

## TECHNICAL NOTE

### PALMDALE BULGE AND ITS SIGNIFICANCE

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As an aftermath to the 1971 San Fernando earthquake in southern California two existing levelling routes were relevelled in order to assess the amount of earth shift that triggered this earthquake. Comparison of the new and old data revealed two important points<sup>(1)</sup>:

- (a) the 1971 earthshift resulted in a maximum uplift of 2 m on the upthrown (Transverse Ranges) side and a maximum subsidence of 110 mm on the downthrown (Los Angeles basin complex) side.
- (b) prior to the 1971 earthshift the area was deforming for at least 10 years, reaching over the period 1968-69 the maximum of about 80 mm uplift in the future epicentral area.

Precursory level changes have been recorded for at least a century, mainly in Japan but also elsewhere<sup>(2)</sup>. The general nature of vertical earth deformation during the secular, pre-earthshift, earthshift and post-earthshift phases<sup>(3)</sup> demonstrates that mountains are uplifted and valleys subside during the earthshift phase, while they subside and elevate respectively during the secular long term phase. During the precursory (pre-earthshift) phase the changes in levels reverse from the secular to the earthshift trend. A continued reversal from the secular trend may thus herald a future earthquake. The San Fernando data substantiate these findings.

Stimulated by the San Fernando results, data from other levelling routes were analysed and it became obvious that an area of at least 12,000 km<sup>2</sup> roughly centered on Palmdale had undergone vertical deformation at least since 1959 and in part of the area at least since 1939 and *continued* to deform after the San Fernando earthquake.

Many factors ranging from bench mark stability, seasonal variations, man-induced deformation such as withdrawal of groundwater must, however, be considered in the analysis. The largest "noise factor" is no doubt the effect of actual earthshifts that have taken place in the intervals between levelling observations. For the larger earthquakes such as the 1971 San Fernando and the 1973 Point Mugu earthshifts, the amount of the individual earthshifts can be approximated and taken into account, provided that the time interval between levellings straddling the earthshift is short. Smaller earthquakes which do not individually produce noticeable earth deformation should also be considered as their cumulative effects may also affect the analysis. However, this area has been virtually free of earthquakes of magnitude 4 and over during the last few decades.

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The absence of noticeable earthquakes may be regarded as a "seismic gap"<sup>(4)</sup> where strain accumulation is accommodated by slow crustal deformation, rather than by sudden strain release in the form of earthshifts and their associated earthquakes. In such a case, continued strain accumulation can be expected to reach the yield strength of the crust and failure will occur. The ultimate strain at which failure will result was calculated by Tsuboi<sup>(5)</sup> as early as 1933 to be 10<sup>-4</sup>. A considerable number of data have subsequently accumulated and Rikitaki<sup>(6)</sup> tabulated 26 cases with ultimate strains ranging from 0.5 to 17 x 10<sup>-5</sup>, the latter value was derived from Reid's<sup>(7)</sup> study of the 1906 San Francisco earthquake.

The amount of potential energy of accumulated strain (that transforms during an earthshift into the kinetic energy of the moving mass, and seismic vibrations and heat) depends very much on the area and volume in which it is stored.

Since the Palmdale Bulge was discovered in 1975, 36 teams sponsored by national, state and local bodies departments are monitoring an area exceeding 80,000 km<sup>2</sup>. Detailed analyses demonstrate a south east migration of uplift and the Palmdale Bulge, which became elevated by at least 350 mm by 1972, subsided between 1974 and 1976 to about 250 mm about its 1955 level.

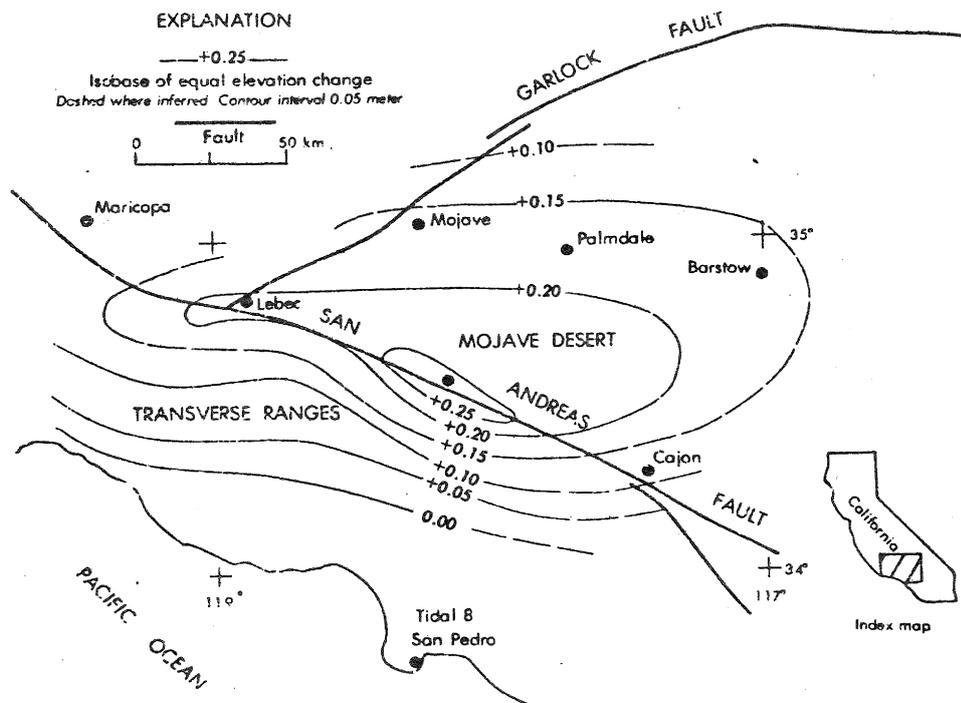
Scientists have now to decide whether these rather large fluctuations in height are either indeed phenomena precursory to a major earthquake, or are merely rather large undulations in the earth's crust which form part of a cyclic pattern of secular vertical deformation typical of that part of California.

Time will tell.

#### REFERENCES

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**FIGURE 1: MINIMUM ESTIMATES OF UPLIFT IN SOUTHERN CALIFORNIA INITIALLY DETERMINED FOR THE INTERVAL 1959-74**