

Comparison of GPS Surveys
with Historical
Triangulation Surveys
in the Southern California
Borderland.

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Global plate models (Minster and Jordan, 1978) predict about 56 mm/yr of motion between the North American and Pacific plates along the plate boundary in southern California, while geodetic and Holocene geological data suggest only 34 mm/yr on the San Andreas fault (Lyzenga and Golombek, 1986). Deformation in the Great Basin does not explain this discrepancy, and it has been suggested that faulting in the offshore of southern California could account for some of the discrepancy. Evidence of deformation in the offshore region of southern California is most abundant in the Santa Barbara Channel (Fig. 1). Geological investigations of folding and faulting in this region (e.g. Yeats, 1983), as well as earthquake investigations (e.g. Yerkes *et al.*, 1980), indicate north-south shortening across the channel on the order of 10-20 mm/yr. The most rapid rates occur to the east of the channel in the Ventura Basin. South of the Santa Barbara Channel, though, evidence for deformation is limited to seismicity studies (e.g. Legg, 1980) which are sparse. Seismic events are abundant in this area (Fig. 2), but their implication for the amount of deformation in the offshore is unclear.

GPS measurements made between June 1986 and May 1988 have been used to obtain vector positions for several stations at which historical first order triangulation observations were performed between the late 1800's and the mid 1900's between the coast of southern California and the nearby offshore islands (Fig. 3). By comparing the spheroidal angles obtained from the GPS positions with the the previously observed triangulation data, shear strain rates can be calculated for the region using Frank's method (Prescott, 1976). In a coordinate system with the 1 axis oriented east-west and the 2 axis oriented north-south, Frank's method solves for $\gamma_1 = e_{11} - e_{22}$ and $\gamma_2 = 2e_{12}$. In this system, north-south shortening would result in $e_{11} = 0$, $e_{12} = 0$, and $e_{22} < 0$, with $\gamma_1 = -e_{22} > 0$ and $\gamma_2 = 2e_{12} = 0$. Similarly, north-south shortening with a component of left-lateral shear on east-west trending faults would result in $\gamma_1 = -e_{22} > 0$ and $\gamma_2 = 2e_{12} < 0$.

The locations of the five strain networks used in this study are shown in Figure 4. Also, shown in Figure 4 are the calculated shear strain rates and the directions of maximum horizontal shear. The fit of these model shear strain rates to the angular changes for the Santa Barbara Channel region is shown in Figure 5. The quality of the fits for the other regions is similar. Each of the regions shows shear strain consistent with north to north-west shortening, except for the region from Catalina Island to San Nicholas Island. In this region, the direction of maximum shear strain is not well constrained because of the low rate of shear strain. Shear strain in the Santa Barbara Channel region is consistent with predominantly north-south shortening accompanied by left-lateral shear on east-west trending faults.

These results seem to suggest that shear strain deformation is occurring in the offshore of southern California as a result of north to north-west shortening. That deformation is most active in the Santa Barbara Channel region and least active between Catalina and San Nicholas islands. Just how much of the "missing" plate motion can be accounted for by this deformation is not known at this time and will have to await further analysis.

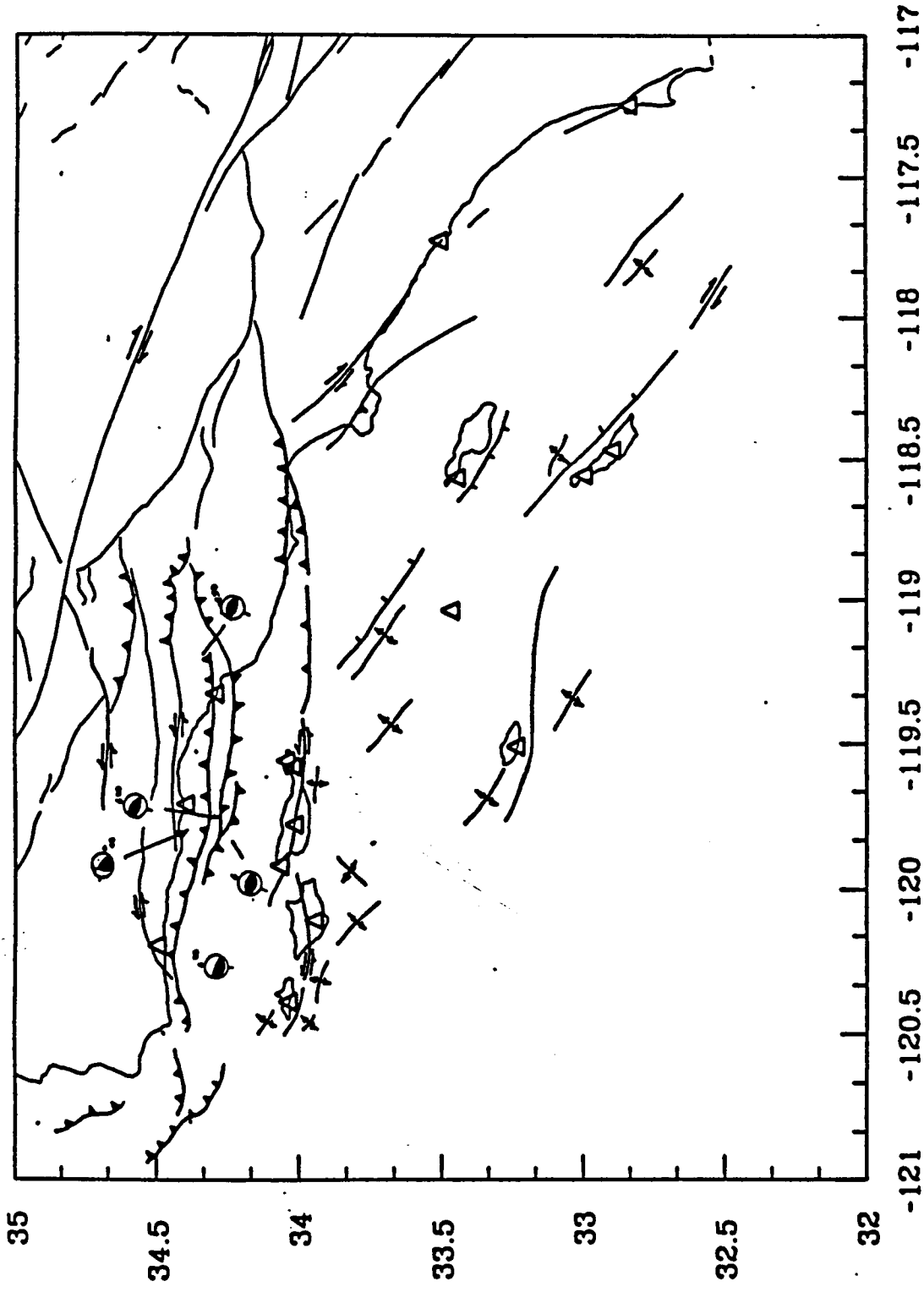


Fig. 1. Location of faults and folds. Thrust faults shown with bars on upper plate. On other faults, sense of offset indicated by arrows and by tick marks on downthrown side. Focal mechanisms are lower-hemisphere projections with compressional quadrants dark and indicated direction and plunge of inferred slip vector (Yerkes *et al.*, 1981).

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Channel Islands Seismicity

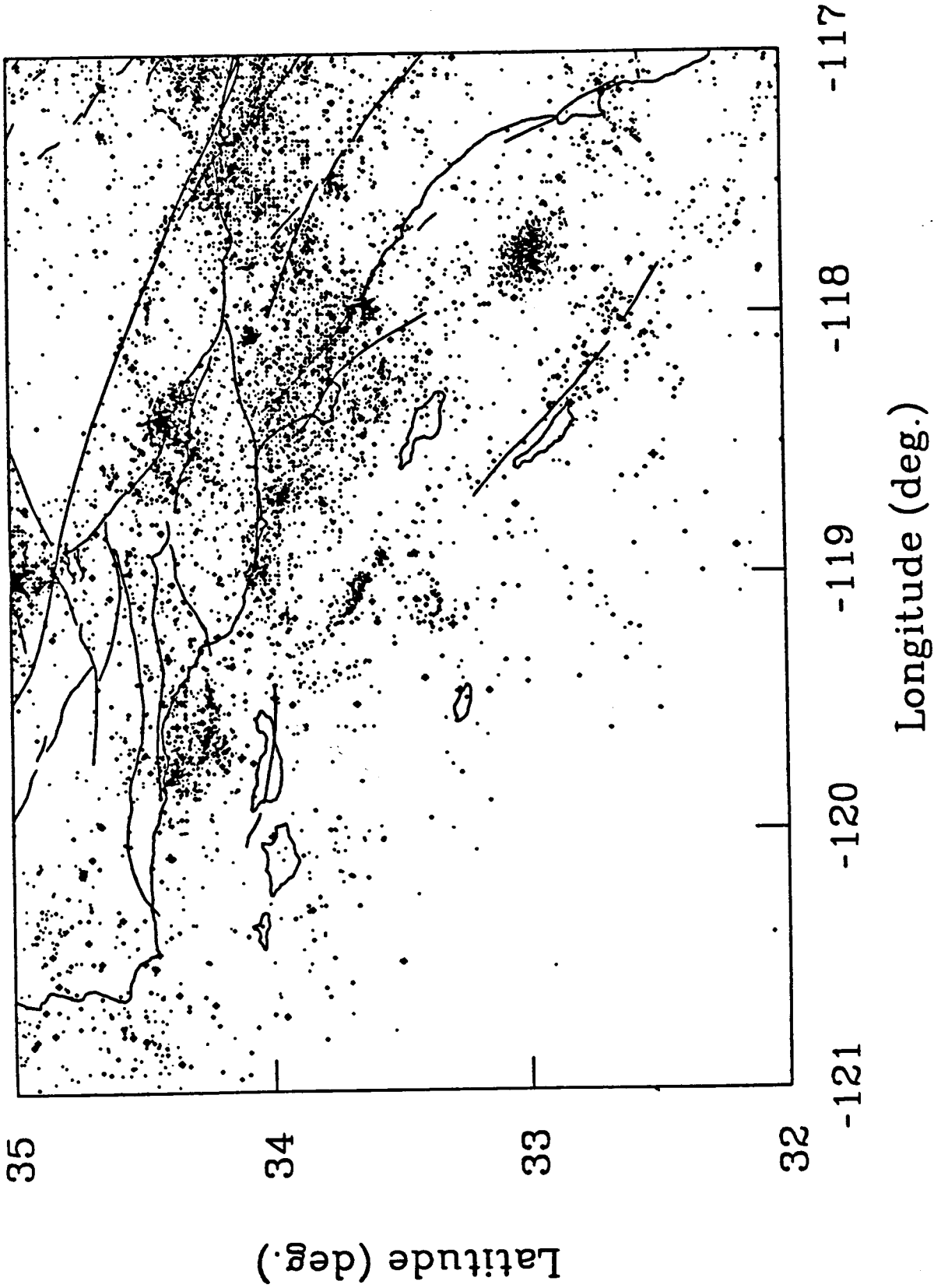


Fig. 2. Regional seismicity 1932-1988 from Caltech catalog.

Channel Islands Network

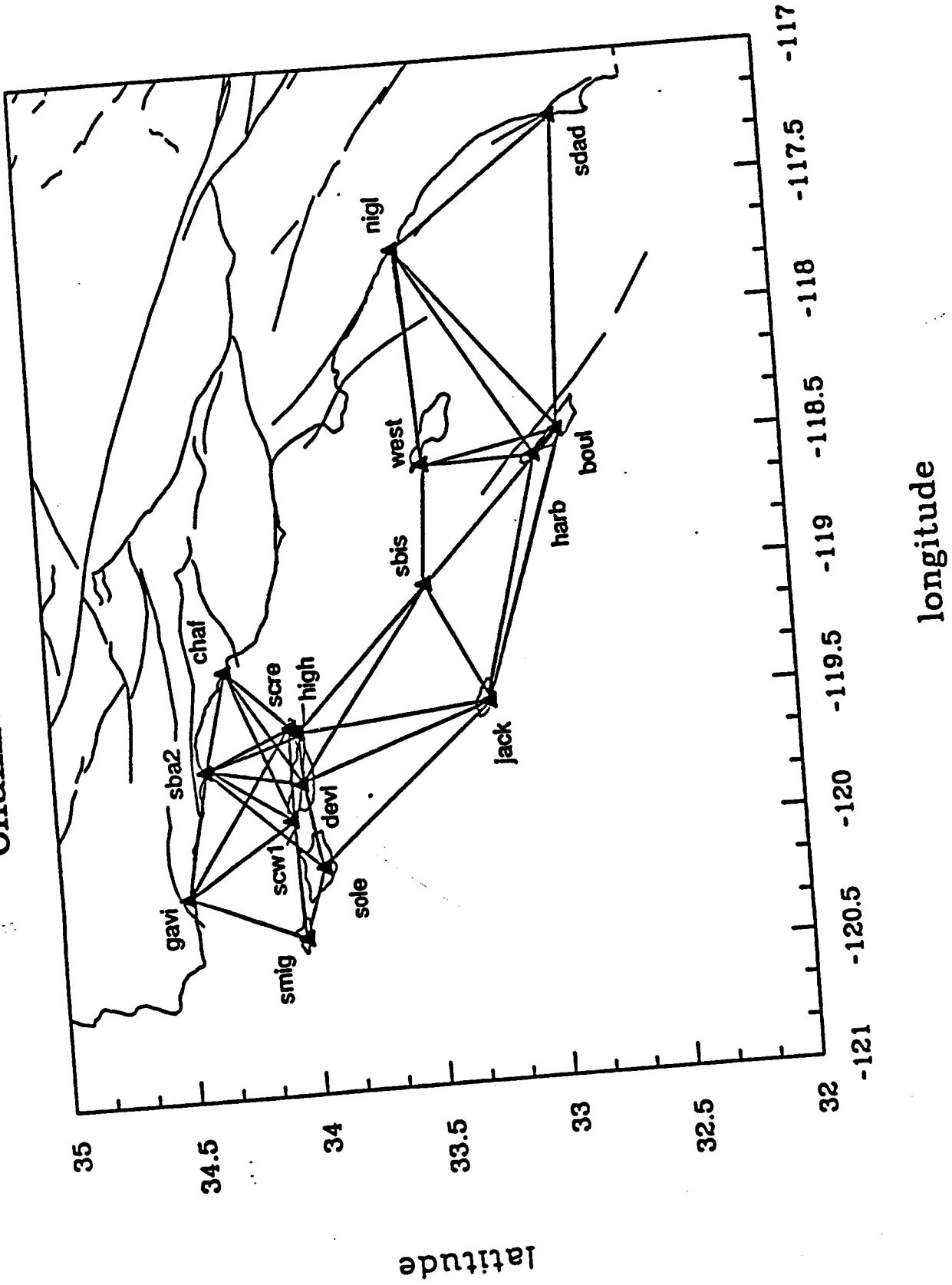
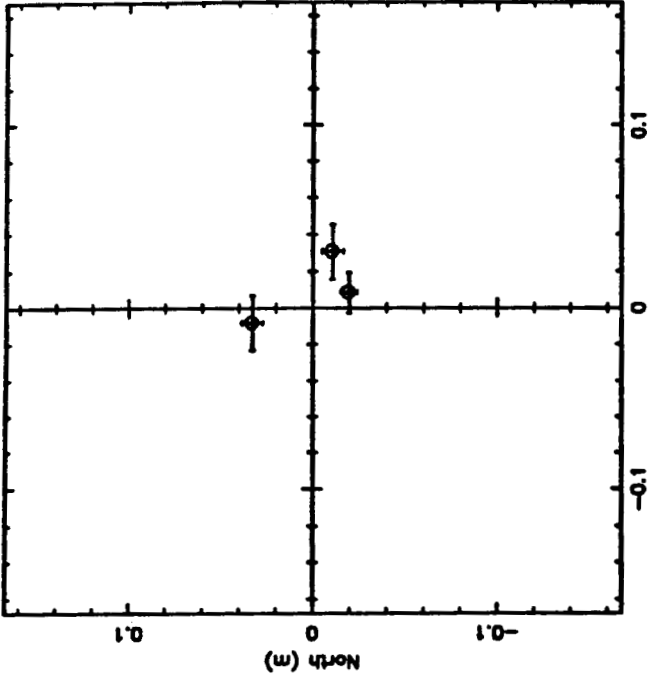


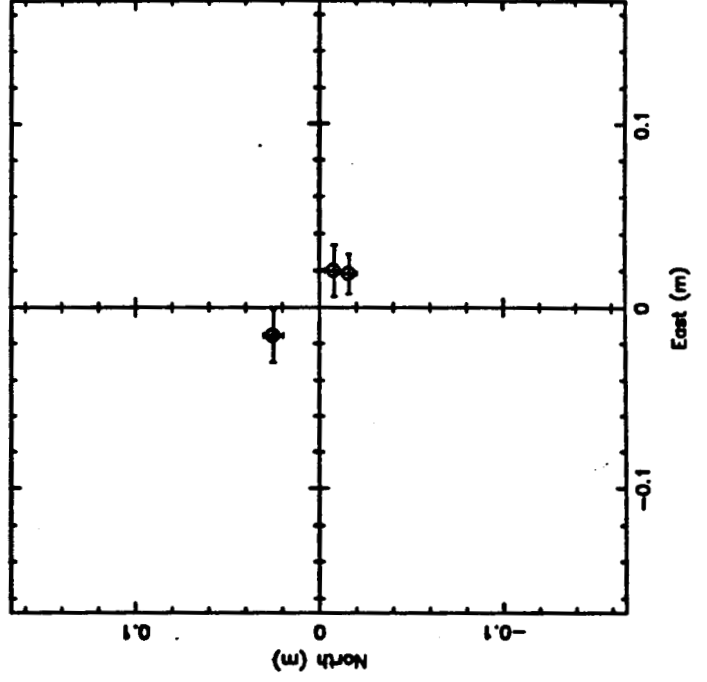
Fig. 3a. Location of triangulation and GPS stations used.

Fig. 3b. North-east scatter plots for GPS data. Best fit baseline length using 57 stations and 241 station-days of data is shown at the top of each plot. Each point represents a one-day solution using the NGS software. Upper left plot shows north-east scatter for all 57 stations relative to station VNDN. The other panels show typical scatter for some stations used in this study. Points are shown with 2σ formal error bars.

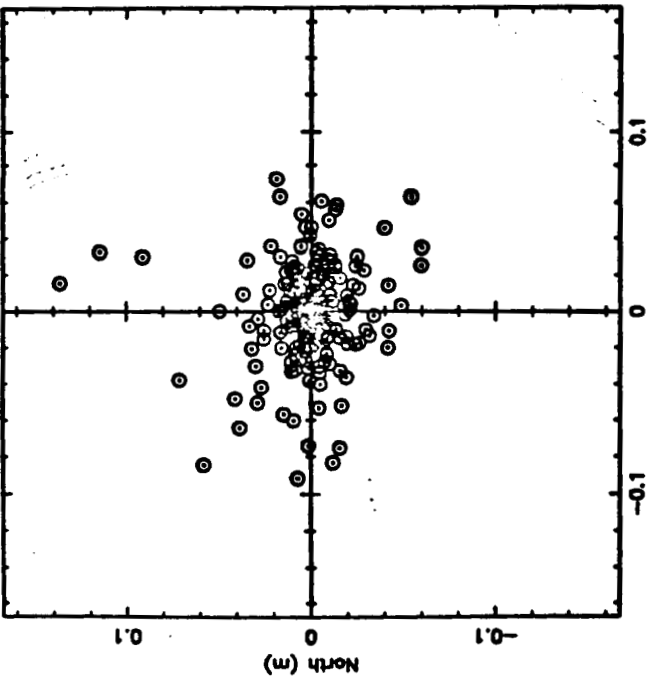
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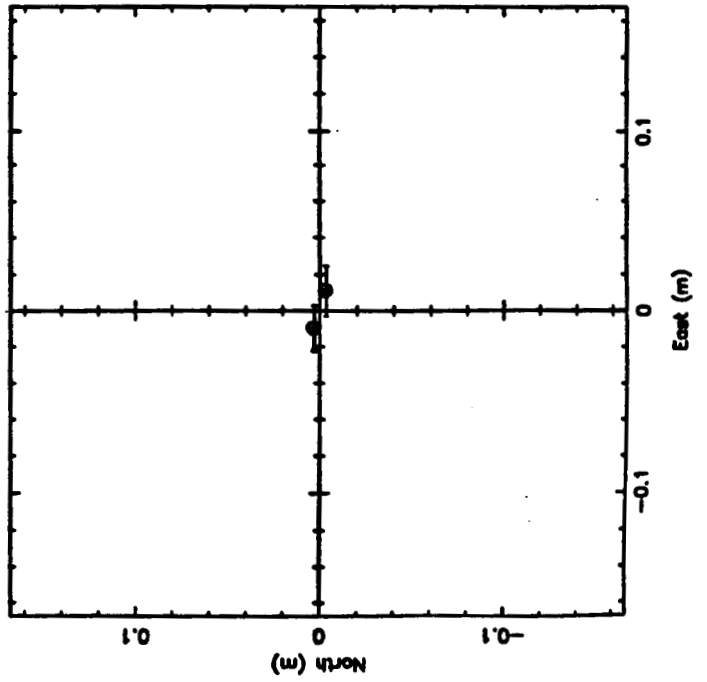
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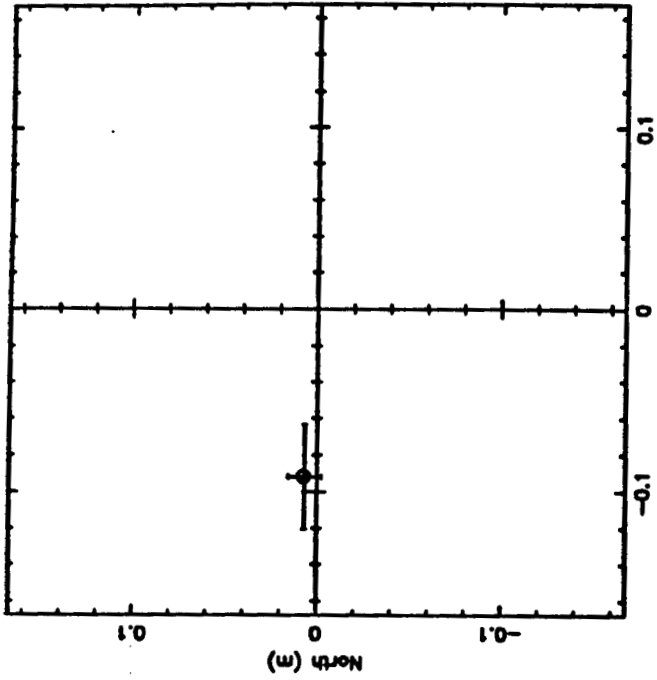
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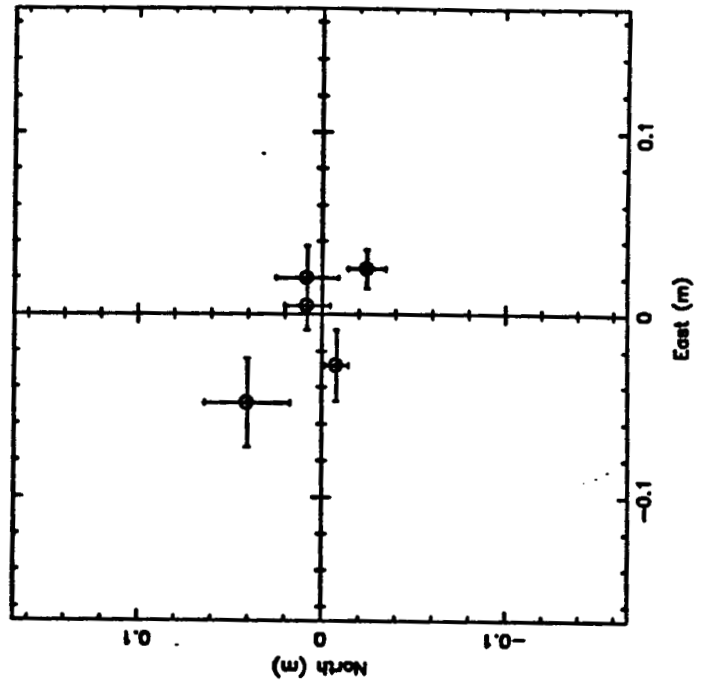
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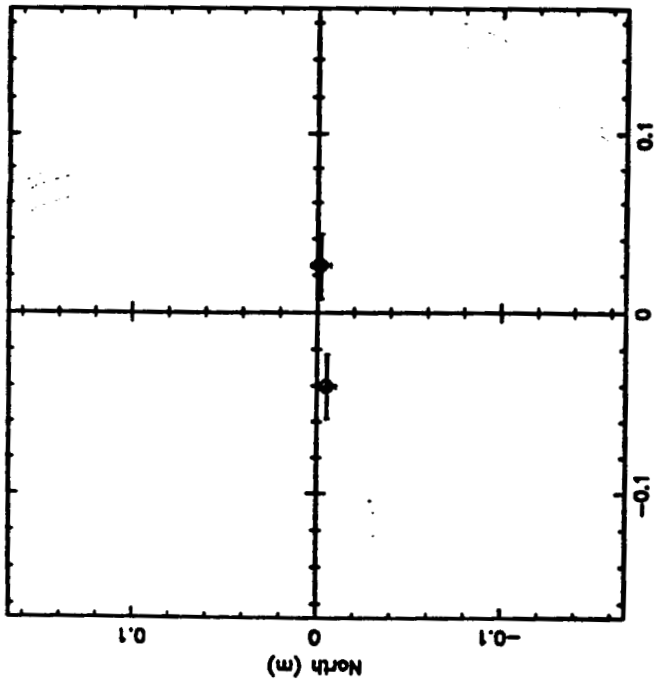


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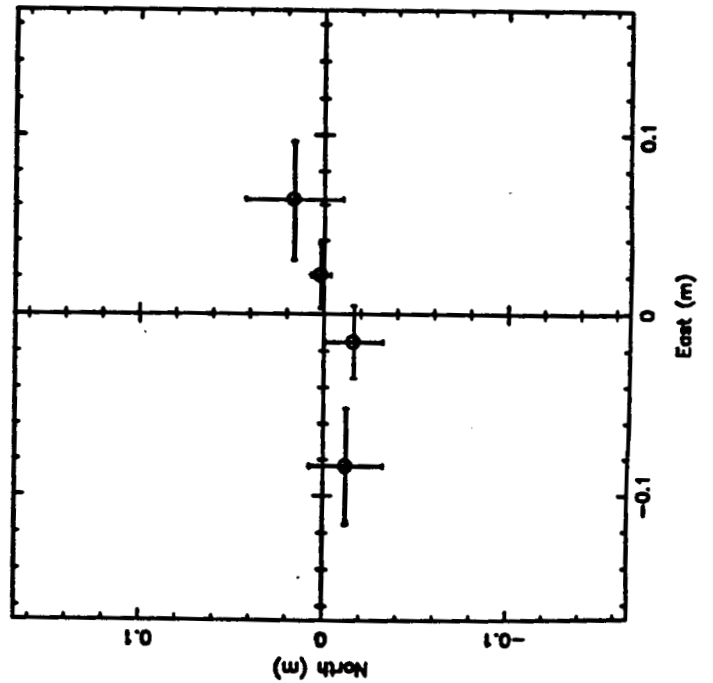


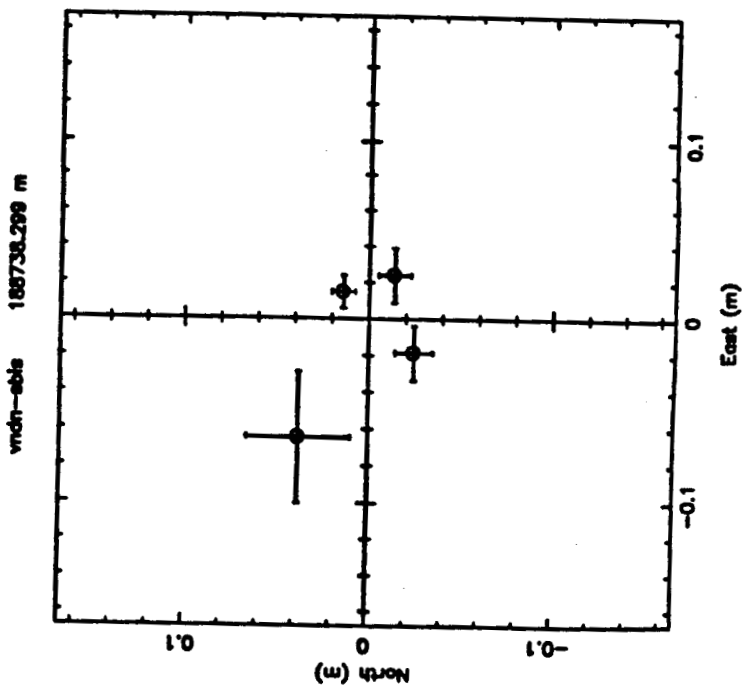
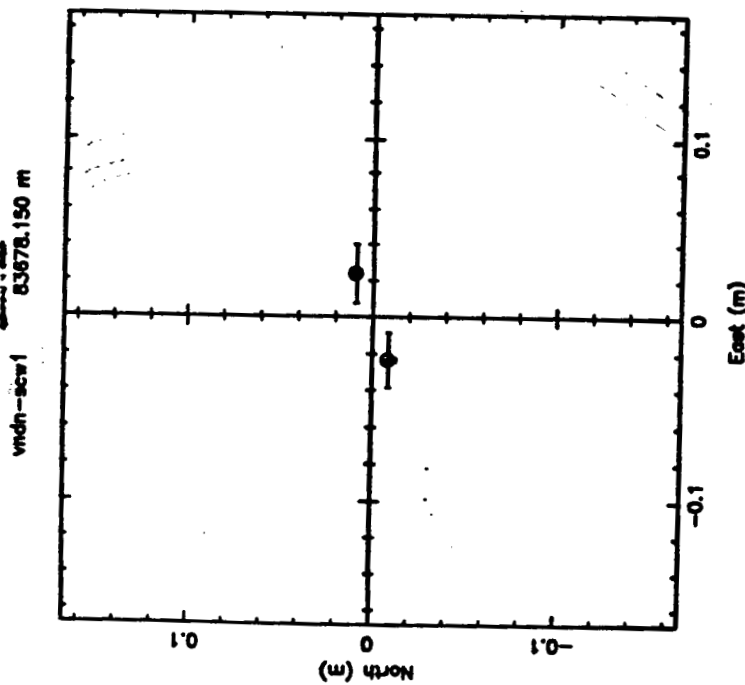
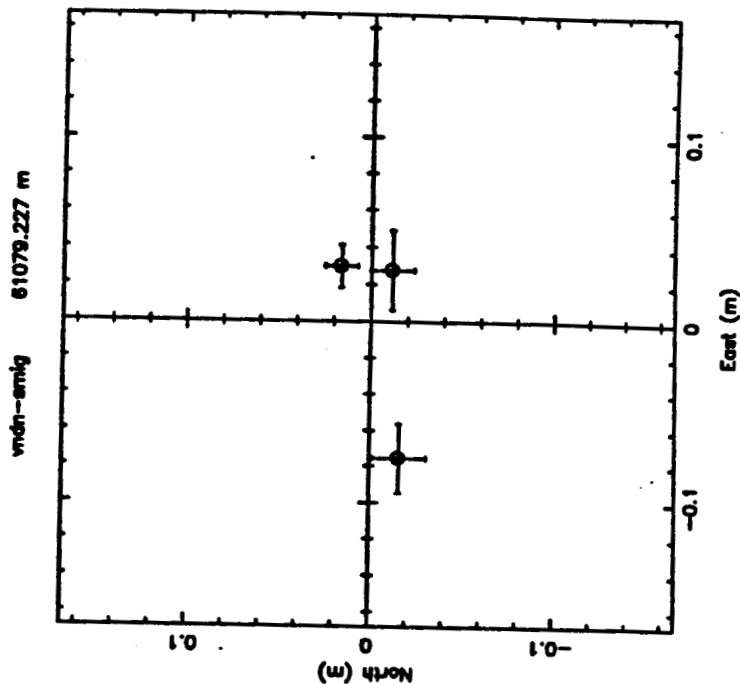
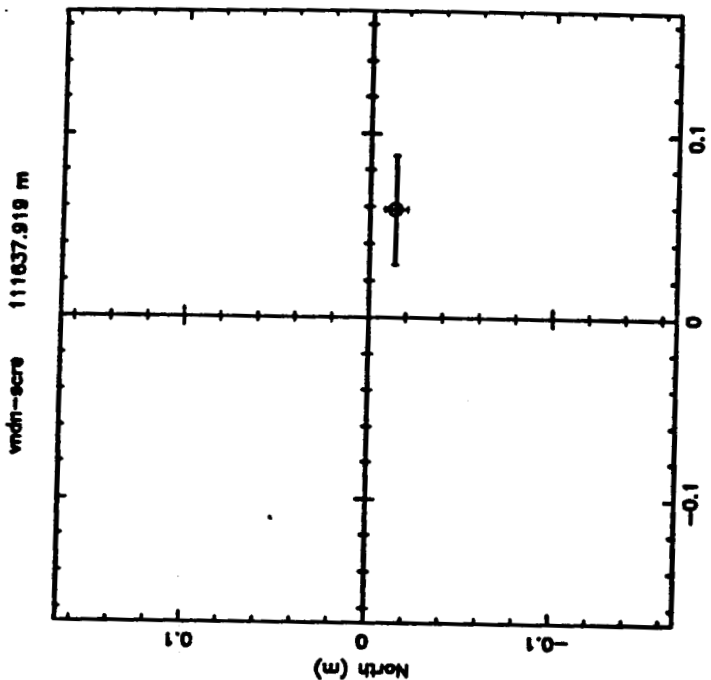
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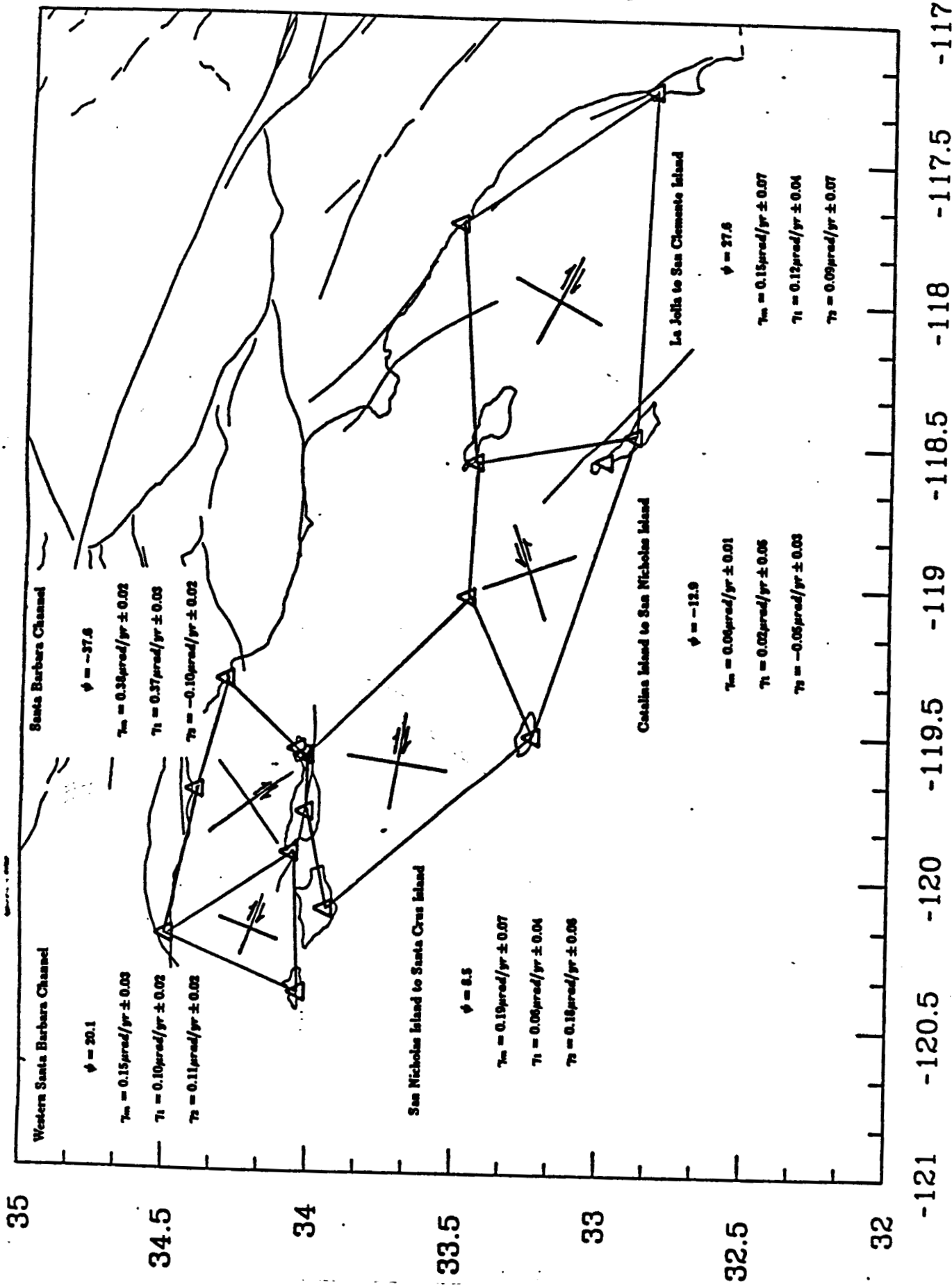
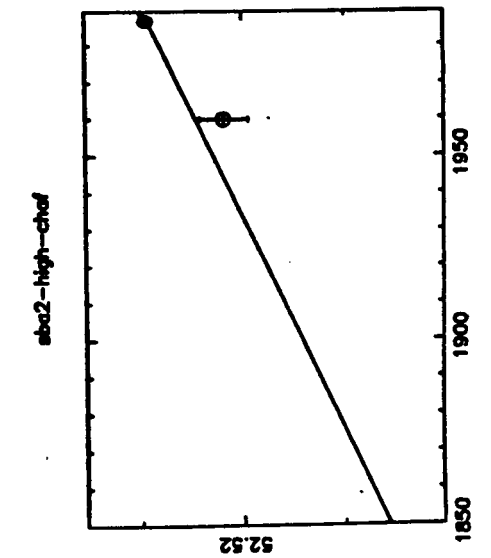
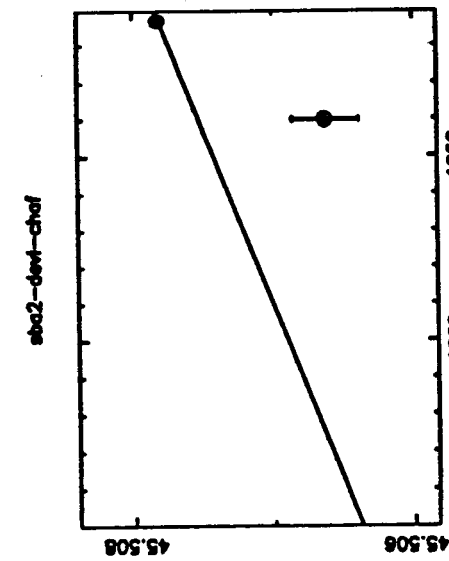
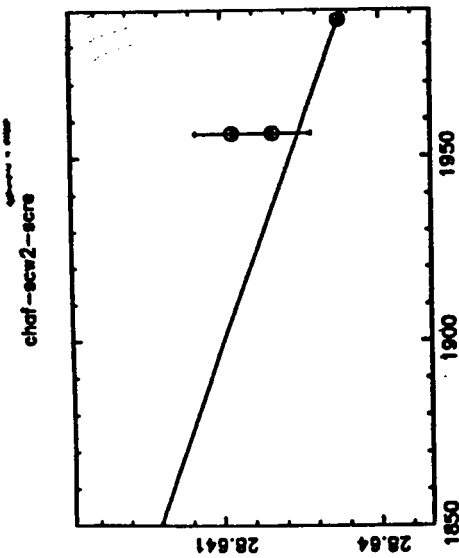
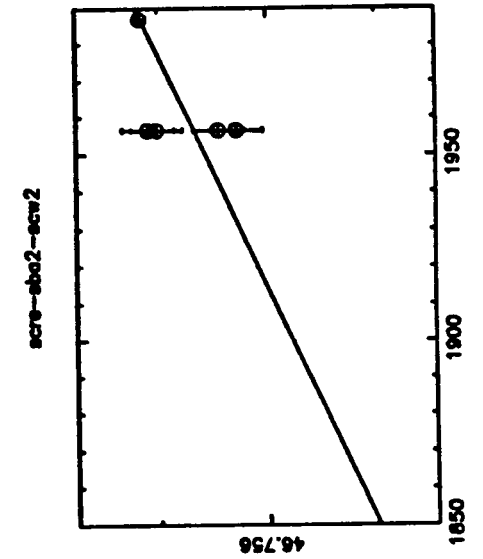
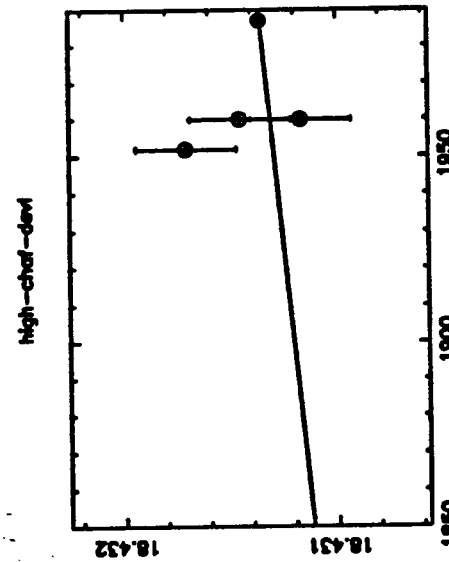
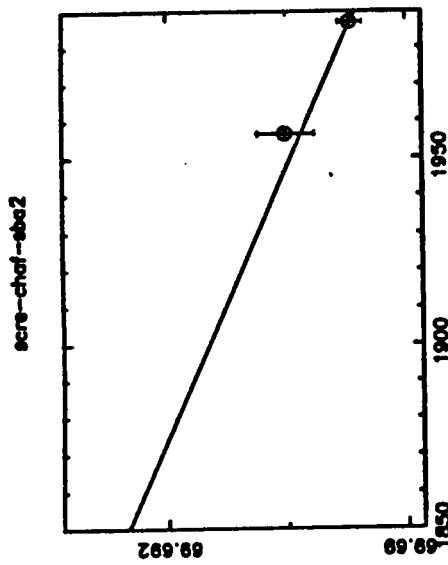
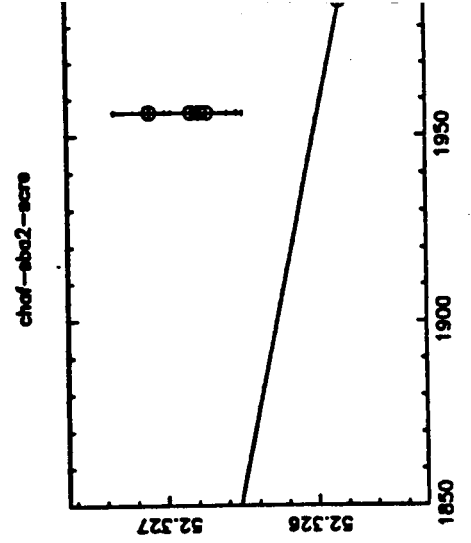
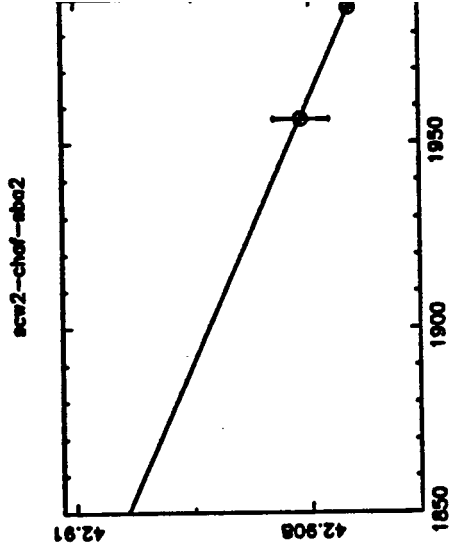
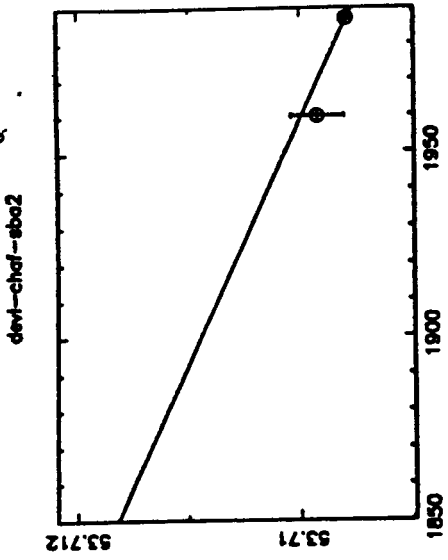
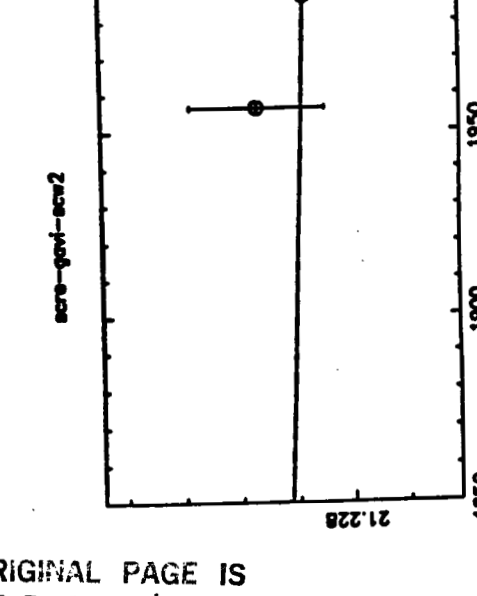
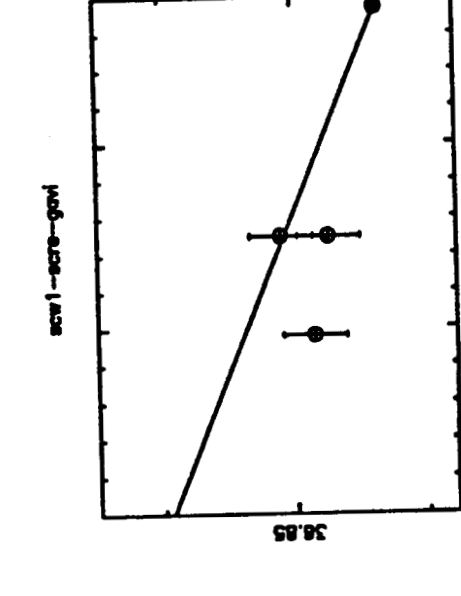
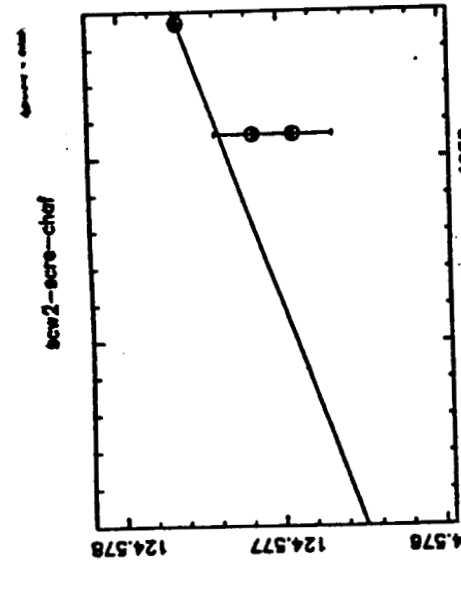
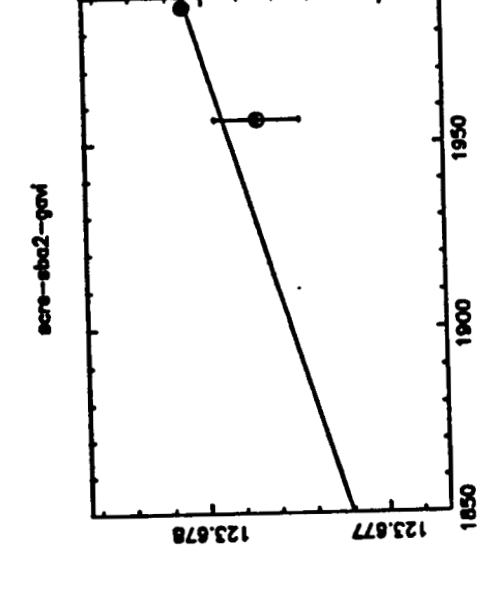
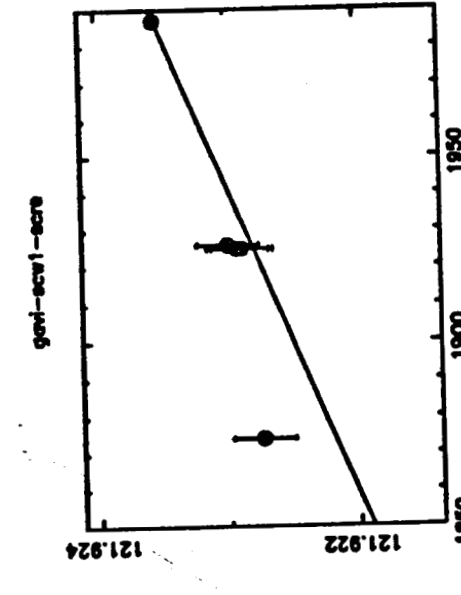
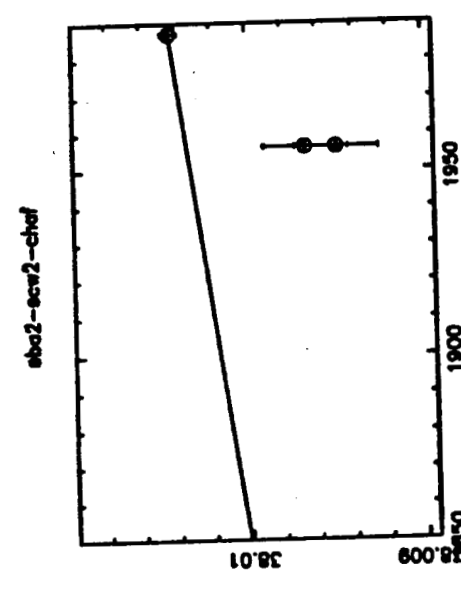
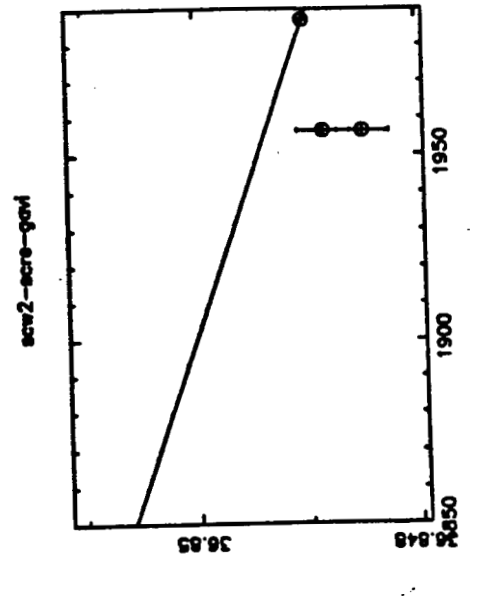
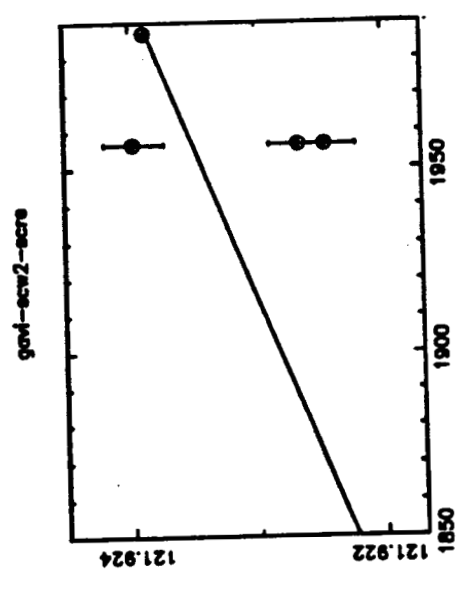
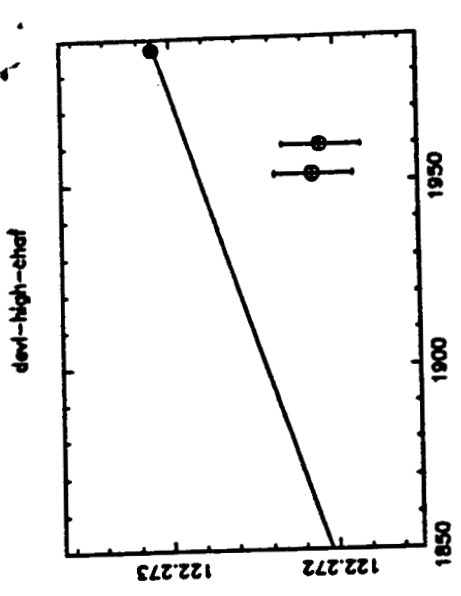


Fig. 4. Location of principal shear strain networks and associated shear strain solutions.

Fig. 5. Angles between stations and the year observed for the Santa Barbara Channel region. Observations after 1986 are angles calculated from GPS observations. Solid line is least squares fit of data in this region to homogeneous shear strain using Frank's method (Frank, 1966).



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