GEO-HAZARD STUDIES IN INDIA

SCA MEETING, OKINAWA

JUNE 14 – 16, 2007

HARSH GUPTA

RAJA RAMANNA FELLOW

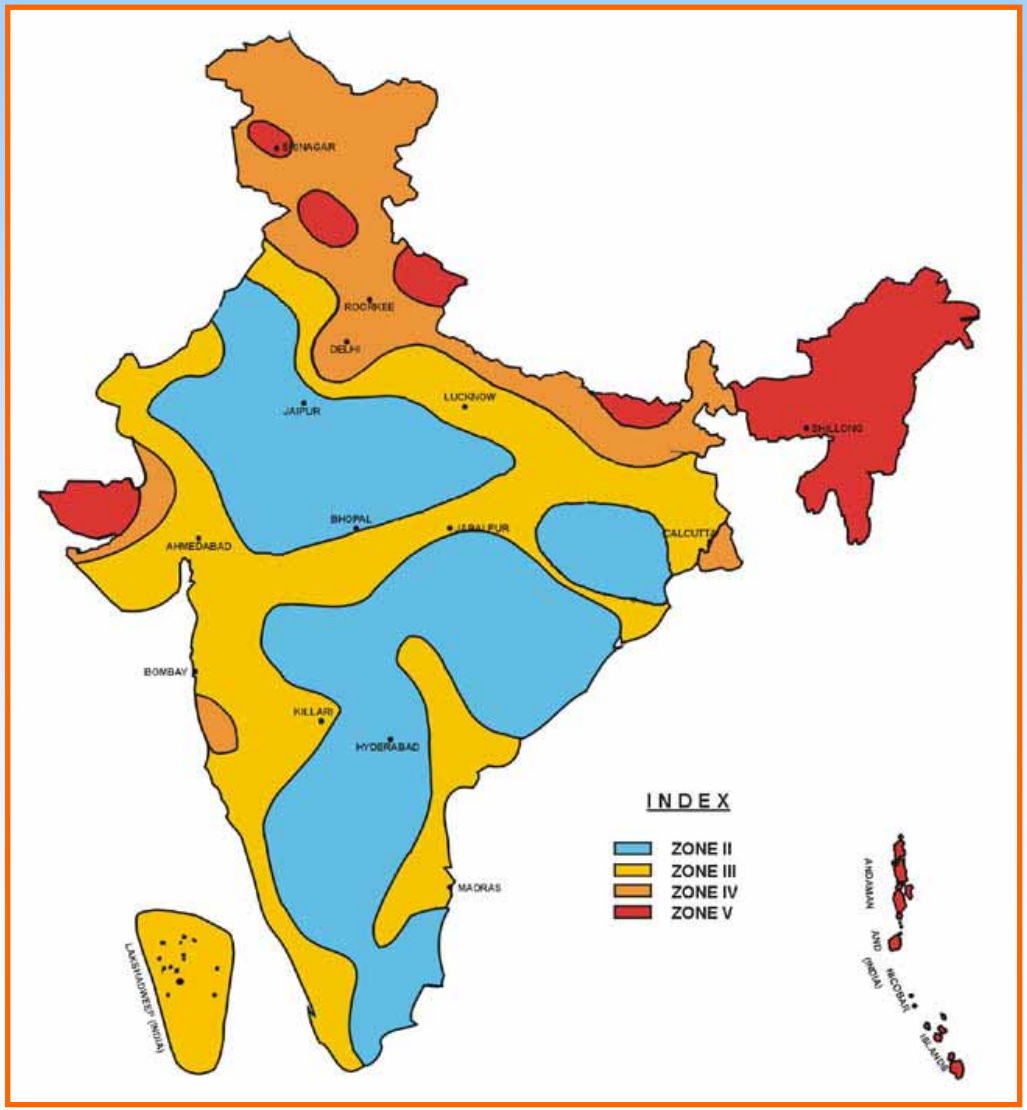
NATIONAL GEOPHYSICAL RESEARCH INSTITUTE


INDIA
GEOLOGICAL MAP
N
AFGHANISTAN
PAKISTAN
CHINA
TIBET
NEPAL
BHUTAN
BANGLADESH
MYANMAR
Vindhvan
Vindhvan
Vindhvan
Siwalik
Alluvial
Upland(Old)
Alluvium
Alluvium
Marine
Tertiaries
Aravalli
Vindhvan
Granities(Old)
Vindhvan
Deccan Trap
Dharwar
Lower
Gondwana
Alluvium
Dharwar
Deccan
Trap
Cuddapah
Granites
Un Classified
Crystalline
Deccan Trap
Un Classified
Crystalline
BAY
OF
BENGAL
ARABIAN
SEA
Cuddapah
Granites
Un Classified
Crystalline
LAKSHADWEEP
ANDAMAN AND NICOBAR ISLANDS
SRI
LANKA
INDIAN
OCEAN
LEGENDS
Recent and Pleistcene
Tertiary
Deccan Trap
Gondwana & Vindhvan
Pre-Cambrian
Cuddapah
Map not to Scale
Copyright © 2006 Compare Infobase Limited

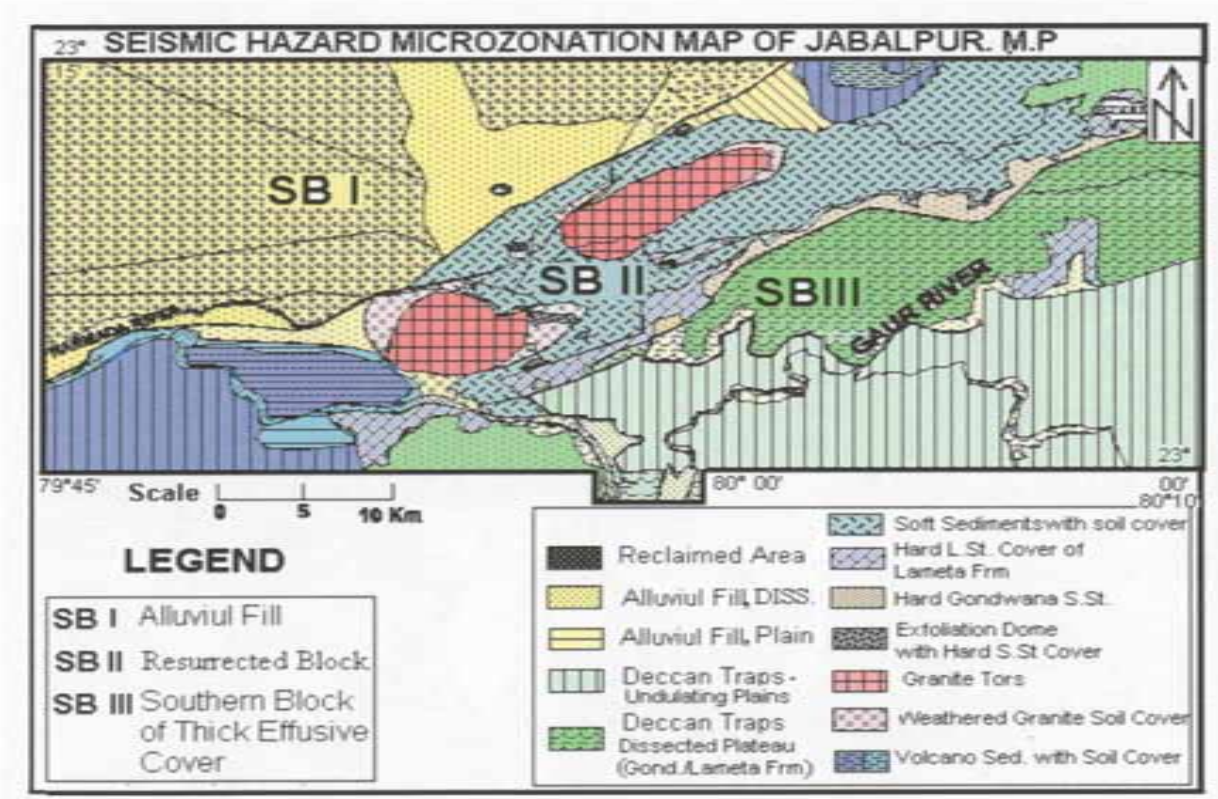
EARTHQUAKE FATALITIES IN INDIA

Date	Region	Magnitude	Fatalities
26th Jan 2001	Gujarat	M 7.6	20,085
4th Apr 1905	Kangra	M 7.5	19,000
15th Jan 1934	Bihar	M 8.1	10,700
29th Sep 1993	Latur- Killari	M 6.2	9,748
19th Oct 1991	Uttarkashi	M 7.0	2,000
15th Aug 1950	Assam- Tibet	M 8.6	1,526
12th Jun 1897	Assam	M 8.3	1,500
20th Aug 1988	Nepal- India	M 6.8	1,450

SEISMIC ZONING MAP



First order Microzonation Map of Jabalpur, M.P.



26 DECEMBER 2004

Mw 9.3 EQ


Marina Beach, Chennai


Marina Beach, Chennai


Kanyakumari

GPS OBSERVATIONS IN ANDAMAN & NICOBAR

APPARENT MOVEMENT OF STATIONS

Figure – 9.5

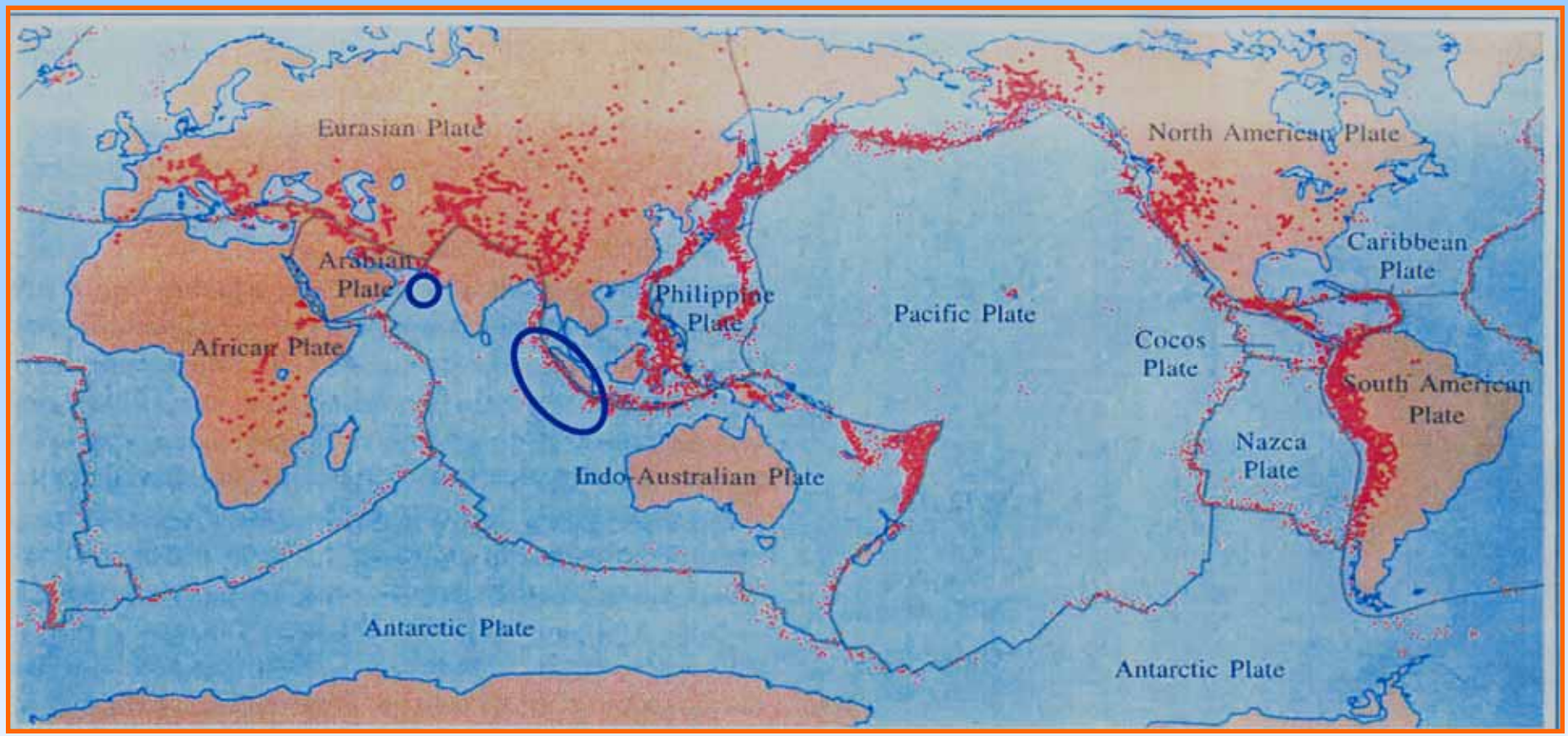
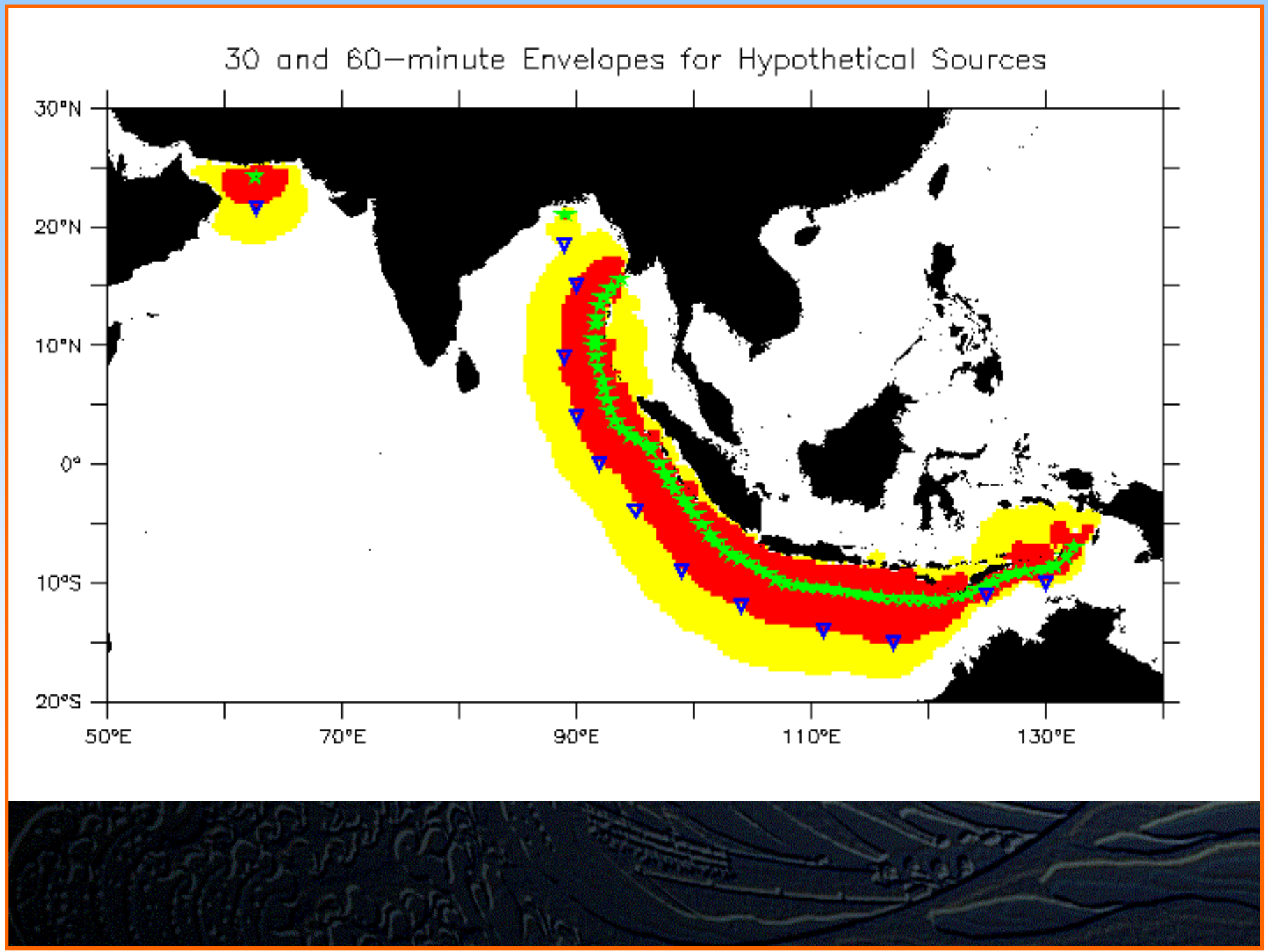


Diagram showing the distribution of earthquakes and major plate boundaries. It may be noted that globally, more than 75% of earthquake energy is released in the circum-Pacific belt, about 20% in the Alpine-Himalayan belt, and remaining 5% through the mid-oceanic ridges and other Stable Continental Region earthquakes. For a tsunami to hit Indian coast, it is necessary that a tsunamigenic earthquake occurs and its magnitude should be larger than M 7, and the possible locations of such events are enclosed in blue circle and ellipse.


30 and 60–minute Envelopes for Hypothetical Sources
30°N
20°N
10°N
0°
10°S
20°S
50°E
70°E
90°E
110°E
130°E

INDIAN TSUNAMI AND STORM SURGE MITIGATION SYSTEM

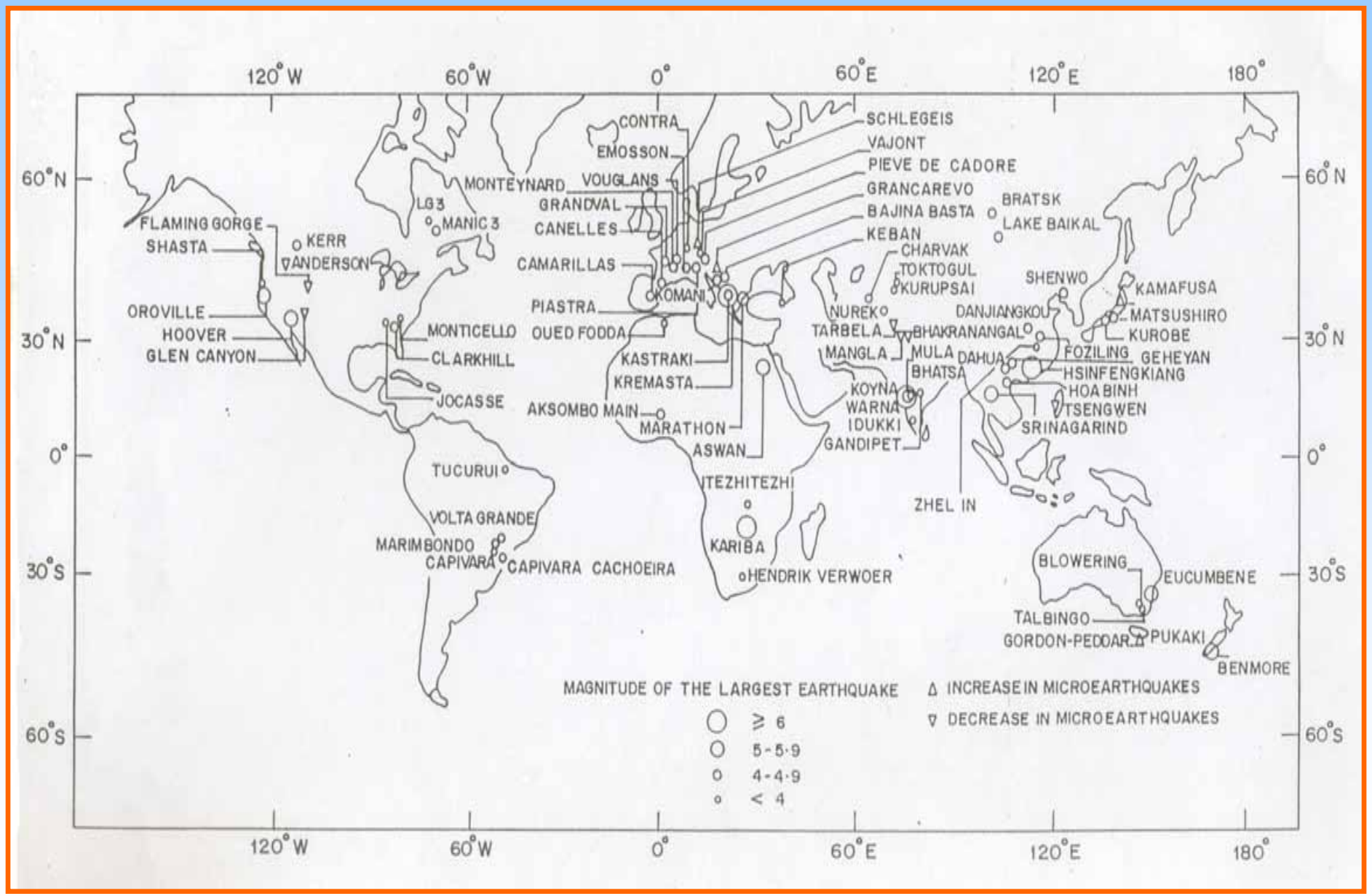
The Indian Tsunami Early Warning System incorporates the needs of storm surge forecast too. The System design is based on end-to-end principle encompassing:

- Near-real time determination of earthquake parameters in the two known Tsunamigenic zones of Indian Ocean region, using a network of land-based Seismic Stations

- Establishing a comprehensive real time Ocean observational network comprising Bottom Pressure Recorders around the two Tsunamigenic zones, Tide Gauges, Radar-based Coastal Monitoring Stations etc.

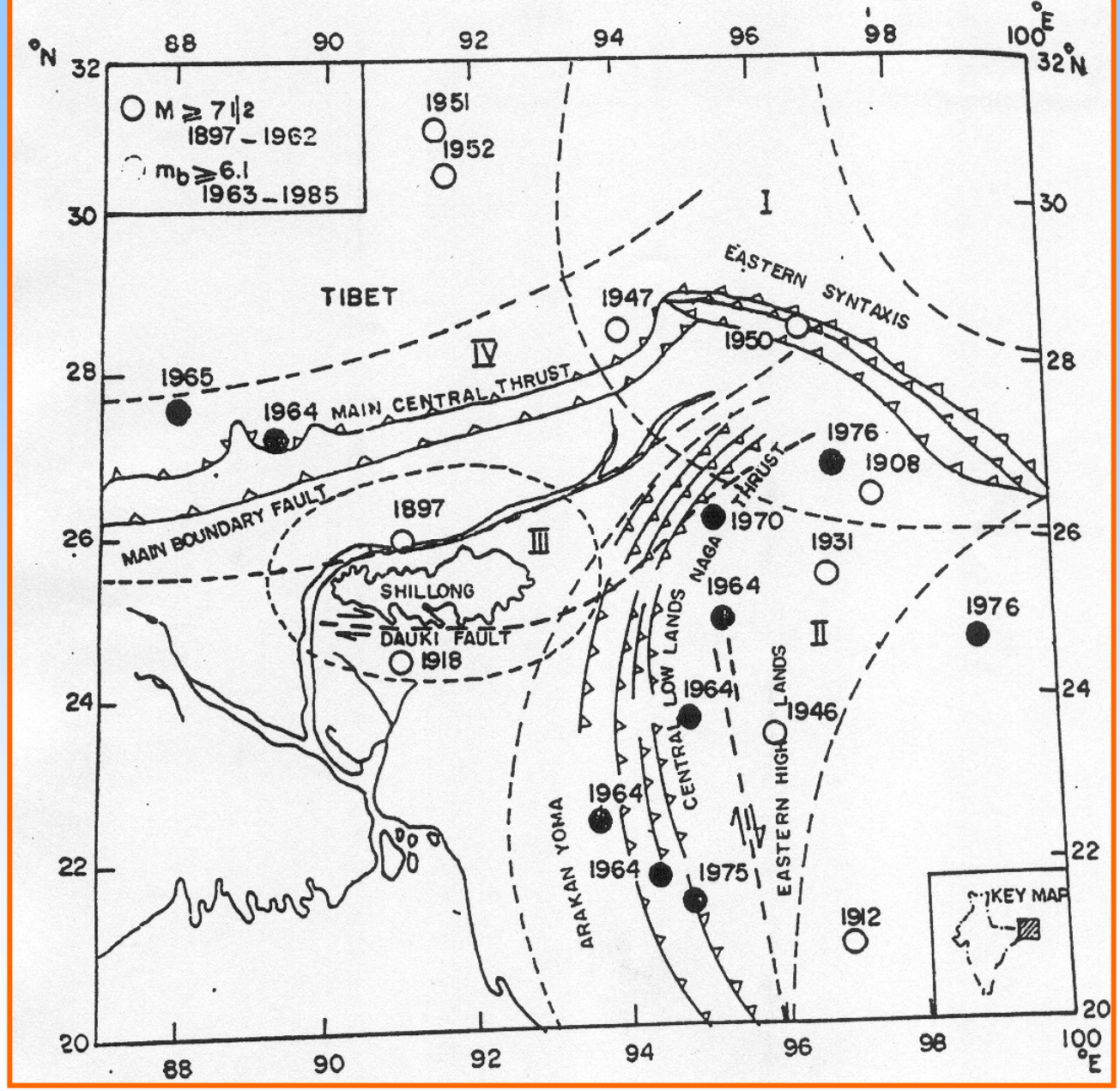
- Developing numerical models for Tsunami and Storm Surges with all associated data inputs
- Generating Coastal inundation and Vulnerability maps
- Setting up a dedicated Tsunami Warning Centre (include Storm Surge) in India and operating it on 24x7 basis for generation of timely advisories
- Capacity building, training, education of all stakeholders
- International connectivity

ARTIFICIAL WATER RESERVOIR FILLING RELATED TRIGGERED EARTHQUAKES


120°W
60°W
0°
60°E
120°E
180°
60°N
30°N
0°
30°S
60°S
CONTRA
EMOSSON
SCHLEGEIS
VAJONT
PIEVE DE CADORE
GRANCAREVO
BAJINA BASTA
KEBAN
MONTEYNARD
VOUGLANS
GRANDVAL
CANELLES
CAMARILLAS
KOMANI
PIASTRA
OUED FODDA
KASTRAKI
KREMASTA
AKSOMBO MAIN
MARATHON
ASWAN
ITEZHITEZHI
KARIBA
HENDRIK VERWOER
LG3
MANIC 3
FLAMING GORGE
SHASTA
KERR
ANDERSON
OROVILLE
HOOVER
GLEN CANYON
MONTICELLO
CLARKHILL
JOCASSE
TUCURUI
VOLTA GRANDE
MARIMBONDO
CAPIVARA
CAPIVARA CACHOEIRA
BRATSK
LAKE BAIKAL
CHARVAK
TOKTOGUL
KURUPSAI
NUREK
TARBELA
MANGLA
MULA
BHATSA
KOYNA
WARNA
IDUKKI
GANDIPET
BHAKRANANGAL
SHENWO
KAMAFUSA
DANJIANGKOU
MATSUSHIRO
KUROBE
FOZILING
DAHUA
GEHEYAN
HSINFENGKIANG
HOABINH
TSENGWEN
SRINAGARIND
ZHEL IN
BLOWERING
EUCUMBENE
TALBINGO
GORDON-PEDOAR
PUKAKI
BENMORE
MAGNITUDE OF THE LARGEST EARTHQUAKE
≥ 6
5-5·9
4-4·9
< 4
Δ INCREASE IN MICROEARTHQUAKES
∇ DECREASE IN MICROEARTHQUAKES

MEDIUM TERM

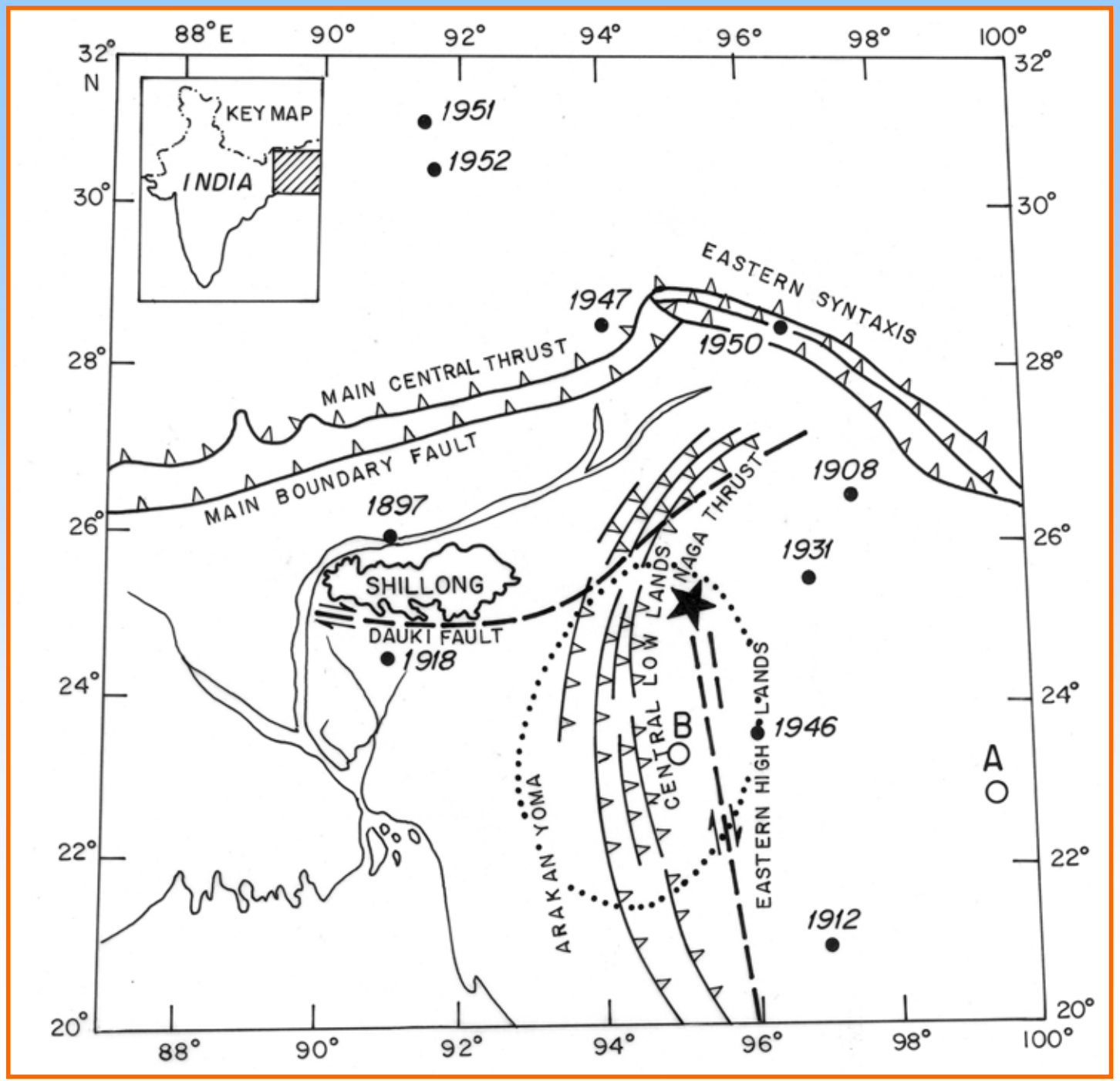
EARTHQUAKE FORECAST



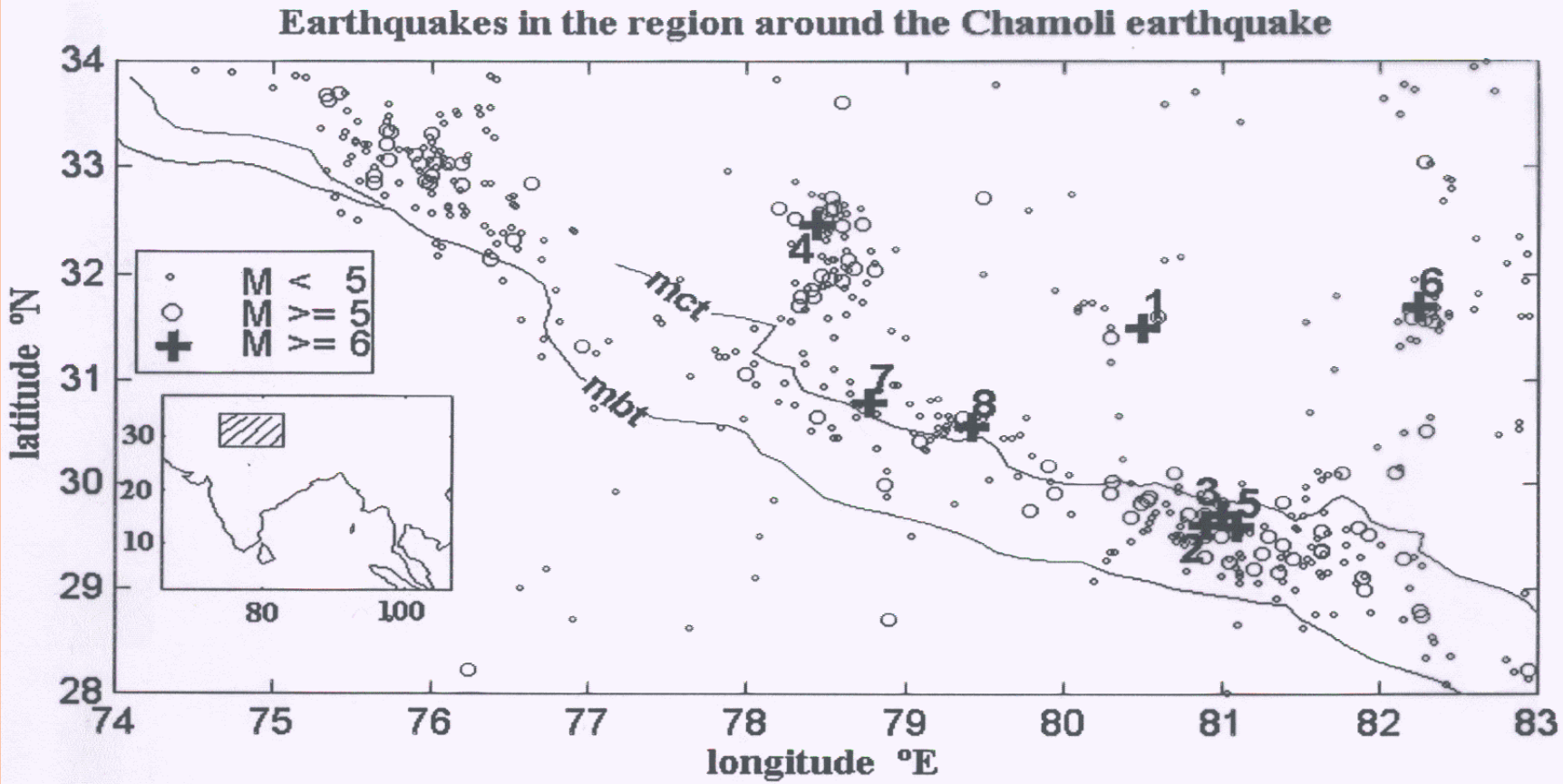
Epicentres of earthquakes of M ≥7.5 for the period 1897-1962 (open circles) and $m_b \geq 6.1$ for the period 1963-1985 (filled circles) in the northeast India region

Forecast of August 6, 1988 earthquake

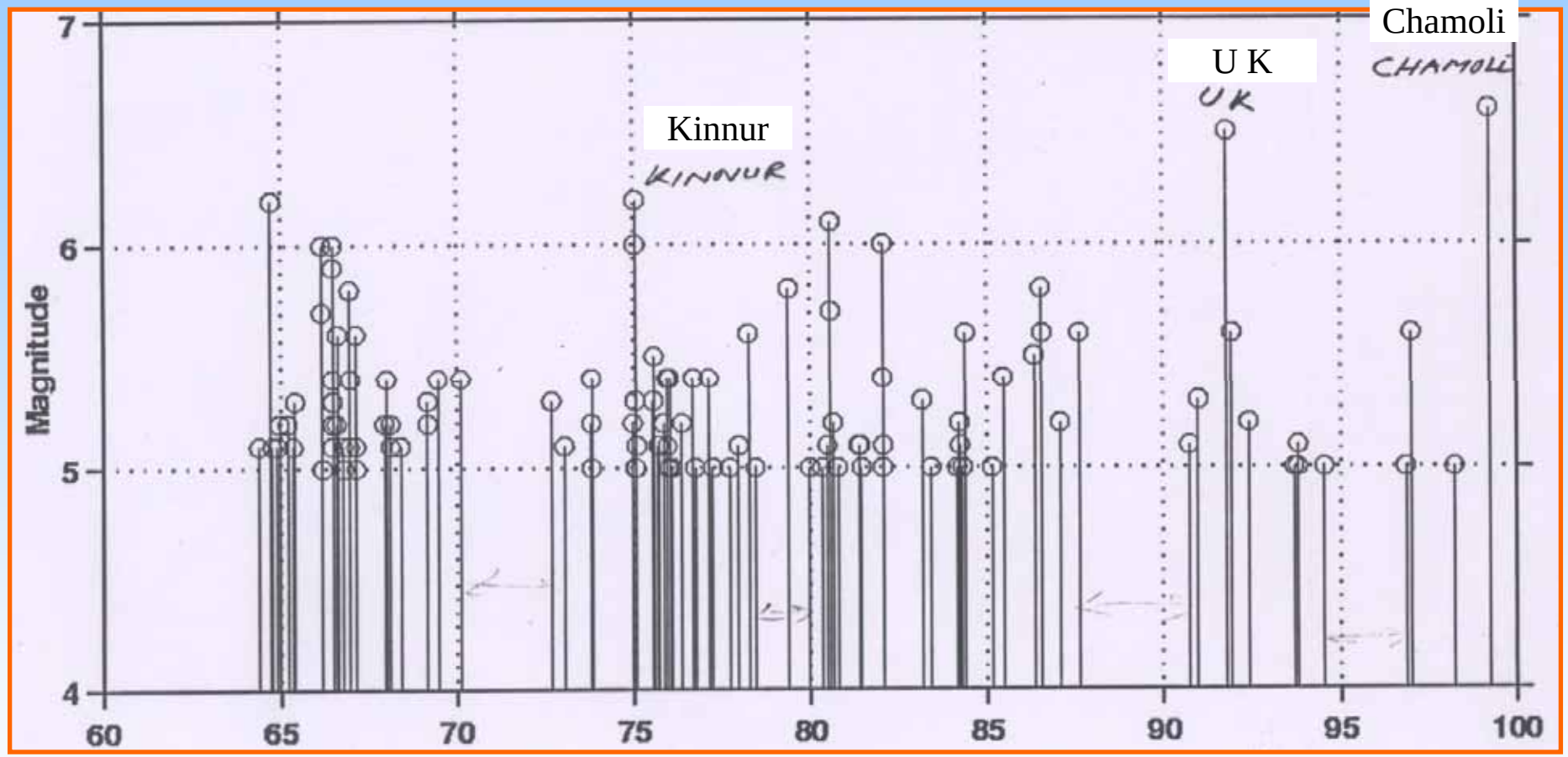
Earthquake Parameters	Prediction (Gupta and Singh, 1986)	Occurrence NEIS (Preliminary Determination)
Epicenter	21 deg N-25 ½ deg N 93 deg E-96 deg E	25.116 deg N 95.171 deg E
Magnitude (M)	8 +/- ½	7 ½
Depth	100 +/- 40 km	115 km
Time	February 1986 - December 1990	August 6, 1988 (00:36:26.9 G.C.T.)


88°E
90°
92°
94°
96°
98°
100°
32° N
30°
28°
26°
24°
22°
20°
KEY MAP
INDIA
1951
1952
1947
1950
EASTERN SYNTAXIS
MAIN CENTRAL THRUST
MAIN BOUNDARY FAULT
1897
SHILLONG
DAUKI FAULT
1918
1908
1931
NAGA THRUST
CENTRAL LOW LANDS
EASTERN HIGH LANDS
ARAKAN YOMA
B
A
1946
1912

The probability of an earthquake of $M \geq 7.5$ occurring in the area and the time interval of prediction due to chance is 0.048 which is very small. Hence the occurrence of the predicted earthquake can be considered significant.



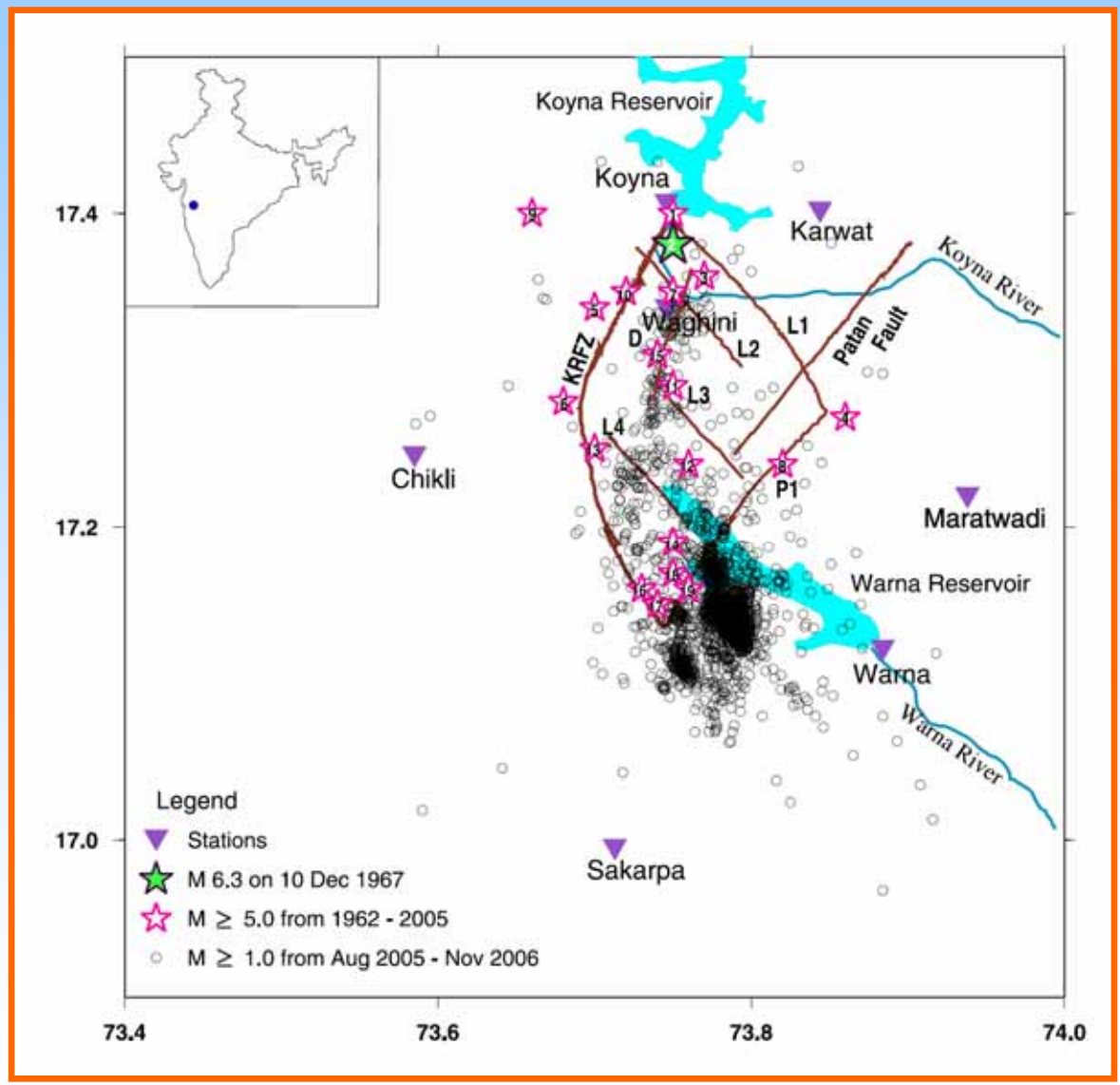
S.No.	year	month	day	hour	minute		mb	Ms	depth km	
1	66	3	6	2	15		6.0		50	
2	66	6	27	10	41		6.0		33	
3	66	6	27	10	59		6.0		13	
4	75	1	19	8	2		6.2	6.8	33	Kinnaur earthquake
5	80	7	29	14	58		6.1	6.5	18	
6	82	1	23	17	37		6.0	6.5	33	
7	91	10	19	21	23		6.5	7.0	10	Uttarkashi earthquake
8	99	3	28	19	5		6.6	6.8	30	Chamoli earthquake

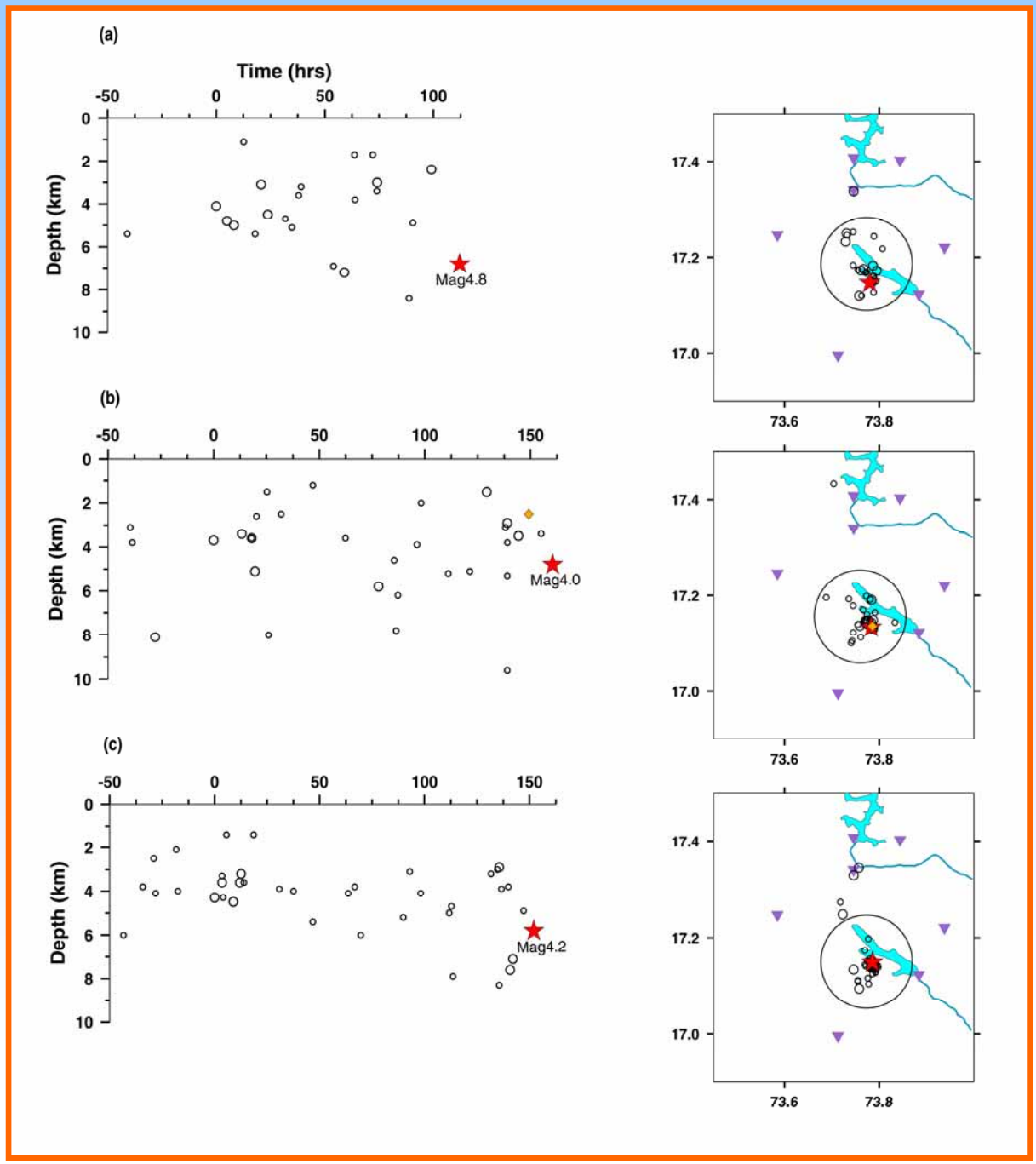


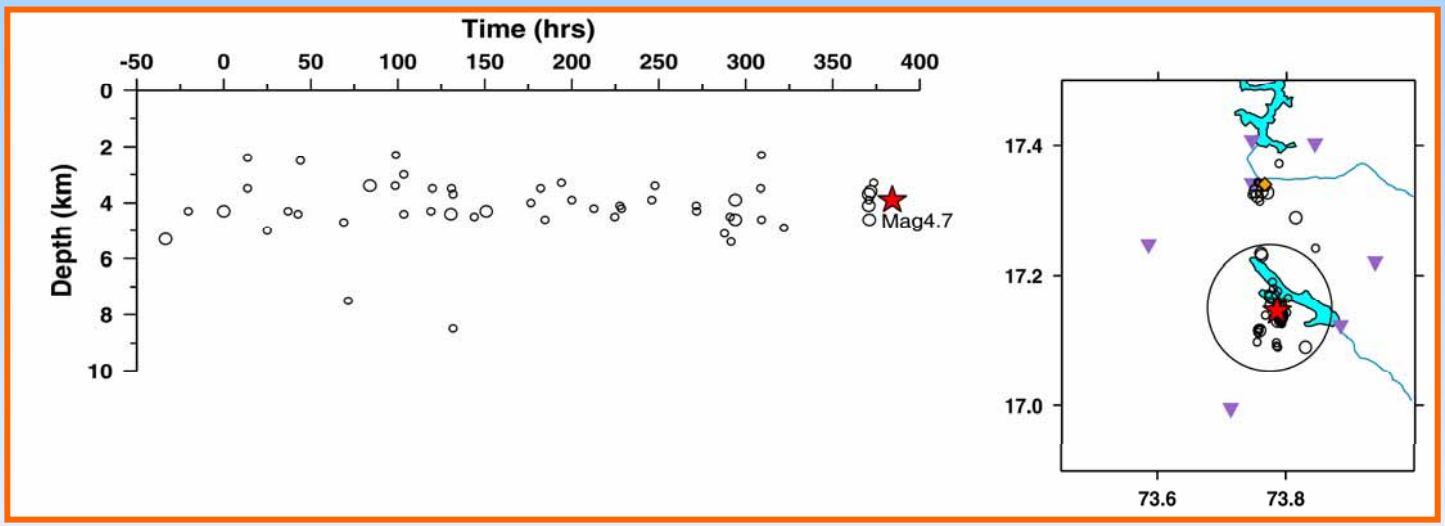
Time in Years

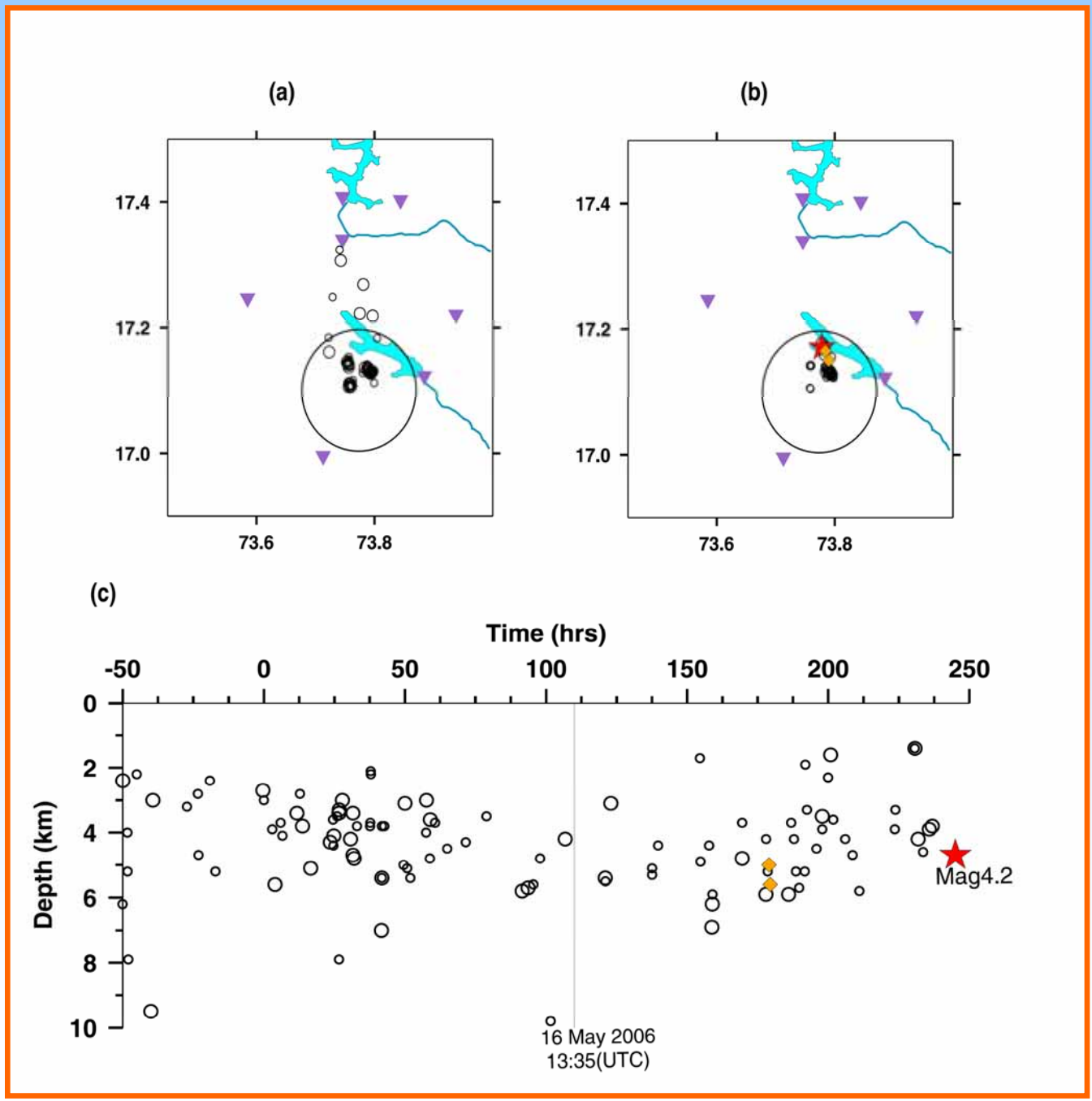
SHORT TERM

EARTHQUAKE FORECAST


Koyna Reservoir
Koyna
Karwat
Koyna River
Waghini
D
KRFZ
L1
L2
L3
L4
Patan Fault
P1
Chikli
Maratwadi
Warna Reservoir
Warna
Warna River
Sakarpa
Legend
Stations
M 6.3 on 10 Dec 1967
M ≥ 5.0 from 1962 - 2005
M ≥ 1.0 from Aug 2005 - Nov 2006
17.4
17.2
17.0
73.4
73.6
73.8
74.0


(a)
Time (hrs)
-50
0
50
100
Depth (km)
0
2
4
6
8
10
Mag4.8
17.4
17.2
17.0
73.6
73.8
(b)
-50
0
50
100
150
Depth (km)
Mag4.0
(c)
Mag4.2


Time (hrs)
-50
0
50
100
150
200
250
300
350
400
Depth (km)
0
2
4
6
8
10
Mag4.7
17.4
17.2
17.0
73.6
73.8


(a)
(b)
17.4
17.2
17.0
73.6
73.8
(c)
Time (hrs)
-50
0
50
100
150
200
250
Depth (km)
0
2
4
6
8
10
Mag4.2
16 May 2006
13:35(UTC)

"On the basis of the data available from 7 seismic stations operating in the Koyna region, we have identified a nucleation, which started on 12 May 2006. This may lead to the occurrence of an M~4 earthquake in the next 15 days. This shallow earthquake (focal depth less than 8 km) will occur within a radius of 10 km centered at 17.1ºN, 73.8ºE. On the basis of our previous experience of studying nucleation – preceding earthquakes in the Koyna region, we expect this earthquake to occur over the next 15 days time (till 31 May 2006), with a 50% probability "

An earthquake of M 4.2 occurred on 21 May 2006 at 20:29:01.2 UTC. The epicenter of this earthquake (17.171 ° N latitude, 73.777 °E longitude) lies with in 10 km of the forecasted epicenter, with a focal depth of 4.7 km (15,16). So the forecast has come true.

CYCLONES

Year	Region	Fatalities
1977	Coastal Andhra Pradesh, India	Over 20,000
1996	East & West Godavari of AP, India	Over 1,000
2005	Coastal Andhra Pradesh, India	About 27

Indian Meteorological Department Cyclone detection Radar network

Significant landslide in India

Year	Location	Deaths
1961	North, Central India	3,000
1968	Rajasthan, Gujrat Northeast India, W Bengal, Assam	4,892
1971	North India	1323
1978	North and Northeast India	3,800
1980	UP, Bihar, Gujrat, Haryana, Kerala	1,600
1989	Maharastra, AP, Gujrat	1,591
1994	NE India, North and western India, Gujrat	2,001
1995	North India, W Begal, Maharashtra	1,479
1997	North India, Central India, Assam, Sikkim, W Bengal	1,442
1998	NE India, North and western India	1,811
2000	North and west India, W Bengal, NE India, Gujrat	1,751
2004	Bihar	900
2005	Gujrat	1,200

Source: EM-DAT

GLACIERS MELTING

IN HIMALAYA

SAMUDRA TAPU, ONE AMONG THE LARGER GLACIERS IN HIMALAYA

PRIOR TO 1962:

LENGTH (L): 20,161 m

AREA (A): 77.67 sq.km

1962:

L: 17,718 m

A: 73 sq km

2000:

L:16,977 m

A:65 sq km

2006:

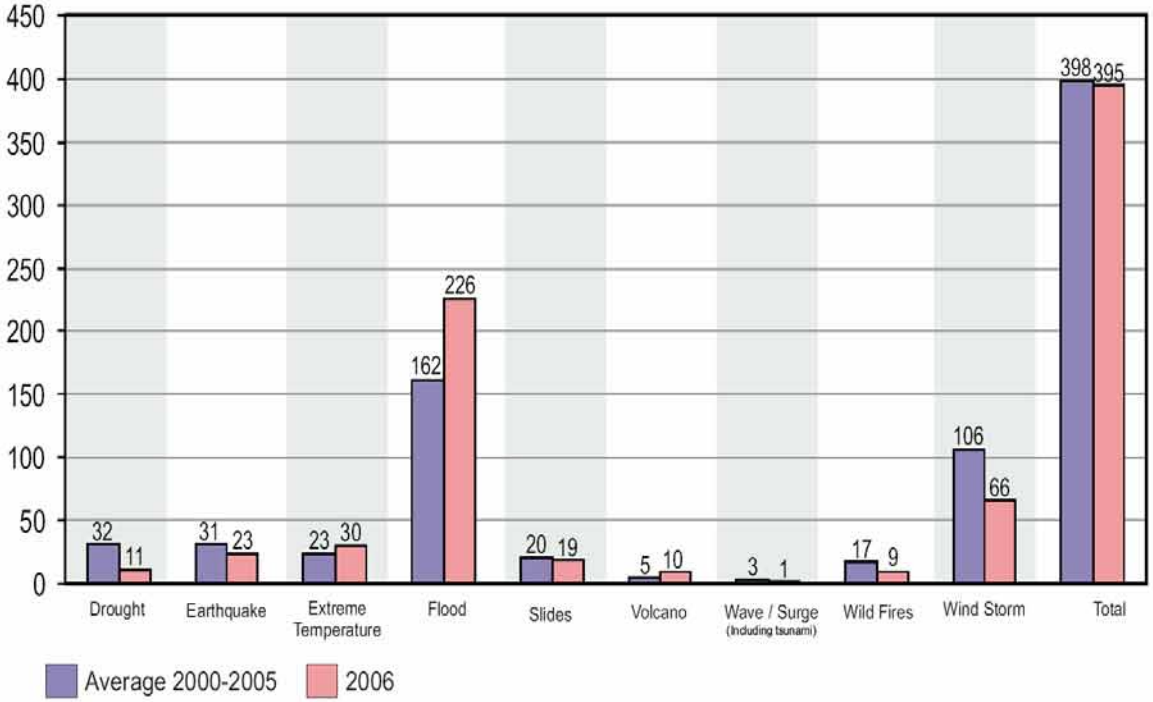
L: 16,918 m

A: 63.2 sq km

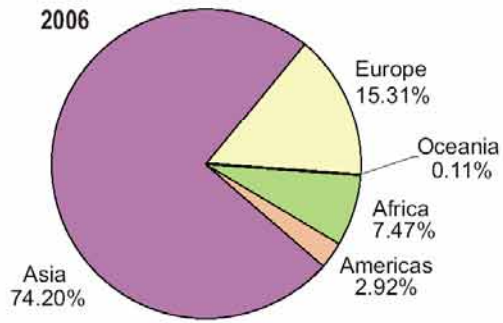
The frequency of natural disasters is rising rapidly:

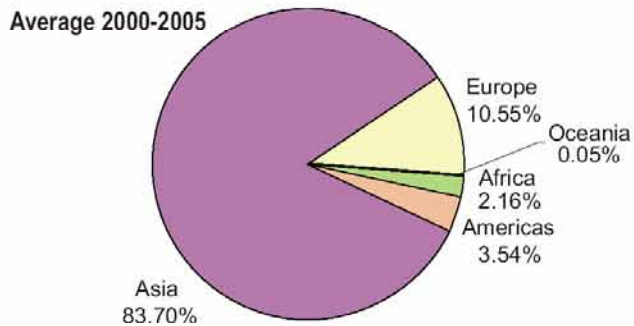
1900 - 1940	100	per decade
1960’s	650	per decade
1980’s	2000	per decade
1990’s	2800	per decade

Natural disaster occurrence by disaster type



Percentage of people killed by natural disasters by continent





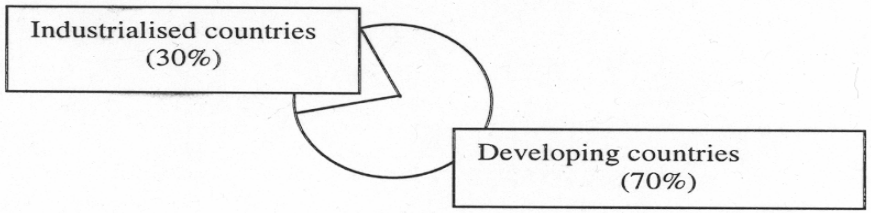
International Strategy for Disaster Reduction (UN/ISDR)
Tel: +41 22 9178908/8907
isdr@un.org
www.unisdr.org

Centre for Research on the Epidemiology of Disasters (CRED), Department of Public Health
Université catholique de Louvain, Belgium
Tel. +32-2-764-3327
cred@esp.ucl.ac.be
www.cred.be

Source of data: EM-DAT: The OFDA/CRED International Disaster Database
www.em-dat.net
Université catholique de Louvain
Brussels - Belgium

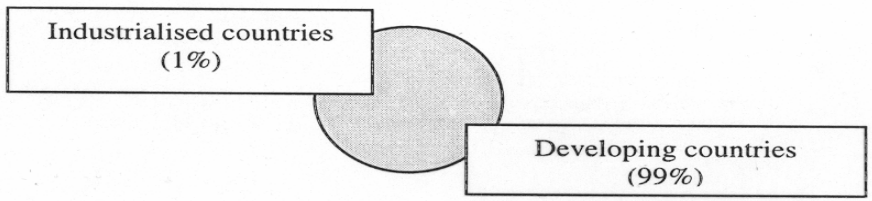
EARTHQUAKE-CAUSED FATALITIES

1900 - 1949



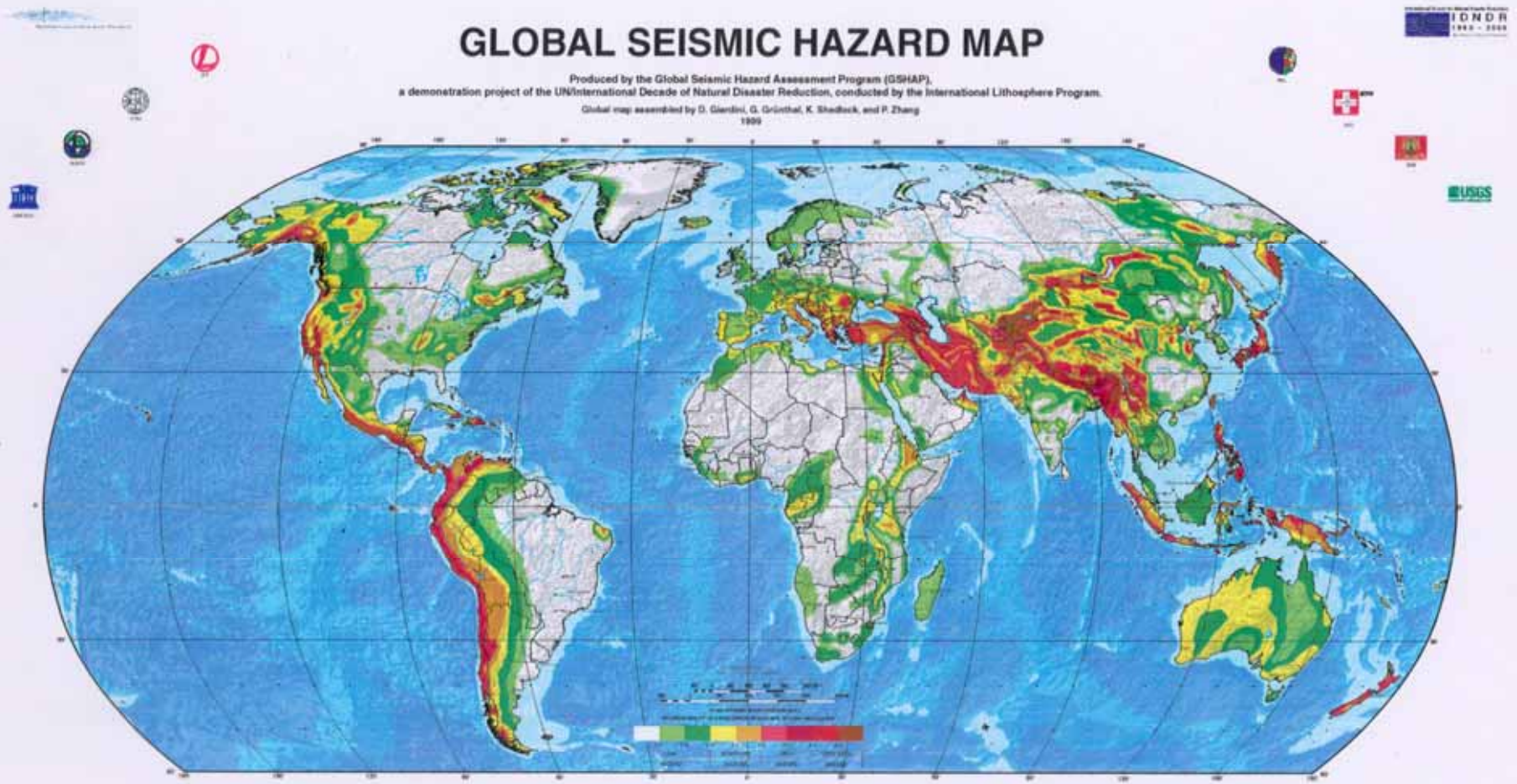
TOTAL ~700 THOUSAND

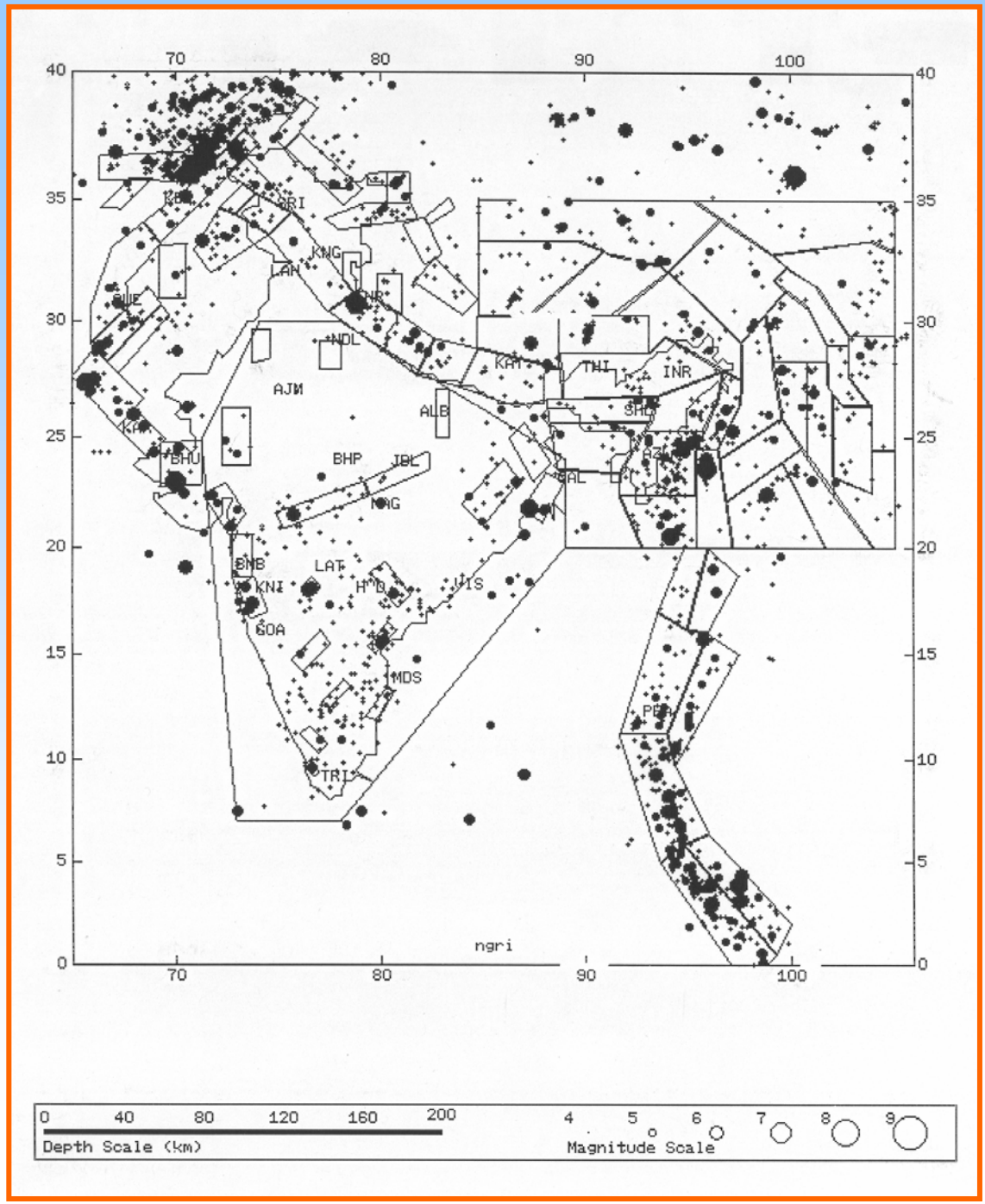
1950 -1992

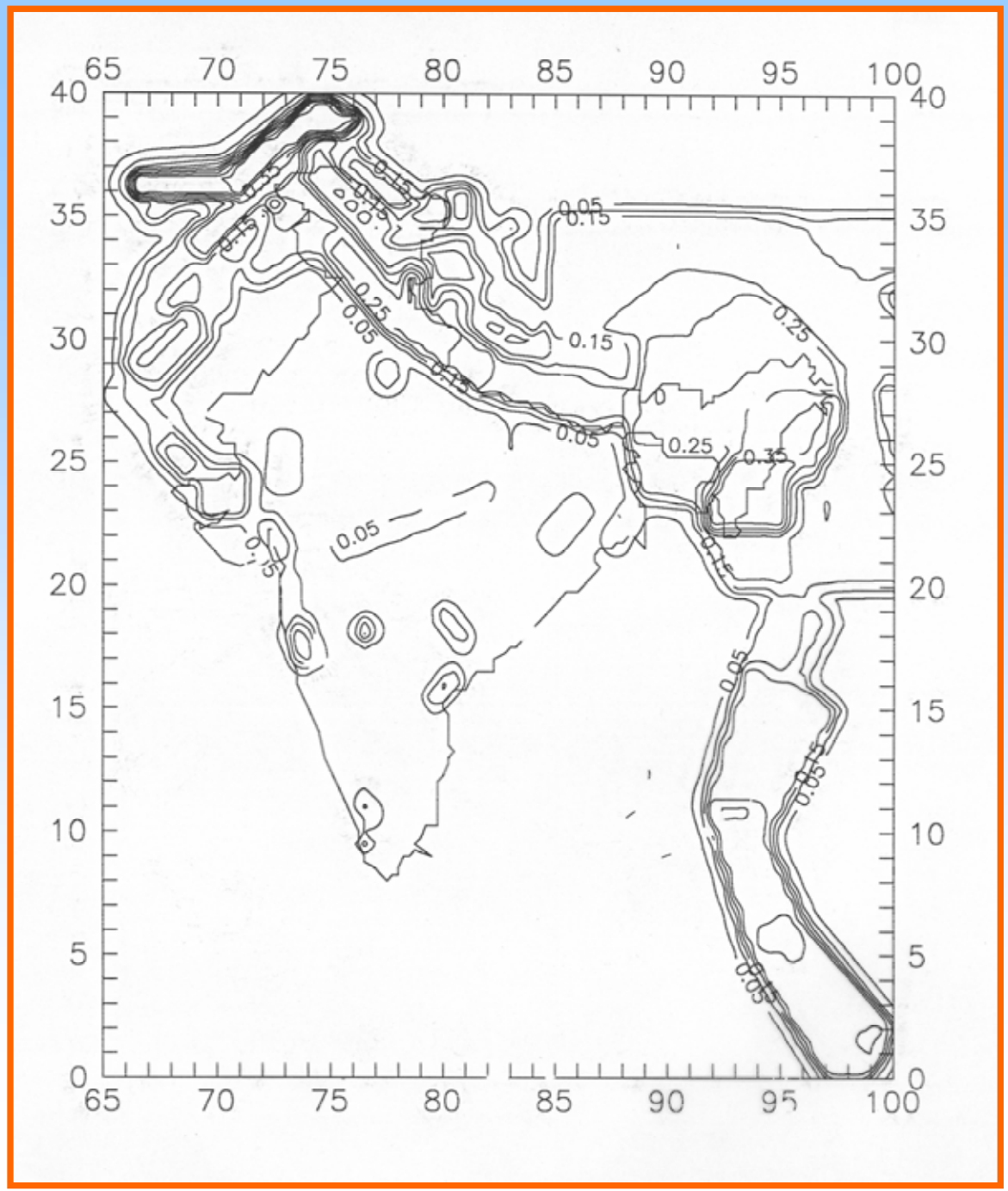


TOTAL~500 THOUSAND

Source: OFDA


GLOBAL SEISMIC HAZARD MAP
Produced by the Global Seismic Hazard Assessment Program (GSHAP),
a demonstration project of the UN/International Decade of Natural Disaster Reduction, conducted by the International Lithosphere Program.
Global map assembled by D. Giardini, G. Grünthal, K. Shedlock, and P. Zhang
1999
IDNDR
1990 - 2000
USGS


70
80
90
100
40
35
30
25
20
15
10
5
0
KRI
KNG
LAN
SUE
NDL
AJM
ALB
KAH
THI
INR
SHL
BHU
BHP
IBL
GAL
BNB
KNI
LAT
GOA
MDS
TRI
PER
ngri
0
40
80
120
160
200
Depth Scale (km)
4
5
6
7
8
9
Magnitude Scale



Seismic Hazard map of India for 10% probability of excedence in 50 yr.

Contour interval 0.05 g.

ICSU INITIATIVE

“NATURAL AND HUMAN INDUCED HAZARDS”

- **Social dimensions are being stressed.**

One of the major challenges is:

"A developmental problem….. the widening gap between advancing science and technology and society's ability to capture and use them"

ICSU REGIONAL OFFICE FOR

ASIA AND PACIFIC (ROAP)

NATURAL HAZARDS

A PRIORITY AREA

EARTHQUAKES

LANDSLIDES

FLOODS

ONE OF THE IMPORTANT ISSUES IS, THAT THE AVAILABLE SCIENTIFIC KNOWLEDGE IS NOT BEING FULLY UTILIZED IN FORECASTING THE HAZARD, ESTIMATING THE RISK, AND THE NECESSARY OUTREACH FOR THE BENEFIT OF THE PUBLIC

NATIONAL DISASTER MANAGEMENT AUTHORITY 2005

UNDER CHAIRMANSHIP OF

PRIME MINISTER OF INDIA


THANK YOU