DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

HORIZONTAL DISTANCE MEASUREMENTS WITHIN LONG VALLEY CALDERA, EASTERN CALIFORNIA, FROM 1978 TO 1983

by

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Open File Report 85-433

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ABSTRACT

This paper presents the results of horizontal distance measurements within Long Valley caldera between August 1978 and August 1983. This interval included significant uplift and extension centered on the caldera's resurgent dome and a large increase in seismicity within and adjacent to the caldera's southern moat. Intracaldera horizontal control data associated with this activity both in space and in time are documented in this report.

INTRODUCTION

In 1975, Long Valley caldera was being studied as a potential geothermal resource (Muffler and Williams, 1975). In order to monitor horizontal deformation associated with the expected geothermal development, the U.S. Geological Survey established a horizontal control (EDM) network within the caldera in 1975. The network was measured five times between August 1975 and September 1978, but no changes were observed that were greater than 3 ppm (the uncertainty in the measurements).

On May 25, 1980, the onset of an exceptionally intense earthquake swarm heralded a pronounced increase in seismicity within the southern moat and south of the caldera. Subsequently it was determined that between August 1979 and August 1980 there had been a 270 mm uplift of the resurgent dome (Denlinger and Riley, 1984; Savage and Clark, 1982). This prompted the expansion of the intracaldera EDM network in May and August 1982. Many new lines were established in the western and southern portions of the caldera in order to brace the existing network and cover critical areas. Subsequent remeasurements of the entire network were made in August 1983 and January 1983, with a partial remeasurement in December 1982 (Denlinger and others, in press). The completely reduced distances for each set of measurements are presented in this report.

METHOD OF DATA COLLECTION

The equipment used to make all of the measurements is listed in Table 1. An HP3808A distance meter that was calibrated for a specific line of sight temperature and pressure was used to measure distances. Therefore it was necessary that each distance measurement be corrected for the temperature and pressure along the line of sight at the time of the measurement.

All network control points were set into bedrock outcrop with concrete, or were clamped onto 5/8 inch copper weld grounding rod driven to refusal. The control points of the horizontal distance network are shown relative to the caldera in figure 1. Latitude and longtitude values for all stations are given in Table 2, station coordinates relative to station CASA are given in Table 3, and station elevations are given in Table 4.

The procedures of data collection varied only in the method used to estimate line of sight temperatures and pressures for reduction of the laser determined distances. These atmospheric values were measured either at the endpoints and averaged, or measured along the line of sight from an airplane as the readings were taken (Table 1.). Each reoccupation of the network is placed in one or two separate tables. All data for a particular reoccupation period that are reduced using line of sight temperature and pressure control are in separate tables (i.e. August 1982) that are identified with the words "line of sight" in the title. Errors exceeding 3 ppm may result from comparing measurements made using line of sight corrections with measurements using endpoint corrections because of atmospheric temperature structures. Instrument and reflector height corrections were made to all values and reduced slope distances are mark to mark.

The completely reduced data are listed as slope distances in Tables 5 through 11. Since the measurement precision depends upon the precision of the atmospheric correction, the standard deviations differ and consequently are listed at the head of each table for the set of values within that table.

ACKNOWLEDGMENT

The authors are indebted to the Los Angeles Department of Water and Power, whose helicopter support and field expertise made much of this work possible, and to Mark Clark (U.S. Forest Service, Mammoth Lakes, CA) for his untiring and knowledgable field assistance.

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Table 1. Equipment used to measure the intracaldera distances.

Distance meter: Hewlett Packard 3808A Ga-As amplitude modulated infrared laser.
Reflectors used: Hewlett Packard, Servco, Nikon
(glass constant = 30mm)
Tripods: Kern tripod with plumb rod.

Endpoint Atmospheric measurement:

Temperature: glass mercury thermometer hung with a wire from the tripod head, shaded from the sun with metal foil.
Range: -20 to +40 degrees Centigrade
Precision: $\pm$ 0.1 degrees Centigrade

Pressure: Wallace and Tiernan altimeter
Range: 0 to 15000 feet
Precision: $\pm$ 10 feet

No humidity correction

Line of Sight Atmospheric measurement:
a small fixed wing aircraft was used,
range of flight speeds; 100 to 150 km/hr

Temperature: Wingstrut mounted thermistors, two in parallel with different response times, (3 second and 0.5 second). Both thermistors were accurate to $\pm$ 0.1 degrees Centigrade.

Pressure: Cabin pressure was monitored with a pressure transducer.
Range: 0 to 15 psi absolute
Precision: $\pm$ .001 psi

No humidity correction.

Table 2. Latitude and longtitude for all intracaldera EDM stations.

STATION	LATITUDE			LONGTITUDE		
	deg	min	sec	deg	min	sec
micro	37	45	54	118	58	48
bald	37	47	2	118	53	59
28dor	37	45	59	118	49	22
puff	37	45	11	118	46	50
flies	37	45	8	118	44	36
easy	37	44	2	118	44	21
26dor	37	44	18	118	49	32
lookout	37	43	44	118	56	44
deer	37	41	55	119	0	34
bailey	37	41	55	118	54	17
bailey2	37	41	55	118	54	18
pine	37	42	17	118	51	6
terrace	37	42	28	118	48	54
bridge	37	41	50	118	45	43
wilfred	37	42	37	118	41	18
gate	37	39	15	118	42	58
ben	37	39	33	118	49	2
rockpt	37	40	9	118	49	29
rhyolite	37	40	41	118	49	51
mariposa	37	40	35	118	50	54
roger	37	39	54	118	52	47
mike	37	39	35	118	56	6
jake	37	39	48	118	57	53
pumice	37	40	44	119	3	27
mammoth	37	37	51	119	1	52
duke	37	37	28	118	59	16
frank1	37	37	49	118	57	1
frank2	37	37	40	118	54	39
casa	37	38	40	118	53	43
casa2	37	38	42	118	53	41
whitmore	37	37	52	118	49	2
d124	37	33	50	118	43	30
e124	37	34	22	118	45	31
tobacco	37	35	23	118	49	39
mine	37	36	24	118	54	54
laurel	37	34	49	118	53	24
levcenter	37	40	26	118	53	34
edmcenter	37	40	23	118	53	39

Table 3. Coordinates in meters for all stations relative to CASA. The first column is distance east (west is negative), and the second column is distance north (south is negative).

STATION	DISTANCE EAST	DISTANCE NORTH
banner	27838.	6762.
glass	16327.	14794.
horse	7056.	37289.
laurel	589.	-7095.
sherwin	19011.	-15373.
tungsten	33159.	-29903.
bald	-672.	15485.
casa	0.	0.
mammoth	-11971.	-1716.
mono	-10159.	25777.
micro	-7467.	13380.
28dor	6390.	13535.
puff	10111.	12055.
flies	13391.	11962.
easy	13758.	9927.
lookout	-4431.	9372.
deer	-10062.	6012.
bailey	-832.	6012.
bailey2	-857.	6012.
pine	3844.	6690.
terrace	7075.	7029.
bridge	11751.	5858.
wilfred	18238.	7307.
gate	15790.	1079.
ben	6879.	1634.
rockpt	6218.	2744.
rhyolite	5680.	3730.
mariposa	4137.	3545.
roger	1371.	2281.
mike	-3501.	1696.
jake	-6120.	2096.
pumice	-14297.	3823.
duke	-8152.	-2220.
frank1	-4847.	-1572.
frank2	-1371.	-1850.
casa2	49.	62.
whitmore	6879.	-1480.
tobacco	5973.	-6074.
pine	-1738.	-4193.
levcente	220.	3268.
edmcente	98.	3176.

Table 4. Elevations in feet determined for the intracaldera EDM network. Elevations are given in feet for easy reference to available U.S. Geological Survey topographic maps. Accuracy of the elevation varied with the technique used, and is indicated by the position of the last significant digit.

STATION	ELEVATION (FT)
bailey	8613.25
bailey2	8610.
bald	9104.
ben	7161.11
bridge	6840.
casa	7918.61
casa2	7914.38
convict	7056.
deer	8793.31
d124	6932.
duke	8355.80
easy	7100.
e124	7207.
flies	7480.
frank1	7859.84
frank2	7348.23
gate	6980.
jake	8501.79
lookout	8348.20
mammoth	11055.99
mariposa	7210.
micro	8478.
mike	8226.68
mine	8624.95
pine	7618.18
puff	7403.
pumice	9898.65
rhyolite	7031.36
rockpt	7080.
roger	8138.80
terrace	7020.
tobacco	8480.
whitmore	7370.
wilfred	7360.
8 dor	7037.03
26dor	6914.
28dor	7531.

Table 5. Slope distances in meters determined in August and September, 1978 using endpoint atmospheric measurements. Standard deviation = 3 ppm.

FROM	TO	DISTANCE (M)
casa2	mine	4609.864
gate	wilfred	6744.479
gate	d124	9776.746
lookout	casa2	10341.700
lookout	bald	7360.525
lookout	28dor	11567.687
lookout	26dor	10669.789
lookout	micro	5060.813
lookout	pumice	11355.501
whitmore	gate	9313.687
whitmore	bridge	8878.670
whitmore	tobacco	4727.163
whitmore	d124	8333.709
whitmore	casa2	7032.666
whitmore	e124	11102.108
ben	casa2	7077.943
ben	bridge	6509.155
ben	gate	8951.904
ben	mariposa	3337.693
ben	mine	10465.424
ben	pine	5920.769
ben	rhyolite	2443.104
ben	terrace	5413.951
ben	tobacco	7809.885
ben	28dor	11903.847
ben	rockpt	1305.345
bridge	gate	6269.601
bridge	pine	8003.842
bridge	wilfred	6651.639
bridge	flies	6346.819
bridge	easy	4565.816
puff	bridge	6398.513
puff	terrace	5819.164
puff	26dor	4302.185
puff	wilfred	9463.443
puff	easy	4222.526
wilfred	easy	5243.031

Table 6. Slope distances in meters determined in May, 1982 using endpoint atmospheric measurements. Standard deviation = 3 ppm.

FROM	TO	DISTANCE (M)
casa2	bailey	6030.5342
casa2	ben	7078.1709
casa2	duke	8494.1934
casa2	frank1	5141.7539
casa2	lookout	10342.1689
casa2	mine	4609.9639
casa2	mike	3922.4509
casa2	roger	2619.0330
frank1	duke	3371.2361
frank1	frank2	3499.7180
frank1	mine	4089.0249
frank1	jake	3897.4800
frank1	whitmore	11752.4316
jake	duke	4760.5879
jake	frank2	6190.0220
bailey	casa2	6030.5342
bailey	deer	9203.2979
bailey	rhyolite	6915.9429
bailey	roger	4345.9639
ben	gate	8951.7949
ben	rhyolite	2443.1411
casa	frank2	2282.5220
mike	bailey	5064.9170
mike	frank1	3530.6899
mike	frank2	4133.9858
mike	jake	2652.4570
mike	mine	6174.0820
mike	roger	4943.1479

Table 7. Slope distances in meters determined in August, 1982 using endpoint atmospheric measurements. Standard deviation = 3 ppm.

FROM	TO	DISTANCE (M)
mike	duke	6064.218
mike	frank1	3530.676
mike	roger	4943.160
mike	frank2	4133.981
mike	casa2	3922.458
mike	mine	6174.086
mike	lookout	7713.838
mike	pumice	11061.303
casa	mine	4557.111
casa	frank2	2282.504
casa	duke	8474.428
casa2	deer	11679.293
casa2	mine	4609.991
casa2	duke	8494.183
casa2	frank1	5141.754
casa2	roger	2619.052
jake	mine	7697.528
jake	frank1	3897.475
jake	duke	4760.589
jake	mike	2652.449
jake	frank2	6190.028
frank1	whitmore	11752.470
frank1	duke	3371.224
frank1	mine	4089.026
frank1	frank2	3499.703
lookout	pumice	11355.683
lookout	bald	7360.599
lookout	micro	5060.827
lookout	26dor	10670.010
lookout	casa2	10342.202
lookout	28dor	11567.857
puff	bridge	6398.576
puff	easy	4222.561
puff	wilfred	9463.486
puff	26dor	4302.191
puff	terrace	5819.133
whitmore	casa2	7032.841
whitmore	bridge	8878.700
whitmore	dl24	8333.515
whitmore	gate	9313.554
whitmore	el24	11101.919
ben	casa2	7078.168
ben	gate	8951.834
ben	28dor	11904.005
ben	mine	10465.946
ben	bridge	6509.137
ben	pine	5920.897
ben	terrace	5414.050
ben	tobacco	7809.954

Table 7 continued

ben	rockpt	1305.364
ben	mariposa	3337.744
ben	rhyolite	2443.149
bridge	terrace	4820.029
bridge	pine	8003.888
bridge	gate	6269.653
bridge	flies	6346.818
bridge	wilfred	6651.576
bridge	easy	4565.803
bailey	bridge	12706.561
bailey	28dor	10411.770
bailey	pine	4802.201
bailey	ben	8918.591
bailey	casa	6083.023
bailey	roger	4345.963
bailey	casa2	6030.523
bailey	mike	5064.907
bailey	mine	10251.134
bailey	deer	9203.325
bailey2	lookout	4883.983
bailey2	bald	9483.086
mammoth	lookout	13261.157
mammoth	pumice	5878.453
mammoth	deer	7733.479
mammoth	bailey	13460.114
mammoth	casa	12137.974
mammoth	bailey	13460.064
mammoth	bailey2	13434.792
roger	pine	5107.029
roger	ben	5576.765
tobacco	whitmore	4727.203
tobacco	casa	8538.524
tobacco	frank2	8538.264
gate	d124	9776.877
gate	wilfred	6744.478
bald	bridge	15554.186
bald	micro	7362.991
deer	lookout	6566.479

Table 8. Slope distances in meters determined in August, 1982 using line of sight atmospheric measurements. Standard deviation = 1 ppm.

FROM	TO	DISTANCE (M)
mike	duke	6064.218
mike	frank1	3530.676
mike	roger	4943.160
mike	frank2	4133.967
mike	casa2	3922.458
mike	mine	6174.086
mike	lookout	7713.836
mike	pumice	11061.291
casa	mine	4557.111
casa	frank2	2282.504
casa	duke	8474.428
casa2	deer	11679.264
casa2	mine	4609.991
casa2	duke	8494.183
casa2	frank1	5141.754
casa2	roger	2619.052
jake	mine	7697.515
jake	frank1	3897.475
jake	duke	4760.589
jake	mike	2652.449
jake	frank2	6190.028
frank1	whitmore	11752.469
frank1	duke	3371.224
frank1	mine	4089.026
frank1	whitmore	11752.454
frank1	frank2	3499.703
lookout	pumice	11355.666
lookout	bald	7360.585
lookout	micro	5060.814
lookout	26dor	10669.983
lookout	casa2	10342.166
lookout	28dor	11567.829
puff	bridge	6398.576
puff	easy	4222.561
puff	wilfred	9463.474
puff	26dor	4302.190
puff	terrace	5819.135
whitmore	casa2	7032.834
whitmore	bridge	8878.698
whitmore	d124	8333.530
whitmore	gate	9313.561
whitmore	e124	11101.919
ben	casa2	7078.158
ben	gate	8951.816
ben	28dor	11903.985
ben	mine	10465.937
ben	bridge	6509.129
ben	pine	5920.882
ben	terrace	5414.050

Table 8 continued

ben	tobacco	7809.942
ben	rockpt	1305.364
ben	mariposa	3337.744
ben	rhyolite	2443.149
bridge	terrace	4820.017
bridge	pine	8003.880
bridge	gate	6269.646
bridge	flies	6346.813
bridge	wilfred	6651.568
bridge	easy	4565.803
bailey	bridge	12706.561
bailey	28dor	10411.780
bailey	pine	4802.199
bailey	ben	8918.578
bailey	casa	6083.010
bailey	roger	4345.957
bailey	casa2	6030.503
bailey	mike	5064.907
bailey	mine	10251.117
bailey	deer	9203.298
bailey2	lookout	4883.970
bailey2	bald	9483.066
mammoth	lookout	13261.130
mammoth	pumice	5878.459
mammoth	deer	7733.479
mammoth	bailey	13460.072
mammoth	casa	12137.945
mammoth	bailey	13460.080
mammoth	bailey2	13434.751
roger	pine	5107.029
roger	ben	5576.766
tobacco	whitmore	4727.194
tobacco	casa	8538.517
tobacco	frank2	8538.265
gate	d124	9776.851
gate	wilfred	6744.465
bald	bridge	15554.164
bald	micro	7362.991
deer	lookout	6566.462

Table 9. Slope distances in meters determined in December, 1982 using endpoint atmospheric measurements. Standard deviation = 3 ppm.

FROM	TO	DISTANCE (M)
casa2	bailey	6030.507
casa2	ben	7078.165
casa2	deer	11679.279
casa2	frank1	5141.744
casa2	lookout	10342.192
casa2	mine	4609.981
casa2	mike	3922.449
casa2	roger	2619.059
casa2	whitmore	7032.833
frank1	frank2	3499.707
frank1	mine	4089.016
frank1	whitmore	11752.488
gate	wilfred	6744.479
gate	d124	9776.858
lookout	bald	7360.584
lookout	deer	6566.443
lookout	28dor	11567.843
whitmore	bridge	8878.727
whitmore	gate	9313.578
whitmore	d124	8333.533
bailey	casa2	6030.514
bailey	deer	9203.317
bailey	mine	10251.122
bailey	pine	4802.204
bailey	rhyolite	6915.962
bailey	roger	4345.973
bailey	mike	5064.918
bailey	28dor	10411.792
bailey2	bald	9483.091
bailey2	lookout	4883.981
ben	bridge	6509.145
ben	gate	8951.822
ben	mine	10465.963
ben	pine	5920.886
ben	roger	5576.770
ben	terrace	5414.060
ben	28dor	11904.021
bridge	gate	6269.667
bridge	pine	8003.896
bridge	terrace	4820.031
bridge	wilfred	6651.580
casa	frank2	2282.516
mike	frank1	3530.670
mike	frank2	4133.970
mike	lookout	7713.835
mike	mine	6174.067
mike	roger	4943.152

Table 10. Slope distances in meters determined in January, 1983 using endpoint atmospheric measurements. Standard deviation = 3 ppm, but probably higher for some lines due to strong temperature inversion that existed during some of the measurements.

FROM	TO	DISTANCE (M)
casa2	bailey	6030.517
casa2	ben	7078.177
casa2	deer	11679.262
casa2	duke	8494.173
casa2	frankl	5141.771
casa2	jake	6511.305
casa2	lookout	10342.160
casa2	mine	4609.989
casa2	mike	3922.472
casa2	roger	2619.068
casa2	whitmore	7032.828
frankl	duke	3371.220
frankl	frank2	3499.712
frankl	mine	4089.029
frankl	jake	3897.465
frankl	whitmore	11752.533
frank2	mine	2452.512
frank2	casa	2282.561
frank2	tobacco	8538.225
gate	wilfred	6744.481
gate	dl24	9776.926
jake	duke	4760.583
jake	frank2	6190.004
jake	mine	7697.498
lookout	bald	7360.554
lookout	deer	6566.450
lookout	28dor	11567.838
whitmore	bridge	8878.789
whitmore	gate	9313.577
whitmore	tobacco	4727.177
whitmore	dl24	8333.526
bailey	deer	9203.304
bailey	mine	10251.115
bailey	pine	4802.212
bailey	rhyolite	6915.943
bailey	roger	4345.972
bailey	28dor	10411.790
bailey2	bald	9483.029
bailey2	deer	9161.508
lookout	bailey2	4883.964
ben	bridge	6509.116
ben	gate	8951.791
ben	mariposa	3337.736
ben	mine	10465.934
ben	pine	5920.916
ben	rhyolite	2443.150
ben	roger	5576.774

Table 10 continued

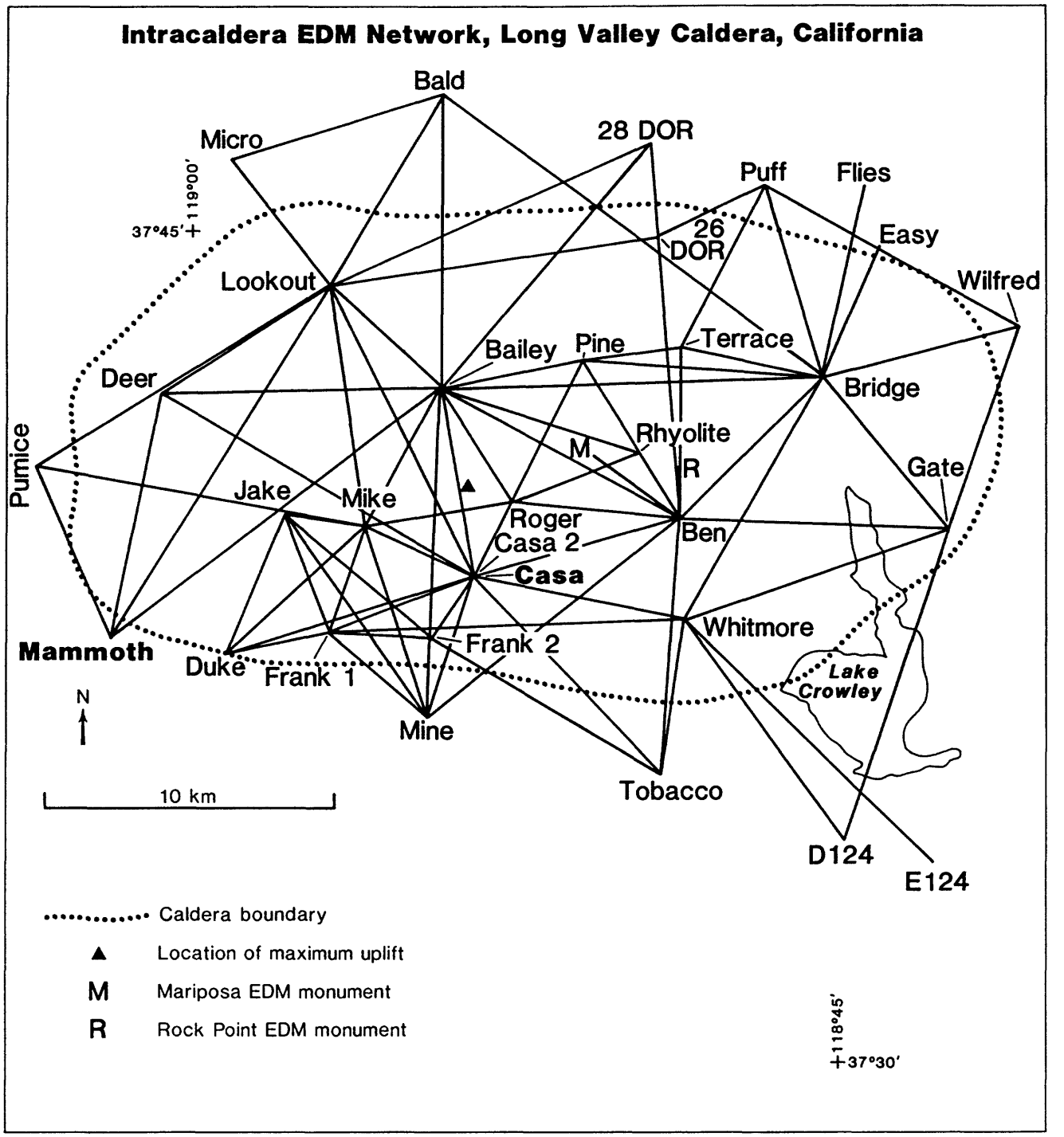
ben	terrace	5414.081
ben	tobacco	7809.904
ben	28dor	11904.014
bridge	bald	15554.117
bridge	gate	6269.658
bridge	pine	8003.877
bridge	puff	6398.584
bridge	terrace	4819.055
bridge	wilfred	6651.579
casa	mine	4557.113
casa	tobacco	8538.457
mike	bailey	5064.937
mike	duke	6064.196
mike	frank1	3530.677
mike	frank2	4133.958
mike	jake	2652.445
mike	lookout	7713.832
mike	mine	6174.072
mike	roger	4943.193
pine	roger	5107.019
puff	terrace	5819.114
puff	wilfred	9463.496

Table 11. Slope distances in meters determined in August, 1983 using line of sight atmospheric measurements. Standard deviation = 1 ppm.

FROM	TO	DISTANCE (M)
frankl	mine	4089.008
frankl	jake	3897.465
frankl	mike	3530.690
frankl	casa2	5141.801
frankl	whitmore	11752.540
frankl	duke	3371.235
mike	mine	6174.059
mike	pumice	11061.286
mike	duke	6064.229
mike	casa2	3922.488
mike	mammoth	9095.212
mike	roger	4943.212
mike	lookout	7713.871
mike	jake	2652.454
casa2	roger	2619.078
casa2	lookout	10342.221
casa2	whitmore	7032.841
casa2	mine	4609.984
casa2	duke	8494.240
casa2	ben	7078.184
bailey	casa2	6030.540
bailey	mine	10251.152
bailey	mammoth	13460.102
bailey	casa	6084.049
bailey	ben	8918.629
bailey	28dor	10411.769
bailey	mike	5064.948
bailey	rhyolite	6915.987
bailey	bridge	12706.580
bailey	deer	9203.325
bailey	roger	4345.981
bailey	pine	4802.213
bailey2	deer	9161.528
bailey2	bald	9483.063
bailey2	lookout	4883.976
puff	lookout	14832.083
puff	26dor	4302.184
puff	bridge	6398.583
puff	easy	4222.558
puff	terrace	5819.128
wilfred	easy	5243.031
wilfred	bridge	6651.561
wilfred	gate	6744.474
lookout	deer	6566.459
lookout	micro	5060.806
lookout	pumice	11355.662
lookout	26dor	10669.992
lookout	mammoth	13261.141
lookout	28dor	11567.864

Table 11 continued

bald	micro	7363.003
bald	lookout	7360.590
frank2	mike	4133.974
frank2	jake	6190.026
frank2	frank1	3499.729
frank2	tobacco	8538.265
casa	tobacco	8538.474
casa	frank2	2282.566
casa2	deer	11679.314
roger	ben	5576.772
roger	pine	5107.025
ben	rhyolite	2443.166
ben	pine	5920.911
ben	tobacco	7809.945
ben	mine	10466.005
ben	mariposa	3337.752
ben	rockpt	1305.369
ben	bridge	6509.115
ben	28dor	11904.002
ben	terrace	5414.063
ben	gate	8951.783
bridge	terrace	4820.012
bridge	gate	6269.650
bridge	bald	15554.199
bridge	flies	6346.818
bridge	easy	4565.799
mammoth	deer	7733.482
mammoth	casa	12137.999
mammoth	pumice	5878.450
mammoth	casa2	12150.603
casa	frank1	5119.585
casa	convict	8231.102
casa	8dor	7080.085
casa	casa2	55.286
jake	duke	4760.584
jake	mine	7697.512
whitmore	el24	11101.905
whitmore	tobacco	4727.193
whitmore	dl24	8333.497
whitmore	gate	9313.532
gate	dl24	9776.853
bridge	pine	8003.880
bridge	whitmore	8878.698


Intracaldera EDM Network, Long Valley Caldera, California
Bald
Micro
28 DOR
Puff
Flies
Easy
26 DOR
Wilfred
Lookout
Bailey
Pine
Terrace
Deer
Bridge
Rhyolite
M
R
Gate
Pumice
Jake
Mike
Roger
Casa 2
Casa
Ben
Whitmore
Mammoth
Duke
Frank 1
Frank 2
Mine
Lake Crowley
Tobacco
D124
E124
N
10 km
37°45'
119°00'
118°45'
37°30'
Caldera boundary
Location of maximum uplift
Mariposa EDM monument
Rock Point EDM monument