

U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Elevations and descriptions for leveling bench marks at Newberry Crater, Oregon

By

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## **PURPOSE OF REPORT**

In August and September 1994, staff of the U.S. Geological Survey (USGS), David A. Johnston Cascades Volcano Observatory (CVO), executed a first-order leveling survey at Newberry Crater, Oregon as part of CVO's program to monitor Cascades volcanoes. The purpose of the leveling survey was 1) to establish a new baseline data set for the 1931 leveling survey, 2) re-survey a leveling line established in 1985 and re-leveled in 1986, and 3) establish baseline elevation for bench marks that were installed in 1993 along the 1931 level traverse, to bring the level traverse up to first-order standards.

In this report we present data for the 1931, 1986, and 1994 surveys. Also included are bench mark descriptions and a location map of all points that were surveyed in 1994.

## **INTRODUCTION**

In 1985 CVO installed 6 bench marks (CVO85-200 to CVO85-205) at approximately 1 km spacing spanning the caldera at Newberry Crater, Oregon (fig. 1, 3 & 4). This section was double run in 1985 and single run with each section in opposing directions in 1986 (Yamashita and Doukas, 1987). In 1994 we re-surveyed a portion (bench mark F 12 1931 to F 1 1931, fig. 2 thru 5) of a regional third-order leveling network first surveyed by USGS in 1931, and the entire section of the 1986 survey.

## **SURVEY PROCEDURE AND DATA COLLECTION**

The 1985, 1986 and 1994 CVO leveling surveys were executed using first-order standards, i.e., using a level instrument with a micrometer plate, and invar rods calibrated yearly by the Institute of Standards and Technology. We measured temperature at each setup, reversed the direction of run after each section, performed a collimation test each day, and maintained stadia balance between back and foresight to 5 meters or less (for more information on the procedures used in this type of survey, see Yamashita and Kaiser, 1992). Data for the 1985 and 1986 surveys were collected and the checks and balance maintained using the HP71b® hand-held computer (Yamashita, 1989). All data for the 1994 survey were collected and the checks and balance maintained in a CMT MC-II® hand-held computer (Yamashita and Yamashita, 1992).

During the 1994 leveling survey, seven of the twenty five sections were double run. In addition, two sections were compared to a "trial survey" (we surveyed two sections in 1993 to see if a leveling survey was warranted) and five sections were compared to the 1986 survey (table 1). The bench mark spacing along the original 1931 leveling line was not up to first-order standards and some bench marks were destroyed or not recovered. Additional marks were installed along the leveling line in 1993 (fig. 2 thru 5). Descriptions for the bench marks along the leveling line are in appendix 1.

During 1977 - 1978 USGS occupied a leveling line that ran north-south along the eastern

end of the 1931 line (fig 5). Bench mark F12 1931 was common to both surveys. The elevation established for F12 in both 1931 and 1977 was 1599.308 m. Since the elevation for F12 is exactly the same for both surveys it would appear that F12 is a stable point and we have held it fixed at 1599.308 m.

In order to compare the 1986 survey to the 1994 surveys we have held the elevation at CVO85-205 fixed to the 1994 elevation. Because of this, any difference in elevation along this segment of the leveling line would represent a minimum change.

The difference in elevation at bench mark F1 1931, at the west end of the leveling line, between the 1931 survey and the 1994 survey is about 1.6 cm (0.63 in), (fig 6), holding bench mark F 12 fixed, but it should be noted that the 1931 survey was a third-order survey and that survey had an 18 cm (0.6 ft) closure error. The fact that the elevation established in 1994 for bench mark F1 1931 compared so well with the 1931 survey seems to indicate that distribution of the 1931 closure error did not adversely effect that portion of the leveling line through Newberry Crater. If this is true, then it would indicate that bench marks at both ends of the leveling line are stable and the changes measured at intermediate bench marks (up to 15 cm of uplift) may reflect real changes. A concern when running leveling surveys is the accumulation of systematic errors due to factors such as pin settling, rod scale error, unequal refraction or collimation errors. These uncertainties can sometimes can be detected when the elevation differences mimic topography. Figure 6 illustrates that the elevation changes do not have a direct correlation to topography.

## **ACKNOWLEDGMENT**

The authors would like to thank all participants of the 1994 leveling survey and especially those volunteers that gave their valuable time in the interest of science.

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## Appendix 1

8.0 km (5.0 mi)

North along State Highway 97 from the north end of the town of LaPine, Oregon to the intersection of State Highway 97 and Forest Service (FS) road 21 leading to Newberry Crater National Monument.

### **F 1 1931**

4.99 km (3.10 mi) southeasterly along FS road 21 from the intersection of highway 97 to approximately 168 m (550 ft) west of a road to Prairie Campground, approximately 91 m (300 ft) west of power pole # T491-L48A, approximately 15 m (50 ft) north of an obscure track road, 7 m (23 ft) south of the centerline of FS road 21, 2.5 m (8 ft) above the road of FS road 21, 0.6 m (2 ft) above the ground and set on the west end of a 1.5 x 1.5 m (5 x 5 ft) embedded boulder. U.S. Department of Agriculture, U. S. Forest Service brass tablet stamped "F1 1931".

5.23 km (3.25 mi)

Southeasterly along FS road 21 from the intersection of highway 97 to an intersection on the north side with FS road 2120 and a sign "Mckay campground".

### **93-200**

1.05 km (0.65 mi) southeasterly along FS road 2120 from the intersection with FS road 21 to just east of a track road to the north, 16.6 m (54.5 ft) south of the road center, across the road and slightly west of power pole # L60, 1.2 m (4 ft) southwest of a witness post, attached to a rod driven 6.1 m (20 ft) and enclosed in a 15 cm (6 in) diameter PVC pipe. U.S. Geological Survey brass tablet stamped "93-200".

### **93-201**

2.66 km (1.65 mi) southeasterly along FS road 2120 from the intersection with FS road 21 to a small clearing on the south side of the road and on the opposite side of the road midway between power pole # L76 and L77, 16.7 m (55 ft) south of the road center, 1.2 m (4 ft) south of a witness post 0.6 m (2 ft) above the road, attached to a rod driven 7.6 m (25 ft) and enclosed in a 15 cm (6 in) diameter PVC pipe in the above clearing. U.S. Geological Survey brass tablet stamped "93-201".

3.13 km (1.95 mi)

Southeasterly along FS road 2120 from the intersection with FS road 21 to a fork in the road on the east (right) with FS road 500 (the left fork is the continuation of the gravel road to Mckay camp ground).

### **93-202**

1.04 km (0.65 mi) intersection with FS road 2120, to the bottom of a steep dip in the road, 16.6 m (54.5 ft) south of the road center, 2.1 m (7 ft) north of a witness post and 1.2 m (4 ft) below the road, attached to a rod driven 7.6 m (25 ft) and enclosed in a 15

cm (6 in) diameter PVC pipe. U.S. Geological Survey brass tablet stamped "93-202".

### **F3 1931**

2.48 km (1.60 mi) easterly along FS road 500 from the intersection with FS road 2120 to a shallow water drainage channel on the south side of the road, midway between power pole # L105 and L106, 8.9 m (29.2 ft) north of the road center, 2.1 m (7 ft) north of a 0.2 x 0.76 m (8 x 30 in) metal witness post, 0.61 m (2 ft) above road, 5 cm (2 in) above ground and set on a 0.36 x 0.76 m (14 x 30 in) embedded boulder. U. S. Department of Agriculture, U. S. Forest Service brass tablet stamped "F3 1931".

### **BOLT**

4.17 km (2.60 mi) Easterly along FS road 500 from the intersection with FS road 2120 to the crest in the road and a shallow water drainage channel to the north, approximately 18 m (60 ft) west of power pole # L122, 7.6 m (25 ft) north of the road center, 1 m (3 ft) above the road, at the south base of a 15 cm (6 in) diameter pine tree, and set in a 0.46 x 0.46 m (1.5 x 1.5 ft) embedded boulder. An unstamped bolt (known as an SBM).

### **F4 1931**

5.61 km (3.50 mi) easterly along FS road 500 from the intersection with FS road 2120 to the west end of a large clear cut logged area and a short track road leading south, approximately 23 m (75 ft) west of power pole # L136, 17.3 m (57 ft) south of the road center of FS road 500, 9 m (30 ft) southwest of the center of the track road, 2.4 m (8 ft) above the road of FS road 500 and set in the top of a 0.46 x 0.46 m (1.5 x 1.5 ft) embedded boulder. U.S. Department of Agriculture, U.S. Forest Service brass tablet stamped "F4 1931".

### **93-204**

7.29 km (4.55 mi) easterly along FS road 500 from the intersection with FS road 2120 to the intersection on the south with FS road 580, approximately 38 m (125 ft) east of power pole # L152, 11.1 m (36.4 ft) south of the center of FS road 500, 10.9 m (35.8 ft) east of the road center of FS road 580, set on a rod driven 3.0 m (10 ft) and enclosed in a 15 cm (6 in) diameter PVC pipe. U.S. Geological Survey brass tablet stamped "93-204".

Alternate route to bench mark 93-204.

18.27 km (11.4 mi)

Southeasterly along FS road 21 from the intersection with State Highway 97 to the intersection with FS road 580, then 0.56 km (0.35 mi) north along FS road 580 to the intersection with FS road 500. Follow description as above.

### **A 1 G 1931**

20.51 km (12.8 mi) southeasterly along FS road 21 from the intersection with State Highway 97 to the intersection with a road to the north leading to a Resort and Boat

launch then 0.08 km (0.05 mi) northerly along this road to the bridge over Paulina creek, 7.0 m (23 ft) west of the center of the bridge, 1.8 m (6 ft) below the bridge and set on a small rock shelf on the south side of Pauline creek. U.S. Department of Agriculture, U.S. Forest Service brass tablet stamped "A 1 G 1924 6330.6".

**93-205**

22.12 km (13.8 mi) southeasterly along FS road 21 from the intersection with State Highway 97 to a downgrade and a curve in the road. At the east end of a 1.8 x 4.3 (6 x 14 ft) rock outcrop, 49 m (160 ft) south of the centerline of FS road 21, 20.5 m (67 ft) south of a witness post, 1.0 m (3 ft) above the road, 0.3 m (1 ft) above the ground and set on the southeast end of a 1 x 2.1 m (3 x 7 ft) embedded boulder. U.S. Geological Survey brass tablet stamped "93-205".

**CVO 85-200**

23.08 km (14.40 mi) southeasterly along FS road 21 from the intersection with State Highway 97 to 45 m (148 ft) west of a dirt road to the north to Paulina Lake summer homes, approximately 35 m (115 ft) north of the centerline of FS road 21, set on the top of a 1.5 m (5 ft) diameter embedded boulder projecting 1 m (3 ft) above the ground and 3.5 m (11.5 ft) below the road. U.S. Geological survey, Cascades Volcano Observatory red brass tablet with a 1 cm nipple in the center stamped " CVO 85-200".

**CVO 85-201**

24.60 km (15.35 mi) southeasterly along FS road 21 from the intersection with State Highway 97 to 0.3 km (0.2 mi) east of the intersection to "Obsidian Flow View point". 53 m (174 ft) east of the centerline of FS road 21, 0.4 m (1.3 ft) above ground and road and set at the east end of a 1 m (3 ft) diameter embedded boulder. U.S. Geological Surevy, Cascades Volcano Observatory red brass tablet with a 1 cm nipple in the center stamped "CVO85-201".

**CVO 85-202**

26.16 km (16.10 mi) southeasterly along FS road 21 from the intersection with State Highway 97 to the base of a slight up grade and a track road to the north (road goes to an old mine). 6.1 m (20 ft) east of a large rock outcrop, 40 m (131 ft) west of the track road, 16.4 m (53.8 ft) north of the centerline of FS road 21, 1.8 m (6 ft) above the road and set on a rock ledge in a small outcrop of rock in a road cut of a lava flow. U.S Geological Survey, Cascades Volcano Observatory red brass tablet with a 1 cm nipple in the center stamped "CVO85-202".

**F 8 1931**

26.16 km (16.10 mi) southeasterly along FS road 21 from the intersection with State Highway 97 to the base of a slight up grade and a track road to the north. Leave FS road 21 and follow the track road north approximately 0.72 km (0.45 mi) to the shore of East Lake then southeasterly approximately 76 m (250 ft) to a steep slope and an outcrop of rock on the north, set on the top of an embedded boulder nearly flush with

the ground. U.S. Department of Agriculture, U.S. Forest Service brass tablet stamped "F 8 1931".

**CVO 85-203**

27.24 km (17.0 mi) southeasterly along FS road 21 from the intersection with State Highway 97 to 0.16 km (0.10 mi) northeast of the entrance to East Lake Campground, 27.3 m (90 ft) southeast of the centerline of FS road 21, 1 m (3.2 ft) above the road, set on a rod driven 7.6 m (25 ft) and enclosed in a 15 cm (6 in) diameter PVC pipe. U.S. Geological Survey, Cascades Volcano Observatory red brass tablet with a 1 cm nipple in the center stamped "CVO 85-203".

**CVO 94-22**

28.53 km (17.8 mi) southeasterly along FS road 21 from the intersection with State Highway 97 to 161 m (530 ft) west of the intersection with a paved road to the northeast to China Hat and a road to the north to the Cinder Hill Campground. 8.4 m (27.6 ft) east of the centerline of FS road 21, 1.2 m (4 ft) above the ground, 0.6 m (2 ft) above the road and set in a small rock exposure at the west end of a road cut. U.S. Geological Survey brass tablet stamped "CVO 94-22"

28.61 km (17.85 mi)

Southeasterly along FS road 21 from the intersection with State Highway 97 to the intersection with road to the northeast and Cinder Hill Campground.

**CVO 85-205**

0.90 km (0.55 mi) north along the road to Cinder Hill campground from the intersection with FS road 21, to the campground, 60 m (197 ft) north of first split in the road within the campground, 2.5 m (8.2 ft) above the road, 0.4 m (1.3 ft) above the ground and set on a 2 m (6.5 ft) diameter embedded boulder. Cascades Volcano Observatory red brass tablet with a 1 cm nipple in the middle stamped "CVO 85-205".

**93-206**

1.61 km (1.0 mi) northeasterly then south along FS road 21 from the intersection to Cinder Hill Campground, to a small 9 x 9 m (30 x 30 ft) clearing on the west side of the road, 20 m (65 ft) south of a pile of rusting tin cans, 21 m (68.9 ft) east of the road center, 5 m (16.4 ft) east of a witness post, attached to a rod driven 4.6 m (15 ft), and enclosed in a 15 cm (6 in) diameter PVC pipe. U.S. Geological Survey brass tablet stamped "93-206".

**F 10 1931**

3.29 km (2.05 mi) south along FS road 21 from the intersection to Cinder Hill Campground, to a sharp curve in the road at the intersection with FS road 2127 to Cabin Lake, approximately 30 m (100 ft) east of a sign "NEWBERRY CRATER WILDLIFE REFUGE", 8.9 m (29.2 ft) north of FS road 21, 4.4 m (14.4 ft) west of a 15 x 15 cm (6 x 6 in) wooden post that stands 2.1 m (7 ft), 5 cm (2 in) above ground, 0.6 m (2 ft)

above road and cemented on a 0.30 x 0.30 m (1 x 1 ft) embedded boulder. U.S. Department of Agriculture, U.S. Forest Service brass tablet stamped "F 10 1931".

**93-207**

5.05 km (3.15 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground, to the southeast end of a 91 m (300 ft) long road fill, 30 m (100 ft) northwest of the northwest end of a 6 m (20 ft) road cut, 15.5 m (50.9 ft) east of the road center, 1 m (3 ft) below the road, attached to a rod driven 15.2 m (50 ft) and enclosed in a 15 cm (6 in) diameter PVC pipe. U.S. Geological Survey Brass tablet stamped "93-207".

**93-208**

6.81 km (4.25 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground, to 0.40 km (0.25 mi) east of FS road 840, to a "U" curve in the road, 30 m (98 ft) south of a culvert, 17.4 m (57 ft) south of the road center, 1.7 m (5.6 ft) south of a metal witness post, 1.2 m (4 ft) below the road, attached to a rod driven 9.8 m (32 ft) and enclosed in a 15 cm (6 in) diameter PVC pipe. U.S. Geological Survey brass tablet stamped "93-208".

**F 11 1931**

8.41 km (5.25 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground, to intersection with FS road 9710 on the north. Leave FS road 21 and continue 0.16 km (0.05 mi) **SOUTH** along the track road opposite FS road 9710 to a triangle formed by the road intersection, 6.3 m (20.7 ft) north of the road center of the road leading east-west, 5 cm (2 in) above the ground and road and cemented in the top of a 0.3 x 0.3 m (1 x 1 ft) embedded boulder. U.S. Geological Survey brass tablet stamped "F 11 1931".

**93-209**

10.26 km (6.40 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground, to a 10 x 15 m (30 x 50 ft) clearing on the east, 14.4 m (47 ft) north of the road center, 1.5 m (5 ft) east of a 1.2 m (4 ft) diameter tree stump that projects 0.46 m (1.5 ft) above the ground, 15 cm (6 in) south of a witness post attached to a rod driven 4.6 m (15 ft), enclosed in a 15 cm (6 in) diameter PVC pipe and 20 cm (8 in) below the ground. U.S. Geological Survey brass tablet stamped "93-209".

**93-211**

11.62 km (7.25 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground, to approximately 120 m (400 ft) east of a 23 x 23 m (75 x 75 ft) clearing on the north side, 38 m (125 ft) west of a shallow drainage channel on the south side of the road, 6.5 m (21 ft) east of a 0.76 m (2.5 ft) diameter Ponderosa pine tree, 5.7 m (18.7 ft) east of a 0.9 m (3 ft) Ponderosa pine tree, across the road and approximately 15 m (50 ft) south-southwest of two 0.9 m (3 ft) diameter Ponderosa pine trees, 11.5 m (37.7 ft) north of the road center and 2.9 m (9.5 ft) north of a witness

post, attached to a rod driven 15.2 m (50 ft) and enclosed in a 15 cm (6 in) diameter PVC pipe. U.S. Geological Survey brass tablet stamped "93-211".

**93-210**

13.14 km (8.20 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground to the southeast end of a small 30 x 30 m (100 x 100 ft) clearing on the south side of the road and a track road leading east-southeast, 15.2 m (50 ft) southeast of the intersection, 10.9 m (36 ft) south of FS road 21, 5.5 m (18 ft) northeast of the track road and 15 m (50 ft) southeast of the above clearing, attached to a rod driven 12.2 m (40 ft) and enclosed in a 15 cm (6 in) diameter PVC pipe. U.S. Geological Survey brass tablet stamped "93-210".

**G 18**

14.82 km (9.25 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground to the approximate middle of a 60 x 180 m (200 x 600 ft) clearing on the south side, approximately 150 m (500 ft) northwest of a track road to the south, 10.6 m (34.8 ft) south of the road center of FS road 21 and attached to a 5 cm (2 in) diameter pipe, 15 cm (6 in) above the ground. Deschutes County Surveys control mark stamped "G 18 0072".

**F 12 Reset**

16.11 km (10.05 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground to the intersection with FS road 18. At the northwest corner of the intersection of FS road 18 and 21, approximately 61 m (200 ft) north of FS road 21 along a track road paralleling FS road 18 and approximately 38 m (125 ft) east of FS road 18, set in a concrete pad flush with the ground. U.S. Geological Survey brass tablet stamped "F 12 Reset 1991".

**F 12 1931**

16.11 km (10.05 mi) south then easterly along FS road 21 from the intersection to Cinder Hill Campground to the intersection with FS road 18. 35.4 m (116 ft) northwest of FS road 18, 24.8 m (81 ft) south of FS road 21, 2.1 m (7 ft) east of the remnants of an old road, 10 m (30 ft) south of a 1 m (3 ft) high earth berm closing the old road and cemented on a 0.3 x 0.3 m (1 x 1 ft) embedded boulder at the southeast corner of FS road 21 and FS road 18. U.S. Geological Survey brass tablet stamped "F 12 1931"

Table 1

Bench mark ID	1931 elev m.	1986 elev m.	1994 elev m.	1994 elev diff between BM
F12 1931 *	1599.30800		1599.30800	
F12 RESET			1600.66414	1.35614
G 18 *			1627.47909	26.81495
93-210 *			1671.58183	44.10274
93-211			1733.49946	61.91763
93-209 *			1787.52677	54.02731
F11 1931 *	1856.00150		1856.06708	68.54031
93-208 *			1926.72369	70.65661
93-207 *			2047.51200	120.78831
F10 1931 *	2136.24570		2136.30507	88.79307
93-206			2024.00739	-112.29768
CVO85-205 @		1953.67809	1953.67809	-70.32930
CVO94-22			1950.73536	-2.94273
CVO85-203 @		1954.04831	1954.04707	3.31171
F8 1931	1945.51540		1945.59223	-8.45484
CVO85-202 @		1955.31613	1955.31155	9.71932
CVO85-201 @		1945.08642	1945.08403	-10.22752
CVO85-200 @		1937.77990	1937.77866	-7.30537
93-205			1962.24149	24.46283
A1G 1931 @&	1929.64080	1929.75403	1929.75447	-32.48702
93-204			1834.71580	-95.03867
F4 1931 &	1764.51750		1764.60597	-70.10983
BOLT &	1666.02735		1666.11150	-98.49447

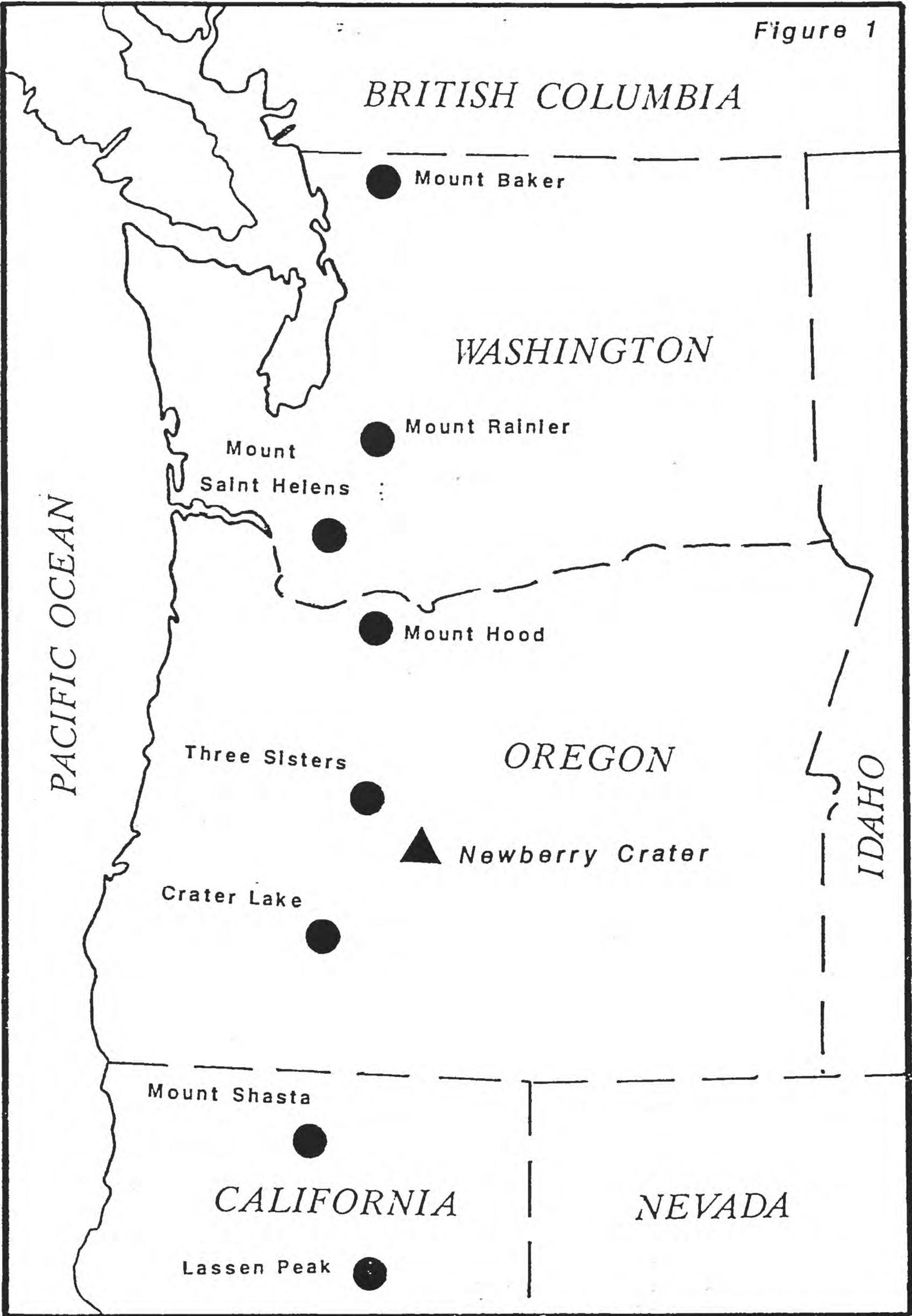
Bench mark ID	1931 elev m.	1986 elev m.	1994 elev m.	1994 elev diff between BM
F3 1931	1581.47940		1581.53385	-84.57765
93-202			1489.96746	-91.56639
93-201			1426.04973	-63.91773
93-200			1367.14549	-58.90424
F1 1931	1314.98970		1315.00604	-52.13945

\* Average differences of sections that were double run  
& Data compared to the 1993 "trial survey"  
@ Data compared to the 1986 survey

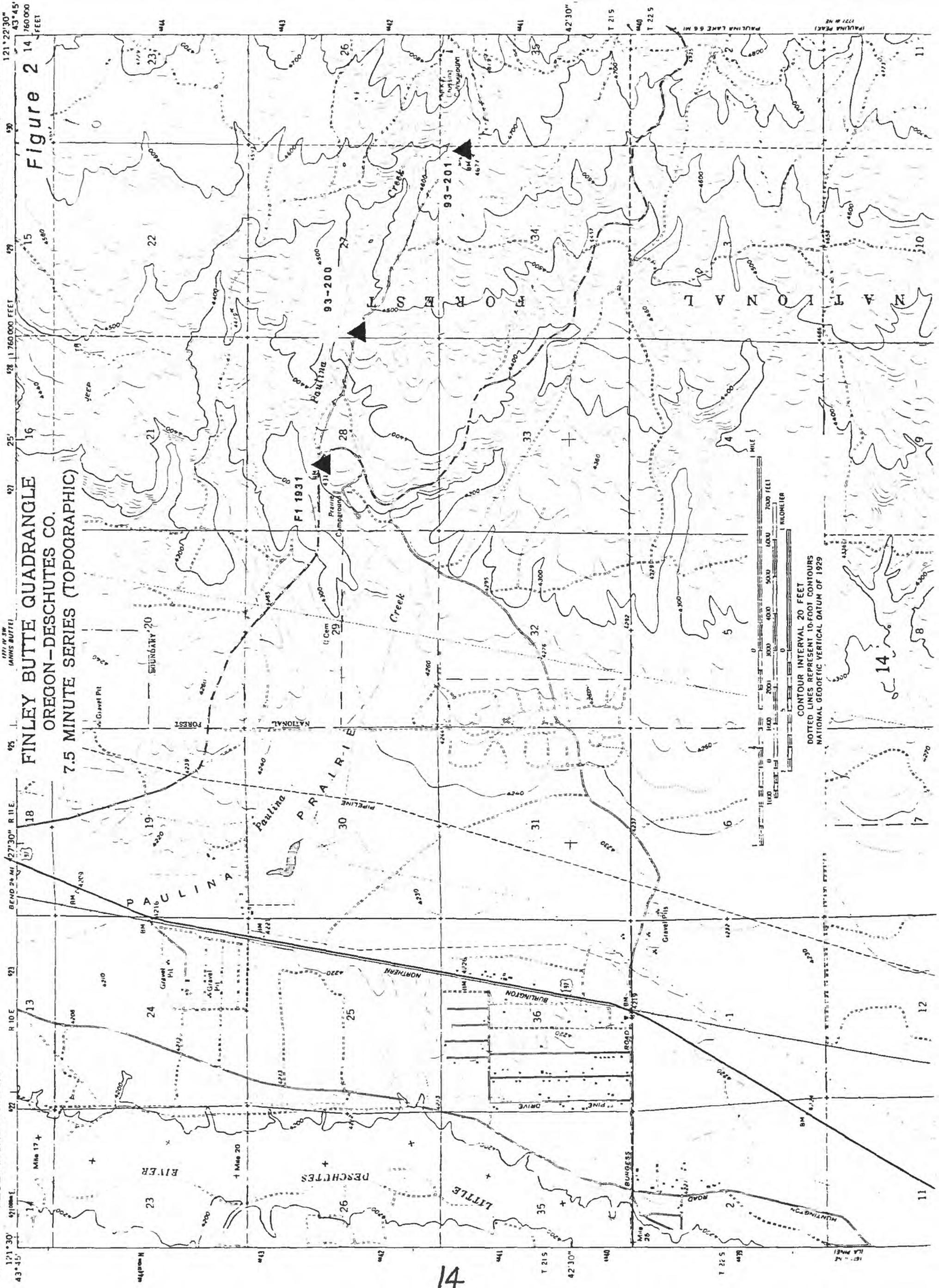
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- Yamashita, K.M. and Kaiser, W.P. 1992; Using first order class II geodetic leveling procedures to monitor vertical displacement. U.S. Geological Survey Bulletin 1966, p. 135-141.
- Yamashita, K.M. and Yamashita, J.M. 1992; Using the MC-II Handheld Computer While Running First or Second Order Leveling Surveys. U.S. Geological Survey Open-File Report 92-184, 18 p.

Figure 1



Location of Cascade Volcanoes



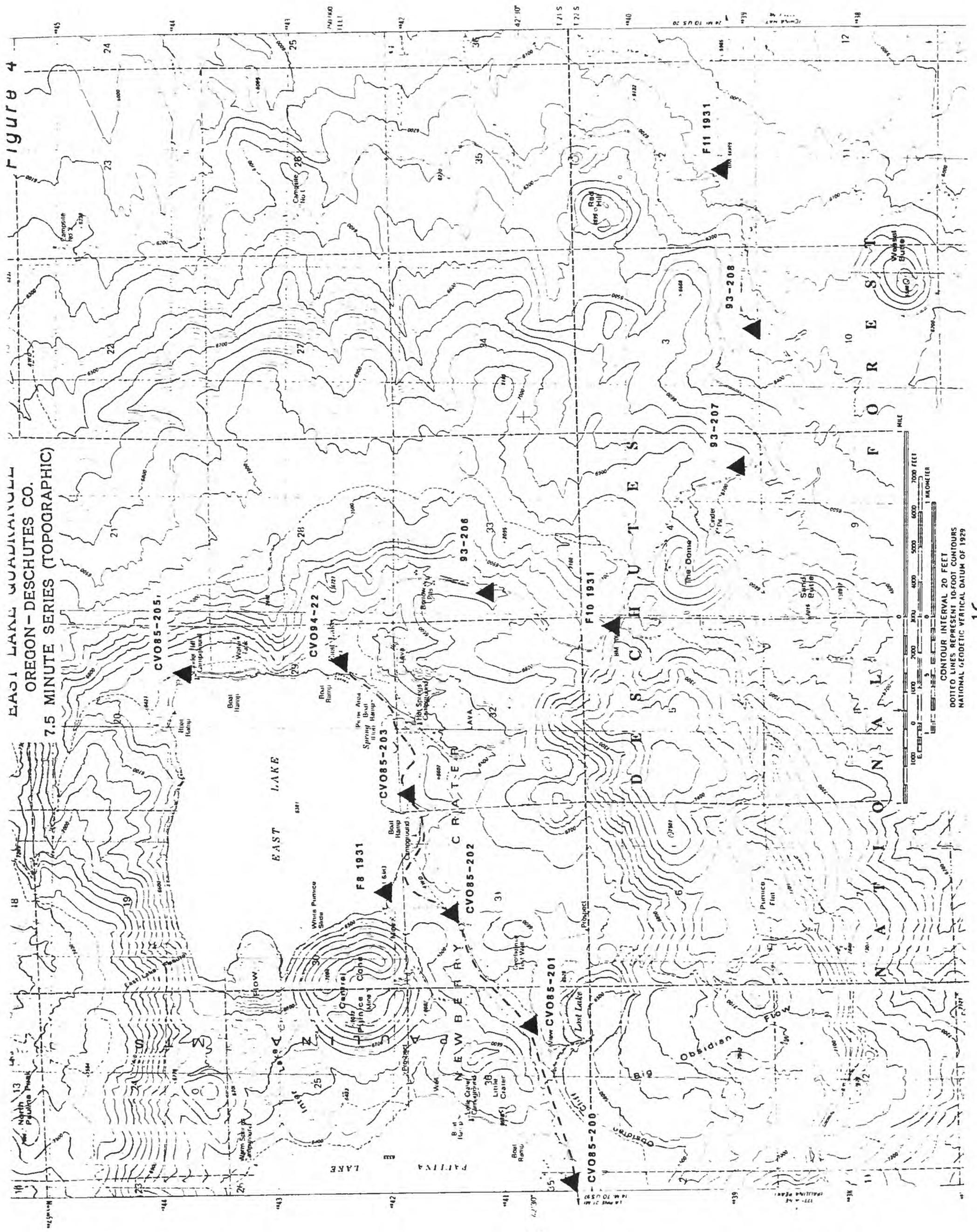
**FINLEY BUTTE QUADRANGLE**  
**OREGON-DESCHUTES CO.**  
**7.5 MINUTE SERIES (TOPOGRAPHIC)**

**Figure 2**



**EAST LAKE QUADRIANGLE  
OREGON - DESCHUTES CO.  
7.5 MINUTE SERIES (TOPOGRAPHIC)**

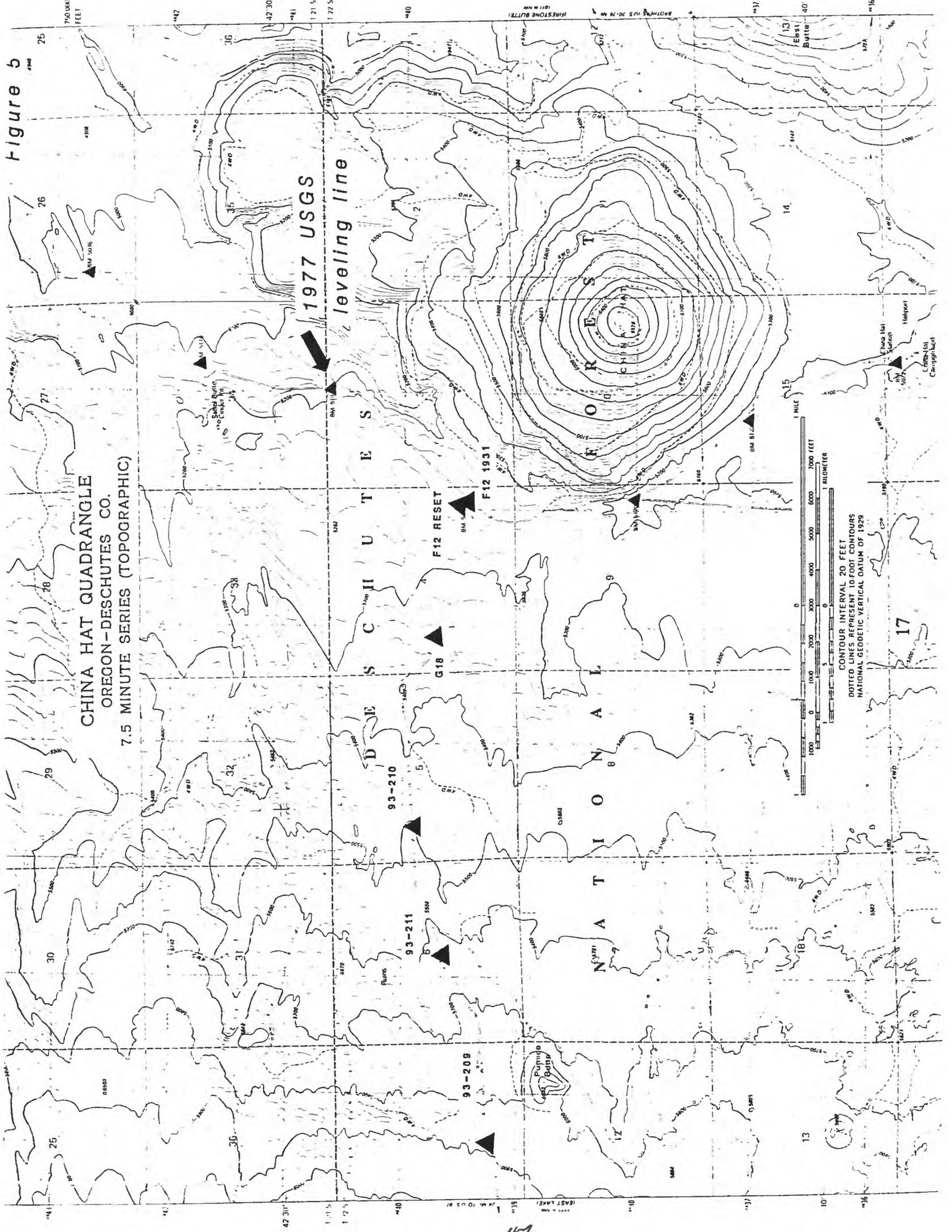
**Figure 4**



CONTOUR INTERVAL 20 FEET  
 DOTTED LINES REPRESENT 10-FOOT CONTOURS  
 NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure b

CHINA HAT QUADRANGLE  
OREGON-DESCHUTES CO.  
7.5 MINUTE SERIES (TOPOGRAPHIC)



1977 USGS leveling line

F12 RESET

F12 1931

G18

93-210

93-211

93-209

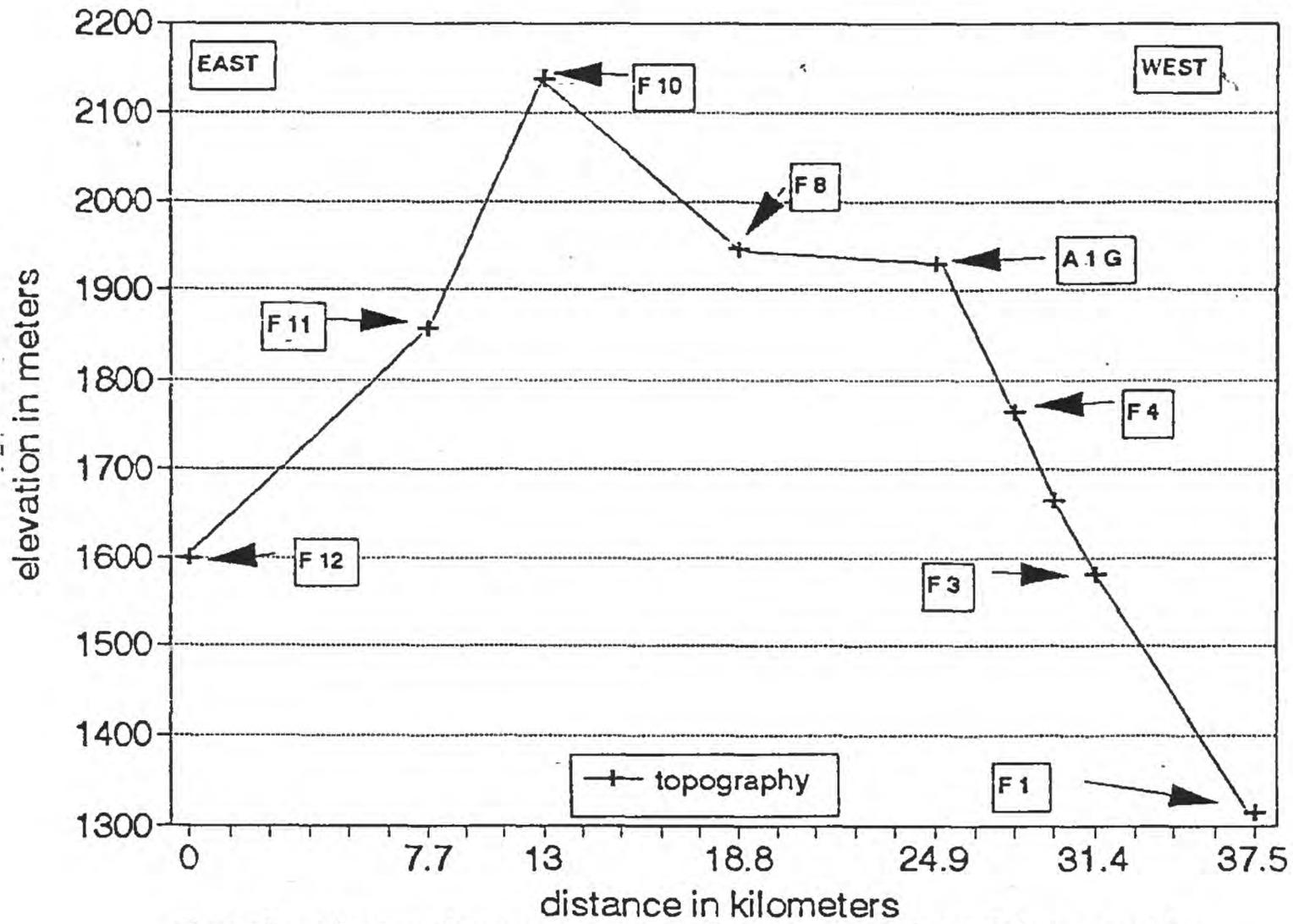


CONTOUR INTERVAL 20 FEET  
DOTTED LINES REPRESENT 10 FOOT CONTOURS  
NATIONAL GEODETIC VERTICAL DATUM OF 1929

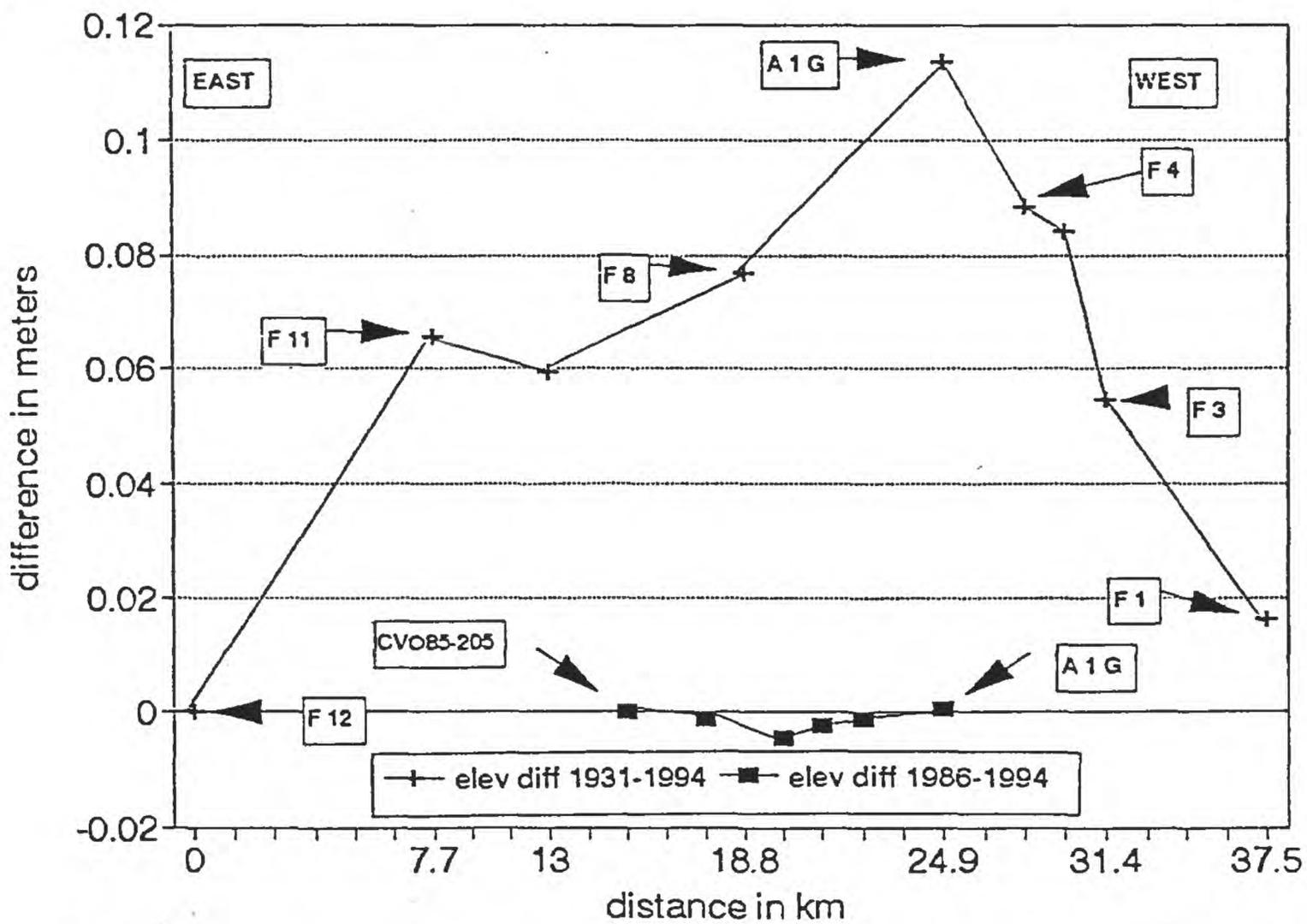
17

141

Figure 6



Graph shows topography along the leveling route



Top plot shows the elevation difference between the 1931 and 1994 survey and the bottom plot shows the elevation difference between the 1986 and 1994 leveling survey.