UNIVERSITY COLLEGE LONDON

EXAMINATION FOR INTERNAL STUDENTS

MODULE CODE : **GEOLGG09**

ASSESSMENT : **GEOLGG09A**
PATTERN

MODULE NAME : **Earthquake Seismology and Earthquake Hazard**

DATE : **30-Apr-15**

TIME : **10:00**

TIME ALLOWED : **2 Hours 30 Minutes**

EARTH SCIENCES GEOLGH07 / GEOLGG09 / GEOLM002

EARTHQUAKE SEISMOLOGY AND EARTHQUAKE HAZARD

Duration: 2 hours 30 minutes

*Answer **THREE** questions. All questions carry equal marks. Where questions comprise more than one part, percentage weightings of marks are given in brackets.*

Question one   **Observational seismology**

You are provided with a broadband seismogram (vertical component [LHZ] of the Global Seismic Network) recorded at Matsushiro, Japan (MAJO) (Latitude: 36.54N; Longitude: 138.21E) from an earthquake (M=7.6, depth 10 km) that occurred, roughly due west in Kashmir, Pakistan, 34.49N 73.63E, at 03:52:37 (GMT) on 8th October 2005 (Fig. 1.1). You are also provided with a Jeffreys-Bullen travel-time diagram (Fig. 1.2).

(a)   Identify the P wave, the S wave and the surface wave trains wherever they occur on the seismogram. Annotate the plot, making clear your reasons for your identifications. (Hand in the figure along with your answer book.)

[40%]

(b)   Describe how particle motions on the seismogram relates to, 1) movement of the earthquake fault and, 2) the general direction from which the signal came.

[20%]

(c)   Use the Jeffreys-Bullen travel-time diagram to calculate the epicentral distance (in degrees) of the earthquake, making use of the time-difference between the arrival of different phases.

Discuss the sources of the errors.

[20%]

(d)   Use the Jeffreys-Bullen diagram to identify body wave phases on the seismograms.

Comment on the identifications.

[20%]

TURN OVER

GEOLGH07 GG09 M002 – EARTHQUAKE SEISMOLOGY & EARTHQUAKE HAZARD

Question two   **Seismotectonics**

The 2008 eastern Sichuan earthquake with epicentre located in Wenchuan County, had the following fault plane solutions according to the USGS fast moment tensor solution, with moment magnitude, M_w, strike, ϕ, and dip, δ, for each nodal plane:

Date	Region	M_W	ϕ_1	δ_1	ϕ_2	δ_2
06/05/08	31.02N 103.37E	7.9	229°	33°	352°	68°

The earthquake focal depth was 19 km

You are provided with a Schmidt net (Fig. 2.1) and tracing paper. You are also provided with a seismicity map of earthquakes of the Sichuan region (Fig 2.2), a fault map (Fig. 2.3) and and image of Wenchuan in the aftermath of the earthquake (Fig. 2.4).

(a)   Sketch and label the focal mechanism of this earthquake, showing the orientation of the two possible fault planes. Identify the dominant type of faulting for the event. Measure the rake angles (or slip) for each of the nodal planes using your Schmidt net. Label the pressure and tension axes (*i.e.*, the P and T axes).

[40%]

(b)   With the aid of the seismicity map of the epicentral region (Fig. 2.2) and fault map (Fig. 2.3), interpret the focal mechanism and the regional tectonics. Discuss, with the aid of a sketch, the recent earthquake in terms of its magnitude and type of faulting in relation to its regional tectonic setting.

[30%]

(c)   Discuss the factors that led to the high death toll in Wenchuan and total estimated death toll of 90,000 people (see the image of Wenchuan in Fig. 2.4).

[30%]

Question three   **Earthquake observation**

With the aid of labelled diagrams and example earthquakes, discuss how inSAR may be employed to:

   1) determine the mechanics of an earthquake and,
   2) contribute to earthquake preparedness.

[100%]

CONTINUED

Question four **Earthquake magnitude, moment and intensity**

(a) Describe the differences between earthquake magnitude, moment and intensity.

[25%]

(b) Discuss how seismic waves are attenuated and amplified in the Earth.

[25%]

(c) Critically assess engineering models of strong ground motion.

[50%]

Question five **Earthquake statistics**

(a) What are the fundamental assumptions of a Poisson process?
Explain how Poisson statistics can be applied to earthquake hazard.

[30%]

(b) Show that the discrete Gutenberg-Richter distribution, described by

$$\log_{10} N = a - b\,m$$

where N is the number of earthquakes in a magnitude range, m is earthquake magnitude and a and b are constants, can be re-written as a continuous Poisson probability density distribution of the form,

$$f_M(x) = \beta\, e^{-\beta x} .$$

(Hint, set $\beta = b \ln 10$.)

What is the meaning of β ?

[30%]

(c) Discuss why, with reference to a particular region, does the Gutenberg-Richter distribution have such wide applicability in earthquake hazard assessment.

[40%]

END OF PAPER

SUPPLEMENTARY SHEETS FOR

GEOLGG09: Earthquake Seismology and Earthquake Hazard
GEOLGH07: Earthquake Seismology and Earthquake Hazard
GEOLM002: Earthquake Seismology and Earthquake Hazard
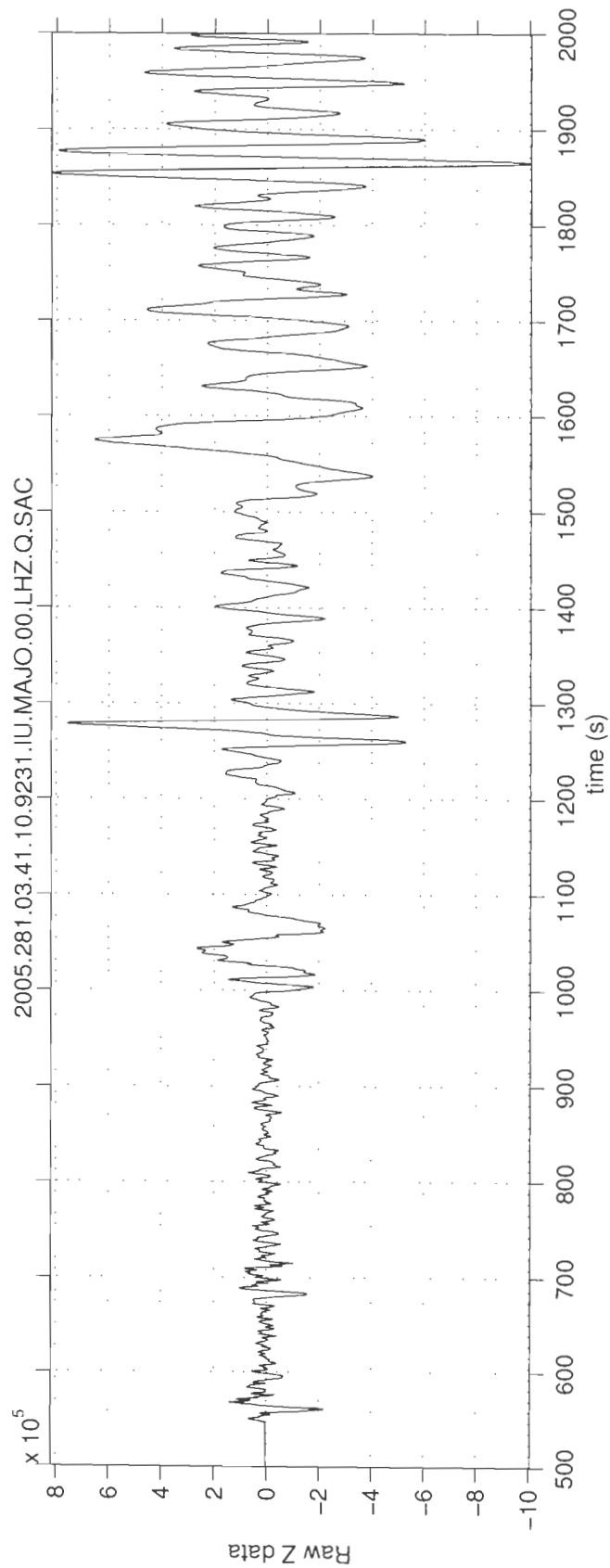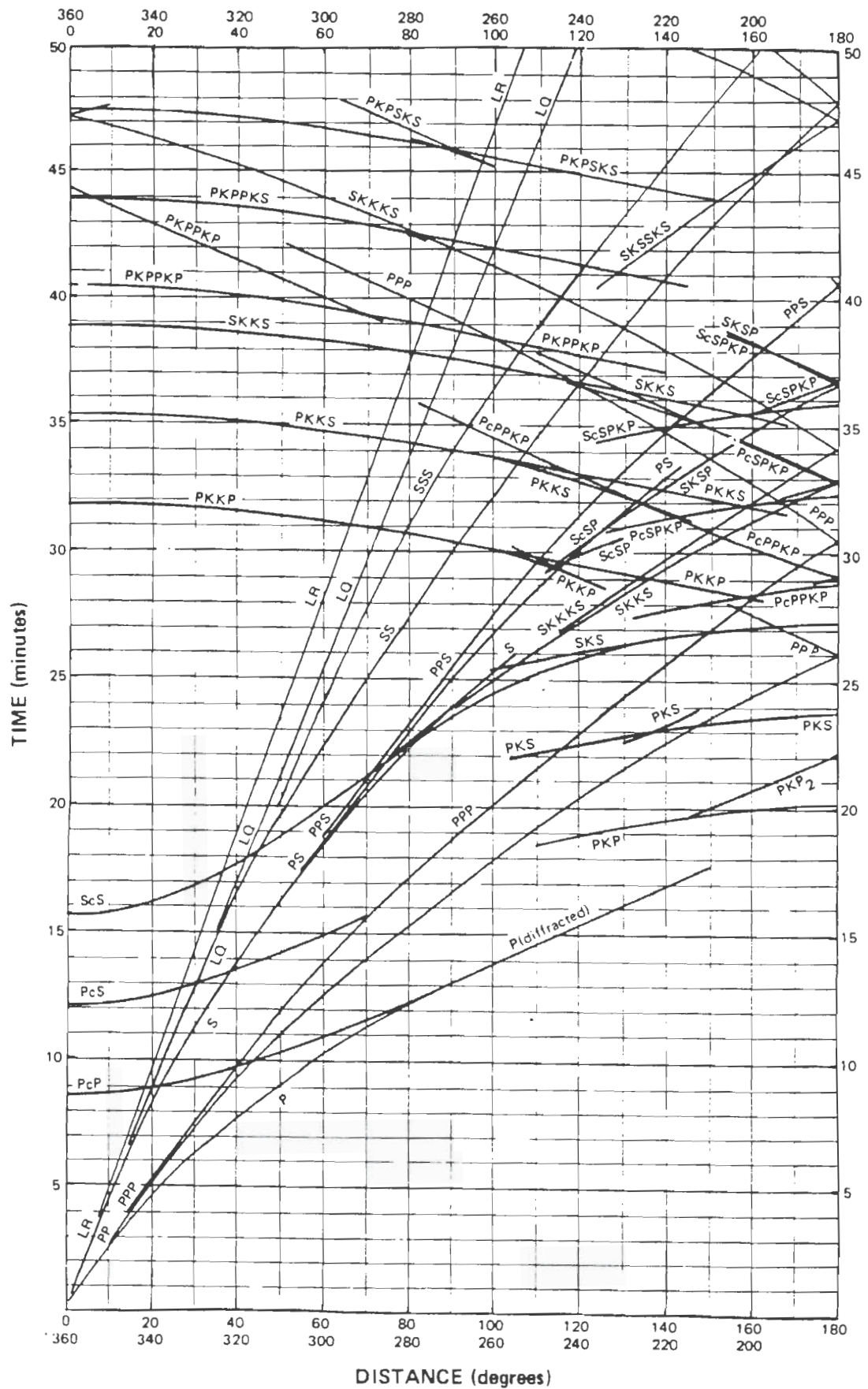
Question one: Observational seismology

Fig. 1.1 Seismogram, vertical component LHZ recorded at MAJO on 8th October 2006. The time origin of the seismogram (t=0) is the time of the earthquake at 03 52 37 (GMT).
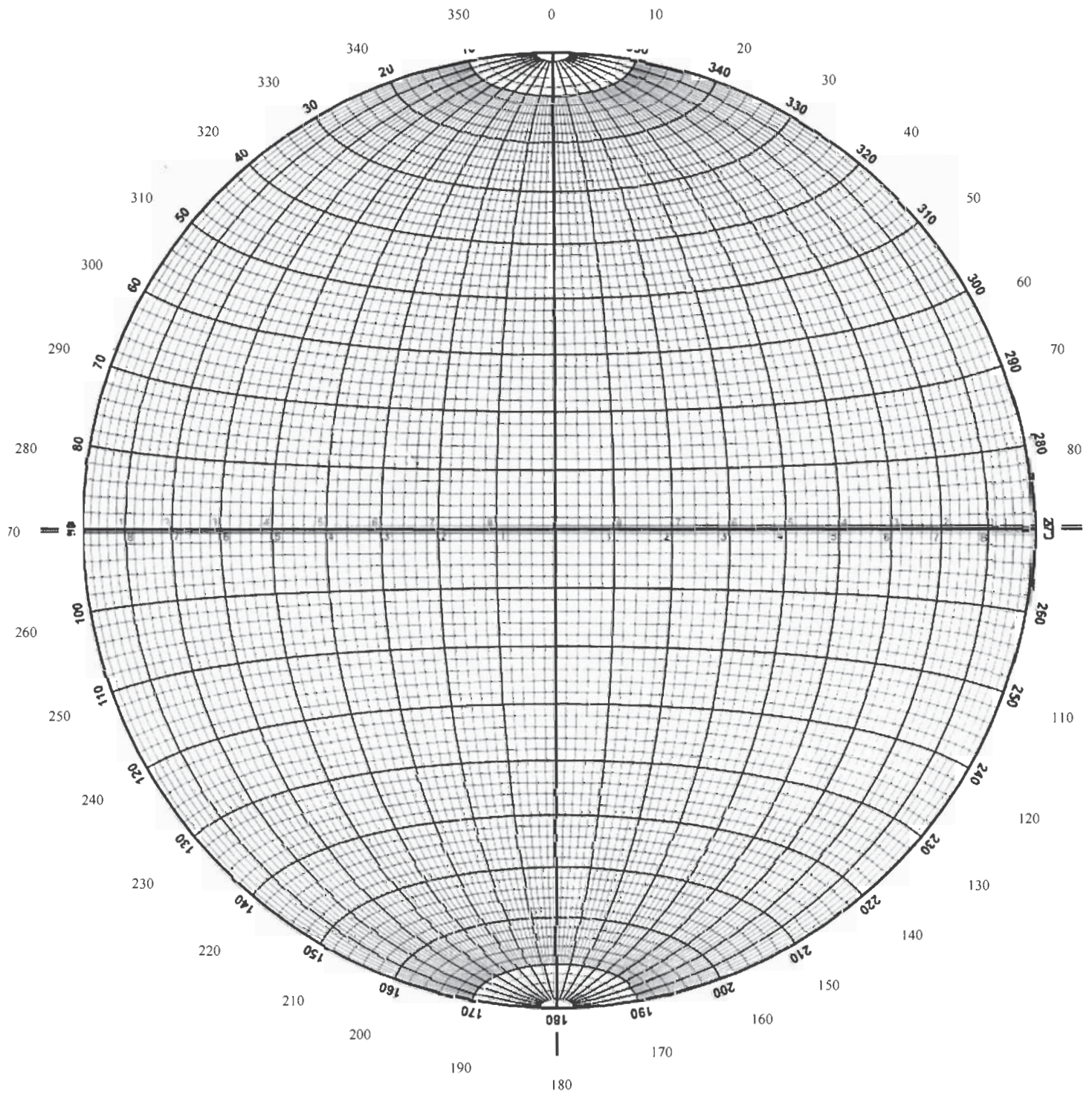
4

Question one: Observational seismology

Fig. 1.2 Jeffreys-Bullen travel-time diagram
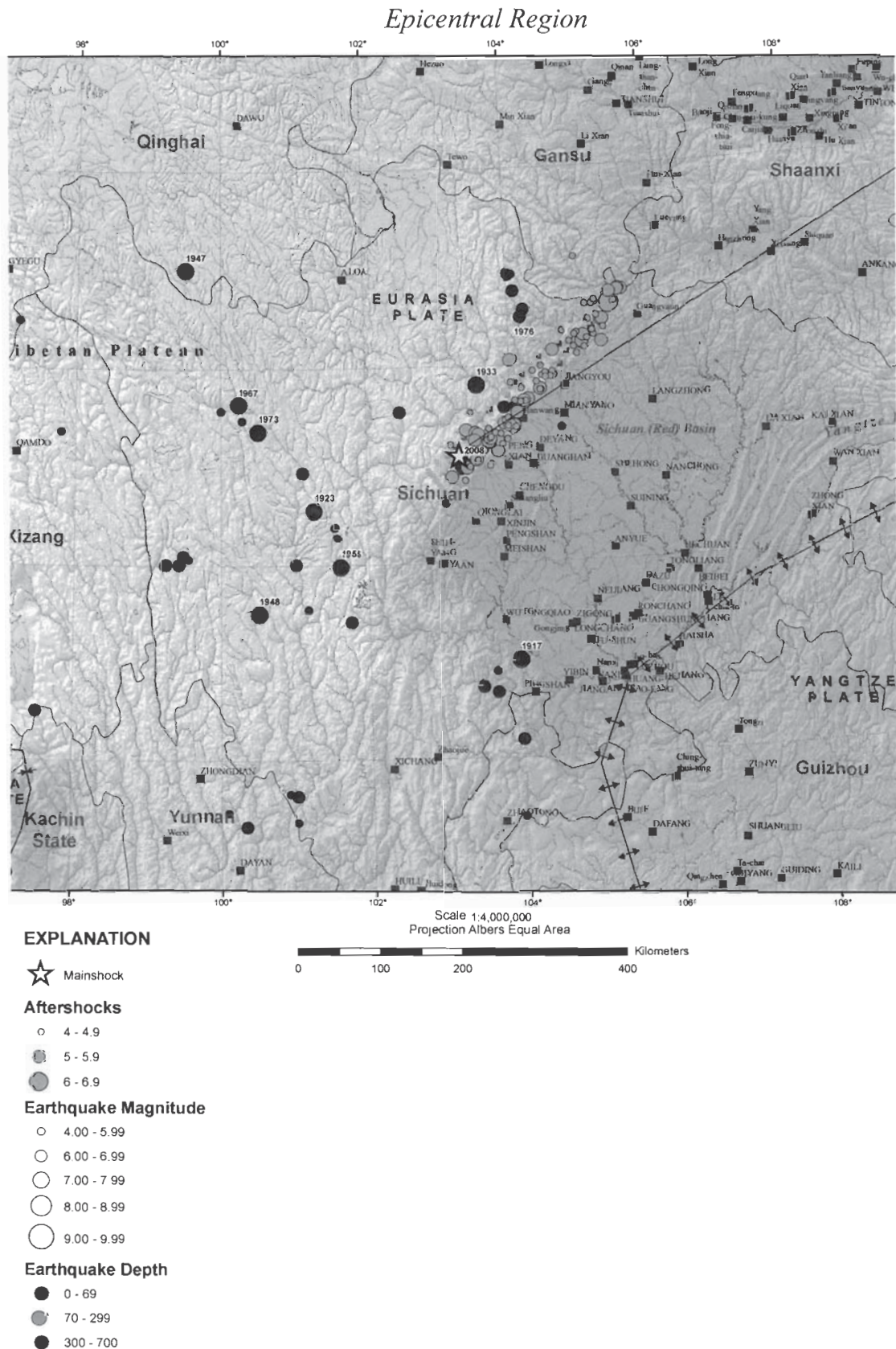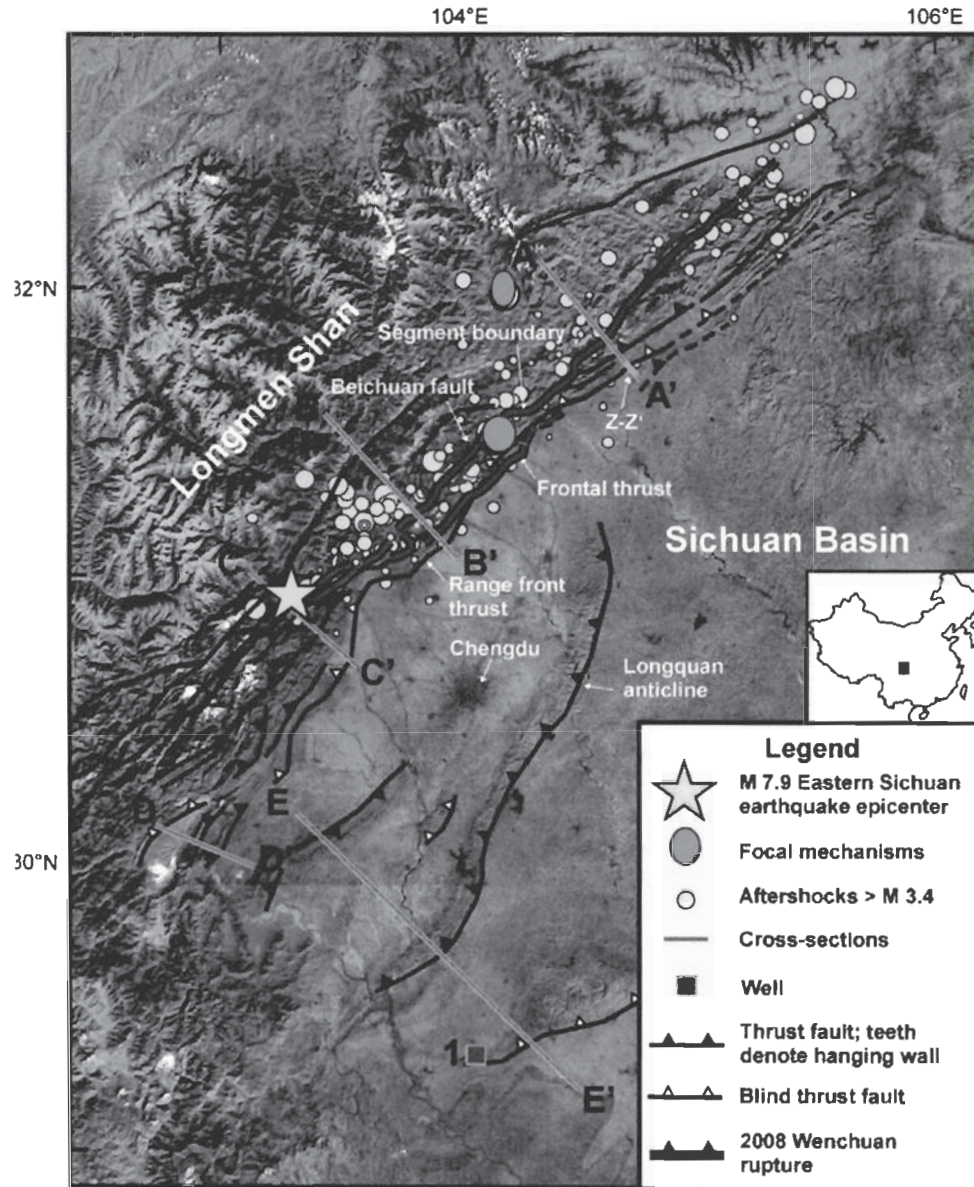
Question two: Seismotectonics

Fig. 2.1 Schmidt net

Question two: Seismotectonics

Fig. 2.2 Seismicity of Epicentral Region

Epicentral Region

Scale 1:4,000,000
Projection Albers Equal Area

EXPLANATION

☆ Mainshock

Aftershocks

o 4 - 4.9

◑ 5 - 5.9

◯ 6 - 6.9

Earthquake Magnitude

o 4.00 - 5.99

O 6.00 - 6.99

◯ 7.00 - 7.99

◯ 8.00 - 8.99

◯ 9.00 - 9.99

Earthquake Depth

● 0 - 69

◑ 70 - 299

● 300 - 700

7

Question two: Seismotectonics

Fig. 2.3 Landsat image of the Longmen Shan and western Sichuan basin, showing the epicentre of the 2008 Wenchuan earthquake, aftershocks, and major faults. (Figure after Hubbard and Shaw, 2010.)

Question two: Seismotectonics

Fig. 2.4 Image of Wenchuan in the immediate aftermath of the 2008 earthquake.