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Remeasurement of a Precision Gravity Network for Monitoring the Lassen Geothermal System, Northern California

by

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Abstract

A precision gravity network consisting of approximately 75 stations (established to monitor the Lassen geothermal system) was remeasured to determine normal seasonal variations. Gravity measurements made in July and September, 1983 were compared to the original measurements made in 1981 and 1982. The average observed change in relative gravity was +.015 mGal with average uncertainties (computed standard errors) of .009 mGal. These small changes can be explained by water table fluctuations of less than a meter. We conclude that the network is sufficiently stable to be an accurate monitor of surface deformation, subsurface magma movement, or changes in the subsurface water mass.

Introduction

The southernmost volcano in the Cascade Range, Lassen Peak, is probably the largest dacitic volcanic dome in the world. It is the most prominent landmark in Lassen Volcanic National Park, northern California. Second to its illustrious sister Mount St. Helens, Lassen Peak is the most recently active volcano in the Cascades. An eruption in 1915 resulted in a mudflow which scoured the northeastern side of the peak. Numerous spectacular hydrothermal features attest to the continued geothermal energy of the region. It is probable that the area will again become volcanically active.

Data from geologic and geochemical investigations suggest that hydrologic connection may exist between the hydrothermal systems beneath Lassen Volcanic National Park and the Lassen Known Geothermal Resources Area (KGRA) located adjacent to and south of the park (Muffler and others, 1982). It follows that development of the geothermal resources in the KGRA could affect the hydrothermal features in the National Park. To provide base-line data for monitoring future mass changes due to crustal deformation, subsurface magma movement, or changes in the mass of water in the subsurface, a reoccupiable gravity station network was established during the summers of 1981 (Jachens and others, 1983) and 1982 (Jachens and Saltus, 1983).

The network consists of about 55 locations, 20 with secondary reading sites, for a total of about 75 stations. The stations fall generally in the southern half of the park extending into the KGRA south of the park (figure 1). Four additional stations are located in the Sierra Nevada about 45 km southeast of the main network.

In order to examine the response of the gravity network to seasonal variations in the water table and to check for any systematic changes, the gravity was remeasured in July and September 1983.

Gravity Measurement Procedures and Reductions

Detailed descriptions of the gravity stations are contained in Jachens and others (1983) and Jachens and Saltus (1983). Description of the gravity meters used and method of reduction to relative gravity in mGal is given in Jachens and Saltus (1983).

The final result of the gravity reduction is a relative difference in gravity between a base location and the station. All stations except LPG01

through LPG06 were measured relative to LPG10 (figure 1) located near Childs Meadows south of the park. LPG01 through LPG06 were measured relative to LP001 near Manzanita Lake at the northwest corner of the park.

Once relative gravity values are known, they can be compared to earlier values at the same stations. Differences represent changes in value of the relative measurement and could indicate absolute changes at either the station itself or the base (or both).

The tables which follow give the relative gravity values determined in July and September, 1983 and the differences between these values and the original values found in 1981 and 1982. In addition, the differences between the July and September, 1983 survey results are listed.

Interpretation of Gravity Changes

The gravity network may be divided into 4 groups of stations based on their geographic distribution and gravity response:

1. Stations outside the geothermal area.
2. Stations high in the park.
3. Low stations, predominately in Feather River Meadows.
4. Stations south along the park road.

Figures 3 through 6 show bar plots of the relative gravity differences for each of these 4 groups.

The stations outside the Lassen Geothermal system show no change in relative gravity and thus imply that base station LPG10 has remained stable. Generally, the stations high in the park show changes in relative gravity that are small compared to the estimated uncertainties. The low stations show an increase in July, 1983 with a subsequent decrease in September, 1983, probably associated with seasonal groundwater fluctuation. The stations along the park road fall into two sub-groups, the southern stations showing significant increases in 1983 over 1982, and the northern stations showing increases between July and September, 1983.

Figure 2 is a plot of monthly rainfall and snowmelt totals recorded at the park headquarters in Mineral for the years 1981, 1982, and 1983 (Richard Vance, written commun.). Most of the network is located at higher elevations where greater snowfall will increase the overall amount of water entering the ground. Colder temperatures at higher elevations will cause the snowmelt to take place later in the year. For higher areas of the park the greater total snowfall and later melting will tend to shift the annual March and April highs over into May, June, and July. Thus, the data suggest that water table levels throughout the network were lowest in 8/81 and highest in 7/83. Water table levels for 8/82 and 9/83 should fall within the two extremes, with 8/82 levels perhaps higher. More snow fell in 1983 than in 1982, but more rain in June and July 1982 may have countered the increased snow runoff from higher elevations for summer 1983.

Gravity changes at stations outside the Lassen geothermal system

Figure 3 contains plots of gravity changes at six stations remote from the rest of the network. LP001 and LP001A are located at the north end of the park. LPG42 and LPG42A are about 1.6 km (1 mile) south of the Lake Almanor spillway, roughly 40 km southeast of Feather River Meadows. LPG47 and LPG47A are located on an outcrop of Sierran(?) granite a few km further east. The stability of these remote stations relative to LPG10, the base of the network near Childs Meadows, implies that any absolute gravity changes taking place at LPG10 must be related to regional changes which have affected these remote stations as well. Thus, relative changes between LPG10 and the other stations of the network may be assumed to be due to local causes at each station.

Gravity changes of stations high in the park

The relative gravity changes between September 1983 and the original station occupations for the highest elevation stations are plotted in figure 4. The first 4 stations, LPG01, LPG01A, LPG05A, and LPG05 were established in August, 1981, the rest in August, 1982. Due to snow cover, all the high stations except LP049 were unreachable in July 1983.

Most of these stations show no significant gravity changes or small decreases. The stations with no change indicate that local water level remained the same. Good drainage from high stations may keep the ground water levels relatively constant. The stations with slight decreases may indicate lower water levels in 9/83 compared with 8/82. Exceptions are LPG05, LPG05A, LPG40, LPG41, and perhaps LPG01A and LP049.

LPG05 and LPG05A are located on top of south Chaos Crag. The area in the vicinity of LPG05 is made up of a precarious jumble of house and car sized rocks. It is unlikely that the increase in gravity at this location is related to water changes. The increase may be due to subsidence or shifting of the boulder holding the reading site. Assuming a relation between gravity change and elevation change of -.2 mGal/m (-.06 mGal/ft), the average of the observed changes at LPG05 and LPG05A could be the result of about 15 cm (6 inches) of subsidence.

Stations LPG40 and LPG41 located in upper and lower Kings Creek Meadows show gravity increases. The increases could be due to a higher water table in 1983 caused by the collection of snow melt from the high north-facing slopes of Bumpass Mountain and its adjoining ridge to the northwest.

The increase at LPG01A is suspect because LPG01 shows no change.

Station LPG49 shows a sizeable increase between July and September, 1983. In July snow was piled high on each side of the road at LP049, in September, most of the snow had melted. The mass of the snow pack above the station in July and its subsequent absence in September along with the increased water table due to this melting, can explain this gravity increase.

Gravity changes of lower elevation stations

The relative gravity changes for lower elevation stations in the Feather River Meadow area are plotted in figure 5. Most of these stations were

established in 8/82 and remeasured in both July and September, 1983. All the stations except LPG22 follow the same pattern: positive gravity changes in 7/83 over 8/82, then back down to near or below the 1982 values in 9/83.

Figure 7 shows change in gravity versus measured local lake or stream levels for four of the Feather River Meadows area stations and for station BERT near Emerald Lake high in the park. With the exception of a questionable 7/83 result for station LPG22, the changes cluster around the line relating change in gravity to change in water level for a ground porosity of 0.45:

$$\frac{\text{change in gravity}}{\text{change in water level}} = .019 \ \frac{\text{mGal}}{\text{meter}} = \left(.0057 \ \frac{\text{mGal}}{\text{foot}}\right) .$$

This result is derived from the equation for the gravity effect of an infinite slab with density σ:

$$.04188\sigma \text{ mGal/m} = .01277\sigma \text{ mGal/ft} .$$

Because water has a density of 1 g/cm^3, a ground porosity of 0.45 means a bulk density change of 0.45 g/cm^3 results from the addition or subtraction of water from the ground.

Gravity changes at stations along the southern park road

Figure 6 contains plots of gravity changes observed for 11 stations of the Lassen precision gravity network along the south portion of the park road. The gravity changes at these stations do not follow the water-level pattern of 7/83 increase and subsequent 9/83 decrease over 8/82. Instead, a systematic increase in relative gravity is present. If similar water-level fluctuations are assumed to have taken place at these stations as we have seen elsewhere in the park, the addition of a systematic increase of 0 to .02 mGal between 8/82 and 7/83 along with a subsequent increase of about .03 mGal between 7/83 and 9/83 would result in the gravity changes of these stations. If this inferred systematic gravity increase were due to ground subsidence, it would indicate a maximum of 15 cm (6 inches) elevation change. Our data do not permit us to decide whether ground subsidence or anomalous water table levels are the cause of these changes.

Conclusion

Based on the comparison of gravity measurements made in July and September, 1983 to original values obtained in 1981 and 1982, we conclude that observed gravity differences are due primarily to changes in the local water table. The stability of the network with regard to remote stations and the correlation of gravity changes with local water table fluctuations, imply that the network can provide a reliable monitor of any future surface deformation, subsurface magma movement, or changes in the mass of water in the subsurface.

References

Jachens, Robert C., Dzurisin, Daniel, Elder, William P., and Saltus, Richard W., 1983, Precision gravity networks at Lassen Peak and Mount Shasta, California: U.S. Geological Survey Open-File Report 83-192, 20 p.

Jachens, Robert C., and Saltus, Richard W., 1983, Precision gravity network for monitoring the Lassen geothermal system, northern California: U.S. Geological Survey Open-File Report 83-193.

Muffler, L.J.P., Nehring, N. L., Truesdell, A. H., Janik, C. J., Clynne, M. A., and Thompson, T. M., 1982, The Lassen geothermal system: Proceedings of the Pacific Geothermal Conference Auckland, New Zealand, November 1982, p. 349-356.

Table 1.--Difference between relative gravity values observed in August, 1982 and remeasured in July, 1983 for 36 stations of the precision gravity network in Lassen Volcanic National Park and vicinity. Standard error for the difference is $s.e._{1,2} = [(s.e._1)^2 + (s.e._2)^2]^{1/2}$ where $s.e._1$ and $s.e._2$ are the computed standard errors of the relative gravity values from the two surveys. Gravity values are in mGals.

Station	1983-1982		August, 1982		July, 1983		
	Delta G New-Base	Standard Error	Base Rel Grav	Base Std Error	New Rel Grav	New Std Error	Base Station
LP001	-0.018	0.0086	-34.055	0.0054	-34.073	0.0067	LPG10
LP001A	-0.005	0.0086	-34.204	0.0054	-34.209	0.0067	LPG10
LPG11	0.025	0.0100	-51.356	0.0080	-51.331	0.0060	LPG10
LPG12	0.035	0.0101	-49.306	0.0080	-49.271	0.0061	LPG10
LPG13	0.035	0.0104	-58.763	0.0079	-58.728	0.0068	LPG10
LPG14	0.028	0.0102	-66.864	0.0079	-66.836	0.0064	LPG10
LPG15	0.018	0.0100	-71.000	0.0079	-70.982	0.0061	LPG10
LPG16	0.002	0.0094	-67.880	0.0071	-67.878	0.0061	LPG10
LPG17	0.021	0.0093	-71.988	0.0070	-71.967	0.0061	LPG10
LPG18	0.009	0.0094	-65.706	0.0071	-65.697	0.0061	LPG10
LPG19	0.012	0.0098	-66.253	0.0072	-66.241	0.0067	LPG10
LPG21	0.027	0.0101	-37.375	0.0071	-37.348	0.0072	LPG10
LPG22	-0.023	0.0118	-27.952	0.0071	-27.975	0.0094	LPG10
LPG23	0.001	0.0097	-26.288	0.0071	-26.287	0.0066	LPG10
LPG24	0.011	0.0102	-25.849	0.0078	-25.838	0.0066	LPG10
LPG27	0.023	0.0097	-83.647	0.0066	-83.624	0.0071	LPG10
LPG28	0.019	0.0096	-81.733	0.0064	-81.714	0.0071	LPG10
LPG29	0.010	0.0099	-78.920	0.0063	-78.910	0.0077	LPG10
LPG30	0.004	0.0095	-47.739	0.0062	-47.735	0.0072	LPG10
LPG31	0.017	0.0095	-23.167	0.0072	-23.150	0.0062	LPG10
LPG33	0.057	0.0096	-65.997	0.0063	-65.940	0.0073	LPG10
LPG34	0.026	0.0091	-85.151	0.0062	-85.125	0.0066	LPG10
LPG35	0.057	0.0111	-93.476	0.0061	-93.419	0.0093	LPG10
LPG36	0.050	0.0095	-103.121	0.0068	-103.071	0.0066	LPG10
LPG37	-0.021	0.0103	-125.420	0.0078	-125.441	0.0067	LPG10
LPG37A	-0.004	0.0109	-123.502	0.0086	-123.506	0.0067	LPG10
LPG38	-0.004	0.0091	-150.582	0.0062	-150.586	0.0066	LPG10
LPG42	-0.002	0.0096	11.367	0.0069	11.365	0.0067	LPG10
LPG42A	0.008	0.0095	11.431	0.0068	11.439	0.0067	LPG10
LPG44	0.035	0.0092	-33.483	0.0064	-33.448	0.0066	LPG10
LPG45	0.045	0.0093	-43.874	0.0065	-43.829	0.0066	LPG10
LPG46	0.017	0.0093	-55.230	0.0065	-55.213	0.0067	LPG10
ML7	0.002	0.0088	-46.187	0.0056	-46.185	0.0068	LPG10
ML7A	0.011	0.0088	-46.195	0.0056	-46.184	0.0068	LPG10
ML8	-0.006	0.0091	-110.707	0.0055	-110.713	0.0073	LPG10
ML8A	-0.022	0.0091	-110.597	0.0055	-110.619	0.0073	LPG10

Table 2.--Differences between relative gravity values initially observed in August, 1981 and August, 1982 and remeasured in September, 1983 for 61 stations of the precision gravity network in Lassen Volcanic National Park and vicinity. Standard error for the difference is $s.e._{1,2} = [(s.e._1)^2 + (s.e._2)^2]^{1/2}$ where $s.e._1$ and $s.e._2$ are the computed standard errors of the relative gravity values from the two surveys. Gravity values are in mGals.

Station	1983-1982		August, 1982		September, 1983		
	Delta G New-Base	Standard Error	Base Rel Grav	Base Std Error	New Rel Grav	New Std Error	Base Station
BERT	-0.002	0.0094	-202.975	0.0070	-202.977	0.0062	LPG10
LP001	-0.001	0.0085	-34.055	0.0054	-34.056	0.0066	LPG10
LP001A	0.000	0.0085	-34.204	0.0054	-34.204	0.0066	LPG10
LP049A	0.010	0.0096	-207.516	0.0063	-207.506	0.0073	LPG10
LPG11	0.007	0.0108	-51.356	0.0080	-51.349	0.0072	LPG10
LPG12	0.000	0.0104	-49.306	0.0080	-49.306	0.0066	LPG10
LPG13	0.013	0.0104	-58.763	0.0079	-58.750	0.0067	LPG10
LPG14	0.000	0.0108	-66.864	0.0079	-66.864	0.0073	LPG10
LPG15	-0.010	0.0097	-71.000	0.0079	-71.010	0.0057	LPG10
LPG16	0.000	0.0090	-67.880	0.0071	-67.880	0.0056	LPG10
LPG17	0.004	0.0090	-71.988	0.0070	-71.984	0.0056	LPG10
LPG18	0.016	0.0091	-65.706	0.0071	-65.690	0.0057	LPG10
LPG19	-0.049	0.0158	-66.253	0.0072	-66.302	0.0141	LPG10
LPG21	0.008	0.0092	-37.375	0.0071	-37.367	0.0058	LPG10
LPG22	-0.011	0.0096	-27.952	0.0071	-27.963	0.0064	LPG10
LPG23	-0.022	0.0096	-26.288	0.0071	-26.310	0.0064	LPG10
LPG24	-0.007	0.0101	-25.849	0.0078	-25.856	0.0064	LPG10
LPG25	0.001	0.0090	-91.963	0.0071	-91.962	0.0056	LPG10
LPG26	0.005	0.0092	-98.698	0.0071	-98.693	0.0058	LPG10
LPG27	-0.023	0.0088	-83.647	0.0066	-83.670	0.0058	LPG10
LPG28	-0.009	0.0086	-81.733	0.0064	-81.742	0.0057	LPG10
LPG29	-0.008	0.0085	-78.920	0.0063	-78.928	0.0057	LPG10
LPG30	0.007	0.0084	-47.739	0.0062	-47.732	0.0057	LPG10
LPG31	0.008	0.0098	-23.167	0.0072	-23.159	0.0067	LPG10
LPG33	0.023	0.0091	-65.997	0.0063	-65.974	0.0066	LPG10
LPG34	0.025	0.0091	-85.151	0.0062	-85.126	0.0066	LPG10
LPG35	0.054	0.0090	-93.476	0.0061	-93.422	0.0066	LPG10
LPG36	0.065	0.0095	-103.121	0.0068	-103.056	0.0066	LPG10
LPG37	0.011	0.0100	-125.420	0.0078	-125.409	0.0063	LPG10
LPG37A	0.025	0.0107	-123.502	0.0086	-123.477	0.0063	LPG10
LPG38	0.015	0.0088	-150.582	0.0062	-150.567	0.0063	LPG10
LPG39	-0.003	0.0088	-174.128	0.0062	-174.131	0.0062	LPG10
LPG40	0.019	0.0092	-163.952	0.0063	-163.933	0.0067	LPG10
LPG41	0.025	0.0092	-161.236	0.0063	-161.211	0.0067	LPG10
LPG42	0.001	0.0093	11.367	0.0069	11.368	0.0063	LPG10
LPG42A	0.000	0.0092	11.431	0.0068	11.431	0.0062	LPG10
LPG44	0.013	0.0091	-33.483	0.0064	-33.470	0.0065	LPG10
LPG45	0.006	0.0091	-43.874	0.0065	-43.868	0.0064	LPG10
LPG46	0.003	0.0091	-55.230	0.0065	-55.227	0.0064	LPG10
LPG50	-0.002	0.0090	-217.449	0.0064	-217.451	0.0063	LPG10
LPG50A	-0.008	0.0089	-216.717	0.0064	-216.725	0.0062	LPG10
LPG51	-0.004	0.0109	-250.359	0.0077	-250.363	0.0077	LPG10

Table 2 (continued)

Station	1983-1982 Delta G New-Base	Standard Error	August, 1982 Base Rel Grav	Base Std Error	September, 1983 New Rel Grav	New Std Error	Base Station
LPG51A	-0.017	0.0109	-250.455	0.0077	-250.472	0.0077	LPG10
LPG52	-0.025	0.0108	-152.461	0.0064	-152.486	0.0087	LPG10
LPG52A	-0.026	0.0112	-152.530	0.0070	-152.556	0.0087	LPG10
LPG53	-0.018	0.0088	-165.597	0.0063	-165.615	0.0062	LPG10
LPG53A	-0.010	0.0088	-165.628	0.0063	-165.638	0.0062	LPG10
LPG54	0.008	0.0111	-147.867	0.0091	-147.859	0.0063	LPG10
LPG54A	-0.001	0.0111	-147.548	0.0091	-147.549	0.0063	LPG10
LPG55	-0.005	0.0088	-134.929	0.0062	-134.934	0.0063	LPG10
LPG55A	-0.003	0.0088	-135.613	0.0062	-135.616	0.0063	LPG10
LPG56	-0.021	0.0089	-83.765	0.0063	-83.786	0.0063	LPG10
LPG56A	-0.013	0.0089	-83.543	0.0063	-83.556	0.0063	LPG10
ML7	0.001	0.0087	-46.187	0.0056	-46.186	0.0067	LPG10
ML8	0.017	0.0087	-110.707	0.0055	-110.690	0.0067	LPG10
ML8A	0.009	0.0087	-110.597	0.0055	-110.588	0.0067	LPG10
SALTUS	-0.016	0.0097	-218.952	0.0069	-218.968	0.0068	LPG10

Station	1983 - 1981 Delta G New-Base	Standard Error	August, 1981 Base Rel Grav	Base Std Error	September, 1983 New Rel Grav	New Std Error	Base Station
LPG05A	0.036	0.0096	-202.186	0.0060	-202.150	0.0075	LP001
LPG05	0.021	0.0091	-202.136	0.0060	-202.115	0.0068	LP001
LPG01	0.009	0.0090	-210.192	0.0060	-210.183	0.0067	LP001
LPG01A	0.051	0.0096	-209.978	0.0060	-209.927	0.0075	LP001

Table 3.--Differences between relative gravity values observed in July, 1983 and remeasured in September, 1983 for 40 stations of the precision gravity network in Lassen Volcanic National Park and vicinity. Standard error for the difference is $s.e._{1,2} = [(s.e._1)^2 + (s.e._2)^2]^{1/2}$ where $s.e._1$ and $s.e._2$ are the computed standard errors of the relative gravity values from the two surveys. Gravity values are in mGals.

	September - July		July, 1983		September, 1983		
Station	Delta G New-Base	Standard Error	Base Rel Grav	Base Std Error	New Rel Grav	New Std Error	Base Station
LP001	0.017	0.0094	-34.073	0.0067	-34.056	0.0066	LPG10
LP001A	0.005	0.0094	-34.209	0.0067	-34.204	0.0066	LPG10
LP049	0.044	0.0103	-207.190	0.0072	-207.146	0.0073	LPG10
LPG11	-0.018	0.0094	-51.331	0.0060	-51.349	0.0072	LPG10
LPG12	-0.035	0.0090	-49.271	0.0061	-49.306	0.0066	LPG10
LPG13	-0.022	0.0095	-58.728	0.0068	-58.750	0.0067	LPG10
LPG14	-0.028	0.0097	-66.836	0.0064	-66.864	0.0073	LPG10
LPG15	-0.028	0.0083	-70.982	0.0061	-71.010	0.0057	LPG10
LPG16	-0.002	0.0083	-67.878	0.0061	-67.880	0.0056	LPG10
LPG17	-0.017	0.0083	-71.967	0.0061	-71.984	0.0056	LPG10
LPG18	0.007	0.0083	-65.697	0.0061	-65.690	0.0057	LPG10
LPG19	-0.061	0.0156	-66.241	0.0067	-66.302	0.0141	LPG10
LPG19A	-0.040	0.0107	-66.304	0.0086	-66.344	0.0064	LPG10
LPG21	-0.019	0.0092	-37.348	0.0072	-37.367	0.0058	LPG10
LPG22	0.012	0.0114	-27.975	0.0094	-27.963	0.0064	LPG10
LPG23	-0.023	0.0092	-26.287	0.0066	-26.310	0.0064	LPG10
LPG24	-0.018	0.0092	-25.838	0.0066	-25.856	0.0064	LPG10
LPG27	-0.046	0.0092	-83.624	0.0071	-83.670	0.0058	LPG10
LPG28	-0.028	0.0091	-81.714	0.0071	-81.742	0.0057	LPG10
LPG29	-0.018	0.0096	-78.910	0.0077	-78.928	0.0057	LPG10
LPG30	0.003	0.0092	-47.735	0.0072	-47.732	0.0057	LPG10
LPG31	-0.009	0.0091	-23.150	0.0062	-23.159	0.0067	LPG10
LPG33	-0.034	0.0098	-65.940	0.0073	-65.974	0.0066	LPG10
LPG34	-0.001	0.0093	-85.125	0.0066	-85.126	0.0066	LPG10
LPG35	-0.003	0.0114	-93.419	0.0093	-93.422	0.0066	LPG10
LPG36	0.015	0.0093	-103.071	0.0066	-103.056	0.0066	LPG10
LPG37	0.032	0.0092	-125.441	0.0067	-125.409	0.0063	LPG10
LPG37A	0.029	0.0092	-123.506	0.0067	-123.477	0.0063	LPG10
LPG38	0.019	0.0091	-150.586	0.0066	-150.567	0.0063	LPG10
LPG42	0.003	0.0092	11.365	0.0067	11.368	0.0063	LPG10
LPG42A	-0.008	0.0091	11.439	0.0067	11.431	0.0062	LPG10
LPG44	-0.022	0.0093	-33.448	0.0066	-33.470	0.0065	LPG10
LPG45	-0.039	0.0092	-43.829	0.0066	-43.868	0.0064	LPG10
LPG46	-0.014	0.0093	-55.213	0.0067	-55.227	0.0064	LPG10
LPG47	-0.004	0.0097	35.212	0.0074	35.208	0.0062	LPG10
LPG47A	-0.004	0.0100	35.375	0.0074	35.371	0.0068	LPG10
ML7	-0.001	0.0095	-46.185	0.0068	-46.186	0.0067	LPG10
ML8	0.023	0.0099	-110.713	0.0073	-110.690	0.0067	LPG10
ML8A	0.031	0.0099	-110.619	0.0073	-110.588	0.0067	LPG10
WILSON	0.007	0.0089	-36.438	0.0060	-36.431	0.0066	LPG10

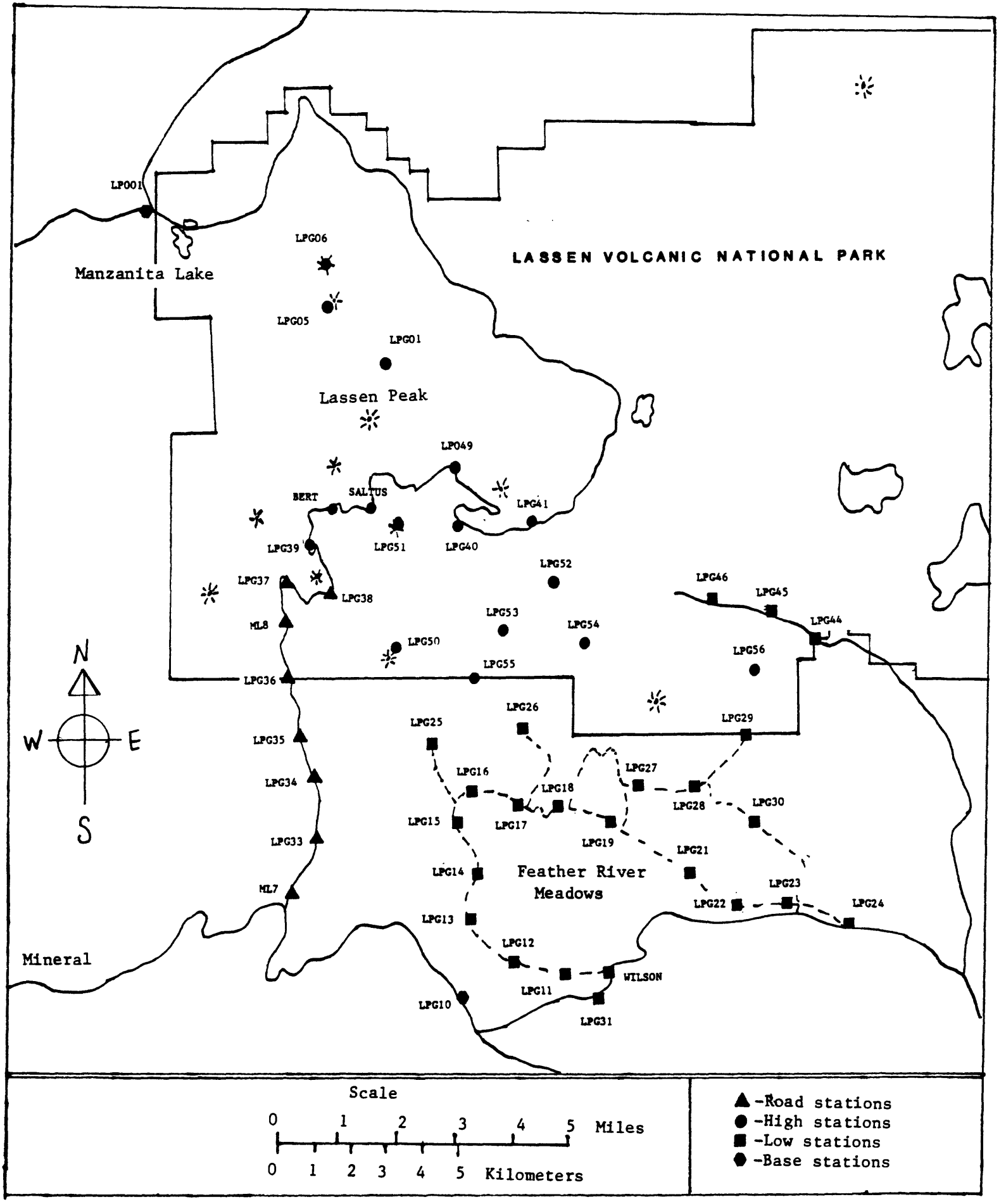

Figure 1.--Location map of the Lassen precision gravity network.

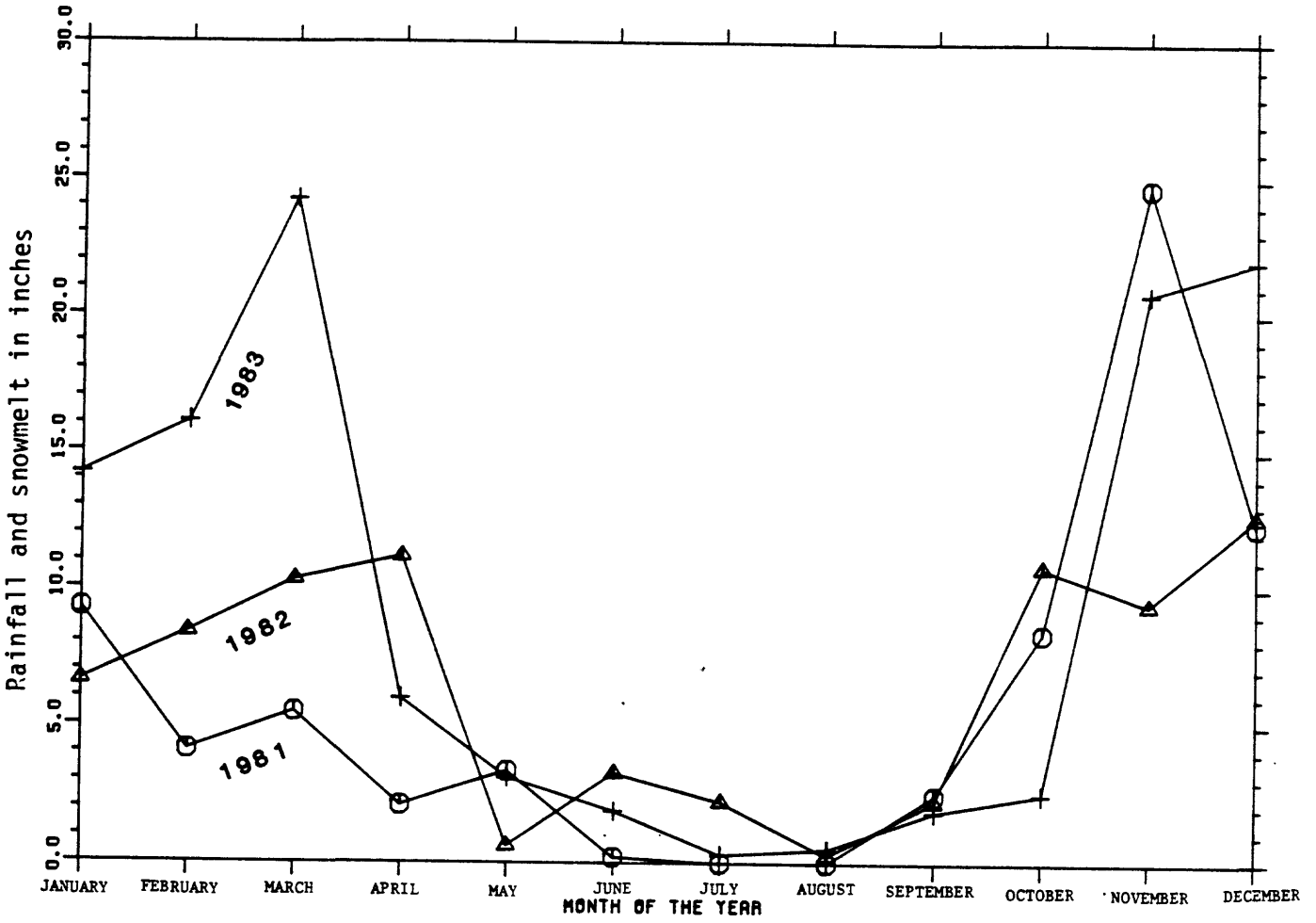

Figure 2.--Plot of total monthly rainfall and snowmelt at the Lassen Park headquarters in Mineral, CA for 1981, 1982 and 1983.

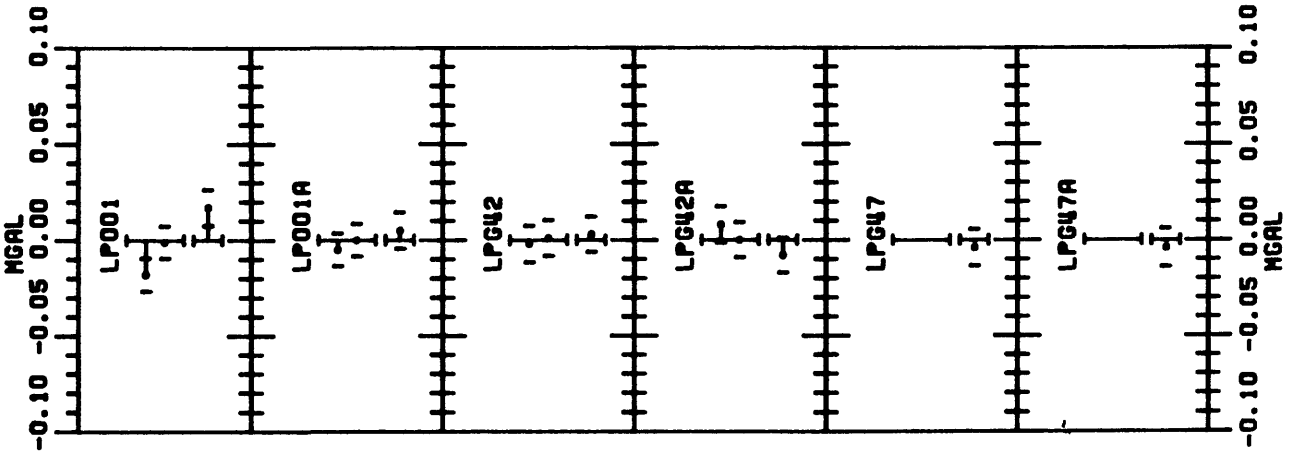

Figure 3.--Plots of relative gravity changes measured at remote stations of the Lassen precision gravity network.

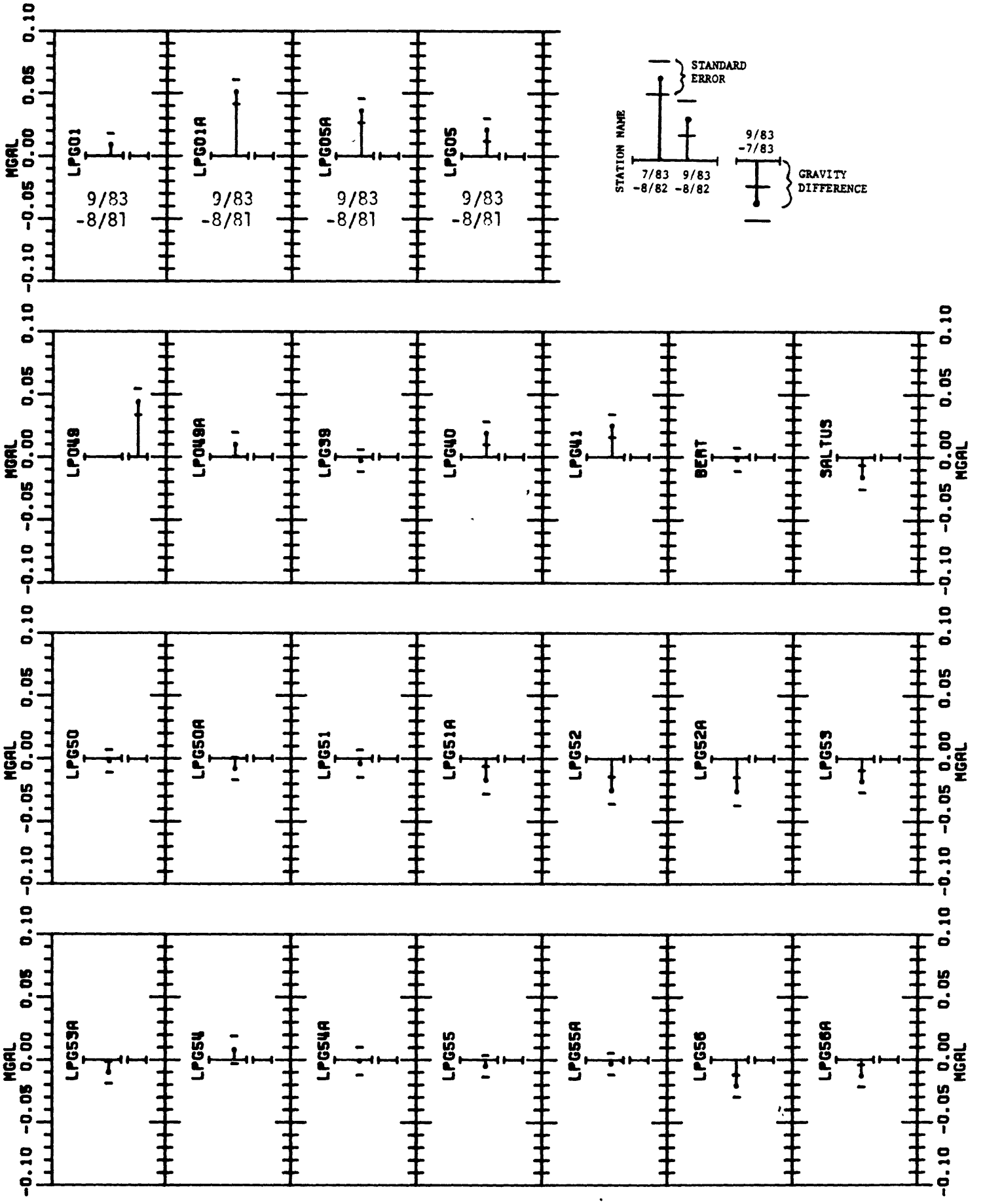

Figure 4.--Plots of relative gravity changes measured at higher elevation stations of the Lassen precision gravity network.

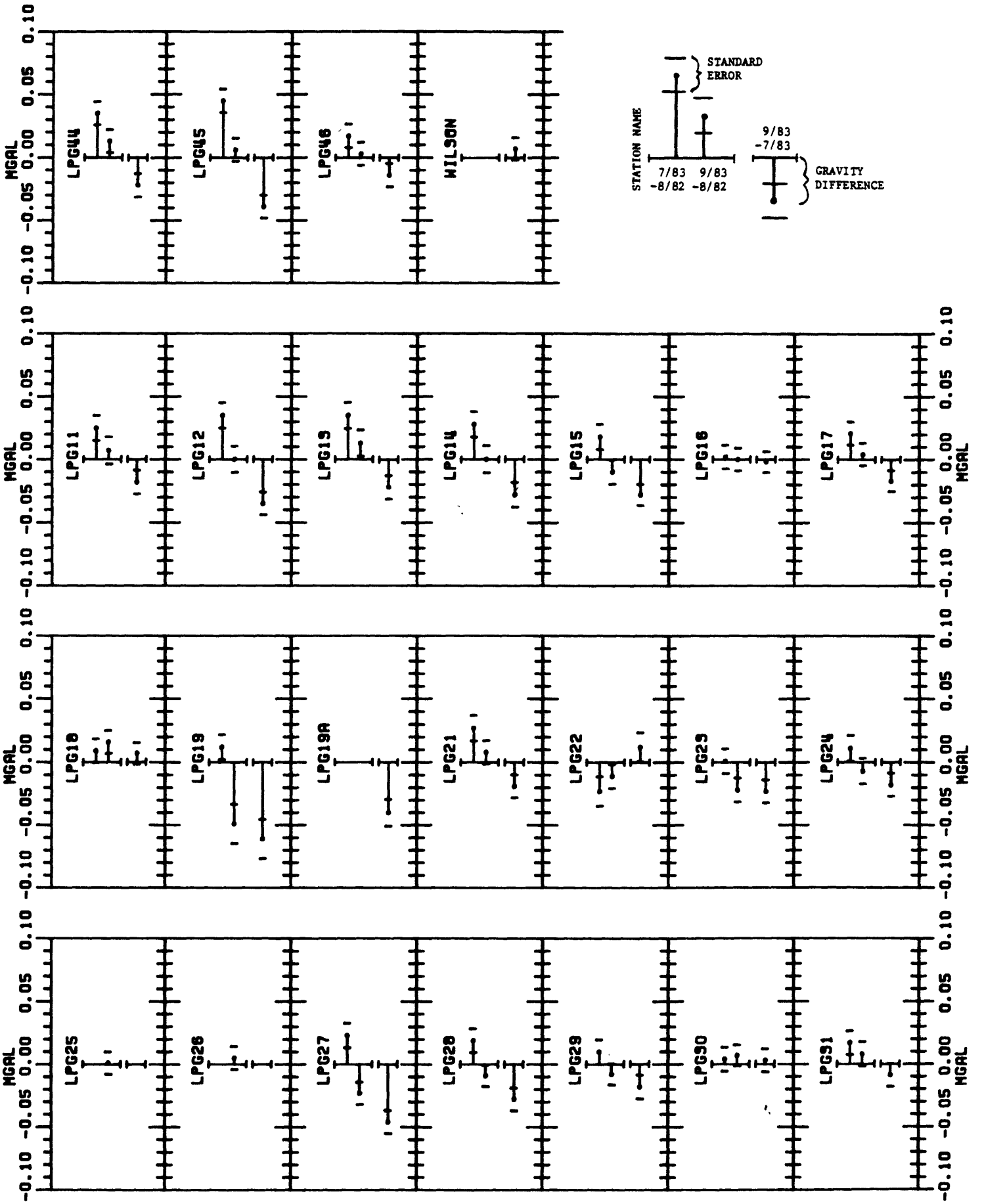

Figure 5.--Plots of relative gravity changes measured at lower elevation stations of the Lassen precision gravity network.

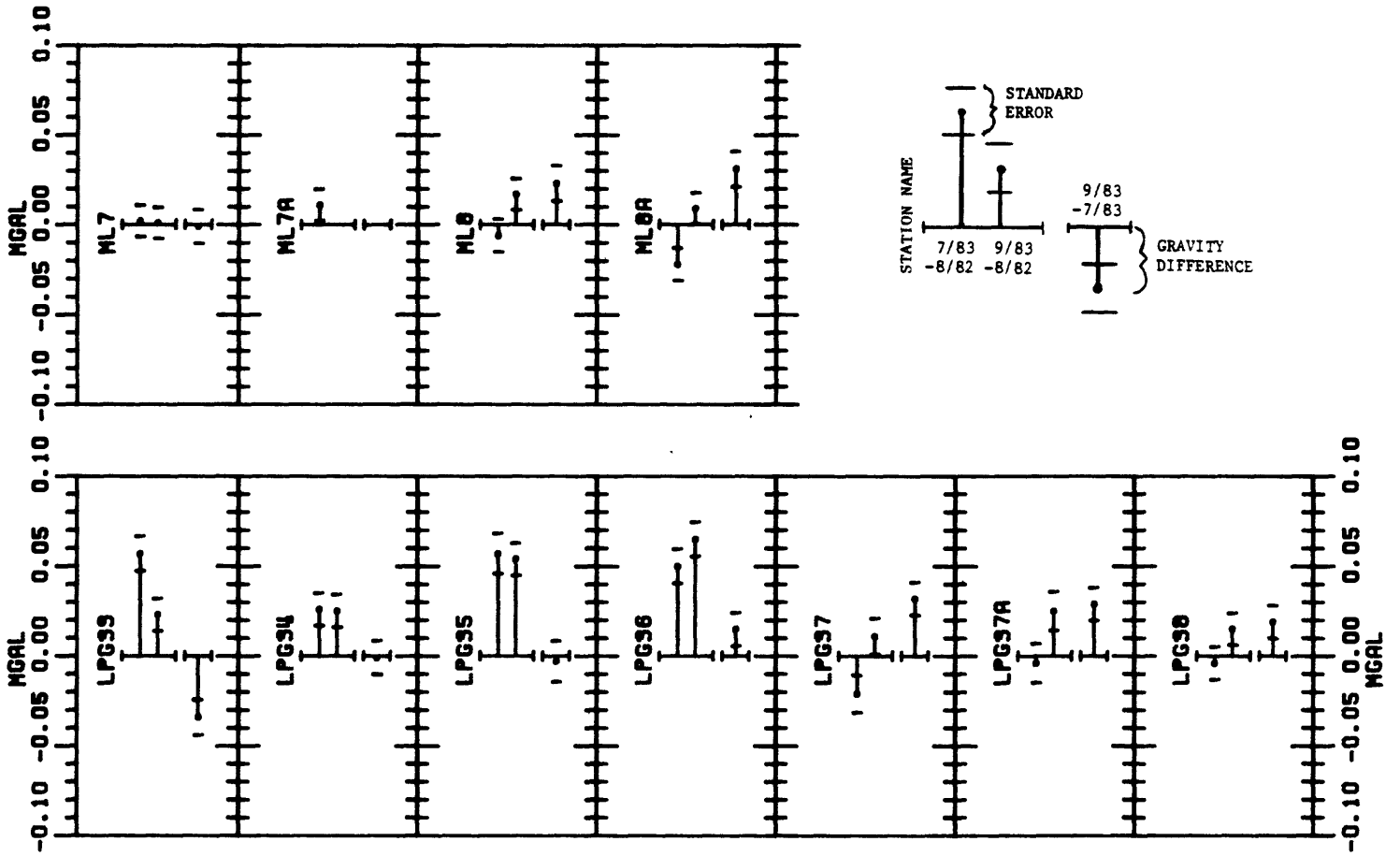

Figure 6.--Plots of relative gravity changes measured at stations of the Lassen precision gravity network along the park road south of Diamond Peak.

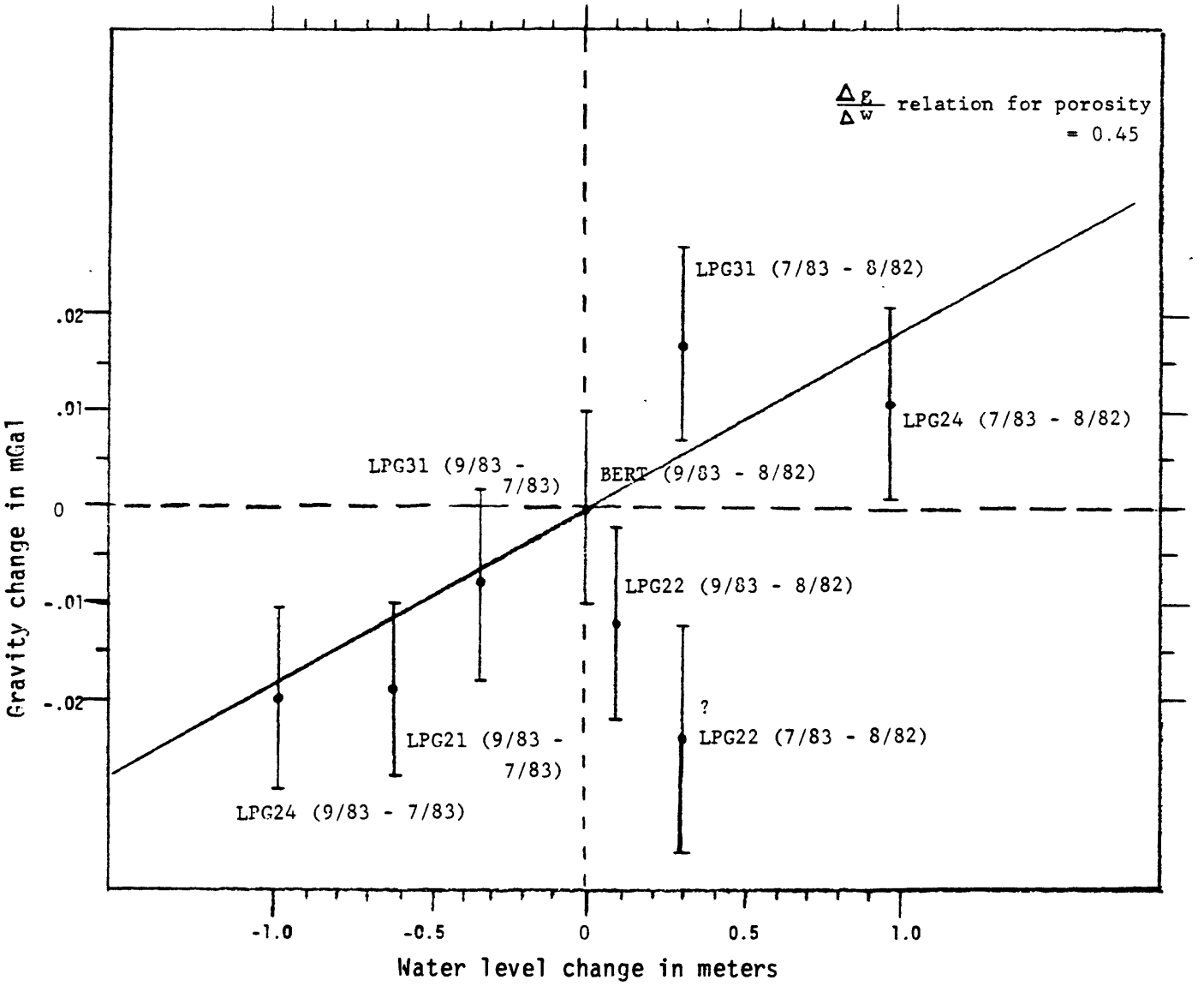

Figure 7.--Plot of change in gravity versus observed change in local stream or lake water levels for a few stations of the Lassen precision gravity network.