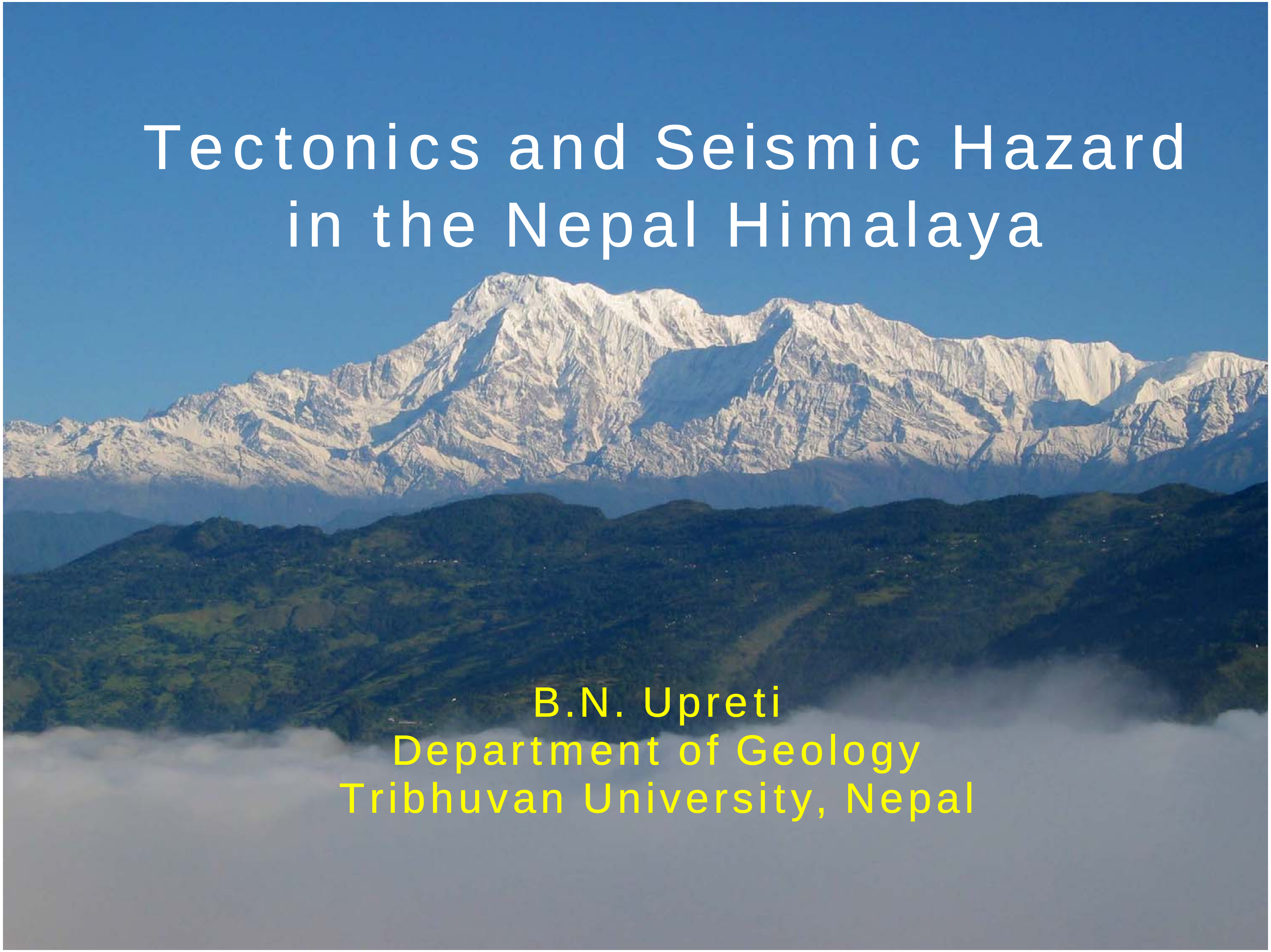
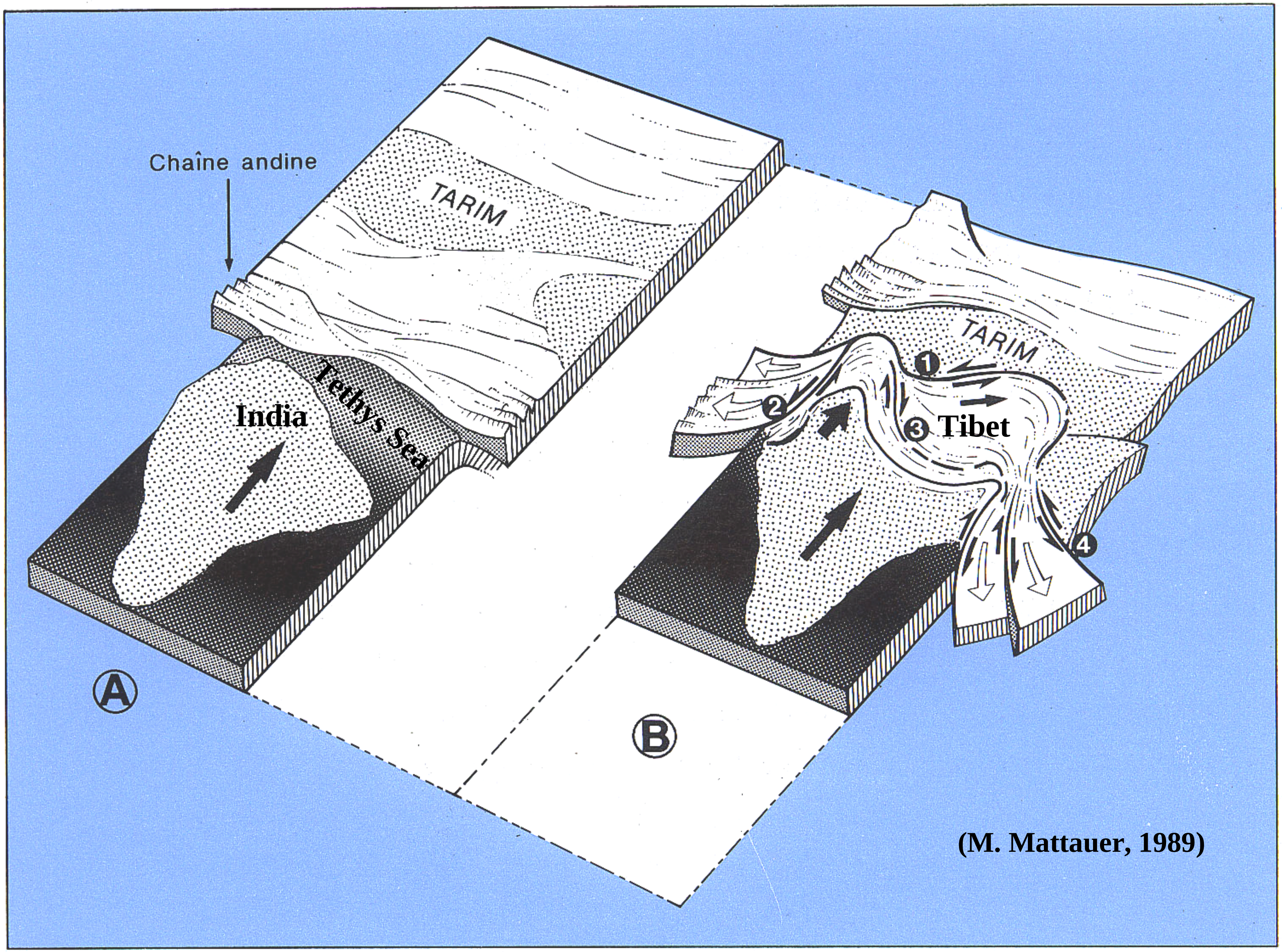


Tectonics and Seismic Hazard in the Nepal Himalaya

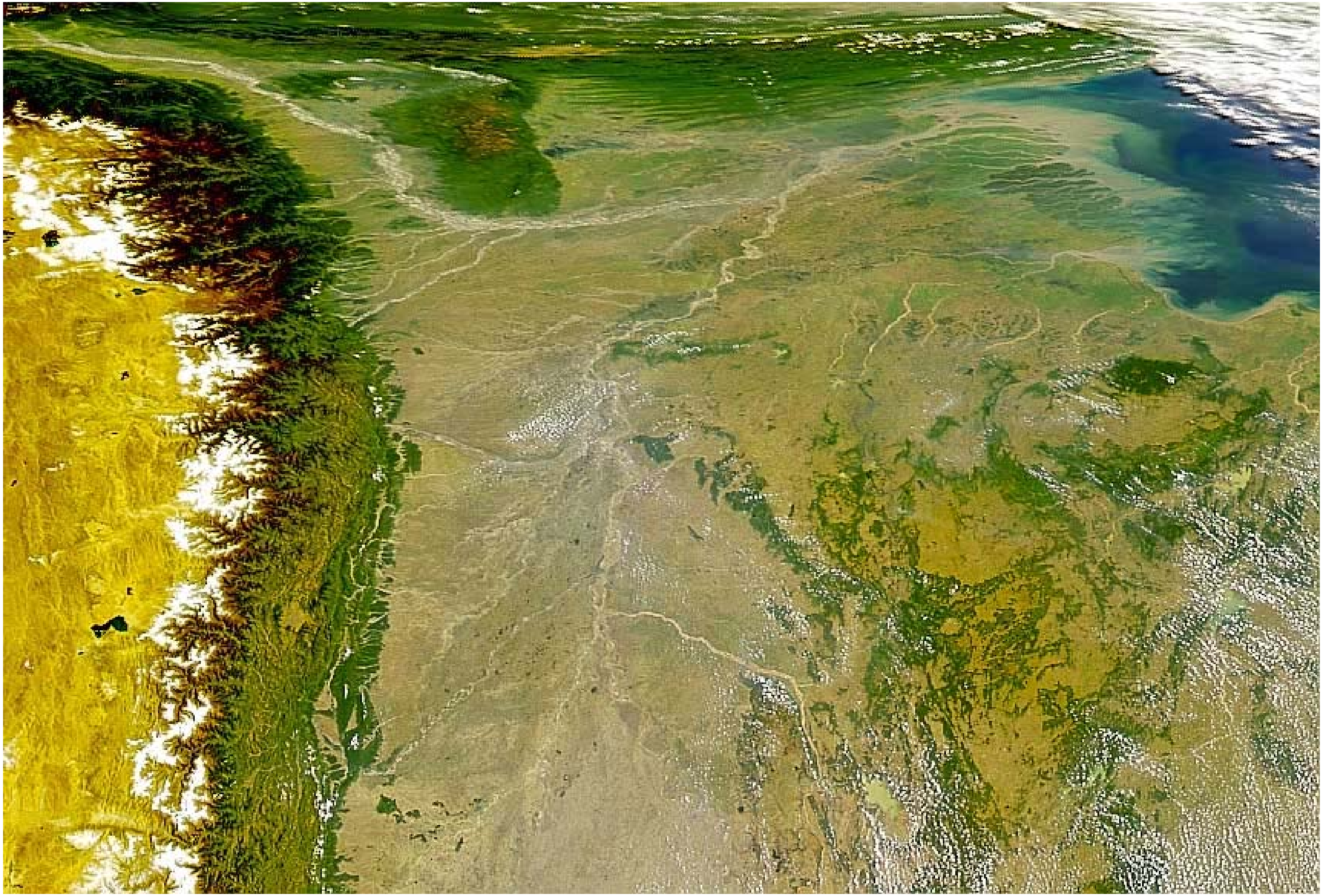
B.N. Upreti
Department of Geology
Tribhuvan University, Nepal

Tectonics

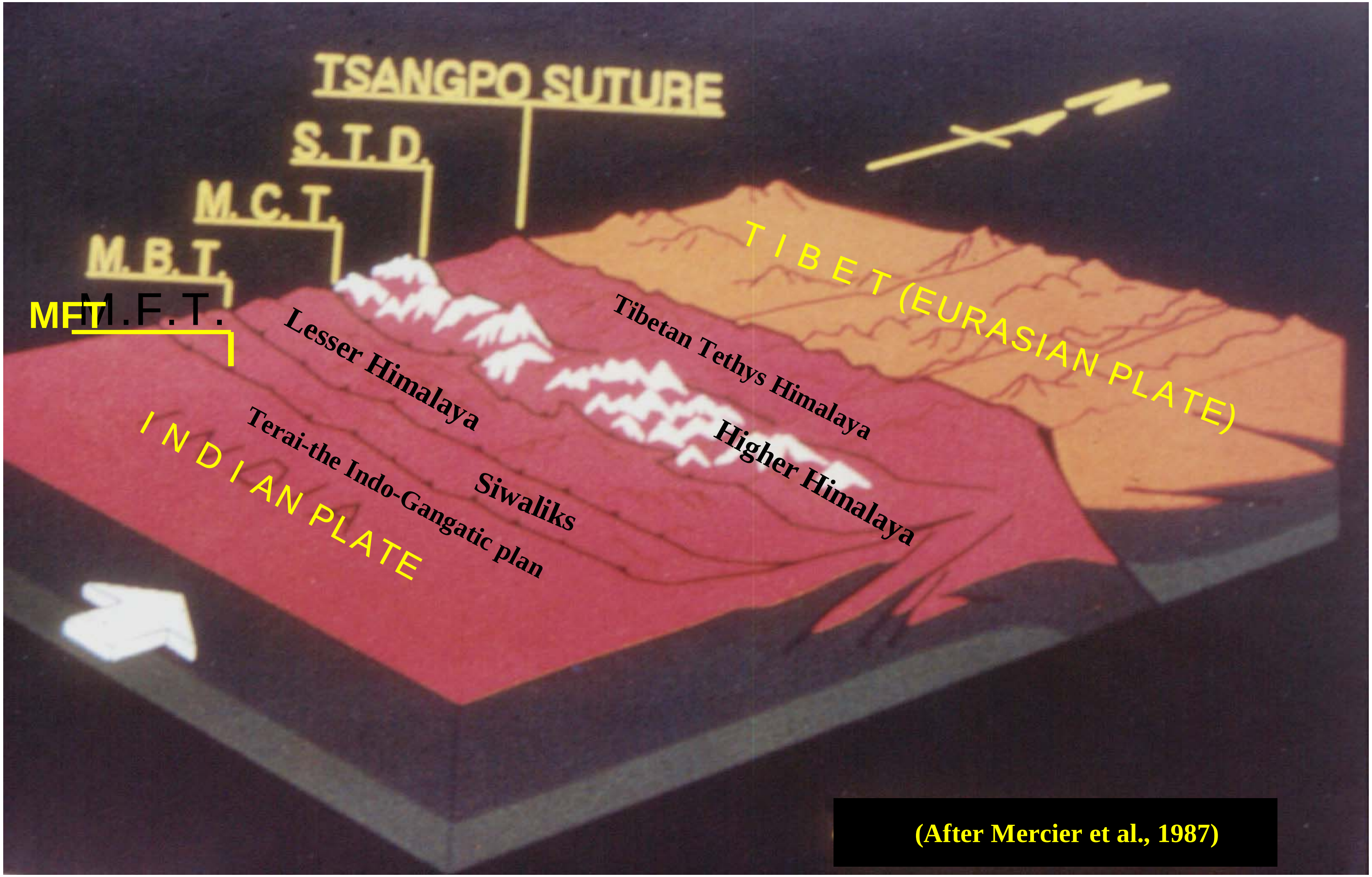


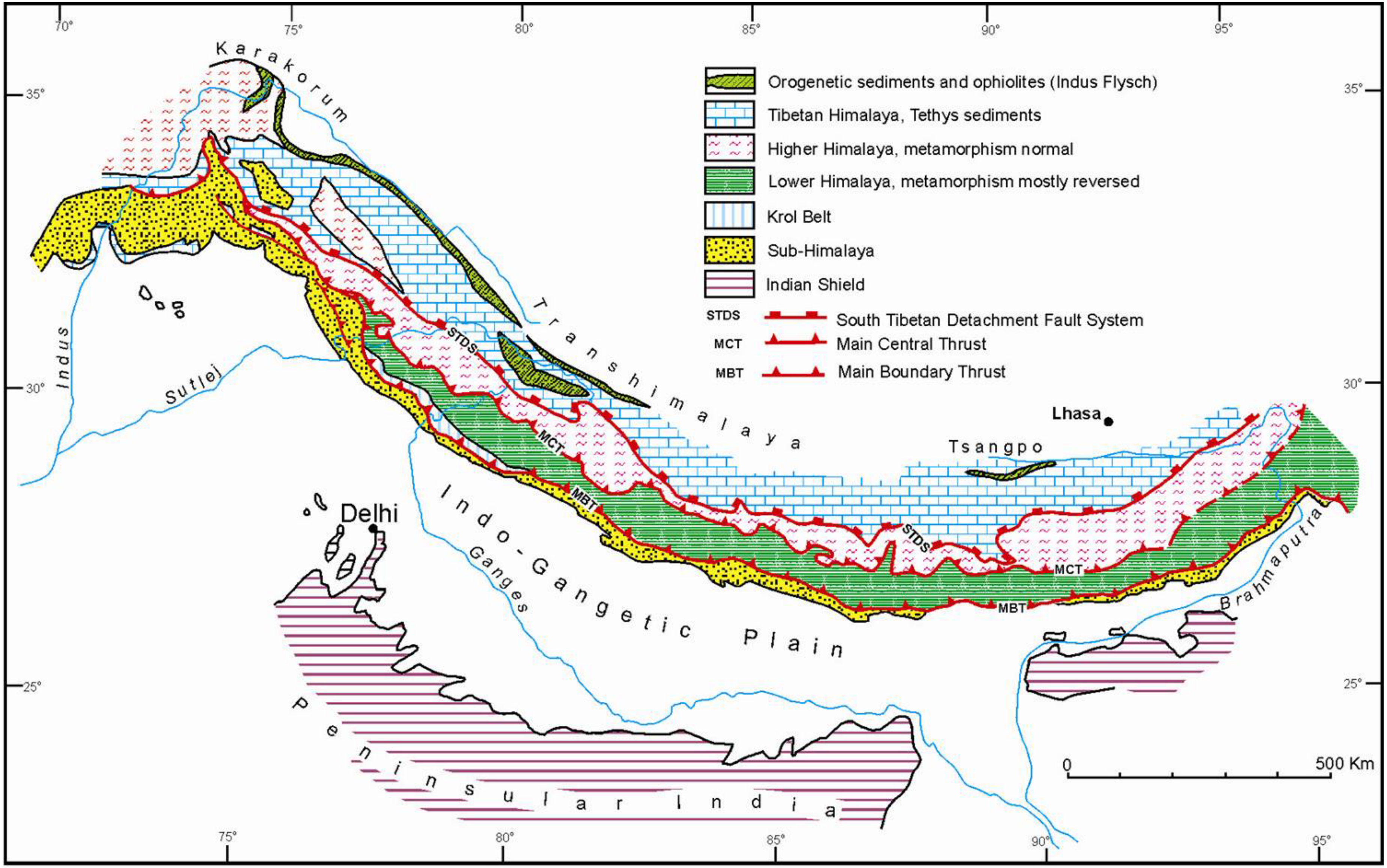
(M. Mattauer, 1989)


China
Afghanistan
Pakistan
Burma
India
Thailand
Image © 2005 EarthSat
Sri Lanka
© 2005 Google
Pointer 20°46'52.51" N 81°46'30.05" E
Streaming |||||||||| 100%
Eye alt 2086.16 mi



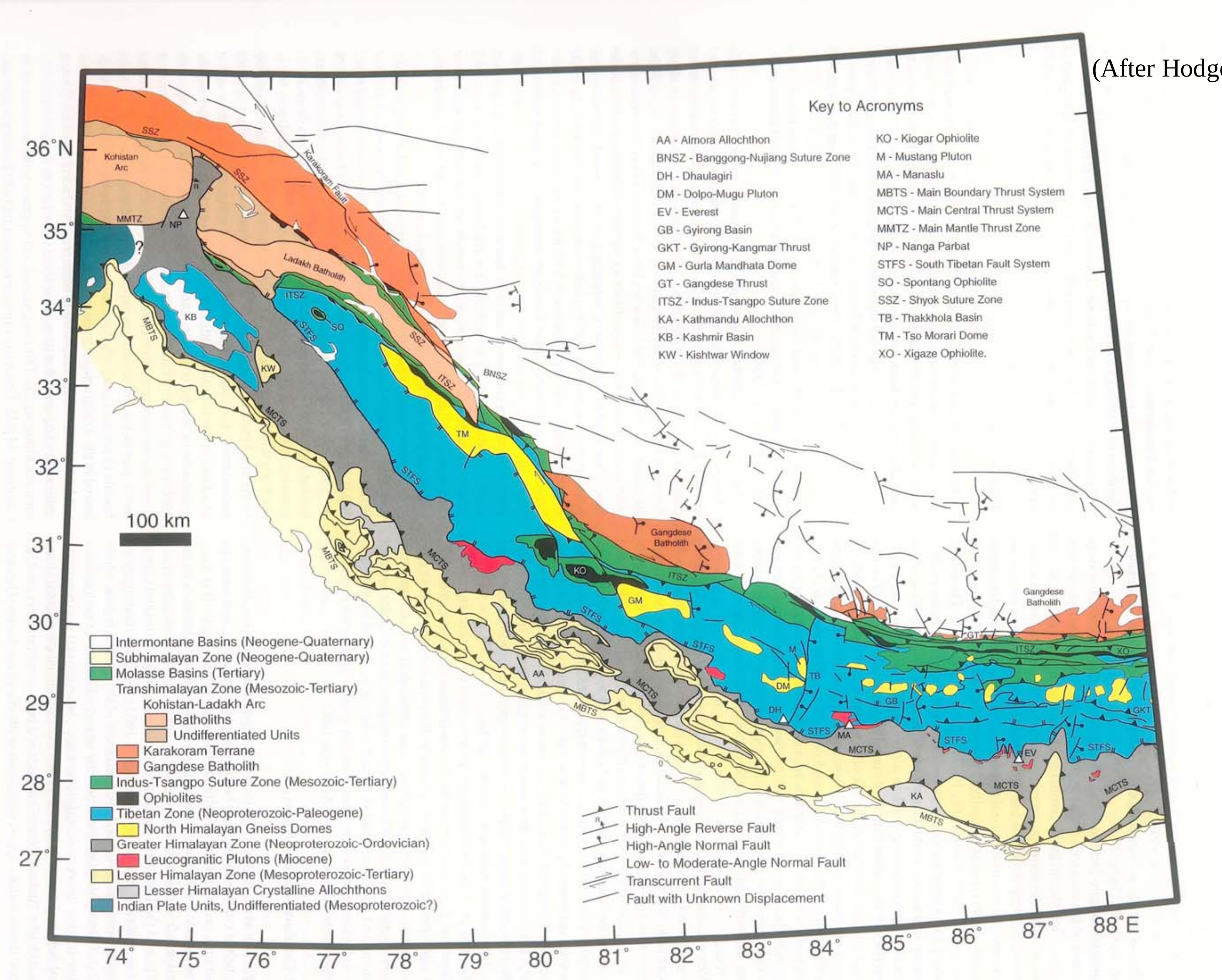
From NASA Website)

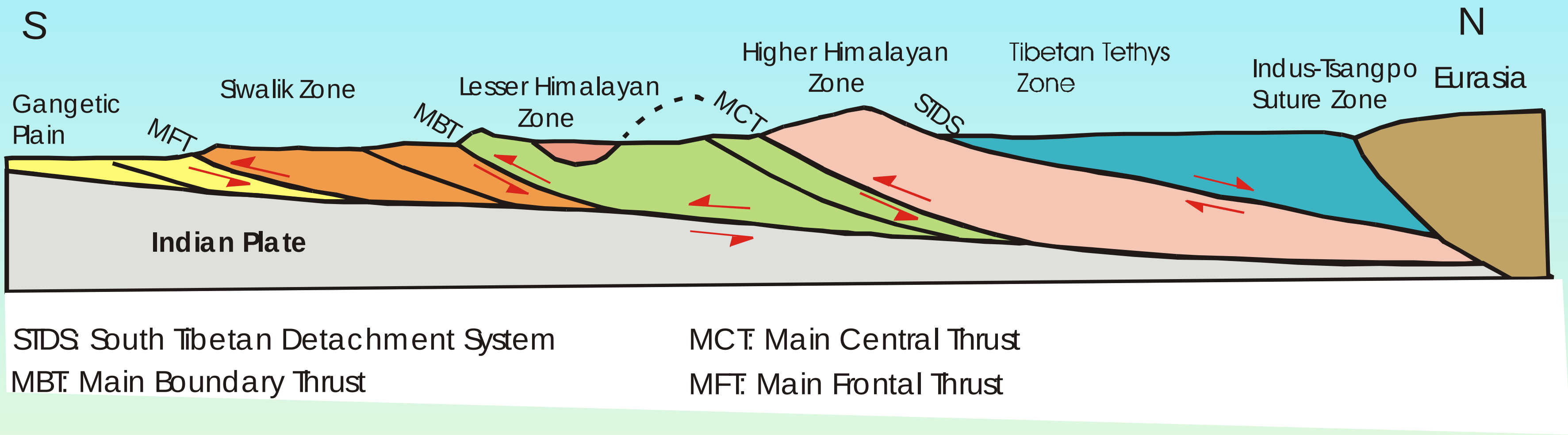

TSANGPO SUTURE
S.T.D.
M.C.T.
M.B.T.
MFT
M.F.T.
Lesser Himalaya
Tibetan Tethys Himalaya
T I B E T (EURASIAN PLATE)
Higher Himalaya
Siwaliks
Terai-the Indo-Gangatic plan
I N D I AN PLATE
(After Mercier et al., 1987)



(After Gansser, 1964)

(After Hodges, 2000)





(Modified after N. Harris, 2002)

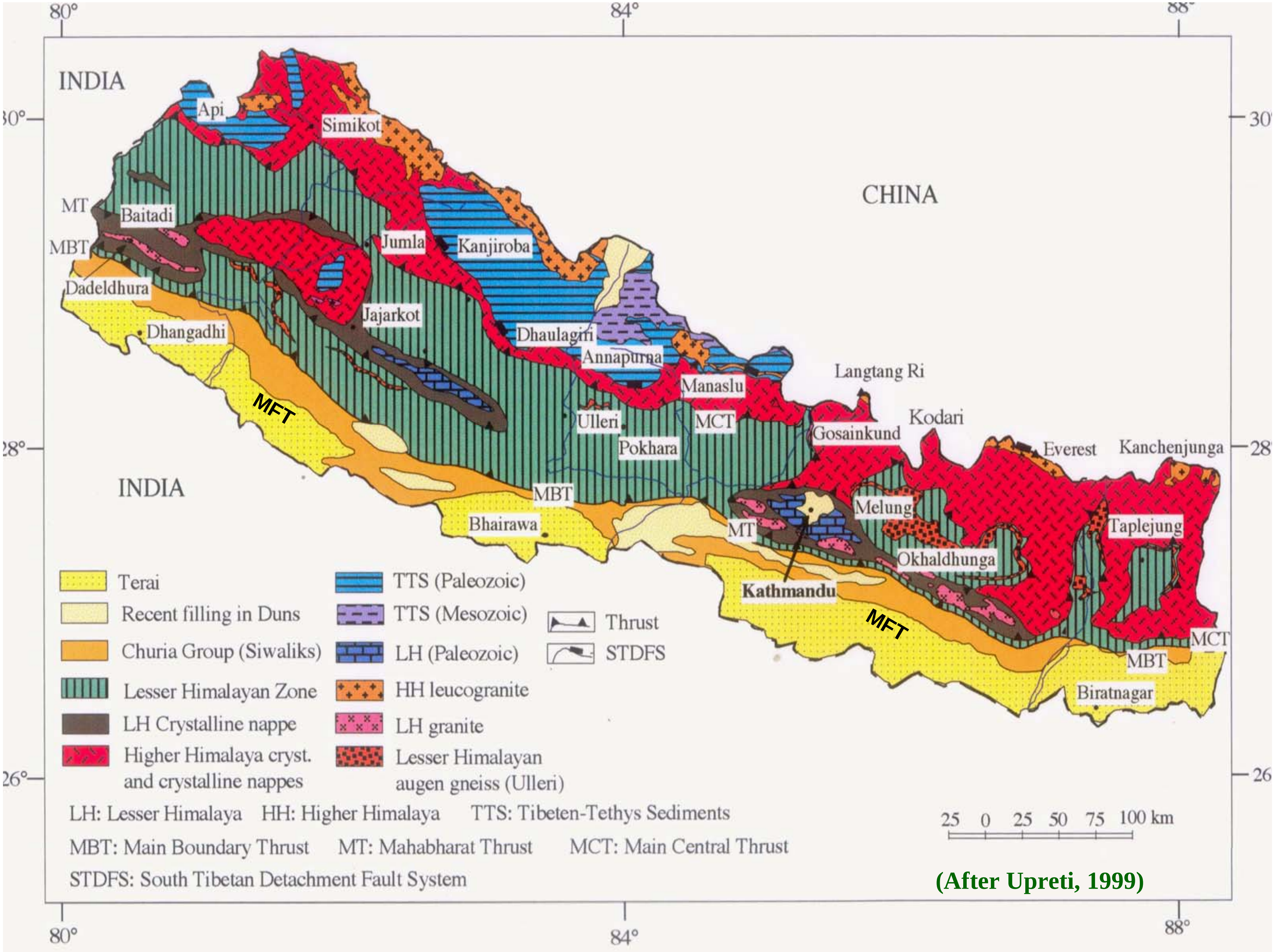
Age of Structures:

MCT: formed at about 24 Ma before

STD: Nearly contemporaneous with MCT

MBT: Formed before 10 Ma

MFT: Less than 2 Ma



(After Upreti, 1999)

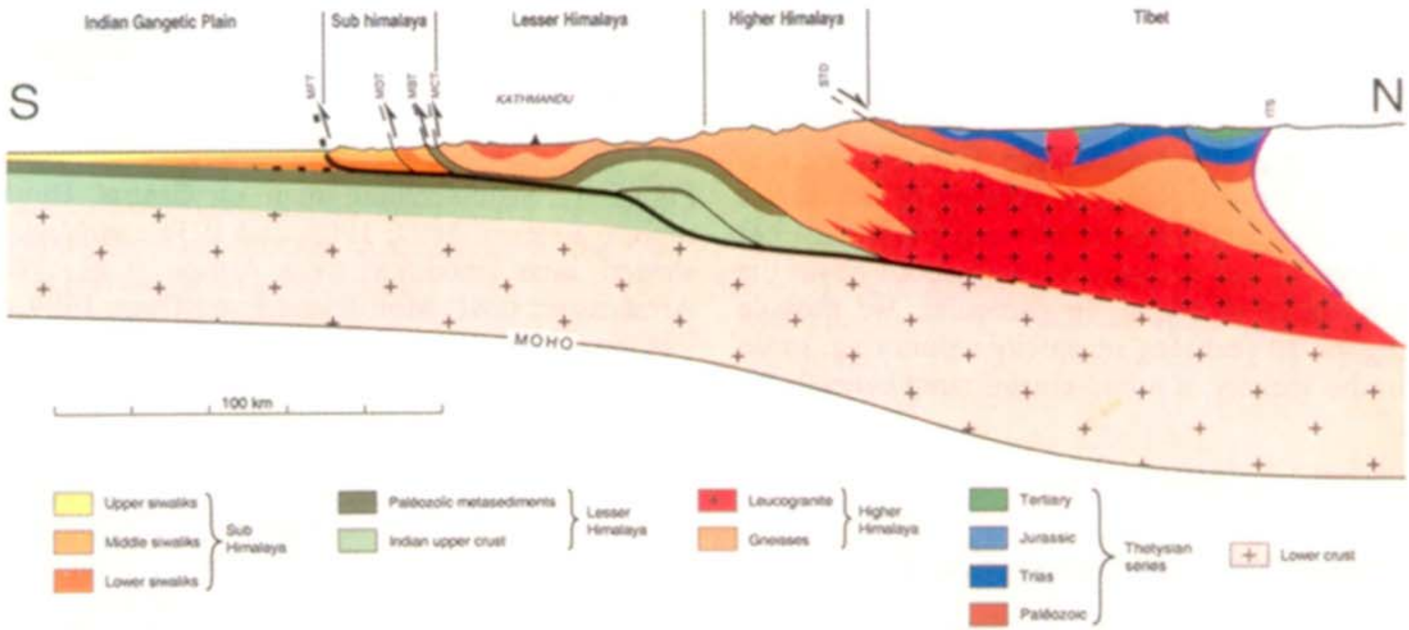
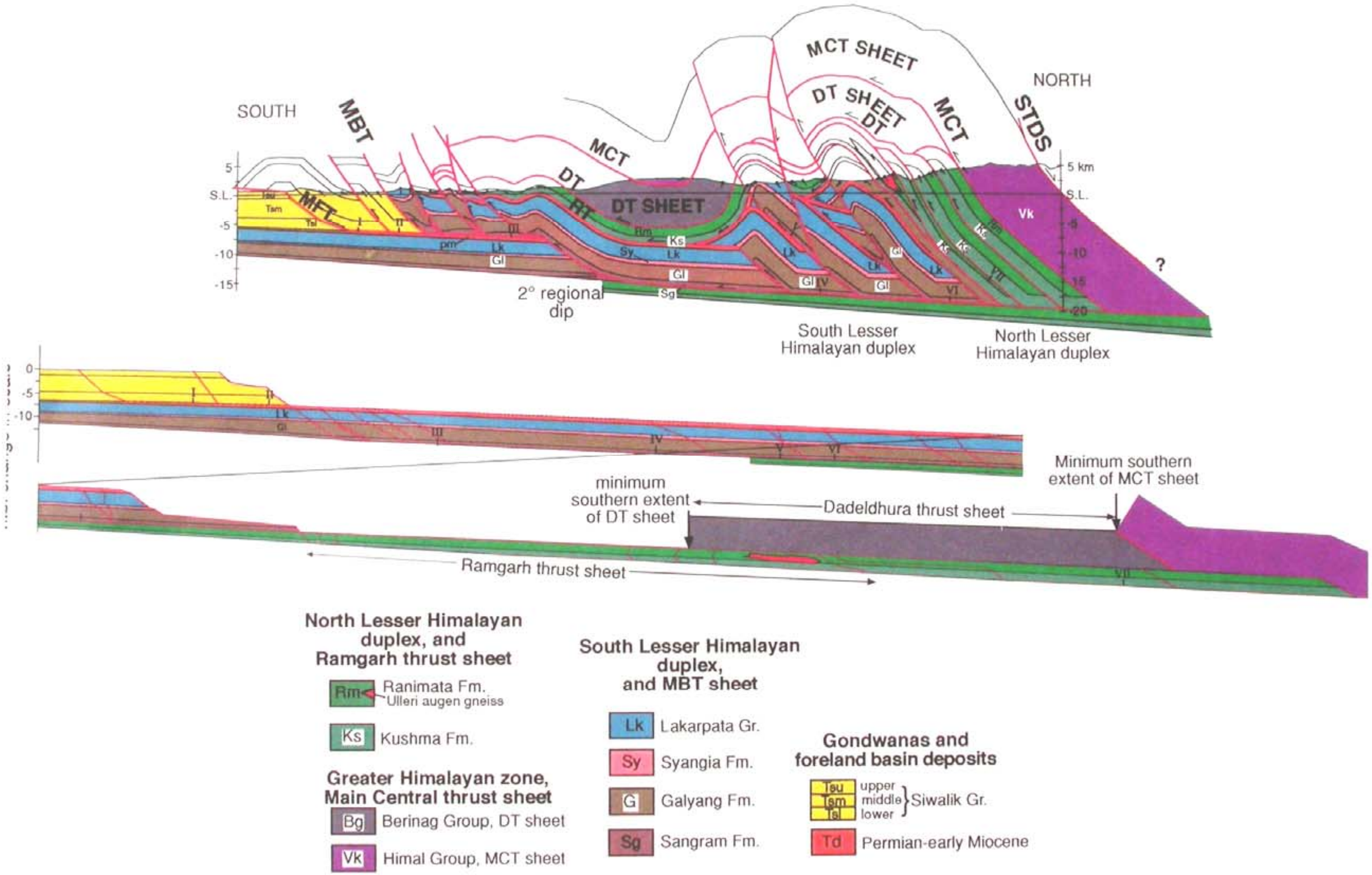
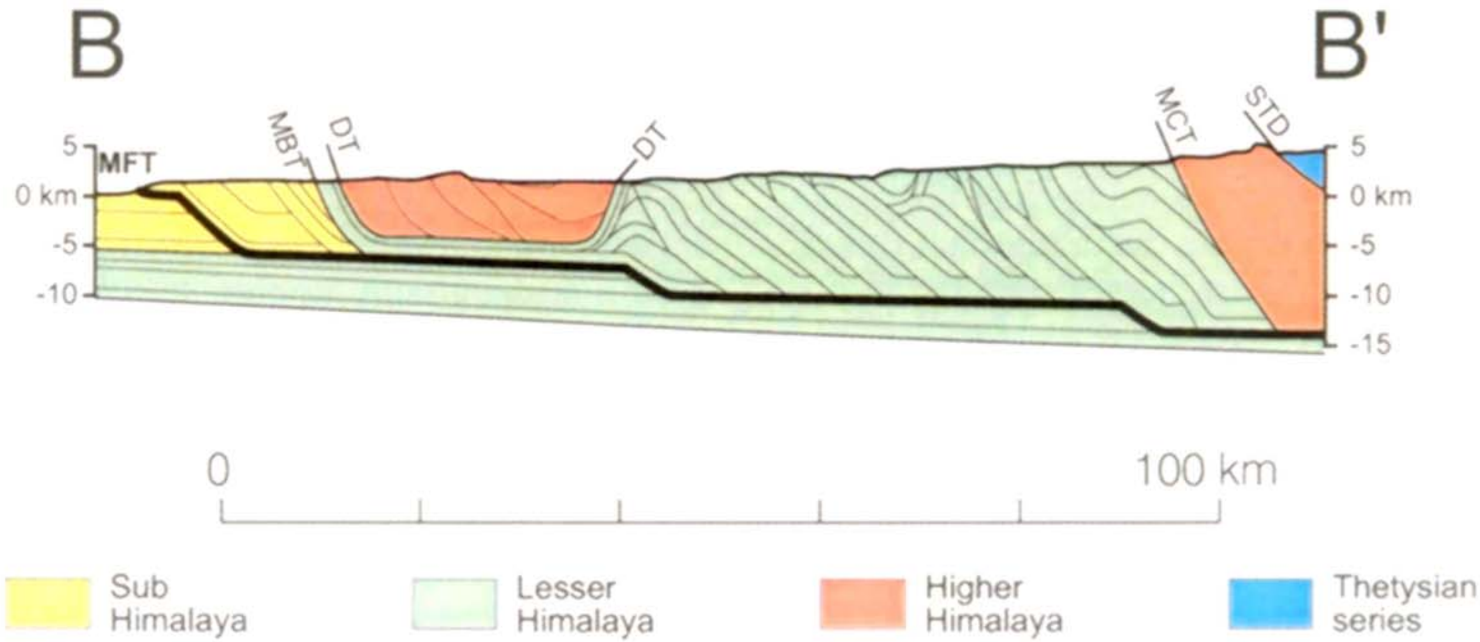


Figure 3: N10°E section across the central Himalaya of Nepal. Geology modified from Brunel [1986] and Schelling [1992]. Topography from ONC (G7).

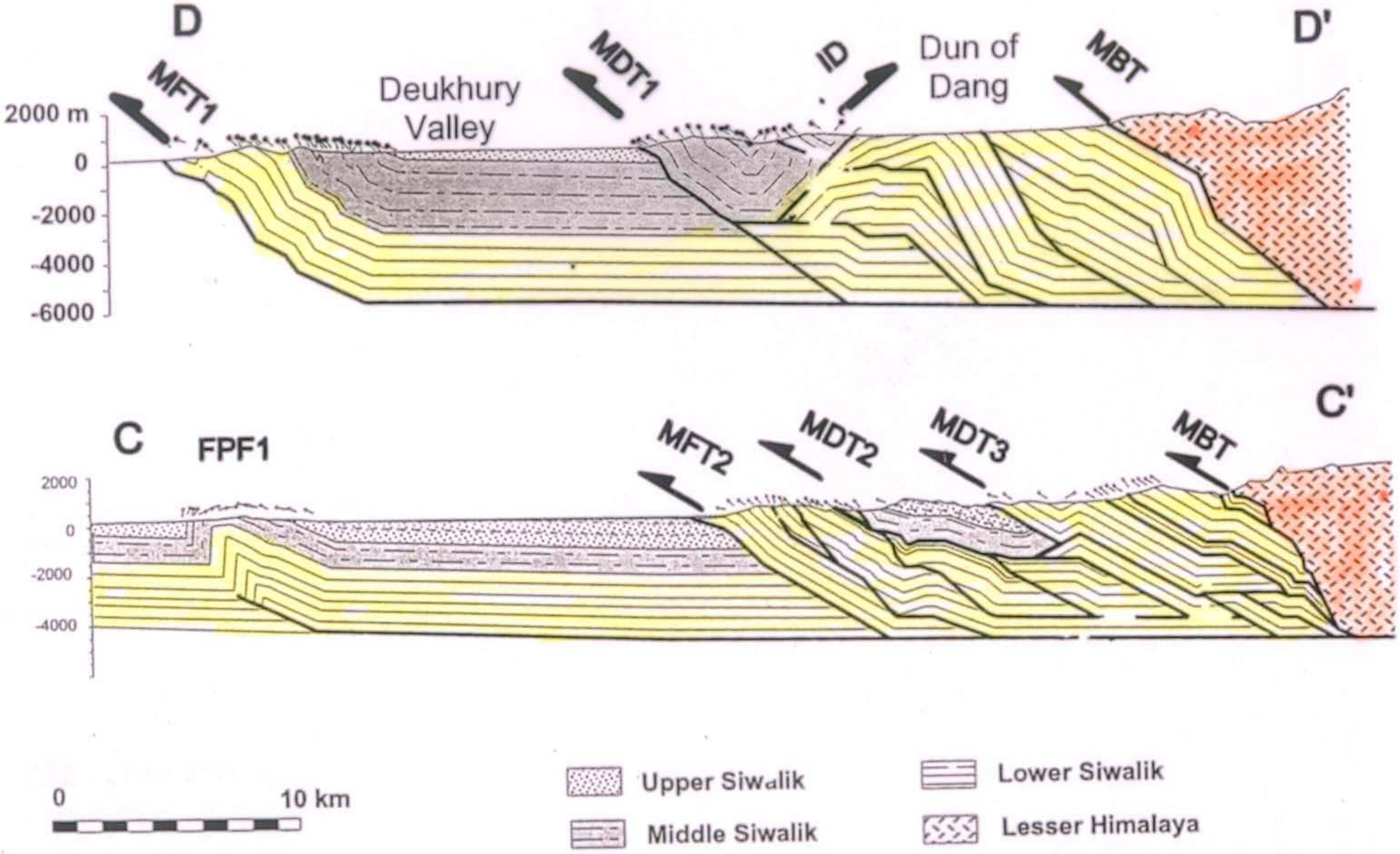
(After Pandey et al., 1999)



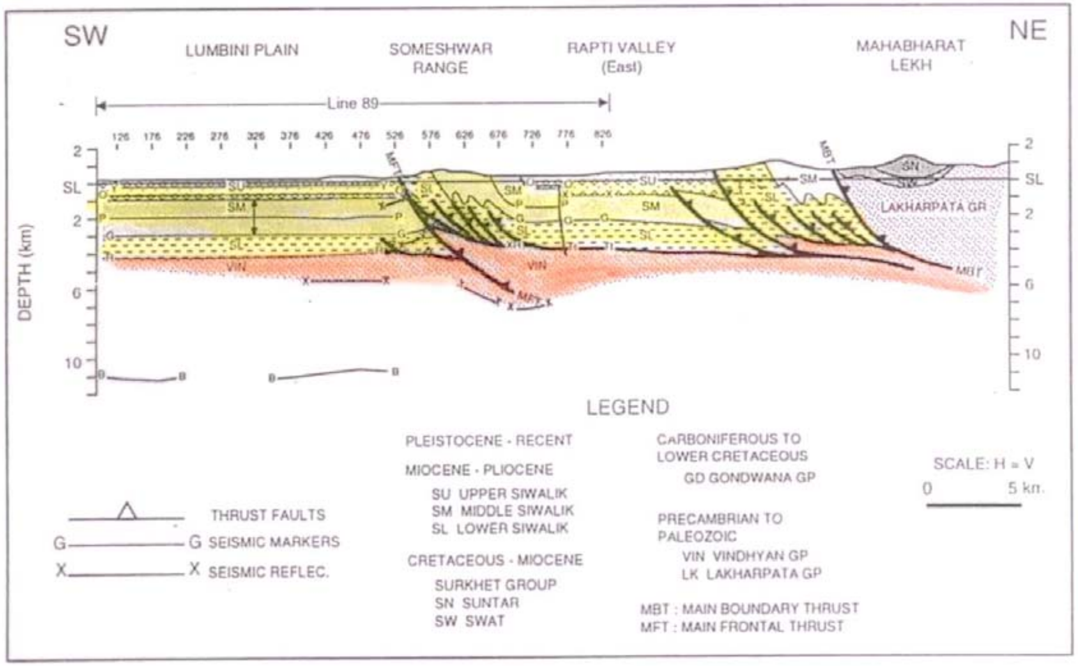
(DeCelles et al, 2001)



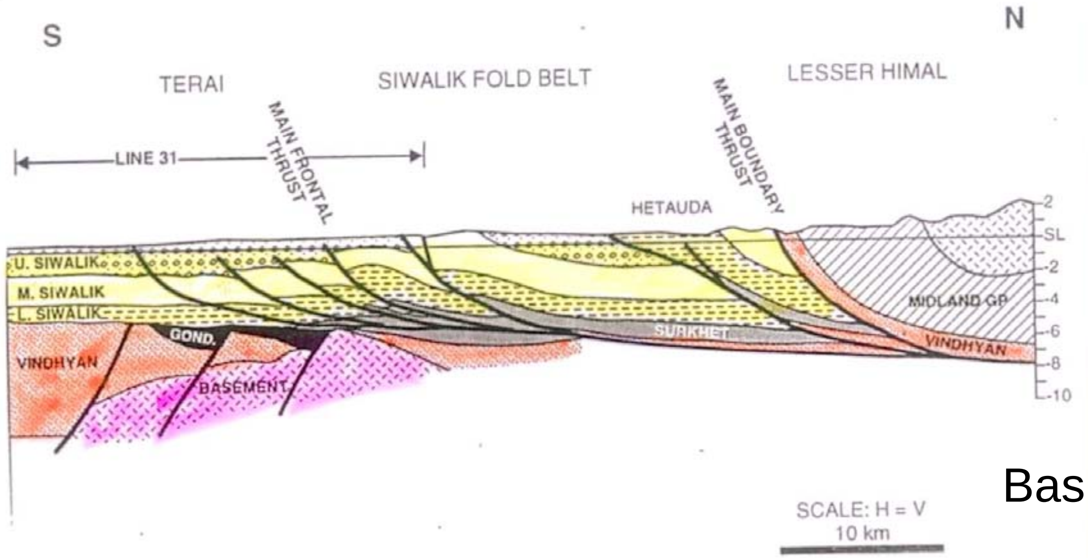
(Pandey et al. 1999)



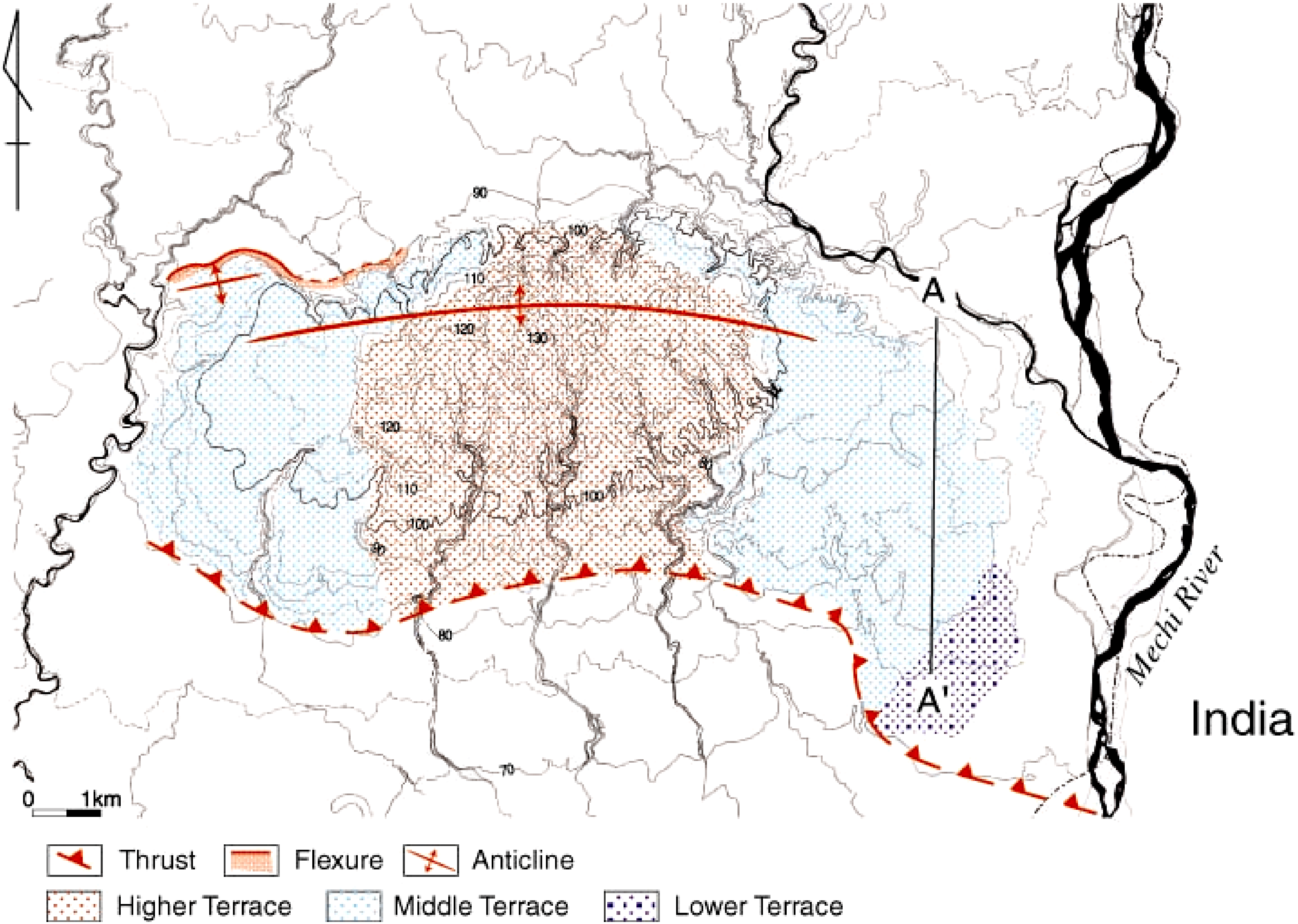
(Mugnier, 1999)



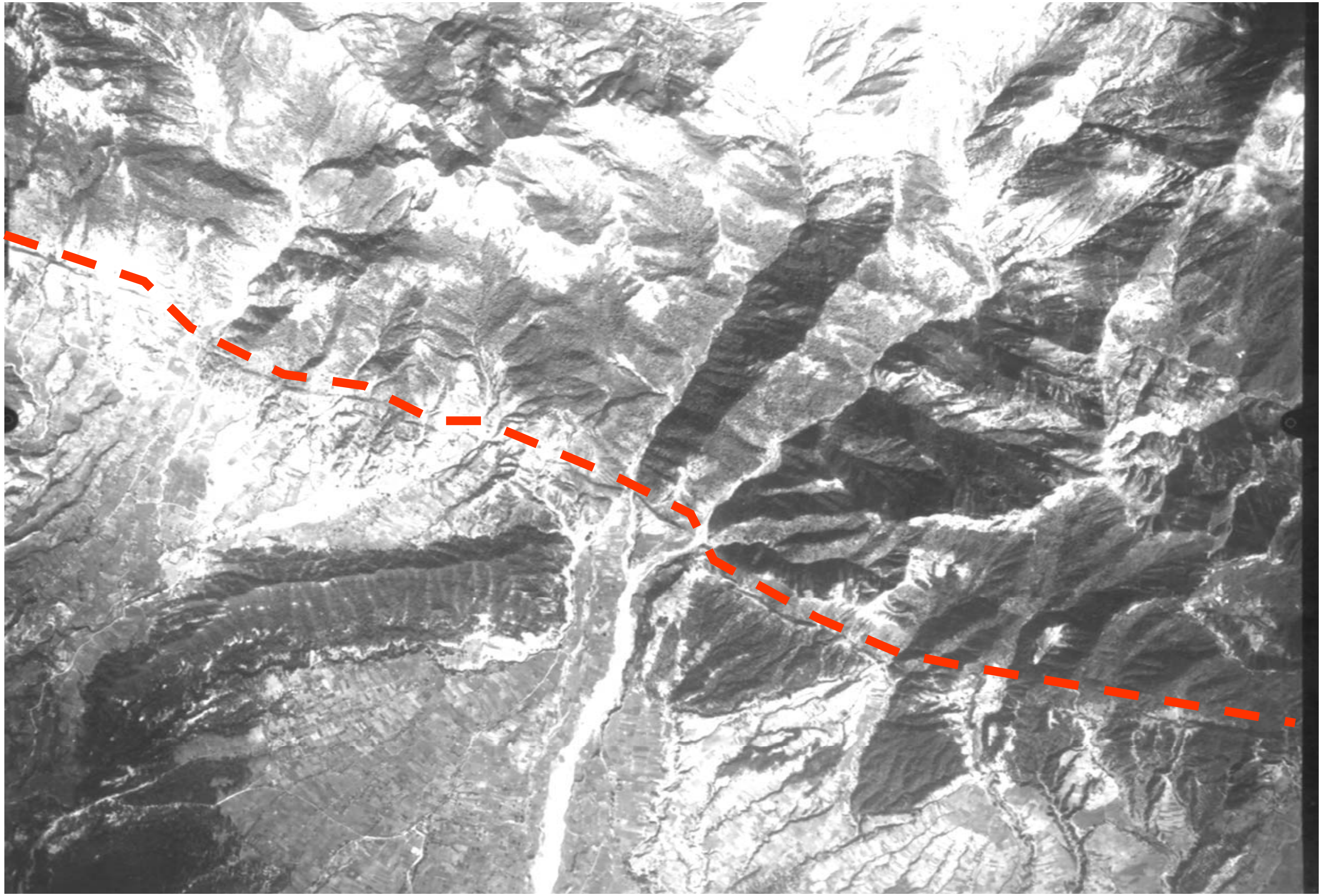
Fig



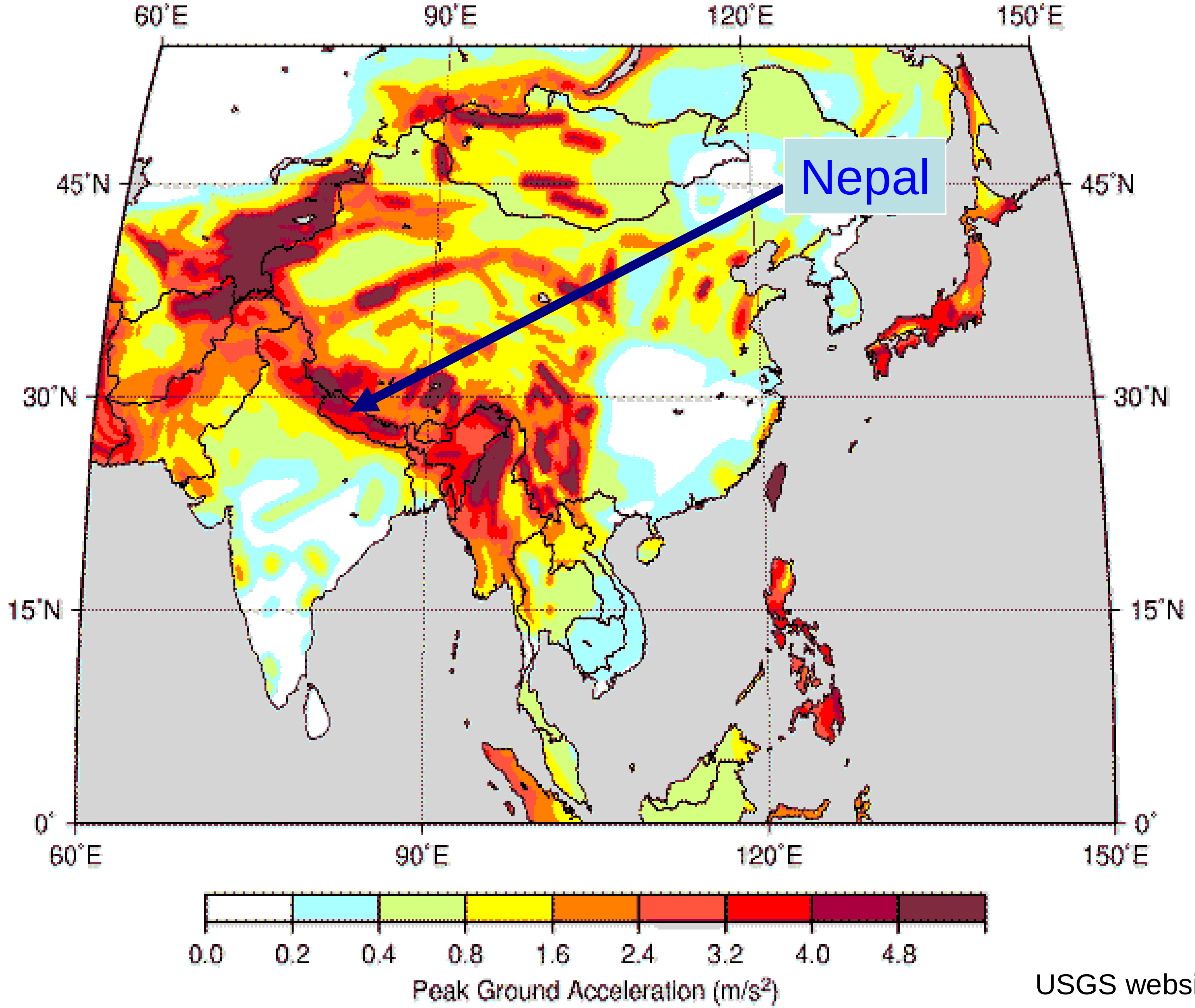
Bashyal, 1996)



90
100
110
120
130
120
110
100
90
80
100
80
70
A
A'
Mechi River
India
0 1km
Thrust
Flexure
Anticline
Higher Terrace
Middle Terrace
Lower Terrace



Earthquakes in the Himalaya



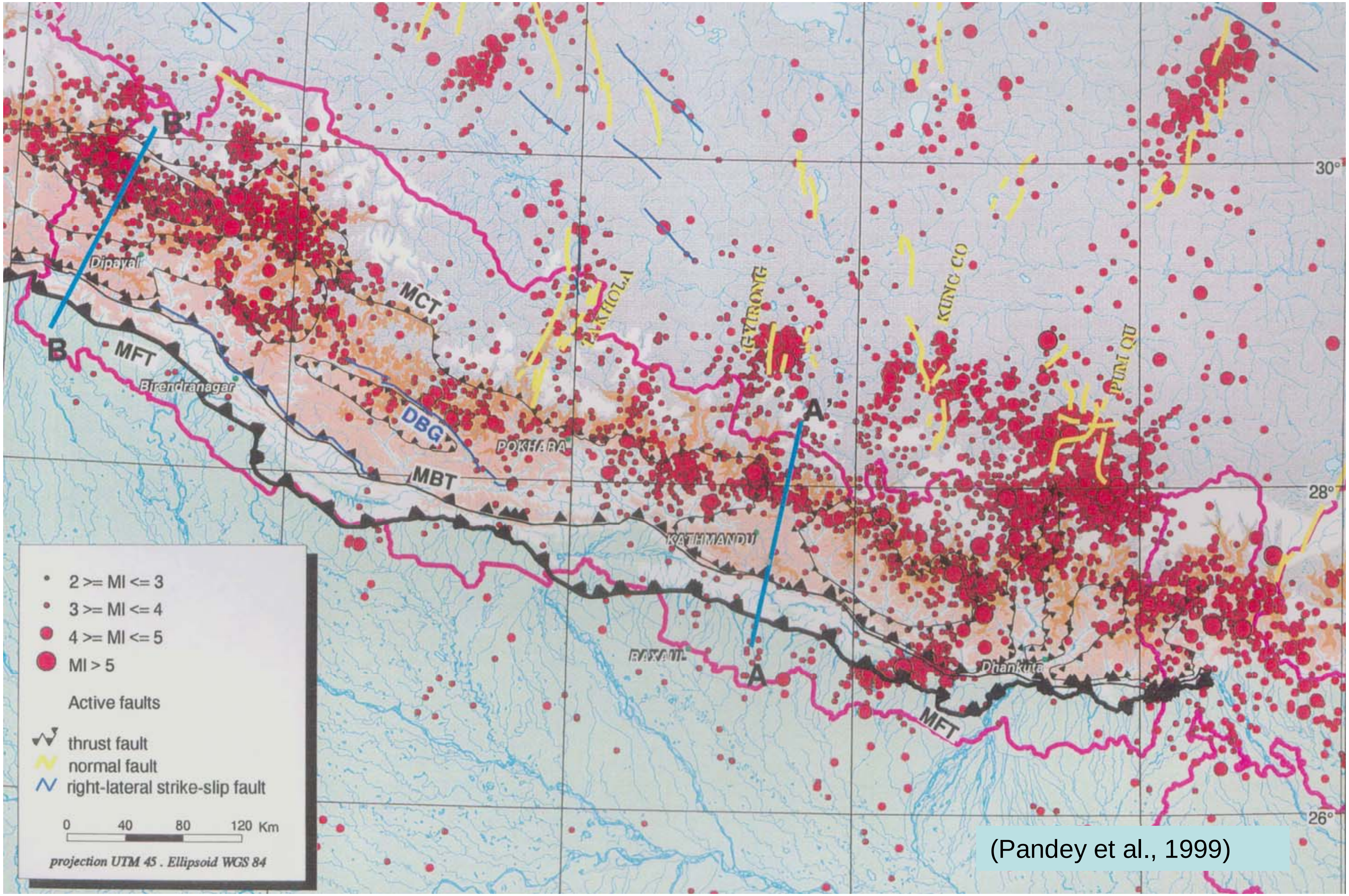
USGS website

Some Historic Earthquakes in Nepal (source: UNDP/UNCHS, 1993, Pandey and Molnar, 1988, Bilham et al., 1995)

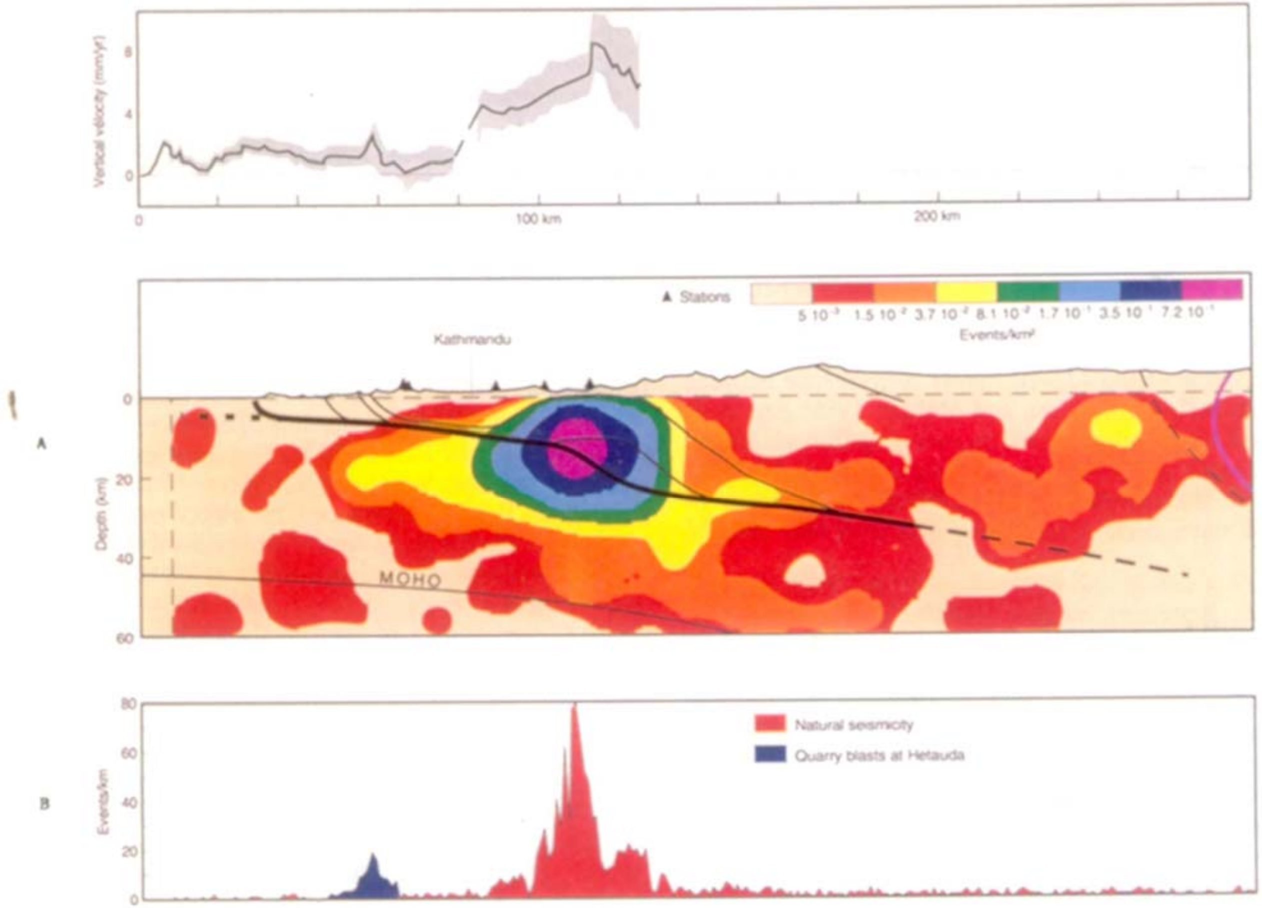
Year (AD)	Deaths	Damages
1255	One third of the population of Kathmandu was affected. Many deaths	A lot of damages to residential buildings and temples
1260	Many people died, Famine after the earthquake	A lot of damages to residential buildings and temples
1408	Many people died	A lot of damages to temples, residential buildings, fissures developed in the ground
1681	Many people died	A lot of damages to residential buildings
1767	No record of deaths	No record of damage
1810	Some people died, many lives were lost particularly in Bhaktapur	A lot of damages to buildings and temples
1823	No record of deaths	Some damage to houses
1833	Estimated magnitude 7.7, 414 people died in the vicinity of the Kathmandu valley	Nearly 4040 houses destroyed in Kathmandu, Bhaktapur, and Patan in the valley and adjoining Banepa and a total of 18,000 buildings damaged in the whole country.
1834	No good record available	Many buildings collapsed

1837	No good record available	No damage in Nepal recorded but greatly affected Patna and other parts of Bihar, India.
1869	No good record available	No good record available
1897	No good record available	No good record available
1917	No record deaths	No record on damage
1934	Estimated Magnitude 8.3 (epicenter, eastern Nepal). 8519 people died out of which 4296 died in Kathmandu valley alone	Over 200,000 buildings and temples etc damaged out of which nearly 81 thousand completely destroyed in the country. Max Intensity X. 55,000 building affected in Kathmandu (12,397 completely destroyed).
1936	No good record available	No good record available
1954	No good record available	No good record available
1966	24 people died	1,300 houses collapsed
1980	Magnitude 6.5 (epicenter far western Nepal). 103 people died	12, 817 buildings completely destroyed, 2,500 houses collapsed
1988	Magnitude 6.5 (epicenter in SE Nepal). 721 people died	66,382 buildings collapsed or seriously damaged.

19 great earthquakes in the last 7 centuries



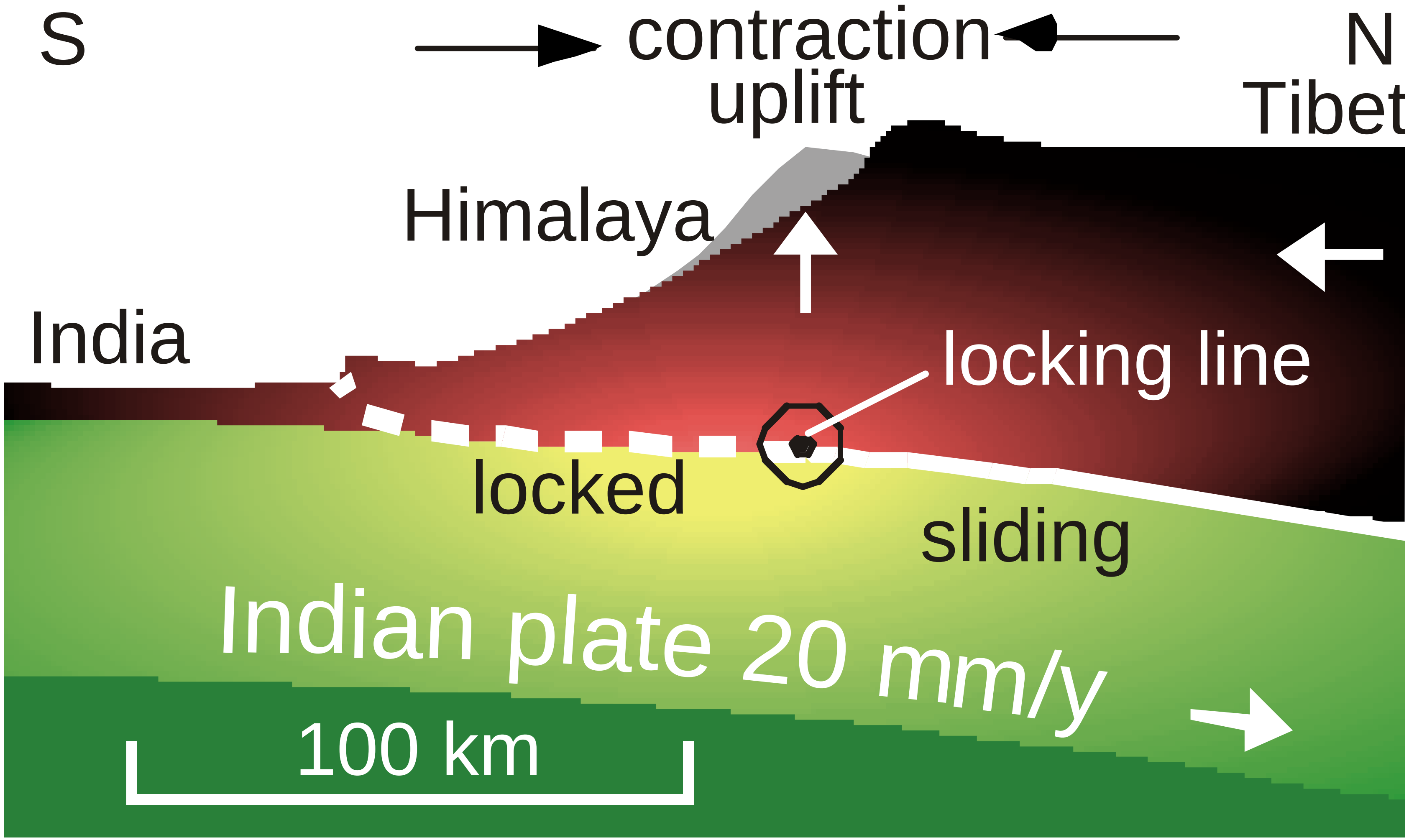
(Pandey et al., 1999)



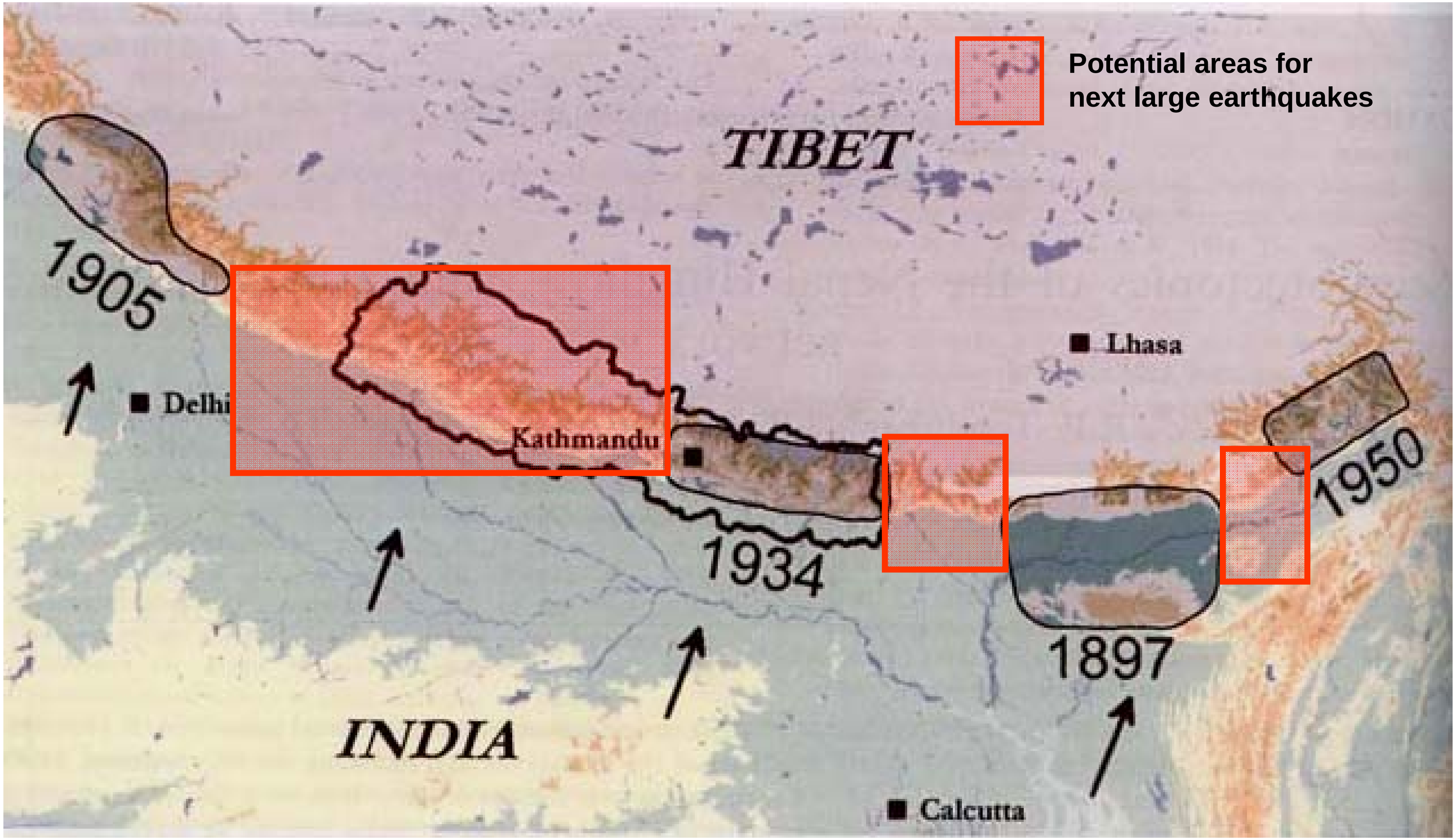
(Pandey et al. 1999)

Figure 4: (A) Density distribution of seismic events along AA' section. All natural seismic events with resolvable depths and within 50 km of section AA' (see box in Figure 2) have been considered. In order to take into account uncertainties on seismic locations the resulting distribution has been filtered using an axisymetric Gaussian filter with σ= 5km (The effect of the filter is to simulate the distribution probabilitity on seismic locations). Note the logarithmic scale for density of microseismic events. Fault geometries reported from Figure 3. (B) Density distribution of seismic events along AA'. All events have been considered including quarry blasts at Hetauda and events with unresolved depths. (C) Vertical velocities deduced from geodetic measurements along the levelling line of Figure 2, from Jackson and Bilham [1994].

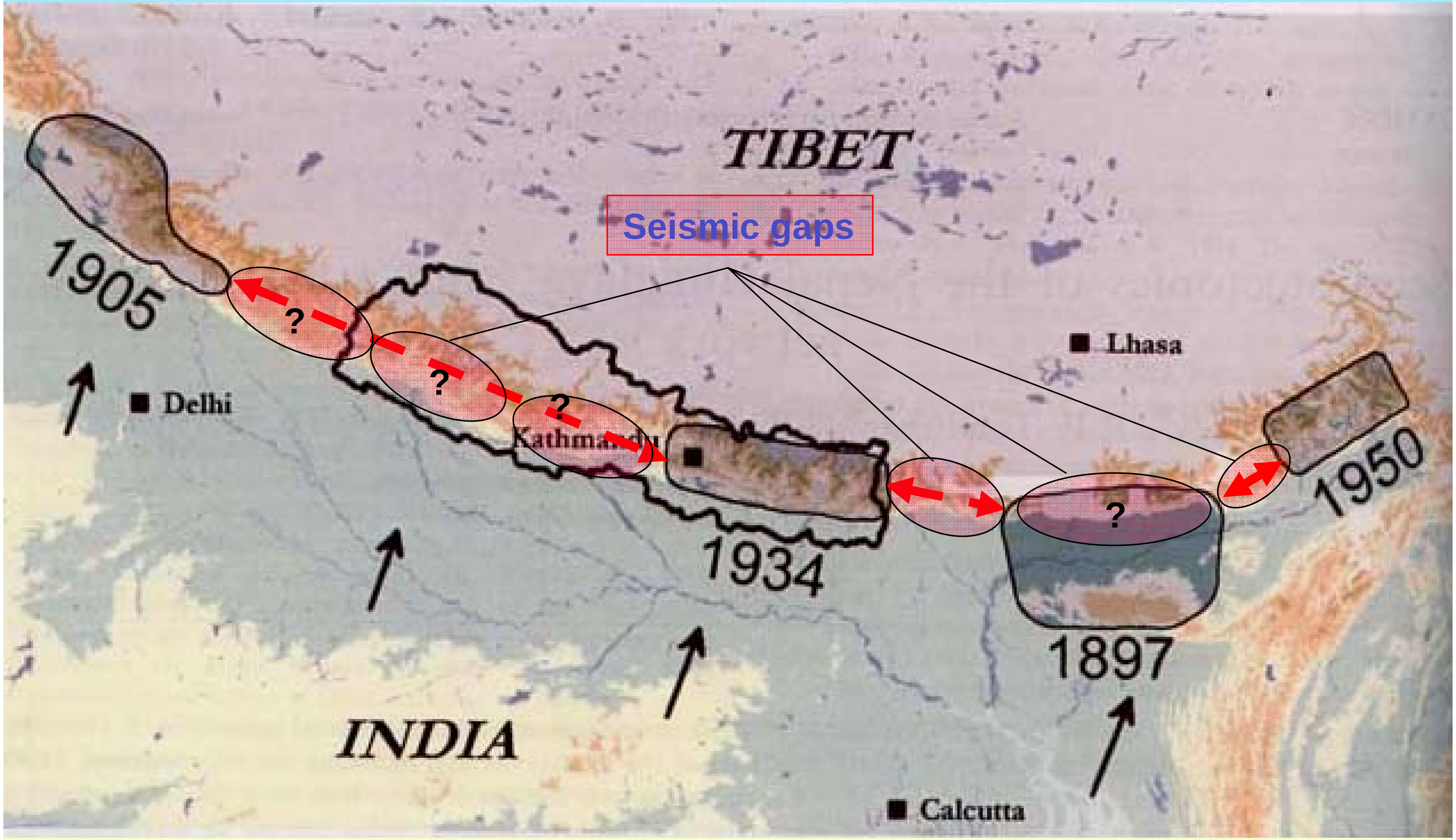
width great ruptures 70-90 km



(Bilham et al. , 2001)

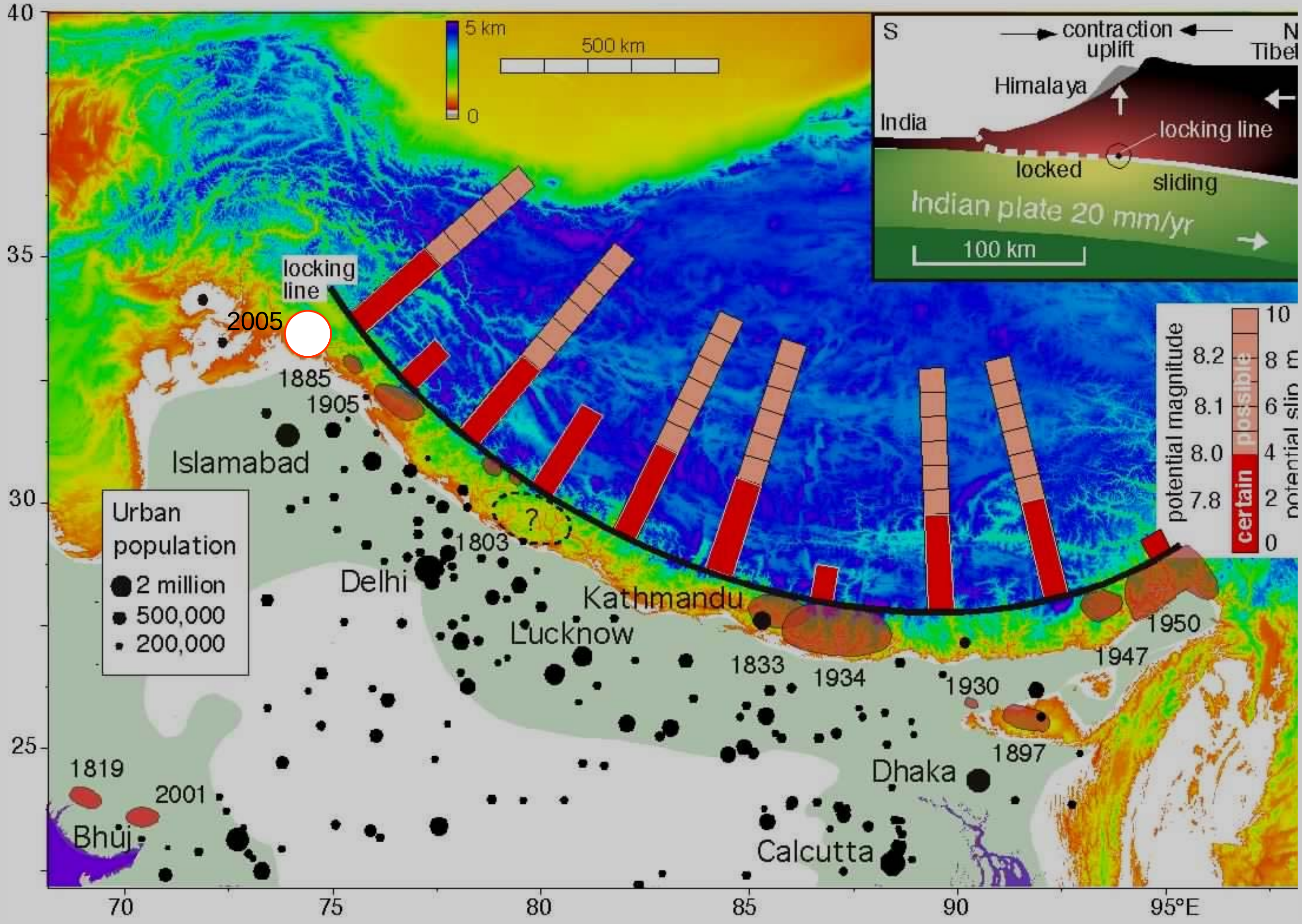


(Modified after Pandey et al., 1999)



(Modified after Pandey et al., 1999)

Historic Earthquakes



Summary of current slip potential

(Bilham et al., 2001)

Collaborating Organizations and projects

In Nepal

1. Labarotoire de Geophyique Applique (LGA), Paris University France

2. Department Analyse Survillance Environment (DASE), France

3. California Institute of Technology (CALTECH), USA

4. Oregon State University, USA

New Projects

1. The Himalayan Nepal Tibet Seismic Experiment (HIMNT)

2. Hi-CLIMB

Nepal-Bihar Earthquake 1934

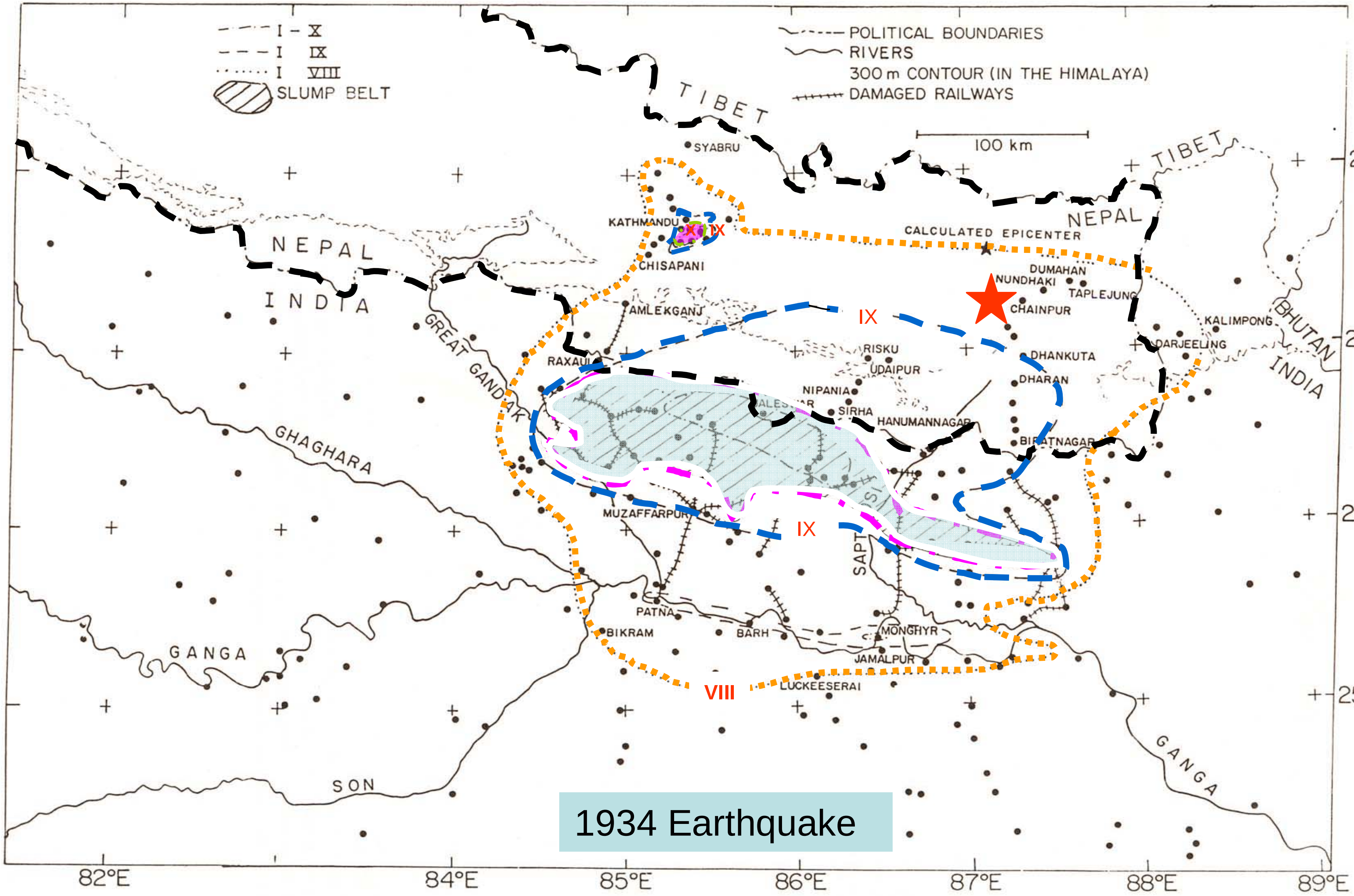
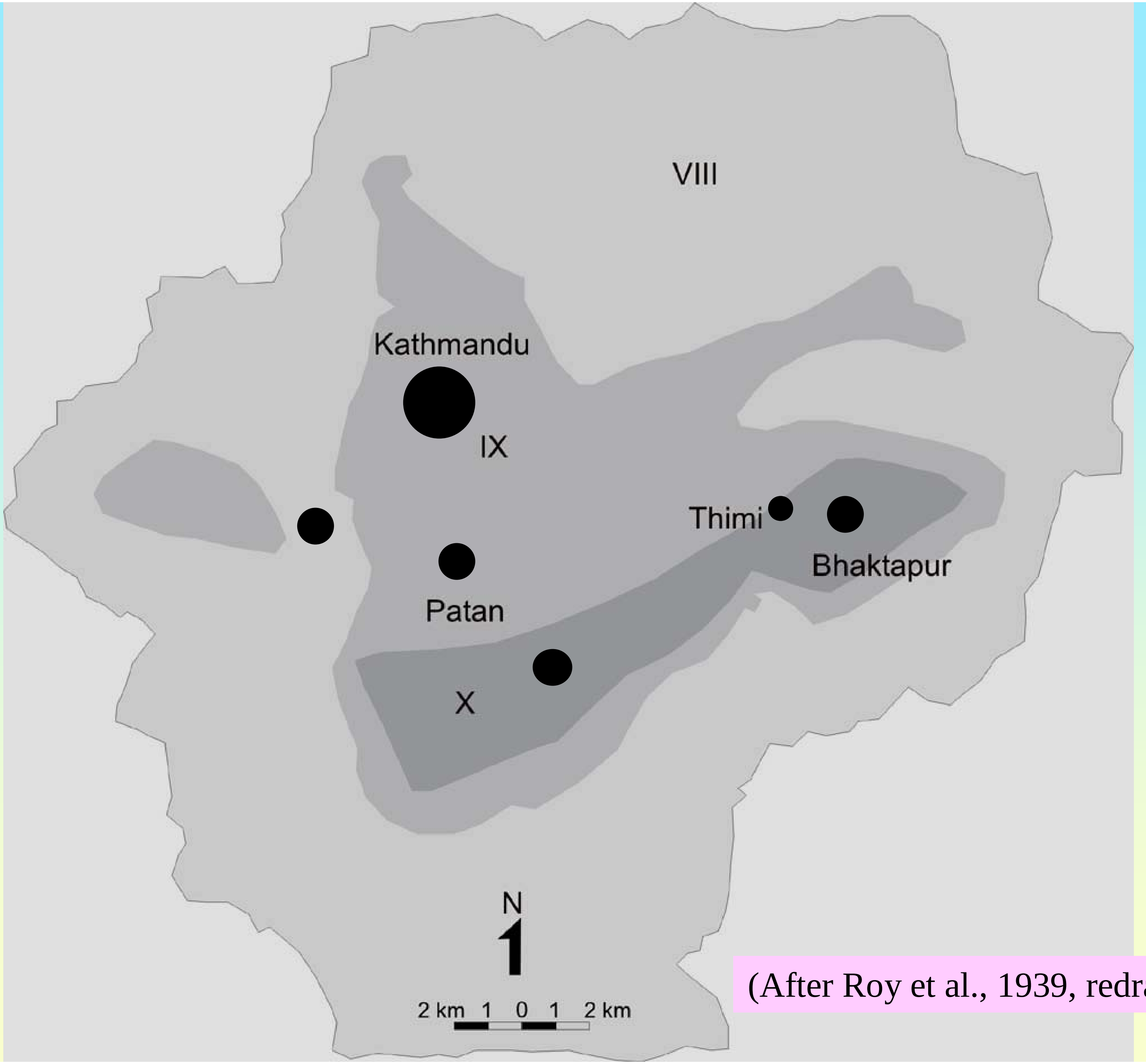
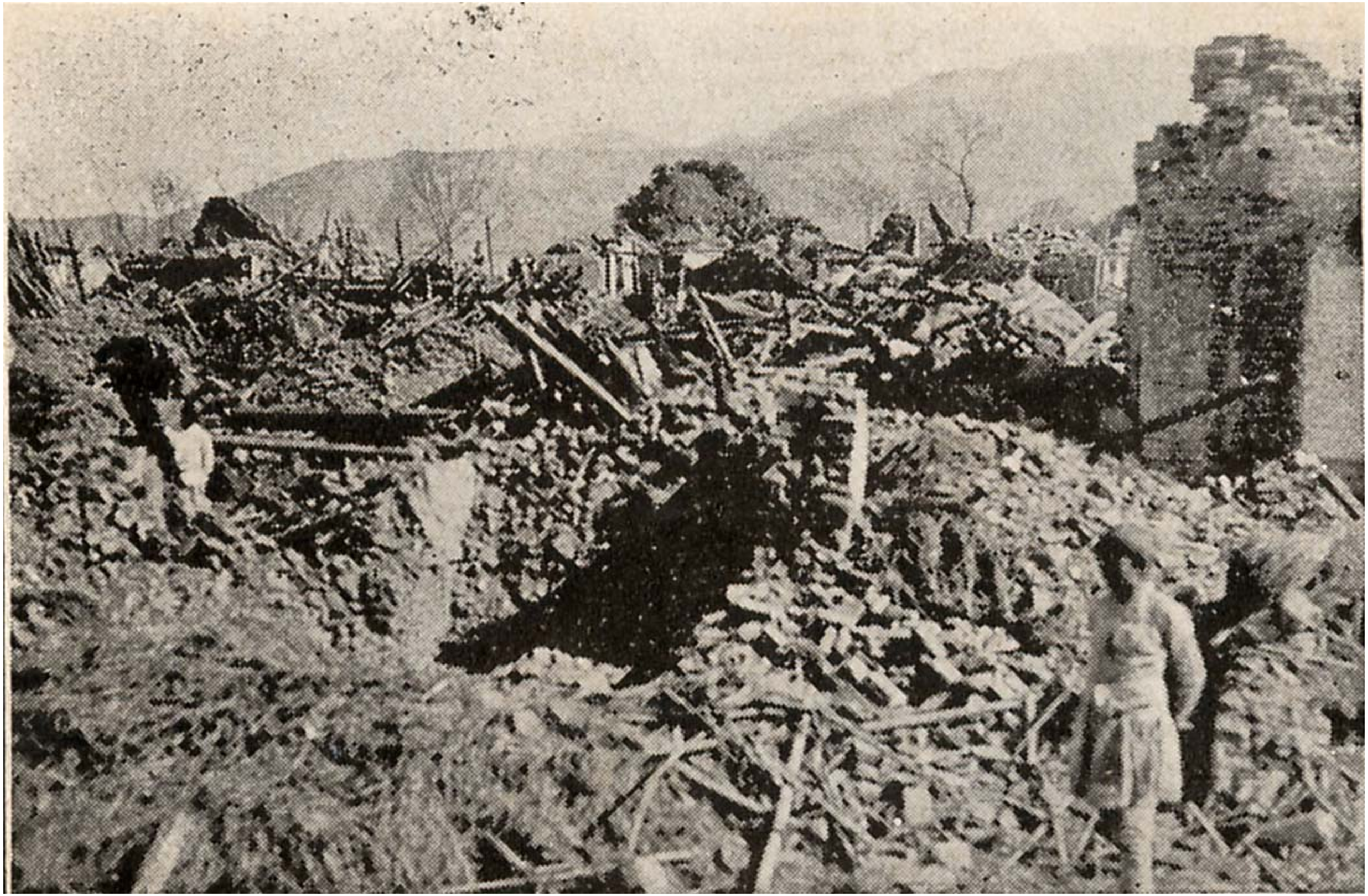


Figure 1 Map showing localities from which damage was reported in Dun et al. (1939). Segments of railways for which there was reported damage and the area call the "slump belt" are also shown. The 300 m contour defines, roughly the edge of the Himalaya. Isoseismals were taken from Dunn et al. (1939) and do not include the information reported by Rana (1935).



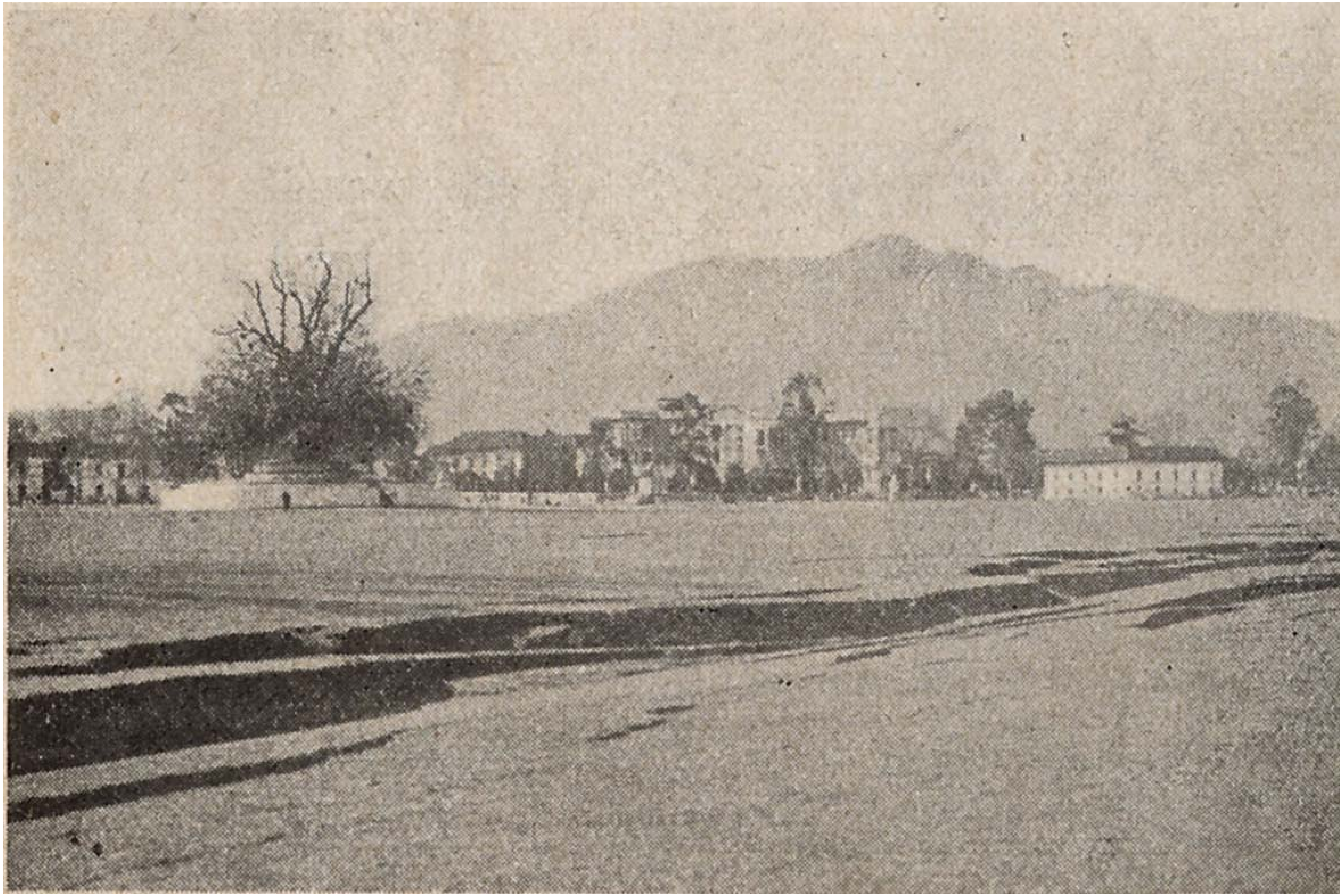
(After Roy et al., 1939, redrawn)

Damage in Bhaktapur, Kathmandu Valley (Rana, 1935)



Lubhu town, Kathmandu valley after the 1934 earthquake (Rana, 1935)

A road in Bhaktapur, Kathmandu Valley (Rana, 1935)



Fissures in Tundikhel, Kathmandu (Rana, 1935)

Deaths due to 1934 earthquake out of Valley

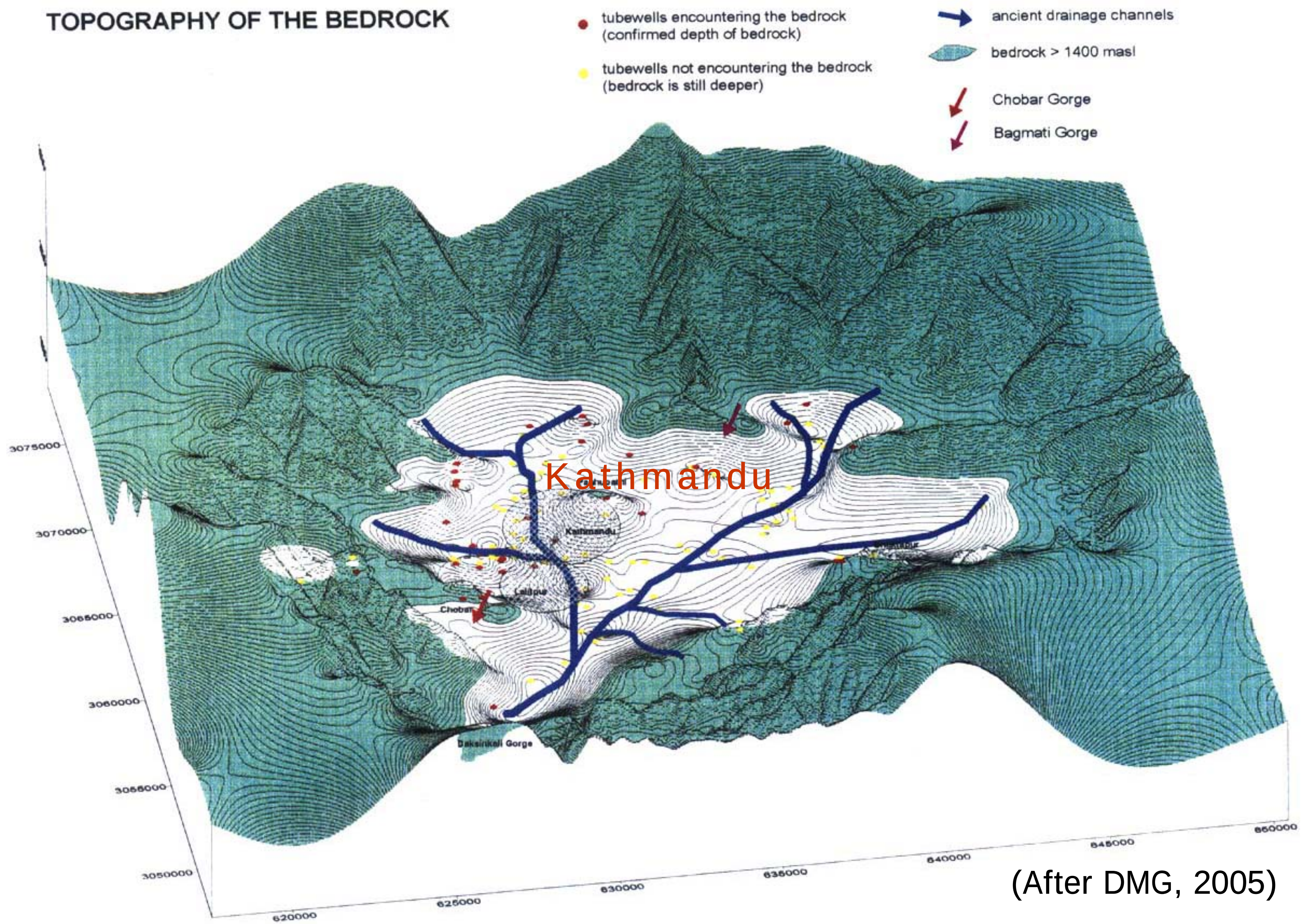
Place	Men	Women	Total
Eastern Mountain region	1792	2182	3974
Western Mountain region	29	36	65
Terai	77	107	184
	1898	2325	4223

Total Deaths by 1934 earthquake			
Kathmandu Valley	1952	2344	4296
Rest of Nepal	1898	2325	4223
Total	3850	4669	8519

Impact of Future Earthquake in Kathmandu

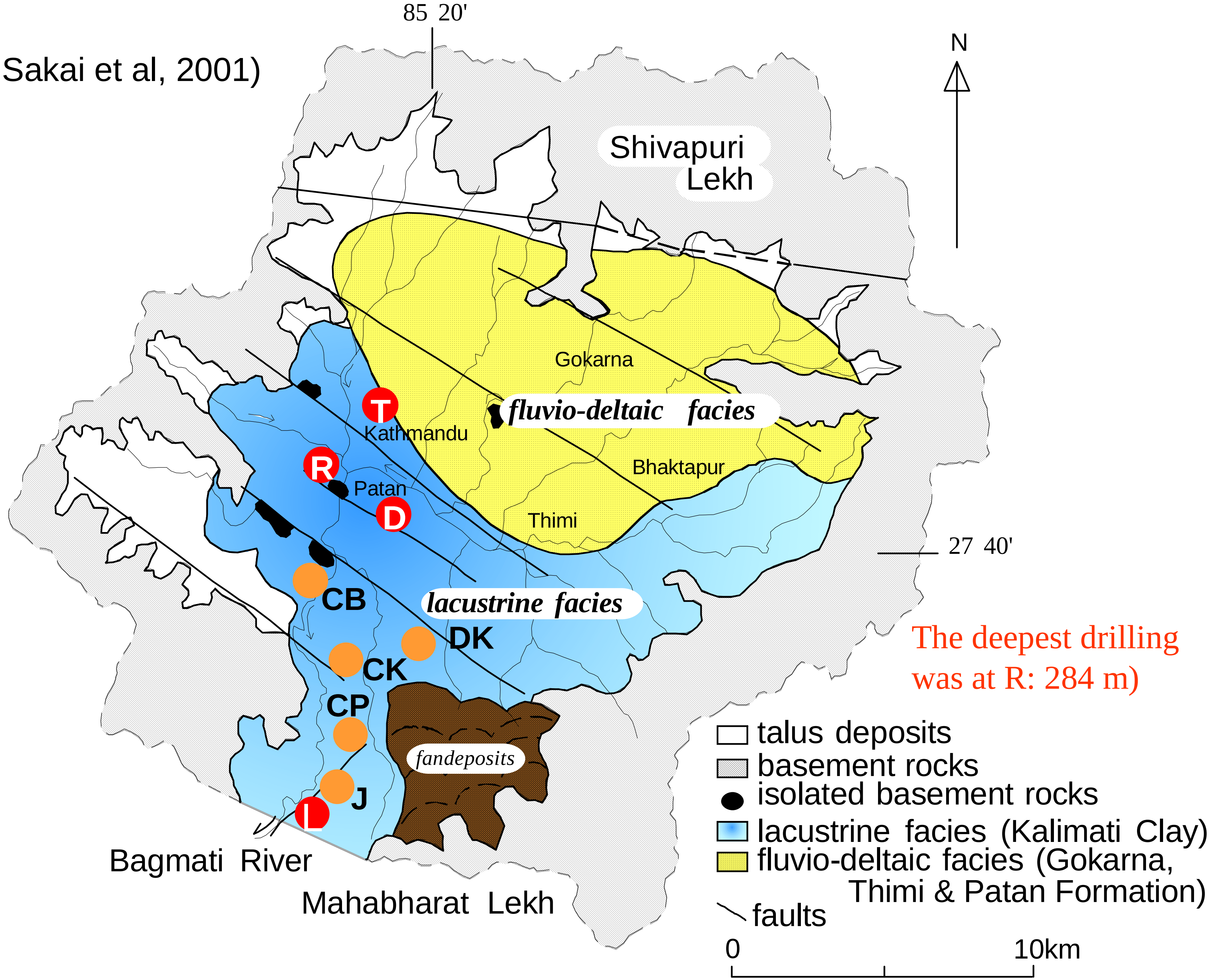
A recent study (UNDP/BCPR, 2004) ranked Nepal as the eleventh most at risk country to earthquakes. Presently Kathmandu is one of the few cities in the world at a very high alert due to Earthquake disaster

GEOMORPHOLOGY

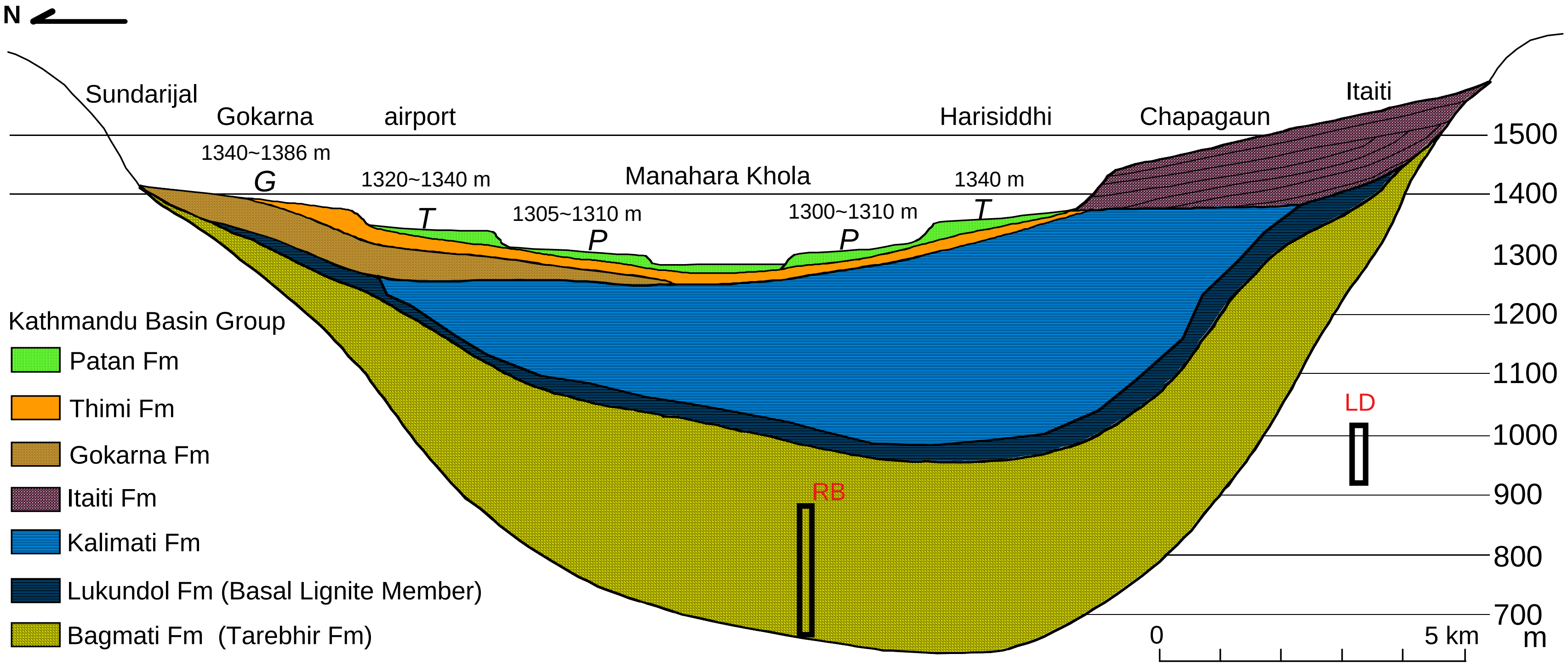


(After DMG, 2005)

(After Sakai et al, 2001)



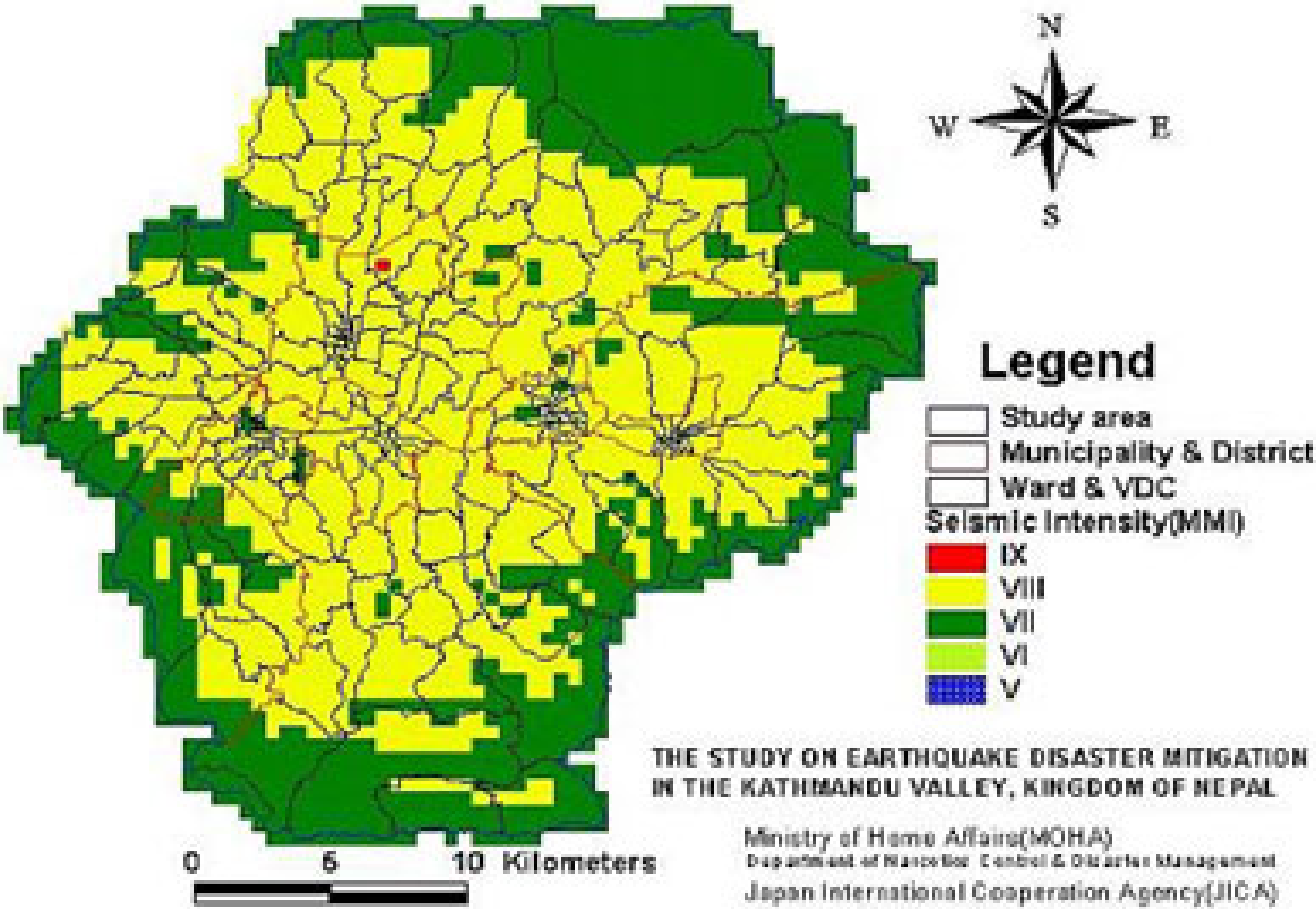
The deepest drilling was at R: 284 m)

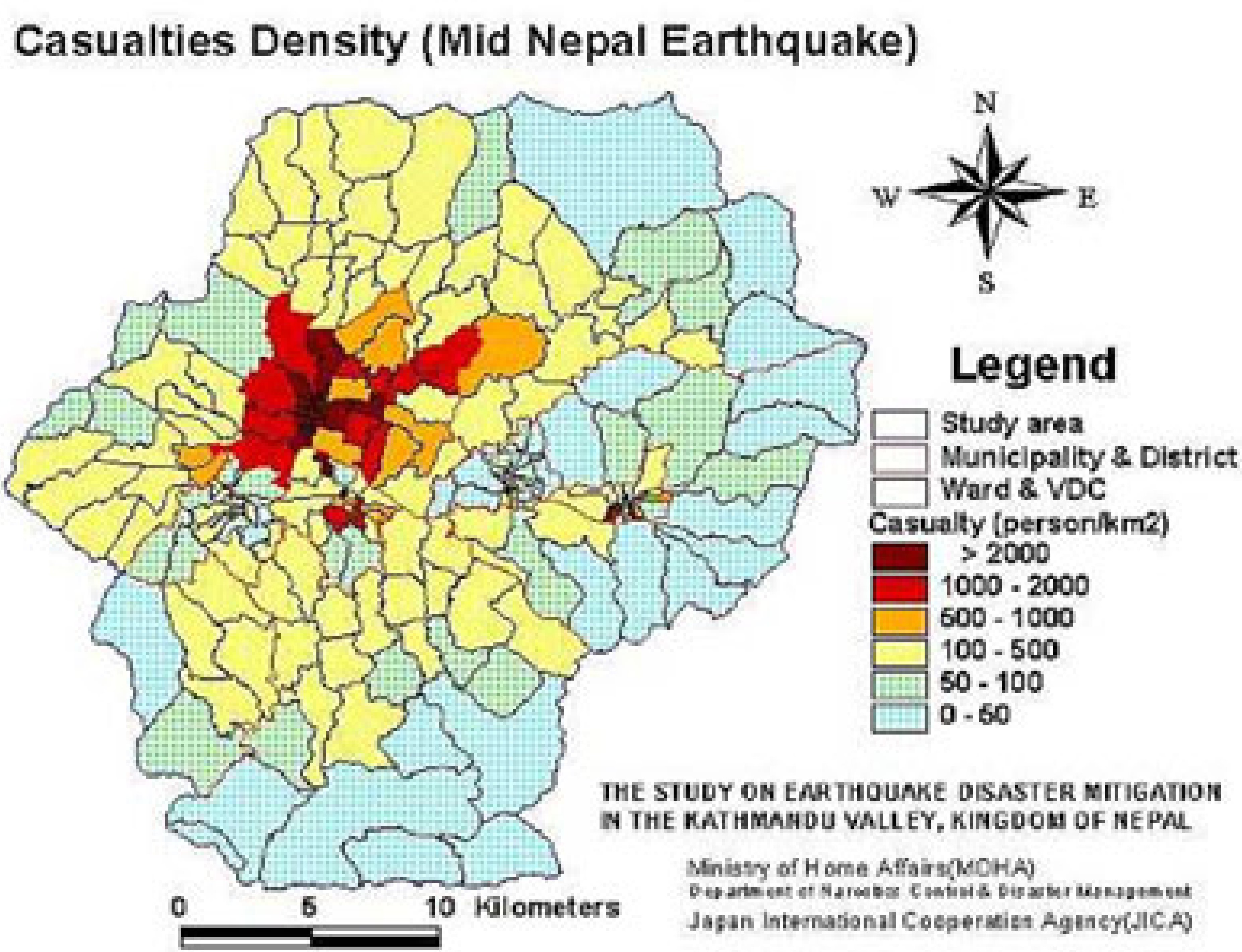


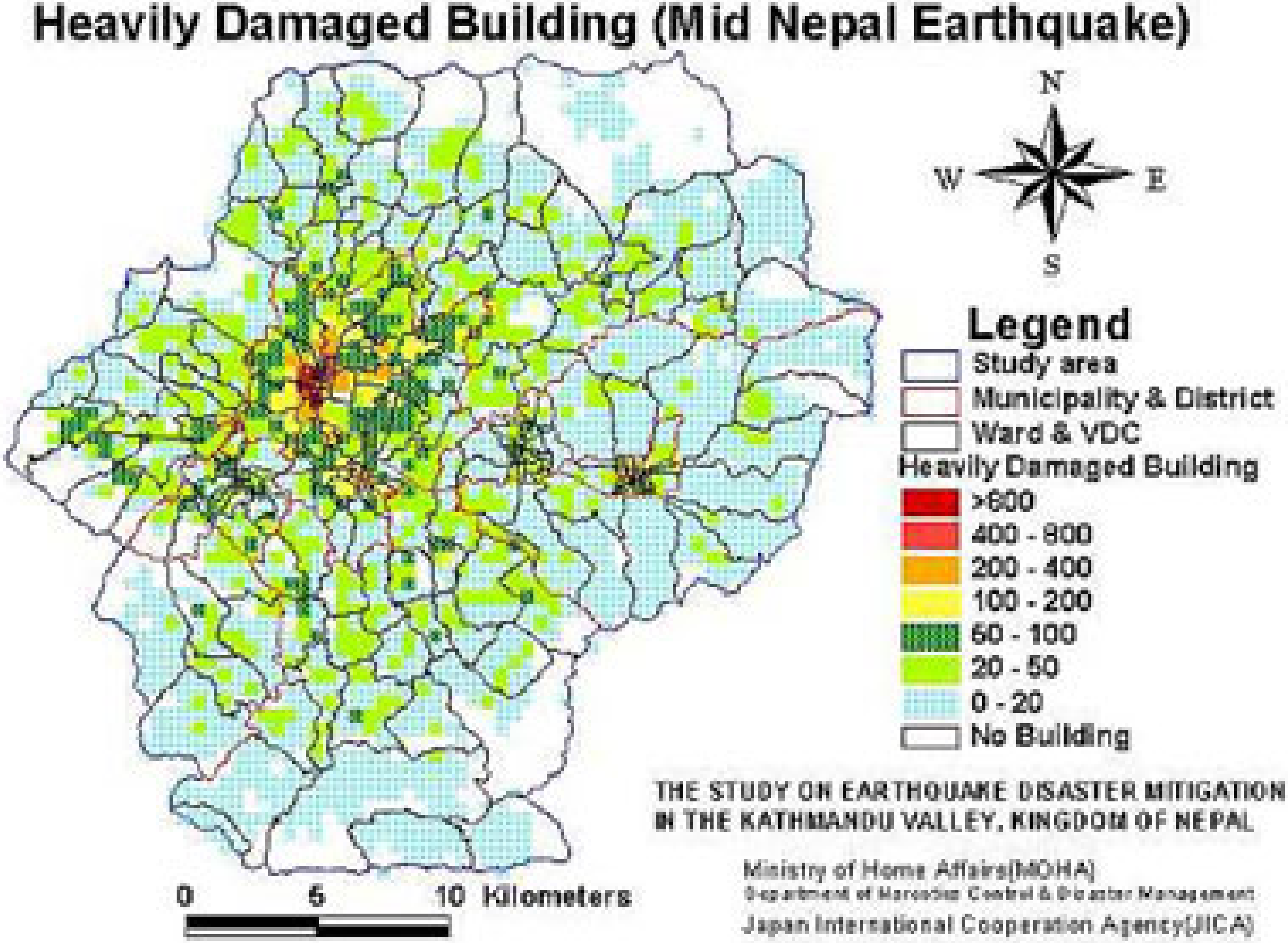
(After Sakai et al., 2001


EveryDay

Seismic Intensity (Mid Nepal Earthquake)

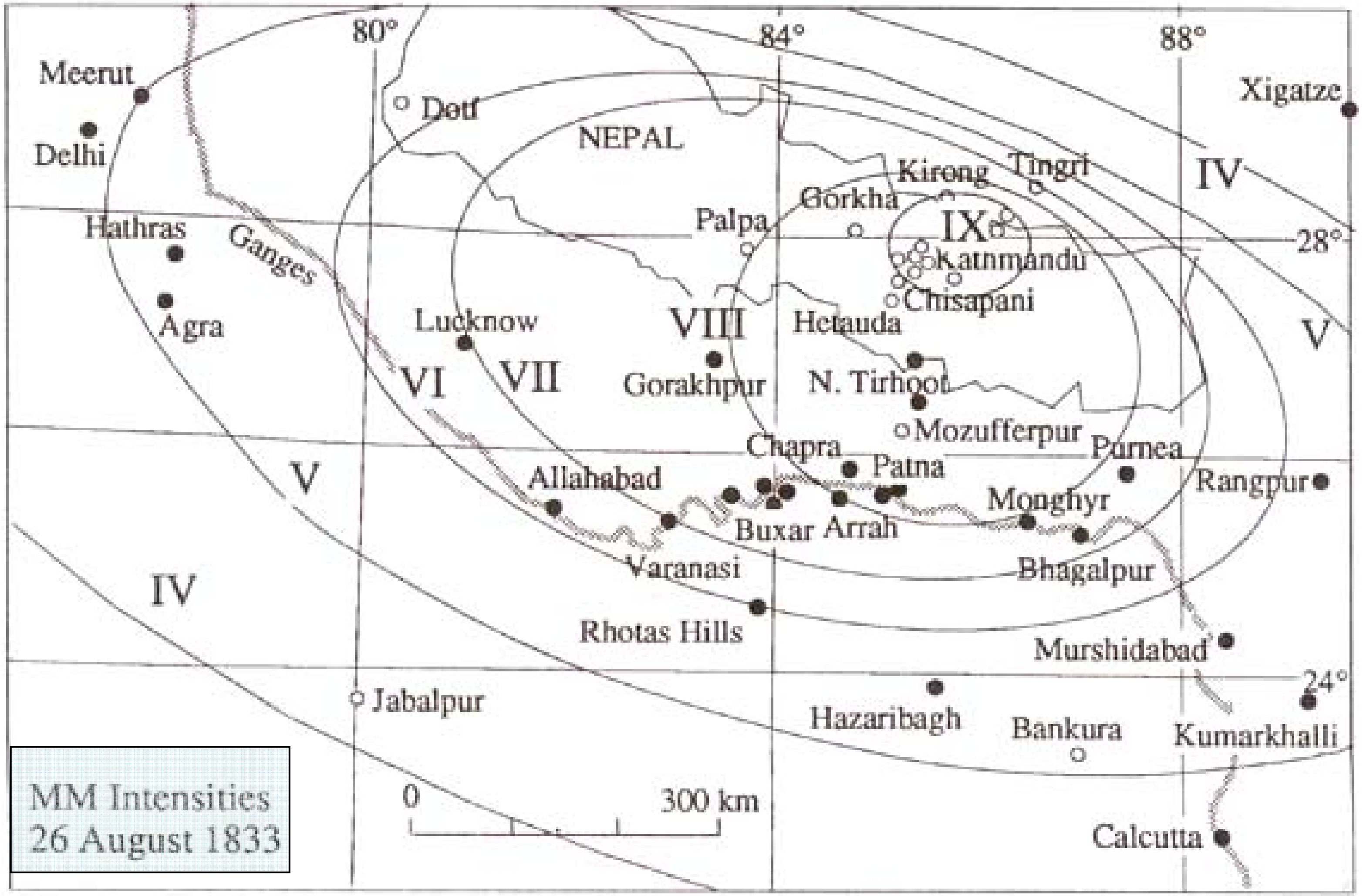



Casualties Density (Mid Nepal Earthquake)
N
W
E
S
Legend
Study area
Municipality & District
Ward & VDC
Casualty (person/km2)
> 2000
1000 - 2000
500 - 1000
100 - 500
50 - 100
0 - 50
THE STUDY ON EARTHQUAKE DISASTER MITIGATION
IN THE KATHMANDU VALLEY, KINGDOM OF NEPAL
Ministry of Home Affairs(MOHA)
Japan International Cooperation Agency(JICA)
0
5
10 Kilometers


Heavily Damaged Building (Mid Nepal Earthquake)
N
W
E
S
Legend
Study area
Municipality & District
Ward & VDC
Heavily Damaged Building
>600
400 - 600
200 - 400
100 - 200
60 - 100
20 - 50
0 - 20
No Building
THE STUDY ON EARTHQUAKE DISASTER MITIGATION
IN THE KATHMANDU VALLEY, KINGDOM OF NEPAL
Ministry of Home Affairs(MOHA)
Japan International Cooperation Agency(JICA)
0
5
10 Kilometers

Potential Impact due to scenario EQ in KV
(KVERMP estimates for IX MMI)

Impact	Extent
Death	>40,000
Injuries	>95,000
Buildings destroyed/collapsed	>60%
Homeless population	>700,000
Bridges impassable	>50%
Road length damaged	>10%
Water supply pipes damaged	>95%
Telephone exchange buildings	most
Telephone lines	>60%
Electric substations	most
Electric lines	40%

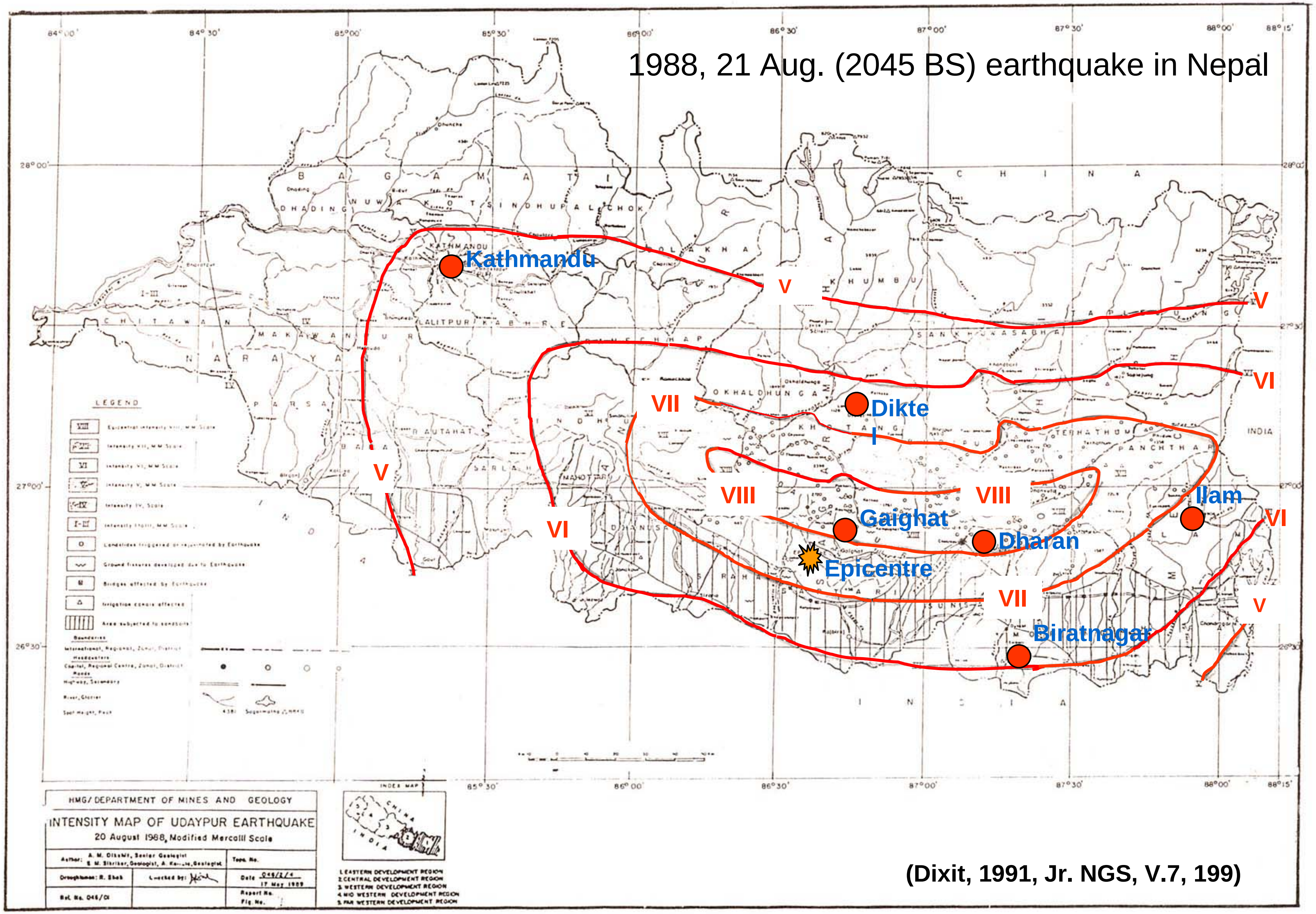


(Bilham, 1995)

Fig. 2 Locations reporting the 26 August 1833 earthquake. Solid circles from newspapers and open circles from Campbell, 1833. The shaded ellipse corresponds to the rupture area adopted by Khattri placed in a location corresponding to maximum damage reported by Campbell. However, the location of the rupture is probably uncertain to ±1 degree, and the rupture area could be a factor of 2 or more larger.

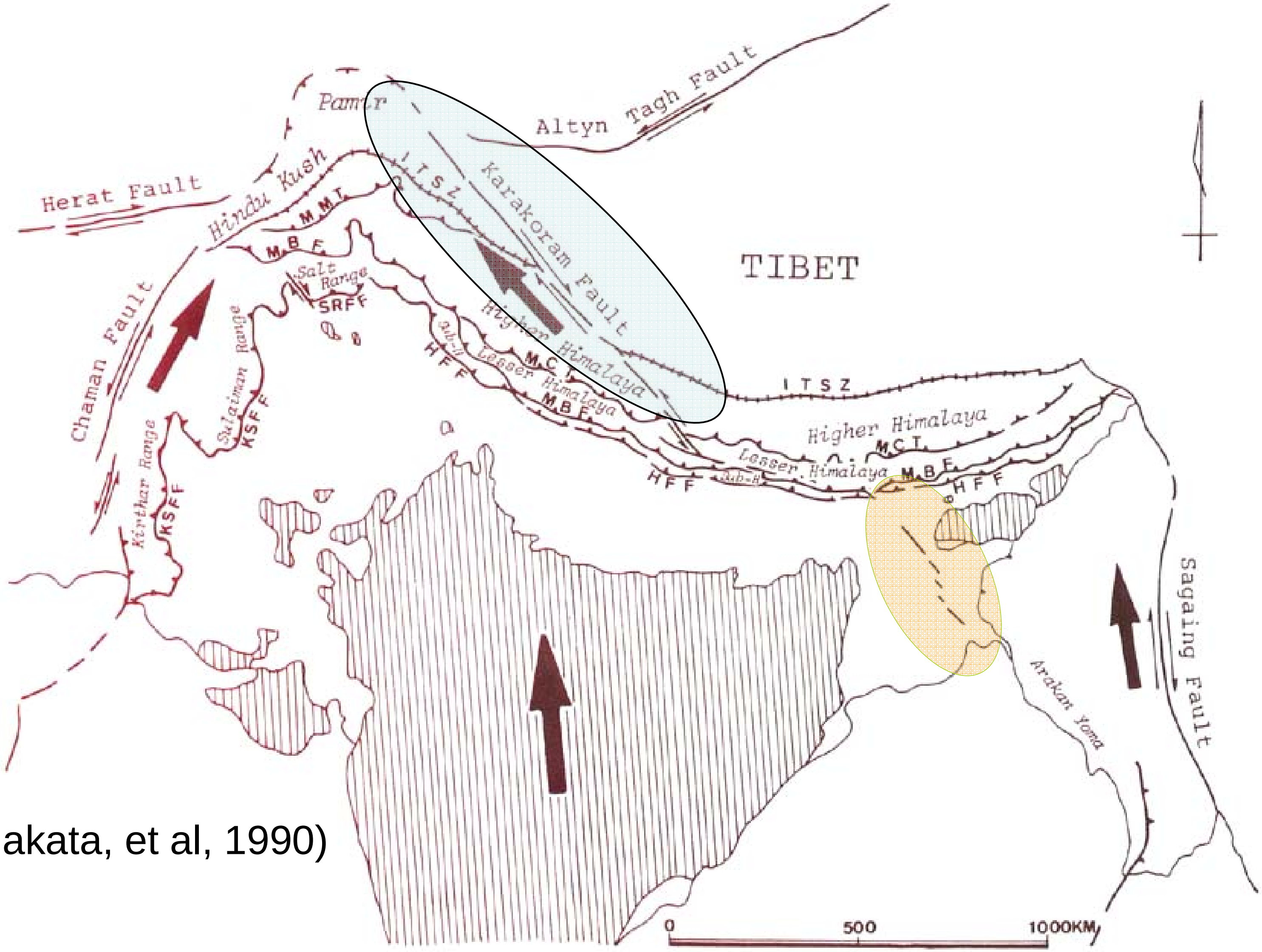
Area affected by the July 29,1980 Bajhang earthquake (6.5 Richter scale)

1988, 21 Aug. (2045 BS) earthquake in Nepal



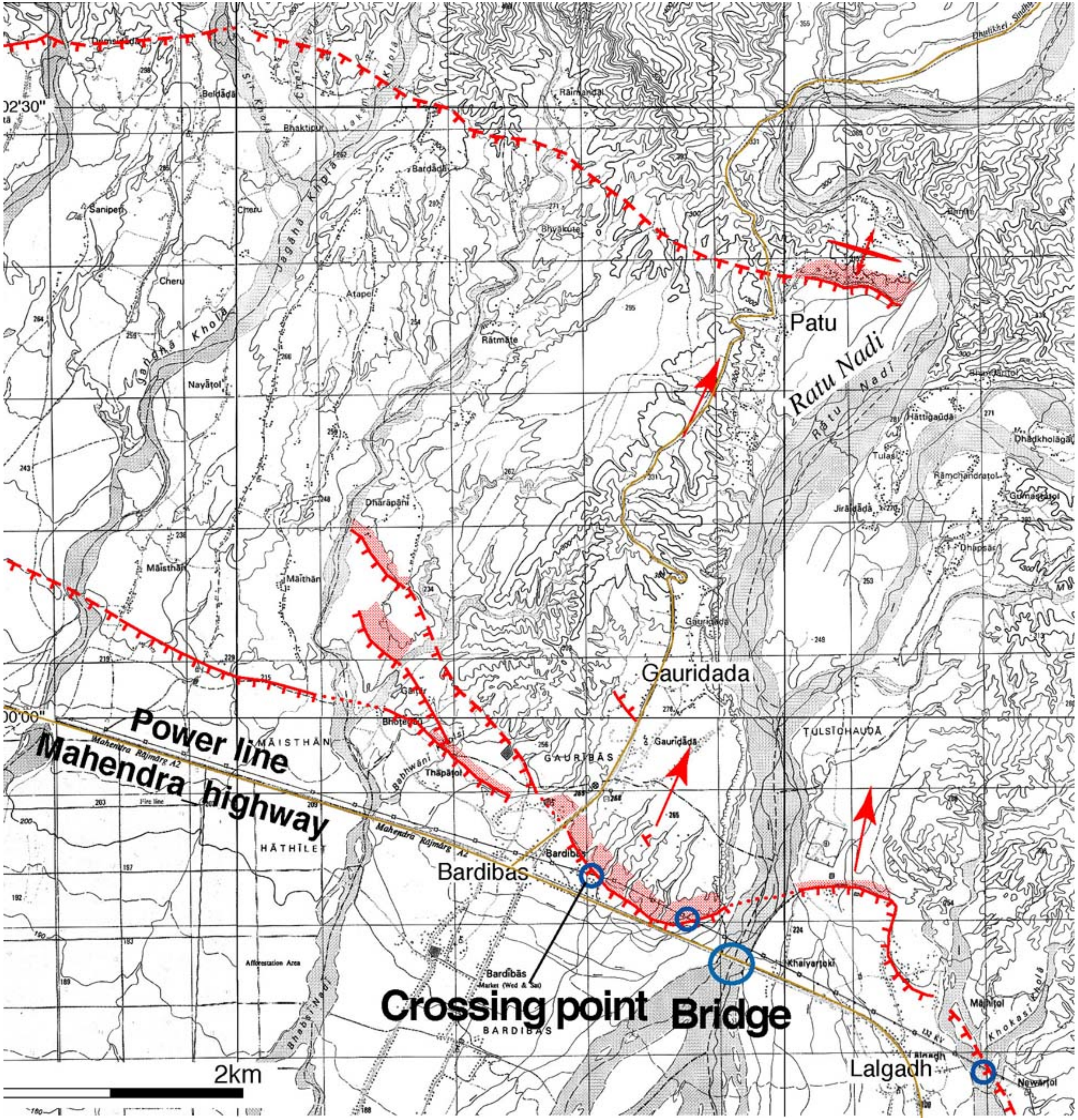
(Dixit, 1991, Jr. NGS, V.7, 199)

Active Faults in Nepal

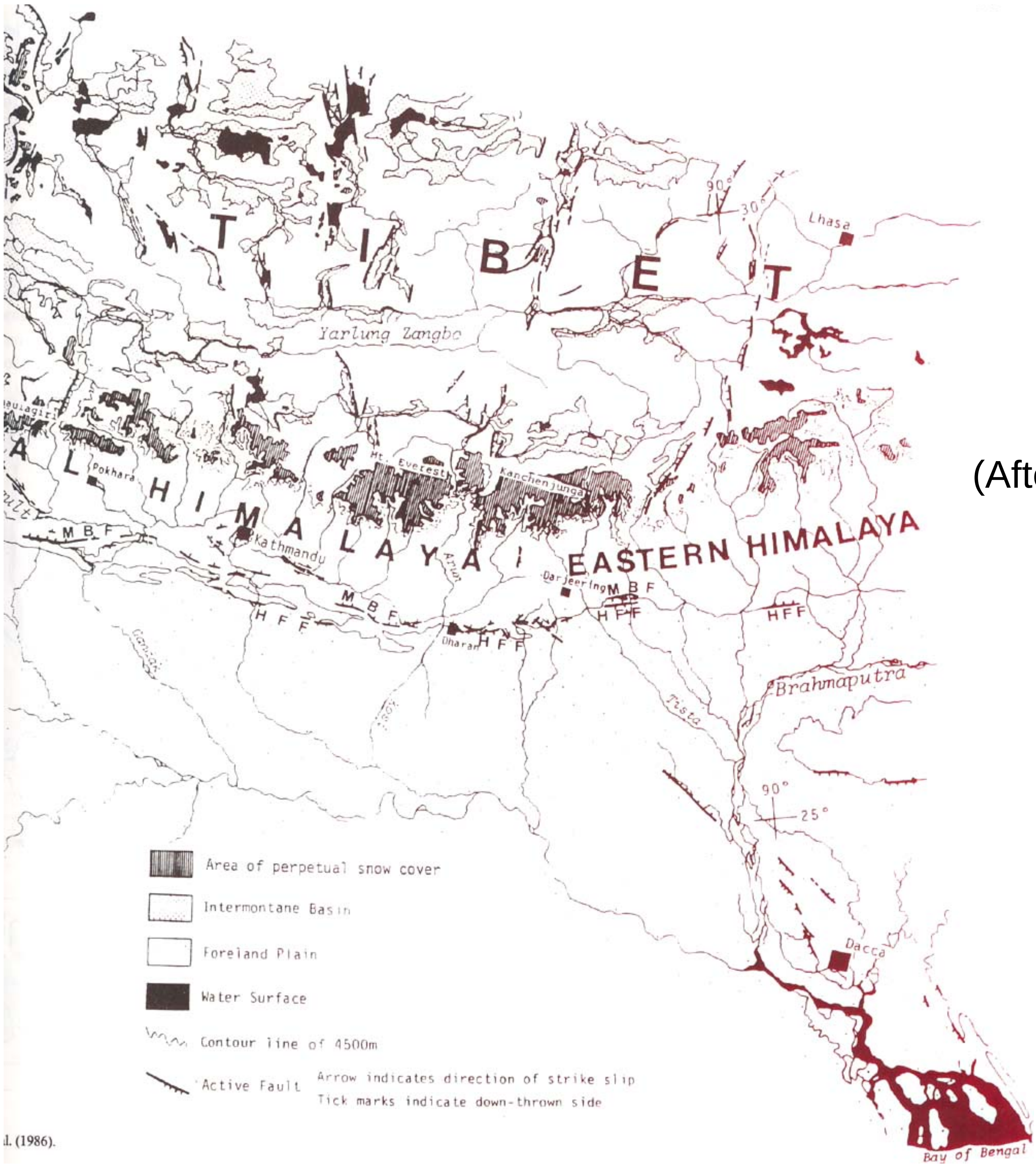


(After Nakata, et al, 1990)

Fig. 2. Tectonic outline of the Himalaya and its surrounding area: *ITSZ* = Indus–Tsuangpo Suture Zone; *MCT* = Main Central Thrust; *MBF* = Main Boundary Fault; *HHF* = Himalayan Front Fault; *SRFF* = Salt Range Front Fault; *KSFF* = Kirthar–Sulaiman Front Fault; *Sub-H* = Sub-Himalayas.



(Nakata et al, unpublished)



(After Nakata, et al, 1990)

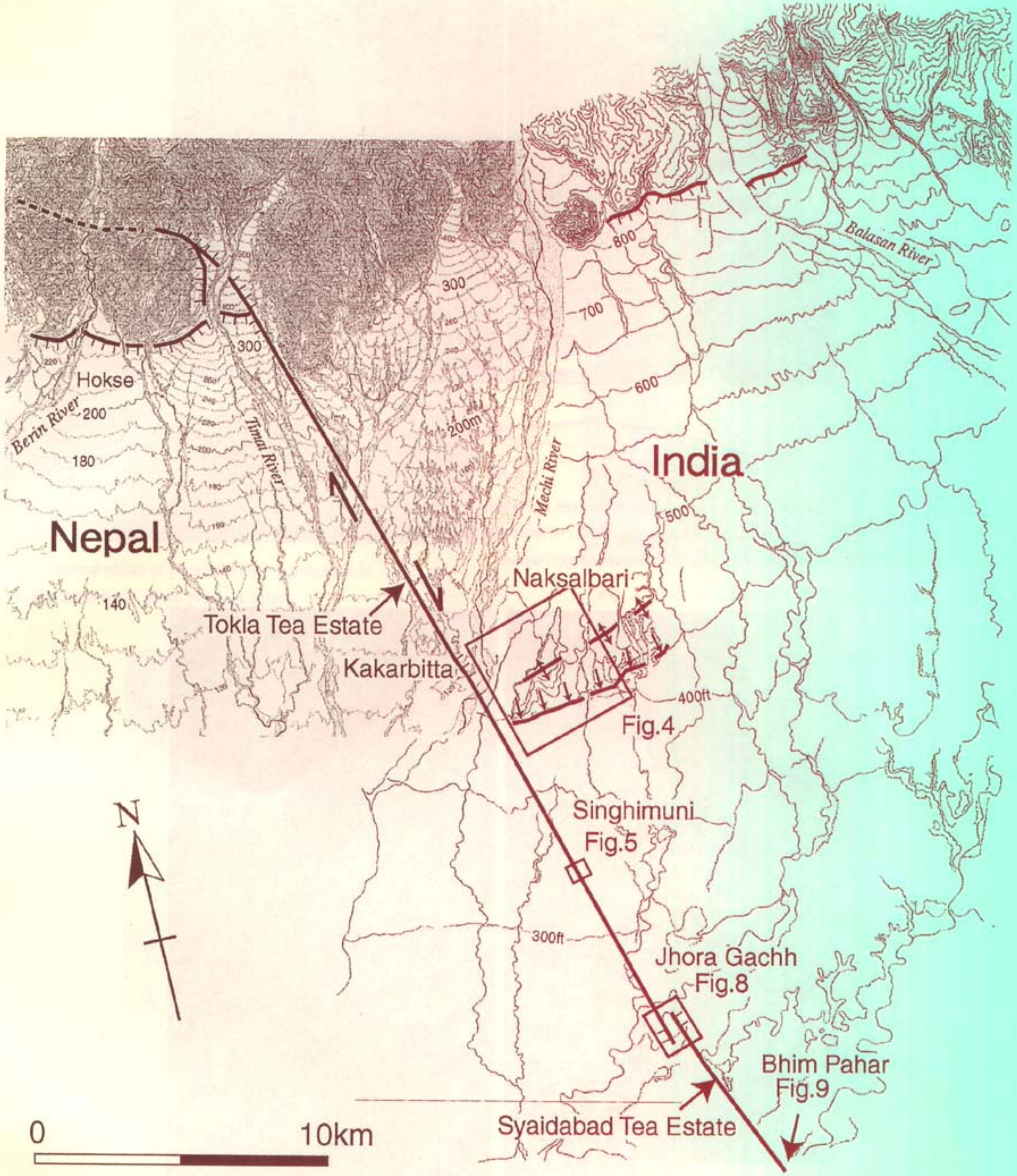
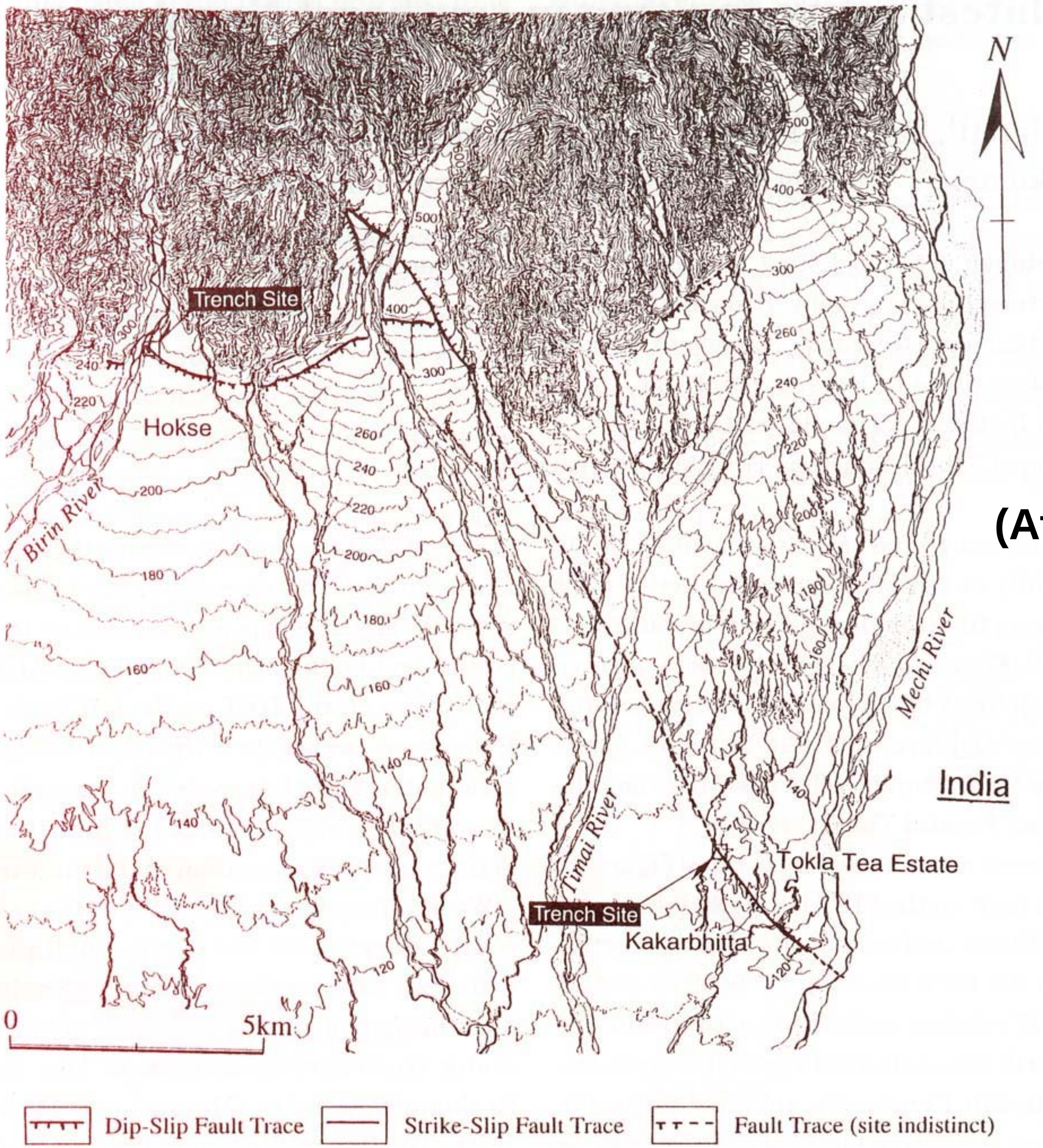
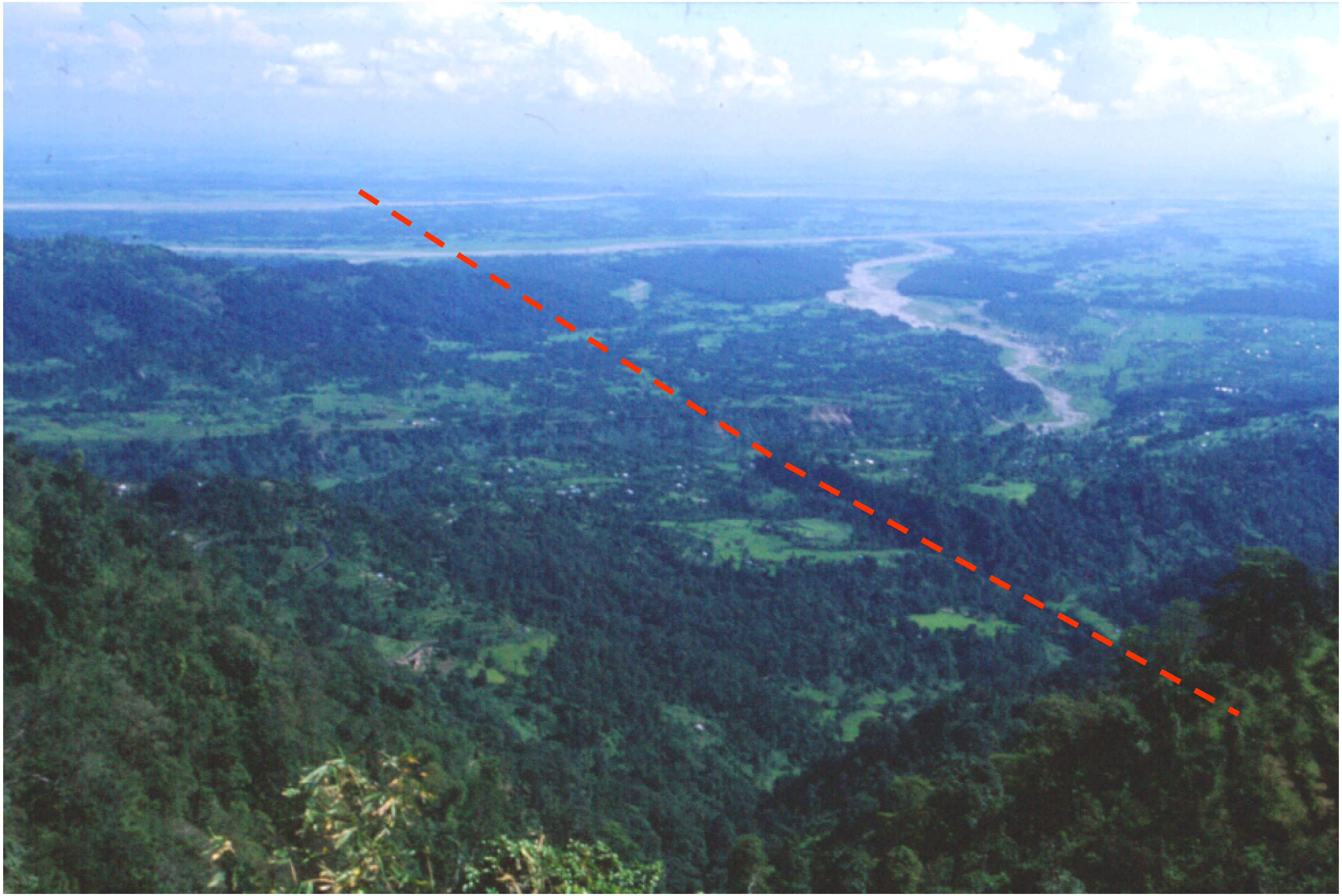


Fig. 3 Active faults around international border between Nepal and India.



(After Upreti et al, 2000)

Figure 2. Trench sites on the active fault traces in southeast Nepal.



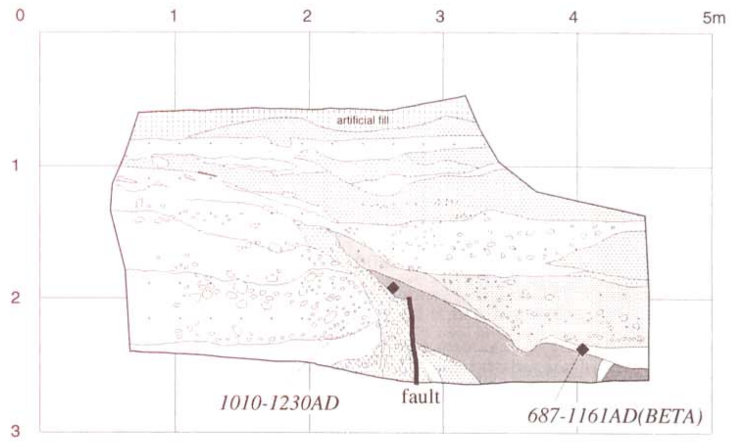


Figure 3. Log of west-wall at the Tokla Tea Estate trench on the Himalaya-Ganges fault about 2 km NW from Kakarbhitta. Clear evidence of late Holocene rupture on a near-vertical fault zone.

(After Upreti et al, 2000)

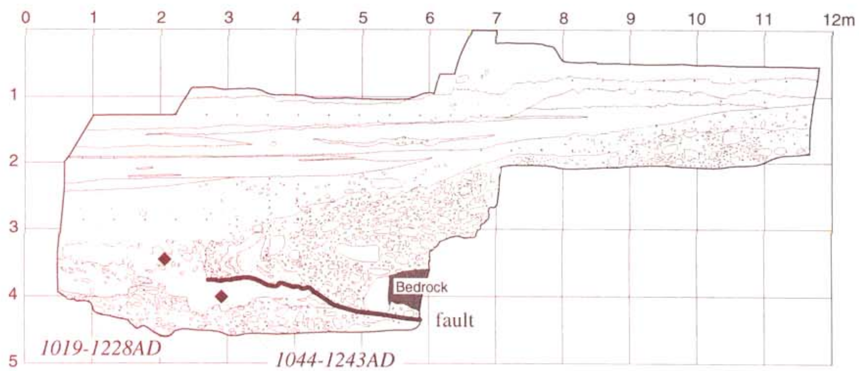


Figure 4. Log of west-wall at the Hokse Trench across the HFT Folded sand and gravel beds overriding late Holocene overbank deposits along a low-angle fault surface.

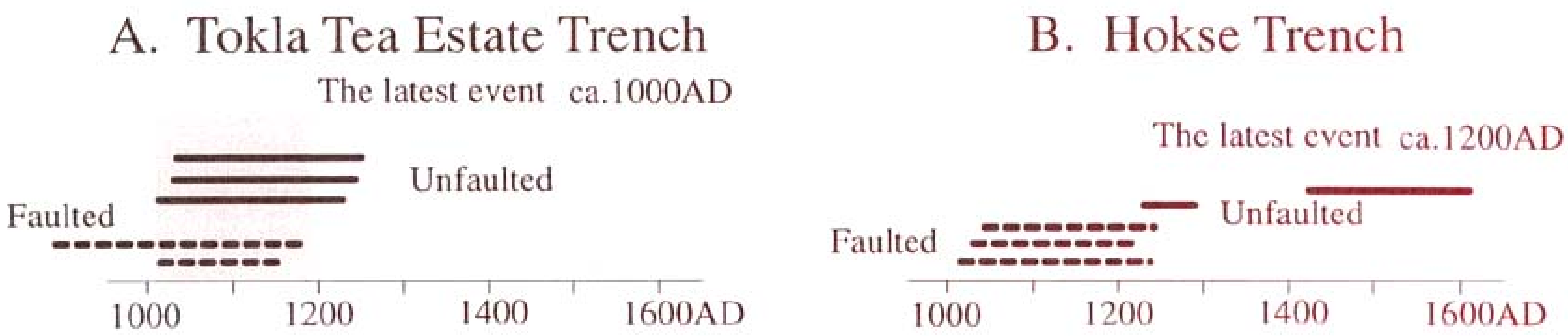
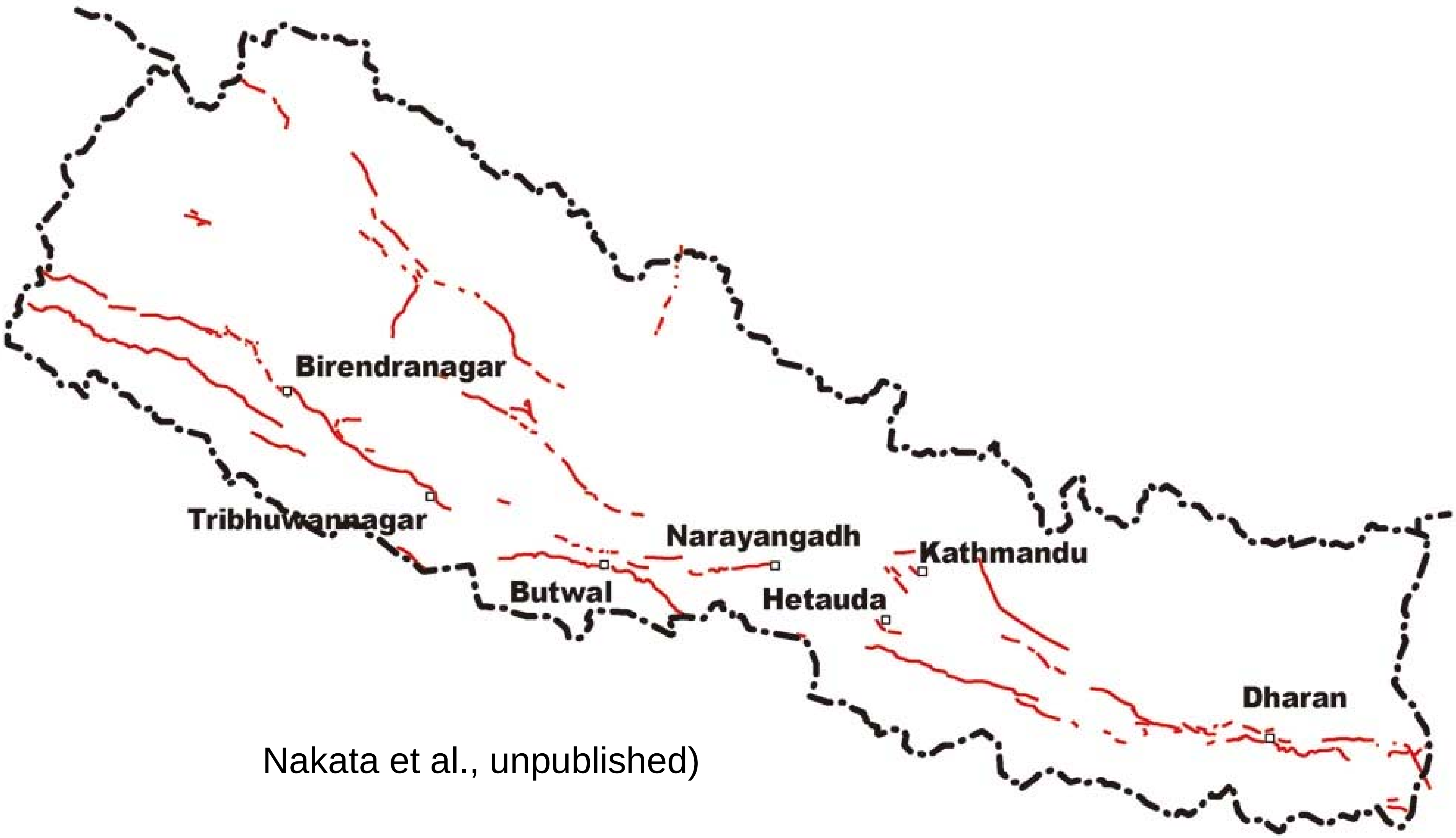


Figure 5. Timing of the latest events. A. Timing of the latest surface rupture at Hokse Trench across the HFT appears to date about 1200 A.D. B. Timing of the latest surface rupture is not well-defined at Tokla Tea Eastate trench, and appears to be between 1000 and 1200 A.D.

(After Upreti et al, 2000)


warping
white silt layer
5m
Bardibas along E-W highway

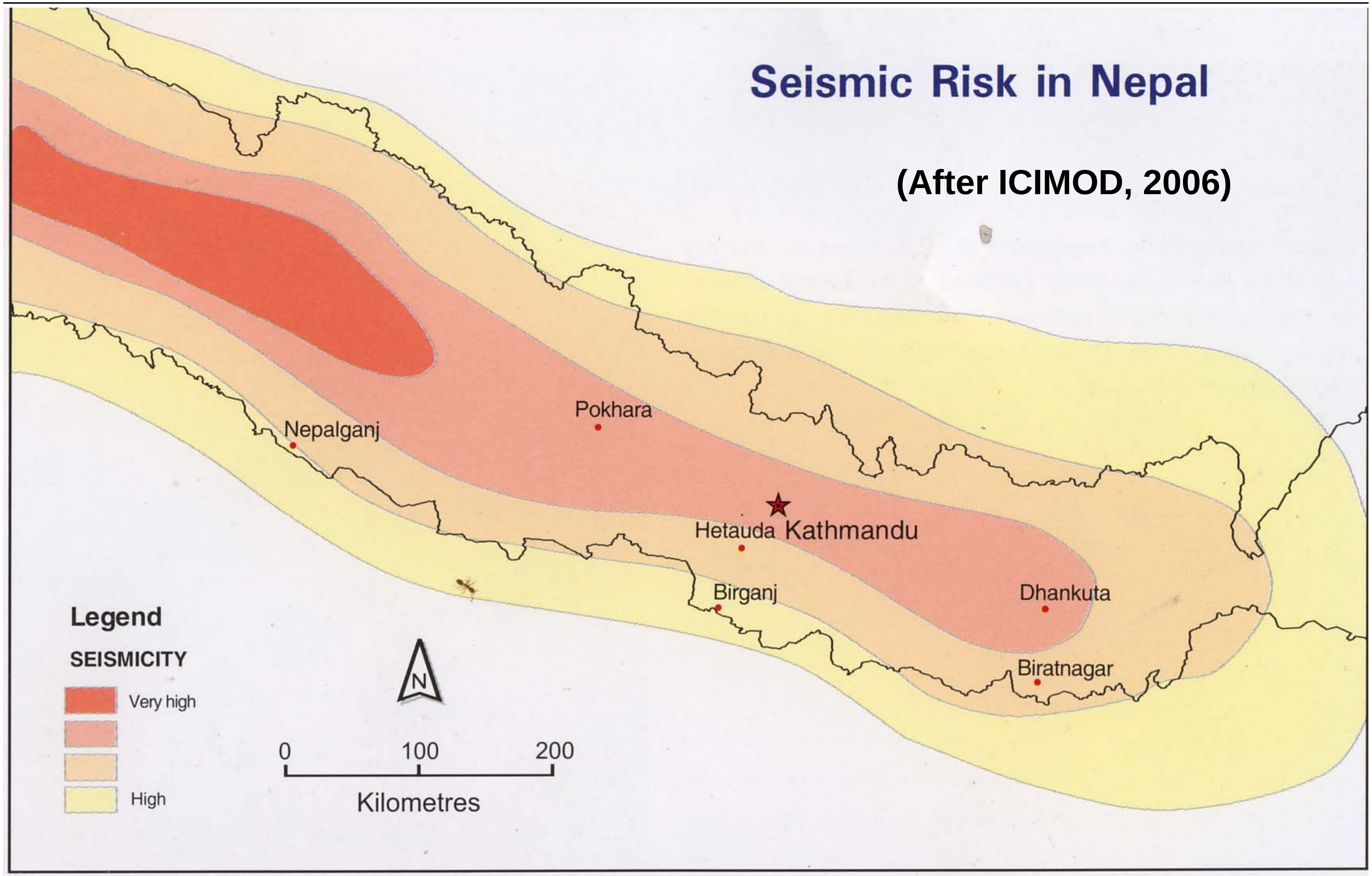


Nakata et al., unpublished)

Table 1 Population of large City on the Fault (PCF)

Kathmandu (including Lalitpur)	834,000
Dharan	95,000
Butwal	75,000
Narayangadh	72,000
Hetauda	68,000
Tribhuwannagar	43,000
Birendranagar	31,000
total	1,218,000
PCF/ total poplation of Nepal	5%

data: 2001census



Source: Adapted from United Nations Disaster Management Team, 2001. Nepal: UN Disaster Response Preparedness Plan, Part I. Kathmandu: The United Nations System


Thank You