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PRELIMINARY CATALOG OF EARTHQUAKES IN NORTHERN IMPERIAL VALLEY, CALIFORNIA JANUARY 1, 1977 TO MARCH 31, 1977

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PRELIMINARY CATALOG OF EARTHQUAKES IN THE NORTHERN IMPERIAL VALLEY, JANUARY 1, 1977 - MARCH 31, 1977

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Introduction

The northern section of the Imperial Valley region in Southern California is an area of known geothermal resources and an area of high seismicity. To study in detail the relationship between geothermal areas and earthquakes, the U.S. Geological Survey has been monitoring seismicity in the Imperial Valley with a sixteen station network since 1973. Six new stations were added to the network in November 1976. This catalog contains a description of the network and a list of preliminary data on earthquakes recorded by the network from January 1977 through March 1977.

AREA COVERED AND INSTRUMENTATION

Earthquakes reported in this catalog are located in the area indicated in Figure 1. Major faults are shown. Locations of most of the seismographic stations used in locating earthquakes reported here are shown on Plate 1 and are listed in Table 1.

The telemetered seismographic network in the Imperial Valley employs the same type of instrumentation developed by the U.S. Geological Survey for use in the central California network (see Wesson and others, 1973). Seismometers are vertical-component L-4C Mark Products seismometers (T_{seis} = 1 sec). Signals from these instruments are filtered in the field (T_{filter} = 0.1 sec) and telemetered to the California Institute of Technology in Pasadena, California, where they are recorded on 16 mm films along with a WWVB time code in Develocorders (T_{galvo} = 0.06 sec). Peak magnification ranges from 10^5 to about 10^6 and occurs at T_{peak} = 0.06 sec (or 14 hz). (Refer to Wesson and others, 1974, or Hill and others, 1975 , for a somewhat

more detailed description of USGS instrumentation.)

DATA ANALYSIS

The data is analyzed using methods developed for the analysis of similar data from the U.S. Geological Survey's central California network (see, for example, Lee and others, 1972b and Wesson and others, 1974). In particular, each roll of film, which contains 24 hours of data, is processed in the following steps.

1) Each film is visually scanned to note approximate times of earthquakes and the stations on which they are recorded.

2) Earthquakes that are recorded "impulsively" on 3 or more stations are manually timed. An "impulsive" signal is formally defined as one in which a) there is no question that the first motion seen is the first arrival, b) the amplitude of the first swing is five times the amplitude of the noise and c) the arrival can be picked with an error of 0.1 second or less.

3) The arrival-time data are punched on computer cards, and the cards are processed using the computer program HYP071 (Lee and Lahr, 1972) to yield preliminary determinations of origin time, hypocenter location, magnitudes, and statistical data concerning the hypocenter solution. HYP071 generates a summary card containing the above information for each earthquake.

4) Information from the summary cards is listed in this catalog. (Table 2) and the preliminary epicenters are plotted on a map (plate 1).

DISCUSSION

Earthquake locations are dependent strongly on the velocity model used in the location program. Epicentral determinations are less strongly dependent on the model than depth determinations, unless the earthquake occurs outside of the perimeter of the station group used in the location. The velocity model used for the earthquake locations in this catalog is based on a seismic refraction study of the Imperial Valley by Biehler and others (1964):

VELOCITY (km/sec)	DEPTH TO TOP OF LAYER (km)
2.0	0.0
2.6	1.0
3.6	2.0
4.7	3.0
6.1	6.0
8.0	20.0

The P-wave delay times assigned to each station (Table 1) were established from a calibration blast detonated by the U.S. Geological Survey on March 23, 1976, at 33° 05.30' N. Latitude and 115° 37.87' W. Longitude, 5 kilometers north of Westmorland. This calibration shot is very near the epicenters of most of the earthquakes of the November 1976 earthquake swarm. Our studies indicate that epicentral locations are probably as accurate as ± 0.5 km; hypocentral locations (depths) are probably accurate only to ± 2 km. The hypocentral locations of these earthquakes relative to one another is probably more accurate, however.

Magnitudes reported in this catalog are based on the method of signal duration described by Lee and others (1972a). The magnitude of a given earthquake is the average at several stations of magnitudes determined by

$$M = -0.87 + 2.00 \log(\tau) + 0.0035\Delta$$

where

Δ is epicentral distance in km, and

τ is signal duration in seconds.

Signal duration is the time interval in seconds from the onset of the P wave arrival to a point where the trace amplitude (peak-to-peak) falls below 1 cm as it is seen on the Geotech film viewer. A 0.0 magnitude (Table 2)indicates that the magnitude was not calculated. In many cases an earthquake signal was truncated by the onset of a larger event or extended by the onset of smaller events. In these cases the method of determining magnitude using signal duration could not be used.

The hypocentral parameters listed in Table 2 are the following

1) Y, year of occurrence
2) M, month of occurrence
3) D, day of occurrence
4) H, hour of occurrence
5) M, minute of occurrence
6) Sec, second of occurrence

} GCT

7) LAT, north latitude of epicenter, in degrees
8) LONG, west longitude of epicenter in degrees
9) DEP, depth of hypocenter in kilometers

10) MAG, magnitude

11) NO, number of P arrivals used in locating the earthquake

12) GAP, maximum gap between stations contributing P-arrivals

13) DMIN, distance from epicenter to nearest station used in locating the earthquake

14) RMS, root mean square of travel time residuals, R_i, in seconds

$$RMS = \sqrt{\sum_{i=1}^{NO} R_i \; / \; NO}$$

15) ERH, standard error of the epicenter, in kilometers

16) ERZ, standard error of the focal depth, in kilometers

17) Q, solution quality of the hypocenter.

18) M, model used in location. M = 1 throughout this preliminary catalog.

A filter is applied to the events in this catalog, to eliminate very bad hypocenter solutions. A solution was not listed or plotted unless RMS $\leq$ 0.50 seconds. No events have been reread to improve preliminary locations and preliminary RMS's.

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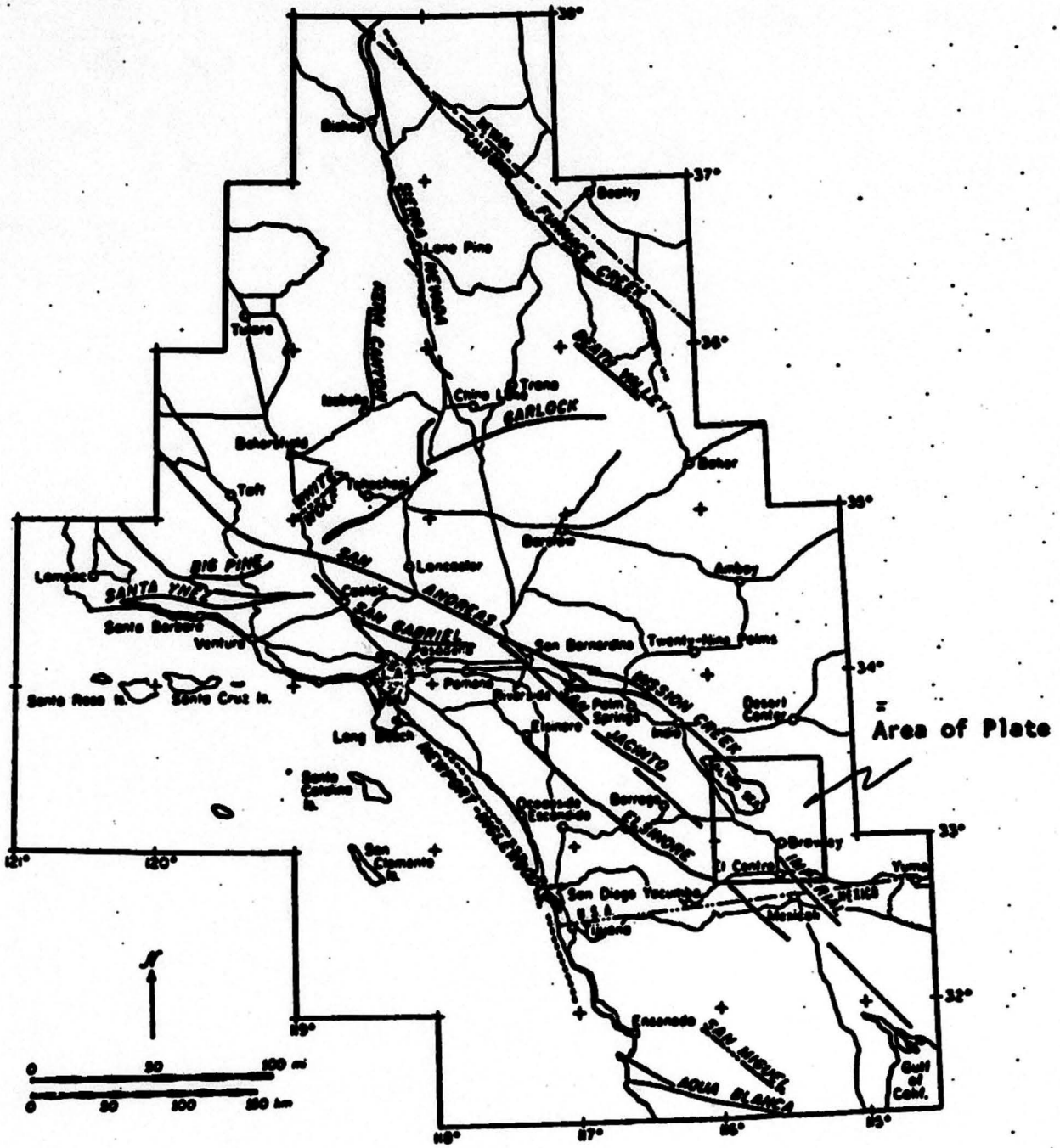

Figure 1. Base map of southern California region with major faults. Area of Plate 1 is shown.

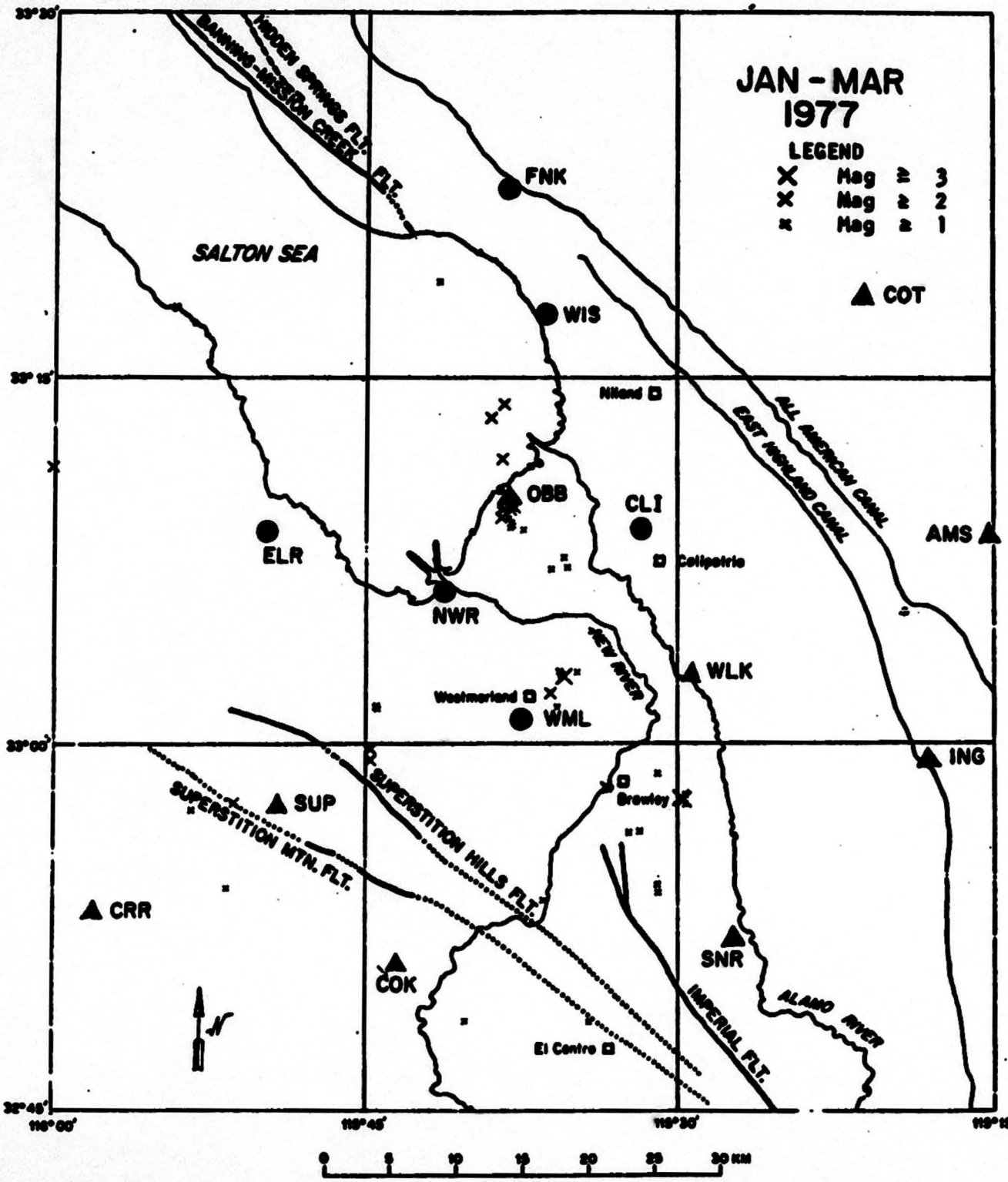

Plate 1. Location of earthquake epicenters in the Imperial Valley with respect to major faults for the period January 1, 1977 through March 31, 1977. Solid triangles are seismograph stations in the Imperial Valley network installed in 1973 (see Figure 1 and Table 1). Solid circles are the seismograph stations installed in November 1976.

Table 1. Station Data

NO.		STATION	LATITUDE DEG MIN	LONGITUDE DEG MIN	ELEV FEET	DELAY SEC
1		RUGR 33	2.73N	115 34.10W	-47	-0.02
2		VERD 33	7.07N	115 33.76W	-61	0.02
3		EPIC 33	5.28N	115 36.28W	-61	0.0
4		BANG 33	5.29N	115 37.84W	-62	0.0
5		ELR 33	8.84N	115 49.95W	-63	-0.55
6		NWR 33	6.10N	115 41.01W	-69	-0.64
7		WIS 33	16.56N	115 35.58W	-68	-0.91
8		WML 33	0.91N	115 37.35W	-44	-0.29
9		CLI 33	8.45N	115 31.64W	-59	-0.20
10		FNK 33	22.98N	115 38.26W	12	-1.13
11		COY 33	21.84N	116 18.63W	210	-1.58
12		HOT 33	18.84N	116 34.89W	1975	-1.39
13		SMO 33	32.15N	116 27.70W	0	-1.34
14		PLT 32	43.87N	114 43.76W	61	-1.52
15		SLU 32	30.10N	114 46.64W	41	-0.97
16		AMS 33	8.48N	115 15.25W	140	-1.13
17	*	COA 32	51.81N	115 7.36W	-35	0.0
18	*	BSC 32	43.49N	115 2.64W	43	0.0
19	*	BLU 34	24.40N	117 43.61W	1880	0.0
20		CPE 32	52.80N	117 6.00W	213	-0.65
21		GLA 33	3.10N	114 49.60W	627	-1.05
22		IKP 32	38.93N	116 6.48W	957	-1.17
23		TPC 34	6.35N	116 2.92W	761	-0.77
24		PLM 33	21.20N	116 51.70W	1692	-0.59
25		BC2 33	39.42N	115 27.67W	1185	-1.05
26		CPM 34	9.24N	116 11.80W	937	-0.61
27		CO2 33	50.83N	115 20.68W	276	-1.10
28		INS 33	56.14N	116 11.66W	1700	-1.35
29		LTC 33	29.34N	115 4.20W	458	-1.21
30		LTM 33	54.9CN	114 55.10W	744	-0.66
31		PNM 33	58.64N	115 48.05W	1147	-0.75
32		SHH 34	11.26N	115 39.27W	1122	-0.66
33		KEE 33	38.30N	116 39.19W	1366	-0.92
34		VGR 33	50.25N	116 48.53W	1500	-0.71
35		WWR 33	59.51N	116 39.36W	702	-0.53
36		BON 32	41.67N	115 16.11W	14	-0.22
37		CCM 33	25.75N	115 27.88W	488	-1.30
38		COK 32	50.95N	115 43.61W	-15	-0.40
39		CRR 32	53.18N	115 58.10W	98	-1.07
40		DAH 32	44.07N	115 33.47W	-6	0.20
41		HSP 32	44.81N	115 33.71W	-6	0.13
42		ING 32	59.3CN	115 18.61W	2	-0.37
43		KBY 33	2.41N	115 42.06W	-51	-0.27
44		OBB 33	10.04N	115 38.20W	-61	-0.62
45		RSE 32	55.53N	115 29.95W	-41	-0.22
46		RUN 32	58.33N	114 58.63W	152	-1.01
47		SGL 32	38.95N	115 43.52W	110	-1.08
48		SNR 32	51.71N	115 26.21W	-30	-0.32
49		SUP 32	57.31N	115 49.43W	219	-1.07

Table 1. (Cont'd.)

NO.	STATION	LATITUDE		LONGITUDE		ELEV	DELAY
		DEG	MIN	DEG	MIN	FEET	SEC
50	WLK	33	3.08N	115	29.44W	48	-0.11
51	FTN	32	33.25N	114	20.01W	263	-1.68
52	PIC	32	54.85N	114	38.59W	263	-0.95
53	YMD	32	33.28N	114	32.66W	76	-0.48
54	EA11	33	46.44N	115	35.83W	780	-1.13
55	HA10	33	42.80N	115	34.90W	536	-0.59
56	ORO9	33	37.05N	115	35.50W	555	-0.79
57	CHO8	33	30.25N	115	35.68W	634	-1.14
58	CHO7	33	27.21N	115	35.50W	585	-1.14
59	COA5	33	22.20N	115	36.10W	18	-1.16
60	HIL4	33	20.37N	115	35.73W	-40	-1.06
61	SAL2	33	15.82N	115	35.25W	-69	-0.83
62	MUD1	33	13.21N	115	35.16W	-70	-0.71
63	ROCX	33	10.58N	115	36.29W	-69	-0.74
64	YNGX	33	7.98N	115	36.61W	-64	-0.08

* Station not used in locating earthquakes

Table 2.
Preliminary hypocenter solutions for
earthquakes in southern California
January 1, 1977 through March 31, 1977.

N	Y	M	D	H	M	SEC	LAT	LONG	DEP	MAG	N	GAP	DM	RMS	ERH	ERZ	Q	M
1	77	1	3	19	1	47.CE	33- 9.1C	115-37.9C	4.3S	1.7S	1S	64	1.8	C.06	0.2	C.2	A	1
2	77	1	4	12	4	17.7C	33- E.9O	115-37.93	4.EC	1.13	E	91	2.1	C.CE	C.5	0.3	B	1
3	77	1	4	22	2E	3S.S7	33-1S.C1	115-41.24	S.CC	1.2O	E	18C	24.2	C.03	C.3	48.9	C	1
4	77	1	5	17	45	17.07	32-11.72	115-38.31	S.41	2.1C	1S	4S	3.1	C.CS	C.3	C.2	A	1
5	77	1	7	2	3S	37.45	33-13.S6	115-38.20	4.41	2.2S	2C	57	6.3	C.21	C.7	C.7	B	1
6	77	1	7	C	31	2C.74	32-5S.5C	115-4E.C1	7.17	C.C	12	88	4.O	C.14	C.7	C.8	A	1
7	77	1	7	12	33	1E.95	33-13.4O	115-3E.E3	4.E2	2.S7	27	5E	6.2	O.1C	0.3	0.3	B	1
8	77	1	1	1	54	3C.12	32-54.21	115-3C.SS	7.13	1.E7	17	8O	E.7	C.13	C.S	C.8	B	1
9	77	113		1	4	55.0S	32-SS.88	115-44.6S	4.E7	2.3E	1S	73	8.E	C.12	0.4	0.4	B	1
10	77	114		C	4O	4.11	33- 7.6E	115-35.37	4.2E	1.3S	13	E3	E.C	C.C9	C.S	C.6	B	1
11	77	114		S	S3	24.34	33- S.2E	115-38.01	4.4S	1.46	1E	81	1.5	C.07	0.2	C.2	A	1
12	77	114		1C	43	3E.03	33- 1.E3	115-44.3S	S.CC	1.72	14	93	11.C	C.C9	C.4	C.4	B	1
13	77	114		1C	46	45.74	33- 1.58	115-44.42	S.CC	1.82	13	93	11.1	C.C8	0.4	C.4	B	1
14	77	114		11	33	4S.C3	33- 1.S1	115-44.34	S.CO	1.SO	1S	93	11.O	C.1O	0.4	C.4	B	1
15	77	118		E	S2	1E.41	33- 4.67	115-34.04	S.4S	C.E4	11	97	7.7	C.11	0.5	0.4	B	1
16	77	118		S	S2	37.77	33- 2.S9	115-35.6C	2.31	1.32	12	99	4.7	C.11	C.4	C.5	B	1
17	77	118		1C	24	3.11	33- 2.E8	115-35.SC	2.SE	1.48	14	98	4.E	C.1C	0.4	C.4	B	1
18	77	118		11	27	22.22	33- 2.82	115-35.4S	2.41	1.E2	1S	51	4.6	C.C7	C.2	C.3	A	1
19	77	118		11	35	47.63	33- 2.79	115-35.39	2.E1	3.13	21	81	4.6	C.11	0.3	1.2	A	1
20	77	119		7	1O	43.74	33- S.28	115-3E.12	4.6S	1.32	12	137	1.4	C.C7	0.4	C.3	B	1
21	77	119		11	4O	22.32	33- E.S8	115-37.E5	S.CC	1.73	2C	49	2.C	C.11	0.4	C.3	A	1
22	77	124		7	1O	43.61	33- S.E2	115-37.91	4.C2	2.17	1E	86	1O.C	C.2C	C.7	1.3	B	1
23	77	124		21	S1	12.44	33- S.72	115-37.72	S.S5	2.67	2C	53	S.7	C.1O	0.3	2.5	B	1
24	77	125		C	28	15.66	33- S.78	115-37.S4	1.2E	2.E1	22	47	13.1	C.CS	C.2	1.7	B	1
25	77	125		2	3	2S.C9	33- S.7S	115-37.S3	3.2S	2.2E	22	67	1O.1	C.11	0.4	C.6	B	1
26	77	125		1C	S2	4S.CC	32-53.62	115-3E.4E	3.S2	1.E1	S	1OC	12.2	C.C7	0.4	C.5	B	1
27	77	2	3	E	41	32.89	33- 9.31	115-3E.3E	4.EE	2.2E	13	111	7.2	C.1O	C.4	C.5	B	1
28	77	2	3	23	5S	47.S9	32-SC.E5	115-44.00	S.7O	3.3E	1E	132	C.8	C.2i	1.O	1.C	B	1
29	77	2	4	C	13	S7.55	33- 8.8C	115-37.33	E.CC	1.E5	11	142	7.6	C.15	C.8	6.7	C	1
30	77	2	5	1E	4S	51.23	32-53.E9	115-2C.9O	5.CC	1.3E	4	173	2S.E	C.O			C	1
31	77	2	6	S	S2	S2.77	32-5E.2S	115-33.42	4.3E	2.7C	21	E7	7.S	C.CS	0.3	0.4	B	1
32	77	2	6	1O	13	SE.74	32-S8.7C	115-44.42	S.33	1.34	E	177	8.2	C.O2	0.2	C.2	B	1
33	77	2	6	1C	23	2S.3E	32-SE.4E	115-44.3C	S.E3	1.32	7	172	E.3	C.C8	C.8	C.6	B	1
34	77	2	6	12	42	3E.83	33- 7.19	115-35.SE	S.C4	1.19	11	84	7.2	C.C6	C.3	C.2	B	1
35	77	2	6	23	59	2S.42	32-5E.4O	115-31.7E	7.SS	1.3E	S	75	12.O	C.CS	C.S	1.3	B	1
36	77	2	9	12	15	13.7O	32-57.6E	115-E1.27	E.43	2.7S	2S	54	3.O	C.22	C.7	1.O	B	1
37	77	2	9	12	21	2S.3S	32-57.41	115-E3.2E	S.CC	C.S9	3	228	6.C	C.1E			C	1
38	77	21C		14	1O	S7.O2	32-4E.6S	115-4O.23	E.1S	1.SS	E	91	6.7	C.12	C.E	2.1	B	1
39	77	212		1E	34	4E.8E	33- S.6S	115-3E.3O	4.ES	1.S8	13	82	C.7	C.CE	0.3	C.1	A	1
40	77	213		S	S8	41.01	33- 9.81	115-3E.43	S.CC	1.83	12	9O	O.S	C.CS	C.S	C.3	A	1
41	77	213		1C	1	27.2E	33- S.67	115-3E.3O	S.CO	1.37	12	E3	C.7	C.C7	C.4	0.2	A	1
42	77	213		1C	39	44.41	33- S.6C	115-3E.2O	S.CC	2.7S	2E	42	O.E	C.1C	C.3	C.2	A	1
43	77	213		11	12	27.OS	33- S.6E	115-3E.3O	S.17	2.1E	2C	E3	C.7	C.1C	C.3	C.2	A	1
44	77	217		S	24	3.8E	32-54.1E	115-51.631	3.3C	1.E2	S	1O6	E.7	C.15	1.2	1.2	B	1
45	77	219		C	48	57.55	32-4E.7S	115-2E.4S	S.SE	1.ES	15	121	S.2	C.CE	C.3	C.4	B	1
46	77	219		S	18	34.51	33- 7.2S	115-35.2O	4.S1	1.E4	2C	63	E.C	C.C8	0.2	C.2	B	1
47	77	227		4	3	31.13	33-11.SS	115-SS.74	C.21	2.24	14	158	3C.E	C.14	C.8	11.8	C	1
48	77	31O		2C	S2	44.SE	33- 1.S2	115-35.74	S.47	1.E4	13	84	2.7	C.12	0.6	C.S	A	1
49	77	313		1C	46	18.31	32-4E.E3	115-34.27	S.CC	1.4S	11	1O5	13.8	C.CS	C.S	1C.S	C	1
50	77	316		11	39	45.C7	32-SE.78	115-3C.89	4.C3	1.S4	14	114	E.3	C.12	0.5	C.S	B	1

N	Y	M	D	H	M	SEC	LAT	LONG	DEP	MAG	N	GAP	DM	RMS	ERH	ERZ	C	M
51	77	324		3	38	36.34	33- 2.55	115-24.75	4.75	0.36	9	81	9.5	0.05	0.3	0.2	B	1
52	77	325		15	20	55.25	32-57.77	115-25.76	4.23	3.08	15	58	9.8	0.13	0.4	0.5	B	1
53	77	325		15	43	58.47	32-57.70	115-25.64	4.36	2.52	15	61	10.0	0.11	0.3	0.4	B	1
54	77	325		15	56	32.08	32-57.51	115-25.54	3.84	1.78	10	106	10.2	0.05	0.6	0.9	B	1
55	77	326		0	47	12.45	32-57.88	115-25.54	4.89	1.69	17	104	9.6	0.22	0.8	1.2	B	1
56	77	326		13	14	53.99	33- 2.09	115-36.05	5.00	2.19	13	100	10.5	0.11	0.5	1.0	B	1
57	77	326		17	32	15.63	32-57.87	115-25.54	3.88	1.94	14	102	9.6	0.17	0.8	1.0	B	1
58	77	328		6	17	30.34	32-56.35	115-37.32	4.55	1.71	9	106	12.8	0.17	0.9	1.1	C	1
59	77	331		5	58	57.53	32-59.40	115-44.70	5.31	2.13	24	58	8.3	0.16	0.4	0.6	B	1
ND	OF	SET																
ND	OF	JOB																