

An overview of seismic activity in Vietnam

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SUMMARY

In this report I want to introduce some information about:

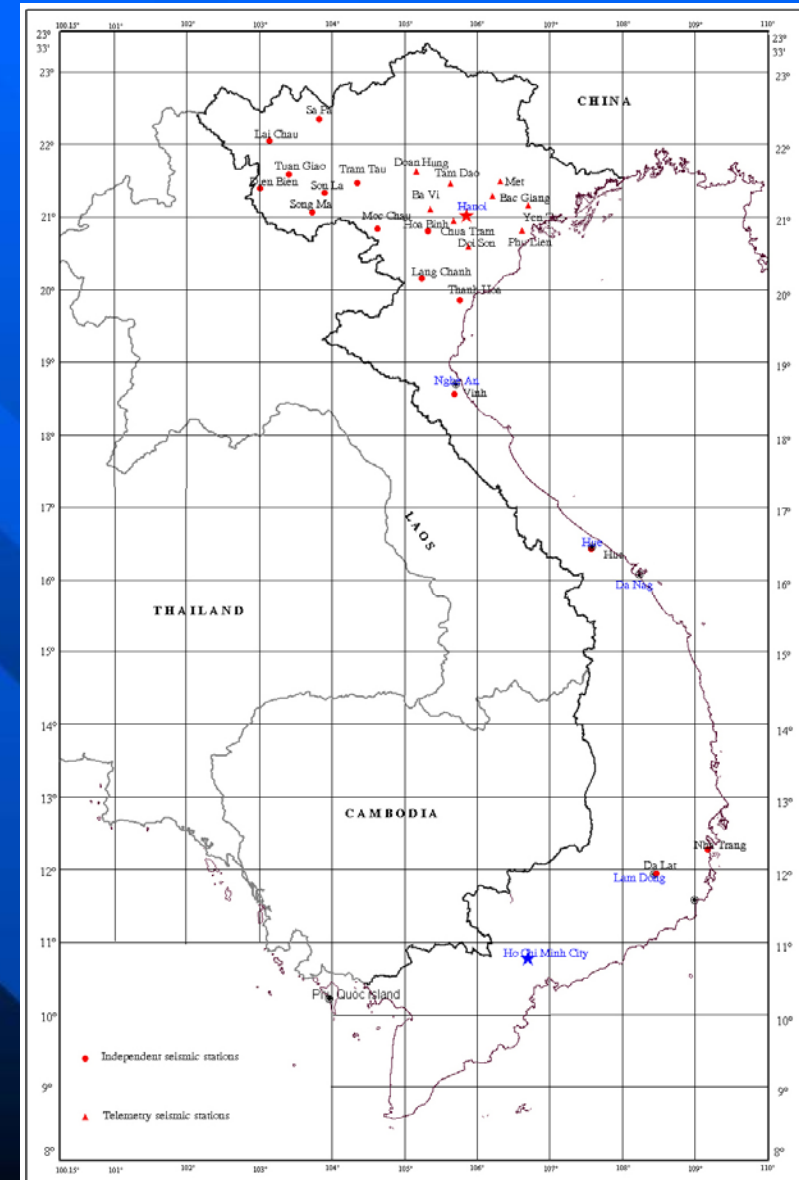
- 1- The seismic station network in the territory of Vietnam;
- 2- The Earthquake Catalogue of the Institute of Geophysics to the end of 2003;
- 3- Comparison of different catalogues for establishment the sufficient catalogue of earthquakes in the territory of Vietnam to the end of 2003;
- 4- The seismotectonic condition;
- 5- Determination of seismic hazard parameter on the basic of GNDT; and
- 6- Earthquake Forecast on the basic of CN and M8s Programmes

1- The seismic station network in the territory of Vietnam

History of development

The seismic network of Vietnam includes 24 stations:

- Phu Lien (1924);
- Nha Trang (1957);
- Sapa (1961);
- Bac Giang (1967);
- Hoa Binh (1972);
- Tuyen Quang (1973);
- Da Lat (1980);
- Dien Bien, Lai Chau, Vinh and Hanoi were built in 1990;
- Son La and Hue (1994-1995);
- Chua Tram*, [Doan Hung*], Tam Dao*, Doi Son*, Ba Vi*, Met*, Yen Tu* (1996-2002)
- Tuan Giao, Tram Tau, Song Ma, Lang Chanh, Thanh Hoa, Moc Chau (2003)



2- The Catalogue of earthquakes of Institute of Geophysics to the end of 2003

The Catalogue of earthquakes of the Institute of Geophysics to the end of 2003 is established on the base of three data sources as follows:

- 1) Historical earthquake;
- 2) Earthquakes investigating in public; and
- 3) Earthquakes recorded from seismic station network of Vietnam.
- 4) The catalogue of earthquakes of the Institute of Geophysics to the end of 2003 contains 1644 events

Due to the deficiency in historical notes and short period of observation (mainly from 1980), this catalogue is not sufficient, it must be to complement with another data sources.

3- Comparison of different catalogues for establishment the sufficient catalogue (by CN programme)

Sufficient catalogue of earthquakes in the territory of Vietnam established to the end of 2003 is based on documentary sources and methodology of Comparison of different catalogues as follows:

The software were using for comparison of different catalogues

The following softwares were using for comparison of different catalogues:

- EDCAT - to edit catalogue and transform it into standard format;
- CATAL - to select sub catalogues, merge and compare catalogues;
- HIST - to make histograms for any parameters of catalogue.

These software provide various facilities for data analysis.

The comparison of different catalogues and establishing the catalogue of earthquakes in Vietnam since 1278 to 2003

The comparison performed among the NOAA, ISC and NEIC data sets for the Vietnamese region. We had compiled an earthquake catalogue for Vietnam bounded by time interval: 114 – 2003 and covers an area approximately within Lat: 5. - 24N, Lon: 100 - 118E.

In order to perform the magnitude compare, the events common to the different catalogues are identified according to the following rules: (a) time difference $\Delta t \leq 1.00$ Min; (b) deviation of latitude and Longitude: $\Delta La = \Delta Lon \leq 0.50$ degree; and (c) $\Delta M \leq 9.00$; $\Delta H \leq 999.00$ Km; (No limitation is imposed on magnitude or depth differences).

- The ISC catalogue is preferable for the time interval after 1994, since it contains more events while only few are missing with respect to the other data sets.
- Before 1994 NOAA is preferable to NEIC, since NEIC contains only 47 additional events, but all of them have epicenter outside Vietnam.
- NOAA contains also information about historical seismicity (before 1900 - 34 events).

Enlist all of the data sets available and description (area, time interval, number of events, type of magnitudes, etc.).

Description of the new vldc catalogue: (*the file name is vldc.dat. Vldc.dat*) by time interval from 114 to 2003 and covers an area approximately within Lat: 5 – 24N, Lon: 100 –118E. The catalogue contains about 1644 events with Ms - from 0.00 to 7.50; depth from 0 km to 350 km.

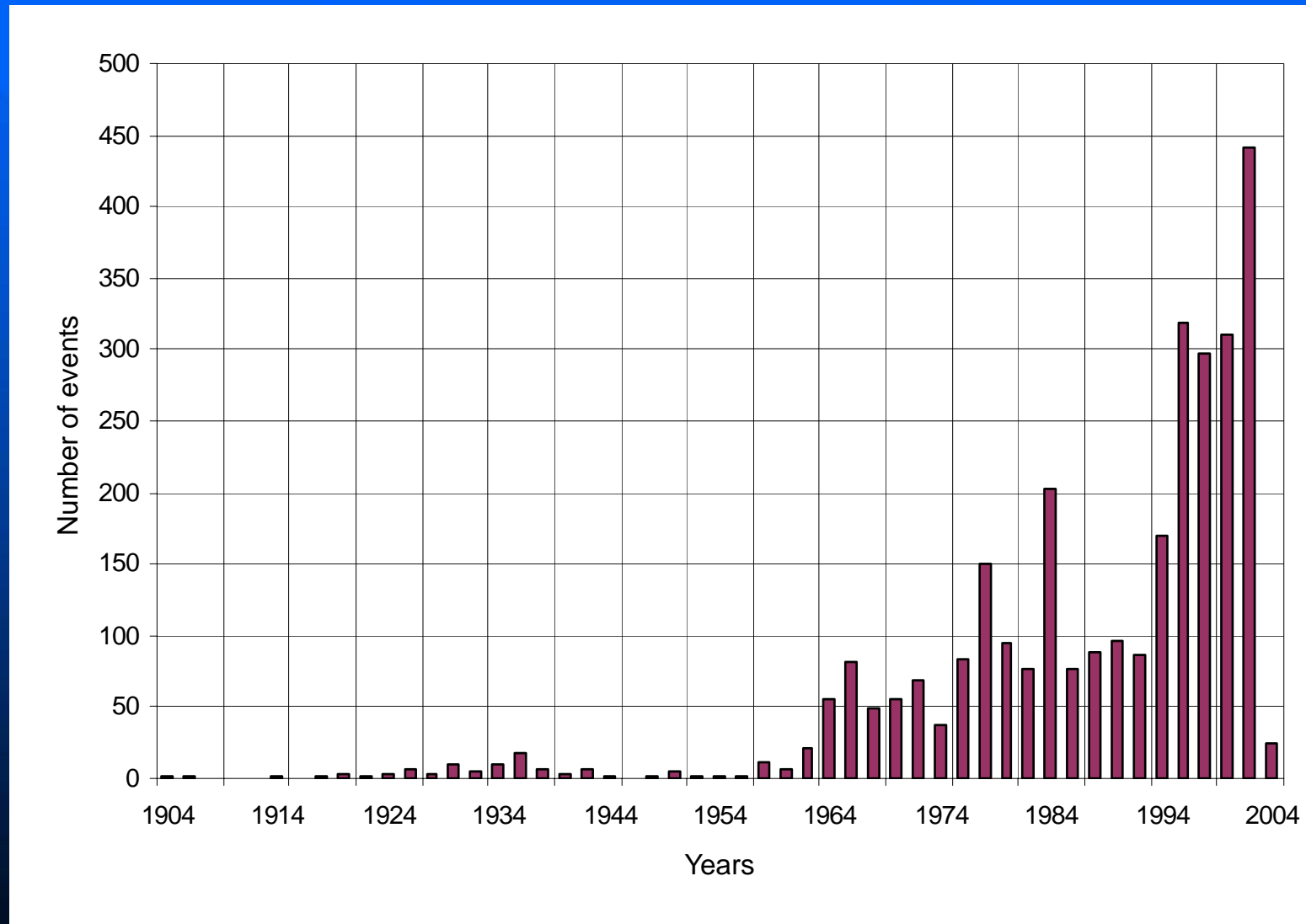
Description of the NEICVN catalogue NE20.dat (its format - 20), we have compiled an earthquake catalogue for Vietnam bounded by time interval: 1918 – 1999 and covers an area approximately within Lat: 5 - 24N, Lon: 100 - 118E. The catalogue contains 193 events with: Magnitude - from 0.00 to 6.70; depth – from 0 to 350 km; In NEIC catalogue used kind of magnitude: Mb, Ms, Ml, and Mw.

The catalogue of earthquakes of the Institute of Geophysics to the end of 2003 contains 1644 events

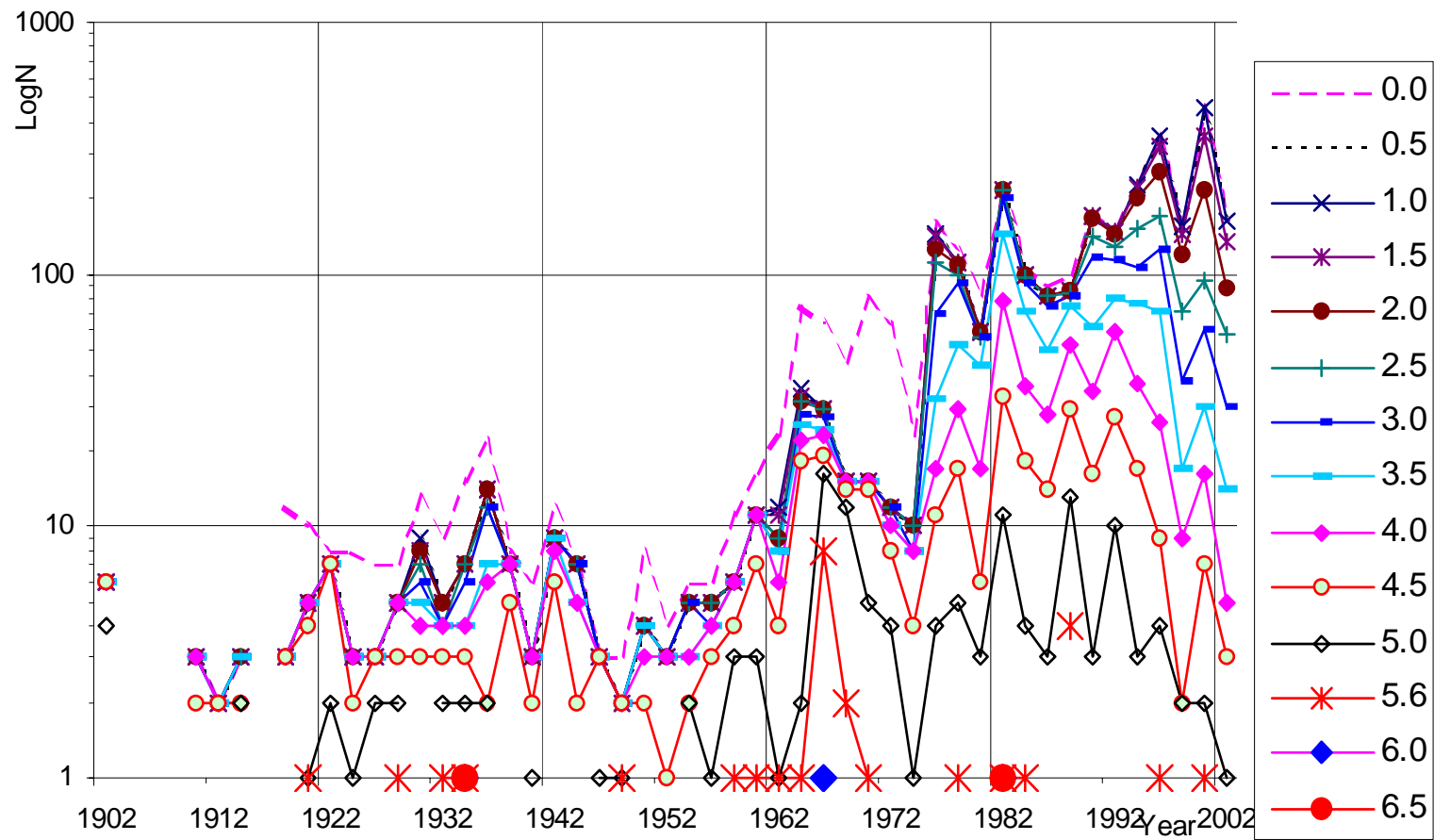
The sufficient catalogue of earthquakes in Vietnam to the end of 2003 contains 1961 records, it has been written in file vnth.dat.

(subcatalogue contains 1961 record with $M > 3.0$, it has been written in file vnth.dat)

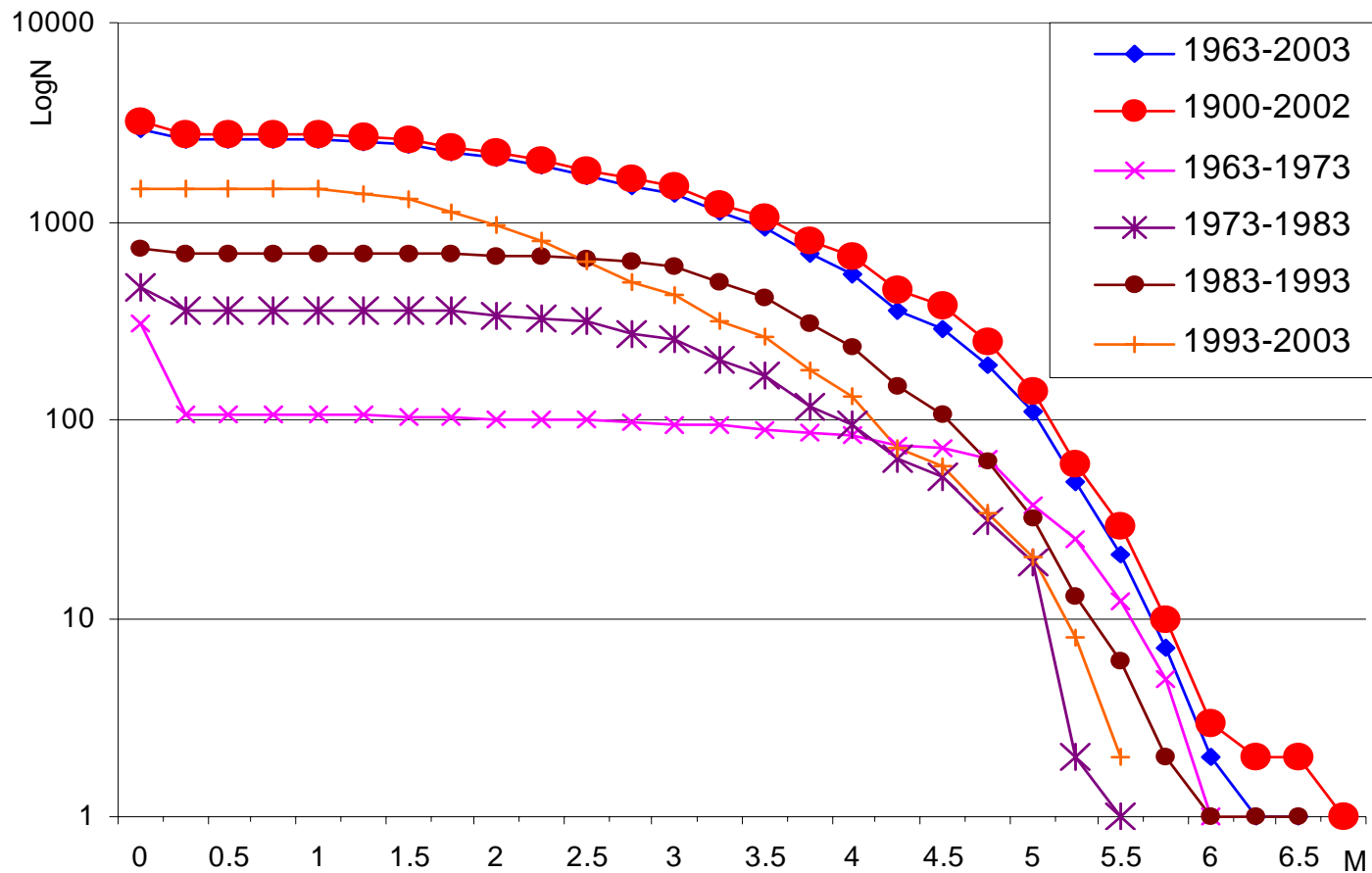
*The time distribution of the number of events in the Vietnam catalogue
(from 1900 to 2003)*



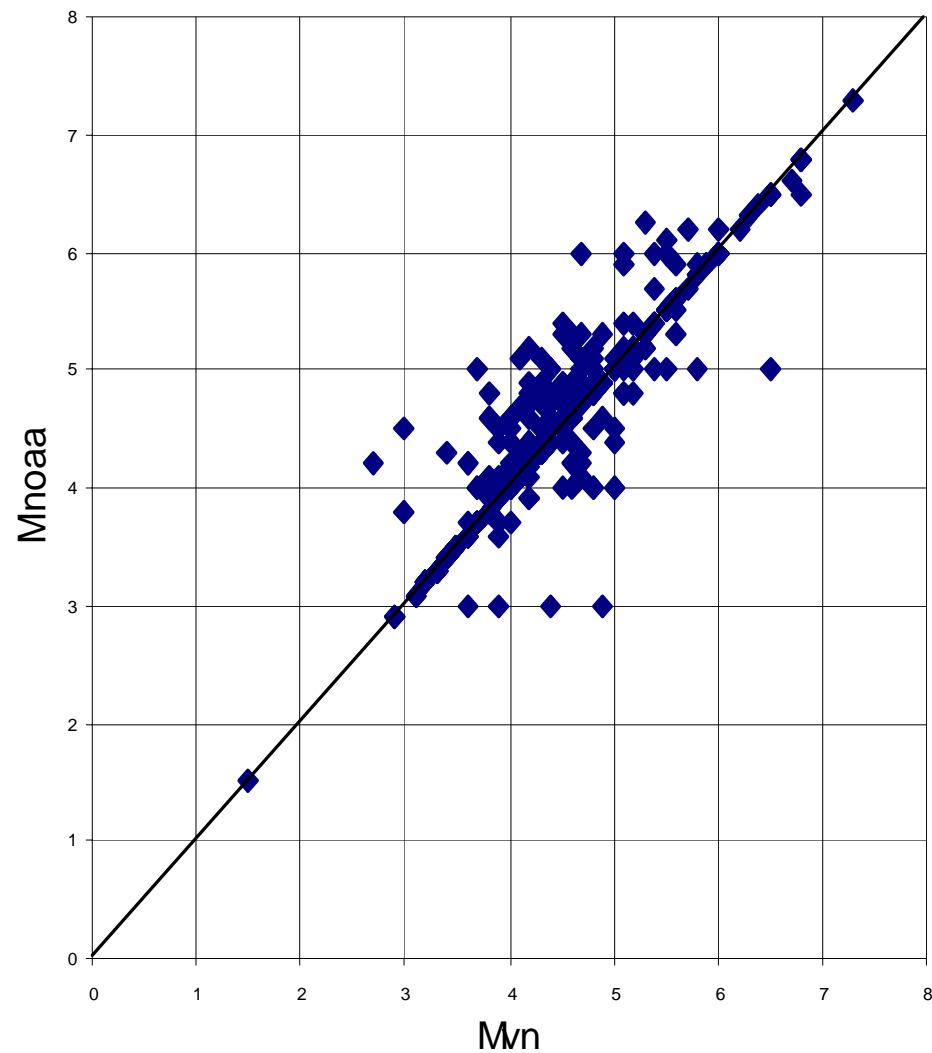
*The time distribution of the cumulative number of events in Vietnam catalogue
and NOAA catalogue merged into Vietnam (from 1900 to 2003)*



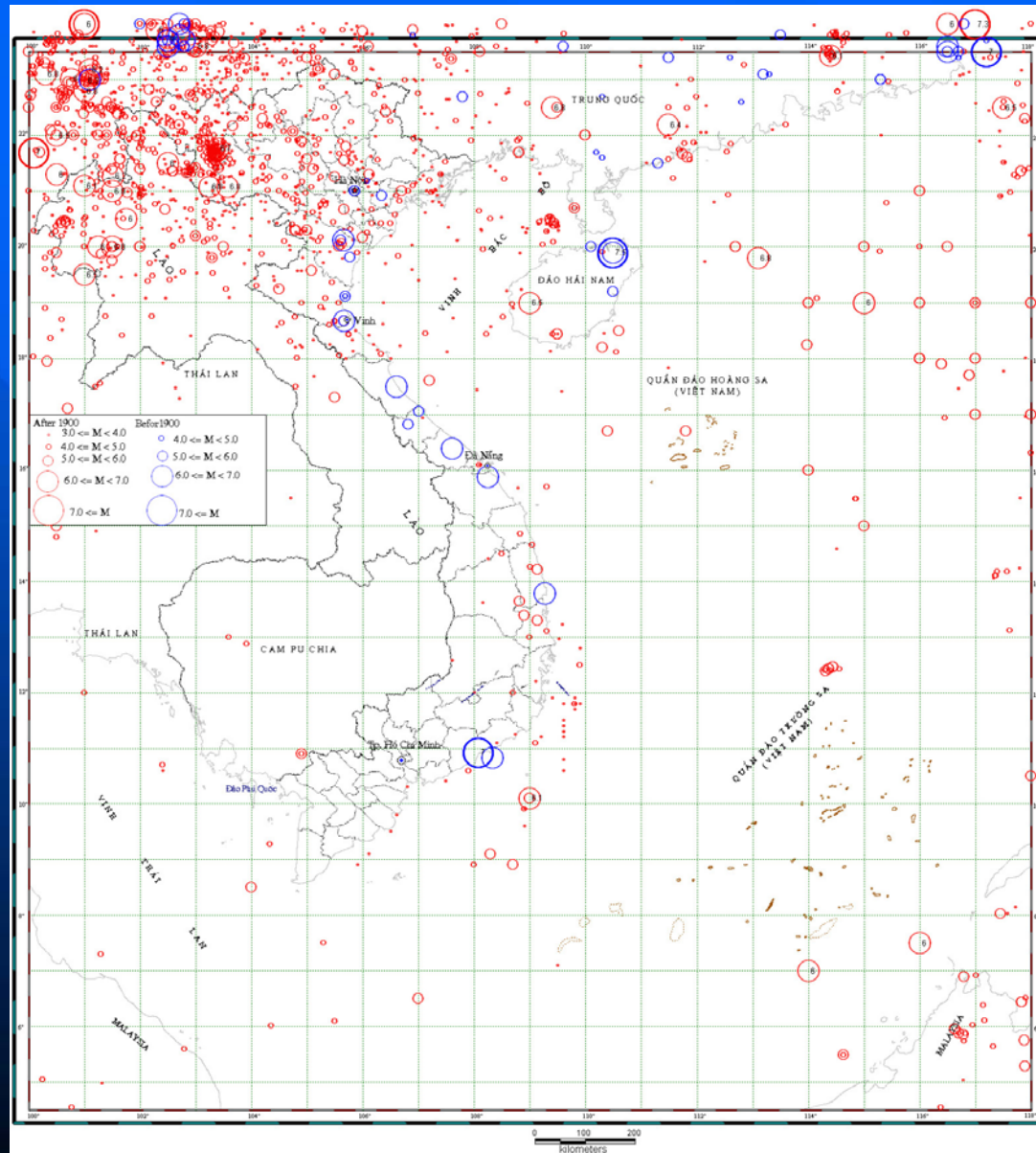
The Gutenberg-Richter frequency-magnitude diagrams: accumulated for all events on the whole Vietnam territory covered by Vietnam catalogue and NOAA catalogue inserted in the Vietnam catalogue inserted in the Vietnam



Relation between the operating magnitude M in the NOAA catalogue and the magnitude in the Vietnam catalogue, without recalculation



The epicenter's distribution (from 114 to 2003)



Typical events in Vietnam since 1900

- 1. Earthquake occurrence in the Dien Bien area (1935)- $M=6.8$, Occurred in 23 hour 22' (Hanoi time) 1st November 1935 to the southeast of the Dien Bien city. It damaged heavily the living houses at the Dien Bien and Son La provinces.
- 2. Earthquake in the Luc Yen (Yen Bai) 1953- $M=5.4$.
- 3. Earthquake in the Luc Yen (Yen Bai) 1954- $M=5.4$, the earthquake epicenter was located quite near to that occurring in 1953. These two earthquake events occurred at the same seismic Intensity but the width of isoseismic (1954) was narrower and its length was longer.
- 4. Earthquake in the Bac Giang, 1961- $M=5.6$, which occurred at 16 hour 58' (Hanoi time) on the 12th Jun, 1961 in the location 11 km of the Bac Giang city to the northeast.
- 5. Earthquake in the Cau river, 1970- $M=5.3$. Cau river earthquake occurred on 12th April 1970 near to the Cau river city Nghia Binh province. This was one of the two strongest earthquakes happening in the territory of southern Vietnam.

- 6. Cau river earthquake in 1972- $M=5.3$. The event happened on the 24th May 1972 in the area near to the Cau river city. The earthquake epicenter nearly coincided with what that happening in 1970 and they had the same seismic Intensity.
- 7. Tuan Giao earthquake 1983- $M=6.7$. It happened at 14 hour on the 24th Jun 1983 11 km far of the Tuan Giao city to the northeast; this earthquake caused heavy losses to the Tuan Giao district and the surrounding area (Nguyen Dinh Xuyen, Cao Dinh Trieu, 1990). After the event, series of aftershocks occurred. The strongest aftershock acted on 15th July 1983 in the same place of maximum magnitude $M=5.4$.
- 8. The Muong Luan $M_s5.0$ earthquake of the 23rd June 1996. The epicenter of this event is $21^{\circ}26'08$ N, $103^{\circ}03'2$ E, the focus depth is about 12 km.
- 9. The Thin Toc $M_s5.3$ earthquake of the 19 February 2001. The epicenter of this event is 21.39 N, 102.83 E; the focus depth is about 12,3 km.

Structure zoning map of the Earth's Crust on the basis of gravity and magnetic anomalies

Continental Crust:

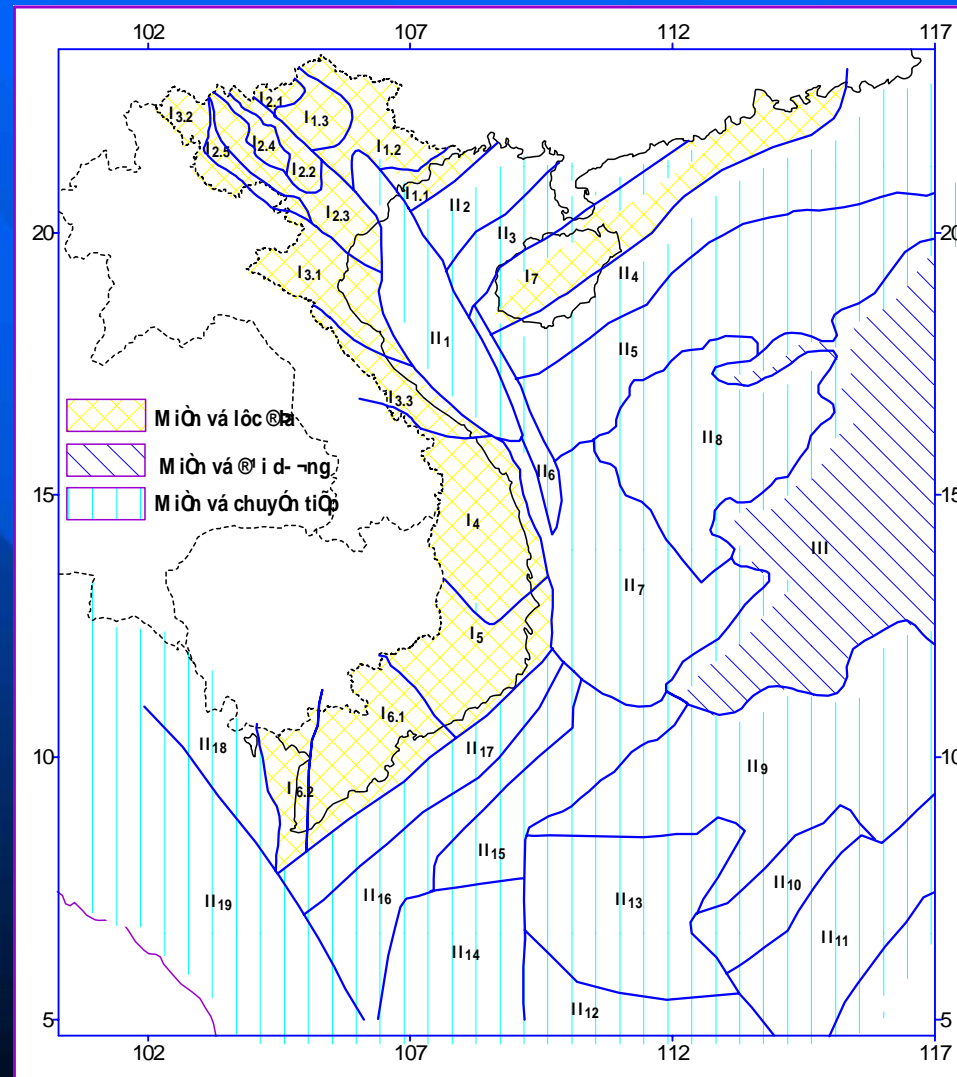
I.1. Dong Bac; I.2. Tay Bac; I.3. Truong Son; I.4. Kon Tum; I.5. Da Lat, I.6. Nam Viet Nam.

Transition Crust:

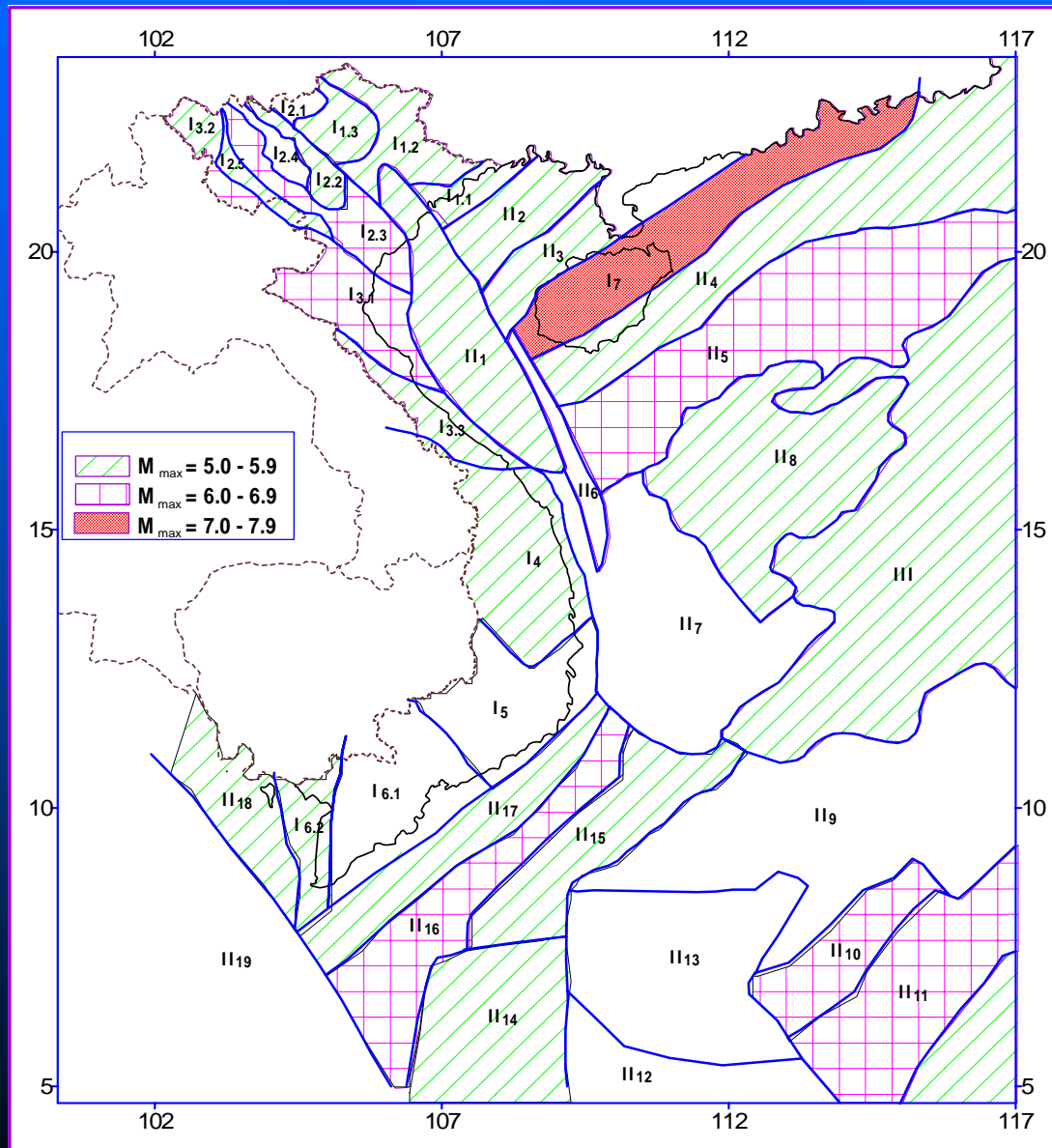
II.1. Song Hong; II.2. Bach Long Vi; II.3. Loi Chau; II.4. Chau Giang; II.5. Bac Hong Sa; II.6. Tri Ton; II.7. Phu Khanh; II.8. Hoang Sa; II.9. Truong Sa; II.10. Suoi Nga-Trang Khuyet; II.11. Sabah; II.12. Sarawak; II.13. Vung May; II.14. Natuna; II.15. Nam Con Son; II.16. Con Son; II.17. Cuu Long; II.18. Phu Quoc; II.19. Malaysia;

Oceanic Crust:

III. Trung Tam Bien Dong



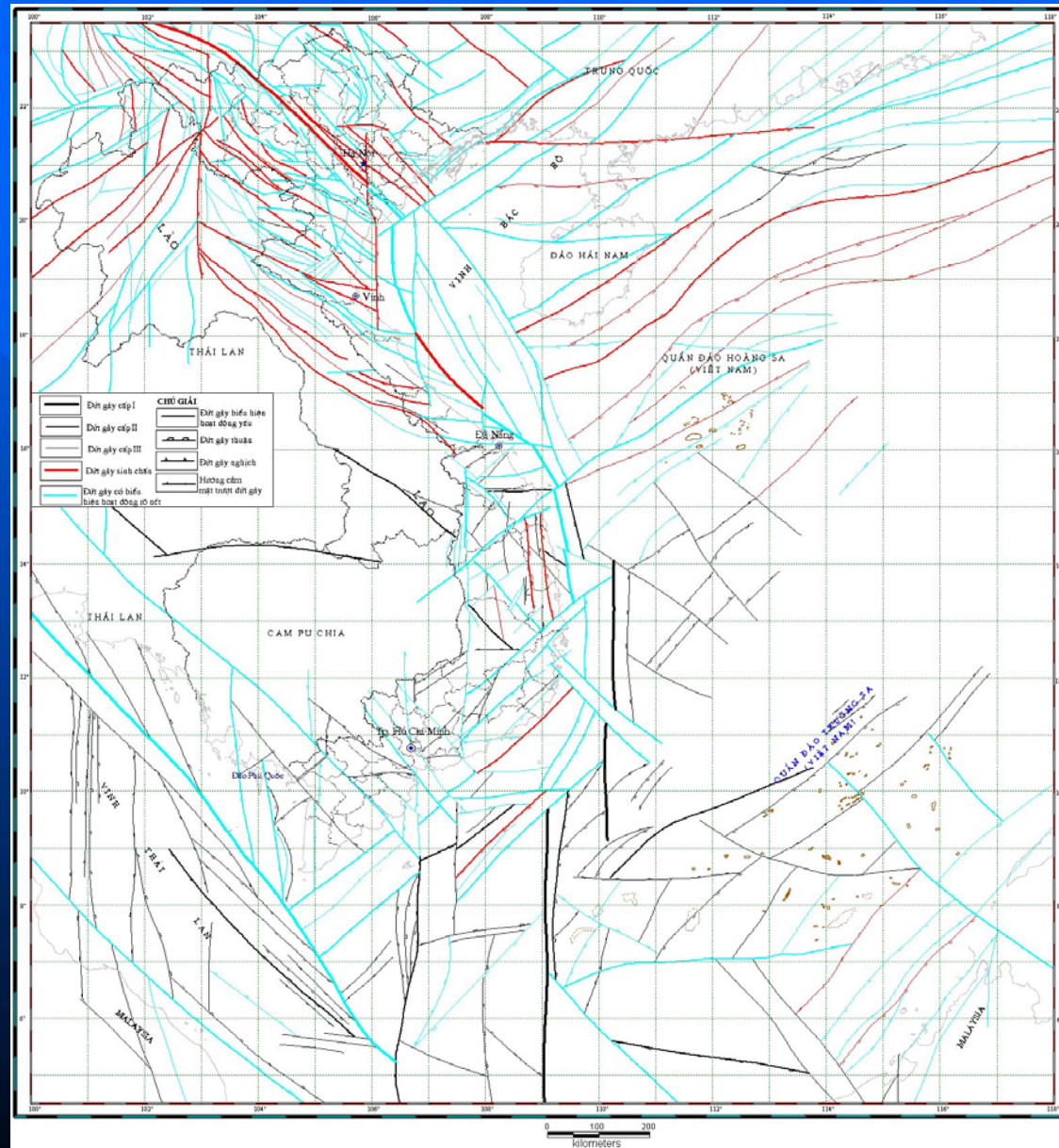
Seismic activity of the geological structures



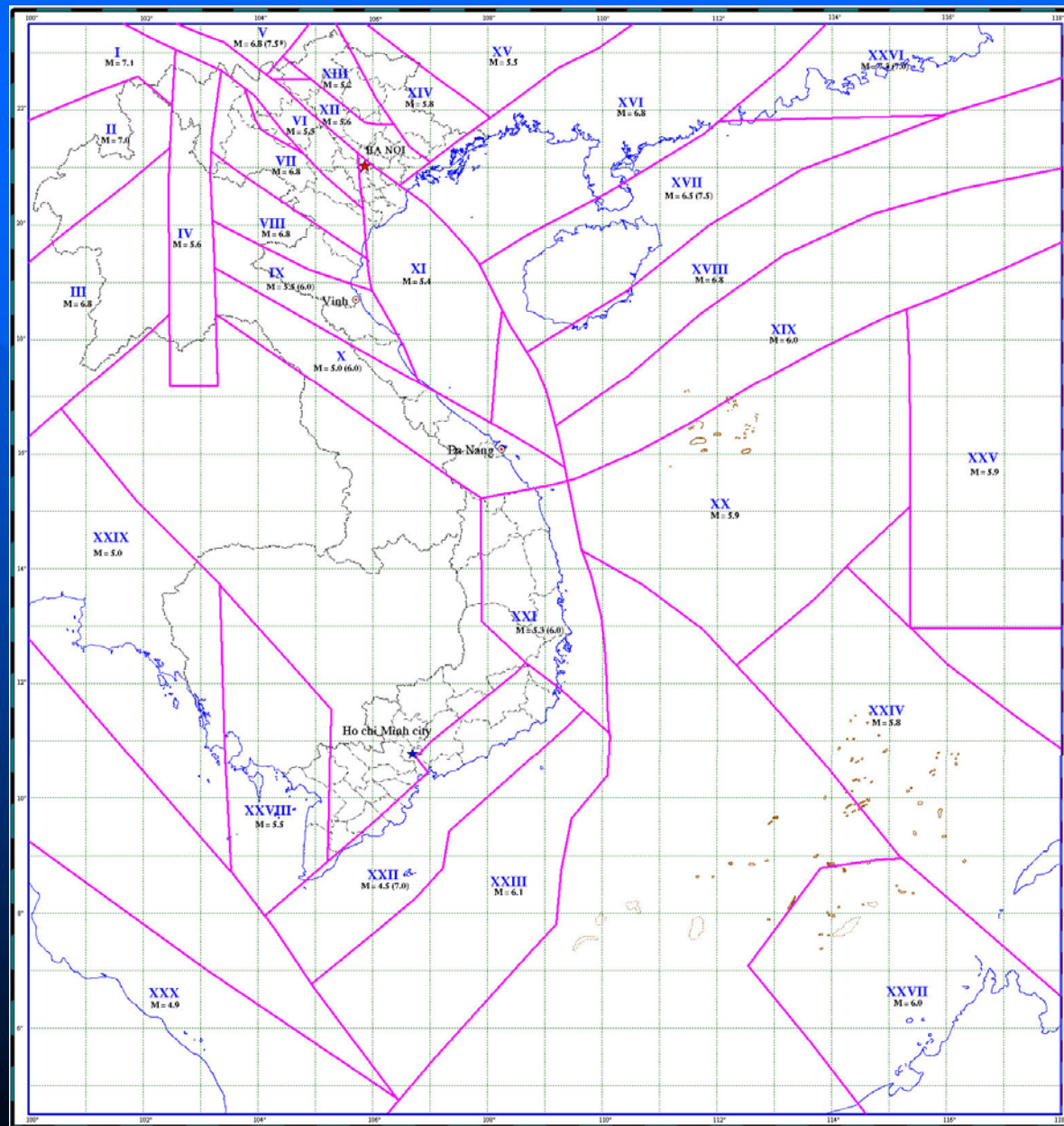
- The maximum earthquake observed in the Dong Back region (index I.1) is: Co To zone ($M_S=5.0-5.9$), An Chau - Song Hiem ($M_S=5.0-5.9$), and Phu Ngu ($M_S=5.0-5.9$).
- The maximum earthquake observed in the Tay Bac region (index I.2) is: Hoang Lien Son ($M_S=5.0-5.9$), Song Da - Son La ($M_S=6.0-6.9$), and Song Ma ($M_S=5.0-5.9$).
- The maximum earthquake observed in the Truong Son region (index I.3) is: Thanh Nghe Tinh zone ($M_S=6.0-6.9$), Muong Te ($M_S=5.0-5.9$), and Binh Tri Thien ($M_S=6.0-6.9$).

The maximum earthquake observed in the Kon Tum (I.4) $M_S=6.0$, Ha Tien (I.7) $M_S=5.0-5.9$, Song Hong basin (II.1) $M_S=5.0-5.9$, Bach Long Vi (II.2) $M_S=5.0-5.9$, Loi Chau (II.3) $M_S=5.0-5.9$, Chau Giang (II.4) $M_S=5.0-5.9$, Bac Hoang Sa (II.5) $M_S=6.0-6.9$, Hoang Sa (II.8) $M_S=5.0-5.9$, Suoi Nga-Trang Khuyet (II.10) $M_S=6.0-6.9$, Sabah (II.11) $M_S=6.0-6.9$, Natuna (II.14) $M_S=5.0-5.9$, Nam Con Son (II.15) $M_S=5.0-5.9$, Con Son (II.16) $M_S=6.0-6.9$, Cuu Long (II.17) $M_S=7.0$, Phu Quoc (II.18) $M_S=5.0-5.9$, and Trung Tam Bien Dong (III) $M_S=5.0-5.9$.

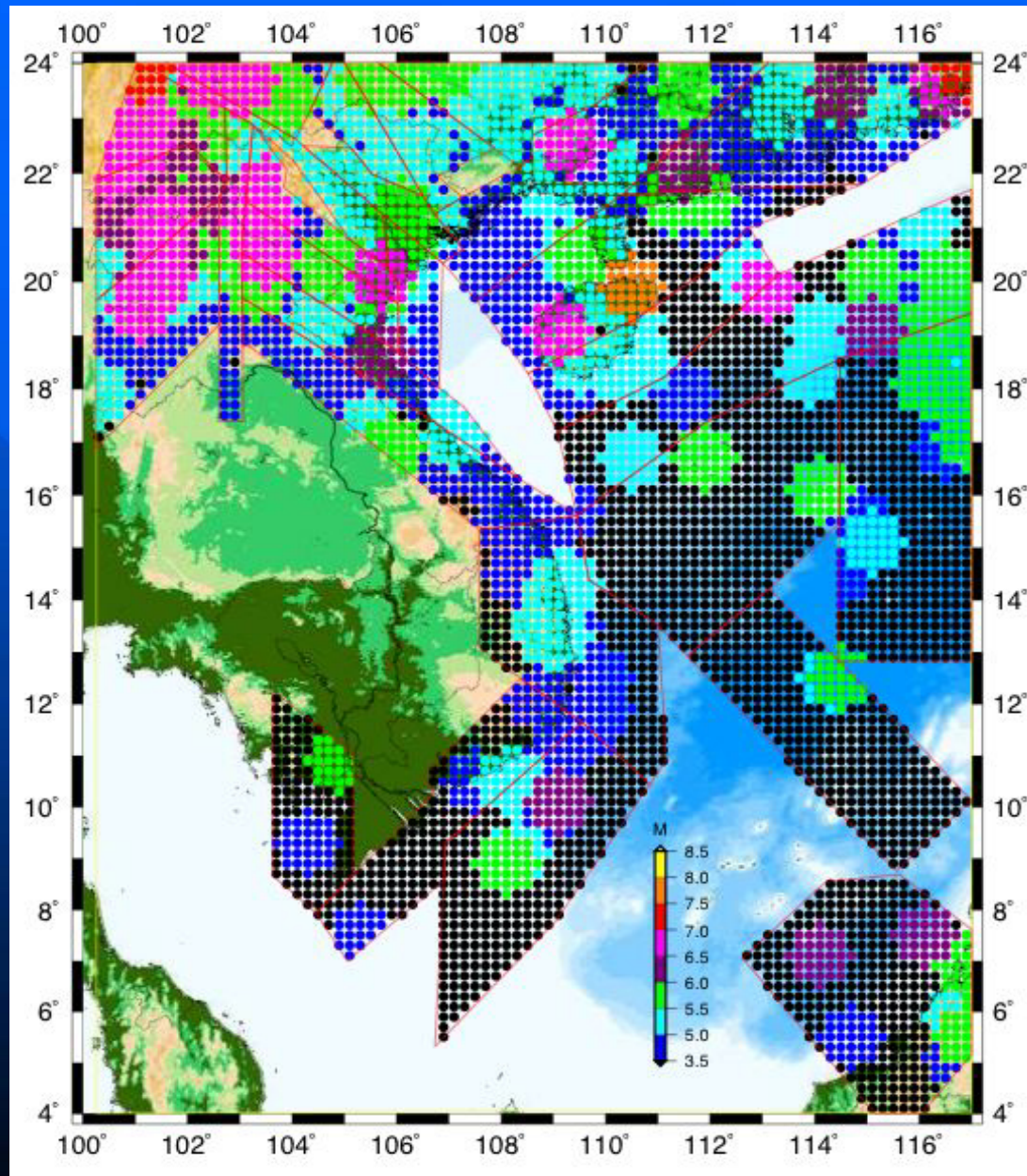
Faulting system of Vietnam territory and adjacent area



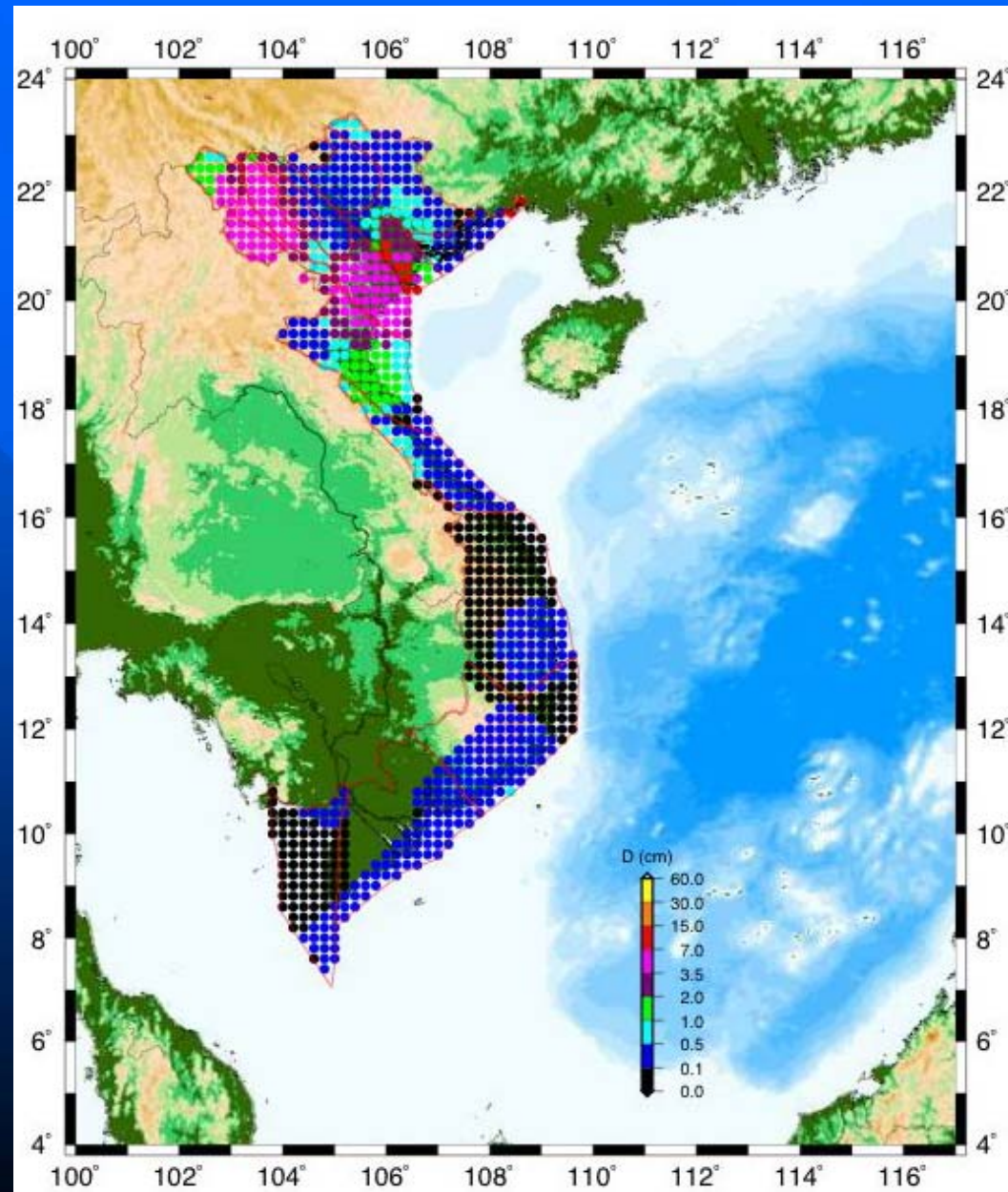
Seismic zones of Vietnam territory and surround areas



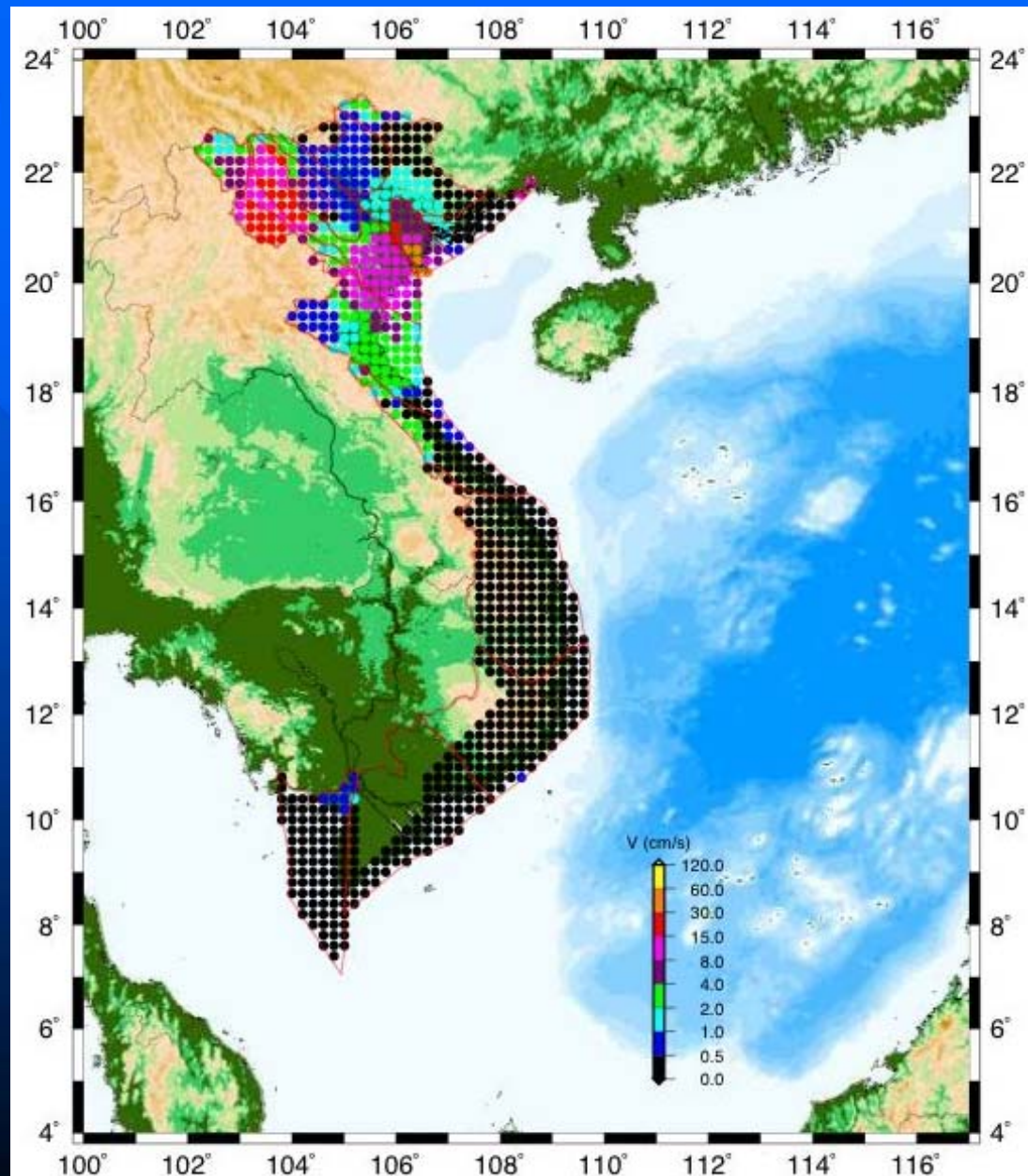
Mmax of Vietnam territory (GNDT)



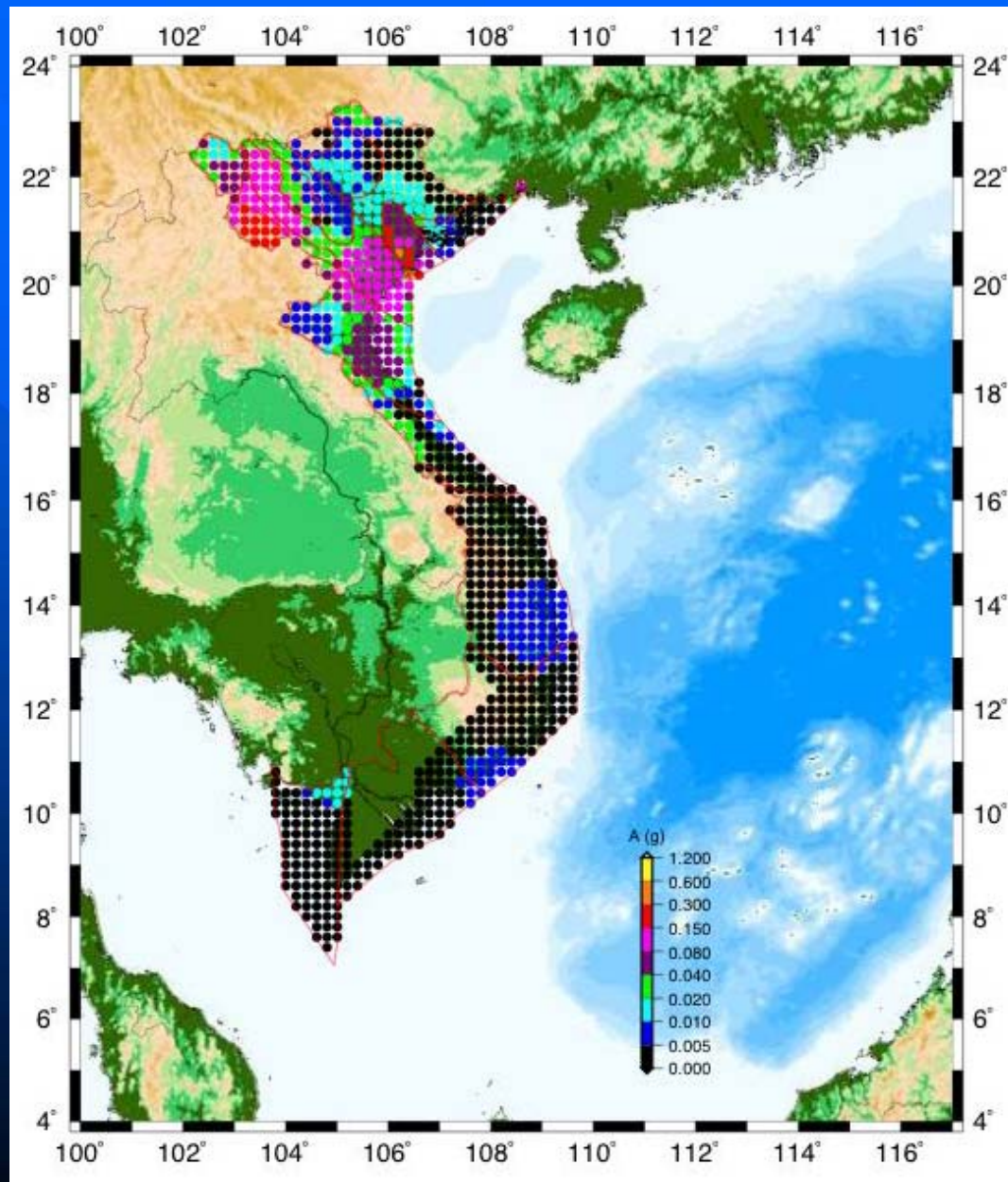
D_{max} of Vietnam territory (GNDT)



V_{max} of Vietnam territory (GNDT)

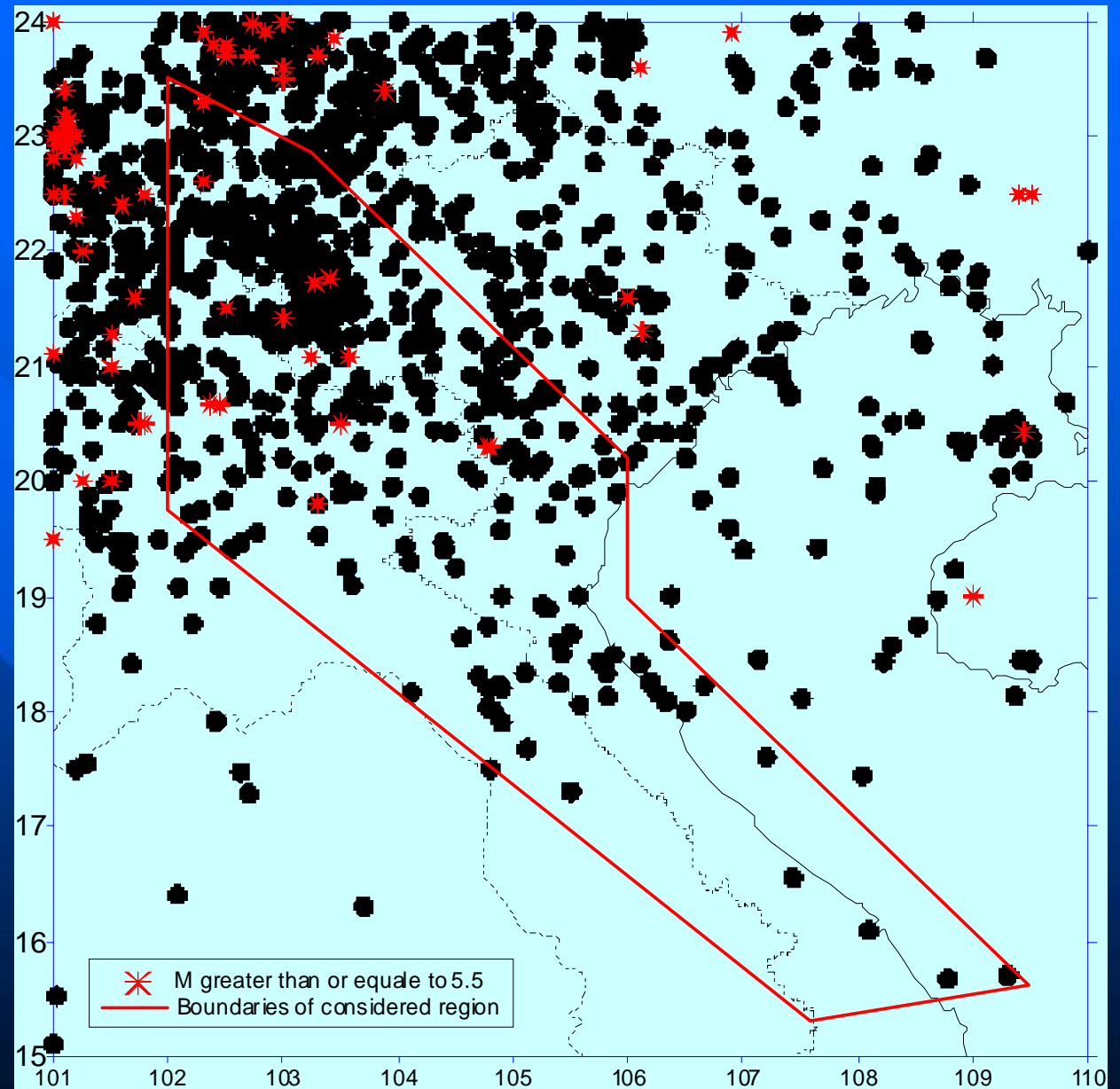


Amax of Vietnam territory (GNDT)

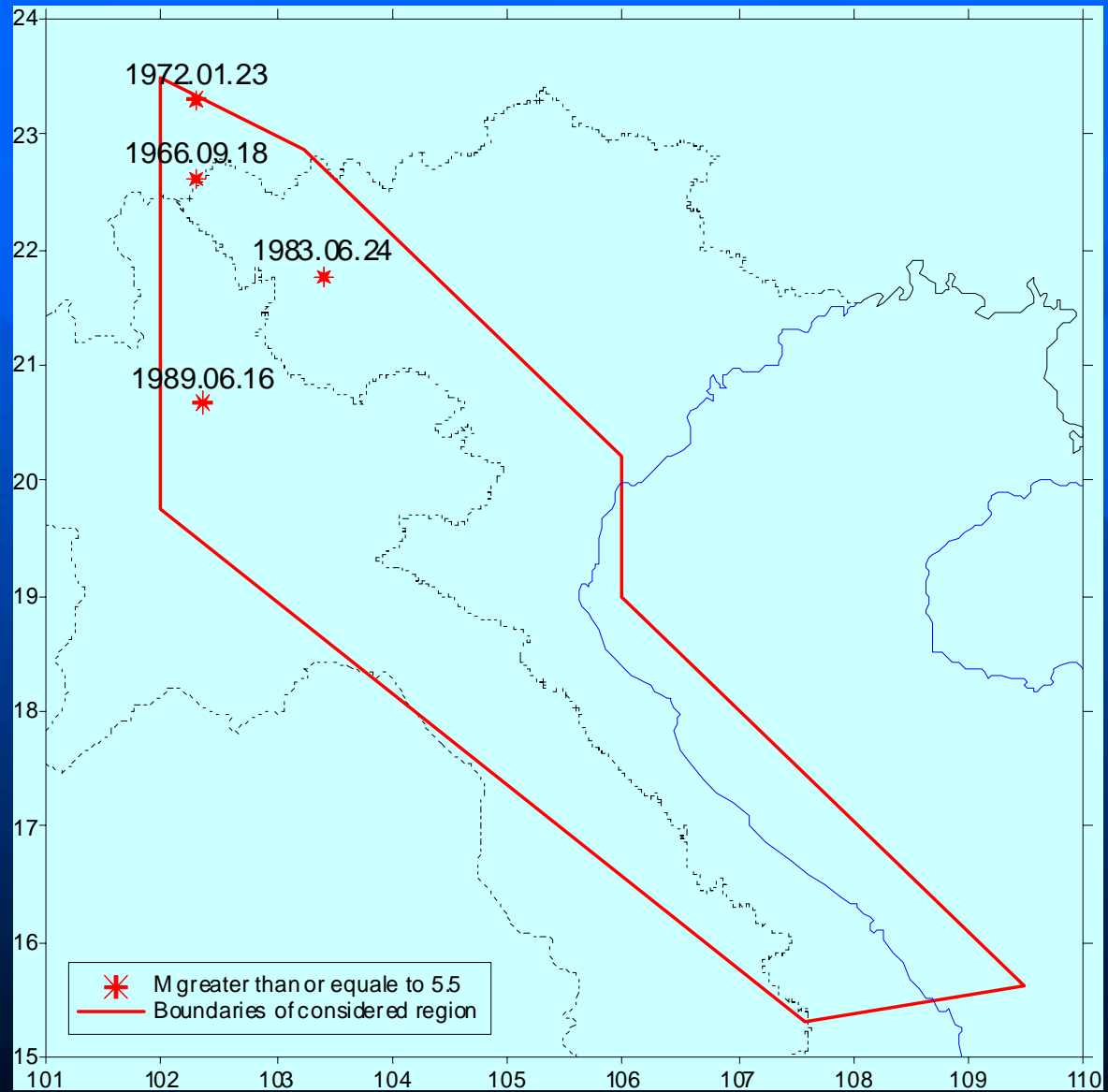


Earthquake Forecast on the basis of CN

Earthquake
Epicenters of Tay
Bac Viet Nam
region
(to use the CN
Programme for
earthquakr
prediction)



Main Events from 1964 to 2002 in Tay Bac with $M > 5.5$



Catalogue of Earthquake from 1964 to 2000

4 Earthquakes:

In 1966 M5.6

In 1972 M5.6

In 1983 M6.7

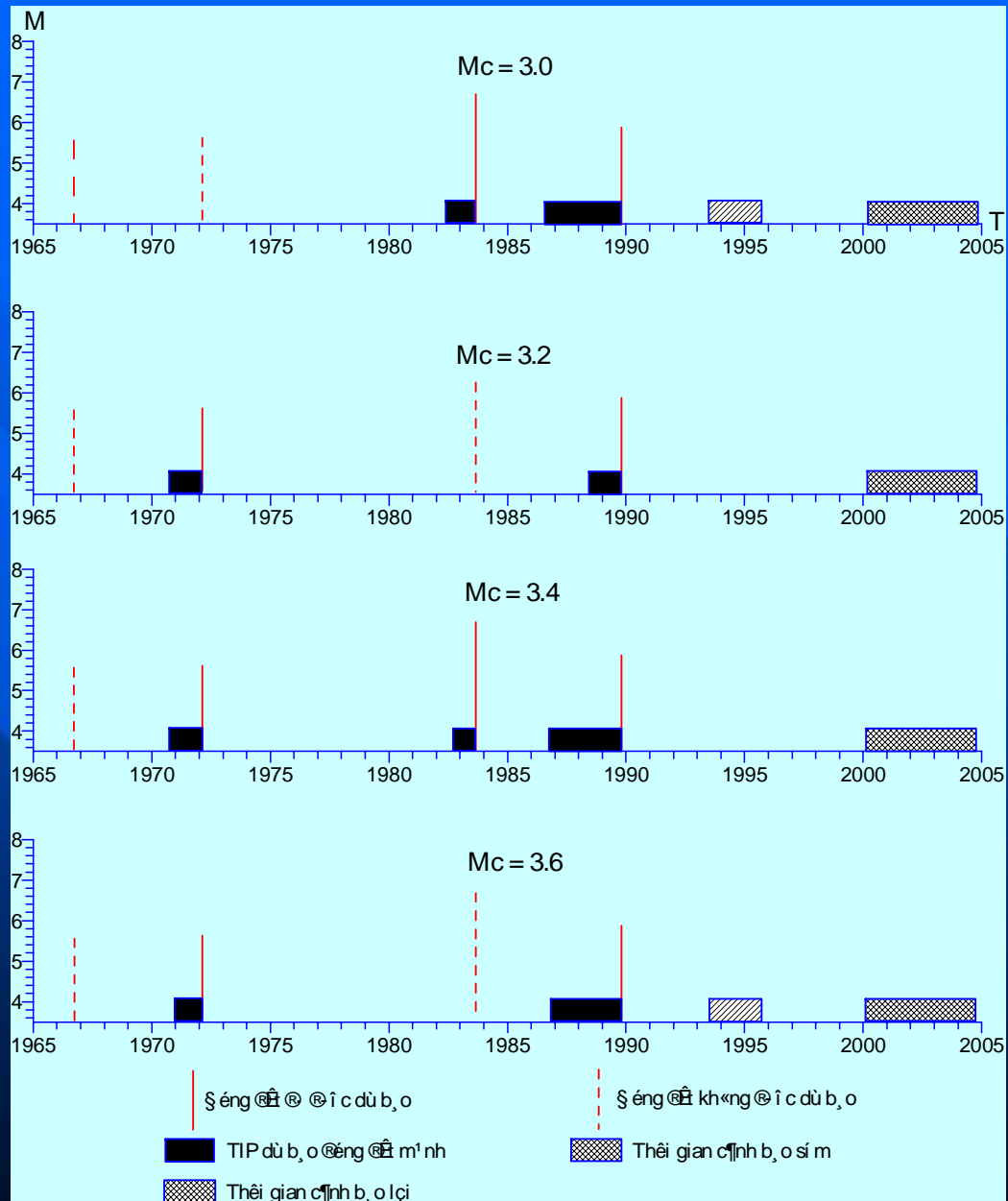
In 1989 M5.9

- The earthquake in 1966
is not recognized

- In 1972, 1983 and 1989
are recognized

- To identify 1 TIP from
2000 to 2005 (Mc=3.2 and
3.4)

In 2001 one earthquake
with M5.3 occurred in
Dien Bien area



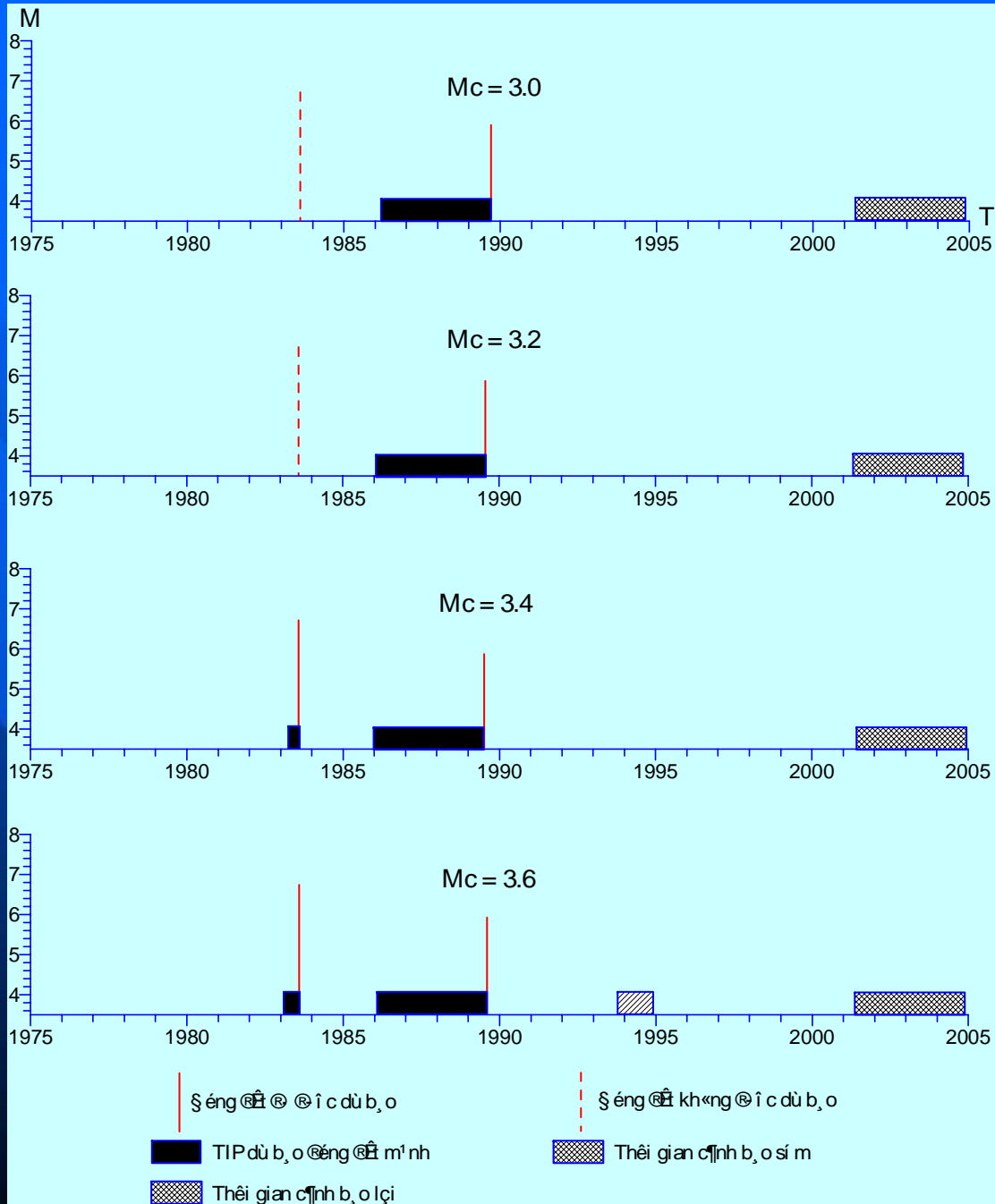
Catalogue of Earthquake from 1975 to 2000

2 Earthquakes:
In 1983 M6.7
In 1989 M5.9

- In 1983 and 1989
are recognized

- To identify 1 TIP from
2001 to 2005 (Mc=3.2
and 3.4)

In 2001 one earthquake
with M5.3 occurred in
Dien Bien area

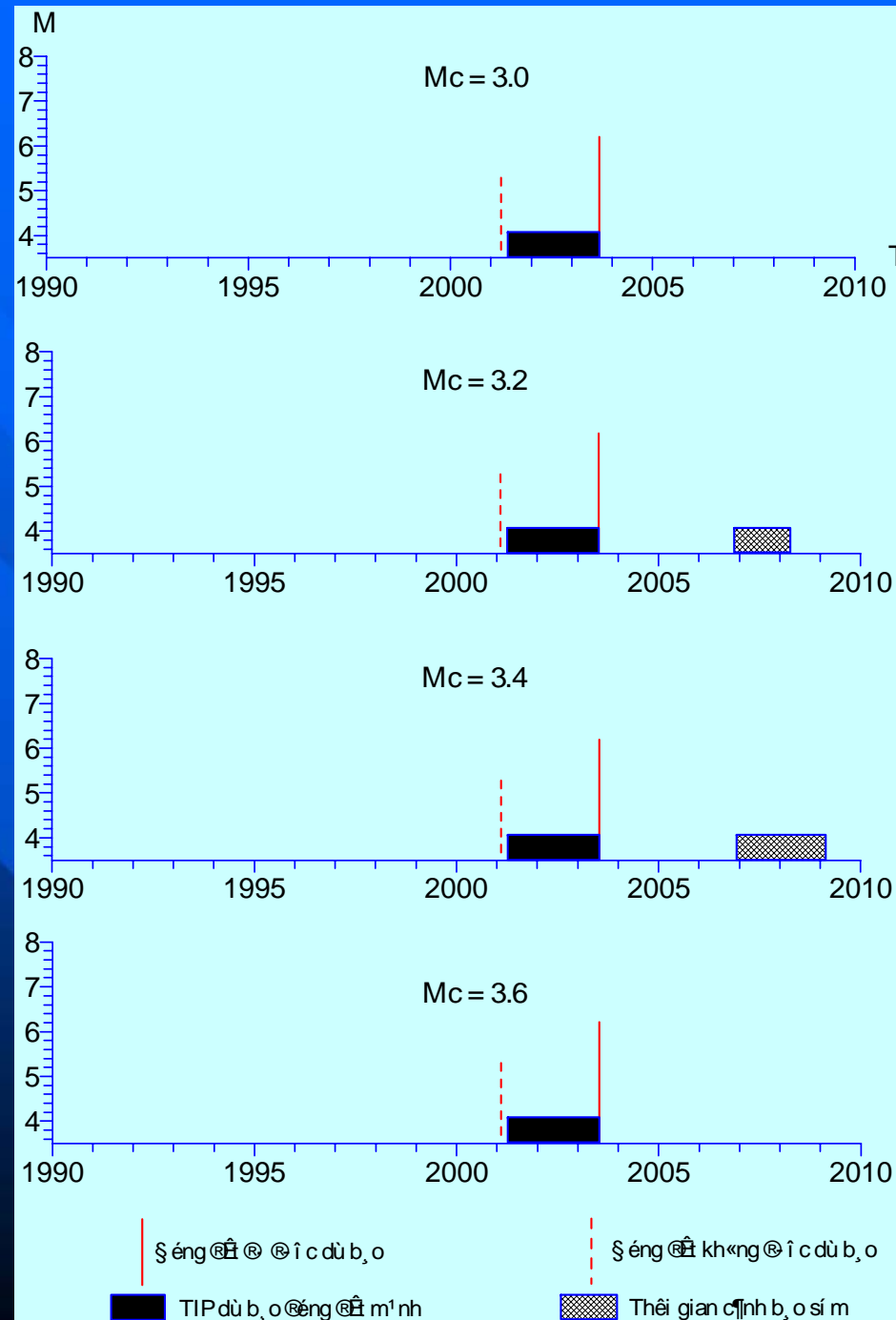


Catalogue of Earthquake from 1990 to 2006

1 Earthquakes:
In 2001 M5.3

- In 2001
is recognized

- To identify 1 TIP
from 2007 to 2012
($M_c=3.2$ and 3.4)

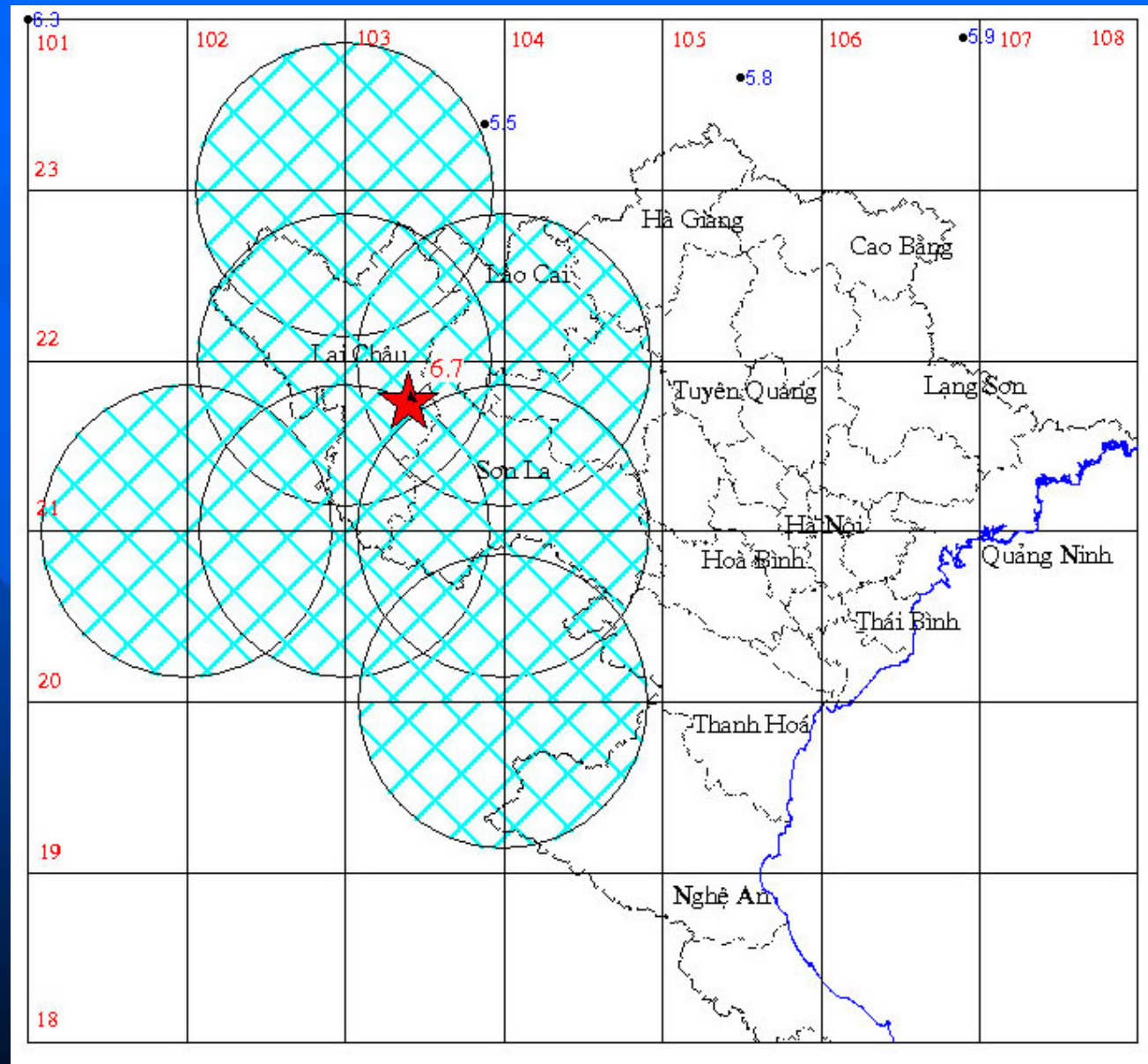


Earthquake Forecast on the basis of M8S Programmes

To recognize Tuan Giao M6.7 Earthquake in 1983

Time interval (Tb, Te) = (1975/01/01, 1980/01/01);
Step in time dt = .50 years

R = 192 km

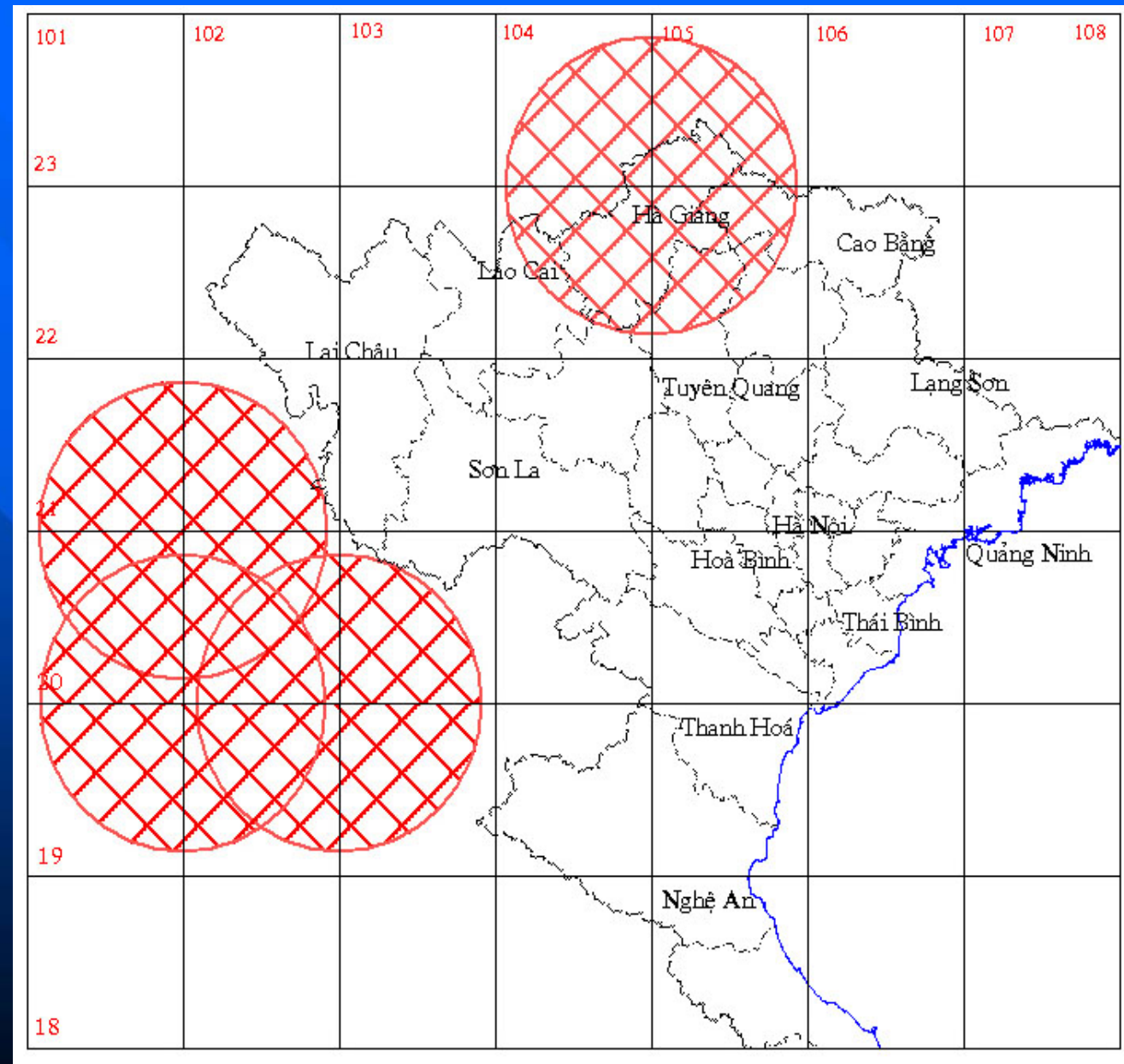


To forecast the Earthquake may be occur in Northern Vietnam

Time interval (Tb, Te) = (1995/01/01, 2004/01/01);
Step in time

dt = .50 years

From 2005 to 2009
To reveal 2 areas threatened the earthquakes with magnitude equal or more than 6.0:
- In Ha Giang, and
- In North-Eastern Lao



CONCLUSION

- 1. The catalogue of earthquakes in the territory of Vietnam established to the end of 2003 is based on: The ISC, NOAA and NEIC databases and the following software: EDCAT, CATAL, and HIST. For the first time the sufficient catalogue of earthquakes has been established in Vietnam. This is the very important and fundamental documentary source for seismic hazards and risk assessments.
- 2. The Dien Bien 1935-M=6.8 and Tuan Giao 1983-M=6.7 earthquakes are the two largest ones that happened in Vietnam main land territory in the 20th century. These events caused heavy losses to the Dien Bien and Son La provinces.
- 3. Upon the standpoint of seismicity, the largest observed maximum earthquake occurrences of the following geological structures: Song Da - Son La (MS=6.0-6.9), Thanh Nghe Tinh zone (MS=6.0-6.9), Bac Hoang Sa (MS=6.0-6.9).
- 4. 30 seismogenic zones could be determined in the territory of Vietnam and surround areas. Among that, the high rank of the earthquake activity are: Muong Te (7.1), Xiao Jiang (MS=6.8), Song Da - Son La (MS=6.7), Sam Nua - Thai Hoa (MS=6.8), Song Ca - Rao Nay (MS=6.8), Lingshan - Ha Long (MS=6.8), Huyen Nhai - Van Ninh (MS=7.5), Guangzhou (MS=7.3), and Bac Hoang Sa (MS=6.8).
- From 2005 to 2010 in Tay Bac Viet Nam one Event could be occurred according to the results of CN and M8S programmes.

The end

Thank you
for your
attention