

HUNGARIAN EARTHQUAKE BULLETIN

1996

L. Tóth, P. Mónus, T. Zsíros

CONTRIBUTORS:

M. KISZELY Z. KOSZTYU

 $Bibliographic\ reference$

Tóth, L., P. Mónus and T. Zsíros, 1997. Hungarian Earthquake Bulletin, 1996. GeoRisk, Budapest, 1997, pp. 67.

BUDAPEST 1997

© GeoRisk Ltd.

Arany János u. 57, H-1221 Budapest, HUNGARY Fax: (36 1) 226 4573 * Email: georisk@part.seismology.hu

Apart from any fair dealing for the purpose of study, research, criticism, or review, as permitted under the Copyright Act, no part may be reproduced by any process without written permission.

This work was supported by PAKS NUCLEAR POWER PLANT LTD.

ISSN: 1219-963X

Felelős kiadó: Dr. Tóth László



Back cover page: The first known intensity map; map of destructed area of Mór (Hungary) earthquake of 1810 with an isoseismal (dotted line) compiled by Kitaibel and Tomtsányi in 1814.

CONTENTS

Acknowledgements	2
Introduction	3
1. Summary of 1996 seismicity	5
2. Seismograph Stations in Hungary	7
PAKS Micro seismic Monitoring Network (MMN)	12
Stations operated by GGKI	
MÉV station	
Strong motion stations	
3. List of Origins / Hypocentre Parameters	15
Method for hypocentre parameter determination	
Crustal velocity model	
Phase data	
4. Significant Earthquakes in 1996	31
9 January 1996 - Baden (Austria)	
29 September 1996 - Füzesgyarmat	
21 October 1996 - Dunaharaszti	
References	49
APPENDIX A: Questionnaire used for collecting macroseismic information .	51
APPENDIX B: European Macroseismic Scale (EMS)	57
APPENDIX C: Significant Earthquakes of the World, 1996	61

ACKNOWLEDGEMENTS

The project is sponsored by *Paks Nuclear Power Plant Ltd. (PART)* under *GeoRisk*'s contract No. B402F-4-02/96/k.

Special thanks due to the *Geodetic and Geophysical Research Institute (GGKI)* who is responsible for the national seismological network and whose cooperation was utmost important both for PA RT and GeoRisk.

Other organisations supplying data for this Bulletin are:

Paks Nuclear Power Plant Ltd. (PA RT)
Ministry of Foreign Affairs
Ministry of Environment
MOL Rt.
GeoRisk Ltd.
GEOS BT.

Data interchange with a number of seismic stations from the neighbouring countries contributed to the accuracy of locations of the events. Those are Austria, Croatia, Czech Republic, Germany, Romania, Slovakia and Slovenia.

INTRODUCTION

The subject of earthquake protection focuses public attention in many countries. The Pannonian Basin area is among those with moderate seismic risk, having experienced some severe damaging earthquakes in the past, like that of Komárom (1763, 1783, 1806, 1851), Mór (1810), Jászberény (1868), Kecskemét (1908,1911), Eger (1925), Dunaharaszti (1956) and Berhida (1985). The widely accepted opinion today on preventing the consequences of such, if rare, events is that research should concentrate on the scientific knowledge of the earthquake process, local geology and tectonics, as well as on the development and improvement of seismic monitoring networks.

After substantial progress with development of the Hungarian earthquake monitoring network in 1995, there has been no significant changes in 1996. A network of eleven seismograph stations supplemented by the access to data from three national stations enabled us to detect local earthquakes with relatively low magnitude threshold and calculate their hypocentre parameters with high certainty.

This bulletin is based on all available earthquake related data provided by different organisations. The geographic region covered is bounded by latitudes 45.5-49.0N and longitudes 16.0-23.0E.

1.

SUMMARY OF 1996 SEISMICITY

1996 was a particularly quiet year for Hungarian seismicity. There were 14 earthquakes (1.8≤ML≤3.2) located within Hungary. Three earthquakes were reported as felt, of those one in Austria, but none of them caused any damage. The highest magnitude (ML) assigned to a shock was 3.2 for an earthquake at Füzesgyarmat followed by five smaller aftershocks.

The highest intensity reported during the year was 4-5 EMS. No earthquake damage was reported.

Reviewing the more notable earthquakes of the year in chronological order, a shock of magnitude 3.6 ML on the 9th of January in Austria produced reports of intensity 3-4 EMS from the Sopron vicinity. The area in which it was felt was about 200-250 km². On September 29th, an earthquake with a magnitude of 3.2 ML was felt slightly in Füzesgyarmat with a maximum intensity of 4 EMS. The main event was preceded by one foreshock with a magnitude of 2.8 ML (some two and half hours earlier) and followed by five aftershocks (2.1-3.1 ML) within six hours. There is speculation that the sequence was induced by filling the nearby natural gas reservoir. On October 21st an earthquake (2.5 ML) in Dunaharaszti gave rise to reports of intensity 4 EMS from South of Budapest.

SEISMOGRAPH STATIONS IN HUNGARY

In 1996, there has been no substantial changes with the Hungarian earthquake monitoring network compared to the previous year.

The Microseismic Monitoring Network (MMN) established by the *Paks Nuclear Power Plant Ltd.* in 1995, has been operational throughout the year. Based on the experience gained during nearly two years of operation three stations of the local network have been reseated and moved to geologically better locations.

In addition to the information from the eleven station PAKS MMN, data is contributed by three stations operated by the Seismological Observatory, Geodetic and Geophysical Research Institute (GGKI). Of those, one belongs to the Ministry of Foreign Affairs and is operated in global cooperation for nuclear test ban monitoring purposes.

Another station was partially available on ad hoc basis for origin determination, belonging to *Mecseki Ércbányászati Vállalat (MÉV)* and operated by *GEOS BT*.

Data interchange with stations from the neighbouring countries and international data centres were also important.

The estimated detection capabilities of the present network with average noise conditions, supposing that at least four stations is needed for origin determination, is typically around 1.5-2.0 ML, somewhat lower in the middle of the country and a little higher towards the border regions. (See Fig. 2.3) This means that in most parts of the country it is very unlikely that felt events go undetected.

During the reporting period we also had access to five strong motion accelerograph stations belonging to and operated by different organisations such as *Paks Nuclear Power Plant, GeoRisk, GGKI, Ministry of Environment* and *MOL RT*.

Table 2.1. Seismic stations, instrumentation and lithology

Code	Latituda (N)	Longitude (E)	Ejőyarja 10	les ellen	Type of Station	Sunsor type (2)		
BUD	47.4836	19.0239	196	dolomite	3C LP	Kirnos	A - C	GGKI
BUDA*	47.4836	19.0239	196	dolomite	3C SP	LE-3D	D - E	GR
GYL	46.5981	21.1718	92	sand	3C SP	SS-1	D-E	GGKI
MEV	46.1128	18.1123	400	limestone	3C SP	SS-1	D-E	GEOS
PKS0	46.5743	18.8449	100	sand	3C SP	LE-3D	D - E	GR
PKS1*	46.5940	18.5786	200	loess	3C SP	LE-3D	D - E	GR
PKS2	46.4920	19.2131	106	sand	3C SP	LE-3D	D - E	GR
PKS3*	46.7869	19.0663	105	loess	3C SP	LE-3D	D · E	GR
PKS4	46.2340	18.4635	220	limestone	3C SP	LE-3D	D · E	GR
PKS5*	46.8092	19.5547	110	sand	3C SP	LE-3D	D - E	GR
PKS6	46.5998	19.5645	120	sand	3C SP	LE-3D	D-E	GR
PKS7	47.0473	19.1609	95	mud	3C SP	LE-3D	D · E	GR
PKS8	46.8787	18.6765	135	rhyolite tuff	3C SP	LE-3D	D · E	GR
PKS9	46.5870	18.2789	240	loess	3C SP	LE-3D	D · E	GR
PKSc*	47.3806	18.4371	200	dolomite	3C SP	LE-3D	D - E	GR
PKSm*	46.2119	18.6413	170	granite	3C SP	LE-3D	D · E	GR
PKSn*	46.8972	19.8673	110	sand	3C SP	LE-3D	D - E	GR
PSZ	47.9184	19.8944	940	andesite	3C BB	STS-2	D - C	GGKI
SOP	47.6833	16.5583	260	gneiss	3C SP	SS-1	D - E	GGKI

^{(1) 1}C - one component vertical seismometer, 3C - three component seismometer

(*) BUDA off date 1996/06/30

PKS1 off date 1996/11/21

PKSc on date 1996/12/20

PKS3 off date 1996/12/16

PKSm on date 1996/11/21

PKS5 off date 1996/11/19

PKSn on date 1996/11/20

SP - short period seismometer, BB - broad band seismometer, SM - strong motion accelerograph

⁽²⁾ STS-2 - Streckeisen broad band seismometer, LE-3D - Lennartz three directional 1Hz geophone, SS-1 - Kinemetrics 1Hz seismometer, Kirnos - 12 s long period seismometer

⁽³⁾ A - analogue, D - digital, C - continuous recording, E - event recording

⁽⁴⁾ GEOS - GEOS BT., GGKI - Institute of Geodesy and Geophysics, GR - GeoRisk Ltd., PART - Paks Nuclear Power Plant Ltd.

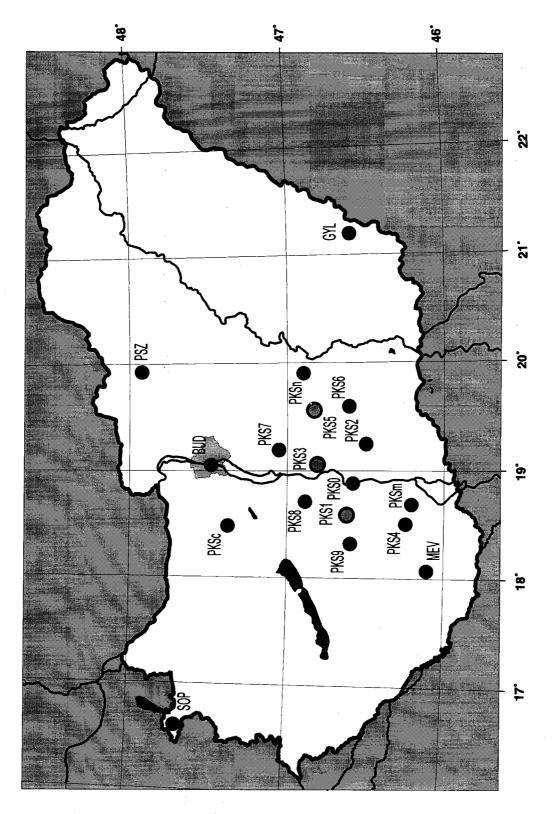


Figure 2.1. Seismograph stations in Hungary (See Table 2.1. for details)

Table 2.2. Strong motion accelerograph stations

Code	Latitule (N)			Alion	Typer opfo- station	Sonson (g/jb	Ros	
ALGY	46.3332	20.2092	90	loose sand	3C SM	AC-23	D · E	GR
BOD	47.322	18.241	250	limestone	3C SM	AC-23	D · E	GR
BPGY	47.4836	19.0239	196	dolomite	3C SM	AC-23	D·E	GGKI
PAKB	46.5743	18.8587	100	sand	3C SM	AC-23	D - E	PART
PAKK	46.5743	18.8449	100	loose sand	3C SM	AC-23	D · E	GGKI

- (1) 1C one component vertical seismometer, 3C three component seismometer

 SP short period seismometer, BB broad band seismometer, SM strong motion accelerograph
- (2) AC-23 triaxial accelerometer package (full scale 0.5g)
- (3) A analogue, D digital, C continuous recording, E event recording
- (4) GGKI Institute of Geodesy and Geophysics, GR GeoRisk Ltd., PART Paks Nuclear Power Plant Ltd.

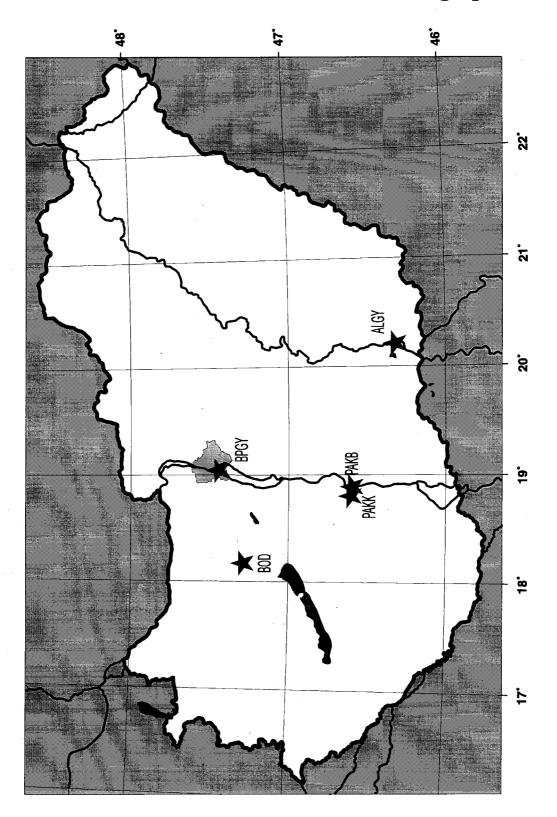


Figure 2.2. Strong motion accelerograph stations in Hungary (See Table 2.2. for details)

PAKS MICROSEISMIC MONITORING NETWORK (MMN)

The system comprises of a network of ten seismometer stations, located within a radius of about 50 km from the Power Plant at Paks (situated in the centre of Hungary) and one in Budapest where the data centre is set up and collected data analysed.

The field stations each consist of a three component short period seismometer located in a pit, with a digital recorder and time signal receiver housed nearby in a heat insulated steel container building.

The seismometers used are the LE-3D three directional compact size high sensitivity 1Hz geophones. The digital acquisition system is the MARS-88 recorder that uses 20 bit AD converters sampling the data 125 times per second. The recorder also performs signal detection by its internal STA/LTA algorithm. Three of the stations are accessible over commercial telephone lines (one of them is a mobile phone) while the others store event and continuous monitor channel data on rewritable magneto-optical disks, which are collected and transferred to the data centre on a weekly basis. Most of the stations are powered by solar panels, and absolute time is provided by DCF-77 time code receivers.

At the data centre a SUN SPARC workstation with 3GB on-line disk capacity serves as a powerful tool for the routine data processing and analysis. Lennartz M88 database software is used for the data management and XPITSA for advanced seismogram analysis. Both waveform and bulletin data are available over the INTERNET for authorised remote users.

The MMN is currently operated and its data processed and analysed by *GeoRisk Ltd*. The *British Geological Survey* have been supervising the network operation through the European Community's PHARE research programme.

STATIONS OPERATED BY GGKI

During 1996 GGKI operated three digital and one analogue seismological stations.

Station *Piszkés (PSZ)* has been installed as an 'Open Station' under a cooperation between the Ministries for Foreign Affairs of Hungary and of Germany with the primary goal of nuclear test ban monitoring (Tóth, 1992). The station is equipped with a triaxial Streckeisen STS-2 broad-band seismometer and Quanterra's data acquisition system with a 24 bit, 80 Hz high resolution digitizer. Three component continuous data streams are recorded in circular buffers on magnetic disks and archived on EXABYTE cartridge. Continuous data is available on-line for more than

a month. All data can be accessed directly and retrieved either in interactive or automatic mode, via the INTERNET or PSDN (X.25) communications channels. A menu driven software (DRM) serves a powerful and easy tool for data access, extraction of data segments at different sampling rates, filtering, communication, system control and station operation. In 1996, PSZ participated in GSETT-3 and also contributed data to GEOFON Project.

GYL and SOP are three component short period stations installed in 1994 under a local project, "Soproni Regionális Műszerközpont (SROM)". Kinemetrics SSR-1 16bit digitizers and event recorders sample and record the output of three component SS-1 Ranger seismometers. Data of recorded events are collected via commercial telephone links.

A long period analogue recording seismograph is operated at the *Seismological Observatory* in Budapest mostly for demonstration purposes.

MÉV STATION

Six vertical short period seismometers are installed on different levels in a uranium ore mine near to Pécs (south of Hungary). Event data is recorded by Teledyne PDAS-100 recorder. There is no formal arrangement to access this station, we received data only on ad hoc informal basis.

STRONG MOTION STATIONS

Although the five strong motion accelerograph stations belong to five different organisations, they are all equipped with the same instrumentation: a AC-23 triaxial accelerometer package (full scale 0.5g) and an SM-2 digital event recorder (manufactured by SIG^{SA}, Switzerland).

During 1996 we had access to all of these stations.

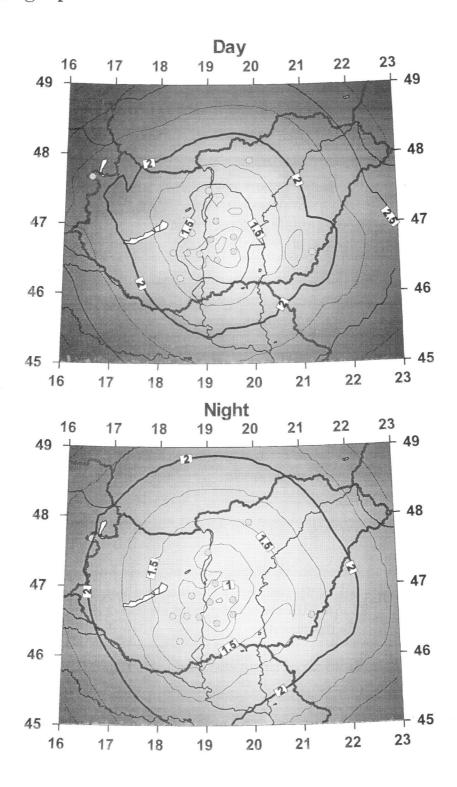


Figure 2.3. Detection capability with average noise conditions. Contour values are Richter local magnitudes (ML).

3.

LIST OF ORIGINS / HYPOCENTRE PARAMETERS

METHOD FOR HYPOCENTRE PARAMETER DETERMINATION

HYPO71PC (Lee and Lahr, 1975) was used for the routine calculation of hypocentre parameters. The original program has been slightly modified in order to implement a routine for Richter local magnitude calculation for the instruments used. For the magnitude calculations the method published by Bakun and Joyner (1984) was used.

A new genetic approach developed by Bondár (1994) for hypocentre determination of local earthquakes has also been tested.

The hypocentre parameters were calculated using phase readings of seismological stations from Hungary and from the neighbouring countries. However, a distance weighting was applied, phase data from stations with epicentral distance greater than 450 km have been assigned a weight of 0. In some cases, when enough P readings were available, S phase readings were not used in the calculations.

CRUSTAL VELOCITY MODEL

The three layer crustal velocity model used in the hypocentre calculations has been derived from crustal phase travel times of several hundreds of local earthquakes (Mónus, 1995).

Velocity (v _P) [km/s]	Depth [km]	Thickness [km]	v_P/v_S
5.60	0.0	20.0	1.78
6.57	20.0	11.0	
8.02	31.0	∞	

Table 3.1. List of events in 1996

7 47.960N 3 46.910N	16.490E 19.256E	4	3.6	6	Austria
3 46.910N			3.6	6	Austria
	19.256E	14			
	19.256E	14			
		. T	3.0		Szabadszállás
	19.831E	15	2.2		Mórahalom
J 40.U48N	20.176E	10	1.9		Serbia
1 47 331N	20 011F	14	2 2		Jászboldogháza
)	20.0112	11	2.2		ouses ruoghueu
7 47.244N	21.374E	7	2.8		Füzesgyarmat
				4	Füzesgyarmat
					Füzesgyarmat Füzesgyarmat
					Füzesgyarmat
					Füzesgyarmat
3 47.242N	21.258E	5	2.7		Füzesgyarmat
					-
47.381N	19.076E	12	2.5	4-5	Dunaharaszti
		10		5	Austria
					Veszprémvarsány
					Bükkszék
					Bükkszék Croatia
	47.244N 47.304N 47.260N 47.225N 47.293N 47.214N 47.242N 47.381N	46.048N 20.176E 47.331N 20.011E 47.244N 21.374E 47.304N 21.379E 47.260N 21.314E 47.225N 21.275E 47.293N 21.393E 47.214N 21.279E 47.242N 21.258E 47.381N 19.076E 47.733N 16.107E 47.444N 17.906E 47.994N 20.208E 48.028N 20.230E	46.048N 20.176E 10 47.331N 20.011E 14 47.344N 21.374E 7 47.304N 21.379E 2 47.260N 21.314E 3 47.225N 21.275E 6 47.293N 21.393E 3 47.214N 21.279E 10 47.242N 21.258E 5 47.381N 19.076E 12 47.733N 16.107E 10 47.444N 17.906E 2 47.994N 20.208E 9 48.028N 20.230E 9	46.048N 20.176E 10 1.9 47.331N 20.011E 14 2.2 47.244N 21.374E 7 2.8 47.304N 21.379E 2 3.2 47.260N 21.314E 3 2.1 47.225N 21.275E 6 2.2 47.293N 21.393E 3 3.1 47.214N 21.279E 10 2.4 47.242N 21.258E 5 2.7 47.381N 19.076E 12 2.5 47.733N 16.107E 10 3.1 47.444N 17.906E 2 1.8 47.994N 20.208E 9 2.0 48.028N 20.230E 9 2.2	46.048N 20.176E 10 1.9 47.331N 20.011E 14 2.2 47.244N 21.374E 7 2.8 47.304N 21.379E 2 3.2 4 47.260N 21.314E 3 2.1 47.225N 21.275E 6 2.2 47.293N 21.393E 3 3.1 47.214N 21.279E 10 2.4 47.242N 21.258E 5 2.7 47.381N 19.076E 12 2.5 4-5 47.733N 16.107E 10 3.1 5 47.444N 17.906E 2 1.8 47.994N 20.208E 9 2.0 48.028N 20.230E 9 2.2

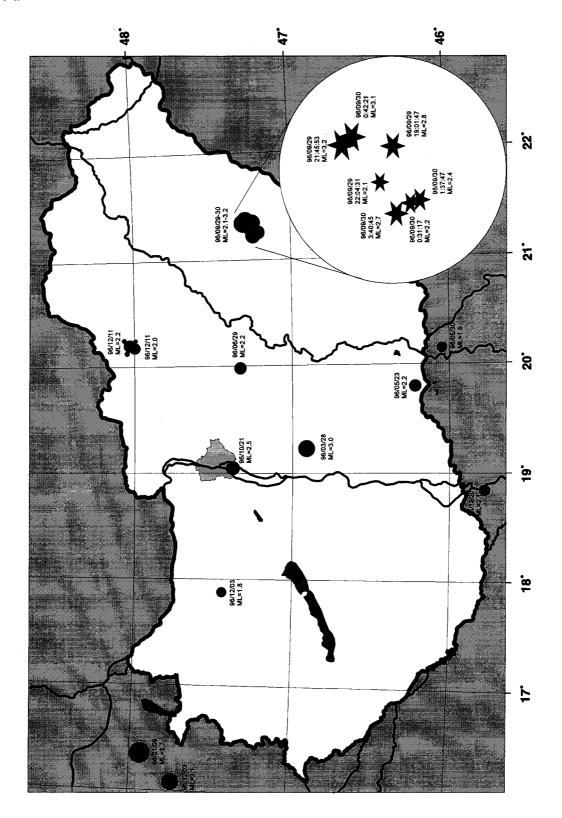


Figure 3.1. Epicentres of Hungarian earthquakes located in 1996.

PHASE DATA

Key to phase data encoding

time: Time of occurrence of event in hours, mins and secs (UTC).

ML: Richter local magnitude of the earthquake.

lat: Latitude of the event in degrees.
lon: Longitude of the event in degrees.
h: Depth of the hypocentre in km.

erh: Standard error of the epicentre in km. ($erh = \sqrt{SDX^2/SDY^2}$, where SDX

and SDY are the standard errors in latitude and longitude respectively, of the epicentre. If $erh = \cdots$, this means that erh could not be computed

because of insufficient data.

erz: Standard error of the focal depth in km. If erz = ---, this means that erz

could not be computed either because focal depth is fixed in the

solution or because of insufficient data.

nr: Number of station readings used in locating the earthquake. P and S

arrivals for the same stations are regarded as 2 readings.

gap: Largest azimuthal separation in degrees between stations.

rms: Root mean square error of time residuals in seconds. $(rms = \sqrt{\sum R_i^2/nr},$

where R_i is the time residual of the i^{th} station.

Locality: A geographical indication of the epicentral area, usually the nearest

settlement.

Comments: Additional comments about the event, eg. maximum EMS intensity

sta: Station name. (For details see Chapter 2.)

dist: Distance from earthquake epicentre to station in km.

azm: Azimuthal angle between epicentre to station measured from North in

degrees.

phase: Phase identifier; the first letter characterizes onset e = emergent i =

impulsive, the second and third indicate the phase eg. Pn, Pg, Sn and Sg, the forth indicates the polarity C=compression/up

D=dilatation/down.

hr mn sec: Arrival time of the phase from input data.

res: Residual of the phase in secs. (res = T_{obs} - T_{cal} , where T_{obs} is the

observed and T_{cal} is the calculated travel time respectively.

```
1996-01-09 time: 1:07:22.66 UTC ML= 3.6
    lat: 47.960N lon: 16.490E h= 4.4 km
                  erh=1.4km
                                 erz=1.2km
    nr=21
                  gap=117
                                 rms = .33
    Locality: Austria
    Comments: Felt 6 at Baden and Ebreichsdorf
sta
       dist azm
                 phase hr mn sec
                                        res
SOP
       31.2 171
                  ePgU
                         1:07:28.33
                                         .10
                  iSg
                           07:32.33
                                        - . 25
VKA
       36.3 339
                  i PgD
                         1:07:28.90
                                        - . 22
SRO 137.3 97
                  i PnC
                         1:07:46.40
                                         .77
                  iSn
                           08:02.80
                                        - .75
BUD 197.3 106
                  ePnD
                         1:07:53.35
                                         .17
PKS9 204.0 138
                  ePnD
                         1:07:54.12
                                         . 10
PKS8 204.1 126
                  ePnD
                         1:07:54.13
                                         .10
PKS1 219.2 134
                  i PnD
                         1:07:55.95
                                         .03
PKS7 225.3 117
                  ePn-
                         1:07:57.01
                                         .31
PTJ 231.4 190
                  iPn
                         1:07:57.40
                                        -.06
                  iSn
                           08:25.40
                                        . 79
ZAG
    239.9 189
                  i PnC
                         1:07:58.80
                                         . 27
PSZ
     254.4 91
                  ePnU
                         1:08:00.13
                                        - .22
LJU 260.1 215
                  ePn
                         1:08:01.10
                                         .02
PKS5 264.4 119
                 ePn-
                         1:08:01.75
                                        .13
VBY 288.8 199
                 i Pn
                         1:08:04.30
                                       -.39
VOY 291.5 223
                 i Pn
                         1:08:04.50
                                       - .53
CEY 292.8 213
                 ePn
                         1:08:04.90
                                       - . 29
SPC 308.9 64
                 ePn
                         1:08:06.90
                                       -.32
                 iSn
                           08:41.80
                                       -.18
HVAR 531.5 180
                 iPn
                         1:08:36.20
                                        . 99
1996-03-28 time: 6:31:22.29 UTC ML= 3.0
   lat: 46.910N lon: 19.256E h= 13.9 km
                 erh= .9km
                                erz=1.0km
  nr=17
                 gap= 93
                                rms = .30
  Locality: Szabadszállás
  Comments: Not felt
sta
      dist azm phase
                       hr mn sec
                                       res
PKS7
     16.9 335
                i PgU
                        6:31:26.23
                                        .03
```

			iSg	31:29.12	13
PKS3	19.9	227	i PgD	6:31:26.59	03
			eSg	31:29.94	05
PKS5	25.4	116	iPgU	6:31:27.27	19
			iSg	31:31.09	40
PKS6	41.7	146	iPgU	6:31:30.19	. 04
			iSg	31:36.35	. 08
PKS8	44.3	266	ePgD	6:31:30.46	11
PKS2	46.5	184	iPgD	6:31:31.26	. 30
			iSg	31:38.05	. 33
BUD:	66.2	345	iPg	6:31:35.60	1.23
PKS9	82.8	244	ePgD	6:31:37.10	18
			eSg	31:48.69	29
PKS4	96.6	219	eP*	6:31:39.21	22
			eS*	31:52.83	.03
PSZ	122.2	23	Sn	6:31:58.20	58
PTJ	275.8	246	e n	6:32:09.90	7.95

1996-05-23 time: 3:20:20.75 UTC ML= 2.2 lat: 46.217N lon: 19.831E h= 15.5 km

erh= 5.4km erz= 2.1km gap=321 rms= .45

nr= 8 gap=32 Locality: Mórahalom

Comments: Not felt

sta PKS6	dist 47.3		phase iPqD	hr mn sec 3:20:29.73	res .10
rksu	47.5	504	Sg	20:35.79	76
PKS2	ან.5	303	Sg	3:20:39.43	. 05
PKS5	69.2	342	iPgU	3:20:33.07	34
			eSg	20:44.02	.74
PKS7	105.6	331	ePn	3:20:39.75	. 78
			eSn	20:52.74	45
PKS8	115.1	310	Sn	3:20:55.44	. 15
PKS9	126.2	289	ePn	3:20:44.37	2.83

1996-05-30 time: 22:47:00.02 UTC ML= 1.9 lat: 46.048N lon: 20.176E h= 9.7 km erh=31.0km erz= 4.6km

nr= 5 gap=344 rms = .56Locality: Serbia Comments: Not felt dist azm phase hr mn sec sta res PKS6 77.3 323 22:47:13.98 i PgD . 04 eSg 47:24.58 - . 22 PKS3 118.4 314 eSn 22:47:35.05 -1.57PKS7 135.7 325 22:47:40.81 .36 iSn PKS8 147.6 309 Sn 22:47:43.83 .72 1996-06-29 time: 8:06:49.40 UTC ML= 2.2 lat: 47.331N lon: 20.011E h= 14.3 km erh=4.2kmerz= 2.8kmrms = .59nr= 12 gap=210 Locality: Jászboldogháza Comments: Not felt dist azm phase hr mn sec res sta PSZ 66.0 352 iPgD 8:07:02.00 .54 07:10.50 -.36 iSg PKS5 67.6 211 8:07:01.22 - .52 i PgU iSq 07:12.20 .84 8:07:01.78 PKS7 71.8 244 iPgU - . 68 07:13.05 .40 iSg PKS6 88.1 203 **P*** 8:07:05.90 . 69 S* 07:17.23 - .32 8:07:09.49 1.00 PKS2 111.4 213 Pn 07:23.94 .56 Sn PKS8 113.1 244 8:07:08.10 -.61 ePn-PKS9 155.7 238 ePn 8:07:16.73 2.71

1996-09-29 time: 19:01:47.72 UTC ML= 2.8 lat: 47.244N lon: 21.374E h= 6.9 km

erh=11.2km erz= 9.3km

rms=1.57

nr= 18 gap=230

Locality: Füzesgyarmat Comments: Not felt

res

.54

```
iSg
                              02:10.83
                                           -.32
  PSZ
       134.2 304
                    ePnC .19:02:10.90
                                            . 29
                     Sn
                              02:27.73
                                          -.73
  PKS5 146.5 251
                    iPnU
                          19:02:10.30
                                         -1.84
                    eSn
                             02:29.77
                                         -1.42
 PKS6 155.3 243
                    i PnU
                          19:02:11.84
                                         -1.40
                    eSn
                             02:32.61
                                          - . 53
 PKS7 169.3 263
                    ePn+
                          19:02:16.69
                                          1.71
                    eSn
                             02:36.37
                                           .12
 BUD
      179.5 279
                    Sn
                          19:02:54.60
                                         16.08
 BZS
      181.8 174
                    i PnD
                          19:02:18.00
                                          1.46
 PKS3 182.7 254
                   eSn
                          19:02:40.87
                                          1.65
 PKS2 184.7 243
                   i PnD
                          19:02:15.37
                                         -1.54
                   iSn
                             02:40.65
                                           . 98
 PKS8 208.9 259
                   ePn+
                          19:02:23.61
                                          3.69
                   eSn
                             02:48.48
                                         3.44
 PKS9 246.8 253
                   ePn-
                          19:02:21.38
                                         -3.27
                   eSn
                                       -22.94
                             02:30.52
 PKS4 249.1 243
                   ePn?
                         19:02:14.70
                                       -10.24
 1996-09-29 time: 21:45:53.71 UTC ML= 3.2
    lat: 47.304N lon: 21.379E
                                 h = 2.0 \text{ km}
                   erh=15.0km
                                  erz=12.3km
    nr= 19
                   gap=233
                                  rms=1.86
   Locality: Füzesgyarmat
    Comments: Felt 4
sta
       dist azm
                phase
                         hr mn sec
                                         res
GYL
      80.0 191
                  i PgU
                         21:46:09.08
                                         1.08
                  eSg
                            46:18.58
                                         -.57
PSZ
     130.9 301
                  ePn
                         21:46:18.74
                                         1.92
                   Sn
                            46:35.83
                                          . 99
PKS5 149.1 248
                        21:46:10.66
                  ePnN
                                        -8.43
                  iSn
                            46:37.78
                                        -1.10
PKS6 158.8 240
                        21:46:19.68
                  i PnD
                                         -.61
                  eSn
                            46:40.65
                                         -.37
PKS7 170.6 260
                  i PnU
                        21:46:21.61
                                         - . 15
                  iSn
                            46:44.37
                                          .73
```

sta

GYL

dist azm

73.4 192

phase hr mn sec

19:02:01.43

ePgD

```
. 99
                       21:46:23.80
BUD 179.0 276
                  Pn
                       21:46:47.62
                                       .80
PKS3 184.9 252
                 eSn
                                   -14.14
                       21:46:09.81
PKS2 188.1 241
                 ePnN
                                       . 85
                          46:48.38
                 iSn
                                      1.02
                       21:46:25.00
BZS 188.4 174
                 iPnD
                                      - . 25
PKS8 210.6 257
                 ePn+
                       21:46:26.50
                                      3.54
                          46:56.06
                 eSn
                                      - .83
PKS9 249.1 251
                 iPnU
                       21:46:30.73
                          47:12.40
                                     11.32
                 eSn
1996-09-29 time: 22:04:30.55 UTC ML= 2.1
   lat: 47.260N lon: 21.314E h= 2.8 km
                               erz=85.5km
                 erh=***km
                               rms=1.36
                 gap=244
   nr= 8
   Locality: Füzesgyarmat
   Comments: Not felt
      dist azm phase
                       hr mn sec
                                      res
sta
                 ePgU 22:04:44.43
                                       .59
GYL
      74.4 188
                          04:53.93
                                      - . 27
                  Sg
                                      1.33
                       22:04:54.69
PSZ 129.5 304
                 ePn
                                       .11
                          05:11.27
                  Sn
                                     -5.61
                       22:04:49.42
PKS5 142.8 249
                 ePn
                                      - .91
                          05:13.21
                 eSn
                                      -.18
                       22:05:16.00
PKS6 152.1 241
                 eSn
                                        .89
PKS2 181.5 242
                       22:05:23.59
                 iSn
1996-09-30 time: 0:31:17.43 UTC ML= 2.2
   lat: 47.225N lon: 21.275E h= 6.1 km
                 erh=13.0km
                               erz=10.2km
                               rms = .33
                 gap=240
   nr= 7
   Locality: Füzesgyarmat
   Comments: Not felt
      dist azm phase hr mn sec
                                      res
sta
                        0:31:30.09
GYL
      70.1 186
                 ePgU
                                        .10
                          31:39.59
                                      -.20
                 iSg
PSZ 129.4 307
                 ePn
                        0:31:40.30
                                        . 49
```

31:56.93

Sn

- . 35

-.36

```
PKS6 147.7 242
                 iSn
                         0:32:01.70
                                        .36
PKS2 177.1 243
                 eSn
                         0:32:09.30
                                       1.44
1996-09-30 time: 0:42:20.92 UTC ML= 3.1
   lat: 47.293N lon: 21.393E h= 2.7 km
                                erz=8.6km
                 erh=10.5km
                                rms=1.21
   nr=17
                 gap=233
   Locality: Füzesgyarmat
   Comments: Not felt
sta
      dist azm phase hr mn sec
                                       res
GYL
      79.1 192
                 ePgU
                         0:42:35.94
                                        . 89
                 iSq
                          42:45.54
                                       -.53
PSZ 132.4 302
                 ePn
                         0:42:45.47
                                       1.35
                  Sn
                           43:02.37
                                       . 15
                         0:42:40.46
PKS5 149.7 249
                 ePn+
                                      -5.82
                           43:04.80
                                      -1.26
                  iSn
PKS6 159.1 241
                 i PnD
                         0:42:46.58
                                       - . 87
                         43:07.78
                                       - . 37
                 iSn
PKS7 171.4 261
                                       - .81
                 iPnU
                         0:42:48.18
                           43:11.13
                                       . 25
                 iSn
PKS3 185.6 252
                         0:42:49.71
                                      -1.04
                 i PnD
                          43:14.47
                                        .45
                 eSn
BZS 187.1 175
                 i PnD
                         0:42:52.00
                                       1.06
PKS2 188.5 242
                 ePn+
                         0:42:45.76
                                      -5.36
```

iSn

0:31:58.99

PKS5 138.7 251

1996-09-30 time: 1:37:47.49 UTC ML= 2.4
lat: 47.214N lon: 21.279E h= 10.0 km
erh=84.8km erz=64.9km
nr= 8 gap=240 rms=1.06

iSn

ePnN eSn 43:15.14

43:22.94

0:42:52.89

. 47

-1.08

3.20

Locality: Füzesgyarmat Comments: Not felt

PKS8 211.4 257

sta dist azm phase hr mn sec res GYL 69.0 187 ePgU 1:37:59.99 .05

	eSg	38:09.94	. 29
PSZ 130.3 307	ePnC	1:38:10.01	.51
	Sn	38:26.83	.16
PKS5 138.7 251	ePn+	1:38:08.85	-1.69
	iSn	38:28.61	.10
PKS6 147.4 242	ePnN	1:38:06.46	-5.17
	eSn	38:31.71	1.25

1996-09-30 time: 3:40:45.32 UTC ML= 2.7

lat: 47.242N lon: 21.258E h= 5.2 km

erh= 7.1km erz= 6.2km

nr= 13 gap=225 rms= .84

Locality: Füzesgyarmat Comments: Not felt

sta	dist	azm	phase	hr mn	sec	res
GYL	71.8	185	ePgD	3:40:5	8.64	. 45
			Sg	41:0	8.04	18
PSZ	127.2	306	ePn	3:41:0	8.60	1.05
			Sn	41:2	24.63	25
PKS5	138.1	250	iPnU	3:41:0	7 . 45	-1.46
			iSn	41:2	27.18	12
PKS6	147.4	241	ePnN	3:41:0	9.11	96
			iSn	41:3	30.56	1.19
PKS7	160.5	262	ePn+	3:41:1	1.02	68
			eSn	41:3	3.84	1.56
PKS3	174.1	253	iPnN	3:41:1	.2.38	-1.02
BZS	182.7	171	i PnD	3:41:1	5.00	. 53
PKS9	238.3	252	ePnN	3:41:2	0.62	78

1996-10-21 time: 1:23:25.51 UTC ML= 2.5 lat: 47.381N lon: 19.076E h= 12.3 km

erh= 1.0km erz= .7km

nr= 8 gap=127

rms= .11

Locality: Dunaharaszti Comments: Felt 4-5

sta dist azm phase hr mn sec res BUD 12.1 341 iPg 1:23:28.52 -.07

			Sg	23:31.00	.01
PKS7	37.6	170	ePg+	1:23:32.75	. 17
			iSg	23:38.30	. 21
PKS8	63.5	208	ePg	1:23:38.21	1.15
			eSg	23:47.45	1.38
PKS3	66.0	181	ePg	1:23:37.55	. 05
PKS5	73.2	150	ePg+	1:23:38.61	15
			iSg	23:50.46	1.36
PSZ	85.9	46	ePgD	1:23:41.03	. 03
			Sg	23:53.23	. 15
PKS6	94.4	157	iP*U	1:23:42.41	06
			eS*	23:55.06	64
PKS2	99.3	174	eS*	1:23:57.05	. 02
PKS9	107.1	214	ePn+	1:23:44.26	06
			eSn	23:59.85	. 85
PKS4	135.8	200	ePn	1:23:48.06	.16
			eSn	24:06.56	1.19
ZST	173.5	302	Sn	1:24:17.20	3.47

1996-12-03 time: 0:30:57.66 UTC ML= 3.1

lat: 47.733N lon: 16.107E h= 10.0 km

erh= 5.0km erz= 4.9km gap=120 rms= .64

Comments: Felt 5 at Gloggnitz

sta	dist	azm	phase	hr mn sec	res
SOP	34.3	99	iPgU	0:31:04.38	. 34
			iSg	31:10.00	. 98
VKA	61.2	15	iPgD	0:31:09.10	. 36
			iSg	31:18.90	1.52
ZST	90.4	55	iPg	0:31:13.20	71
			iSg	31:26.20	38
SR0	165.6	87	ePn	0:31:26.20	2.13
			iSn	31:46.10	1.44
PKS8	216.3	116	i PnU	0:31:30.15	23
KBA	220.9	251	i PnD	0:31:30.50	46
			iSn	31:55.20	-1.73
KHC	243.3	310	Pn	0:31:34.50	. 75
PKSM	256.5	131	ePn+	0:31:34.64	75

PRU	275.9	335	ePn	0:31:39.00	1.19
			Sn	32:10.50	1.37
WTTA	340.9	261	i PnC	0:31:46.20	. 28
			iSn	32:31.00	7.43
WATA	344.0	263	i PnD	0:31:46.50	. 19
			iSn	32:32.50	8.24
SQTA	373.6	261	iPnC	0:31:50.10	.10
			iSn	32:42.30	11.47
MOTA	379.2	263	iPnD	0:31:50.30	40
			iSn	32:43.10	11.03

1996-12-03 time: 4:17:53.90 UTC ML= 1.8 lat: 47.444N lon: 17.906E h= 1.5 km

erh= 3.2km erz= 3.5km gap=162 rms= .67

Locality: Veszprémvarsány

Comments: Not felt

sta	dist	azm	phase	hr mn sec	res
SR0	51.2	37	iPg	4:18:03.10	. 04
			iSg	18:10.60	. 40
PKS8	85.8	137	ePgU	4:18:09.77	. 53
			eSg	18:20.03	-1.16
ZST	103.0	324	ePg	4:18:12.00	30
			eSg	18:25.00	-1.65
PKS7	104.8	115	eSg	4:18:26.73	48
PKS4	141.1	162	eSn	4:18:37.36	03
PKS6	157.2	127	eSn	4:18:42.22	1.25

1996-12-11 time: 18:53:12.72 UTC ML= 2.0

lat: 47.994N lon: 20.208E h= 9.2 km

erh= 2.3km erz= 1.1km

nr= 5 gap=302 rms= .04

Locality: Bükkszék Comments: Not felt

sta dist azm phase hr mn sec res PSZ 24.9 250 iPgD 18:53:17.49 .04 eSg 53:21.11 -.04

```
PKSN 124.6 192 eSn 18:53:50.80 .00
PKS7 131.5 217 ePn+ 18:53:34.92 -.05
eSn 53:52.38 .05
```

1996-12-11 time: 23:27:22.15 UTC ML= 2.2

lat: 48.028N lon: 20.230E h= 9.0 km

erh=5.7km erz=2.3km

nr= 5 gap=308

rms = .13

Locality: Bükkszék Comments: Not felt

sta	dist	azm	phase	hr mn sec	res
PSZ	27.9	244	i PgD	23:27:27.44	. 05
			eSg	27:31.34	13
PKSN	128.7	192	eSn	23:28:00.86	32
PKS7	135.6	216	i Pn+	23:27:44.89	04
			eSn	28:02.91	. 21

1996-12-20 time: 19:14:24.88 UTC ML= 2.1

lat: 45.780N lon: 18.862E h= 10.0 km

erh= 3.4km erz= 1.8km

nr= 9 gap=303

rms= .37

Locality: Croatia Comments: Not felt

sta	dist	azm	phase	hr mn sec	res
PKSM	50.9	340	ePg+	19:14:33.78	37
			iSg	14:41.32	06
PKS2	83.6	19	ePg-	19:14:39.68	24
			eSg	14:52.00	. 35
PKS9	100.4	333	ePg+	19:14:43.80	.91
			eSg	14:56.46	48
PKS6	106.0	31	eP*+	19:14:43.74	08
			eS*	14:58.65	.06
PKS8	122.9	353	iSn	19:15:02.58	. 17

4.

SIGNIFICANT EARTHQUAKES IN 1996

(Earthquakes that was felt in Hungary)

9 January 1996

- Baden (Austria)

29 September 1996

- Füzesgyarmat

21 October 1996

- Dunaharaszti

METHOD USED FOR ESTIMATION OF INTENSITY

The earthquake effects (macroseismic observations) are usually gathered on questionnaires (APPENDIX A). Based on these reports the intensity values were estimated by a computer algorithm (Zsíros et al, 1990 and Zsíros 1994).

The assigned intensities correspond to the $European\ Macroseismic\ Scale\ 1992\ (EMS)$ edited by Grünthal (1993). (APPENDIX B)

9 January 1996 - Baden (Austria)

HYPOCENTRE PARAMETERS

Date:

1996/01/09

Origin Time:

01:07:22.7 UTC

Latitude and Longitude: 47.960N 16.490E (S.D. 1.4km)

Depth:

4.4 km (S.D. 1.2km)

Magnitude:

3.6 ML

Maximum Intensity:

6 (3-4 in Hungary)

DISCUSSION

The Baden (Austria) earthquake of 9 January had intensity 6 at the epicentral area and produced reports of intensity 3-4 EMS from Sopron vicinity in Hungary. The area in which it was felt in Hungary was relatively small, just about 200-250 km².

This event is a representing example of the significant contribution to the earthquake hazard expected in Hungary from earthquake sources outside of the territory of the country (Zsíros and Tóth, 1988).

A fault plane solution was attempted but due to the incomplete station coverage no reliable single solution could be obtained. However, the main compression axis shows a unambiguous direction of WNW (Figure 4.2.).

The intensity distribution of the event (only in Hungary) is shown in Table 4.1. and Figure 4.3.

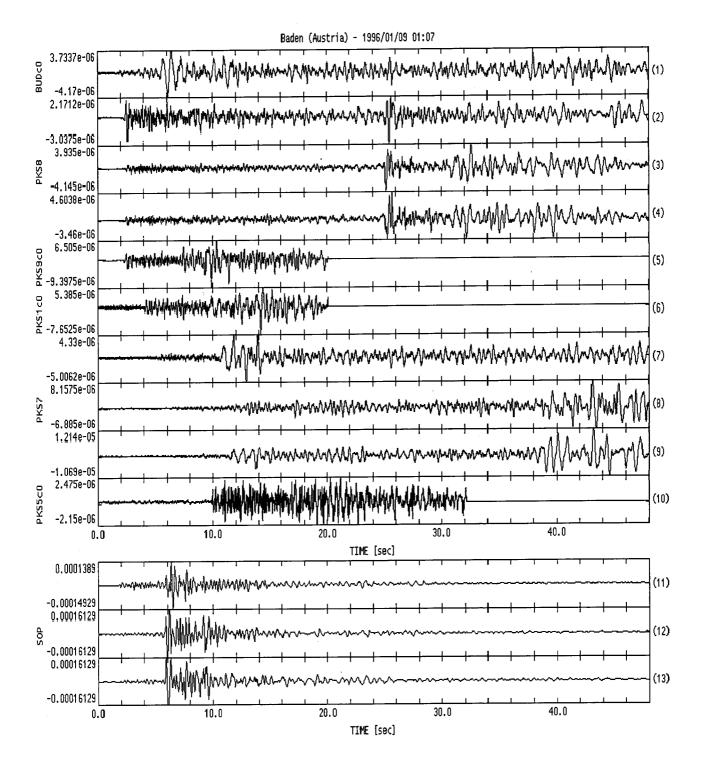


Figure 4.1. Seismogram of the Baden (Austria) Earthquake 9th January 1996, 1:07:23 UTC. (BUD, PKS9, PKS1 and PKS5 vertical components; PKS8, PKS7 and SOP three components)

The vertical axis is ground velocity in m/s.

1996-01-09 01:07:23

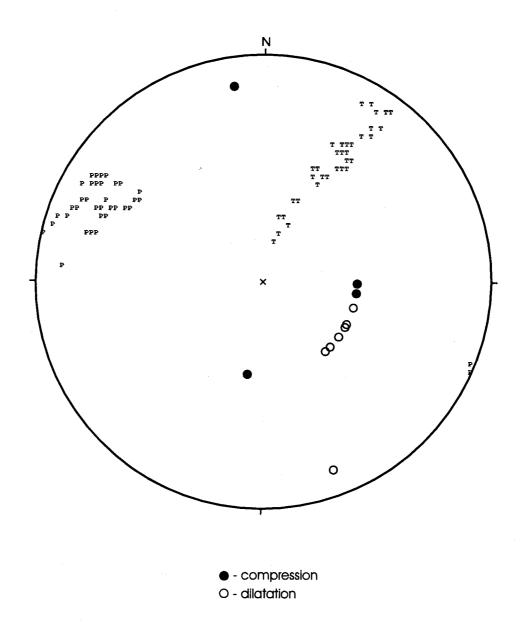


Figure 4.2. Stereographic projection of the lower focal hemisphere for the Baden (Austria) Earthquake 9th January 1996, 1:07:23 UTC.

P and T are the possible main compression and tension axes.

Table 4.1. Intensity distribution of the Baden (Austria) Earthquake 9th January 1996, 1:07:23 UTC

	Location	Coordinates	Ι	R	N
1	Ágfalva	47.692 N 16.509 E	.0	0.%	1
2	Bezenye	47.959 N 17.223 E	.0	0.%	1
3	Fertőrákos	47.722 N 16.646 E	3.5	34.%	2
4	Halászi	47.889 N 17.330 E	.0	0.%	2
5	Hegyeshalom	47.919 N 17.148 E	.0	0.%	3
6	Jánossomorja	47.782 N 17.138 E	.0	0.%	2
7	Kapuvár	47.593 N 17.036 E	.0	0.%	2
8	Kimle	47.816 N 17.376 E	.0	0.%	2
9	Kópháza	47.637 N 16.634 E	3.0	33.%	3
10	Kőszeg	47.394 N 16.535 E	.0	0.%	2
11	Levél	47.894 N 17.209 E	.0	0.%	2
$\overline{12}$	Mosonmagyaróvár	47.866 N 17.272 E	.0	0.%	1
13	Pereszteg	47.596 N 16.723 E	3.0	29.%	3
14	Rajka	47.995 N 17.205 E	.0	0.%	3
15	Sopron	47.690 N 16.583 E	3.5	41.%	2
16	Sopronhorpács	47.481 N 16.744 E	.0	0.%	2
17	Sopronkövesd	47.548 N 16.736 E	.0	0.%	1

I - Intensity

R - relative reliability

N - number of reports

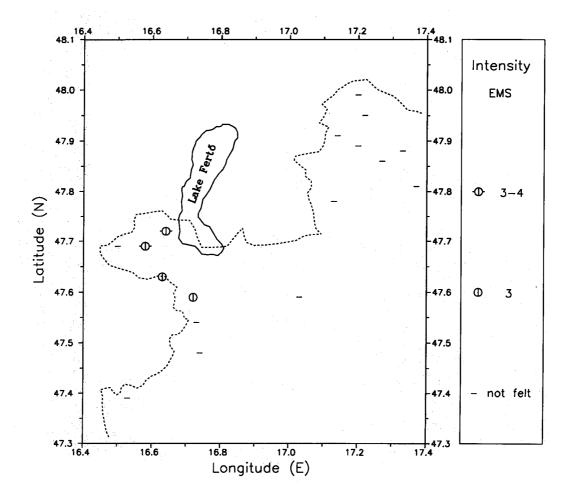


Figure 4.3. Intensity distribution of the Baden (Austria) Earthquake 9th January 1996, 1:07:23 UTC

HYPOCENTRE PARAMETERS

Date:

1996/09/29

Origin Time:

21:45:53.7 UTC

Latitude and Longitude: 47.304N 21.379E (S.D. 15.0km)

Depth:

2.0 km (S.D. 12.3km)

Magnitude:

3.2 ML

Maximum Intensity:

4

DISCUSSION

On September 29th, an earthquake with a magnitude of 3.2 ML was felt slightly in Füzesgyarmat with a maximum intensity of 4 EMS. The main event was preceded by one foreshock with a magnitude of 2.8 ML (some two and half hours earlier) and followed by five aftershocks (2.1-3.1 ML) within six hours.

There is speculation that the sequence was induced by filling the nearby natural gas reservoir. However, the area has some earthquake history: an intensity 4 event in 1789, an intensity 3 in 1819 and two earthquakes in 1823 with intensity 3 and 5 were reported from Füzesgyarmat.

The cross section of the seven events (Figure 4.5) shows fault plane with ENE strike direction.

A fault plane solution was attempted (Figure 4.6) but due to the low signal-to-noise ratio at the recording stations no reliable single solution could be obtained. However, the possible main compression axis indicates SSE compression very well agreement with ENE strike direction given by the cross section.

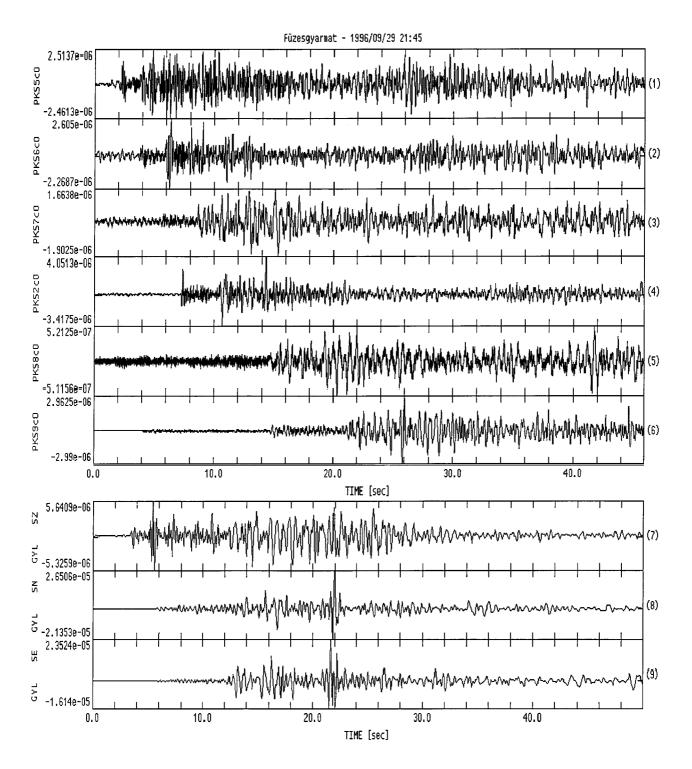


Figure 4.4. Seismograms of the Füzesgyarmat Earthquake (the main shock) 29th September 1996, 21:45:54 UTC (PKS5, PKS6, PKS7, PKS2, PKS8 and PKS9 vertical components; GYL three components)

The vertical axis is ground velocity in m/s.

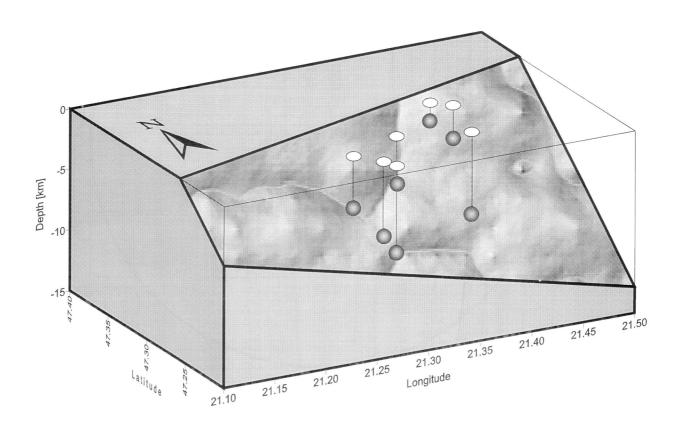


Figure 4.5. The cross section of the seven Füzesgyarmat earthquakes 29-30th September 1996 indicates ENE fault plane with 71 degrees strike and 42 degrees dip directions.

1996-09-29 21:45:53

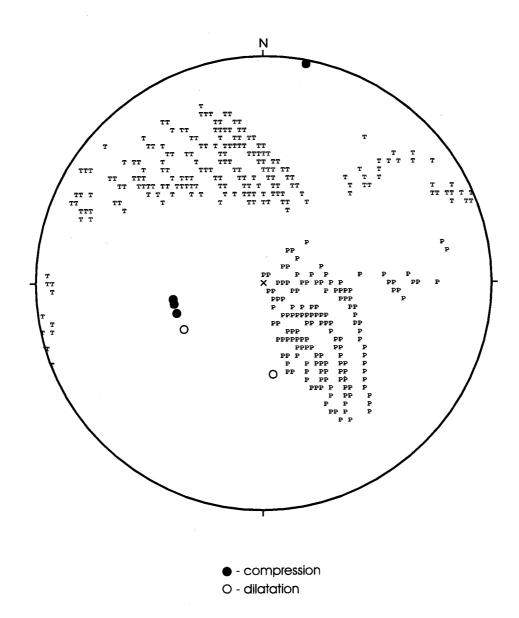


Figure 4.6. Stereographic projection of the lower focal hemisphere for the Füzesgyarmat Earthquake (the main shock) 29th September 1996, 21:45:54 UTC.

 \boldsymbol{P} and \boldsymbol{T} are the possible main compression and tension axes.

Table 4.2. Intensity distribution of the Füzesgyarmat Earthquake 29th September 1996, 21:45:54 UTC

	Location	Coordinates	I	R	N
1	Bihardancsháza	47.230 N 21.318 E	.0	0.%	1
$\overset{-}{2}$	Biharnagybajom	47.207 N 21.229 E	.0		2
3	Bihartorda	47.216 N 21.351 E	.0		1
4	Bucsa	47.204 N 21.000 E	.0	0.%	
5	Csökmő	47.028 N 21.284 E	.0	0.%	
6	Darvas	47.105 N 21.335 E	.0	0.%	
7	Dévaványa	47.030 N 20.952 E	.0	0.%	1
8	Gyomaendrőd	46.931 N 20.790 E	.0	0.%	1
9	Furta	47.129 N 21.455 E	.0	0.%	1
10	Füzesgyarmat	47.104 N 21.207 E	4.0	34.%	4
11	Gyomaendrőd	46.790 N 20.790 E	.0	0.%	2
12	Körösladány	46.960 N 21.077 E	.0	0.%	1
13	Körösújfalu	46.961 N 21.394 E	.0	0.%	1
14	Okány	46.899 N 21.344 E	.0	0.%	1
15	Sárrétudvari	47.240 N 21.184 E	.0	0.%	2
16	Szeghalom	47.022 N 21.169 E	.0	0.%	1
17	Szerep	47.230 N 21.139 E	.0	0.%	2
18	Túrkeve	47.104 N 20.739 E	.0	0.%	2
19	Vekerd	47.092 N 21.400 E	.0	0.%	2
20	Vésztő	46.916 N 21.253 E	.0	0.%	3
21	Zsáka	47.133 N 21.427 E	.0	0.%	2

I - Intensity

R - relative reliability

N - number of reports

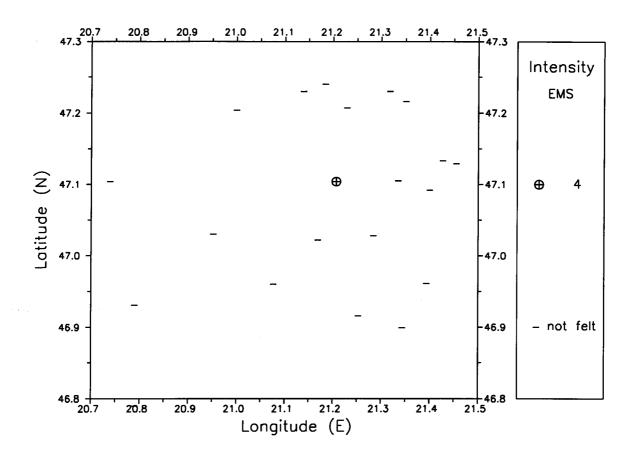


Figure 4.7. Intensity distribution of the Füzesgyarmat Earthquake 29th September 1996, 21:45:54 UTC

HYPOCENTRE PARAMETERS

Date:

1996/10/21

Origin Time:

01:23:25.5 UTC

Latitude and Longitude: 47.381N 19.076E (S.D. 1.0km)

Depth:

12.3 km (S.D. 0.7km)

Magnitude:

2.5 ML

Maximum Intensity:

4-5

DISCUSSION

The Dunaharaszti earthquake of 21 October with a magnitude of 2.5 ML was felt over a small area of 100-150 km². The macroseismic survey carried out at the time of the event resulted a maximum intensity of 4-5 at the epicentre. The intensity distribution is shown in Table 4.3. and Figure 4.7.

Dunaharaszti is a known source of earthquakes from the past. The most significant event at the same site was the 12th January 1956 earthquake with a magnitude of 5.6 Ms (with epicentral intensity 8) followed by hundreds of aftershocks.

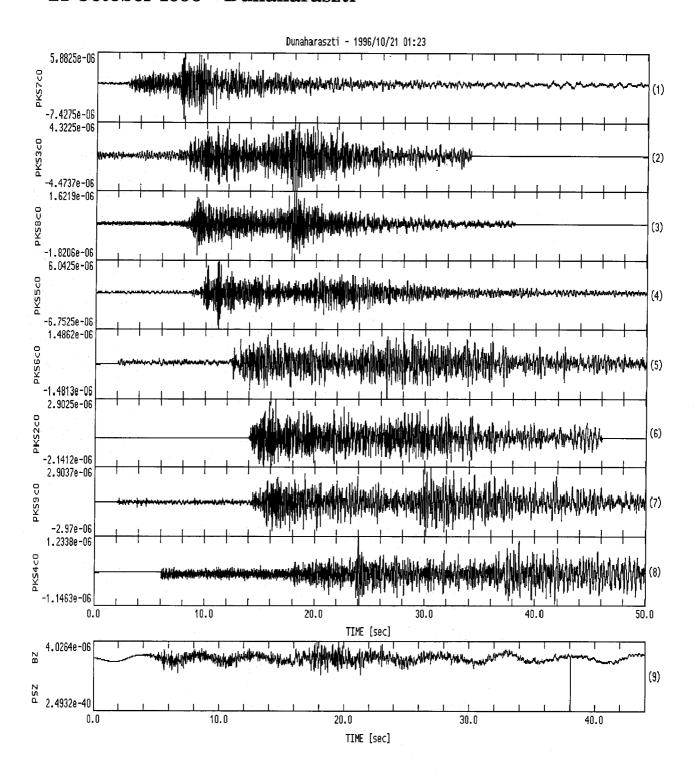


Figure 4.8. Seismograms of the Dunaharaszti Earthquake 21st October 1996, 1:23:26 UTC (vertical components).

The vertical axis is ground velocity in m/s.

Table 4.3. Intensity distribution of the Dunaharaszti Earthquake 21st October 1996, 1:23:26 UTC

	Location	Coordinates	I	R	N
1	Alsónémedi	47.320 N 19.166 E	4.0	46.%	1
2	Budapest (XXIII)	47.407 N 19.123 E	3.5	40.%	2
3	Diósd	47.411 N 18.956 E	.0	0.%	2
4	Dunaharaszti	47.361 N 19.099 E	4.5	32.%	6
5	Dunavarsány	47.283 N 19.070 E	.0	0.%	3
6	Felsőpakony	47.343 N 19.238 E	.0	0.%	2
7	Gyál	47.384 N 19.221 E	.0	0.%	1
8	Halásztelek	47.369 N 18.980 E	.0	0.%	1
9	Szigetcsép	47.270 N 18.972 E	.0	0.%	1
10	Szigetszentmiklós	47.350 N 19.049 E	3.5	35.%	3
11	Taksony	47.332 N 19.063 E	3.5	31.%	3
$\overline{12}$	Tököl	47.318 N 18.967 E	.0	0.%	1

I - Intensity

R - relative reliability

N - number of reports

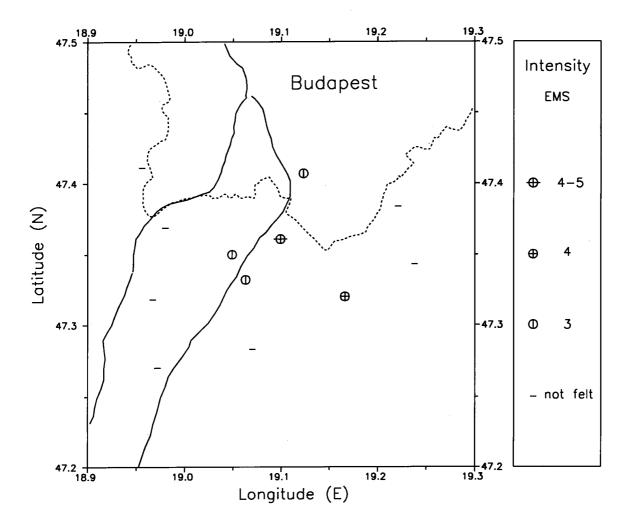


Figure 4.10. Intensity distribution of the Dunaharaszti Earthquake 21st October 1996, 1:23:26 UTC

REFERENCES

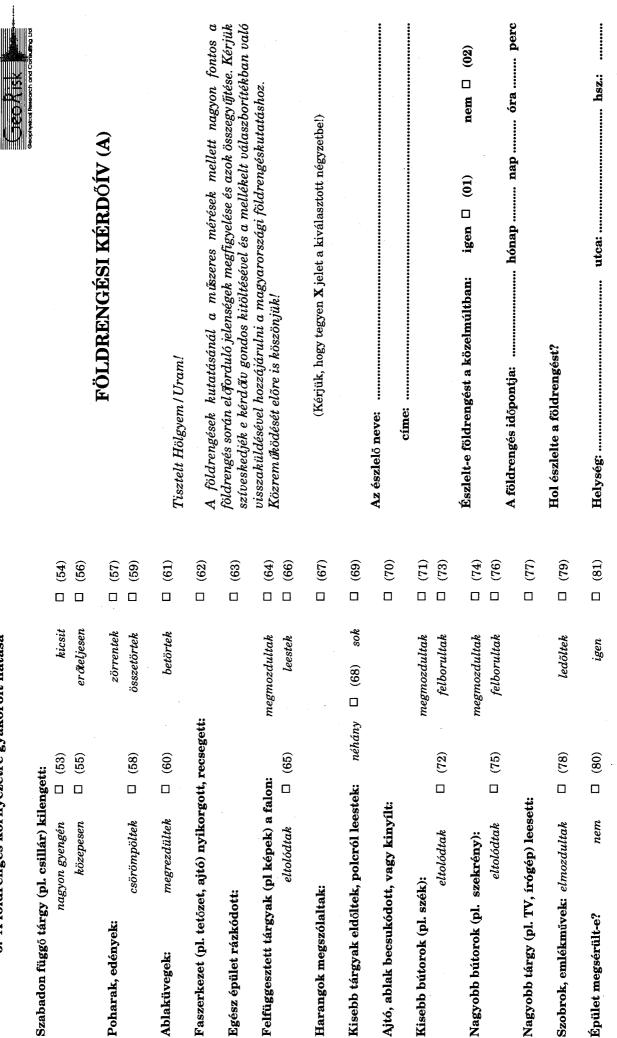
- Bakun, W.H. and W.B. Joyner, 1984. The Ml scale in central California. Bull. Seismol. Soc. Am., 74, 1827-1843
- Bondár, I., 1994. Hypocentre determination of local earthquakes using genetic algorithm. Acta Geod. Geoph. Hung., 29, (1-2), 39-56
- Grünthal, G. (editor), 1993. European Macroseismic Scale 1992. Conseil de L'Europe, Luxembourg, 1993. pp. 79.
- Lee, W.H.K. and J.C. Lahr, 1975. HYPO71 (Revised): A computer program for determining hypocenter, magnitude, and first motion pattern of local earthquakes. U. S. Geological Survey Open-file report 75-311.
- Mónus, P., 1995. Travel time curves and crustal velocity model for the Pannonian basin. MTA GGKI Technical report
- Tóth, L., 1992. The New Hungarian Open Station PSZ. Proceedings of the GERESS Symposium, p. 171-180.
- Zsíros, T. and L. Tóth, 1988. Earthquake Hazard from outside of Hungary, Acta Geod. Geoph. Mont. Hung., Vol. 23 (2-4), pp. 411-415.
- Zsíros, T., P. Mónus and L. Tóth, 1990. Computer estimation of intensities; the 1985 Berhida, Hungary, earthquake, PAGEOPH, 132, 533-543.
- Zsíros, T., 1994. Macroseismic observations in Hungary (1989-1993), Seismological Observatory, Geodetic and Geophysical Research Institute, Budapest, 1994. pp. 44.

APPENDIX A

QUESTIONNAIRE USED FOR COLLECTING MACROSEISMIC INFORMATION

,

3. A földrengés környezetre gyakorolt hatása



Egyéb megjegyzés, észrevétel:

1. A rengés észlelési körülményei

2. A földrengés hatása élőlényekre

Épületben tartózkodott?	igen ?	(03)	men ()	(04)	A rengést érezték:	néhányan		(33)	sokan	(34)
	földszinten	(02)	i) hányadik emeleten?	(90)		legtöbben		(35)	-	
Az észlelés idején:	ült	(80)	() állt	(60)	A rengés hatására emberek:	berek:				
feküdt	feküdt (ébren volt)	(10))) aludt	(11)	megijedtek:					
gépjármu	gépjárm ívön utazott	(12)	!) járkált	(13)		senki sem		(36)	néhányan	(37)
Az észlelési hely:	síkvidék	(14)	t) dombvidék	□ (15)		sokan		(38)	legtöbben	(39)
	hegyvidék	(16)	i) folyópart	(11)	épületből szabadba menekültek:	dba menekülte	ŭ	•		
	tópart	(18)	3) lápos terület	(19)						
	völgy	(20)	(senki sem		(40)	néhányan	(41)
						sokan		(42)	legtöbben	(43)
A felszíni anyag főleg:	kemény k <i>æ</i> et	(21)	l) laza üledék	(22)						
átlag	átlagos szilárdságú	(23)) nem tudom	(24)	felébredtek:	senki sem		(44)	néhányan	□ (45)
Állapota: száraz	□ (25)	nedves	i 🗆 (26) vizes	(27)		sokan		(46)	legtöbben	(47)
A rengés jellege:			hullámzó mozgás	(28)	egyensúlyukat vesztették:	vesztették:				
hi	hirtelen lökés	(29)) rázkódás	(30)		senki sem		(48)	néhányan	(49)
A rengés időtartama másodpercben:	isodpercben:		(31) (32)			sokan		(20)	legtöbben	(51)
					Állatok megijedtek:			(52)		



FÖLDRENGÉSI KÉRDŐÍV (B)

Tisztelt Hölgyem/Uram!

A földrengések kutatásánál a műszeres mérések mellett nagyon fontos a földrengés során történt épületsérülések és károk felmérése. Amennyiben az Ön környezetében is történt épületsérülés a közelmúltban előforduló földrengés során, kérjük szíveskedjék e kérdőívet kitölteni és a mellékelt válaszborítékban visszaküldeni.

Amennyiben az Ön által lakott épület nem sérült, de tud a településen sérült épületről, kérjük szíveskedjék e kérdőivet nekik továbbadni.

Közreműködését előre is köszönjük!

(Kérjük, hogy tegyen X jelet a kiválasztott négyzetbe!)

A feladó neve:								
címe:	•••••	••••••	***************************************	***************************************				
Az épület(ek) sérülésének időpontja:	év	hónap	na	póra				
Az Ön tudomása szerint a településükön milyen arányban sérültek meg az épületek?								
néhány (kevesebb mint 10%) 🗆 (01) so	k (10-60%)	□ (02)	legtöbb (több n	nint 60%) 🗆 (03)				
A településen megsérült épületek általábai	n milyen tí	pusúak?						
$vertfalii$ \Box (04) $valyog$ \Box (05) $salak$ \Box (08) $vasbeton$ \Box (09)		tégla □ (06) faház □ (10)		□ (07) □ (11)				
A TOVÁBBIAKAT CSAK AZ ÖN ÉPÜLETÉR	RE VONAT	KOZÓAN KÉRJ	<u>ÜK KITÖLTEN</u>	<u>NI:</u>				
A sérült épület tetőszerkezete:	lapos	□ (12)	sátor	□ (13)				
	nyereg	□ (14)	manzard	□ (15)				
	egyéb			□ (16)				
A sérült épület födémének anyaga:	vasbeton	. (1 <u>7</u>)	£	U (10)				
A seruit epuiet iodemenek anyaga:		, ,	fa	□ (18)				
	egyéb			□ (19)				
A sérült épület tetőborítása:	$n\acute{a}d$	□ (20)	cserép	□ (21)				
	pala	□ (22)						
	egyéb			□ (23)				

						ÜLE				- 12
	100 T		$\frac{1}{\mathbf{V}}$	2 V	3	4 K	5 5	6 °	7 F	8
Az épület sérülés	SÉNEK TÍPUSAI		E	Á	T É	o o	A	A	A	
Kérjük, hogy a szabadon hagyott né	gyszögekben X-el jelölje m	ieg	R T	L Y	G L		L A	S B	H Á	
az épülettípusnál törté	int sérüléseket!		F	О	A		K	E	Z	
国际		100	A L	G				T 0		
			Ú					N		
	válaszfalon	1								
Hajszálrepedések a vakolatban	főfalon	2								
	mennyezeten	3								
	nyílászárónál	4								
	válaszfalon	5 6	\vdash							
Repedések a vakolatban	főfalon mennyezeten	7								
	nyílászárónál	8	-							
	válaszfalon	9	_							
	föfalon	10	\vdash							
Repedések a falban	mennyezeten	11	<u> </u>							
	nyílászárónál	12								
	kéménynél	13								
Burkolóelemek	sérülése	14								
(csempe, stb.)	lehullása	15								
	néhány kimozdult	16								
Kémény sérülése	tégla lehullott	17			,					
Kemeny serulese	részben ledőlt	18								
	ledőlt	19	_							
Cseréphullás	néhány	20			,					
	sok	21								
	válaszfalban	22								
Mély törések, rések	főfalban	23	\vdash							
	mennyezeten	24	ļ	<u> </u>						
	oromfalban	25 26								H
Mennyezet leomlása			╟							
Válaszfal leomlása		27	_			,				Щ
Főfal leomlása		28	_	_						
Épületrész leomlása		29						·		
Egész épület összedőlése		30								

APPENDIX B

$\begin{array}{c} \textbf{EUROPEAN MACROSEISMIC SCALE} \\ \textbf{(EMS)} \end{array}$



EMS INTENSITY SCALE

1 Not felt

Not felt, even the most favourable circumstances.

2 🖝 Scarcely felt

Vibration is felt only by individual people at rest in houses, especially on upper floors of buildings.

3 r Weak

The vibration is weak and is felt indoors by a few people. People at rest feel a swaying or light trembling.

4 • Largely observed

The earthquake is felt indoors by many people, outdoors by very few. A few people are awakened. The level of vibration is not frightening. Windows, doors and dishes rattle. Hanging objects swing.

5 🖝 Strong

The earthquake is felt indoors by most, outdoors by few. Many sleeping people awake. A few run outdoors. Buildings tremble throughout. Hanging objects swing considerably. China and glasses clatter together. The vibration is strong. Top heavy objects topple over. Doors and windows swing open or shut.

6 • Slightly damaging

Felt by most indoors and many outdoors. Many people in buildings are frightened and run outdoors. Small objects fall. Slight damage to many ordinary buildings eg. fine cracks in plaster and small pieces of plaster fall.

7 r Damaging

Most people are frightened and run outdoors. Furniture is shifted and objects fall from shelves in large numbers. Many ordinary buildings suffer moderate damage: small cracks in walls, partial collapse of chimneys.

8 • Heavily damaging

Furniture may be overturned. Many ordinary buildings suffer damage: chimneys fall, large cracks appear in walls and few buildings may partially collapse.

9 🖝 Destructive

Monuments and columns fall or are twisted. Many ordinary buildings partially collapse and few collapse completely.

10 **☞** Very destructive

Many ordinary buildings collapse.

11 • Devastating

Most ordinary buildings collapse.

12 Completely devastating

Practically all structures above and below ground are heavily damaged or destroyed.

(For details see Grünthal, 1993)

APPENDIX C

SIGNIFICANT EARTHQUAKES OF THE WORLD

1996

Earthquakes of magnitude 6.5 or greater or ones that caused fatalities, injuries or substantial damage.

Source:

U.S. Geological Survey

National Earthquake Information Center (telnet: neis.cr.usgs.gov, Username: QED)

.

January 1, 1997

SIGNIFICANT EARTHQUAKES OF THE WORLD, 1996

Earthquakes of magnitude 6.5 or greater or ones that caused fatalities, injuries or substantial damage.

BRK--Berkeley. PAS--Pasadena.

UTC TIME DEP GS MAGS SD STA REGION AND COMMENTS LAT LON HR MN SEC USED MB Msz

JAN 1996

0.729 119.931 24 G 6.3 7.6 1.2 368 MINAHASSA PENINSULA, 01 08:05:10.8 SULAWESI. Mw 7.8 (GS), 7.9 (HRV). Me 7.4 (GS). Ms 7.6 (BRK). Mo=5.1*10**20 Nm (GS). Mo=7.8*10**20 Nm (HRV). Mo=2.6*10**20 Nm (PPT). At least eight people killed, one person missing and more than 350 buildings damaged in the Bangkir-Tolitoli area. A local tsunami with estimated runup heights of one to five meters contributed to the damage in the epicentral area. Two

events about 2.4 seconds apart. 53.826 159.586 33 N 5.9 6.6 1.4 316 NEAR EAST COAST OF 01 09:57:51.4

KAMCHATKA Ms 6.6 (BRK). Felt (IV) at Petropavlovsk-Kamchatskiy. 53.304 142.738 8 G 5.6 5.3 0.9 453 SAKHALIN ISLAND. Mw 5.6 08 10:04:47.8 (GS), 5.6 (HRV). Ms 5.1 (BRK) Mo=3.1*10**17 Nm (GS). Mo=3.0*10**17 Nm (HRV). Fourteen houses damaged at Okha. Felt (VII) at Russa; (VI) at Okha and Tungor; (V) at Moskalvo,

Nogliki and Vostochnyy; (IV) at Nekrasovka and Rybnoye. -32.921 -178.298 33 N 5.6 6.7 1.0 137 SOUTH OF KERMADEC 30 22:29:57.1 ISLANDS. Mw 6.4 (HRV). Ms 6.9 (BRK). Mo=4.4*10**18 Nm (HRV). Mo=6.2*10**18 Nm (PPT).

FEB 1996

03 11:14:19.8 27.299 100.341 10 G 6.3 6.5 1.1 415 YUNNAN, CHINA. Mw 6.5 (GS), 6.6 (HRV). Me 6.6 (GS). Mo=5.6*10**18 Nm (GS). Mo=9.8*10**18 Nm (HRV). At least 251 people killed, 4,027 seriously injured, approximately 1,000,000 left homeless and at least 329,000 houses destroyed in northwestern Yunnan Province, mainly in the Lijiang-Zhongdian area. Maximum intensity IX at

Lijiang. Rockslides occurred in the Lijiang area. 45.321 149.909 33 N 6.3 7.0 1.1 433 KURIL ISLANDS. Mw 7.1 07 21:36:45.1 (GS), 7.2 (HRV). Mo=4.7*10**19 Nm (GS). Mo=6.5*10**19 Nm (HRV). Some minor damage (V) on Iturup. Felt (IV) on Kunashir.

16 09:44:58.1 -1.524 -15.222 10 G 6.0 6.3 1.0 244 NORTH OF ASCENSION ISLAND. Mw 6.4 (GS), 6.5 (HRV). Mo=5.1*10**18 Nm (GS). Mo=7.1*10**18 Nm (HRV). Mo= 6.3*10**18 Nm (PPT).

37.343 142.474 33 N 6.2 6.2 1.0 366 OFF EAST COAST OF HONSHU, JAPAN. Mw 6.6 (GS), 6.7 (HRV). Mo=8.7*10**18 Nm (GS) 16 15:22:57.8 Mo=1.3*10**19 Nm (HRV). Mo=1.2*10**19 Nm (PPT). Several people slightly injured in the epicentral area. Felt (IV JMA) at Fukushima, Ichinoseki, Ishinomaki, Mito, Morioka, Ofunato, Sendai and Shirakawa. Felt on the Izu Peninsula and at Tokyo. Also felt on Hokkaido.

17 05:59:29.7 -0.950 137.027 33 N 6.5 8.1 1.2 136 IRIAN JAYA REGION, INDONESIA. Mw 7.9 (GS). Mo=7.2*10**20 Nm (GS). Mo=9.0*10**20 Nm (PPT). At least 108 people killed, 423 injured, 58 missing, 5,043 houses destroyed or damaged in the epicentral area. Extensive damage on Biak and Supiori from the tsunami, which reached heights of 7 meters in many areas. Also damage along the north coast of Irian Jaya from Manokwari to Sarmi.

-0.591 135.874 33 N 5.8 6.7 1.2 92 IRIAN JAYA REGION, INDONESIA. Mw 6.7 (GS), 6.4 (HRV). Mo=1.3*10**19 Nm (GS). 17 14:21:23.7 Mo=4.9*10**18 Nm (HRV).

17 20:18:07.1 -0.879 136.054 33 N 6.0 6.6 1.1 50 IRIAN JAYA REGION,

INDONESIA. Mw 6.6 (HRV). Mo=8.0*10**18 Nm (HRV).
-1.411 136.598 33 N 5.7 6.4 1.2 76 IRIAN JAYA REGION, 18 02:25:36.1 INDONESIA. Mw 6.5 (GS), 6.4 (HRV). Mo=5.5*10**18 Nm (GS). Mo=4.2*10**18 Nm (HRV). Mo=9.0*10**18 Nm (PPT).

18 23:49:28.0 -1.283 -14.274 10 G 6.3 6.4 1.1 278 NORTH OF ASCENSION ISLAND. Mw 6.5 (GS), 6.6 (HRV). Mo=7.2*10**18 Nm (GS). Mo=9.3*10**18 Nm (HRV). Mo=6.8*10**18 Nm (PPT).

21 12:51:04.3 -9.620 -79.568 33 N 5.8 6.6 1.2 183 OFF COAST OF NORTHERN PERU. Mw 7.3 (GS), 7.5 (HRV). Mo=1.1*10**20 Nm (GS). Mo=2.2*10**20 Nm (HRV). Mo=3.0*10**20 Nm (PPT). Four people killed, three missing and two injured from a local tsunami. The tsunami also destroyed about 150 huts along the coast near

```
Chimbote. Felt (IV) at Chimbote and Huarmey; (III) at Casma;
                  (II) at Huacho and Huaraz.
                 -33.693 -71.706 44 D 5.9 5.5 1.0 205 NEAR COAST OF CENTRAL
22 13:40:53.5
                  CHILE. Mw 6.0 (GS), 5.9 (HRV). Mo=1.1*10**18 Nm (GS).
                 Mo=9.2*10**17 Nm (HRV). One person injured and minor damage (V)
                  at Santiago. Minor damage at Las Cabras, Melipilla and San
                 Antonio. Felt (V) at Coquimbo, Rancagua and Valparaiso; (IV) at
                 Maule.
25 03:08:18.8
                  16.204
                           -97.963 33 N 5.9 6.9 1.2 273 OAXACA, MEXICO. Mw 7.1
                  (GS), 7.0 (HRV). Mo=5.4*10**19 Nm (GS). Mo=3.5*10**19 Nm (HRV).
                 Felt along the coast of Guerrero and Oaxaca States. Also felt
                 at Mexico City.
MAR 1996
03 14:55:11.8
                  11.657 -86.856 33 N 5.7 6.5 1.3 307 NEAR COAST OF NICARAGUA.
                 11.905 -86.772 33 N 5.7 6.7 1.2 293 NEAR COAST OF NICARAGUA. Mw 6.8 (GS), 6.7 (HRV). Ms 6.7 (BRK). Mo=1.8*10**19 Nm (GS). Mo=1.2*10**19 Nm (HRV). Mo=1.5*10**19 Nm (PPT). Some damage at
03 16:37:31.5
                 Chinandega and Granada. Felt strongly at Managua.
                 24.092 122.215 30 6.1 6.4 1.0 360 TAIWAN REGION. Mw 6.3 (GS), 6.5 (HRV). Ms 5.9 (BRK). Mo=2.8*10**18 Nm (GS). Mo=5.9*10**18 Nm (HRV). Felt strongly at Tai-pei. Felt in many
05 14:52:28.6
                 parts of Taiwan.
16 22:04:06.2
                  28.983 138.944 477 D 5.9
                                                     0.9 348 BONIN ISLANDS REGION. Mw
                 6.6 (GS), 6.6 (HRV). mb 6.1 (BRK). Mo=9.3*10**18 Nm (GS).
                 Mo=1.0*10**19 Nm (HRV).
17 14:48:56.7
                 -14.705 167.297 164 D 5.8 6.0 0.9 162 VANUATU ISLANDS. Mw 6.6
                 (GS), 6.7 (HRV). Ms 6.1 (BRK). Mo=9.2*10**18 Nm (GS).
                 Mo=1.2*10**19 Nm (HRV). Mo=1.7*10**19 Nm (PPT).
                  39.993 76.696 28 D 5.7 6.0 1.0 273 SOUTHERN XINJIANG,
19 15:00:26.0
                 CHINA. Mw 6.1 (GS), 6.3 (HRV). Mo=1.5*10**18 Nm (GS).
                 Mo=3.5*10**18 Nm (HRV). At least twenty-four people killed, 128
                 injured and more than 15,314 houses destroyed in the
                 Artux-Jiashi area. Also felt at Bachu, Kashi, Wuqia and
                 Yecheng.
                  51.221 178.695 20 G 5.7 6.6 1.2 477 RAT ISLANDS, ALEUTIAN
22 03:24:20.0
                 ISLANDS. Mw 6.8 (GS), 6.7 (HRV). Me 6.5 (GS). ML 6.6 (PMR). Ms 6.5 (BRK). Mo=1.7*10**19 Nm (GS). Mo=1.4*10**19 Nm (HRV).
                 Mo=2.0*10**19 Nm (PPT). Felt on Adak.
-1.036 -78.737 33 N 5.8 5.2 0.8 296 ECUADOR. Mw 5.9 (GS)
28 23:03:49.8
                 5.9 (HRV). Ms 5.1 (BRK). Mo=7.6*10**17 Nm (GS). Mo=8.6*10**17
                 Nm (HRV). At least 19 people killed, 58 injured, several
                 thousand homeless and considerable damage and destruction to
                 homes, bridges and water pipes in Cotopaxi, Pastaza and
                 Tungurahua Provinces. Landslides blocked several roads in the
                 epicentral area. Minor damage (VI) at Ambato, Latacunga and San
                 Miguel de Salcedo. Felt (IV) at Quito: (III) at Ibarra: (II) at
                 Cuenca and Guayaquil. Felt in many parts of Ecuador.
APR 1996
                 -24.061 -177.036 111 D 6.4 6.8 1.0 376 SOUTH OF FIJI ISLANDS.
16 00:30:54.6
                 Mw 7.1 (GS), 7.1 (HRV). Mo=5.6*10**19 Nm (GS). Mo=5.7*10**19 Nm
                 (HRV). Mo=9.5*10**19 Nm (PPT).
                 -23.944 -70.093 50 D 6.0 6.1 1.0 295 NEAR COAST OF NORTHERN
19 00:19:31.1
                 CHILE. Mw 6.6 (GS), 6.6 (HRV). Me 6.5 (GS). Mo=8.3*10**18 Nm
                 (GS). Mo=8.4*10**18 Nm (HRV). Mo=1.4*10**19 Nm (PPT). Felt
                 (V-VI) at Calama; (V) at Antofagasta, Maria Elena and
                 Tocopilla; (IV) at Taltal.
-6.518 154.999 44 G 6.3 7.5 1.0 301 SOLOMON ISLANDS. Mw 7.1
29 14:40:41.0
                 (GS), 7.2 (HRV). Me 6.8 (GS). Mo=4.8*10**19 Nm (GS). Mo=7.6*10**19 Nm (HRV). Mo=4.7*10**19 Nm (PPT). One person
                 killed and several houses collapsed in western Bougainville.
                 Felt throughout the island of Bougainville.
MAY 1996
                 16.130 120.600 33 N 5.2 5.0 1.0 113 LUZON, PHILIPPINE ISLANDS. Three people injured at Dagupan. Felt (V RF) at
02 06:30:24.8
                 Dagupan; (IV RF) at Baguio and Manila; (III RF) at Quezon.
-4.548 154.833 500 G 5.6 1.0 242 SOLOMON ISLANDS. Mw 6.5
02 13:34:28.9
                 (GS), 6.6 (HRV). Mo=6.0*10**18 Nm (GS). Mo=1.0*10**19 Nm (HRV).
                 Mo=9.2*10**18 Nm (PPT).
```

```
40.774 109.661 26 D 5.5 6.0 1.0 268 WESTERN NEI MONGOL,
03 03:32:47.1
                    CHINA. Mw 5.9 (GS), 6.0 (HRV). Mo=8.3*10**17 Nm (GS).
                    Mo=1.2*10**18 Nm (HRV). At least 18 people killed, 300 injured
                    and extensive damage in the Baotou area. Felt at Beijing,
Hohhot, Taiyuan, Xian and Yinchuan. 03 04:04:22.6& 47.760 -121.876 4 5.2
                                                                    307 WASHINGTON: <SEA-P>. MD
                    47.760 -121.876 4 5.2 307 WASHINGTON. <SEA-P>. MD 5.3 (SEA). ML 5.5 (PGC). Two people injured and slight damage in the epicentral area. Felt (V) at Baring, Bothell, Bremerton, Burlington, Carnation, Clinton, Hansville, Kenmore, Kingston, Kirkland, Lake Stevens, Maple Valley, Marblemount, Marysville, Mount Vernon, Pacific, Peshastin, Port Hadlock, Preston, Redmond, Redondo, Ronald, Seattle, Silverdale, Snoqualmie and Woodinville, Felt throughout Western Washington, east as far as
                    Woodinville. Felt throughout western Washington, east as far as
                    Wenatchee, Washington and south as far as Astoria and Portland,
                    Oregon. Felt to the north at Castlegar, Kelowna, Mission,
                    Nelson, Penticton, Victoria and Vancouver, British Columbia,
                    Canada.
                                  53.594 33 N 4.9 4.7 0.9 116 SOUTHERN IRAN. Twenty
                     27.847
24 06:35:58.7
                    people injured and some damage in the Khonj area.
JUN 1996
                    10.797 -42.254 10 G 6.1 6.9 1.1 383 NORTHERN MID-ATLANTIC RIDGE. Mw 6.8 (GS), 7.0 (HRV). Mo=2.0*10**19 Nm (GS).
02 02:52:09.5
                    Mo=3.0*10**19 Nm (HRV). Mo=4.3*10**19 Nm (PPT).
41.657 88.690 0 G 5.9 4.3 0.9 368 SOUTHERN XINJIANG,
08 02:55:57.9
                      41.657
                    CHINA. Probable underground nuclear explosion.
                      51.491 -178.128 33 N 5.9 6.3 0.9 328 ANDREANOF ISLANDS,
08 23:19:15.1
                    ALEUTIAN IS. Mw 6.4 (GS), 6.5 (HRV). Ms 6.1 (BRK). ML 5.6 (PMR). Mo=3.9*10**18 Nm (GS). Mo=6.6*10**18 Nm (HRV). Felt
                    strongly on Adak.
                     17.444 145.458 149 D 6.0 5.9 1.0 220 MARIANA ISLANDS. Mw 6.5 (GS), 6.5 (HRV). Mo=7.1*10**18 Nm (GS). Mo=6.8*10**18 Nm (HRV).
09 01:12:16.7
                     Felt strongly on Saipan.
                    -13.481 167.130 200 D 5.8 5.9 1.0 301 VANUATU ISLANDS. Mw 6.7 (GS), 6.7 (HRV). Ms 6.0 (BRK). Mo=1.2*10**19 Nm (GS).
10 01:04:46.9
                    Mo=1.3*10**19 Nm (HRV).
                    51.564 -177.632 33 N 6.6 7.6 0.9 508 ANDREANOF I ALEUTIAN IS. Mw 7.9 (GS), 7.9 (HRV). Ms 7.4 (BRK).
                                             33 N 6.6 7.6 0.9 508 ANDREANOF ISLANDS,
10 04:03:35.4
                    Mo=7.3*10**20 Nm (GS). Mo=8.6*10**20 Nm (HRV). Mo=8.6*10**20 Nm
                     (PPT). Felt (VI) on Adak and Atka. Tsunami generated with wave
                    heights (peak-to-trough) recorded at the following selected
                     tide stations: 102 cm on Adak, 15 cm on Shemya, 12.5 cm at
                     Kodiak and 10.2 cm at Sand Point, Alaska; 46 cm on Midway; 55
                    cm at Kahului, 38 cm at Hilo, 33 cm at Nawiliwili and 10 cm at
                     Honolulu, Hawaii; 30 cm at Crescent City, California; 10 cm at
                    Port Angeles, Washington.
                    51.478 -176.847 26 G 5.9 7.1 1.0 333 ANDREANOF ISLANDS, ALEUTIAN IS. Mw 7.1 (GS), 7.2 (HRV). Ms 6.9 (BRK).
10 15:24:56.0
                    Mo=5.5*10**19 Nm (GS). Mo=8.4*10**19 Nm (HRV). Mo=1.1*10**20 Nm
                    (PPT). Felt strongly on Adak.

12.614 125.154 33 N 6.0 7.0 0.9 307 SAMAR, PHILIPPINE
ISLANDS. Mw 6.9 (GS), 7.1 (HRV). Ms 7.2 (BRK). Mo=2.4*10**19 Nm
11 18:22:55.7
                     (GS). Mo=5.3*10**19 Nm (HRV). Mo=5.7*10**19 Nm (PPT). Felt (V
                     RF) at Catarman; (IV RF) at Bulusan, Luzon and Palo, Leyte;
                    (III RF) at Legaspi, Luzon; (I RF) at Quezon, Luzon.
-7.137 122.589 587 D 6.6 1.2 476 FLORES SEA. Mw 7.8 (GS),
17 11:22:18.5
                    7.9 (HRV). Mo=6.0*10**20 Nm (GS). Mo=7.9*10**20 Nm (HRV). Mo=5.6*10**20 Nm (PPT). Some damage at Kupang, Indonesia. Felt
                     at Larantuka and Maumere, Indonesia. Also felt at Putatan,
                    Malaysia.
                     51.568 159.119 20 G 6.0 6.6 1.1 350 OFF EAST COAST OF
21 13:57:10.0
                    KAMCHATKA. Mw 7.0 (GS), 6.8 (HRV). Ms 6.5 (BRK). Mo=3.3*10**19 Nm (GS). Mo=2.0*10**19 Nm (HRV). Mo=2.4*10**19 Nm (PPT). Felt
                     (IV) in the Petropavlovsk-Kamchatskiy area.
JUL 1996
15 00:13:28.6
                                   5.977 5 G 4.5 4.5 1.2 111 FRANCE. One person
                      46.015
                     slightly injured and minor damage at Cruseilles. Felt strongly
                     at Annecy. Also felt at Lyon. Widely felt in the Alps and
                     southern Switzerland.
                      17.600 -100.965 18 G 5.7 6.5 1.2 165 GUERRERO, MEXICO. Mw 6.6
15 21:23:34.0
                     (GS), 6.6 (HRV). Me 6.2 (GS). Mo=9.8*10**18 Nm (GS).
```

Mo=9.3*10**18 Nm (HRV). Felt strongly at Acapulco, Ixtapa and

16 03:48:28.3	Mexico City. 56.084 164.998 33 N 5.8 6.4 1.2 205 KOMANDORSKY ISLANDS REGION. Mw 6.3 (GS), 6.5 (HRV). Mo=3.6*10**18 Nm (GS).
16 10:07:36.6	Mo=6.4*10**18 Nm (HRV). Mo=1.2*10**19 Nm (PPT). 1.016 120.254 33 N 6.0 6.4 1.0 145 MINAHASSA PENINSULA, SULAWESI. Mw 6.6 (GS), 6.6 (HRV). Mo=7.6*10**18 Nm (GS). Mo=8.5*10**18 Nm (HRV). Some damage in Tolitoli area. Felt
22 14:19:35.7	widely in northwestern Sulawesi. 1.000 120.450 33 N 6.0 6.9 1.2 214 MINAHASSA PENINSULA, SULAWESI. Mw 6.9 (GS), 7.0 (HRV). Mo=2.8*10**19 Nm (GS). Mo=3.8*10**19 Nm (HRV). Mo=3.7*10**19 Nm (PPT). Some damage
23 03:32:12.6	(VIII) in the Tolitoli area. Felt (V) in the Palu area26.753 -177.199 33 N 5.8 6.4 1.1 208 SOUTH OF FIJI ISLANDS. Mw 6.5 (GS), 6.5 (HRV). Mo≈6.6*10**18 Nm (GS). Mo=5.6*10**18 Nm (HRV). Mo=1.1*10**19 Nm (PPT).
29 01:48:57.8	41.824 88.420 0 G 4.9 0.7 97 SOUTHERN XINJIANG, CHINA. Underground nuclear explosion.
AUG 1996	
02 12:55:29.3	-10.769 161.445 33 N 6.2 7.1 1.1 271 SOLOMON ISLANDS. Mw 6.9 (GS), 6.9 (HRV). Mo=2.3*10**19 Nm (GS). Mo=2.8*10**19 Nm (HRV). Mo=4.3*10**19 Nm (PPT).
05 02:08:58.2	-15.267 -173.126 41 G 6.0 6.7 1.4 319 TONGA ISLANDS. Mw 6.7 (GS), 6.7 (HRV). Me 6.2 (GS). Mo=1.2*10**19 Nm (GS). Mo=1.2*10**19 Nm (HRV). Mo=1.2*10**19 Nm (PPT). Felt (III) at
05 22:38:22.0	Apia, Western Samoa20.690 -178.310 550 D 6.4 0.9 508 FIJI ISLANDS REGION. Mw 7.3 (GS), 7.4 (HRV). Mo=1.1*10**20 Nm (GS). Mo=1.3*10**20 Nm (HRV). Mo=1.5*10**20 Nm (PPT). Felt (II) on Raoul Island,
10 18:12:17.3	Kermadec Islands. 38.909 140.530 10 G 6.0 5.7 0.9 369 EASTERN HONSHU, JAPAN. Mw 5.9 (GS), 5.9 (HRV). Mo=7.9*10**17 Nm (GS). Mo=7.3*10**17 Nm (HRV). Six people injured in northeastern Yamagata Prefecture.
14 01:55:02.5	Four people injured and fifteen houses damaged at Naruko, Miyagi Prefecture. Felt (V JMA) in the Kurikoma area, (IV JMA) at Shinjo and (III JMA) at Ichinoseki and Oga. 40.754 35.340 10 G 5.3 5.6 1.1 316 TURKEY. Mw 5.7 (GS), 5.8 (HRV). Mo=3.9*10**17 Nm (GS). Mo=4.8*10**17 Nm (HRV). Nine people injured by a landslide at Oymaagac. Some damage in the Amasya area. Felt strongly in the areas of Cankiri, Kastamonu, Samsun, Sivas and Tokat.
25 14:09:03.2	-1.084 -78.674 51 5.1 4.2 0.8 158 ECUADOR. Two people injured and several houses destroyed in the Ambato area. Also felt at Latacunga and Pelileo.
SEP 1996	
05 08:14:14.4	-22.118 -113.436 10 G 6.2 7.0 1.1 360 EASTER ISLAND REGION. Mw 6.7 (GS), 6.9 (HRV). Me 6.5 (GS). Ms 7.0 (BRK). Mo=1.3*10**19 Nm (GS). Mo=2.5*10**19 Nm (HRV). Mo=1.7*10**19 Nm (PPT).
05 20:44:09.2	42.803 17.936 10 G 5.6 6.0 1.3 360 ADRIATIC SEA. Mw 5.7 (GS), 6.0 (HRV). Mo=4.2*10**17 Nm (GS). Mo=1.1*10**18 Nm (HRV). Several people injured, 2,000 left homeless and extensive damage (VIII) in the Ston-Slano area, Croatia. Felt in many parts of Bosnia and Herzegovina, Croatia and Yugoslavia. Felt (V) in the Shkoder area, Albania and (IV) at Skopje, Yugoslavia.
05 23:42:06.1	21.898 121.498 20 G 6.4 6.6 1.0 372 TAIWAN REGION. Mw 6.6 (GS), 6.8 (HRV). Me 6.8 (GS). Mo=9.4*10**18 Nm (GS). Mo=1.9*10**19 Nm (HRV). Mo=4.5*10**19 Nm (PPT). Felt on Taiwan.
20 04:10:27.6	9.463 126.284 33 N 5.8 6.4 1.1 199 MINDANAO, PHILIPPINE ISLANDS. Mw 6.6 (GS), 6.6 (HRV). Mo=7.6*10**18 Nm (GS). Mo=7.6*10**18 Nm (HRV). Mo=1.3*10**19 Nm (PPT). Felt at Butuan and Surigao. Also felt on Leyte.
OCT 1996 09 13:10:52.1	34.556 32.126 33 N 6.4 6.8 1.0 482 CYPRUS REGION. Mw 6.8 (GS), 6.8 (HRV). Me 7.2 (GS). Mo=1.9*10**19 Nm (GS). Mo=2.1*10**19 Nm (HRV). Mo=5.2*10**19 Nm (PPT). One person died of a heart attack and twenty others injured on Cyprus. One person killed in Egypt. Felt in Egypt, Israel, Jordan, Lebanon
14 23:26:20.0	and Syria7.133 155.568 24 G 5.9 6.9 1.1 263 SOLOMON ISLANDS. Mw 6.7 (GS), 6.8 (HRV). Me 6.3 (GS). Mo=1.2*10**19 Nm (GS).

18 10:50:20.8	Mo=1.7*10**19 Nm (HRV). Mo=1.3*10**19 Nm (PPT). Felt strongly on Shortland and Treasury Islands. 30.568 131.093 10 G 6.0 6.6 1.2 308 KYUSHU, JAPAN. Mw 6.8 (GS), 6.8 (HRV). Mo=1.5*10**19 Nm (GS). Mo=1.8*10**19 Nm (HRV). Mo=1.7*10**19 Nm (PPT). Felt (IV JMA) in eastern Kagoshima Prefecture; (III JMA) in Miyazaki and western Kagoshima Prefectures. Also felt (III JMA) on Tanega-shima. Local tsunami generated with wave heights up to 17 cm recorded on
19 14:44:40.7	Tanega-shima. 31.885 131.468 22 G 6.3 6.6 1.0 396 KYUSHU, JAPAN. Mw 7.0 (GS), 6.8 (HRV). Me 6.6 (GS). Mo=3.2*10**19 Nm (GS). Mo=1.9*10**19 Nm (HRV). Mo=2.1*10**19 Nm (PPT). Some damage (V JMA) at Kanoya and Miyazaki. Felt (IV JMA) at Kumamoto, Kurume and Oita. Tsunami generated with recorded wave heights of Tanega-shima. Minor tsunami also observed on Shikoku.
19 14:53:48.7	-20.412 -178.510 591 D 6.1 0.8 558 FIJI ISLANDS REGION. Mw 6.8 (GS), 6.9 (HRV). Mo=2.1*10**19 Nm (GS). Mo=2.4*10**19 Nm (HRV). Mo=3.5*10**19 Nm (PPT).
24 19:31:54.1	66.965 -173.159 20 G 6.0 5.9 1.0 288 NEAR N. COAST OF EASTERN SIBERIA. Mw 6.0 (GS), 6.1 (HRV). Me 5.8 (GS). Mo=1.1*10**18 Nm (GS). Mo=1.4*10**18 Nm (HRV). Mo=2.2*10**18 Nm (PPT). Felt on the Chukotka Peninsula.
NOV 1996 05 09:41:34.7	-31.160 179.998 369 D 5.9 1.0 356 KERMADEC ISLANDS REGION.
03 03.11.31.7	Mw 6.7 (GS), 6.8 (HRV). Mo=1.4*10**19 Nm (GS). Mo=1.5*10**19 Nm (HRV). Mo=2.7*10**19 Nm (PPT).
06 20:00:58.8	27.999 143.538 9 G 6.4 6.5 0.8 388 BONIN ISLANDS REGION. Mw 6.4 (GS), 6.6 (HRV). Me 6.4 (GS). Mo=4.4*10**18 Nm (GS). Mo=8.1*10**18 Nm (HRV). Mo=1.3*10**19 Nm (PPT).
12 16:59:44.0	-14.993 -75.675 33 N 6.5 7.3 1.1 365 NEAR COAST OF PERU. Mw 7.7 (GS), 7.7 (HRV). Mo=3.7*10 **20 Nm (GS), Mo=4.4*10**20 Nm (HRV).Mo=7.7*10**20 Nm (PPT). At least 14 people killed, 560 injured and 12,000 homeless from Chincha Alta to Acari.Over 4,000 houses damaged or destroyed (VIII) at Nazca. Felt (VII) in the Marcona area; (VI) at Ica and Palpa; (IV) at Arequipa and Camana; (III) at Lima and Tacna; (II) at Huancayo and Pucallpa. Felt by people in high-rise buildings at Guayaquil, Ecuador and La Paz, Bolivia. This thrust earthquake is associated with the subduction of the Nazca Ridge (a major feature of the Nazca plate) beneath the South American plate. It originated near the southern end of a seismic gap between the large Peruvian earthquakes of August 24, 1942 and October 3, 1974, with the aftershock sequence progressing southward into the zone of the 1942 event. This is a complex earthquake, with at least two larger events occurring about 20 and 33 seconds after the onset, observed on broadband displacement seismograms.
19 10:44:46.0	35.345 78.133 33 N 6.1 7.1 1.4 339 EASTERN KASHMIR. Mw 6.8 (GS), 6.9 (HRV). Mo=2.0*10**19 Nm (GS). Mo=2.2*10**19 Nm (HRV). Mo=2.5*10**19 Nm (PPT). Felt at Hotan, Shule, Wushi and Yecheng, China.
DEC 1996 02 22:17:59.2	31.789 131.314 49 6.0 6.6 1.0 332 KYUSHU, JAPAN. Mw 6.7 (GS), 6.8 (HRV). Me 6.3 (GS). Mo=1.4*10**19 Nm (GS). Mo=1.6*10**19 Nm (HRV). Mo=1.7*10 **19 Nm (PPT). Felt (V JMA) in southern Miyazaki Prefecture. Felt from Fukuoka to Kagoshima. Minor local tsunami observed along the southeast coast of Kyushu.
10 08:36:18.7	0.870 -30.039 10 G 6.0 6.2 0.9 209 CENTRAL MID-ATLANTIC RIDGE. Mw 6.6 (GS), 6.6 (HRV). Mo=9.1*10**18 Nm (GS). Mo=1.0*10**19 Nm (HRV). Mo=1.8*10 **19 Nm (PPT). This event has
22 14:53:27.6	a small precursor about seconds earlier. 43.207 138.920 227 D 6.0 0.9 442 EASTERN SEA OF JAPAN. Mw 6.5 (GS), 6.5 (HRV). Mo=6.6*10** 18 Nm (GS). Mo=6.6*10**18 Nm

Hypocenters for February through December to be recomputed.

Compiled by Waverly J. Person

