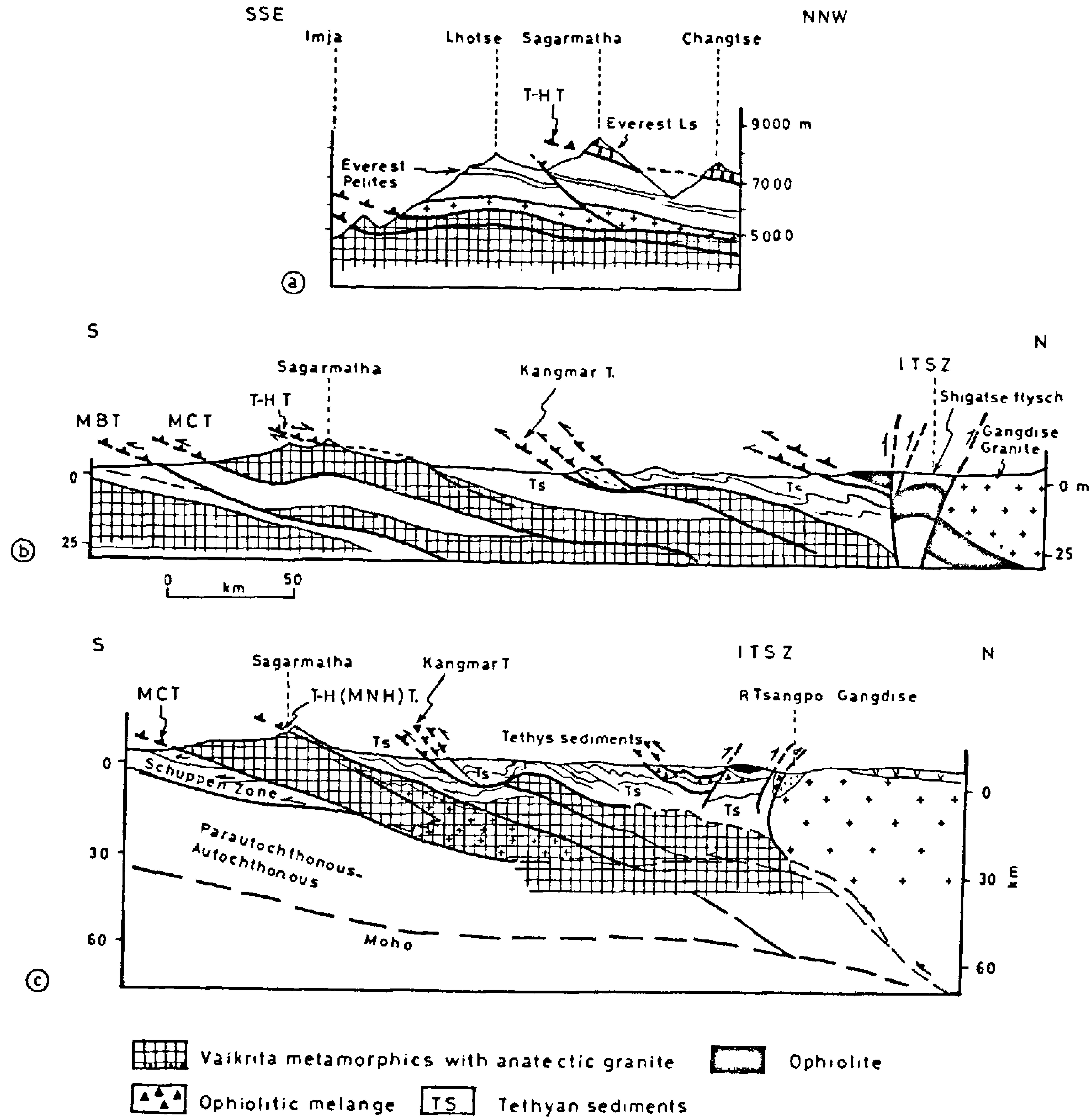


Figure 6. T-HT separates the high-grade metamorphics of the Sagarmatha (Everest) massif from the Tethyan succession beginning with Ordovician sediments[11,19].

and Phijor[18]. The anticlinal fold (Nar Dome) north of Annapurna characterized by centripetally overturned folds[9] (figure 5c) and the anticlinal structure related to the Kangmar Thrust north of Sagarmatha[19] represent basement upwarps (figure 6b).

GEOPHYSICAL CONDITIONS OF THE COLLISION ZONE

The occurrence of 10–15 m y. old potassic lavas in the Neogene volcanic belt immediately to the north

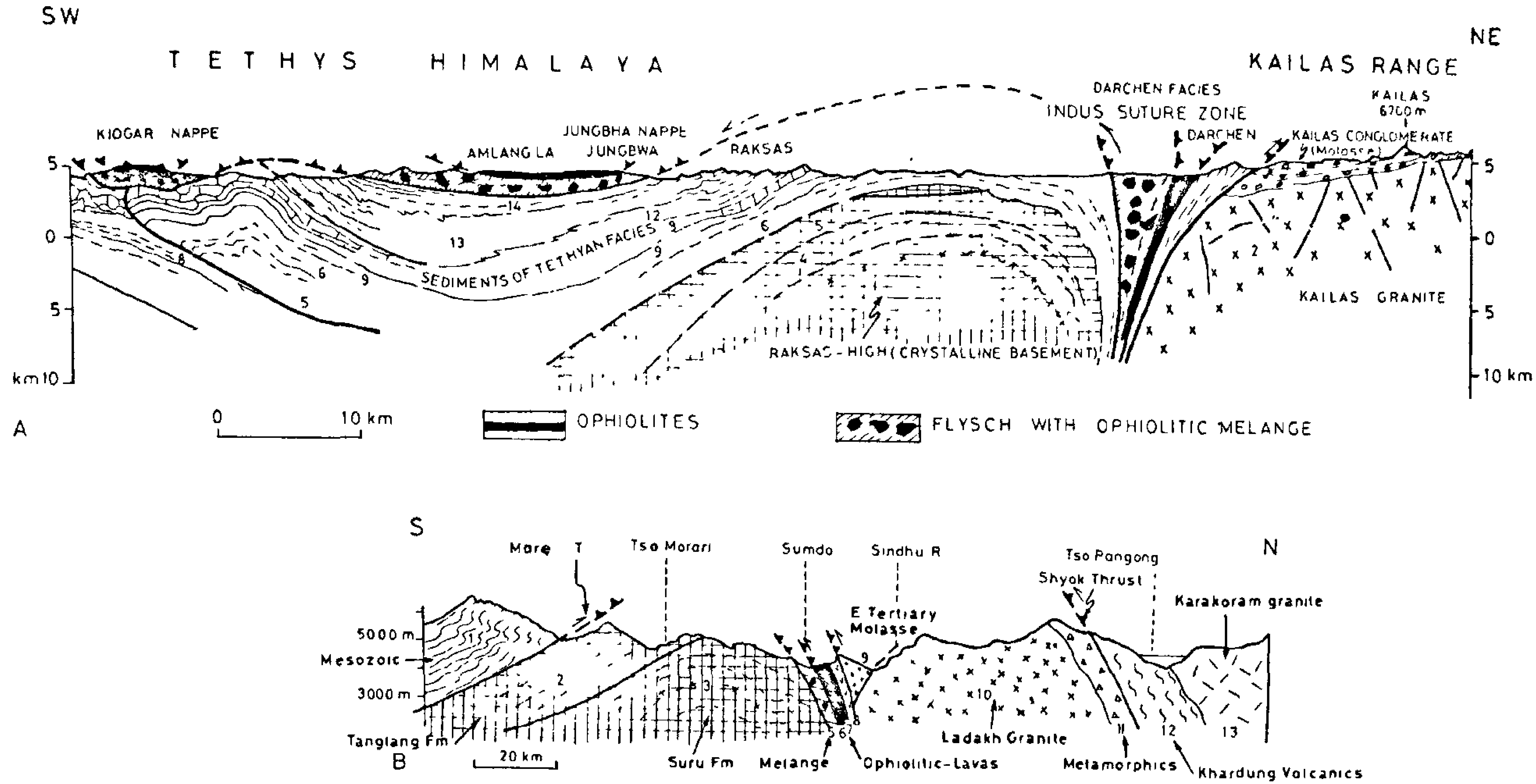


Figure 7. Sections of the Kailas-Mansarovar[14,15] (north of Kumaun) and TsoMorari (SE Ladakh)[16,17] areas showing domal upwarps exposing the basement metamorphics at the leading edge of the Indian plate.

of the ITSZ and of 6–8 m.y. old granite in the Kangmar area about 80 km south of the ITSZ[20] coupled with pronounced geothermal activity in the collision zone as manifest in 400 hydrothermal areas[21] and high heat flow of the order of 125–175 mW/m^2 imply very shallow origin and young age of the magmatic activity[22] (figure 9). The existence of high conductivity layer (parallel resistance 3–5 Ωm) at the depth of 3–14 km south of the ITSZ as defined by magnetotelluric studies[20] indicates partial melting in the very shallow part of the upper crust. These facts are consistent with the model of the basement upwarp in the Indian crust against the steeply dipping subduction zone.

CONCLUSIONS

Developed between ITSZ and MCT, the T-HT cuts the 10–20 km thick homoclinal Great Himalayan (Himadri) slab from the sedimentary cover and registers upthrusting of the Precambrian basement complex that initiated gravity gliding and consequent backfolding of the cover (Tethyan) sediments[2,23]. The T-HT developed in the continental margin of the Indian shield following the blocking of the movement around 45 m.y. ago on the zone of collision (ITSZ).

The basement upwarps of considerable dimension developed at the leading edge of the northward

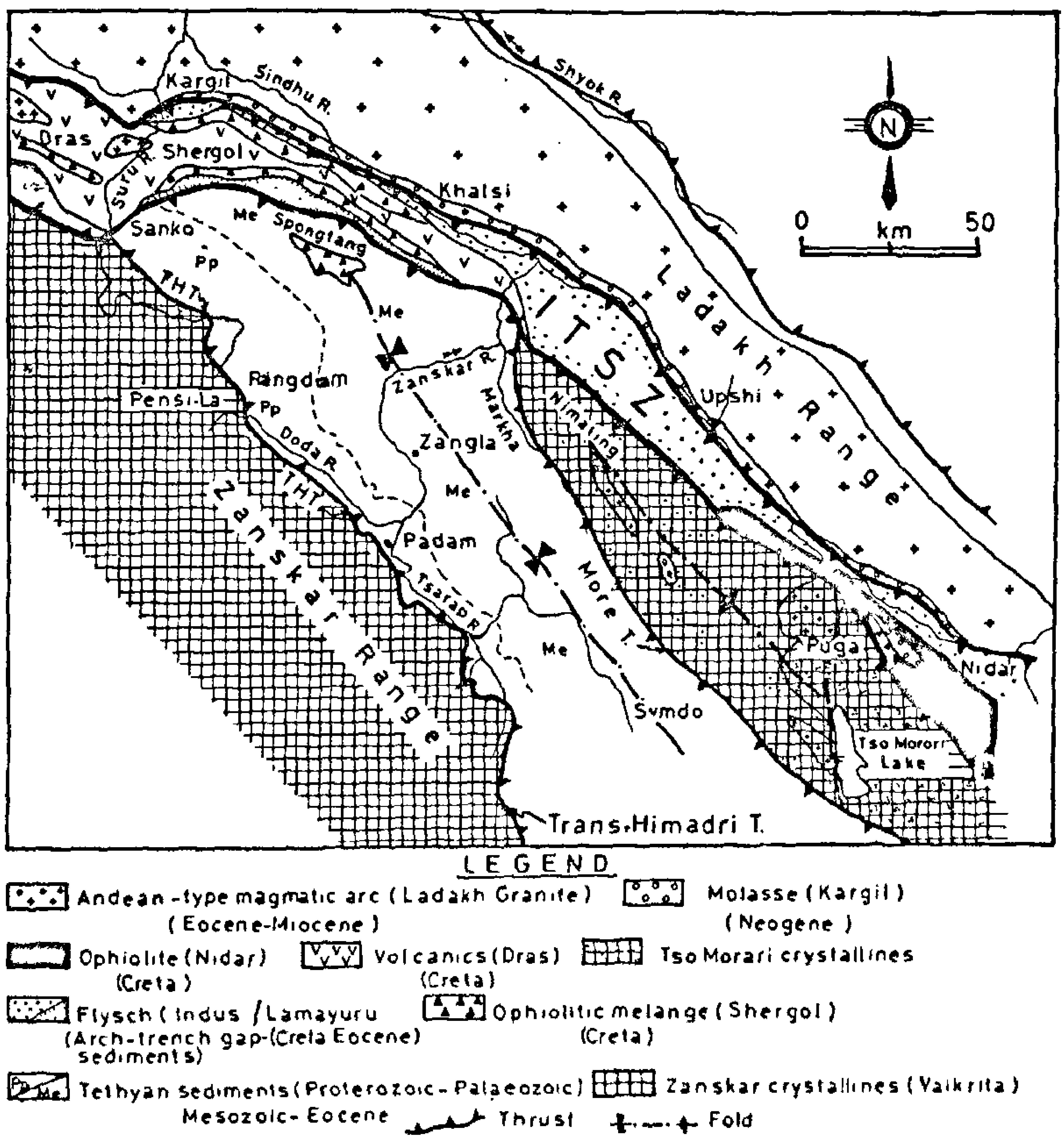


Figure 8. The map (modified after Thakur[16]) shows the ITSZ obliquely truncating the Tethyan synclinorium and the elongate TsoMorari-Nimaling dome of the basement crystallines. All Himalayan structures abruptly end against the ITSZ.

moving crust indicate that the Indian crust buoyed up, and was thus prevented from significant underthrusting beneath the Tibetan plateau. Indeed the buoyancy resistance was so strong that the back part of the moving crust broke up along the basement-cover contact, giving rise to the T-HT. These fea-

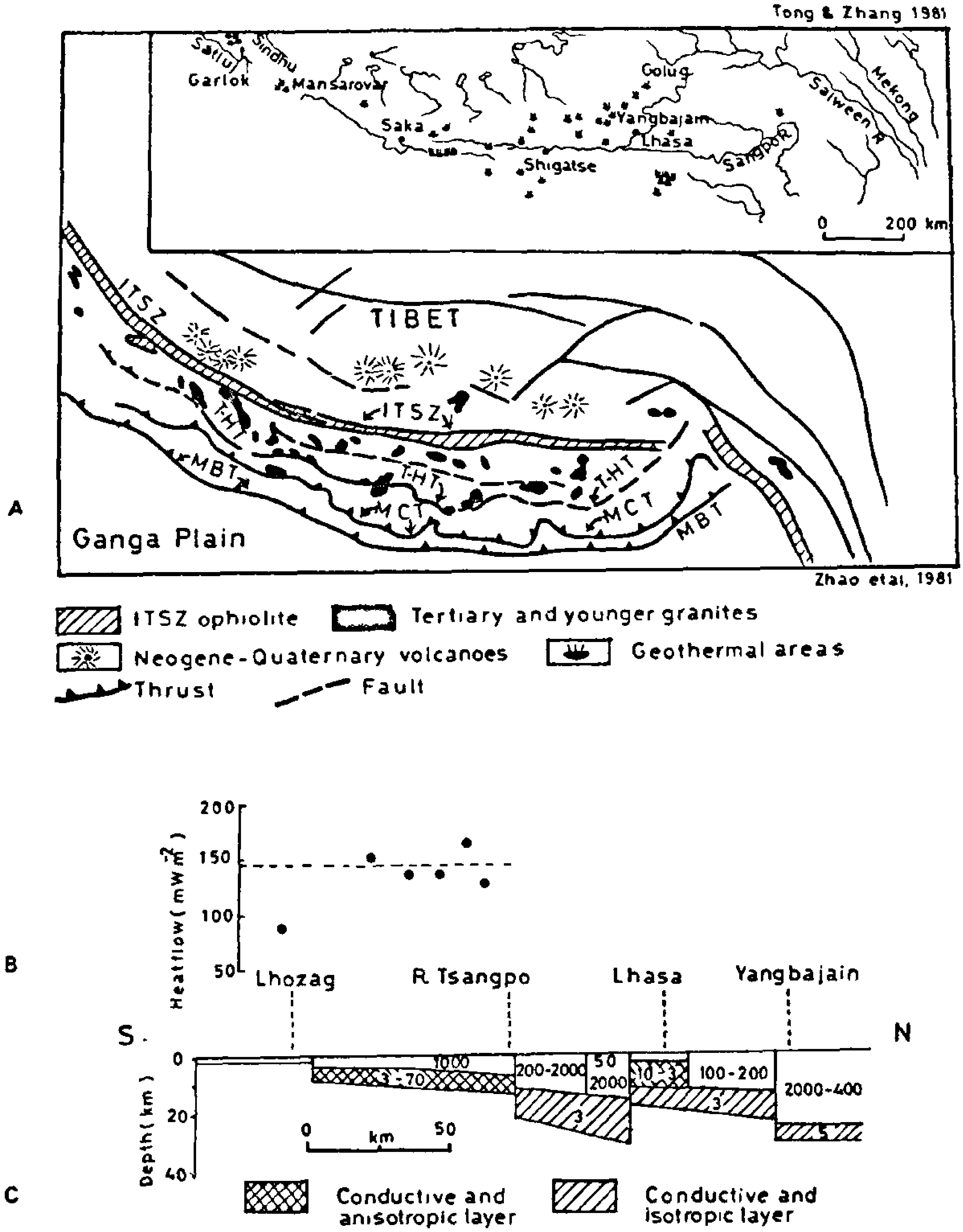


Figure 9a – c. **a.** On the two sides of the collision zone (ITSZ) there are Neogene-Quatenary volcanoes and young granites[27]. The inset shows distribution in Tibet of high-temperature geothermal areas in the proximity of the ITSZ[21]. **b.** High heat flow values between Great Himalaya and southern Tibet[20,22]. **c.** The magnetotelluric studies outline a layer of anomalously high conductivity in the shallow part (3 – 14 km depth) of the crust, both to the north and south of the ITSZ[20]. This layer possibly is the source of high heat flow and magmatic-volcanic activities.

tures together with the fact that very small part of the sedimentary prism of the Tethyan shelf has been lost in the obduction in the ITSZ, repudiate the postulation that a large part of the Indian crust has slid under the Tibetan crust.

This conclusion is consistent with the analysis of studies on the seismic wave velocity structure beneath Tibet implying compression and horizontal shortening[24], the seismic surface wave dispersion and attenuation that do not support crustal underthrusting model[25], the flexural rigidity of the Indian crust which would not allow entire Himalaya to underthrust Tibet[26] and the shortening by at least 40% of early Tertiary molasse of the collision zone and absence of systematically migrating elevated front that would have generated southern-derived molasse sediments[27]

ACKNOWLEDGEMENT

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