The Wider Himalaya, a Model for Scientific Research

By AUGUSTO GANSSER

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Synopsis

The Himalaya and part of Tibet were formed by the collision of India with Eurasia. Following a complicated pre-collision history, the post-collision phases, after the formation of the Suture Zone with its ophiolites, were characterised by the Transhimalayan plutons – their uplifts and erosion producing a molasse which forms the famous Kailas mountain – the subsequent intracrustal thrusting, and the Himalayan metamorphism with the final leucogranite intrusions. These initiated the morphogenic phase, with the uplift of the Himalaya and Tibet, en area of 2500000 km^2, in Pleistocene time. The related inland glaciation produced, on melting, numerous lakes, and was followed by the early immigration of a population which adapted to the difficult conditions, assisted by their religious belief and their cultural heritage.

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Introduction

Since ancient times, the Himalaya, the highest and youngest of the world's mountain ranges, has had a special attraction to mankind. As a mysterious, impassable barrier it was the abode of good and bad spirits, of gods and many more goddesses. Its numerous cave were a retreat for meditating hermits, such as the world-famous Milaräpa with unforgetable legends and the "hundred thousand" songs which have spread all over the Himalaya and Tibet.

Scientific investigations in the Himalaya began relatively early, considering its relative remoteness, and compared to other mountain ranges. With the foundation of the Geological Survey of India in 1851 started a golden age of Himalayan exploration. It was in particular the efforts of famous European geologists which provided a cover of the Himalaya except its eastern part but including some regions of southern Tibet and Afghanistan. Though modern travel faclities did not exist in those early days, there was plenty of time, and contact with the field was much more intimate compared to our hectic exploration with rapid but superficial coverage by jeeps and helicopters. Political boundaries already existed, and work in Tibet had to be done by trained natives – the famous "pundits" – or in disguise. Nepal and Bhutan were hermetically sealed countries.

The results of these early explorations were mostly stratigraphical. The recognition of complicated structures was handicapped by failure to recognize the conspicuous allochtonous masses in many regions, in spite of the fact that the nappe theory was understood in the Himalaya before it was published in the Alps. It was the Hungarian geologist Louis von Loczy who visited Sikkim in 1878 and, on the basis of previous work and his own field observations, recognized for the first time huge recumbent folds or nappes. These had a crystalline core over 10 km thick and were thrust southwards for over 100 km on top of the Permocarboniferous Damudas, which again were thrust over the Tertiary molasse, the Siwaliks (Fig. 1). At the same time Alpine geologists were still struggling with the famous "Glarner Doppelfalte", until Marcel Bertrand in 1887 published his sweeping interpretation of the Glarus thrust without ever having been on the spot. Unfortunately, regarding scientific priorities, von Loczy did not publish his findings until 1907, nearly 30 years after his discovery. Much later E. Argand, in his masterly synthesis "Tectonie de l'Asie" (1924), expressed some surprisingly modern views, suggesting crustal collision between Gondwana and Eurasia. Ten years earlier, however, Colonel Burrard of the Indian Survey had on the basis of geodetic evidence already suggested underthrusting of India as the reason for the origin of the Himalayan mountains. But more than 20 years elapsed before Auden, Heim and Gansser convinced Himalayan geologists of the existence of large crystalline thrust sheets (Auden 1937, Heim and Gansser 1939).

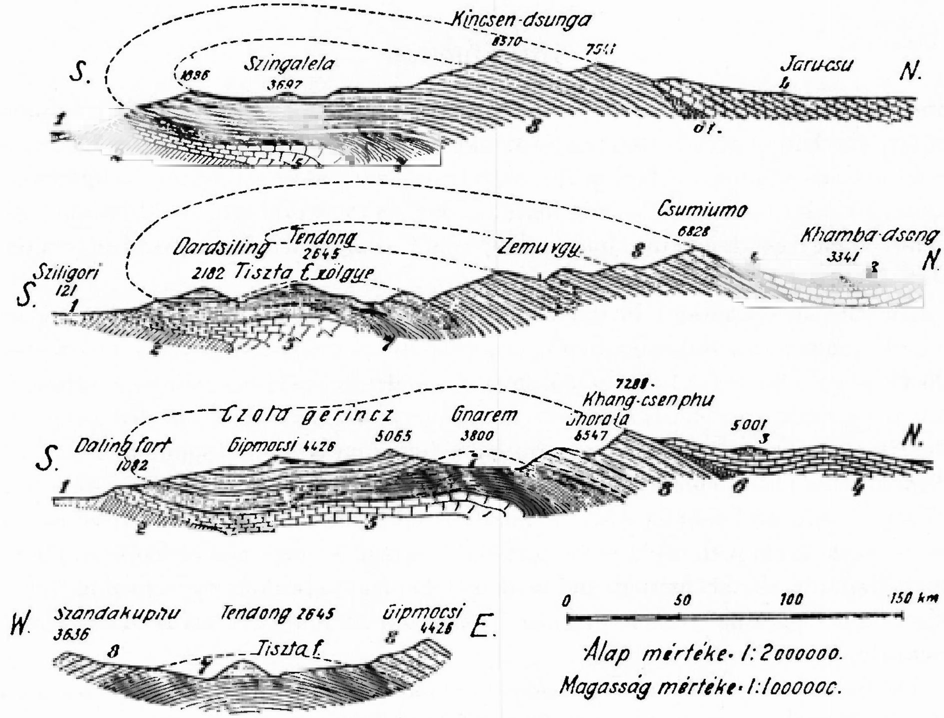


Fig. 1. The recumbant folds in the Sikkim Himalaya by L. v. Lóczy 1907 (observed 1878).

Geological History

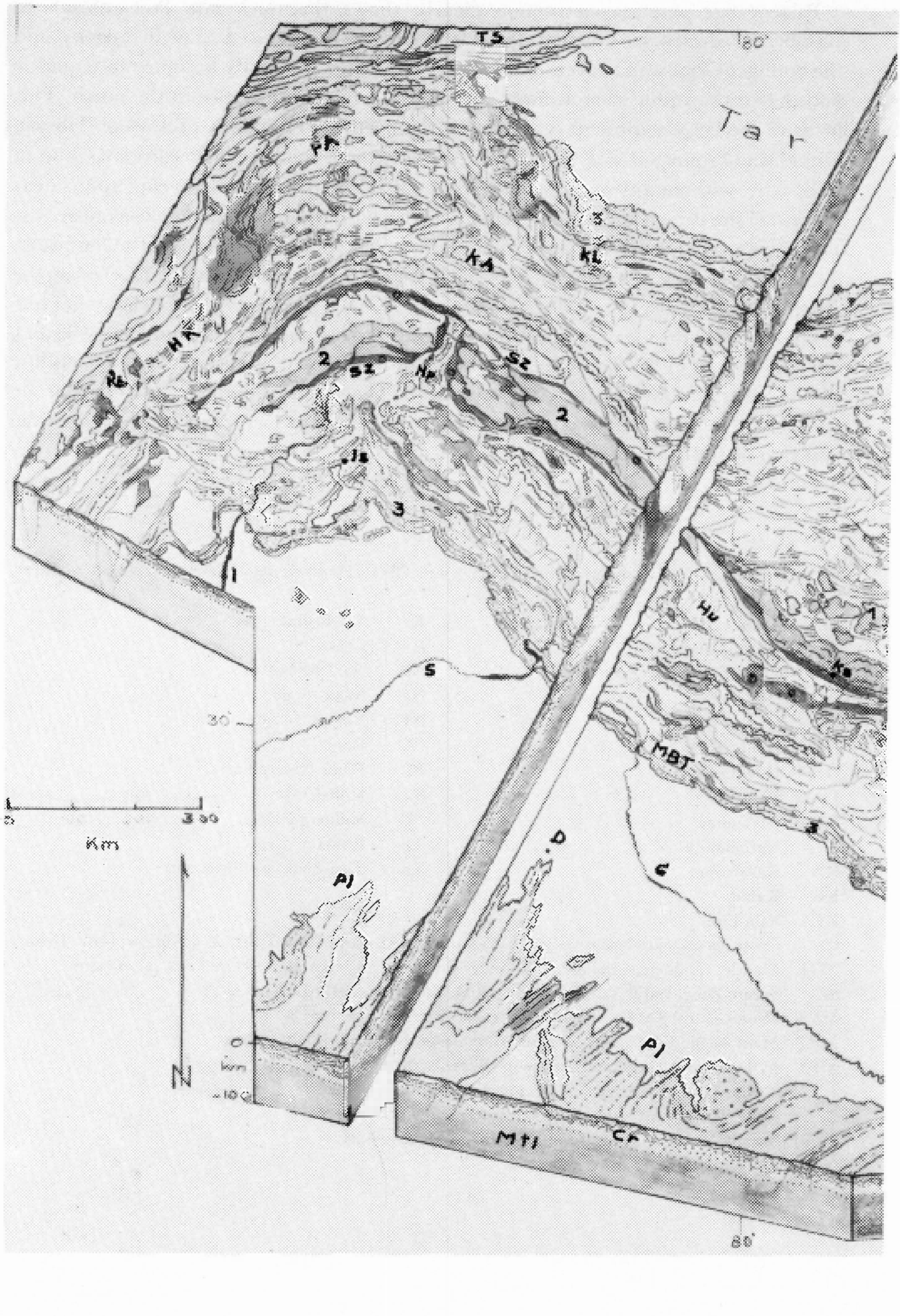
The present fascinating picture of the Himalaya and adjoining Tibet, the largest positive land mass on earth, is based on a most complex geological history (Fig. 2). There is hardly any doubt that the Himalayan orogen is the product of a collision between the greater Indian block and a complicated Eurasian mass, and we may subdivide the process of Himalayan mountain building into a pre- and post-collision phase. In pre-collision time, from the Precambrian to the end of the Palaeozoic, northern India was bordered by a shallow marine belt, which was called Paleotethys by some authors without, however, their having a precise idea of the size of this shallow shelf sea. It seems likely that this shelf, with no oceanic crust, was never bordered by a wide ocean, and that India was never far away from an Eurasian continent. An excellent account of this situation was recently given by J. B. Auden in his inspiring paper, "India's former crustal neighbours", published on the occasion of the Wadia commemoration (Auden 1981).

Palaeogeographic reconstruction clearly shows the thick late Precambrian to Cambrian sediments of northern India following the pronounced Aravalli orogeny, and the younger Gondwana cover. These latter sediments gradually become more marine and the stratigraphic section more complete the further one goes to the north. This leads to the large sedimentary section of the northern Himalaya (Tethys or Tibetan Himalaya of some authors) which represents a conformable sequence from Cambrian to Eocene, without any orogenic break but with some marked epeirogenic uplifts near the end of the Palaeozonic. This event coincided with a basaltic alkaline volcanism, the Panjal trap, localised in the western Himalaya only. The interfingering of a Gondwana and a Tethyan facies is well known in the Kashmir region and has been observed on the north side of Mt. Everest (Mu An Tse et al. 1973). These facts clearly show that one cannot support the idea, often ventured by various authors, of two sedimentary basins, one Gondwana in the south and one Tethyan to the north, separated by a crystalline divide which has formed the High Himalaya. This divide did not yet exist during the time of deposition, but was formed much later (Main Central Thrusts), after the collision of India and Eurasia.

Fig. 2. Geological block-diagram of the Himalaya and Tibet. (Photoreduction colored map by A. Gansser, 1979.) ▶

AT	Astin Tagh	Ks	Mt. Kailas
B	Brahmaputra river	L	Lhasa
CL	Chomo Lungma (Everest)	NB	Namche Barwa
D	Delhi	Ng	Naga range
G	Ganges river	NP	Nanga Parbat
HK	Hindu Kush	PA	Pamir
Hu	Hundes basin	PI	Peninsular India
I	Indus river	S	Sutledj river
Is	Islamabad	SH	Shillong plateau
K	Kathmandu	TB	Isaidam basin
KA	Karakorum	TS	Tien-Shan (southern part)
Kb	Kabul		
KL	Kun Lun		

Cr Crust: base 30 km below India, 70–75 km below Himalaya and Tibet, 30 km below Tarim basin.
MTL Mantle, "obducted" along SZ and older sutures in central and northern Tibet (Kun Lun).
SZ Suture Zone, Indus Tsangpo Line, doubled in western Himalaya.
MCT Main Central Thrust, major intra-crustal fracture. (Miocene).
MBT Main Boundary Thrust, on southern molasse (Siwaliks). (Pleistocene).
MFT Main Frontal Thrust, recent events, Siwaliks thrust on Quaternary.
1 Tertiary to Quaternary acide to interm. volcanics in Tibet.
2 Transhimalayan Pluton, 110–40 my, located N of Suture Zone.
3 Siwalik Molasse in S and southern Tarim Molasse in N.
0 Ophiolites along Suture Zone.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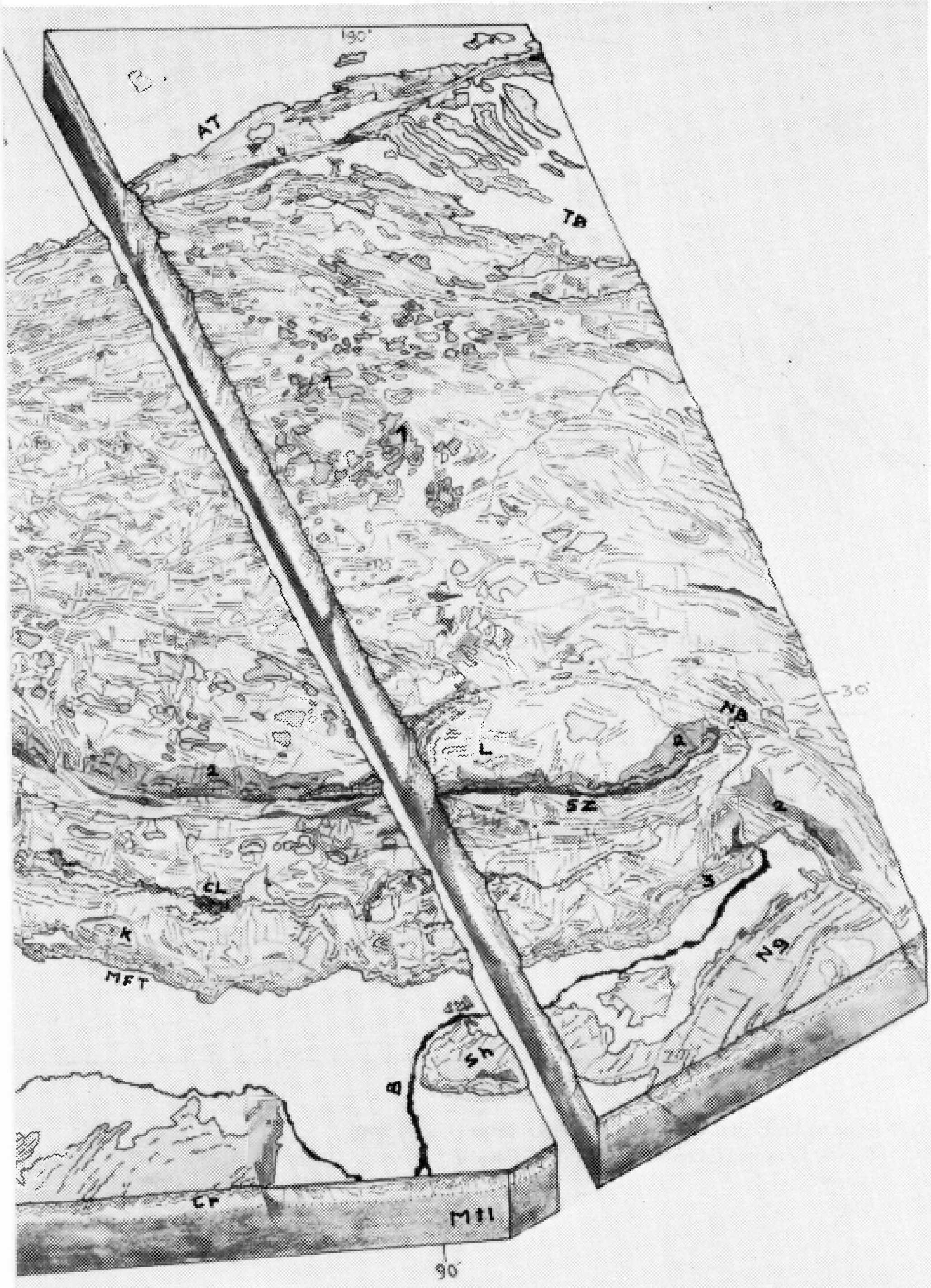
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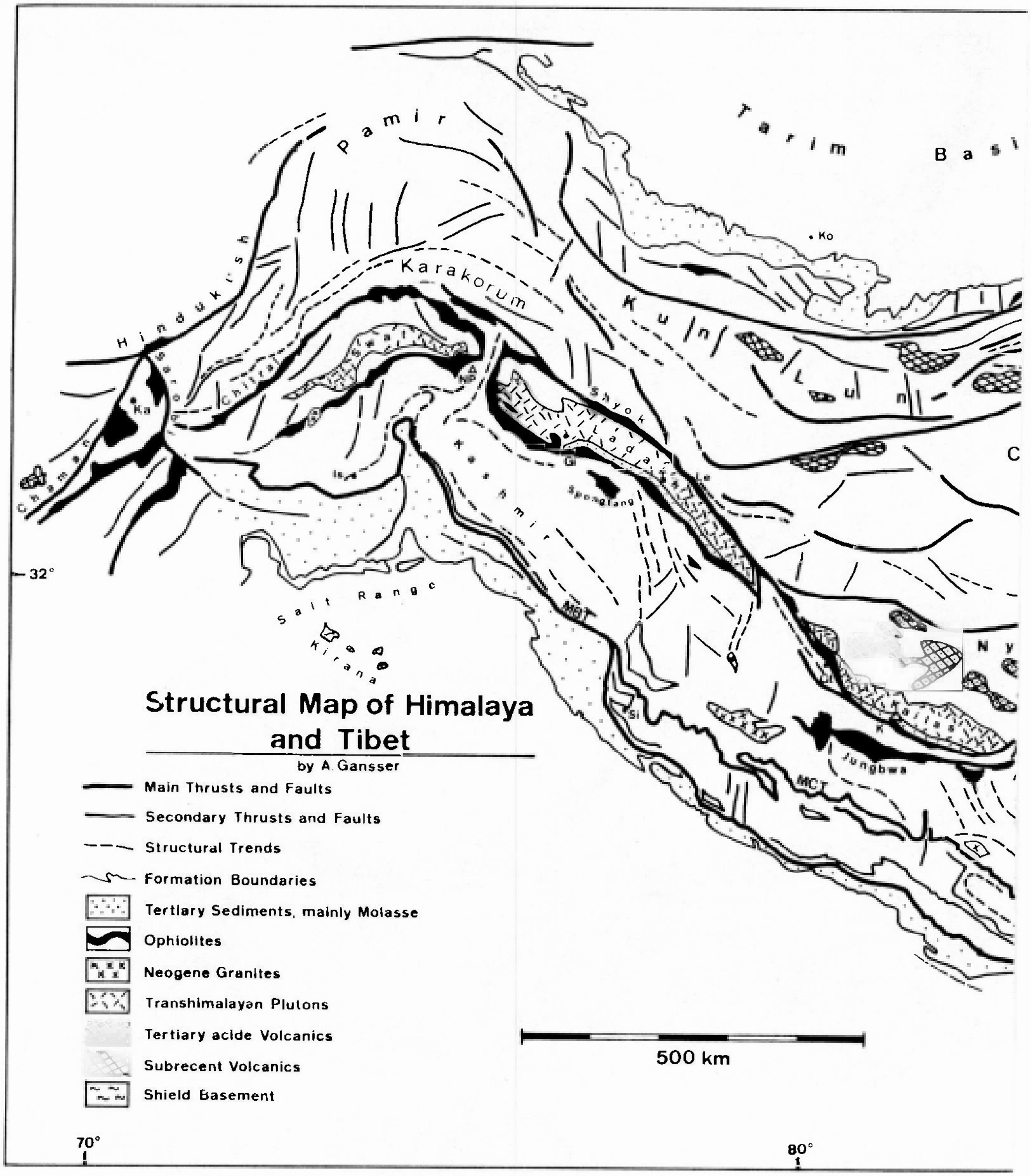
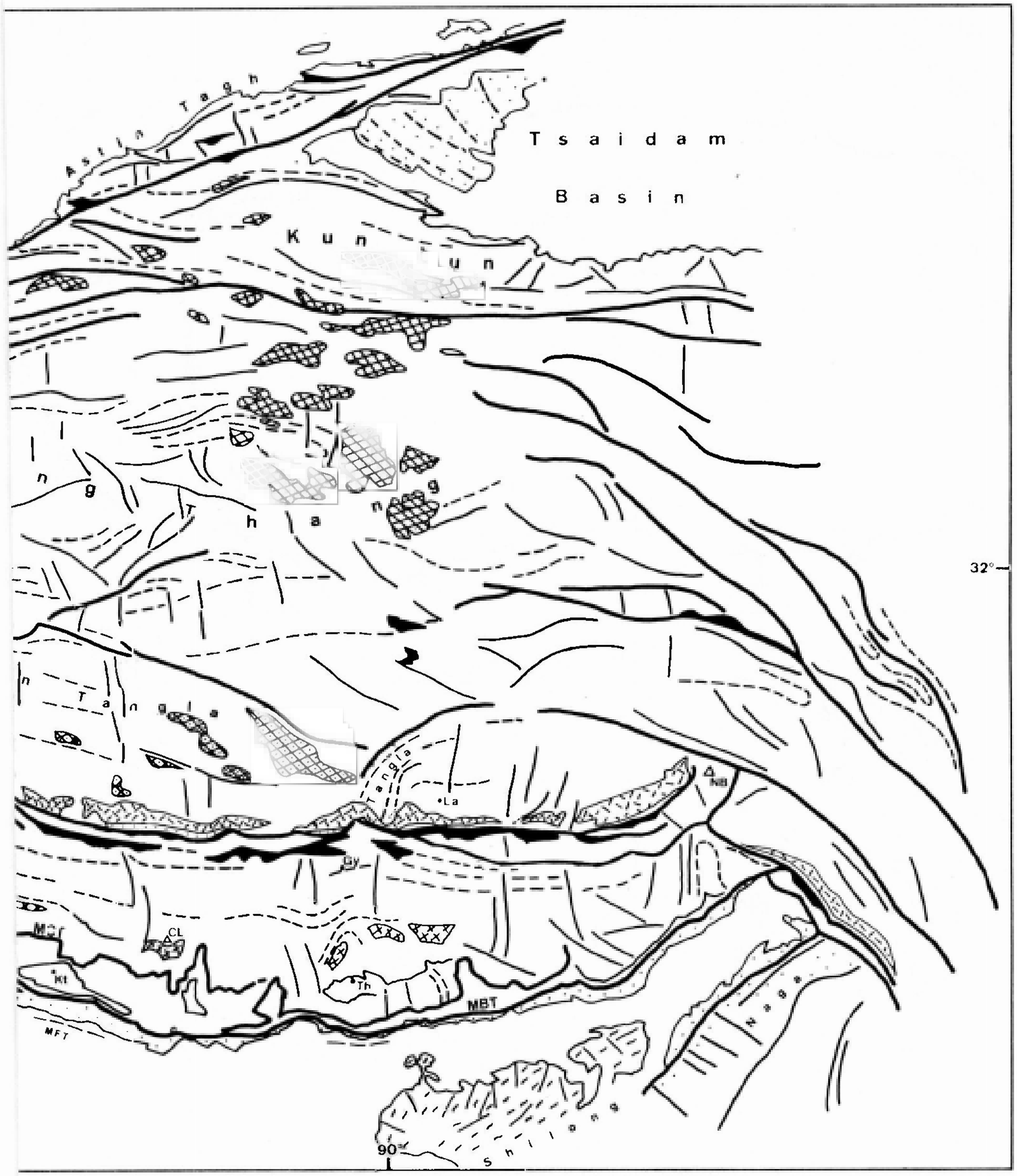


Fig. 3. Structural map of the Himalaya and Tibet. (After Gansser 1980).

CL	Chomo Lungma (Everest)	Ka	Kabul	Le	Leh
Gt	Gartok	K	Kailas Mt.	NB	Namche Barwa
Gi	Gilgit	Kt	Kathmandu	NP	Nanga Parbat



Gy Gyantse Ko Khotan Si Simla
Is Islamabad La Lhasa Th Thimphu
SZ Suture Zone, MCT Main Central Thrust, MBT Main Boundary Thrust, MFT Main Frontal Thrust.

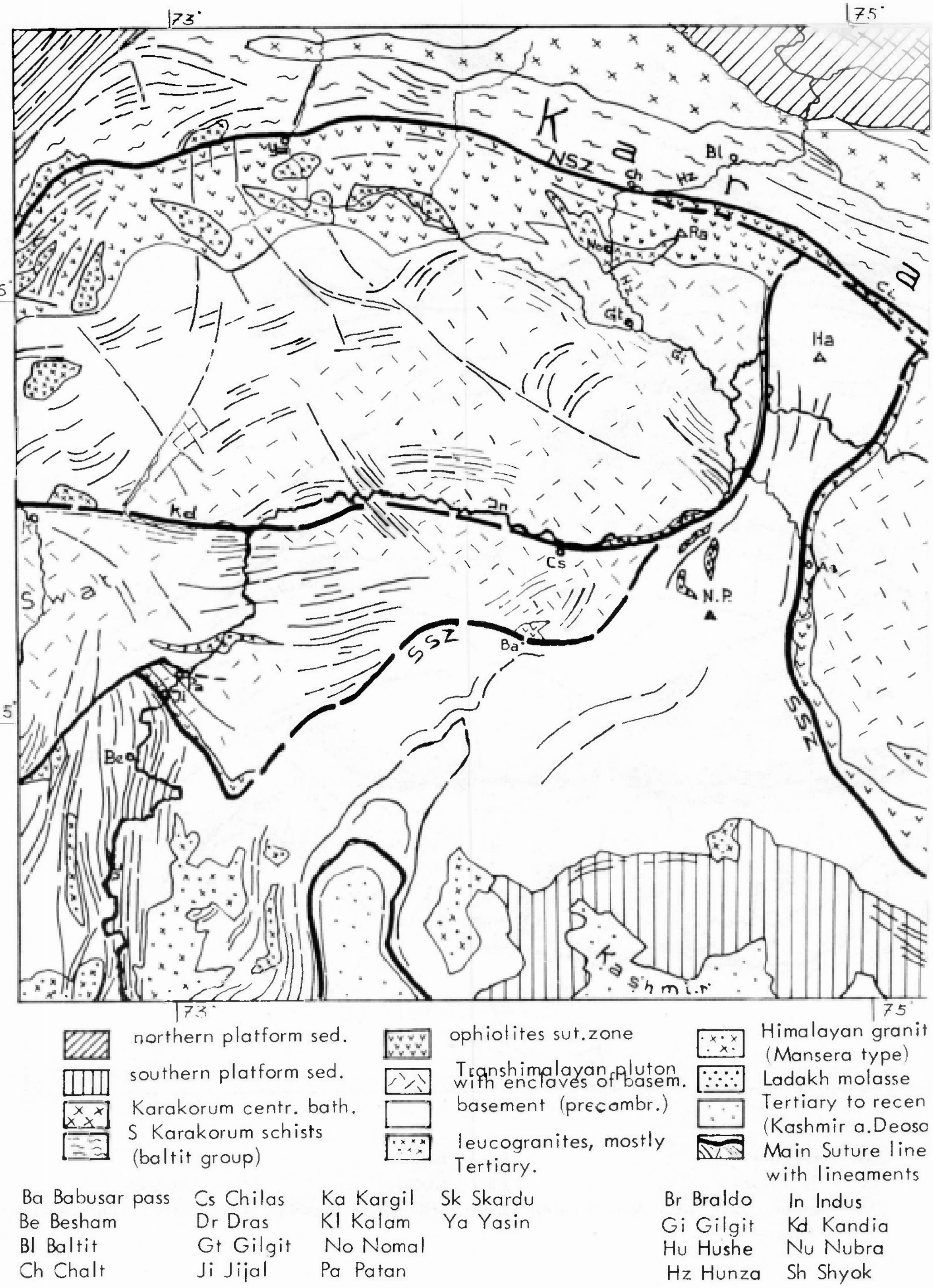
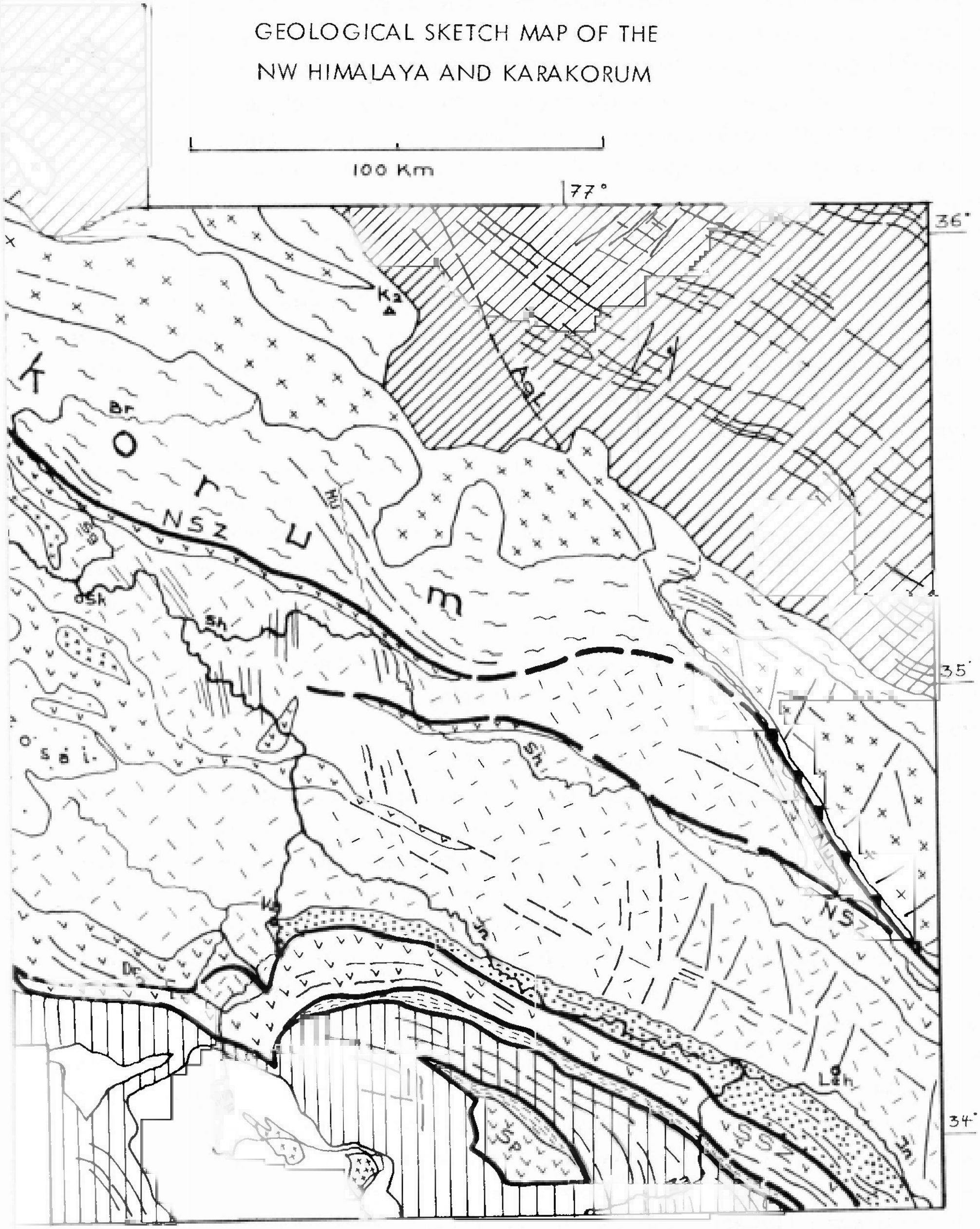


Fig. 4. Geological sketch map of the NW Himalaya and Karakorum. (After Gansser 1980).

GEOLOGICAL SKETCH MAP OF THE
NW HIMALAYA AND KARAKORUM



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Ha	Haramosh	NSZ	Northern Suture Zone
NP	NangaParbat	SSZ	Southern Suture Zone
Ra	Rakaposhi	Agl	Aghil Line
CL	Chogo Lungma Gl.	Spa	Spongtang Nappe

The collision of India with the complex southern margin of Eurasia, which included some micro-continents of doubtful origin (today called "displaced continents"), is well outlined by the Peri-Indian Suture Zone. This exposes ophiolitic rocks which range from volcanics with pillow lavas to ultramafics with associated ophiolitic melanges and oceanic sediments, predominantly in the form of radiolarites. This association, in particular the melanges, suggests originally steep and narrow oceanic basins and not large oceans as frequently suggested on the basis of palaeomagnetic results. The suture zone can be followed over a length of 5000 km from Karachi in the SW over the Quetta belt (western section) to the High Himalaya (northern section) and the Arakan Yoma branch to the Andaman islands in the SE (eastern belt), still with well exposed ophiolitic melanges. In all these sections the overall composition of the ophiolites is, in spite of most complicated tectonics, surprisingly similar. Actually the ophiolitic belt is the only constant feature all along the Alpine-Himalayan orogeny in spite of the greatly varying fore- and backlands (Gansser 1974, 1980a).

The collision took place during the very latest Cretaceous and early Eocene, with the final emplacement of the oceanic rocks (ophiolites) pre-middle Eocene in the Himalaya, while in the Middle East this process was mainly pre-Maestrichtian and in the Alps proper pre-Upper Jurassic and Upper Cretaceous. This phase and the subsequent formation of conspicuous ophiolite nappes not only characterises the Himalayan section but in precisely the same way occur along the Quetta belt which was never along the front of northwards drifting India. In all the ophiolitic nappes we note the curious facts that the ultramafic masses, representing mantle sections, form the highest structural element, underlain by the ophiolitic melanges and the oceanic volcanics.

After this major collision we note a certain calm with no orogenic activity. During this period the intrusion of the Transhimalayan batholiths ended all along and to the north of the Himalayan suture zone with pronounced volcanic activity 40 my ago (Fig. 3). Convincing geochemical evidence shows that the Transhimalayan batholiths were derived by melting of a downwarped oceanic crust. This melt was intruded along the continental rocks of the southern Asian plate border with more or less pronounced contamination. The intrusions started about 110 my ago with basic, mostly noritic gabbros, grading over diorites to the widespread tonalites (60 my) and ending with granites and vulcanics of 40 my (Honegger et al. 1982). The intrusive activity was not continuous but occurred in various phases, well displayed in the Ladakh area with granites along the southern border, while south of Lhasa to the east the older, more basic rocks outcrop in the south and become more acid and younger in a northward direction. The famous granite of Lhasa is highly contaminated by Jurassic limestones of the northern continental crust (Academia Sinica 1980).

In the western Himalaya the suture zone consists of two sutures. The Transhimalayan intrusions occur between a southern (Indus) and a northern (Shyok) suture, the latter forming a sharp structural contact between the Himalaya and the Karakorum. The two sutures merge westwards towards the Kabul region where they are sharply cut by the N-S-trending Sarobi fault which limits the northwards directed Kabul spur (a possible continuation of the Indian shield) to the east. Both suture zones, particularly the southern one, are affected by the late N-trending Nanga Parbat/Haramosh crystalline antiform, which runs perpendicular to the E-W-trending Karakorum (Fig. 4). This remarkable structure also cuts the Transhimalayan batholith into an eastern Ladakh and a western Swat batholith. Both batholiths contain large inclusions of pre-batholithic basement, some not unlike the crystalline of the Nanga Parbat/Haramosh, which however is different from the Indian shield crystalline to the south of the suture. Most of these large inclusions still show a N-S-structural grain, contrasting with the E-W regional trend, and are parallel to the Nanga Parbat spur (Gansser 1980b). "Displaced" microcontinents of as yet unknown origin may have influenced the tectonic trends of this part of the Himalaya. This highly complicated area can hardly be explained as one large island arc (Coward et al. 1982). We have here one of the most fascinating and problematic sections of the whole Himalayan range.

The possible existence of microcontinents along the southern front of Tibet is another most important but still unsolved problem. We know that a large slice of southern Tibetan crust, the Nyenchen Tangla belt (Fig. 3), is separated by fault zones and sporadic ophiolite outcroups – some shown on the new 1:1 500 000 map of Tibet (1980) – from the northern part of Tibet, suggesting a northern suture zone which however does not reach the importance of the Tsangpo/Indus Suture to the south. From the latter suture, the northern suture branches off NW of Gartok were the Indus river turns east towards its sources north of Kailas mountain. It has recently been investigated by French-Chinese teams to the north of Lhasa (E.U.G. abstracts 1983). The eastern continuation of the Nyenchen Tangla belt is the Lhasa block of the French teams, separated from the Nyenchen Tangla belt by the abnormally NE-striking Precambrian Tangla range.

Returning to the Transhimalayan batholith we note that the intrusions and volcanism were followed by a very rapid uplift, so that the Transhimalaya dominated the Himalaya, forming an important watershed. The remarkable uplift and consequent erosion was responsible for the formation of a molasse, deposited along the south side of the range and transgressing with a large basal conglomerate directly onto the plutonic rocks. Volcanic pebbles increase in abundance upwards and dominate together with some Lower Eocene limestones which give a lower age limit for this upper part of the molasse. The average age is most likely Oligocene. This molasse is particularly well developed in the central part of the over 2000 km long Transhimalaya and dominates in the Kailas mountain, a most striking relic of 4000 m of near-horizontal conglomerates and subordinate sandstones sitting on the tonalite and granites. This Kailas molasse is surprisingly thickly bedded in contrast to similar molasse in the Ladakh region (Fig. 5).

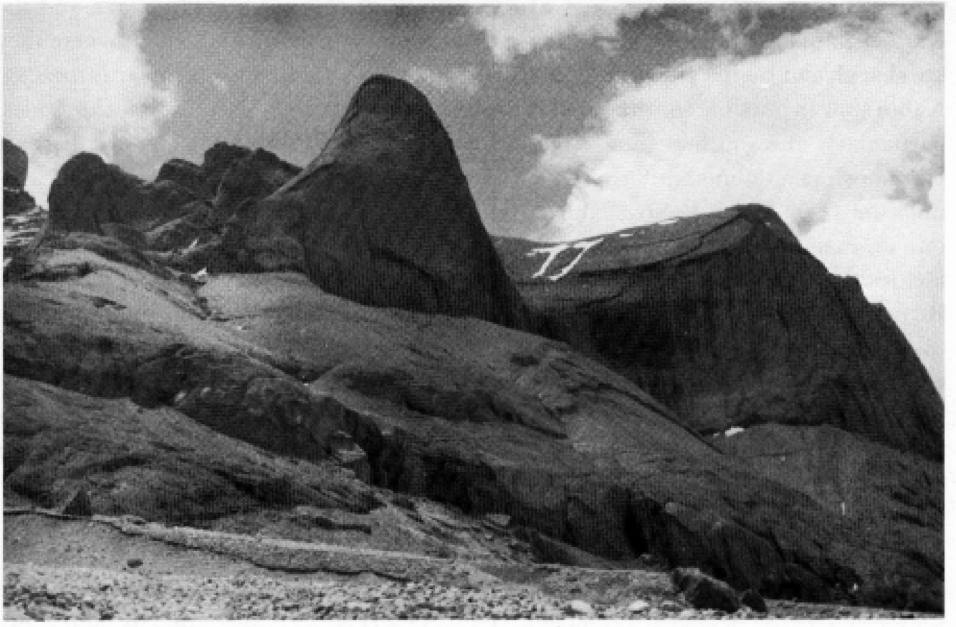

Fig. 5. The very thickbedded lower conglomerates of the Kailas Molasse, view eastwards, summit of Kailas to the left. (Fot. A. Gansser).

With its 6800 m the Kailas is most likely the highest molasse mountain known and because of its extraordinary shape (Fig. 6) it has become the most holy mountain of Asian religions (Allen 1982). It has been widely illustrated in old wall paintings together with its surrounding monasteries and the holy lakes of Manasarovar and Raksas, also important places of worship (Fig. 7). Not only the form of Kailas but also its geographical position is striking: all the largest rivers of the Himalaya and Transhimalaya have their sources near this mountain, the Indus in the north, the Sutledj in the west, the Tsangpo (Brahmaputra) in the east and the Ganges in the south (Fig. 8). The fact that in the old scripts Kailas was regarded as the centre of the known world has its geographical meaning.

After the deposition of the Kailas molasse and a period of relative orogenic calm, India reassumed its northward drift, but since the suture zone was welded and fixed, this movement was compensated by intracrustal adjustments. In the Miocene we recognize the Main Central Thrust along which a crystalline slab more than 15 km thick and its Tethyan sedimentary cover moved more than 100 km over the metasediments of the Lower Himalaya. At the base of the MCT we note a highly complicated zone of imbrications, particularly well exposed in Nepal, from which larger secondary thrust

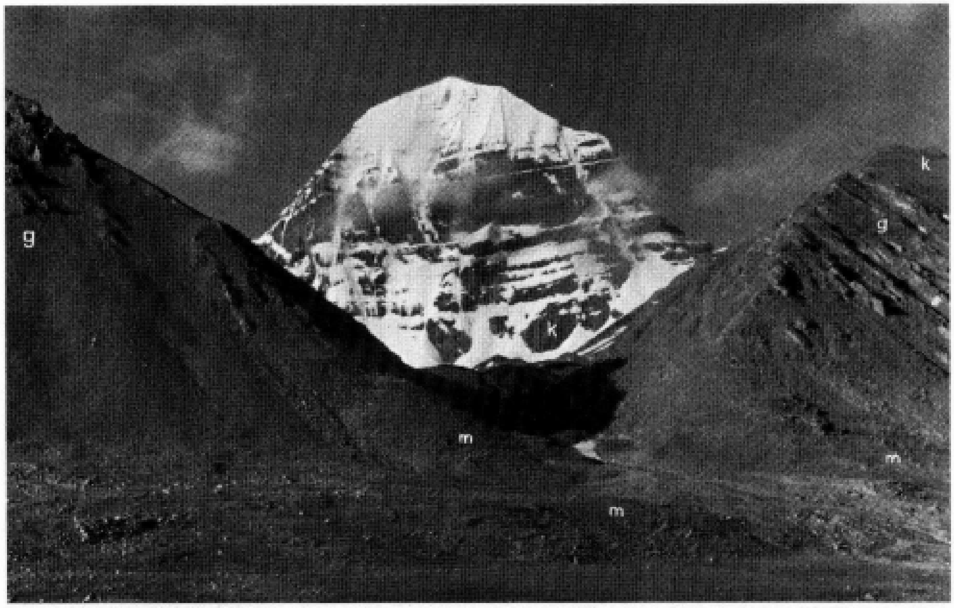

Fig. 6. The Mt. Kailas, seen from the N. The most holy mountain in the world. k=Kailas Molasse, g=Transhimalayan granite to tonalite, m=local moraines. (Fot. A. Gansser).

sheets developed, such as the crystalline thrust of Almora in the Kumaon Himalaya. A further pulse from India was taken up by the Lower Pleistocene Main Boundary Thrust further to the south, bringing the Lower Himalayan rocks over the frontal molasse, the Plio-Pleistocene Siwaliks. At present the Siwalik belt is steeply thrust along the Main Frontal Thrust over the Quaternary, tilting and warping the foothill deposits, in an area outlined by recent seismicity. These facts clearly reveal the intracrustal activity becoming younger and shallower from north to south (Fig. 3).

The regional Himalayan metamorphism coincides with the renewed Miocene orogeny. It is interesting to note that this metamorphism affected mostly the already metamorphosed rocks dating from late Precambrian events. Rarely it involves younger sediments, such as the lower Mesozoic of the western Himalaya (Nun Kun region in Ladakh – Honegger et al. 1982). In the adjoining Spiti basin the transgressive Ordovician sediments are non-metamorphic and enclose Precambrian metamorphic rocks in their basal conglomerates, proving without any doubt the presence on an old pre-Himalayan metamorphism (Fuchs 1982). The Himalayan metamorphism, which in the Lower Himalaya overprints the late-Precambrian sediments, is of anchi to high greenschist facies. The metamorphic grade increases towards the inner and higher

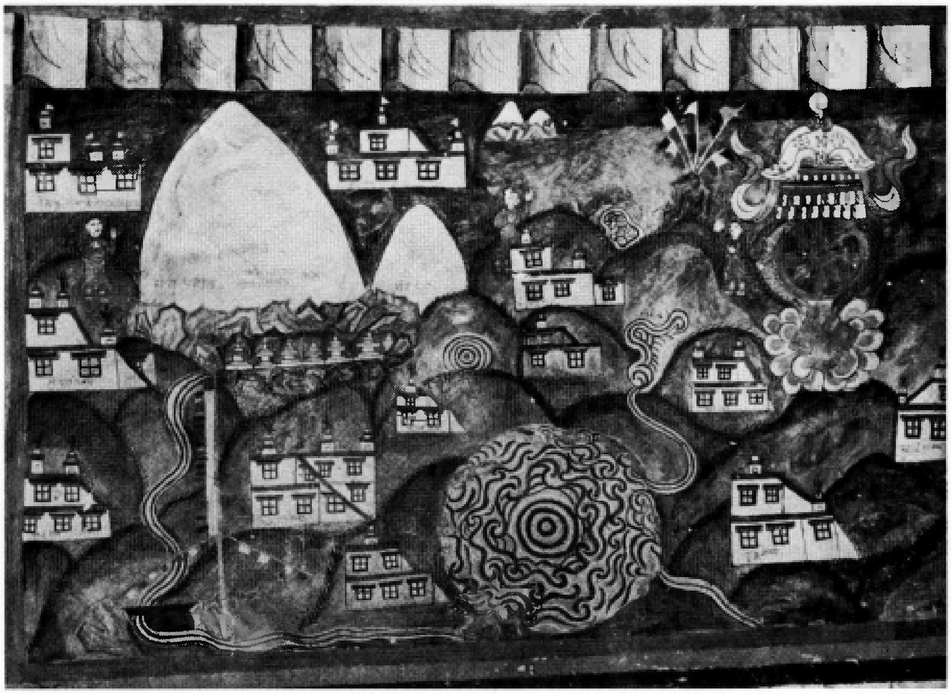

Fig. 7. Old wall painting of Mt. Kailas (upper left) and lake Manasarowar (bottom center) with monasteries which belonged to Bhutan, 1000 km away! Fotographed in a small village temple in Tinkar, NW Nepal, by A. Gansser.

units, displaying a remarkable reversed metamorphism. Within the crystalline thrust sheets of the Higher Himalaya only the lowest sections expose a reversed metamorphism (kyanite/staurolite to sillimanite); the metamorphic grade decreases again gradually towards the overlying Tethyan sediments. In the high-grade crystalline units it is most difficult to distinguish the Himalayan metamorphic overprint from Precambrian metamorphic events. The existence of the latter is furthermore documented in a few places by radiometric ages of 1800 and 1400 my (Bhanot et al. 1977). As a final and closing phase of the Himalayan metamorphism we note the intrusions of leucogranites in the High Himalaya which outdate the metamorphism and cut all visible structures. They usually intrude the highest part of the range from Nanga Parbat in the west over Badrinath, Manaslu, Shisha Pangma, Makalu to the Bhutan peaks in the east. Over a distance of nearly 2000 km their composition, age and mode of intrusion is surprisingly constant (Le Fort 1973). They usually intrude high-grade metamorphic rocks but can reach locally into the Mesozoic sediments of the Tethyan cover, where

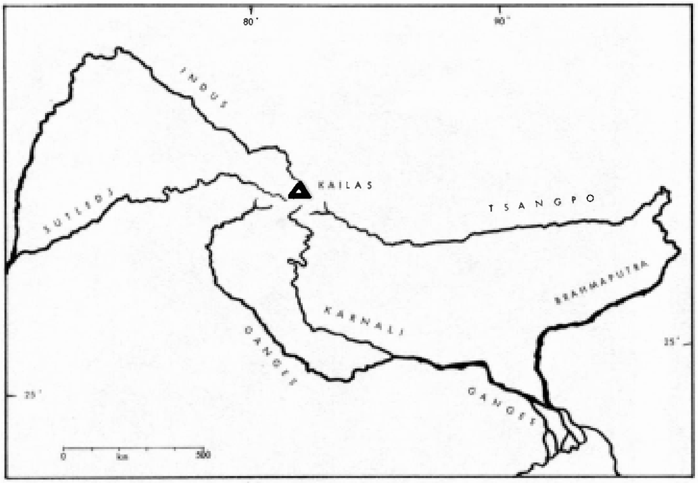

Fig. 8. The unique position of Mt. Kailas, the source of all the major Himalayan rivers. The "center of the world".

they produce a marked contact metamorphism. The extremely high (^{87}SR/^{86}Sr) ratio suggests melting of old sialic crust which distinguishes the leucogranites clearly from the Transhimalayan intrusions (Dietrich and Gansser 1982). The leucogranites close the Himalayan orogenic and metamorphic events and initiate the regional uplift of the range, the morphogenic phase.

Morphogenic phase

This regional uplift involves not only the Himalaya and Transhimalaya but also the large adjoining mass of Tibet to the north as well, an enormous area of over 2 500 000 km^2. New investigations of flora and fauna from terraces now between 5000 and 6000 m a.s.l. on the northern slopes of the Himalaya in the Sisha Pangma region revealed subtropical and tropical species, suggesting uplifts since the early Pleistocene of 4–5000 m (Hsu et al. 1978). Well known are the famous Karewa lake beds of Kashmir, which also suggest subrecent to recent upplifts in the western Himalaya (De Terra and Paterson 1939). Already over 100 years ago, in the gravel terraces of Hundes, nearly 5000 m up in the Tibetan part of the northern Central Himalaya, Lydekker found rhinoceros bones in beds which, in spite of having been uplifted several thousand metres, are still perfectly horizontal (Lydekker 1881). These gravel horizons are cut by steep gullies, and in the rock walls as well as on steep cliffs there are remnants of monasteries from the time of the kings of Guge. They contain the oldest and finest buddhist wall paintings known (Fig. 9), which, unfortunately, are slowly deteriorating (Tucci 1937).

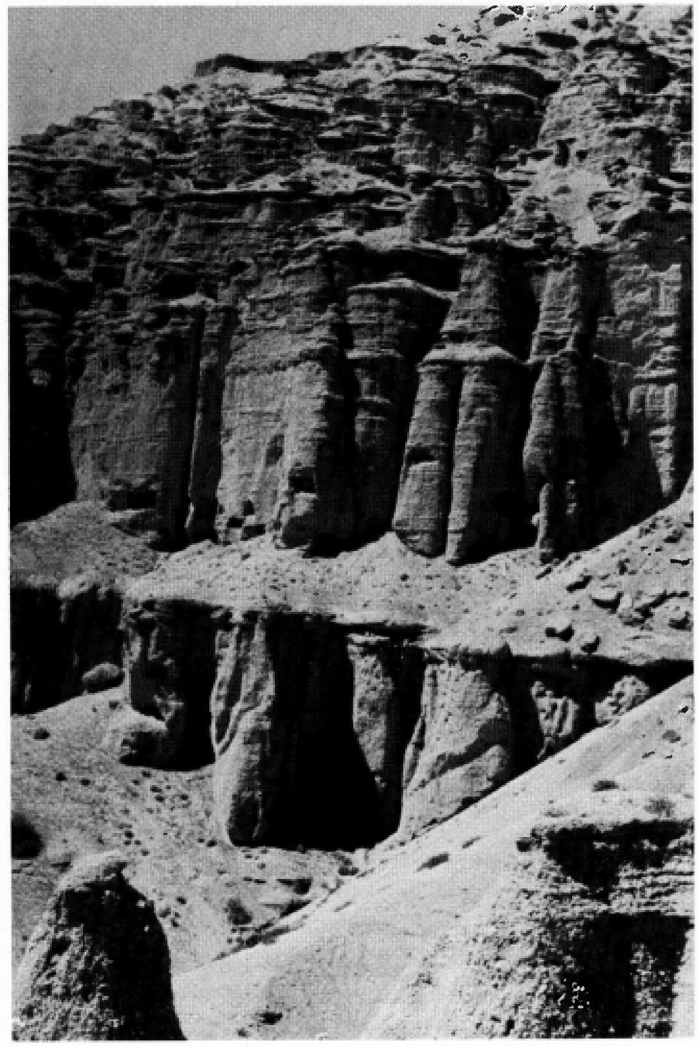

Fig. 9. The eastern end of the large Hundes basin with Quaternary terraces rich in old remnants of cave monasteries. In the central basin the horizontal gravels contain tropical mammal bones, now at 4–5000 m elevation. (Fot. A. Gansser).

New results on precise levelling and triangulations which may provide quantitative data on recent uplifts are not yet available. Fault zones along the foothills show movements more of a horizontal than a vertical nature. The recent measurements of Everest (Chomolungma) suggest increasing height, but previous data were not too reliable. In his last publication of 1982, Eric Norin, who died at an age of 87 years, discussed the triangulation work of the 1932 Swedish expedition into western Tibet. Between 1857 and 1861 the Survey of India under excellent British surveyors carried out triangulation work over Leh into SW Tibet. The subsequent, careful Swedish triangulation work of 1932 found a general increase of about 37 m and this over a span of only 71 years. This would give the incredible uplift rate of about 0.5 m per year for this particular area. This is far in excess of a reasonable morphogenic uplift rate for the whole Himalaya and Tibet, covering 2 500 000 km^2, which is assumed to be about 1–1½ cm year. Accepting such a figure one has to realize that the morphogenic uplift was never uniform in time nor in place. The present rates, at least for the Himalaya, are probably slowly increasing.

The effect of this young, regional uplift in connection with the later glaciations is of particular interest. According to Li and Cheng (1980) and recently Kuhle (1982), the Pleistocene snow line was at about 3800 m in northern Tibet and was lower along its southern border. This old snow line level is lower than the average height of the plateau (4200–5200 m) which rises in its central part as well as at its border into mountains between 6000–8000 m, all highly glaciated and with some perfectly preserved plateau glaciers (Landsat photos). These facts suggest that during the largest ice age (the third or second last period) a great part of the Tibetan plateau was covered by a widespread inland ice type glaciation (Kuhle 1982). An extended ice cover was already suggested for the eastern Karakorum and NW Tibet by Norin on the basis of results from his expeditions from 1927 to 1935 (Norin 1982). After the skrinkage of the inland ice cover, great depressions must have been preserved for some time by dead ice bodies which began melting along their border, giving rise to marginal lakes, the sediments of which can still be observed high on the flanks of such basins. This is even the case in large valleys such as the upper Indus. Most of the numerous present Tibetan lakes resulted from melting of such an ice cap and were originally fresh water bodies. Judging from the present lake sediments some must have had a very large extension. During their rather short existence of 10 000–20 000 years they gradually became brackish and finally salty. The eventual drying up of those water bodies can be seen on the Landsat photos which show many strand terraces surrounding the lakes concentrically.

This partly ice covered highest and largest land mass on our globe, situated in the northern desert girdle, must have influenced the Pleistocene climate to a great extent. The strong irradiation effect may have changed the higher atmospheric circulation and even been responsible for the drying up of the Sahara (discussions during Tibet conference 1980). The main change to present conditions began about 12 000 years ago at the end of the last ice age. This last stage was however not very pronounced and many of the Tibetan lakes originated already during the last interglacial period. Lake sediments show sometimes the effects of an overburden of lateral glaciers of the last stage (Bürgisser et al. 1982).

The foundation of famous monasteries is sometimes related to mysterious, now vanished lakes. The old history of the well known Lamayuru monastery in the Ladakh region is based on a mystic lake, which was the abode of the bad Naga spirits. Once a

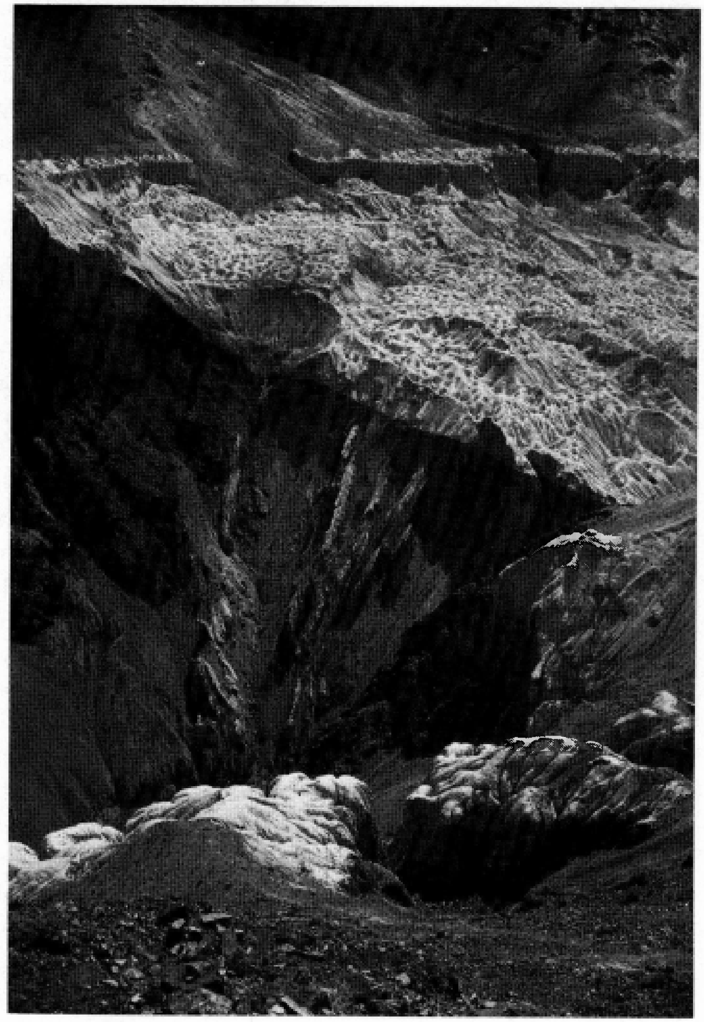

Fig. 10. Lake sediments which indicate the existence of a former Lamayuru lake. They have been strongly eroded with a 600 m deep gorge draining towards the Indus river. (Ladakh) (Fot. A. Gansser).

famous lama landed on a small island in this lake. He made offerings to appease the bad spirits and drained the lake thus preparing the site for this famous monastery. Old lake sediments are still present in this area, preserved 600 m above the level of the Indus river (Fig. 10). Unique is the rare depiction of boats surrounded by bodhisattvas in the Alchi monastery, the most famous and oldest temple of the Ladakh region (Fig. 11).

Human history

Uplift, glaciation and subsequent deglaciation in the Himalaya and Tibet must have caused special conditions as far as the flora and fauna were concerned. Survivals from the central ice plateau are most unlikely and the post ice age immigration must have come from the peripheral and more favorable regions. Unfortunately practically nothing is known of this early beginning. One realizes today how flora and fauna have adapted to the height, insolation and temperatures. The Himalayan traveller is struck by the adapted form of rubarb or the fury aspect of a *Saussurea*, living above 4500 m, to give just two examples. Even less is known of the human migrations and populations of the High Himalaya and Tibetan plateau. Archeological work has hardly begun. Of interest are the human artifacts in the Karewa lake beds of Kashmir, believed to be older than the last glaciation and the latest uplift of the Himalaya (De Terra and Paterson 1939). During the time of Peking man, travelling over the Himalaya must have been easier and the subtropical hipparion grazed happily on both sides of the range.

Fig. 11. The presentation of boats in the middle of Bodhisattwas in the hall of the Alchi monastery, the oldest buddhistic temple in Ladakh. (Fot. K. Riklin).

Between these meagre paleolithical data and 600 AD exists a large historical gap. It is the time when the animistic Bön religion, rich in sagas, was widespread in the northern Himalaya and Tibet. Many of the sagas were orally delivered, often in the form of songs, still popular to the present day. Most famous of all are the songs of the Geza Epos, well known today in the Bhutan Himalaya, which are a treasure of old religious history (Olschak 1979). The old sagas also tell us of the famous flood, the great event known all over the world, even in such remote regions as in the South American jungles. They tell us that Tibet (and the northern Himalaya) was covered by a big lake and that a "Buddha of that period" had mercy upon the land and with his sword cut a gap into the mountains of SE Tibet, draining the lake (Bell 1928). This gap is preserved today in the unique gorge of the Tsangpo river, where it cuts the 7800 m high Namche Barwa mountains in one of the wildest canyons in the world, and even today only partly explored. The flood story of Tibet refers to the lakes formed after the melting of the ice cap. It is certainly not related to the so-called Tethyan sea which once covered the Himalaya and Tibet, often referred to in interpretations of old texts. It is well known that most of the Himalaya and practically all of Tibet became land after the Tethyan sea vanished in the Middle Eocene, 40 my ago, and that since that time the whole area, not yet uplifted to its present height, was a large continent.

According to the old sagas, the Tibetans originated in the Yarlung valley. This drains the mountains to the E of the Bhutan Himalaya and its river flows northwards into the Tsangpo, southeast of Lhasa. The first Tibetans were believed to have lived in caves in this valley, which are still venerated today. They resembled large langoor monkeys more than human beings, but they cut their tails and began to populate the area. The first Tibetan Kings are reported from the Yarlung valley and there they built the first towered castle, the prototype for the dzongs, the famous fortress monasteries of the Bhutan Himalaya. This outstanding building, the oldest in Tibet, still existed and was photographed by Ernst Krause of the Schäfter expedition in 1938, but after the Chinese invasion of Tibet it has been completely destroyed. In the Lower Yarlung valley the grave hills of the ancient kings are still preserved, similar to the "tepes" in the Middle East. They seem hardly touched by archeological investigations. The famous 5th Dalai Lama, the founder of the Potala in Lhasa and the most outstanding figure in Tibetan history, was born in 1617 in the Yarlung valley. According to old legends even the eastern Himalaya was populated from the Yarlung region.

The northern Bhutan Himalaya is dominated by a famous peak, the Masang Kang (Fig. 12). Its name relates to the Masang tribes, the mythological forefathers of the Tibetans, whose descendents, coming from SE Tibet, settled in NE Bhutan. Gesar, the hero of the epic songs, is said to be a son of the Masangs, as recorded in precious old block prints (Olschak 1979). It may not be a mere coincidence that just at the foot of the Masang Kang we find the small village of Laya at 3900 m elevation. Here the inhabitants are strikingly different from the rest of the Bhutanese mountain people.

Fig. 12. The holy Masang Kang seen from the Toma La at the Tibetan border in the northern Bhutan Himalaya. The highly glaciated 7200 m high peak is the abode of the mythological Masang tribes which are reported to have populated the Bhutan Himalaya. (Fot. A. Gansser).

The women wear long dresses of sheep and yak wool, with a peculiar colour design. Contrasting with other Bhutanese they have long hair and speak a special dialect (Fig. 13). Their buddhist religion seems highly mixed with animistic Bön elements. Could these little known Laya people be some remnants of the famous Masang tribes?

In the western Himalaya and adjoining western Tibet we may find some even earlier migrations. Since ancient times western Tibet was known for its gold digging. The legends of gold-digging ants were already mentioned by Herodot (Lindegger 1982). They tell of huge ants "smaller than dogs but larger than foxes" which dug gold nuggets from deep narrow holes. Giuseppe Tucci discovered near Jiu monastery at the Manasarowar lake old gold-digging sites, exposing many deep narrow holes which reminded him of giant ant holes, "tanti formicai" (Tucci 1937). The Buddhist authorities in Lhasa later forbade mining in Tibet. Along the middle Indus river and in the Hunza region there exist old rock carvings and paintings. The black rocks, covered by desert varnish along the rivers, present an ideal surface to carve and scratch drawings and inscriptions. These petroglyphs have been recently investigated by Karl Jettmar, who

Fig. 13. The women of Laya, a small village at 3900 m in northern Bhutan. It lies at the foot of the holy Masang Kang. These unique people may be the remnants of the mythological Masang tribes? (Fot. A. Gansser).

discovered over 1000 pictures and inscriptions spanning a time interval of over 3000 years, not unlike visiting cards of the passing caravans (Jettmar 1981) (Fig. 14). Surprising are old inscriptions dating from the time of the Persian kings during the reign of Alexander. The results of these current investigations will eventually shed new light on the migration and population of the western Himalaya and Tibet, and tell of the caravans which travelled from NW India through the Baltistan mountains along the Indus and Hunza rivers towards Tibet. An interesting relic may be the Hunza people which kept their own special language. One may even venture the suggestion that this old trail, which joins the »silk road« in the north, may actually be a revival of much older, possibly even paleolithic migration routes from Kashmir (Karewa lake beds) through the western Himalaya at a time when the mountains had not yet reached their forbidding height.

In historical time, the great elevation of Tibet and the wild mountain ranges of the Himalaya were no longer an impassable barrier for the inhabitants which populated these areas. With the taming of the wild yak they found an incredible domestic animal which carries heavy loads, climbs like a goat over the highest passes ploughing through deep snow, but also capable of ploughing the fields. Its wool is used for blankets, ropes and tents, it has a particularly rich milk for butter and cheese, and its yak dung is a precious fuel in regions above the tree line. It feeds very frugally, but can also be eaten itself when necessary. Along steep rock slopes ingenious trails were built with dry stone clinging to inclined rock faces. Most important of all was the construction of hanging bridges which cross the wildest rivers in the Himalayan mountains. Originally "invented" in China, they were known already over 2000 years ago from the eastern Himalaya, built of bamboo and liana (Fig. 15). After the 6th century iron-chain hanging bridges

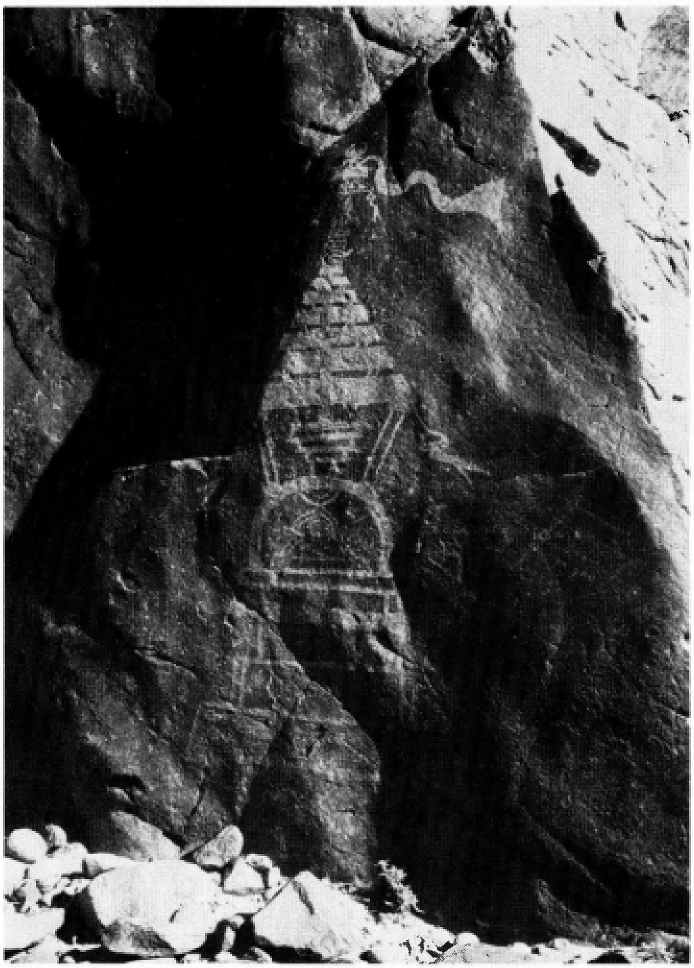

Fig. 14. A buddhistic stupa drawn on gabbroidic rocks at the Indus river near Chilas (Baltistan). Here and in the Hunza region Karl Jettmar has studied over 1000 drawings and inscriptions, spanning a time of 3000 years. They suggest a very old migration route to western Tibet. (Fot. A. Gansser).

Fig. 15. A primitive hanging bridge in the northeastern Bhutan Himalaya. This bridge is built in a primitive way, only by liana and bamboo, a systhem over 2000 years old. (Fot. A. Gansser).

began to appear. They were propagated by the Bhutanese lama Thang-stong Gyalpo who used an ingenious method of welding the various chain links. The locally mined iron was melted into rods. These were forged to chain links and the links where welded together, probably on the spot. The analysis of such a welding seam (at the ETH in Zürich) showed an arsenic content of 2.6%. Arsenic lowers the melting temperature but produces a very hard welding junction. It is most surprising that this completely forgotten method was used in these remote areas (Epprecht 1979). Hanging bridges are up to now still the best system, considering the irregular floods of the wild Himalayan rivers.

Today we note a new type of migration. It has already invaded the western and central part of the Himalaya and now infiltrates also the eastern part and even to some extent southern Tibet. Is is international tourism with trekking and mountaineering, mostly in groups littering their paths with modern sediments. A certain contamination of the local population seems unavoidable, and it may be to the detriment of its important heritage, still documented in the numerous religious centres. It is a heritage of outstanding importance, considering the ill-fated development of our civilisation. Modern science may be able to preserve and to better understand those valuable documents, many still hidden in block prints of remote monasteries but many more destroyed.

The visitor who enters the inner courtyard of the famous Paro Dzong, the monastery fortress in the western Bhutan Himalaya, is struck by a large wall painting. It represents a mandala of outstanding interest. Within a frame of red flames it shows the cosmic rings suggesting the planetary system or the modern picture of an atom. This Buddhist iconograph is the more astonishing since its conception is over 1000 years old (Fig. 16).

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Fig. 16. The "Cosmic Mandala" in the Paro Dzong, western Bhutan Himalaya. It represents a strikingly modern picture of a forgotten wisdom from ancient times. (Fot. U. Markus-Gansser).

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