

# Welcome to Vibrationdata

Acoustics • Shock • Vibration • Signal Processing

December 2004 Newsletter

## Ni hao

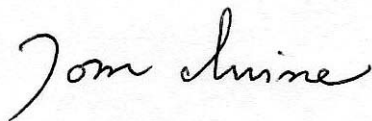
One of my goals is to measure a wide variety of oscillating signals. In some sense, I am pursuing a “unified field theory” of acoustics, shock, vibration, and signal processing. This effort includes biomedical signals.

The first article thus discusses the heart’s electrical waveforms, as represented by an EKG.

I recently obtained a Vernier LabPro data acquisition system, which is intended for classroom instruction and science projects. This system can measure data from a variety of transducers including EKG sensors. The article gives some of the EKG data that I have measured with this system.

The second article presents data from a Taiwanese earthquake, as measured on my Lehman seismometer.

Sincerely,



Tom Irvine  
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## Feature Articles



## EKG Waves



## Taiwan Earthquake

## The Heart: Inside

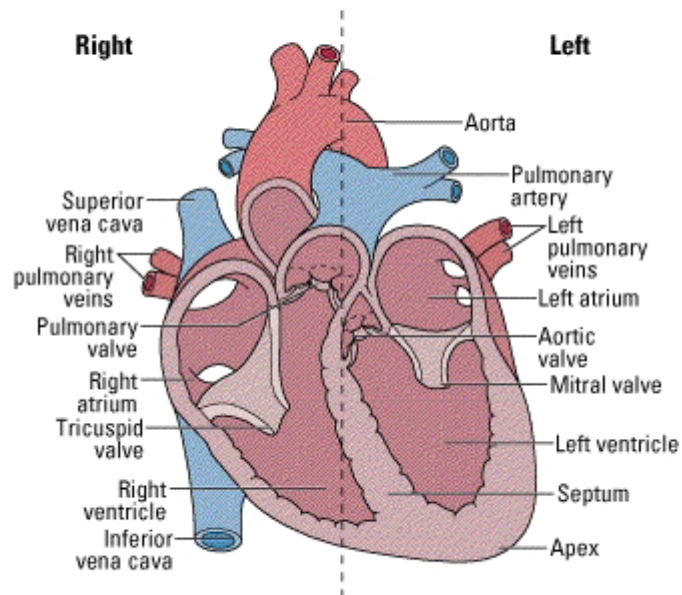


Figure 1. Heart Diagram

### Introduction

An electrocardiogram (ECG or EKG) is a recording of the electrical activity in the heart, as measured on the body's surface. The EKG correlates somewhat indirectly with the mechanical action of the heart.

The body acts as a giant conductor of electrical currents. Any two points on the body may be connected by electrical leads to monitor the rhythm of the heart.

Specifically, the EKG monitors the potential changes due to excitation (depolarization) and recovery (repolarization) of the heart muscle.

The various electrical events generate waveforms.

Normally, as the electrical impulse moves through the heart, the heart contracts about 60 to 100 times a minute. Each contraction represents one heartbeat. The upper chambers (atria) contract a fraction of a second before the lower chambers (ventricles) so the blood empties into the ventricles before the ventricles contract.

### Electrical Impulses

Heart muscle cells are polarized at rest. The electrical charge is due primarily to sodium ions. In addition, ions such as potassium, calcium, chlorine, and charged protein molecules play a roll.

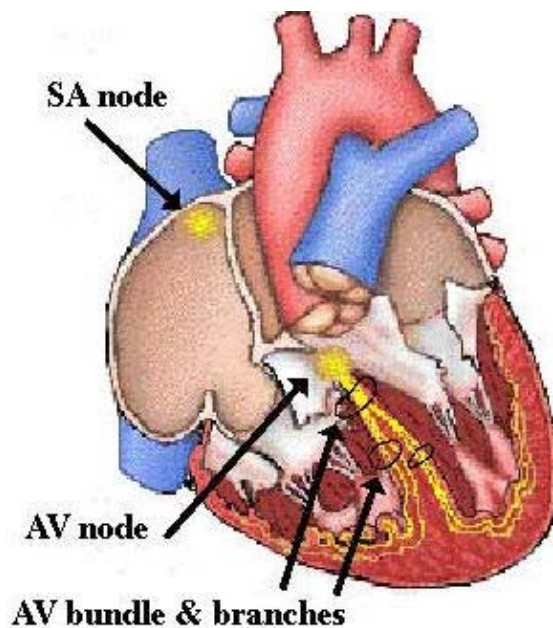


Figure 2. Heart Nodes (Image courtesy of The University of Michigan)

The electrical impulses originating in the sinus node (SA) trigger atrial depolarization. The SA node cells function as a pacemaker.

The direction of electrical activity is from the SA to the atrioventricular (AV) node.

The impulse is conducted down a special bundle of conduction fibers, called the AV bundle, to the ventricles. Next, the Purkinje fibers bring depolarization to all parts of the ventricles almost simultaneously.

This process has a small time delay, so there is a short pause after the atria contract and before the ventricles contract.

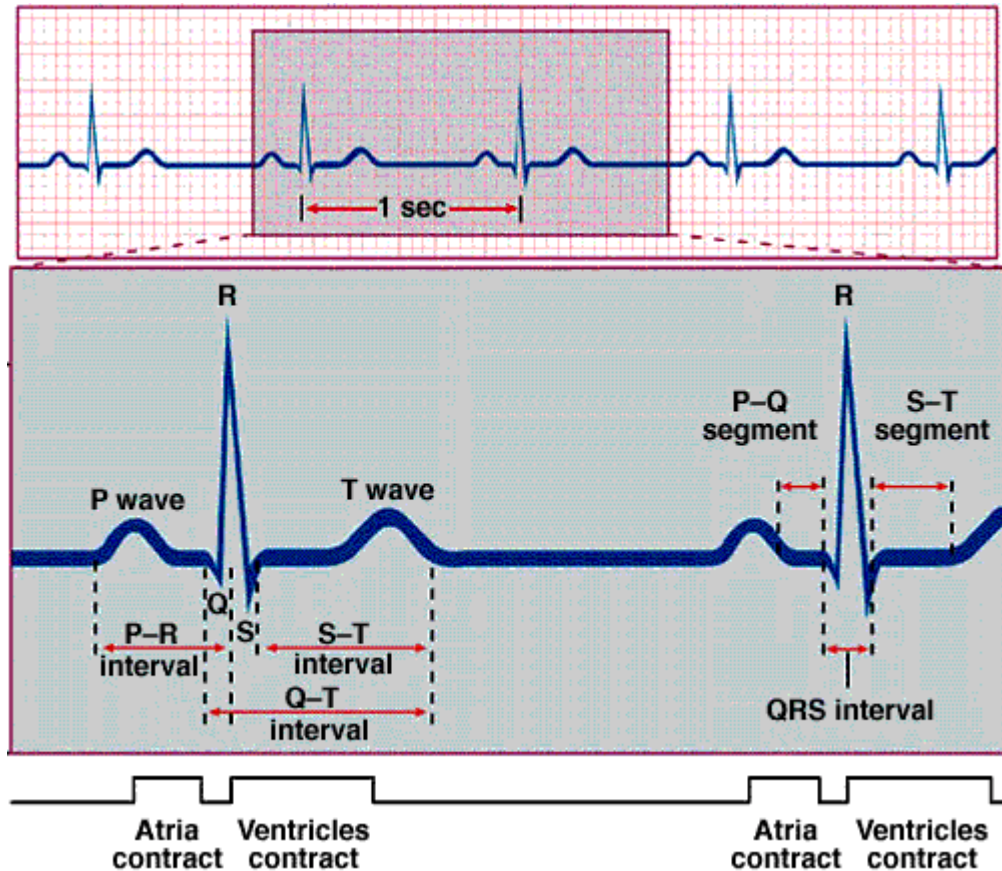


Figure 3. EKG Waveforms (Image courtesy of James Madison University)

### P-Wave

The P-wave shows the heart's atria contracting, during atrial depolarization. Both the left and right atria contract simultaneously.

The P-wave is viewed normally as small and curved with a positive deflection.

The P-R interval is normally 0.12 to 2.0 seconds in duration.

The normal P-wave duration is less than 0.1 seconds.

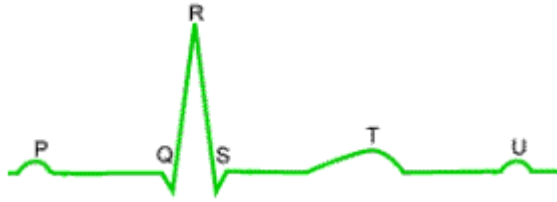


Figure 4. EKG Waveforms including the U-wave  
(Image courtesy of Howard Hughes Medical Institute)

### QRS Complex

The QRS complex represents ventricular depolarization. It consists of three waveforms.

The normal complex begins with a downward deflection known as the Q-wave, followed by an upward deflection called the R-wave. The next downward deflection is the S-wave.

The QRS complex corresponds to the current that causes contraction of the left and right ventricles. This contraction is much more forceful than that of the atria and involves more muscle, resulting in a greater EKG deflection.

The normal QRS interval is 0.04 to 0.10 seconds.

Note that atrial repolarization takes place during ventricular depolarization.

### T-wave

The T-wave shows the heart's lower chambers (ventricles) repolarizing, or relaxing. Its shape is rounded and taller and wider than the P-wave.

The T-wave is also more sensitive to physiologic and hormonal changes in shape but usually has a positive deflection.

### U-wave

A U-wave may follow a T-wave. The U-wave is thought to represent late repolarization of the Purkinje fibers in the Ventricles.

THE AUTHOR'S EKG AT REST RATE = 81 BEATS/MIN

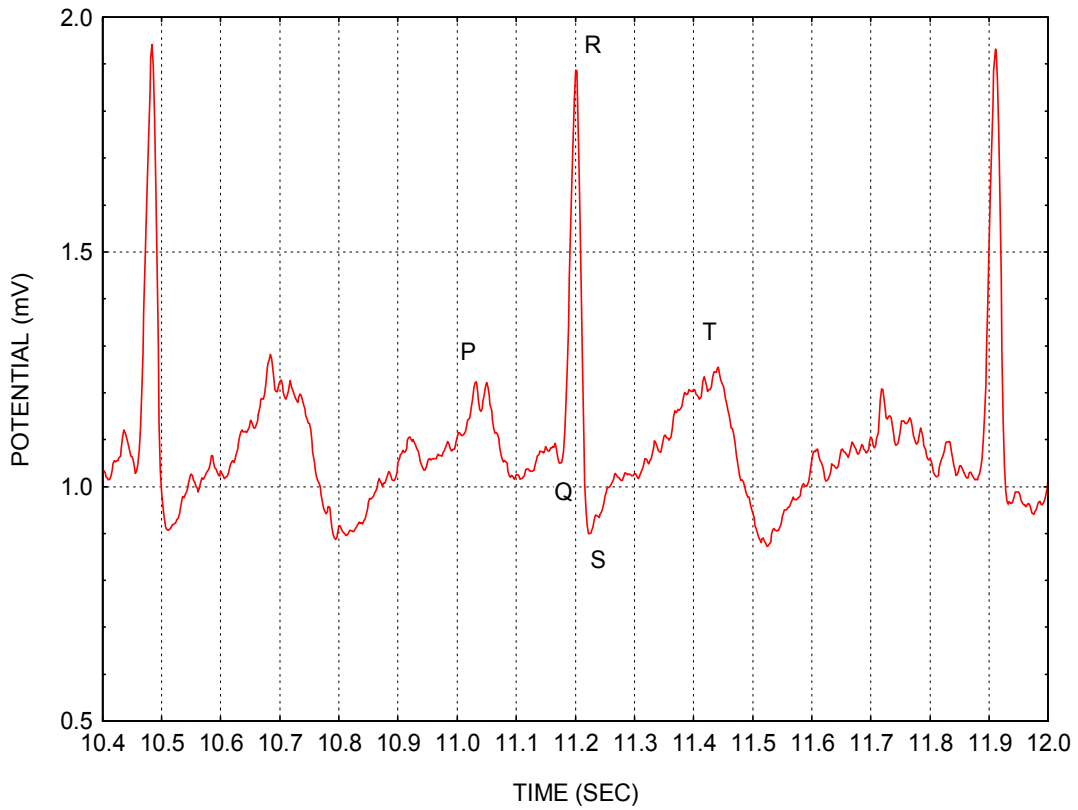


Figure 5.

The EKG was taken with three leads, using the Vernier LabPro and EKG sensors. The approximate intervals are given in the follow table.

Interval	Duration (sec)
P-R	1.4
QRS	0.08
Q-T	0.35
S-T	0.30

Note that the EKG signal may include electrical impulses originating in other muscles and organs besides the heart.

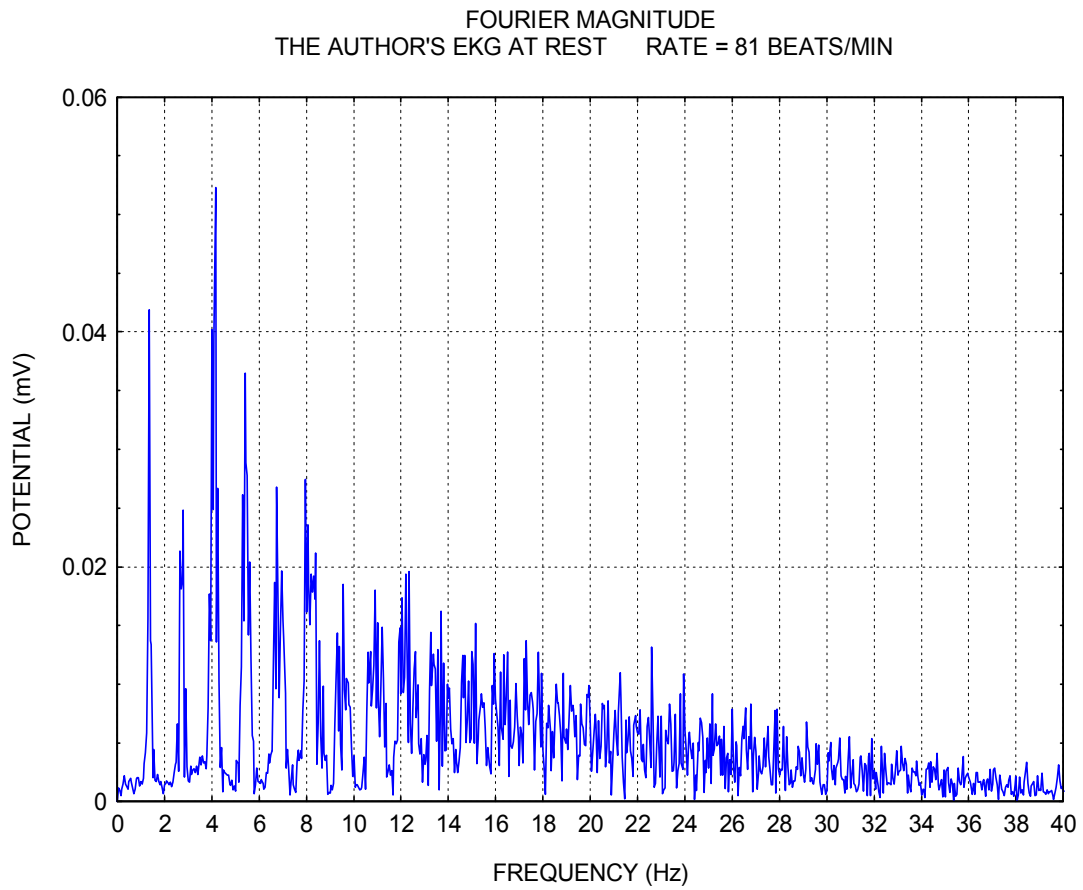
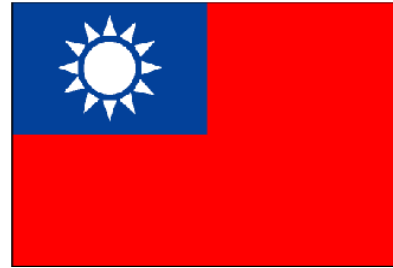


Figure 6.

The first spectral peak occurs at 1.35 Hz, which corresponds to 81 beats/min. Harmonic peaks occur at integer multiples of the fundamental frequency.

## Taiwan Earthquake by Tom Irvine



### Introduction

A strong earthquake shook Taiwan on Friday, October 15. The quake forced the Taipei subway system to shut down during the lunchtime rush. No serious injuries were reported.

The tremor gently rocked buildings for about one minute and was felt on Japan's southern coast. On Taipei's streets, the quake caused sidewalks to shake slightly.

Fires were reported in Taipei City, an Internet café in Koashiung as well as a transponder box right across the street from the Koashiung's City Hall. Otherwise, no serious property damage occurred.

This was the strongest quake in Taiwan since the Chi-Chi quake in September 1999 that killed more than 2,100 people

and destroyed or damaged thousands of buildings. The Chi-Chi quake had a magnitude of 7.7.

### Plate Tectonics

Taiwan is located above a subduction zone, where the Philippine Plate is being subducted under the Eurasian Plate. It is part of the "Pacific Ring of Fire."

### Seismic Time History

I recorded the Taiwan earthquake on my Lehman seismometer, located in my home in Mesa, Arizona. This seismometer is a horizontal pendulum design. The resulting time history plots are given in Figures 1 and 2. Reference data from the USGS is given after these seismograms.



TAIWAN EARTHQUAKE UTC 2004/10/15 04:08:50  
RECORDED ON LEHMAN HORIZONTAL SEISMOMETER IN MESA, ARIZONA

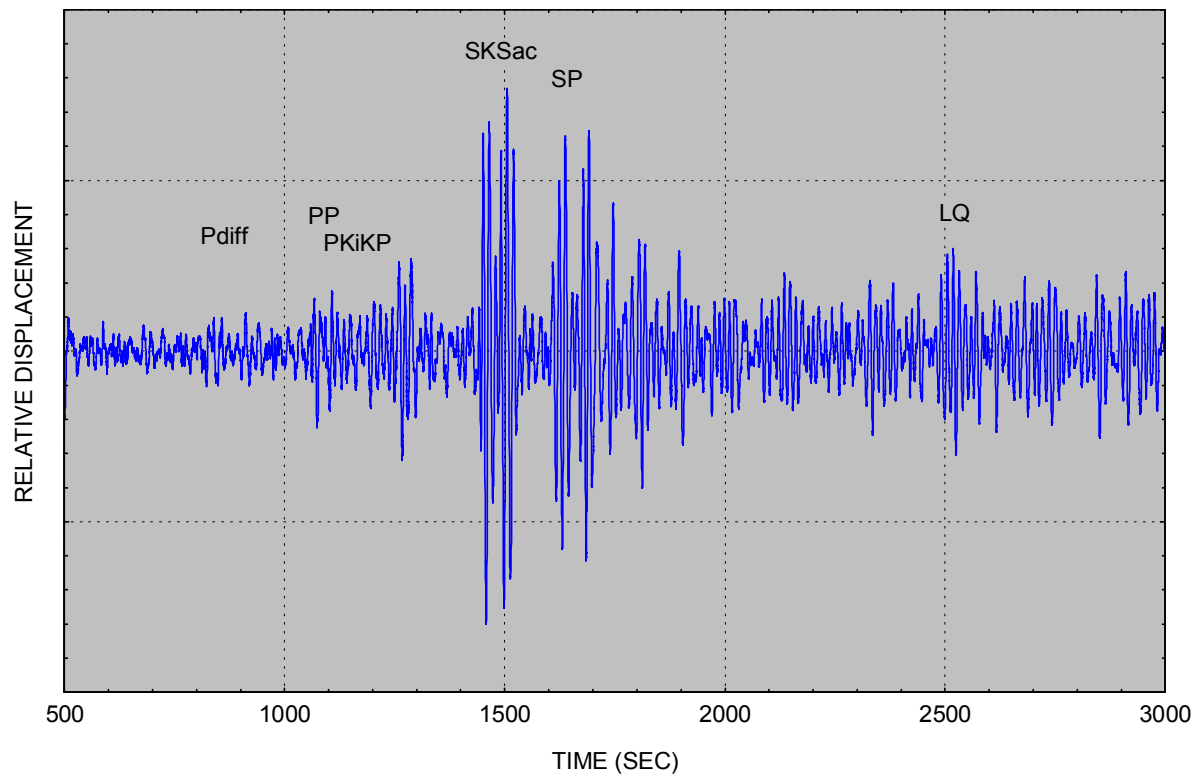


Figure 1.

Pdiff is a P-wave that has diffracted around the Earth's core.

Mesa Arizona is on the edge of the "Shadow zone" for the Taiwan earthquake.

The shadow zone is the area of the earth from angular distances of 103 to 140 degrees that, for a given earthquake, does not receive any direct P waves.

The shadow zone results from the P-waves being bent or diffracted by the liquid core. In addition, the S-waves are stopped entirely by the liquid core.

TAIWAN EARTHQUAKE UTC 2004/10/15 04:08:50  
RECORDED ON LEHMAN HORIZONTAL SEISMOMETER IN MESA, ARIZONA

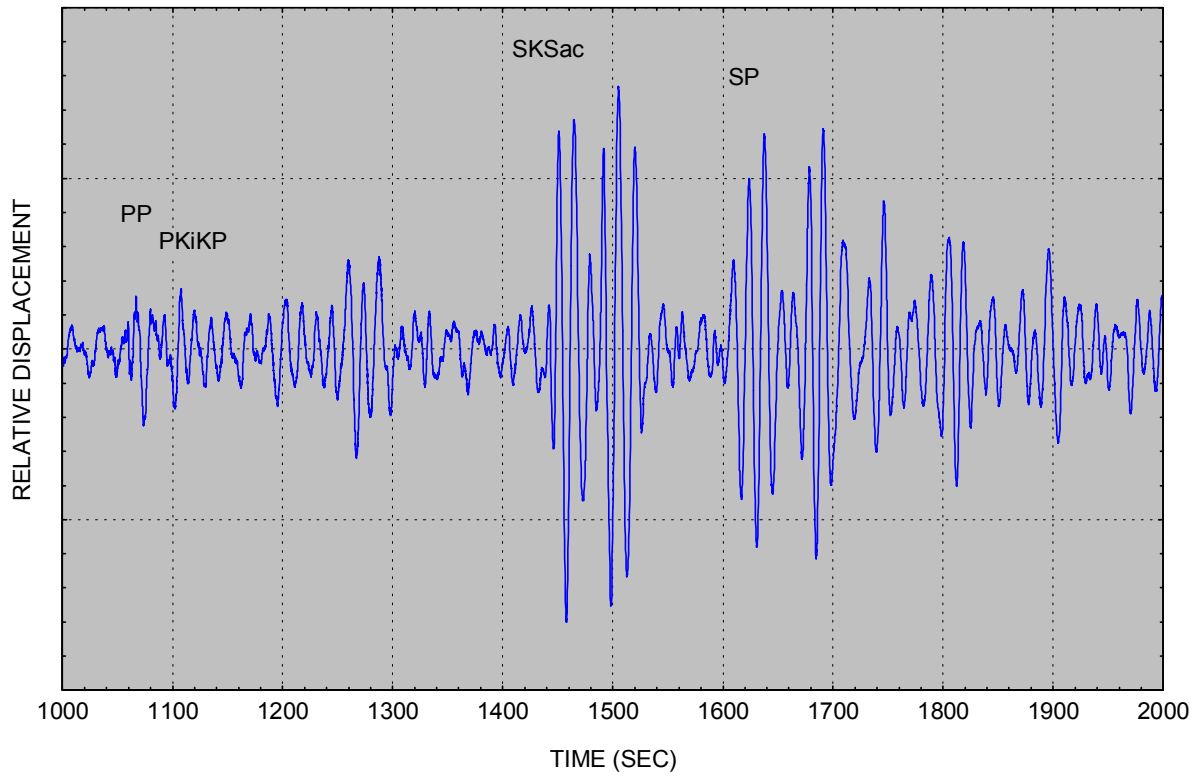
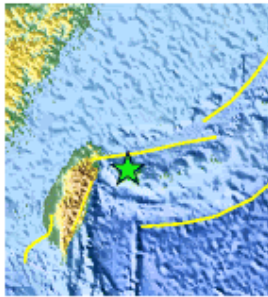


Figure 2.



**Magnitude** 6.7

**Date-Time** **Friday, October 15, 2004 at 04:08:50 (UTC)**

= Coordinated Universal Time

**Friday, October 15, 2004 at 12:08:50 PM**

= local time at epicenter

Time of Earthquake in other Time Zones

**Location** 24.515°N, 122.670°E

**Depth** 95 km (59.0 miles)

**Region** TAIWAN REGION

**Distances**

85 km (50 miles) E of **Su-ao, Taiwan**

125 km (80 miles) ENE of **Hua-lien, Taiwan**

130 km (80 miles) ESE of **T'AI-PEI, Taiwan**

155 km (95 miles) W of **Ishigaki-jima, Ryukyu Islands, Japan**

**Location** horizontal +/- 6.9 km (4.3 miles); depth +/- 7.5 km (4.7

**Uncertainty** miles)

**Parameters** Nst=156, Nph=156, Dmin=130.1 km, Rmss=0.97 sec,

Gp= 54°,

M-type=teleseismic moment magnitude (Mw), Version=8

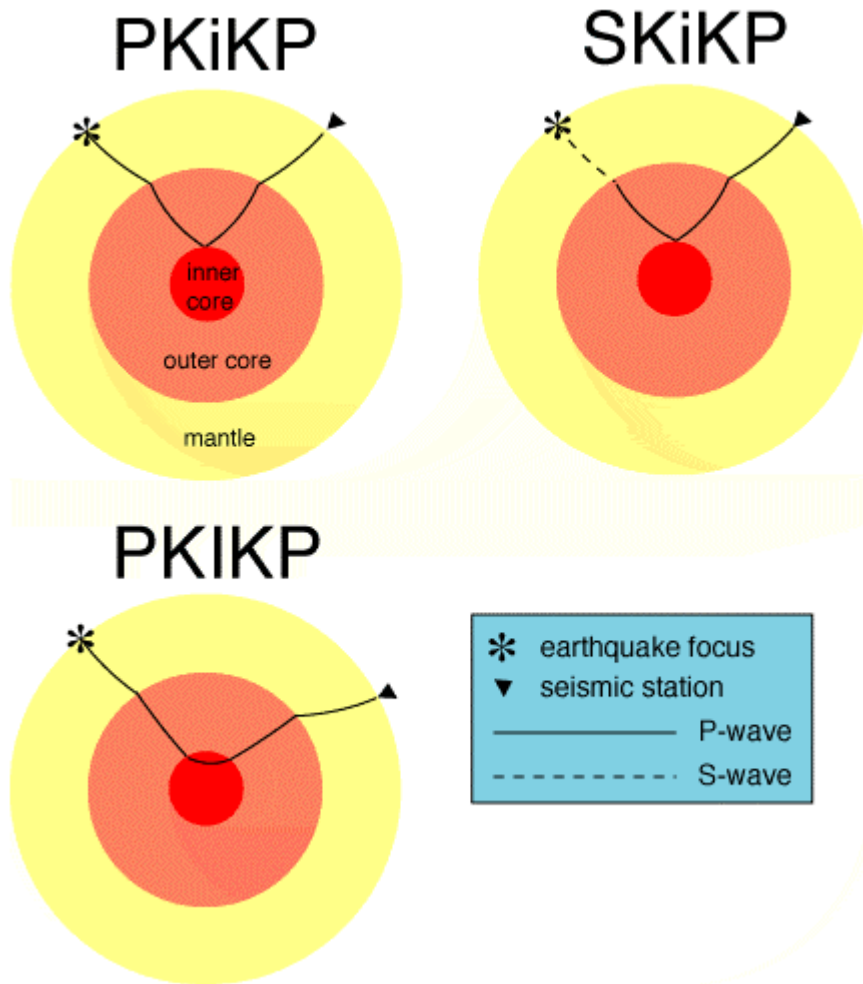
**Source** USGS NEIC (WDCS-D)

**Event ID** uspqan

DATE-(UTC)-TIME      LAT      LON      DEPTH MAG    Q      COMMENTS  
 2004/10/15 04:08:50    24.51N 122.67E    95.0 6.7      US:  
 TAIWAN REGION  
     Expected 1s period body wave amplitude      [ 1.45E-01  $\mu$ m]  
 [ 9.09E-01  $\mu$ m/s]

delta      azimuth (degrees clockwise from north)  
 (deg)      eq-to-station      station-to-eq  
 102.49      44.3      310.5

#	code	travel time(s)	arrival time			
			dy	hr	mn	sec
1	Pdiff	825.20	0	4	22	35
2	pPdiff	850.47	0	4	23	0
3	sPdiff	860.86	0	4	23	10
4	PP	1079.13	0	4	26	49
5	PKiKP	1086.20	0	4	26	56
6	pPKiKP	1112.44	0	4	27	22
7	sPKiKP	1122.61	0	4	27	32
8	SKiKP	1292.40	0	4	30	22
9	SKSac	1455.82	0	4	33	5
10	pSKSac	1491.36	0	4	33	41
11	SKKSac	1493.84	0	4	33	43
12	sSKSac	1501.78	0	4	33	51
13	Sdiff	1521.08	0	4	34	11
14	pSdiff	1554.32	0	4	34	44
15	sSdiff	1565.48	0	4	34	55
16	SP	1616.59	0	4	35	46
17	PS	1628.61	0	4	35	58
18	PKKPbc	1784.20	0	4	38	34
19	PKKPdf	1791.95	0	4	38	41
20	SS	1951.70	0	4	41	21
21	SKKPbc	1996.80	0	4	42	6
22	SKKPdf	1997.95	0	4	42	7
23	PKKSbc	2007.02	0	4	42	17
24	PKKSdf	2008.12	0	4	42	18
25	SKKSdf	2213.97	0	4	45	43
26	SKKSac	2217.88	0	4	45	47
27	P'P'df	2284.84	0	4	46	54
28	S'S'ac	3132.37	0	5	1	2
29	S'S'df	3140.49	0	5	1	10
30	LQ	2601.36	0	4	52	11
31	LR	2887.14	0	4	56	57



Courtesy of Princeton Earth Physics Project.

An “i” means that a wave goes through the inner core.

An “i” means that the wave reflects off of the inner core.

“K” refers to a P-wave in the fluid outer core.

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New Testament, Matthew 24: 7

For nation shall rise against nation, and kingdom against kingdom: and there shall be famines, and pestilences, and earthquakes, in divers places.