UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Preliminary hypocentral locations from the Loma Prieta, California, earthquake of October 17, 1989

by

U.S. Geological Survey[1]

Open-File Report 89-638

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HOW TO GET LOMA PRIETA HYPOCENTER DATA
FROM THE U.S. GEOLOGICAL SURVEY

The hypocenters of Loma Prieta earthquakes are available to anyone over the INTERNET network by using the anonymous user option in the file transfer protocol ftp. Use these instructions to get the data:

1. Connect to our computer over the internet by using the command:
   ftp isunix.menlo.usgs.gov
   or if your nameserver doesn't know our address you can use the command:
   ftp 130.118.4.53
   If you are on a different network you will need to use a gateway. Ask your network specialist for instructions.
2. For the login name give the response "anonymous" (without the quotes).
3. For the password give your own name. This will let us identify the users.
4. Change to the pub directory with the command:
   ftp> cd pub
   Note that "ftp>" is the prompt.
5. Get the disclaimer file which explains the limitations of the data with the command
   ftp> get DISCLAIMER
   This file also includes a description of the summary cards.
6. Get the hypocenter summary cards in HYPOINVERSE format with the command:
   ftp> get loma.sum
   HYPOINVERSE format contains a great deal of information, however it is very densely packed and some people find it hard to read. For this reason we are also offering this data in HYPO71 format. HYPO71 format is easier to read, but it does leave out a lot of the detailed information that can be very useful when interpreting the data. HYPOINVERSE format will be our standard format for releasing data in the future. You are advised to learn how to read it. If you want the HYPO71 format data give this command:
   ftp> get loma.smp
7. In the future as we add data to this directory we will describe it in a file called CONTENTS. To get this file use the command:
   ftp> get CONTENTS
   You can look at this file on your own machine and then use the get command to retrieve any other files you want.
8. Disconnect from our computer by giving the command:
   ftp> quit

DISCLAIMER

The Loma Prieta hypocenter data provided by the U.S.G.S. is preliminary. This means that there are known and unknown errors in the data and that interpretations based on this data may be erroneous. Much effort has gone into compiling these data, but yet the following problems exist.

1. Almost all the post-main shock (10/18/89) locations are computed from Real Time Processor (RTP) data. Over the next year these data will be re-timed from digital waveforms, but for the present there has been almost no verification of the RTP arrival times.

2. The catalog is not complete for the post-main shock period, particularly the first two days of the aftershock sequence.

3. During energetic periods of seismicity, the RTP cannot discriminate between earthquakes closely spaced in time form one long earthquake. In these cases the reported coda duration reflects the duration for multiple events and the resulting magnitude may be grossly exaggerated.

4. The velocity model used to locate the Loma Prieta earthquakes changed as of 10/18/89 and again on 11/08/89. Before 10/18/89 time earthquakes were located with the best available velocity model developed for the hypocentral region (Klein, personal communication 1989). A new model was developed for the Loma Prieta sequence, but earlier data has not been relocated yet. Check columns 103-105 of the HYPOINVERSE locations and Table 4 (enclosed) for the velocity model used. All data will be eventually relocated with the "LOM" model.

5. Magnitudes are calculated from the median of individual station coda duration magnitudes. Before 9/83 coda measurements were not read for every station, and thus magnitude estimates may be based on small numbers of readings. After 9/83 readings were computed automatically by computers, but readings have not been checked.

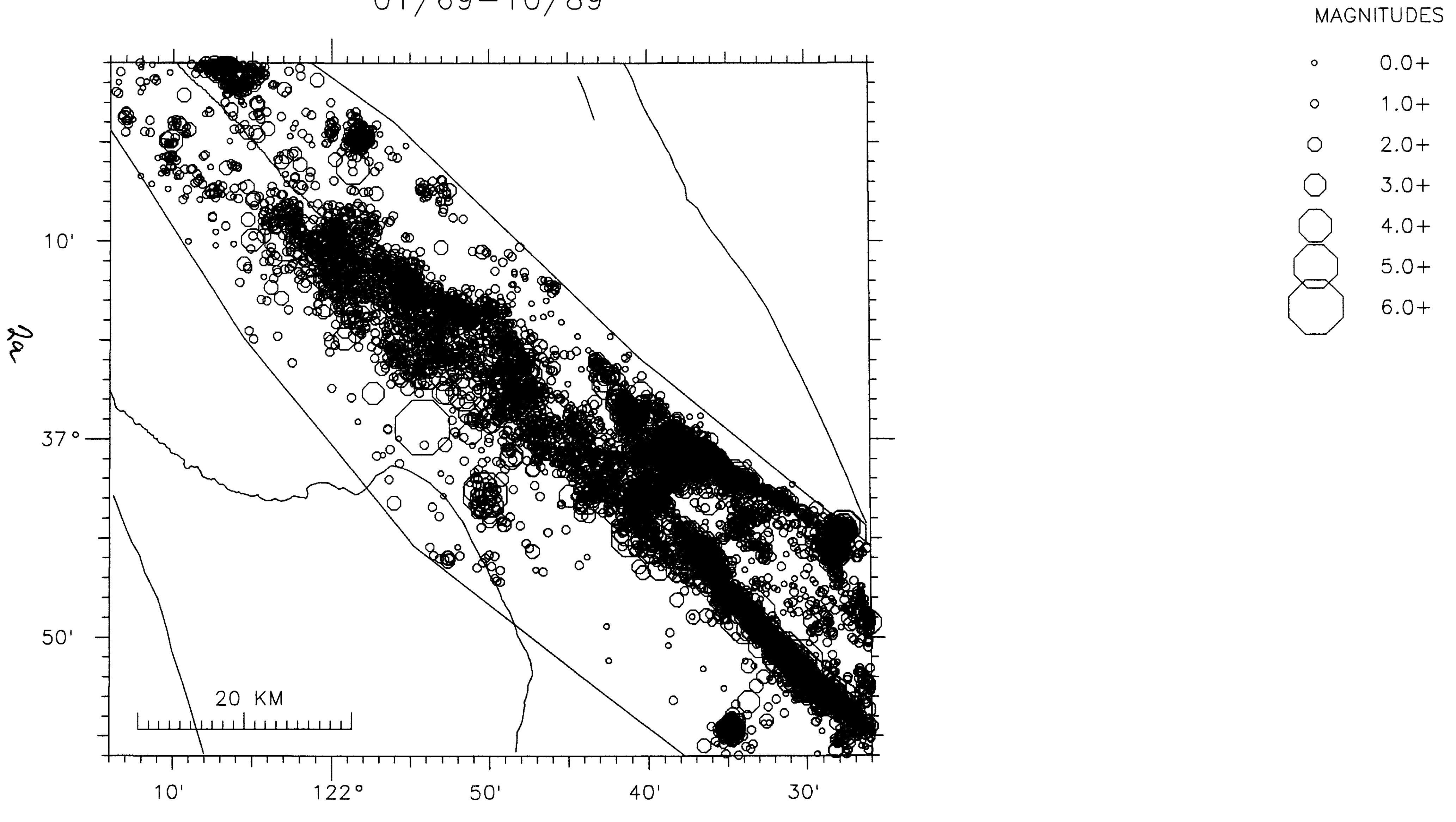
6. Changes in network operations resulted in unknown systematic shifts in magnitude determination in 1977 and possibly at other times. Magnitudes of events >5 and <1.2 may be in error by several tenths of a magnitude unit.

7. Erroneous travel time readings contaminate the data set. Usually HYPOINVERSE (Klein, 1989) will weight-out inconsistent travel times if sufficient data is available to constrain the solution. However, for earthquakes containing small (<6) numbers of readings, the solutions are affected. Tests indicate that up to 10% of the locations before the Loma Prieta main shock may be affected by contaminated arrival times. The percentage of contaminated solutions following the main shock is almost certainly larger.

8. Earthquakes based on less than 6 readings are included for completeness, but may not be well located. To ensure reliable locations, the locations should be culled from the entire catalog using criteria such as solution RMS, horizontal and vertical uncertainty (ERH, ERZ), number of readings, and distance to the nearest station (DMIN).

9. Quarry explosions have not been removed from the file, but are sometimes indicated on the summary cards.

01/69–10/89



2a

LOMA PRIETA, CALIFORNIA, (M=7.1) EARTHQUAKE SEQUENCE

MAGNITUDE 4.0 AND LARGER EARTHQUAKES AS OF 5:00 PM PST, NOV 9, 1989

GREENWICH MEAN TIME				LOCAL TIME (PDT BEFORE 10/29) (PST AFTER 10/29)	LATITUDE		LONGITUDE		DEPTH	MAGNITUDE	
MO	DA	HR	MN	(DA HR MN)	DEG	MIN	DEG	MIN	(KM)		
10	18	0	4	(17 17 4)	37	2	121	53	18.5	7.1	<-- MAINSHOCK
10	18	0	9	(17 17 9)	37	1	121	51		4.3	
10	18	0	12	(17 17 12)	37	7	122	1		4.5	
10	18	0	25	(17 17 25)	37	2	121	48		4.8	
10	18	0	30	(17 17 30)	37	5	122	0		4.2	
10	18	0	38	(17 17 38)	37	10	122	1		4.3	
10	18	0	41	(17 17 41)	37	10	122	3		5.2	
10	18	0	45	(17 17 45)	36	55	121	43		4.0	
10	18	2	15	(17 19 15)	37	4	121	44		4.5	
10	18	2	26	(17 19 26)	37	1	121	46		4.2	
10	18	4	16	(17 21 16)	37	3	121	54		4.1	
10	18	4	50	(17 21 50)	37	8	122	3		4.3	
10	18	5	18	(17 22 18)	37	1	121	51		4.2	
10	18	10	22	(18 3 22)	36	59	121	51		4.5	
10	19	8	45	(19 1 45)	36	57	121	51		4.3	
10	19	9	53	(19 2 53)	36	55	121	41		4.5	
10	19	10	14	(19 3 14)	36	57	121	50		5.0	
10	19	12	25	(19 5 25)	36	55	121	41		4.0	
10	21	0	49	(20 17 49)	37	1	121	53		4.3	
10	21	22	15	(21 15 15)	37	3	121	53		4.6	
10	25	1	27	(24 18 27)	37	5	121	50		4.5	
11	02	5	50	(01 21 50)	37	3	121	49		4.4	
11	05	13	37	(05 5 37)	37	3	121	53		4.0	
11	07	23	42	(07 15 42)	37	13	122	2		4.0	

HYPOINVERSE SUMMARY FORMAT

The catalog file contains a summary line with location and other data for each event. They are in chronological order and in yearly files.

The FORTRAN formats below are to be used for reading the fields. Decimal points may or may not appear, and if not, their places are implied by the format as indicated.

Cols.	Format	Data
1-10	5I2	Year, month, day, hour and minute.
11-14	F4.2	Origin time seconds.
15-16	F2.0	Latitude (deg).
17	A1	S for south, blank otherwise.
18-21	F4.2	Latitude (min).
22-24	F3.0	Longitude (deg).
25	A1	E for east, blank otherwise.
26-29	F4.2	Longitude (min).
30-34	F5.2	Depth (km).
35-36	F2.1	Amplitude magnitude.
37-39	I3	Number of P & S times with final weights greater than 0.1.
40-42	I3	Maximum azimuthal gap.
43-45	F3.0	Distance to nearest station (km).
46-49	F4.2	RMS travel time residual.
50-52	F3.0	Azimuth of smallest principal error (deg E of N).
53-54	F2.0	Dip of smallest principal error (deg).
55-58	F4.2	Magnitude of smallest principal error (km).
59-61	F3.0	Azimuth of intermediate principal error.
62-63	F2.0	Dip of intermediate principal error.
64-67	F4.2	Magnitude of intermediate principal error (km).
68-69	F2.1	Duration (coda) magnitude.
70-72	A3	Event location (geographic region) code (See table 3).
73-76	F4.2	Magnitude of largest principal error (km).
77-78	2A1	Event remarks (such as Q=quarry or NTS, *=poor convergence, F=felt, L=long period, B=blast, etc. See table 2).
79-80	I2	Number of S times with weights greater than 0.1.
81-84	F4.2	Horizontal error (km).
85-88	F4.2	Vertical error (km).
89-90	I2	Number of P first motions.
91-93	F3.1	Total of amp. magnitude weights (approx. number of readings).
94-96	F3.1	Total of duration magnitude weights.
97-99	F3.2	Mean-absolute-difference of amplitude magnitudes.
100-02	F3.2	Mean-absolute-difference of duration magnitudes.
103-05	A3	3-letter code of crust and delay model (See table 4).
106	A1	Crust model type code (H or T).
107	A1	Most common P & S data source code (See table 1).
108	A1	Most common duration magnitude data source code.
109	A1	Most common amplitude magnitude data source code.
110	I1	Coda magnitude type code (1=duration 2=tau).
111-13	I3	Number of valid readings initially assigned positive weights.

HYPO71 SUMMARY FORMAT

Cols.	Format	Data
1-6	3I2, 1X	Year, month and day.
8-11	2I2	Hour and minute.
12-17	F6.2	Origin time seconds.
18-20	F3.0	Latitude (deg).
21	A1	S for south, blank otherwise.
22-26	F5.2	Latitude (min).
27-30	F4.0	Longitude (deg).
31	A1	E for east, blank otherwise.
32-36	F5.2	Longitude (min).
37-43	F7.2, 2X	Depth (km).
46-50	F5.2	Duration magnitude.
51-53	I3	Number of P & S times with weights greater than 0.1.
54-57	F4.0	Maximum azimuthal gap.
58-62	F5.1	Distance to nearest station (km).
63-67	F5.2	RMS travel time residual.
68-72	F5.1	Horizontal error (km).
73-77	F5.1	Vertical error (km).
78	A1	Q for quarry, blank otherwise
79	A1	Overall quality A (best) to D (worst), see Lee and Lahr USGS Open file report 75-311 for details
80	A1	Data source, see HYPOINVERSE column 107 and Table 1 for details

Table 1. DATA SOURCE CODES

The following table was taken from Klein et al., Seismic Station Data for Northern California and Surrounding Areas, USGS Open File Report 88-448, 1988.

(_ stands for a blank space).

1-letter code	Meaning	Original 6-letter codes
H	Hand timed	H_____ ______ 1_____ CALNEW _ALNEW,
	"	CALDVL CALHEL
R	Main RTP	XP P-remark. May find: R_____ 2_____,
	"	CALRTP
P	Prototype RTP	YP P-remark. May find: CALPRO
O	Motorola RTP	CALMOT
1	CUSP Tustin A/D #1	CALT1_
2	CUSP Tustin A/D #2	CALT2_ _ALT2_
E	CUSP-Eclipse digitized	CALECL _ALECL
F	CUSP-VAX/750 digitized	CALFMT
3	Pasadena Tustin #1	CITT1_
4	Pasadena Tustin #2	CITT2_
5	Pasadena 11/34 online	CITN34
6	Pasadena 11/34 online	CITS34
7	Pasadena Nova/Eclipse	CITD1_
8	Pasadena VAX digitized	CITFMT
C	Pasadena hand timed	CITHEL CITNEW _ITNEW CITPNK
M	Readings from Mexico	CITMEX
J	Jerry Eaton hand timed	______
U	U. Nevada Reno readings	RENO__ _ENO__ RENO_1
B	UC Berkeley readings	
Y	Woodward-Clyde readings	
G	CDMG readings	
L	LLL readings	
S	USC readings	
T	Tera Corp. or PG&E readings	
?	Unknown or undefined	

Table 2. EVENT REMARKS

The 3-letter event remark is the geographic region code. The regions were defined on the basis of seismicity patterns. The codes were assigned by HYPOINVERSE when the epicenter was calculated and they are also recognized by the QPLOT plotting program.

The 1-letter remarks may consist of the following (some may not be used):

Q Suspected quarry blast or NTS shot (not confirmed or consistently applied)
B Quarry blast
F Felt
T Associated with harmonic tremor
L Long-period seismogram

* Problem solution. May result from: depth held fixed because of insufficient constraint, did not converge after 20 iterations, solution was forced because normal residual weighting would have left less than 4 stations,

or hypocenter did not reach a minimum RMS residual.

Table 3. GEOGRAPHIC REGION CODES

Lake Almanor	ALM
Alum Rock	ALU
Anno Nuevo	ANN
Auburn	AUB
Bald Mtn. (MOB)	BAL
Bartlett Springs Fault	BAR
Bitterwater Valley	BIT
Black Mountain	BLM
Basin & Range Calif %	BRC
Busch Fault	BUS
Bear Valley	BVL
Casa Diablo Mtn. (VOT)	CAS
Chalk Bluffs (VOT)	CHA
Chalfant Valley (BRC)	CHV
Coalinga	COA
Concord Fault	CON
Coso Range (BRC)	COS
Ciervo Hills	CRV
Coyote North	CYN
Coyote South	CYS
Danville	DAN
Del Norte	DEL
Death Valley (BRC)	DEV
Resurgent Dome (LVC)	DOM
East Moat (LVC)	EMO
El Paso Mtn. (BRC)	EPM
Eureka	EUR
Geysers	GEY
Glass Mtn. (MOB)	GLA
Gold Hill	GOL
Greenville Fault	GRN
Green Valley Fault	GVL
Mt. Hamilton	HAM
Hayward Fault	HAY
Hilton Crk. Flt. (LVC)	HCF
Hollister	HOL
Inyo Craters (LVC)	INC
Indian Wells Val. (BRC)	IWV
San Joaquin Valley	JQN
June Lake (LVC)	JUN
Kaiser Peak	KAI
Klamath Mountains	KLA
Konocti Bay	KON
Lassen	LAS
Loma Prieta	LOM
Long Valley Caldera %	LVC
Maacama Fault	MAA
Mammoth Mtn. (LVC)	MAM
Marin	MAR
Mono Caldera (MOB)	MCA
Mono Craters (MOB)	MCR
Mendocino Escarpment	MEN
Middle Mountain	MID
Mission Fault	MIS
Mono Basin %	MOB
Modoc Plateau	MOD
Mono Lake (MOB)	MOL

Monterey Bay	MON
Mt. Morrison (RSM)	MOR
Nevada	NEV
North Moat (LVC)	NMO
Oregon	ORE
Oroville	ORO
Ortigaleta Fault	ORT
Owens Valley (BRC)	OWV
Pacific Ocean	PAC
Paicines	PAI
Panoche Pass	PAN
Point Arena	PAR
Pinnacles	PIN
Quiensabe	QUI
Paso Robles	ROB
Rogers Creek Fault	ROG
Red Slate Mountain %	RSM
Round Valley (VOT)	RVL
Sacramento Valley	SAC
Salinas Valley	SAL
Sargent Fault	SAR
Southern Calif.	SCA
Santa Clara Valley	SCV
South S.F. Bay	SFB
San Felipe	SFL
S.F. Peninsula	SFP
Shasta	SHA
Sherwin Lakes (RSM)	SHE
Silver Peak (RSM)	SIL
Simmler	SIM
San Juan Bautista	SJB
Slack Canyon	SLA
South Moat (LVC)	SMO
San Simeon	SSM
Stone Canyon	STN
Sunol	SUN
Big Sur (Hosgri Fault)	SUR
Tolay Fault	TOL
Volcanic Tableland %	VOT
Walker Lane	WAK
Wheeler Crest No. (RSM)	WCN
Wheeler Crest So. (RSM)	WCS
White Mountains (BRC)	WHI
West Moat (LVC)	WMO
Yosemite	YOS

Table 4. CRUSTAL MODELS

Code	Name	Delay status	Source of original model	How derived
AUB	Auburn	2	Eaton & Simirenko (OFR 80-604, 1980)	test&modify
BAS	Basin & Range	0	averaged Prodehl (Prof Pap 1034, 1979)	refract
COA	Coalinga	2	Eaton OFR 85-44 (1985)	test&modify
COY	Coyote Lake	2	Reasenberg & Ellsworth (JGR 1982)	VELEST
CST	Central Coast	2	Poley & Eaton pers. comm.	test&modify
DIA	Diablo-Bear Valley	2	Dietz pers. comm. &	VELEST
			Walter & Mooney (BSSA 1982)	refract
EBY	East Bay	2	Olson pers. comm. &	
			Ellsworth & Marks OFR (1980)	VELEST

GAB	Gabilan-Bear Valley	2	Dietz pers. comm. & Walter & Mooney (BSSA 1982)	VELEST refract
GEY	Geysers	2	Eberhart-Phillips & Oppenheimer (JGR 1984)	VELEST
LAS	Lassen	2	S. Walter pers. comm.	VELEST
MAA	Maacama Fault	2	same as Geysers & Mendocino	guess
MAM	Mammoth Lakes	2	Kissling (PhD thesis 1986?) & Cockerham & Kissling pers. comm.	refract & inversion
MEN	Mendocino	2	Eaton pers. comm.	test&modify
MOR	Morgan Hill	2	Cockerham & Eaton (USGS Bulletin 1639, 1987)	VELEST
NBY	North S.F. Bay	2	Eberhart-Phillips & Oppenheimer (JGR 1984)	VELEST
NCG	N. Calif. gradient	1	default model derived from:	
NCA	N. Calif. layer	1	standard CALNET, Eaton pers. comm.	test&modify
PAR	Parkfield	2	Poley & Eaton pers. comm.	test&modify
PEN	S.F. Peninsula	2	Olson (Proc. Rec. Crus. Mvmts. 1987?)	VELEST
SCA	Southern Calif.	0	Jones pers. comm.	refract?
SHA	Shasta & Oregon	0	average from Zucca et al. (JGR 1986)	refract
SJB	San Juan Bautista	2	Moths pers. comm.	VELEST
TRA	Transverse Ranges	0	Prodehl PP-1034 (1979)	refract
TRE	Tres Pinos	1	Dietz pers. comm. & Walter & Mooney (BSSA 1982)	VELEST refract
WAL	Walker Pass	1	Jones & Dollar (BSSA 1986)	test&modify

The status codes for the station delays are:
0 No station delays at present.
1 Delays are from original investigator for layer model.
2 Delays refined for present region and gradient model from original delays.