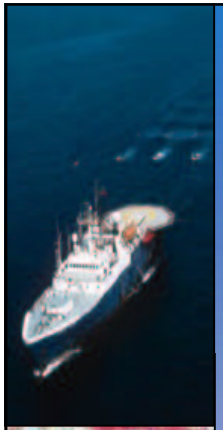
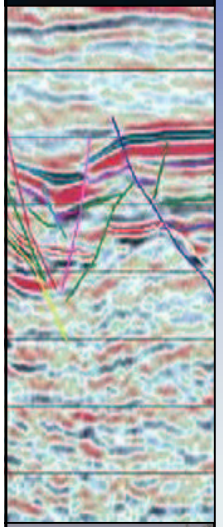
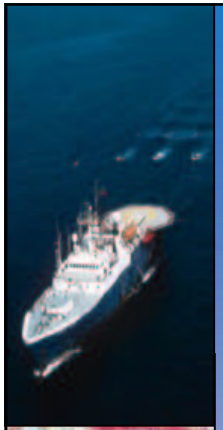
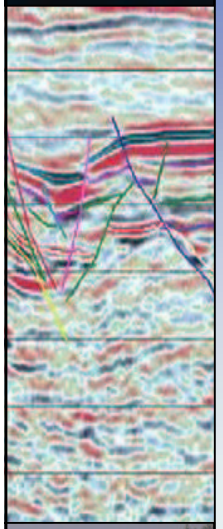




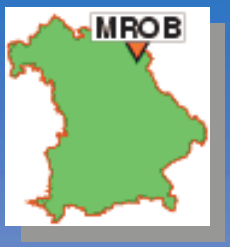
Seismology

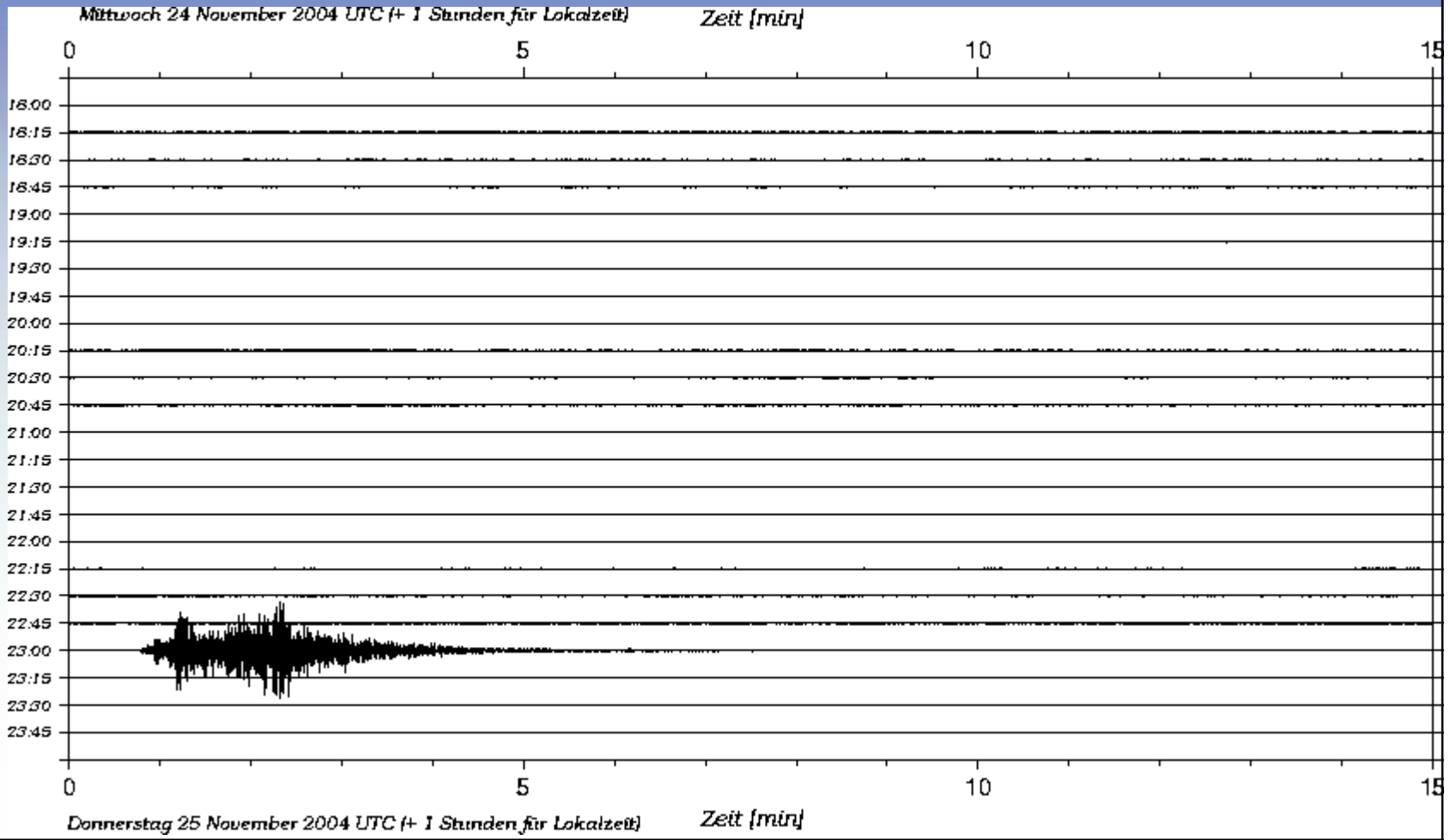
- How can we determine the origin time of an earthquake?
- How can we determine the epicentre and hypocentre of earthquakes?
- How can we measure the size of an earthquake (Richter scale)?
- What describes the damage of an earthquake (seismic intensity, Mercalli scale)?

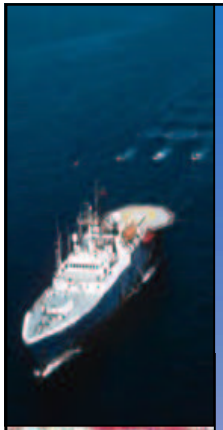


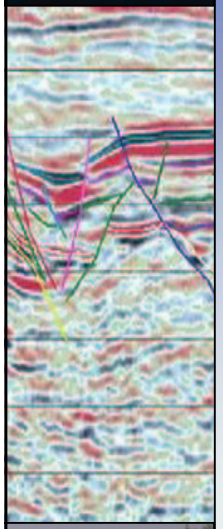


Gardasee event

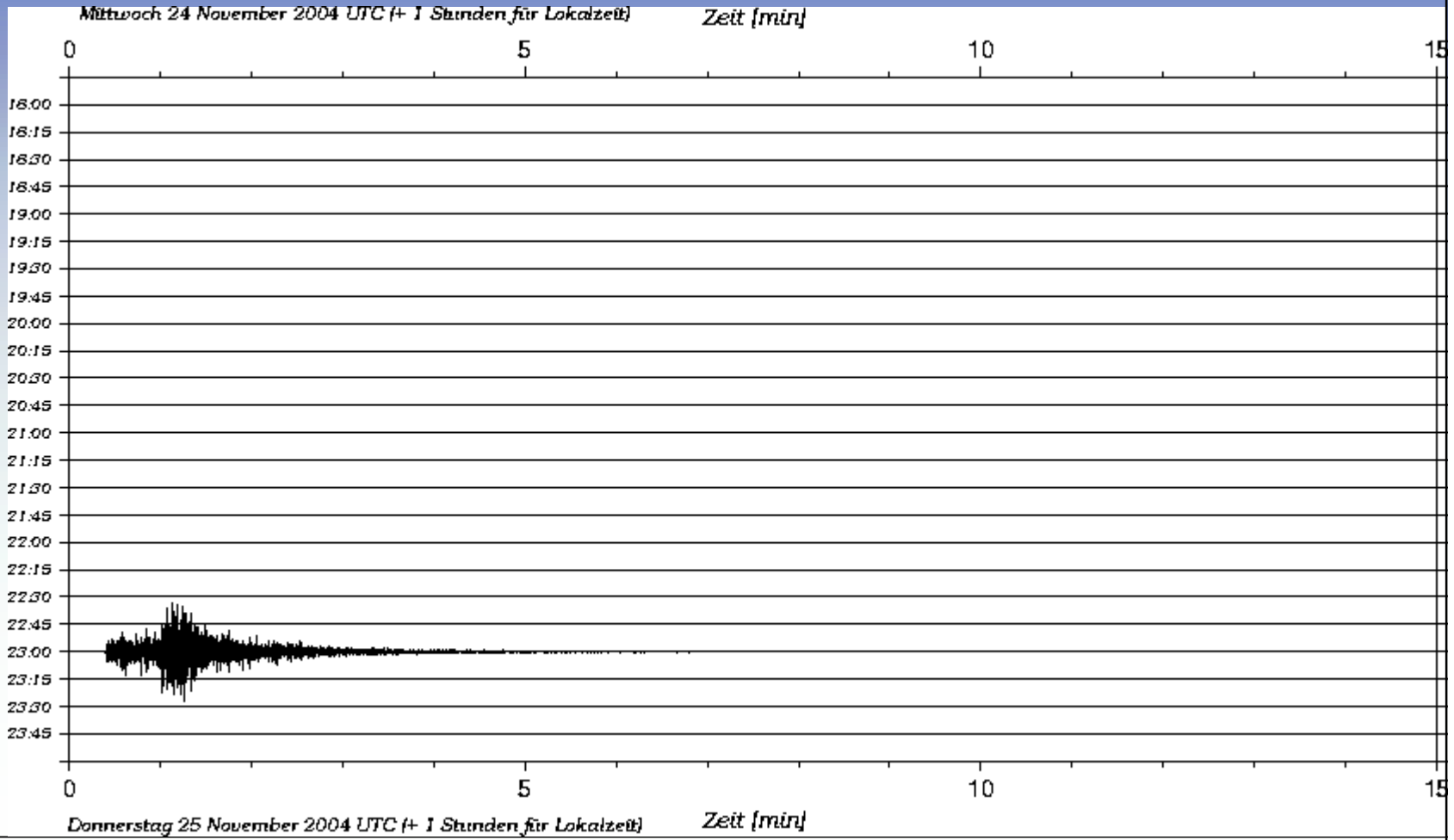


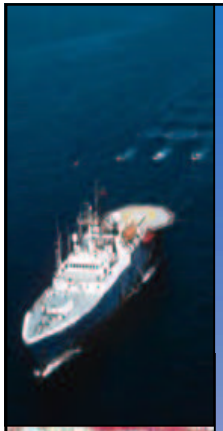


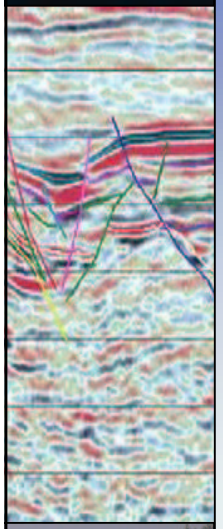




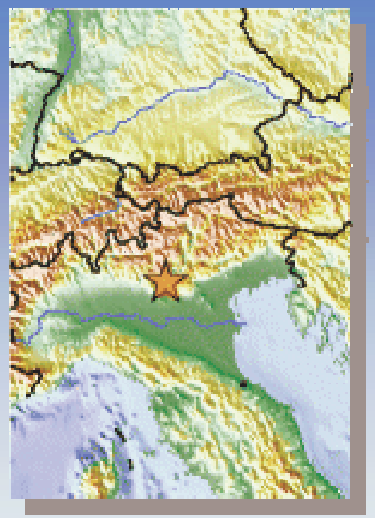
Gardasee event

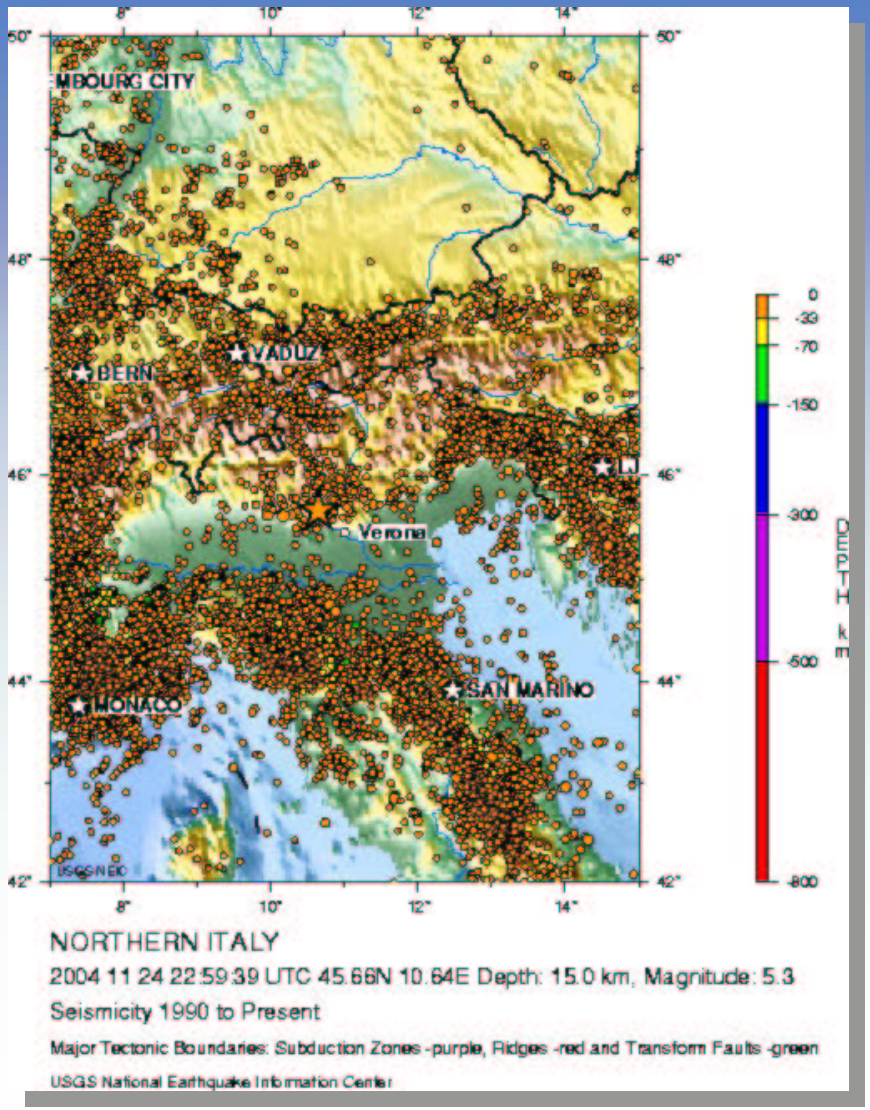


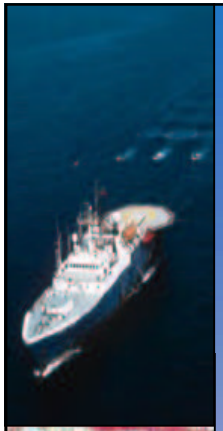


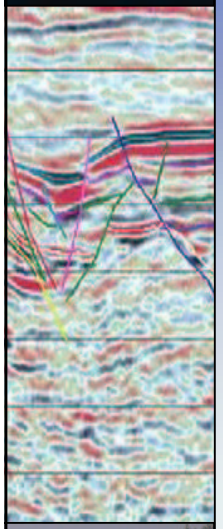


Location




LUXEMBOURG CITY
BERN
VADUZ
Verona
MONACO
SAN MARINO
USGS/NEIC
8°
10°
12°
14°
50°
48°
46°
44°
42°
0
-33
-70
-150
-300
-500
-800
DEPTH km
NORTHERN ITALY
2004 11 24 22:59:39 UTC 45.66N 10.64E Depth: 15.0 km, Magnitude: 5.3
Seismicity 1990 to Present
Major Tectonic Boundaries: Subduction Zones -purple, Ridges -red and Transform Faults -green
USGS National Earthquake Information Center





NEIC

USGS Earthquake Hazards Program: Earthquake Report: NORTHERN ITALY -Netscape

Datei Bearbeiten Anzeigen Gehe Lesezeichen Extras Fenster Hilfe

http://wwwneic.cr.usgs.gov/neis/bulletin/neic_ifcl.html

Suchen

eMail AIM Anfang Netscape.de Suche Lesezeichen

Current Earthquakes

USA
World

ShakeMaps

Seismogram Displays

Past & Historical Earthquakes

Earthquake E-Mail Notification

Earthquake Activity in the Last 8 - 30 Days

Large/Significant Earthquakes This Year

Significant Earthquake Posters

Fast Moment

Preliminary Earthquake Report
U.S. Geological Survey, National Earthquake Information Center
World Data Center for Seismology, Denver

Versión en Español

Magnitude	5.3
Date-Time	**Wednesday, November 24, 2004 at 22:59:39 (UTC)** - Coordinated Universal Time Wednesday, November 24, 2004 at 11:59:39 PM local time at epicenter Time of Earthquake in other Time Zones
Location	45.66N 10.64E
Depth	15.0 kilometers
Region	**NORTHERN ITALY**
Reference	35 km (25 miles) NW of **Verona, Italy** 100 km (60 miles) NNE of **Parma, Italy** 110 km (65 miles) SSW of **Bolzano, Italy** 445 km (275 miles) NNW of **ROME, Italy**
Location Quality	Error estimate: horizontal +/- 9.4 km; depth +/- 0.0 km
Location Quality Parameters	Nst=110, Nph=110, Dmin=1451.2 km, Rmss=1.04 sec, Erho=9.4 km, Erzz=0.0 km, Gp=75.7 degrees
Source	USGS NEIC (WDCS-D)

Location Maps

Did You Feel It?
Report shaking and damage at your location.

Historical Seismicity

Theoretical P-Wave Travel Times

mzbern.ch -Netscape

Datei Bearbeiten Anzeigen Gehe Lesezeichen Extras Fenster Hilfe

http://www.mzbern.ch/pages/index.cfm?dom=31&rub=100004702&nrub=0&sda=1&Artikel_ID=100588765

Suchen

eMail AIM Anfang Netscape.de Suche Lesezeichen

Branchenführer
Fahrzeuge
Immobilien
Jobs

Baloise Bank SoBa

radio 32

Service
Bildung
Bonus
Bücher
CD-Charts
Computer
Moneybox
Ozonberichte
Pollenberichte
Schneeberichte
Suchmaschinen
Tourismus
Verkehr
Zeitungs-Archiv

Community
Gästebuch
Hits/Radio
Kontaktanzeigen
Newsletter
Vereine
Wohin man geht

E-Government
Bund & Kantone
Gemeinden
Guichet virtuel

VS/H Gruppe
Aktuell
Porträt
Organe
Situationsplan
Offene Stellen
Lehrstellen
Feedback

TAGBLATT RUNDSCHAU heute

VS/H MEDIEN VOGT-SCHILD/HABEGGER

Vermischtes

MZ NEWS - Front
Blaulicht
Kantone
Regionen
Schweiz
Ausland
Business
Sport
Kultur
Vermischtes
Dossier
Forum
TED-Umfragen

Tageszeitung
Verlag
Druck

moneybox
Vereinsführer
wohin man geht
AEK
Haushalt Shop

Wetter

Fr	Sa	So
9°	9°	5°

ROM

Erdbeben in Norditalien

Ein Erdbeben der Stärke 5,2 auf der Richterskala hat in der Nacht weite Teile Norditaliens erschüttert. Vier Menschen wurden leicht verletzt. Das Ausmass der Sachschadens war zunächst unklar.

Schutt auf den Strassen von Salò
(Foto: Keystone)

Das über 30 Sekunden lange Beben ereignete sich um 23.59 Uhr und war von Genua im Westen bis Venedig im Osten zu spüren. Der Erdbebendienst in Zürich meldete, auch in weiten Teilen der Schweiz seien die Erschütterungen spürbar gewesen, insbesondere im Tessin und in Südbünden. Schäden seien aber unwahrscheinlich.

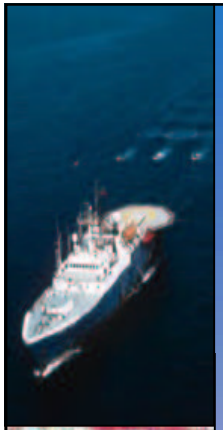
Im Tessin zitterten Fenster und Möbel, wie Zeugen berichteten. Vor allem im Mendrisiotto war das Beben demnach während 10 bis 15 Sekunden deutlich wahrnehmbar. Viele Menschen riefen die Polizei sowie das Radio und Fernsehen der italienischen Schweiz (RTSI) an. Verletzte gab es keine. Auch lagen keine Schadensmeldungen vor.

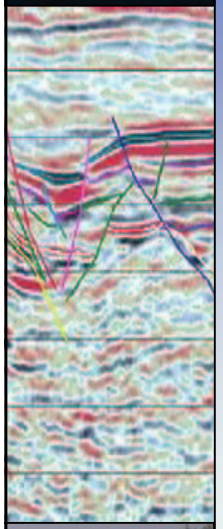
Das Epizentrum befand sich am Ufer des Gardasees in etwa 25 Kilometer Tiefe unter der Erde. Am Gardasee registrierten die Behörden Gebäudeschäden, unter anderem in den Ortschaften Salò und Gardone Riviera. Mehrere Spitäler in der Region wurden vorsorglich evakuiert. Einige verlassene Bauernhöfe stürzten ein.

In mehreren Ortschaften am Gardasee liefen nach Angaben des Zivilschutzes Menschen in Panik aus ihren Häusern auf die Strasse. In Salò errichtete der Zivilschutz im Sportstadion mehrere Zelte. Dort verbrachten Menschen die Nacht, die Angst vor einer Rückkehr in ihr Haus hatten.

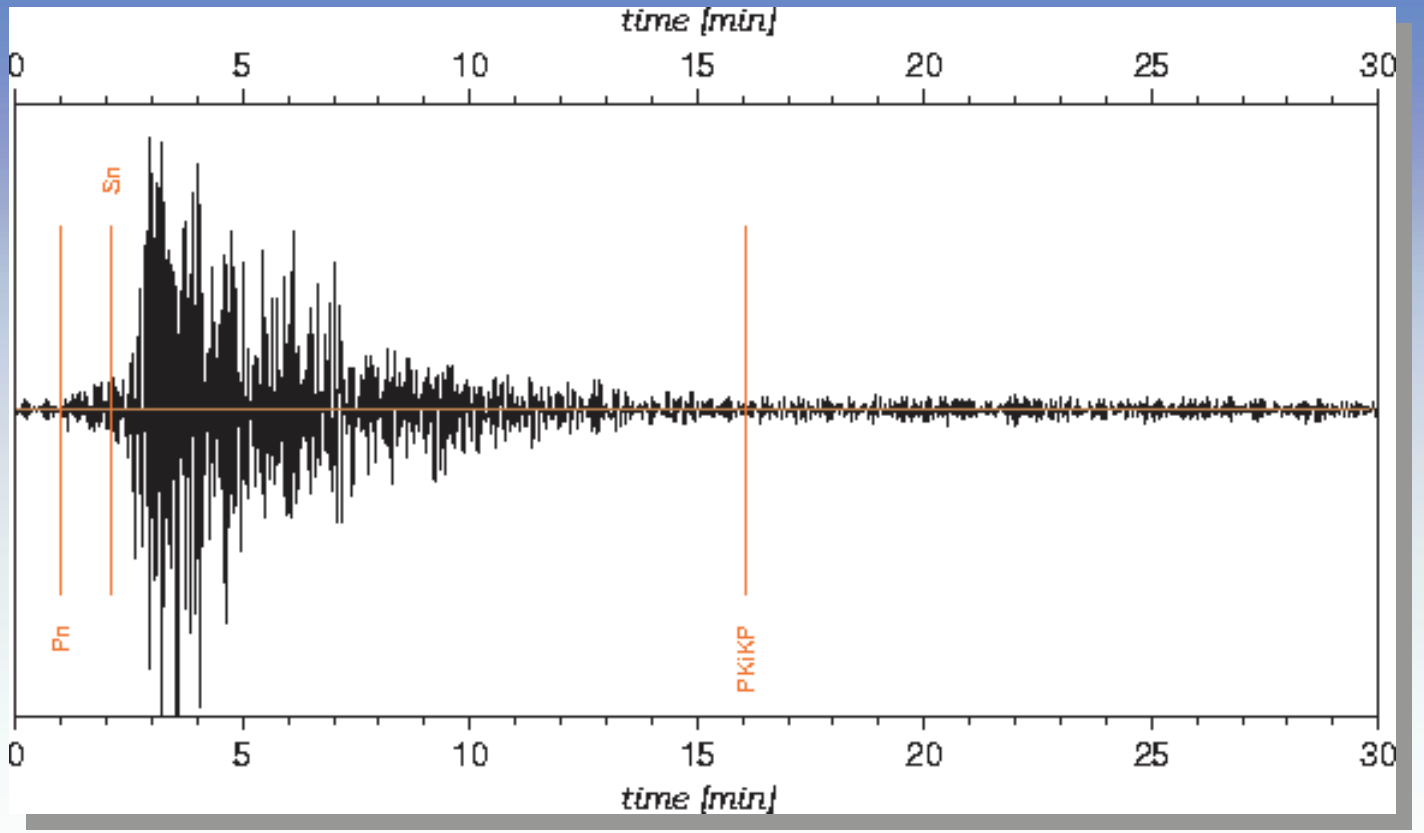
In Italien kommt es immer wieder zu Erdbeben, wobei Erdstösse im Norden seltener als im Süden vorkommen. Bei einem schweren Erdbeben in Süditalien waren am 23. November 1980 über 3000 Menschen ums Leben gekommen. *(sda)*

Fertig

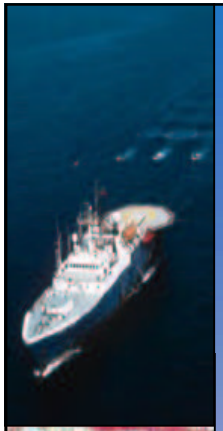


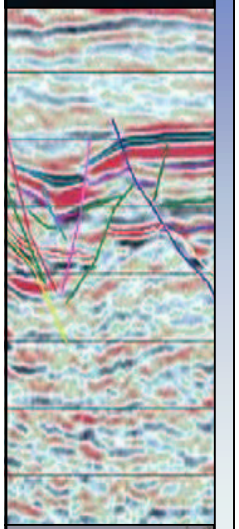


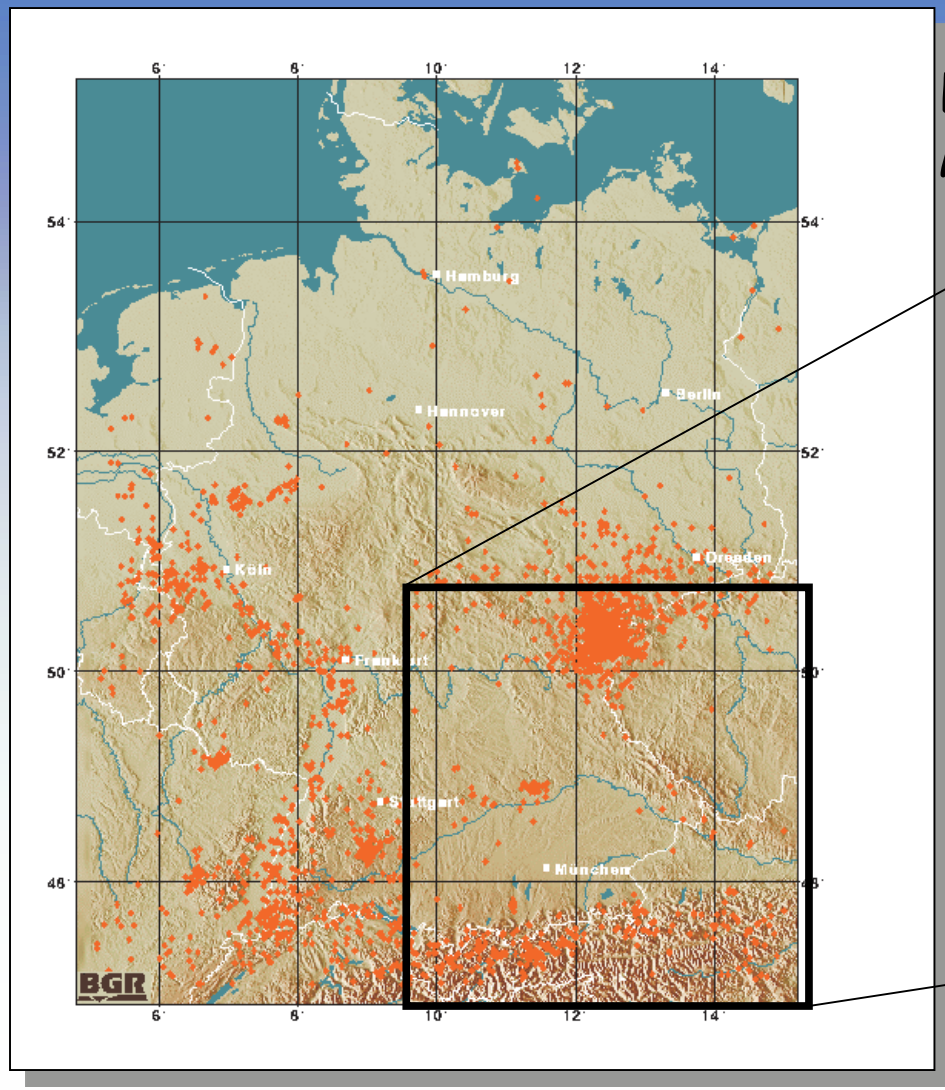
Seismograms



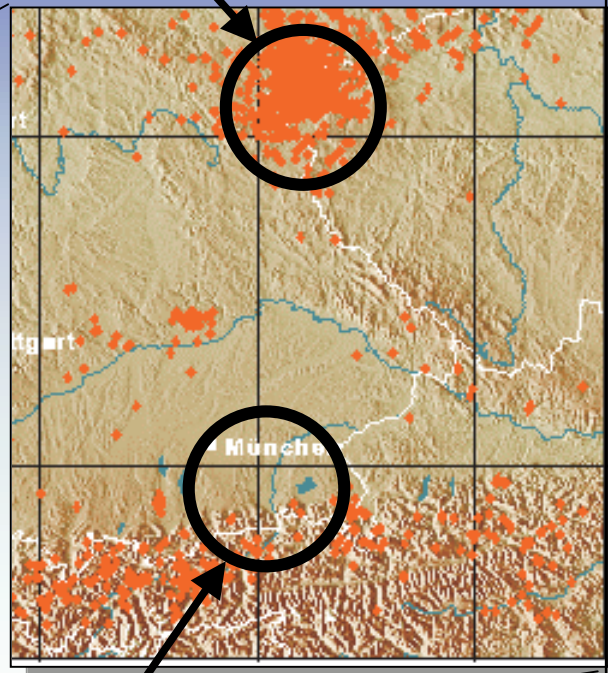
Earthquakes in Bayern ?



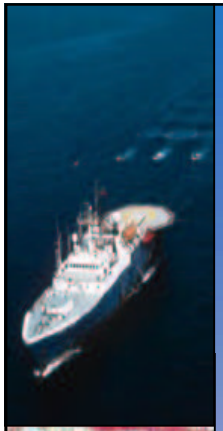


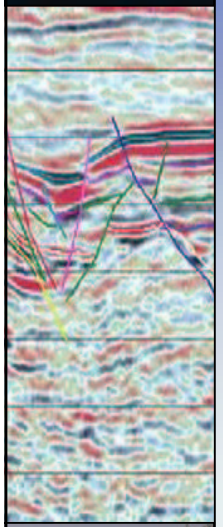


Bereich Marktredwitz

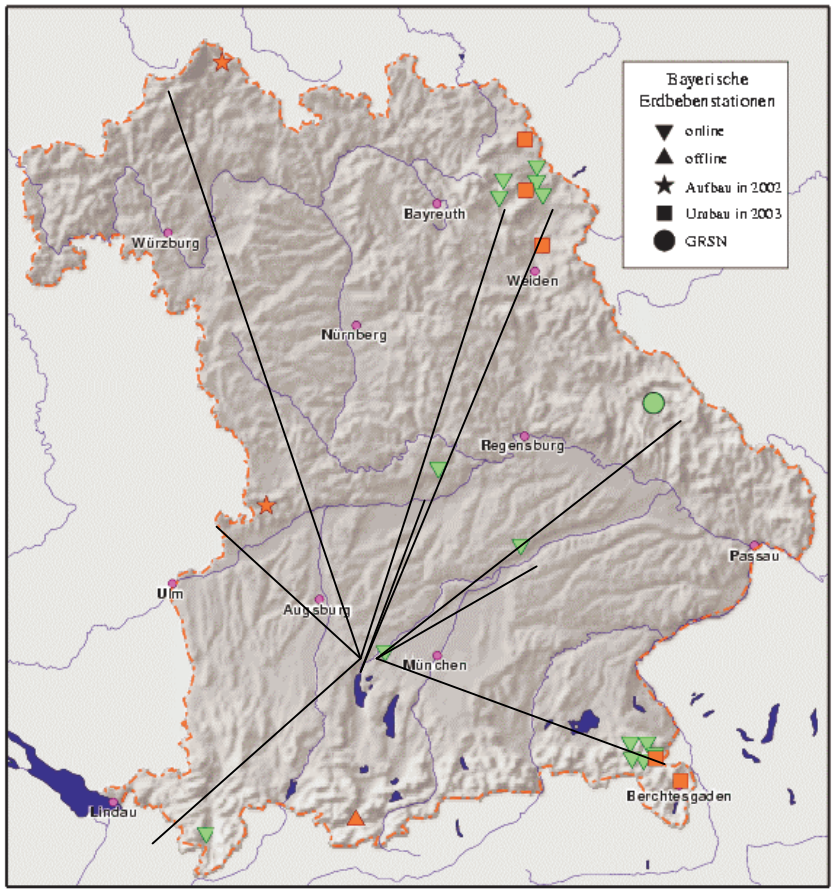


Bad Reichenhall

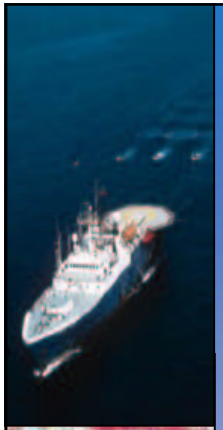


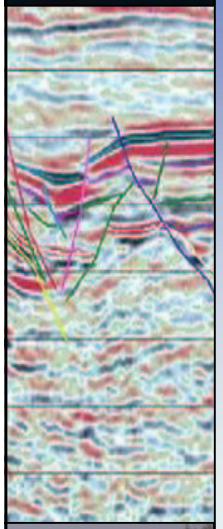


Seismic stations in Bavaria

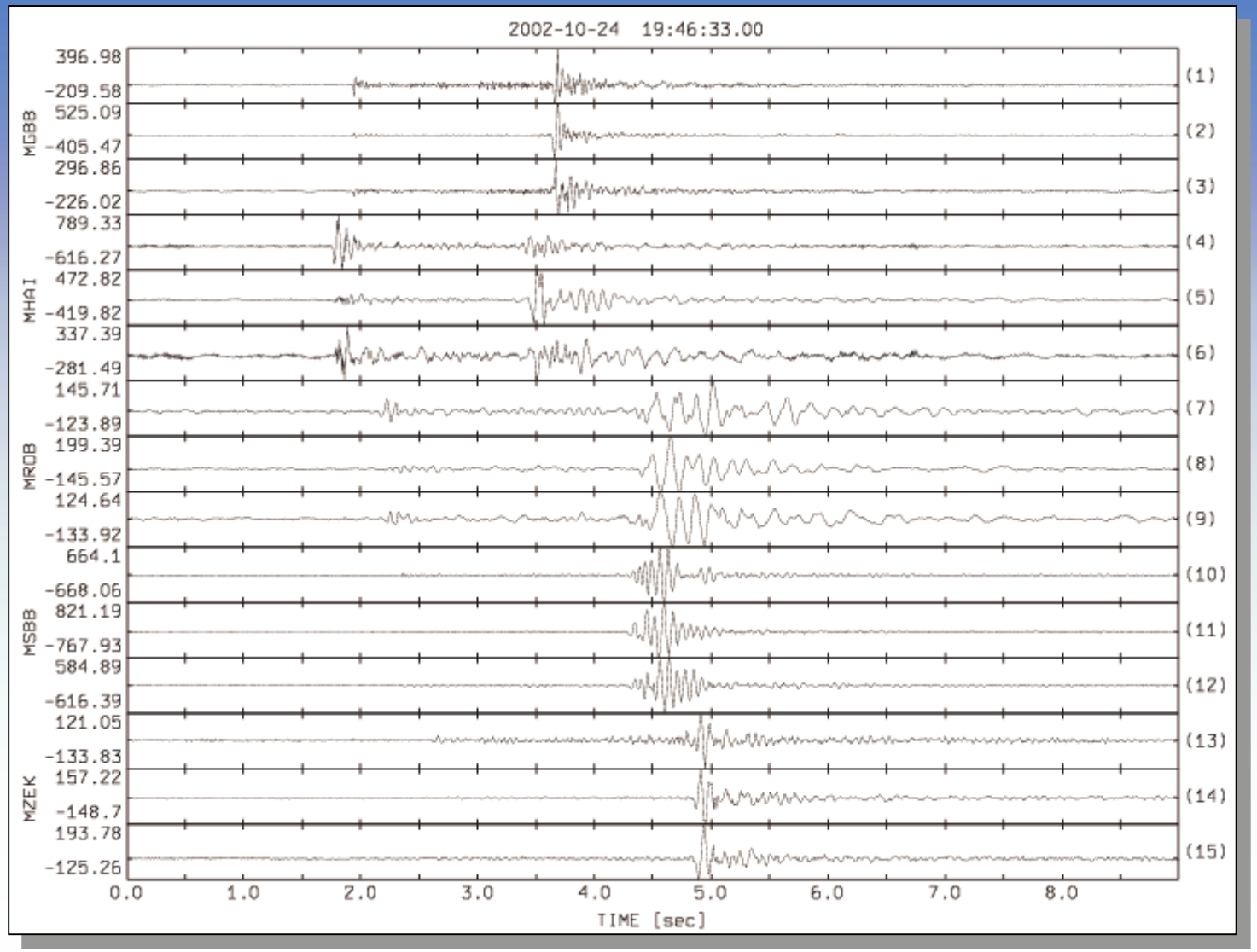


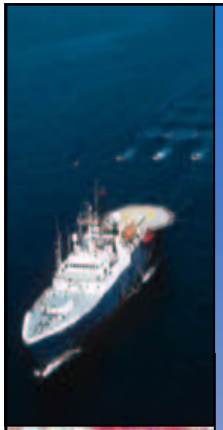
ISDN Verbindung mit Stationen alle 20Min.

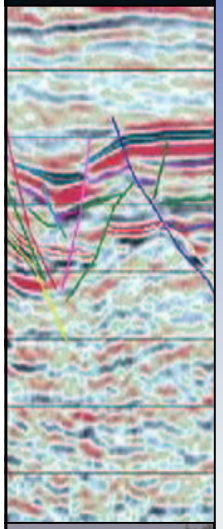




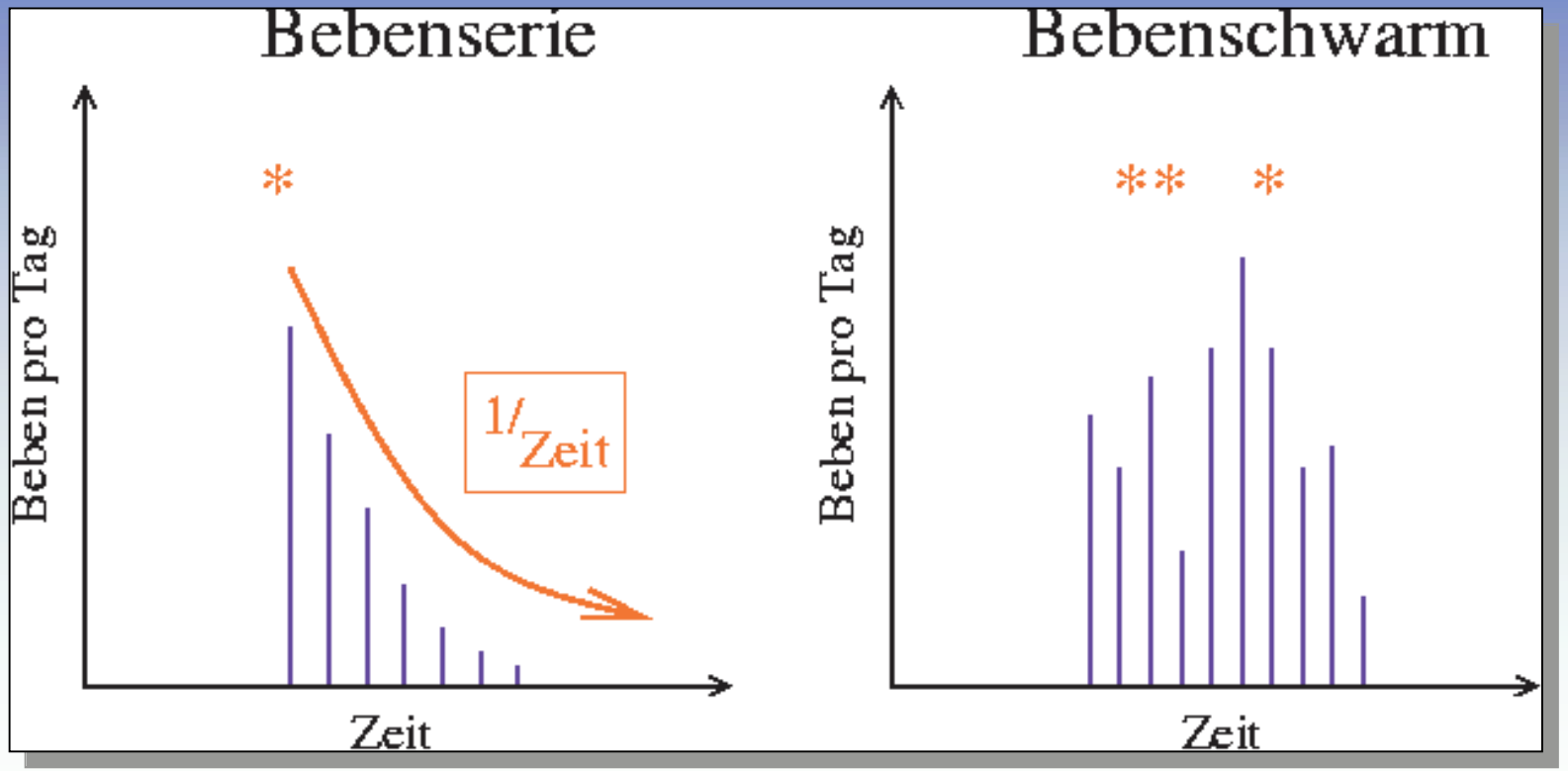
Earthquake near Marktredwitz, 24.10.2002

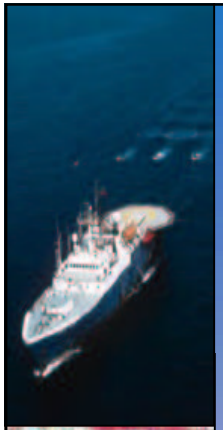


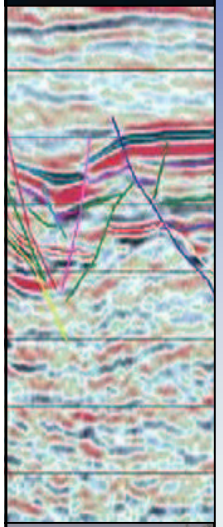




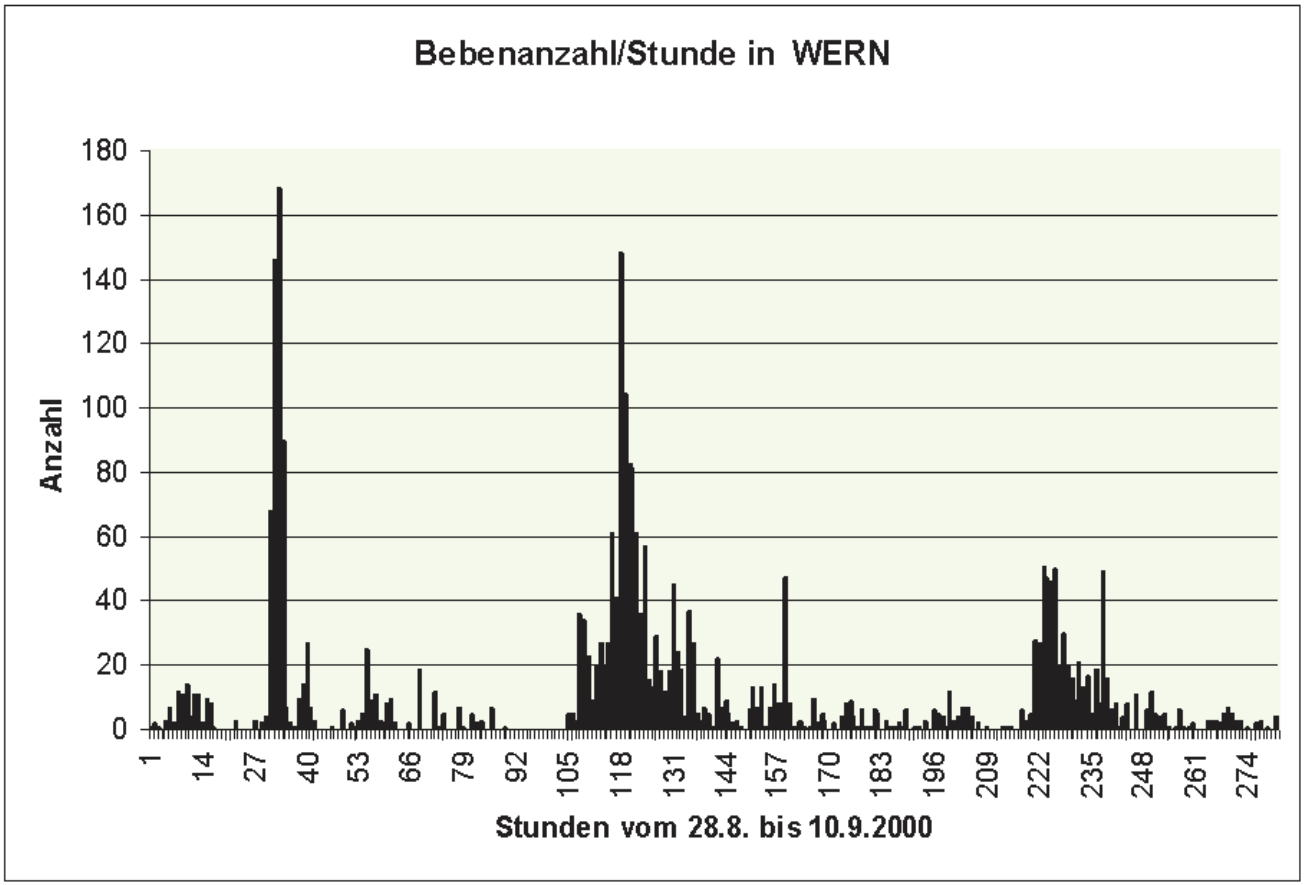
Swarmquakes

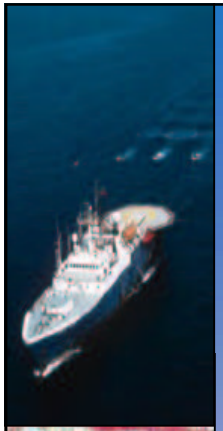


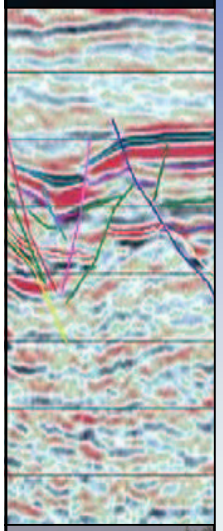




Was sind Schwarmbeben?
Beispiel: Vogtland

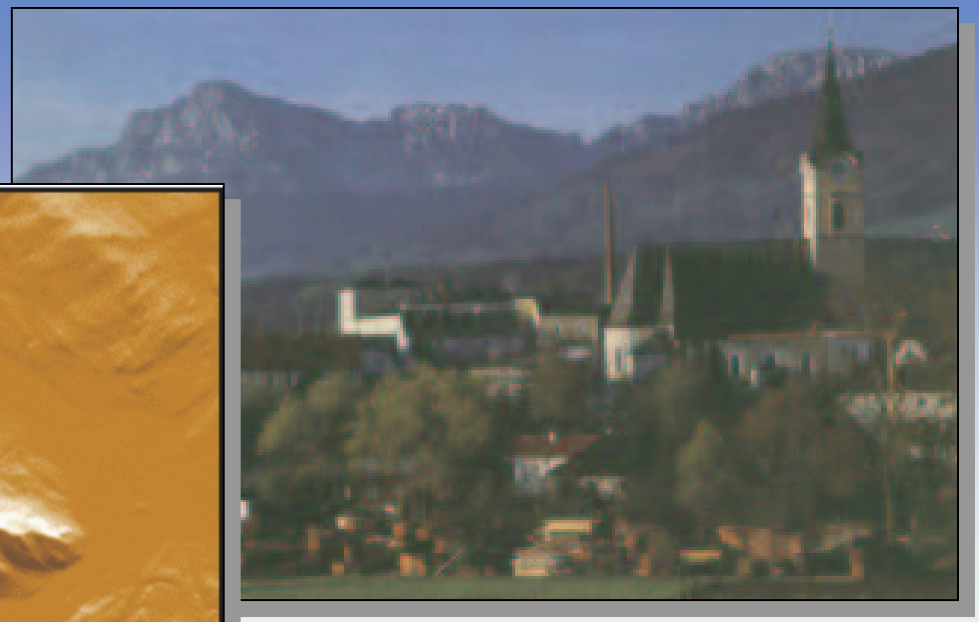


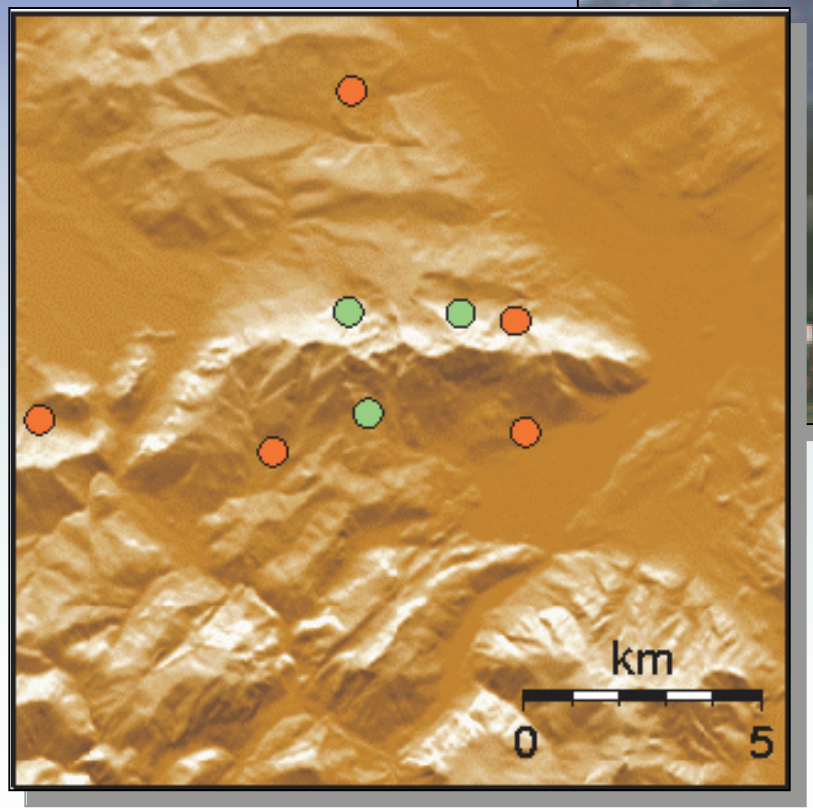


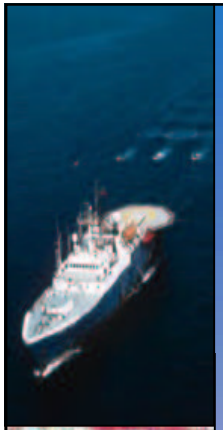


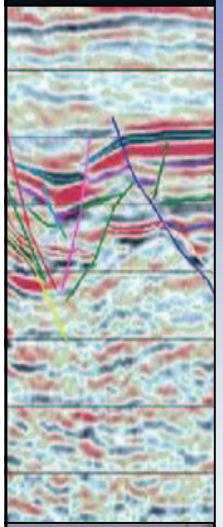
Swarmquakes

Example: Bad Reichenhall

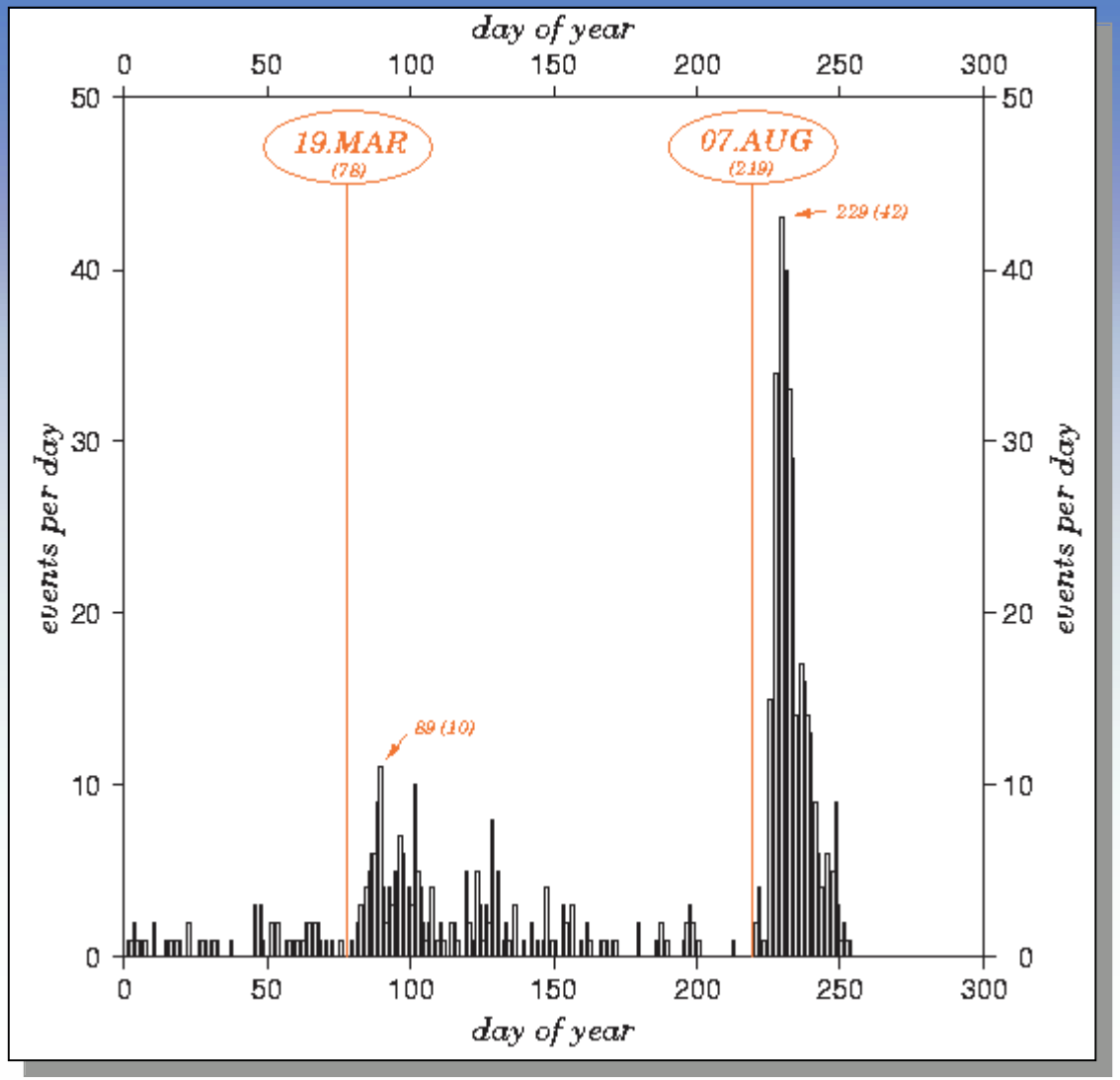


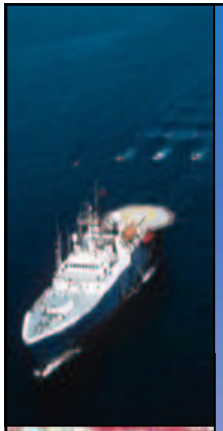


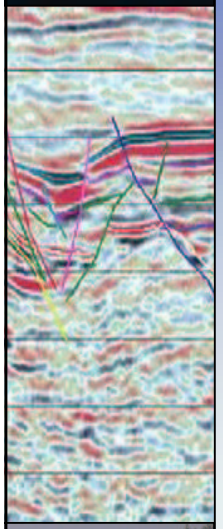




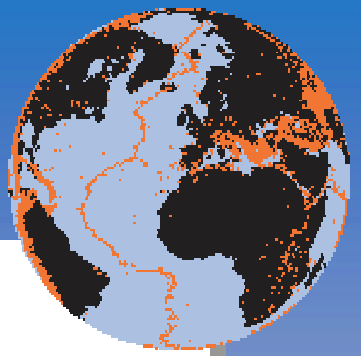
Swarmquakes
Example: Bad Reichenhall

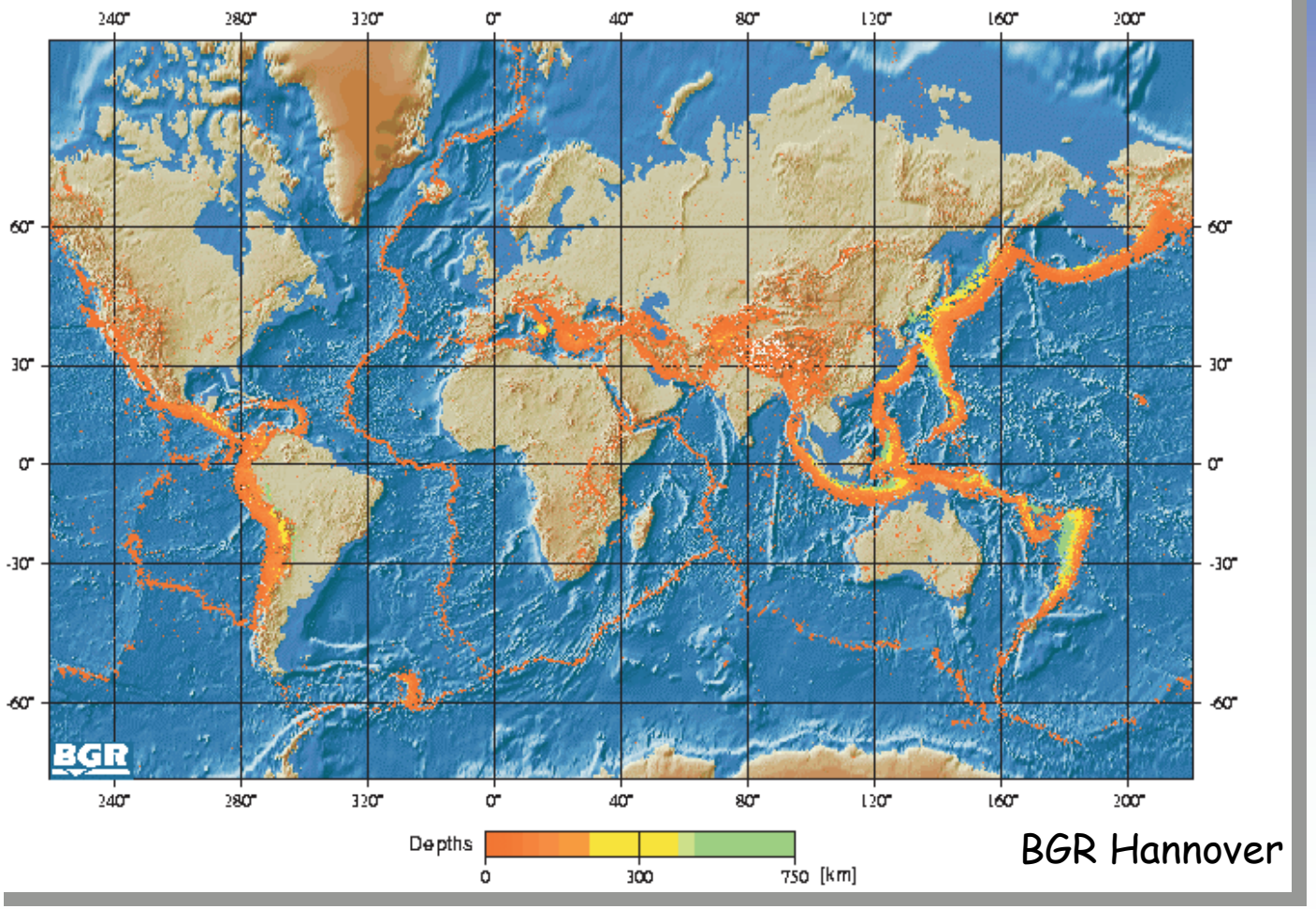




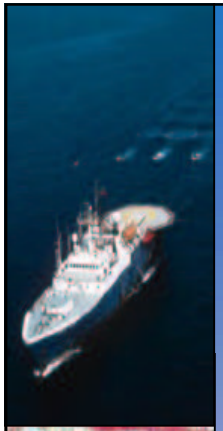


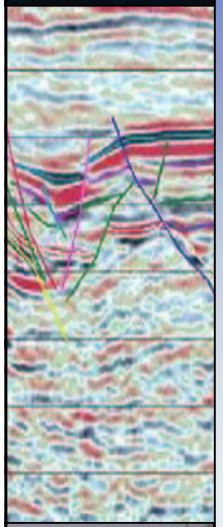
Earthquakes around the Globe





BGR Hannover





Earthquake location

What do we have?

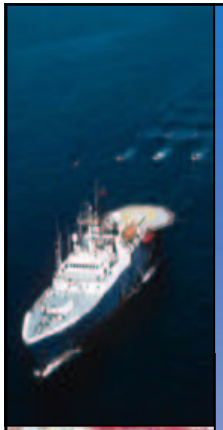
- Arrival times of P and S waves at various seismic stations

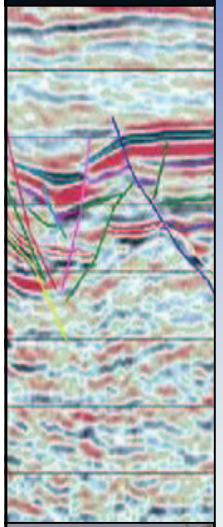
What do we want to know?

- origin time of the earthquake
- the epicenter and depth

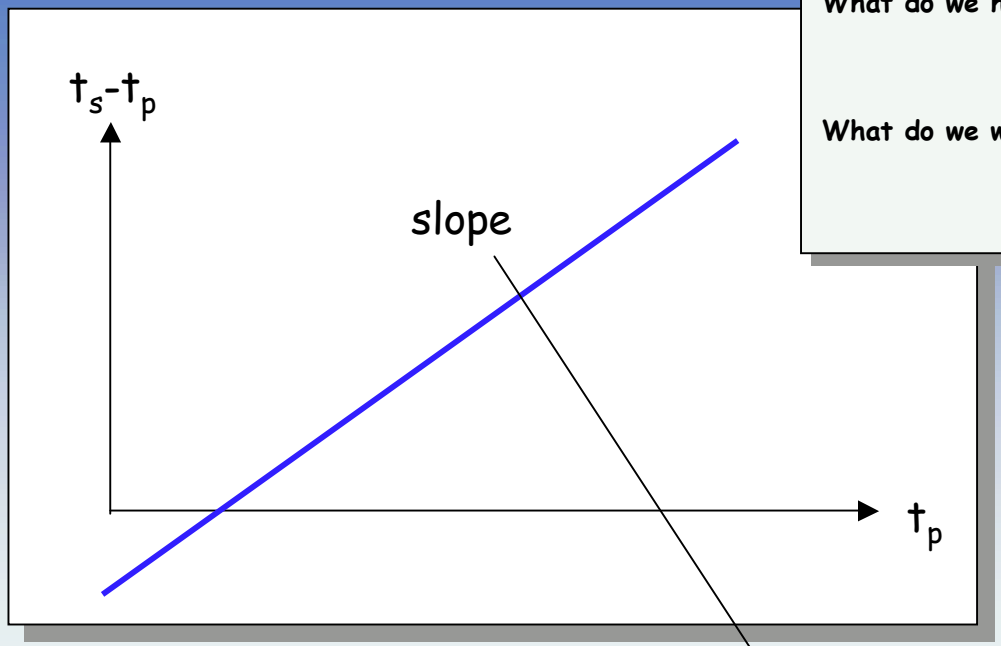
Let us assume the earthquake happened at time t_0 and we know the seismic wave velocities of the ground to be v_p (P-waves) and v_S (S-waves). When we record an earthquake at a distance Δ we have

$$v_P = \frac{\Delta}{t_P - t_0}, \qquad v_S = \frac{\Delta}{t_S - t_0}$$





Wadati diagram



What do we have?

- Arrival times of P and S waves at various seismic stations

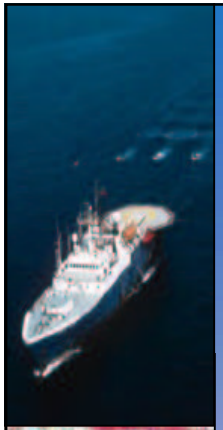
What do we want to know?

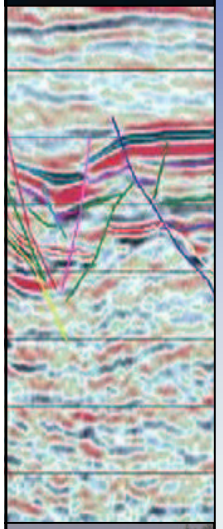
- origin time of the earthquake
- the epicenter and depth

... after combining and rearranging ...

$$(t_S - t_P) = (\frac{v_P}{v_S} - 1)(t_P - t_0)$$

$$y = a \quad x$$





Earthquake location

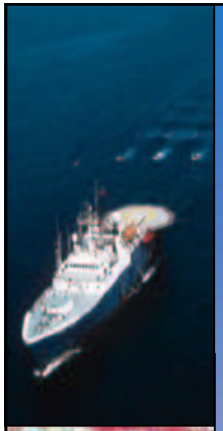
With the slope v_p/v_s-1 of the diagram we can get the v_p/v_s ratio, again after rearranging we can calculate the origin time t_0 of the earthquake

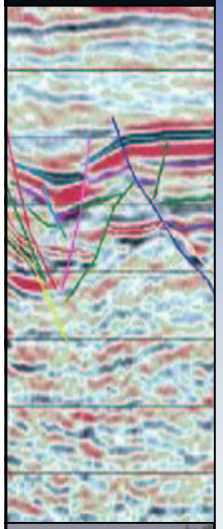
$$t_0 = t_P - \frac{t_S - t_P}{\frac{v_P}{v_S} - 1}$$

and the distance of the earthquake from each receiver i with P arrival time t_{Pi}

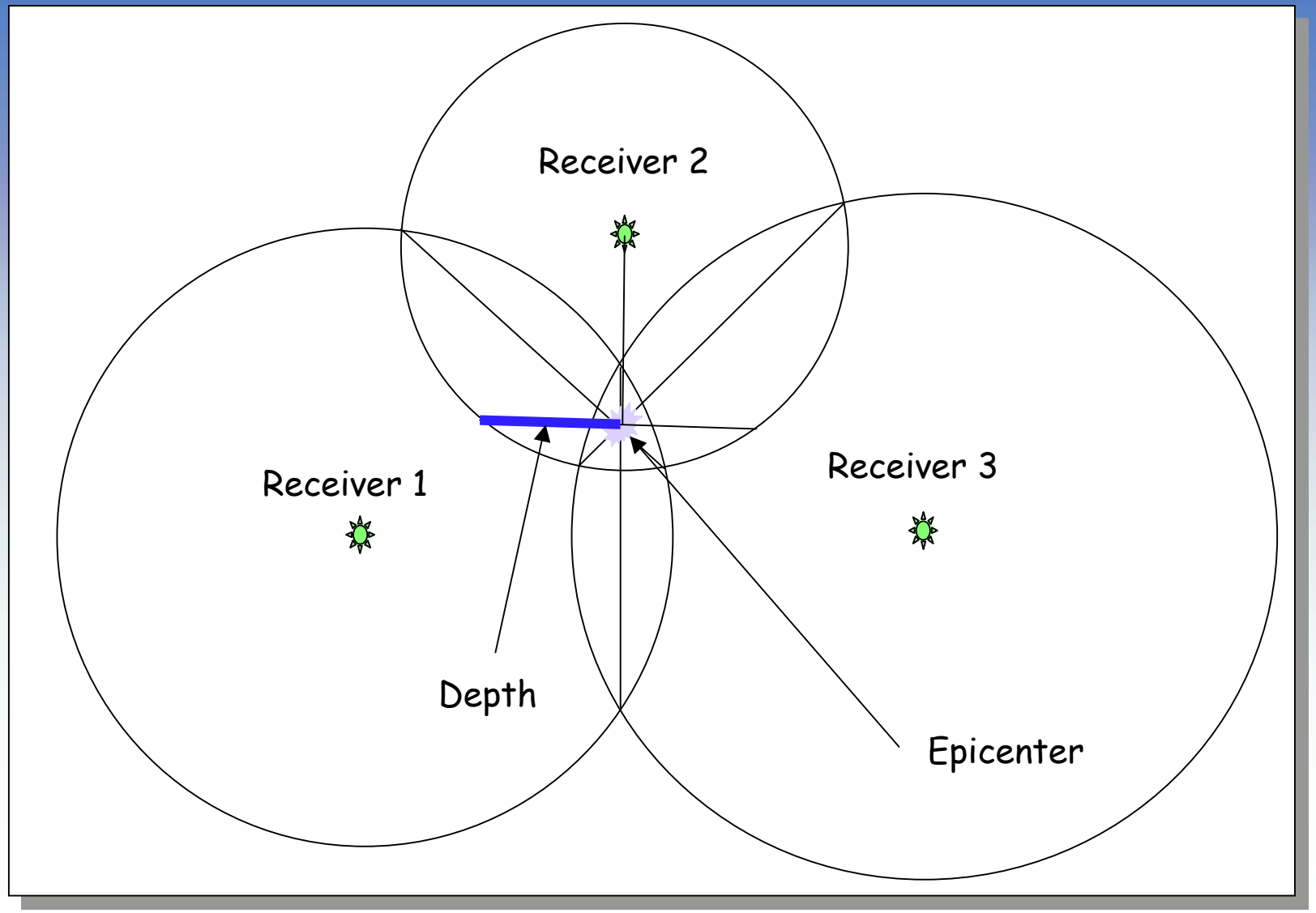
$$\Delta_i = v_P (t_{Pi} - t_0)$$

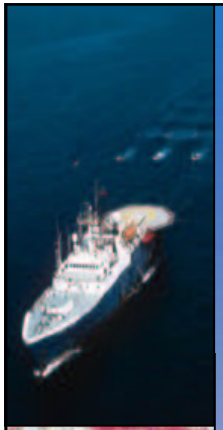
But how can we determine epicenter and depth?

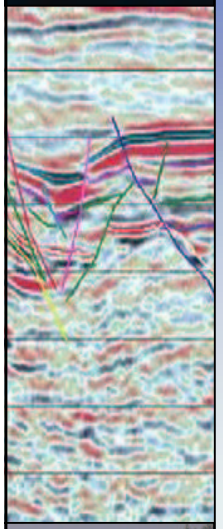




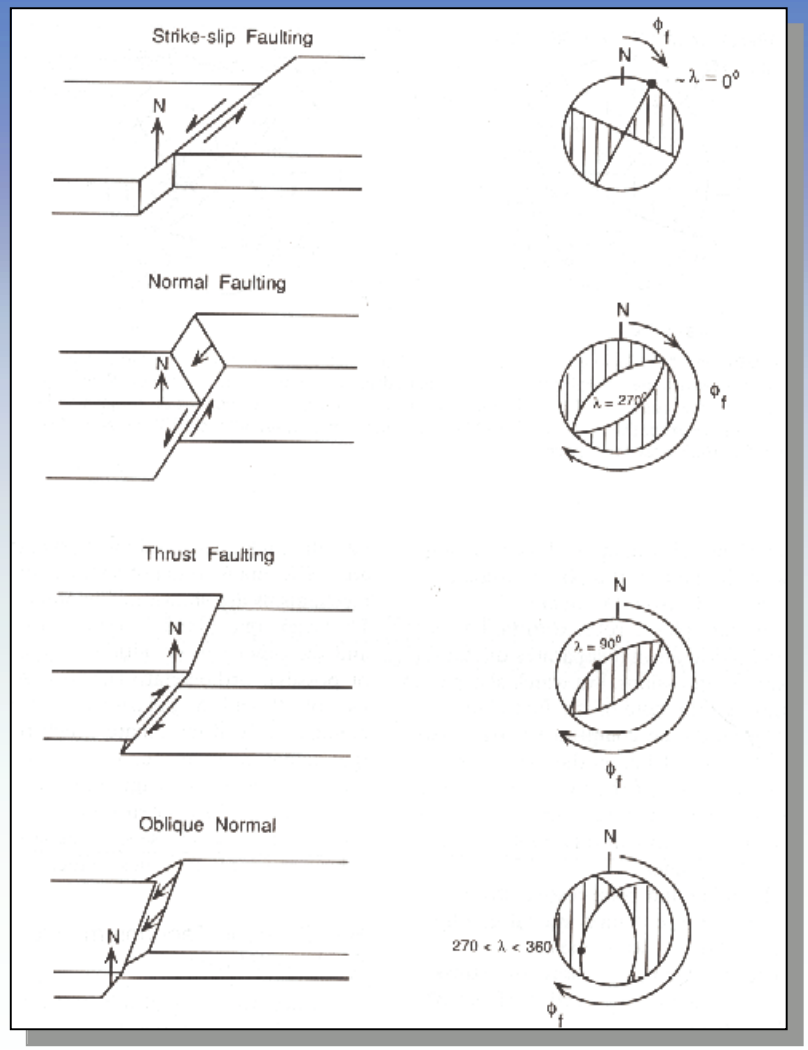
Earthquake location – epicenter and depth



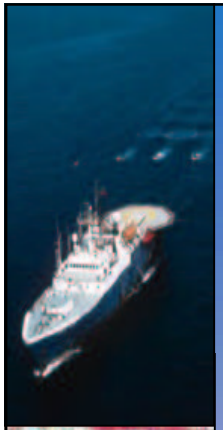


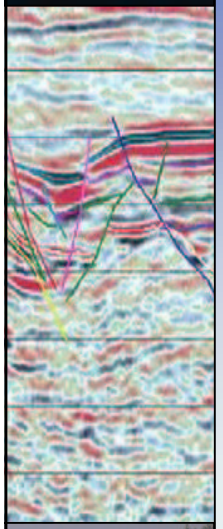


Fault types



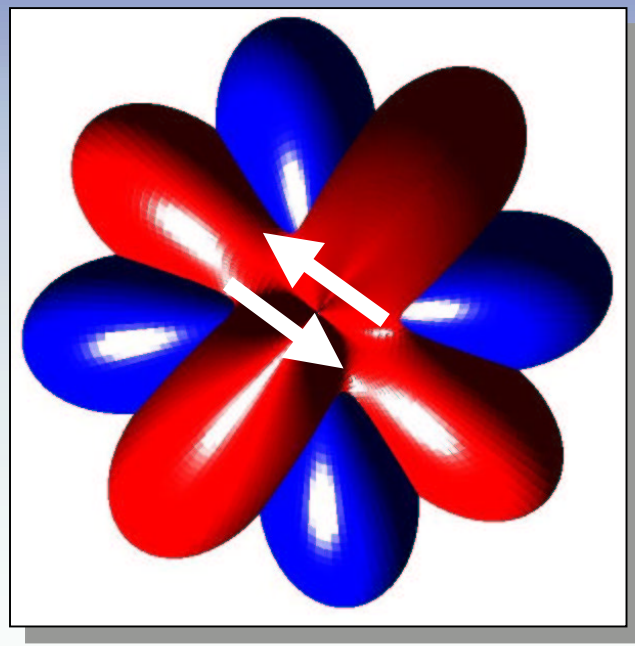
Basic fault types and their appearance in the focal mechanisms. Dark regions indicate compressional P-wave motion.

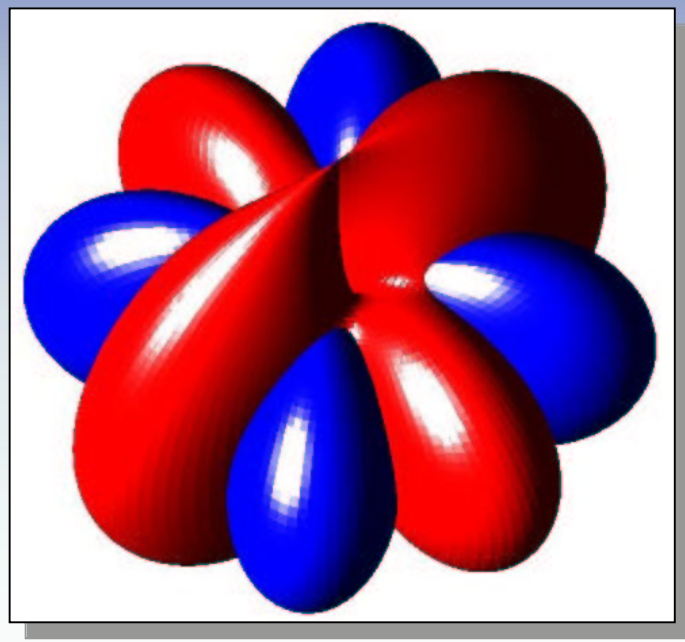


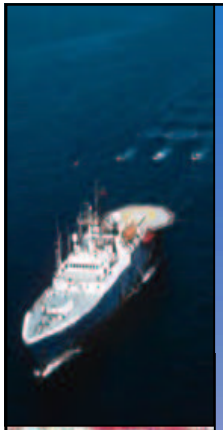


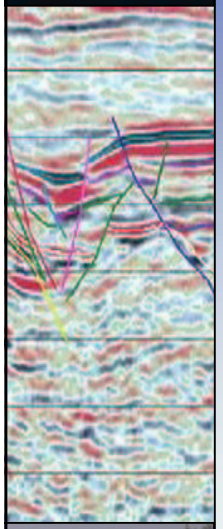
Radiation pattern

Far field P – blue
Far field S - red

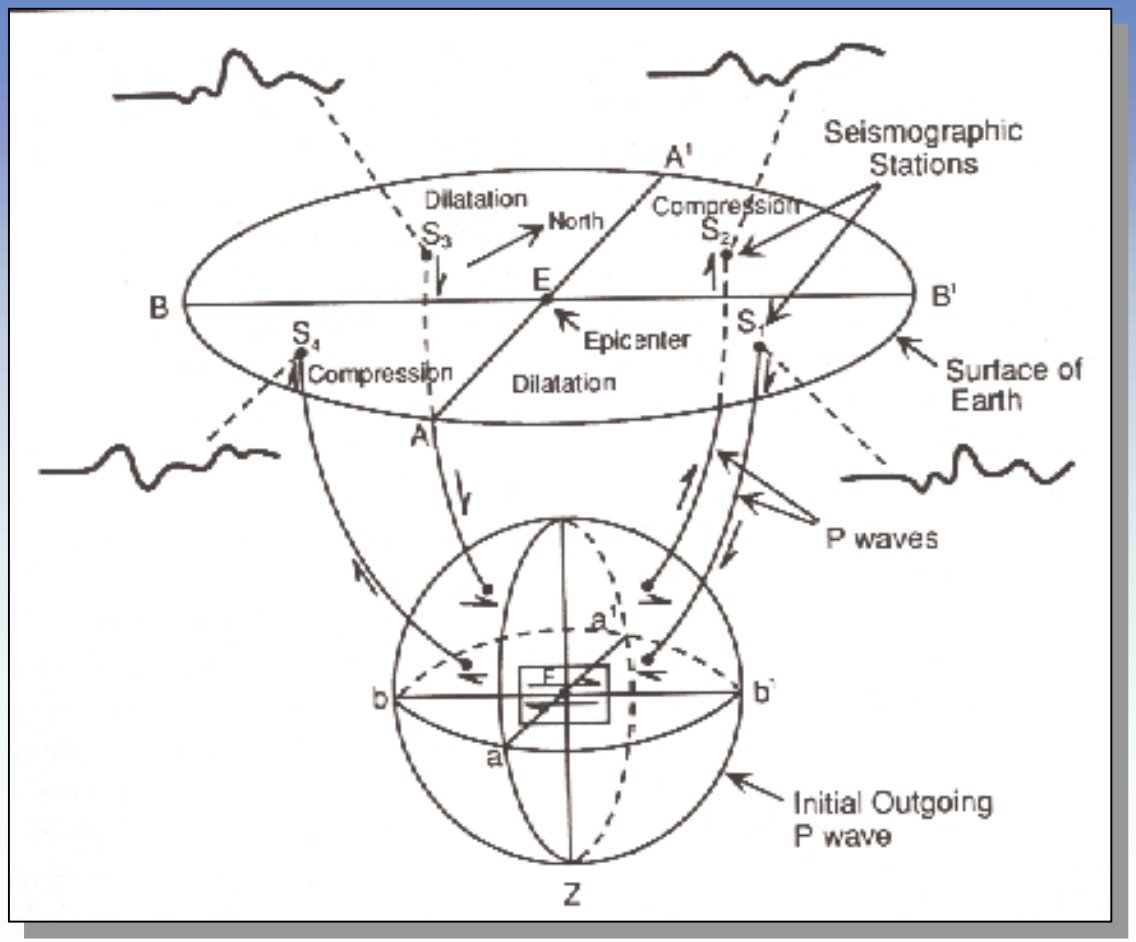






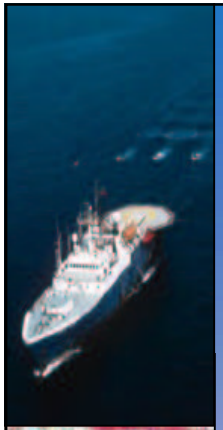


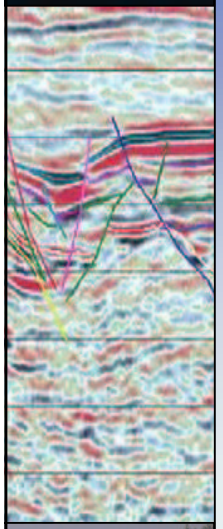
Radiation from shear dislocation



First motion of P waves at seismometers in various directions.

The polarities of the observed motion is used to determine the point source characteristics.





Beachballs and moment tensor

Moment Tensor	Beachball	Moment Tensor	Beachball
$\frac{1}{\sqrt{3}}\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$		$-\frac{1}{\sqrt{3}}\begin{pmatrix}1&0&0\\0&1&0\\0&0&1\end{pmatrix}$	
$-\frac{1}{\sqrt{2}}\begin{pmatrix}0&0&0\\0&0&1\\0&1&0\end{pmatrix}$		$\frac{1}{\sqrt{2}}\begin{pmatrix}0&0&0\\0&1&0\\0&0&-1\end{pmatrix}$	
$\frac{1}{\sqrt{2}}\begin{pmatrix}0&1&0\\1&0&0\\0&0&0\end{pmatrix}$		$\frac{1}{\sqrt{2}}\begin{pmatrix}0&0&1\\0&0&0\\1&0&0\end{pmatrix}$	
$\frac{1}{\sqrt{2}}\begin{pmatrix}1&0&0\\0&-1&0\\0&0&0\end{pmatrix}$		$\frac{1}{\sqrt{2}}\begin{pmatrix}1&0&0\\0&0&0\\0&0&-1\end{pmatrix}$	
$\frac{1}{\sqrt{6}}\begin{pmatrix}1&0&0\\0&1&0\\0&0&-2\end{pmatrix}$		$\frac{1}{\sqrt{6}}\begin{pmatrix}1&0&0\\0&-2&0\\0&0&1\end{pmatrix}$	
$\frac{1}{\sqrt{6}}\begin{pmatrix}-2&0&0\\0&1&0\\0&0&1\end{pmatrix}$		$-\frac{1}{\sqrt{6}}\begin{pmatrix}-2&0&0\\0&1&0\\0&0&1\end{pmatrix}$	

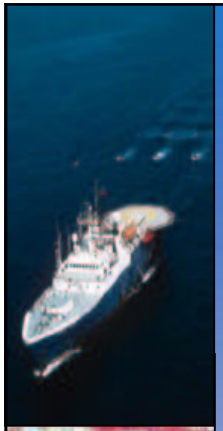
explosion - implosion

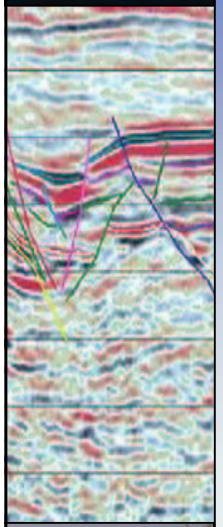
vertical strike slip fault

vertical dip slip fault

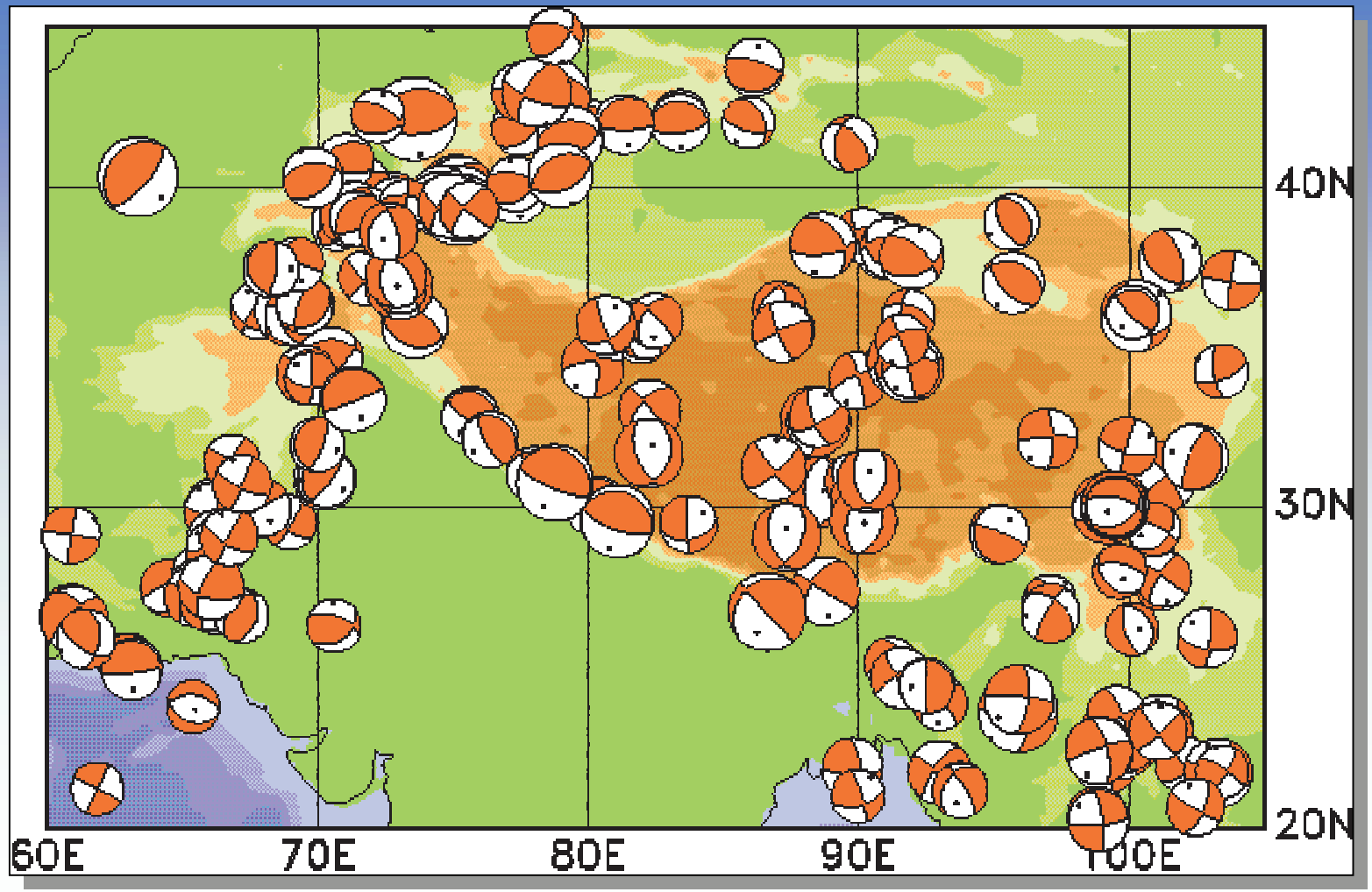
45° dip thrust fault

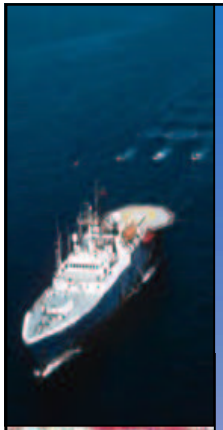
compensated linear vector dipoles

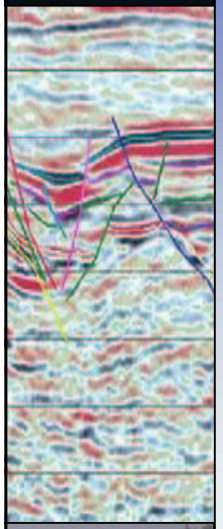




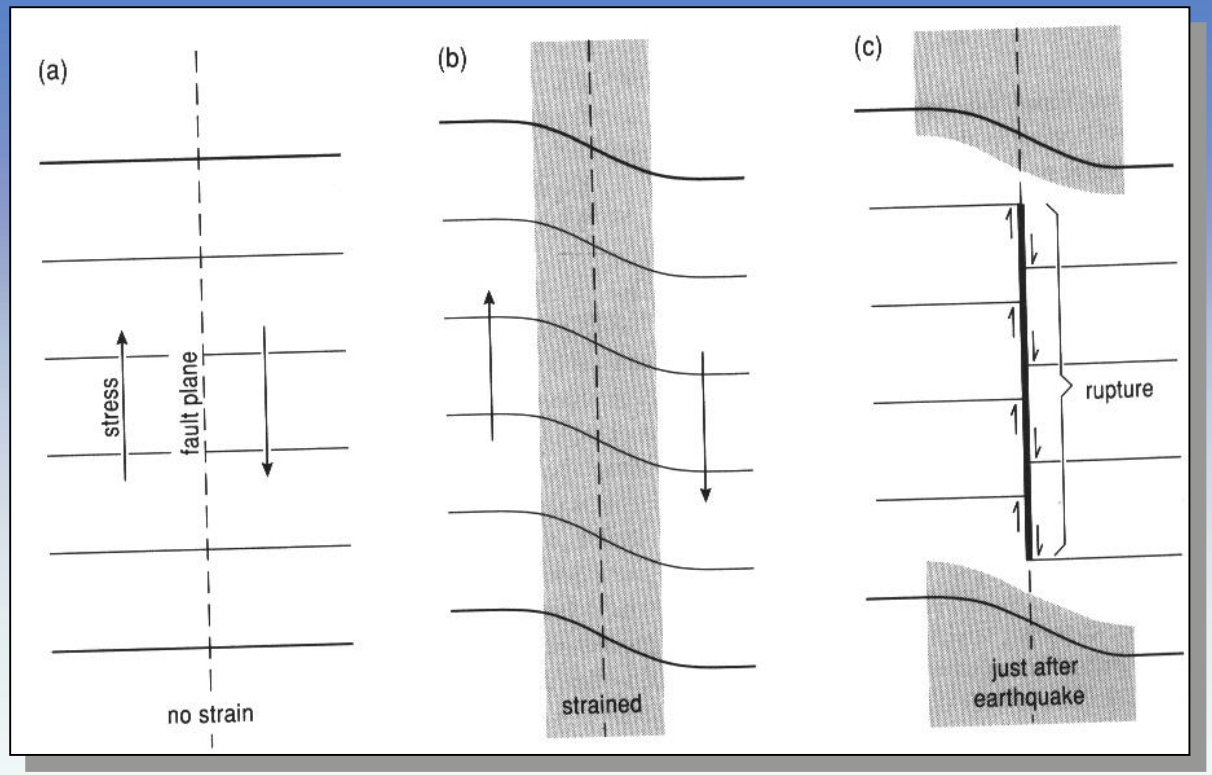
Beachballs - Himalaya



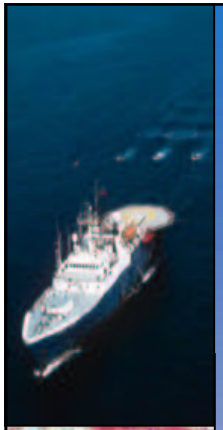


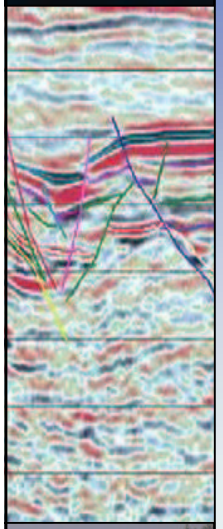


Elastic rebound (Reid, 1910)

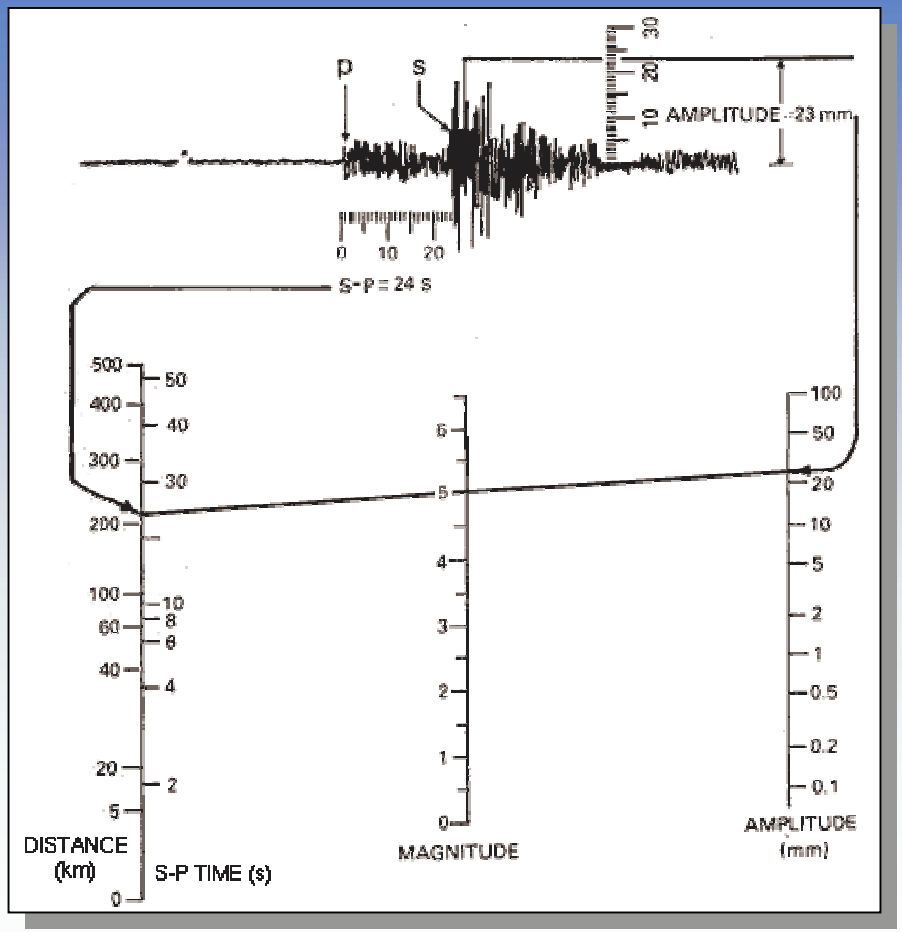


We need to relate the size of the (observed) displacement with the size (magnitude, power strength) of earthquakes: How can we quantify earthquakes?





Richter Scale

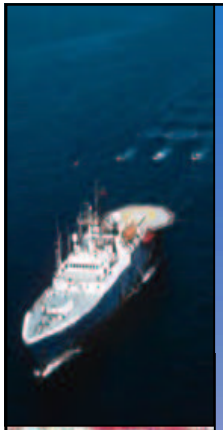


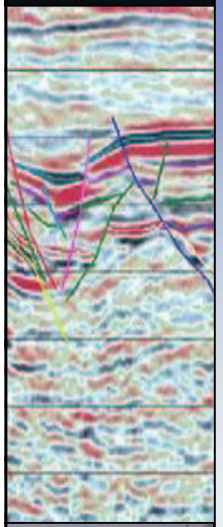
Determination of the magnitude of an earthquake graphically.

$$M_L = \log_{10} A(mm) + (\text{Distance correction factor})$$

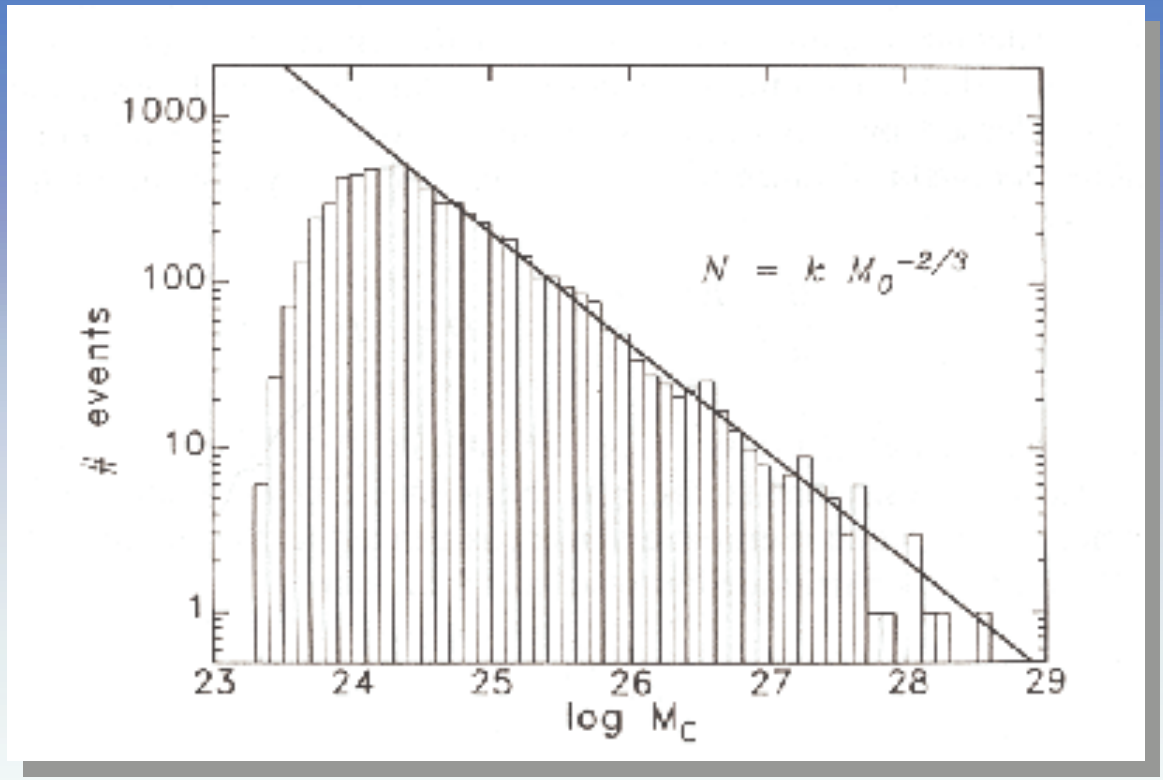
Mercalli Intensity and Richter Magnitude

Magnitude	Intensity	Description
1.0-3.0	I	**I.** Not felt except by a very few under especially favorable conditions.
3.0 - 3.9	II - III	**II.** Felt only by a few persons at rest, especially on upper floors of buildings. **III.** Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0 - 4.9	IV - V	**IV.** Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. **V.** Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5.0 - 5.9	VI - VII	**VI.** Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. **VII.** Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
6.0 - 6.9	VII - IX	**VIII.** Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. **IX.** Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	VIII or higher	**X.** Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. **XI.** Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. **XII.** Damage total. Lines of sight and level are distorted. Objects thrown into the air.

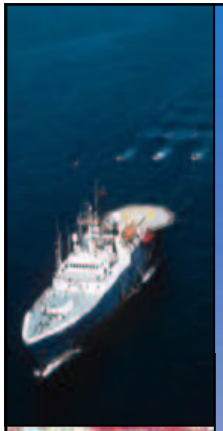


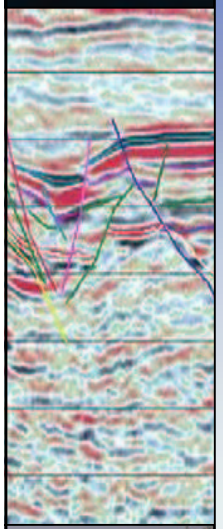


Earthquake statistics
The Gutenberg Richter Law

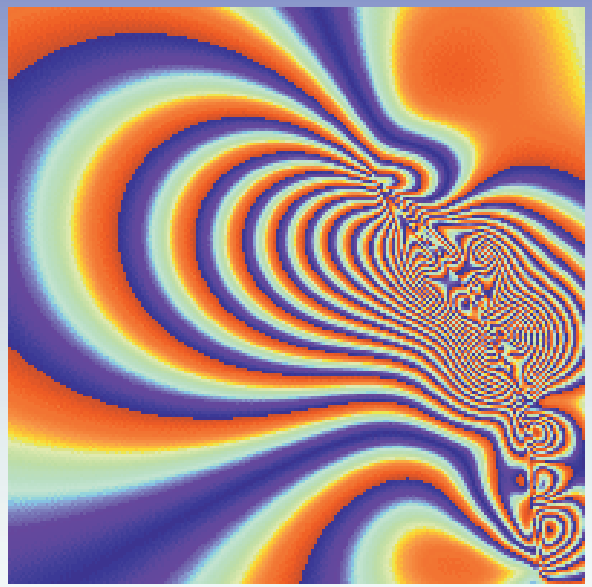


Number of earthquakes as a function of seismic moment from global data sets for shallow events.

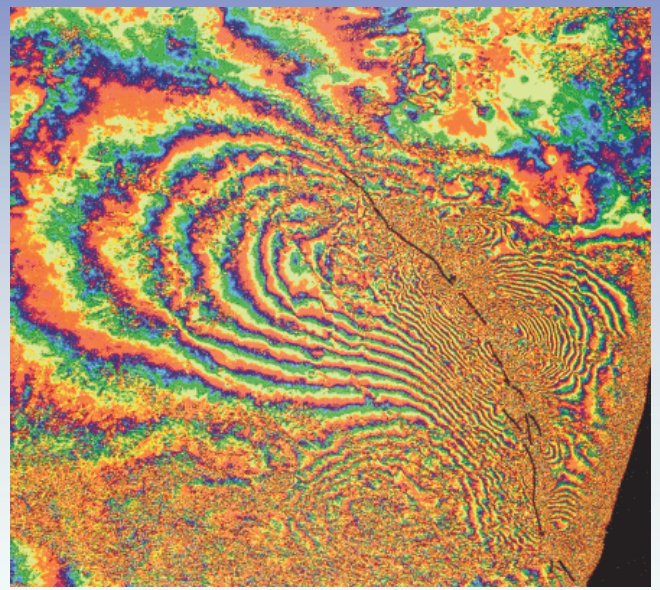




Co-seismic deformation

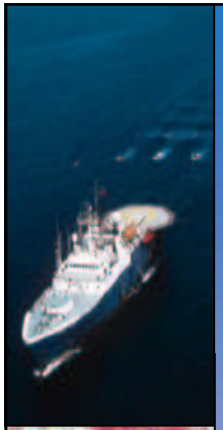


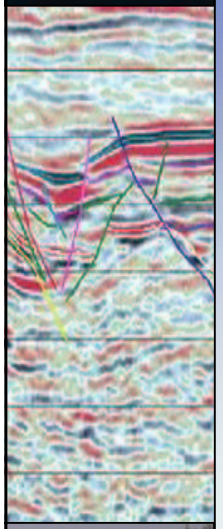
Simulated deformation



Observed deformation

Source Kim Olsen, UCSB





Summary – Seismology

- The origin time of an earthquake can be determined using the difference between P- and S-velocities (Wadati diagram)
- the epicenter and depth of an earthquake can be estimated graphically using the distances of each station from the earthquake
- The magnitude of an earthquake is determined as the logarithm of the local displacement and a correction factor (Richter scale)
- An earthquake is characterized by the orientation of a fault plane and the slip direction
- These geometrical properties can be determined from information in the radiation pattern of P and S waves
- The frequency of earthquakes as a function of magnitude is governed by the Gutenberg-Richter Law (log-log plot with slope –1)