MAGNETIC FIELD MONITORING OF TECTONIC STRESS IN SOUTHERN CALIFORNIA

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INTRODUCTION

This project was initiated in 1973, with the establishment of 10 observation sites along the San Jacinto fault zone, from the vicinity of Pearblossom to the Anza Valley. During the summer of 1978, a two-dimensional array of sites was completed covering a large portion of Southern California. During the past years, 4 sites have been relocated to improve reliability of data or to make field surveys more efficient; and at the present time, 43 sites are being measured 3 or more times per year(Fig.1). This annual technical report follows an annual technical report submitted on October 23, 1979 for the previous year.

The earlier history of the project has been reviewed in previous reports. This report presents results based upon our second complete year of observation of the enlarged array of sites.

TECHNIQUES

Simultaneous readings of the earth's total magnetic field strength are taken at two adjacent sites separated by 10 to 15 Km. The means of values at each site are differenced, and these differences, as they change significantly with time, are an indication of tectonic stress change beneath the sites. Proton precession magnetometers, with one-quarter gamma digital readout, are used for the measurements. Problems related to site location have been discussed previously.

ACCOMPLISHMENTS OF THE YEAR

Three surveys were conducted across the array during December 1979, April 1980 and June 1980. All raw data from the surveys were analyzed and interpreted. During the past winter and spring the personnel most active in conducting this research became involved in the effort of the U.S. Geological Survey to take continuously recorded differential magnetic data at sites in Southern California. Working cooperatively with Dr. Malcolm Johnston, Mr. Robert Mueller, and Mr. Vince Keller of the U.S. Geological Survey, the Principal Investigator and two lead students investiagors, Mr. Mark Horne and Mr. Gregory Cash, took over the deployment of the continuously recording equipment and the data collection during June and July, 1980.

A cooperative effort with Dr. David D. Jackson of UCLA resulted in the preparation of a paper currently in preparation entitled, "Secular variation model for geomagnetic variations in Southern California". Raw data

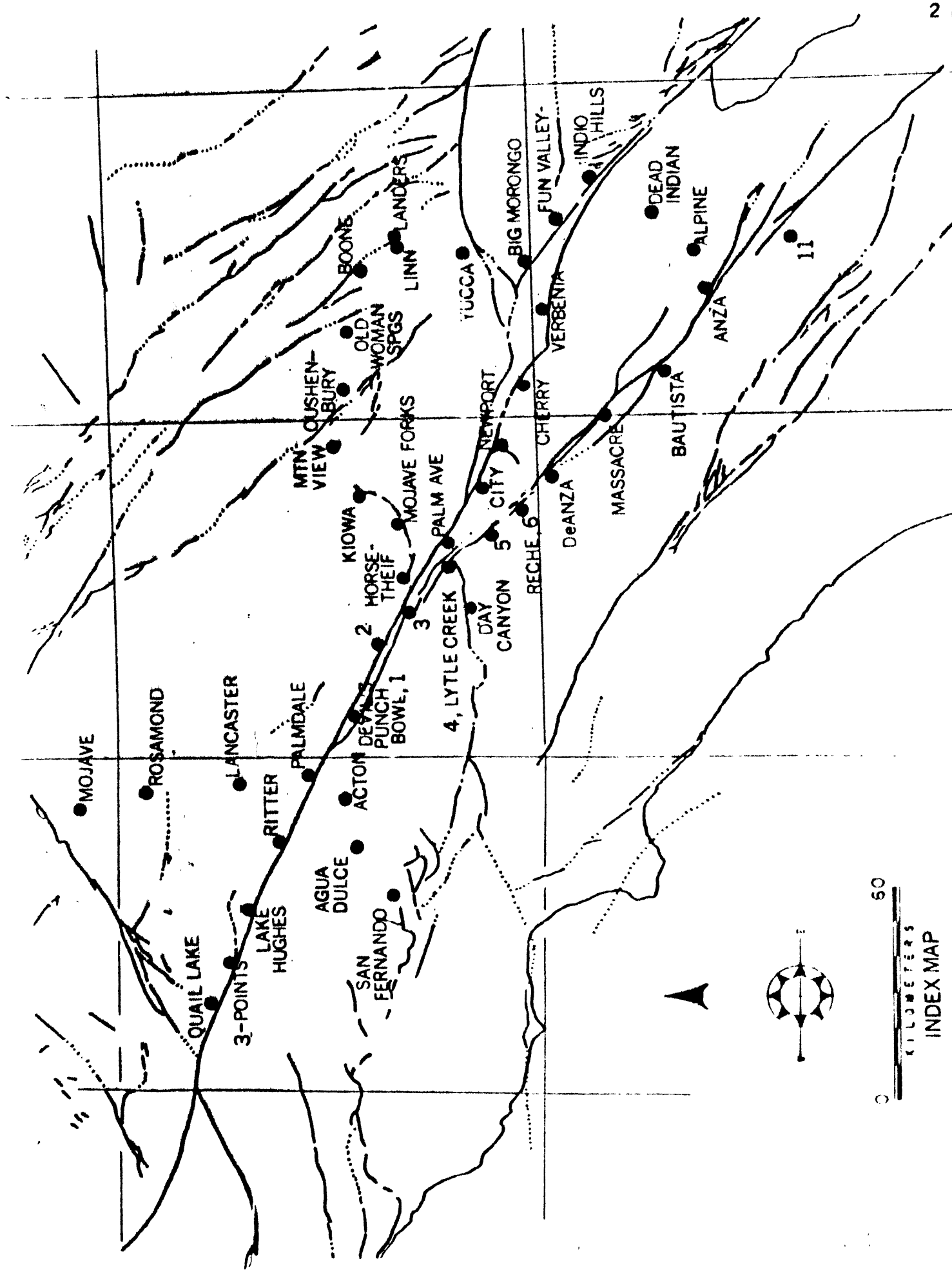
2
MOJAVE
ROSAMOND
LANCASTER
PALMDALE
RITTER
ACTON
DEVIL PUNCH BOWL, 1
AGUA DULCE
LAKE HUGHES
3-POINTS
QUAIL LAKE
SAN FERNANDO
4, LYTLE CREEK
DAY CANYON
2
3
KIOWA
HORSE-THEIF
MOJAVE FORKS
PALM AVE
CITY
5
RECHE
6
DeANZA
MASSACRE
BAUTISTA
ANZA
11
ALPINE
DEAD INDIAN
INDIO HILLS
FUN VALLEY-
BIG MORONGO
TUCCA
VERBENTA
CHERRY
NEWPORT
MTN VIEW
OUSHEN-BURY
OLD WOMAN SPGS
BOONE
LINN
LANDERS
50
KILOMETERS
INDEX MAP

FIGURE 1

from this research project were used in the analysis conducted by the UCLA research team.

Field data taken before, during and following the Landers swarm of earthquakes of March 1979 were forwarded to Dr. Stick Ware of CIRES at Boulder, Colorado in September, 1980. He is interested in refining our interpretation of events by correcting for error due to diurnal variation effects.

ANALYSIS OF DATA

The errors in our data have been assessed in various ways, and these procedures have been reviewed in earlier reports. Our conclusion at this time is that a change of the difference of means between adjacent sites of 2 to 3 quarter gammas is significant. If refinements based upon the time of day that the measurements were taken can be developed, then these changes can be applied to the original data, since all of our times for recording field observations have been controlled by radio time signals.

The results of the December, 1979 survey were reported in my Semi-Annual Report of March 5, 1980, but for completeness the results are briefly reviewed here. Another survey was completed during 10 days in April 1980, and the most recent survey was conducted furing June and July 1980.

Earlier map presentations utilized contoured rates of change of the differences of means of the total magnetic field strength between adjacent sites, with one map drawn for each interval of time between surveys. Because of the inaccuracies associated with the contours, this report presents significant results on the maps simply as shaded areas (Figures 2,3,4).

RESULTS

Because the survey has a 2-dimensional distribution across a large portion of Southern California, it is appropriate to present our results on a map. Previous experience with large amounts of persistent change in the Palmdale area that was not associated with earthquakes has convinced the writer that a certain threshold rate of change of the data is important. For this reason the shaded areas on Figures 2,3, and 4 are considered to be significant anomalies based upon unsually high rates of change. To prepare the maps, a number was determined for each site pair of the array which is the absolute value of change (of the difference of the mean values) in quarter-gammas per 30-day month. These numbers were contoured and the high areas within the 2-value contours were designated as significant change by shading. Doing away with the contours will allow a more conservative and perhaps has misunderstood presentation of the results.

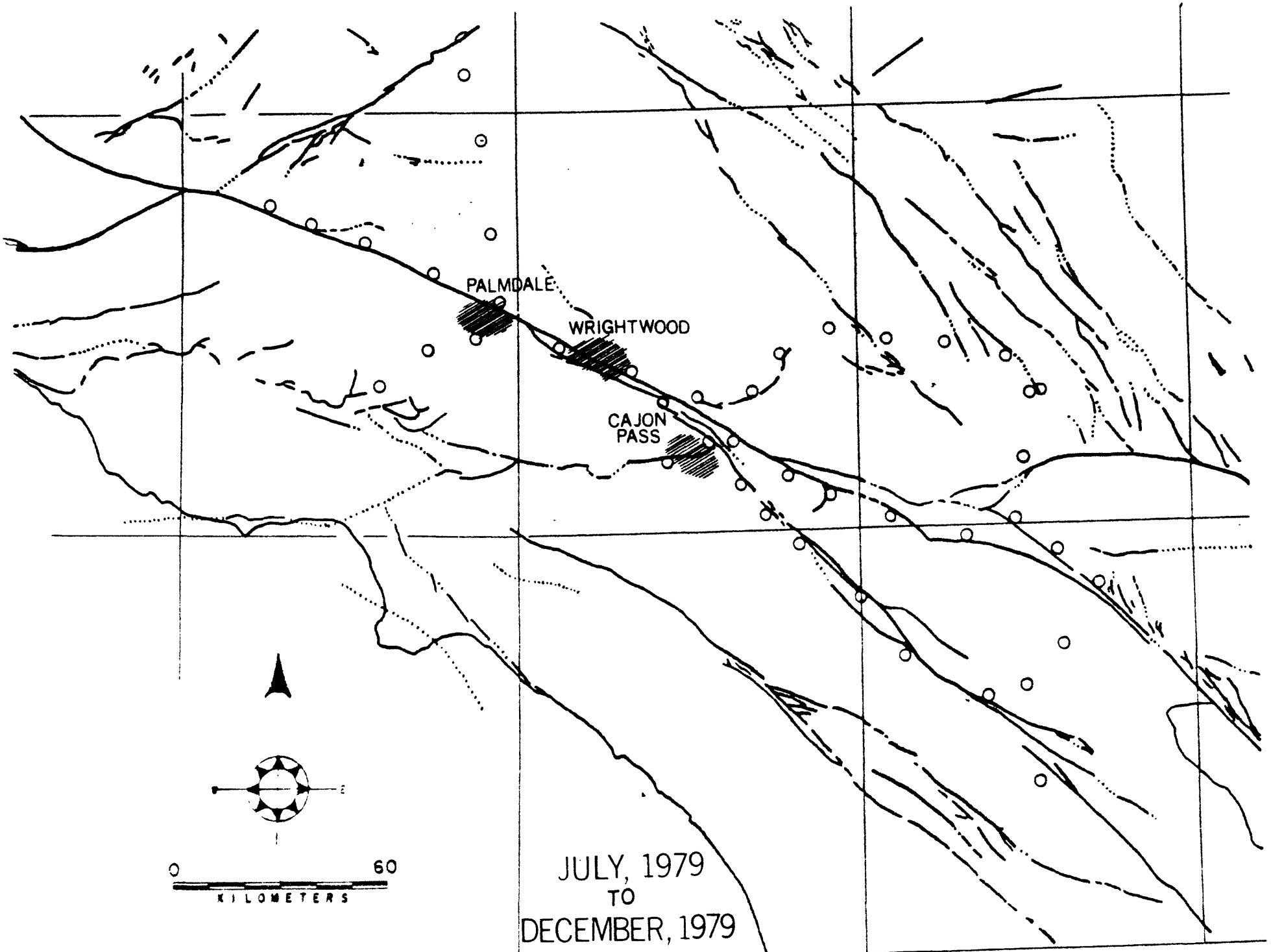
PALMDALE
WRIGHTWOOD
CAJON
PASS
0
60
KILOMETERS
JULY, 1979
TO
DECEMBER, 1979

FIGURE 2

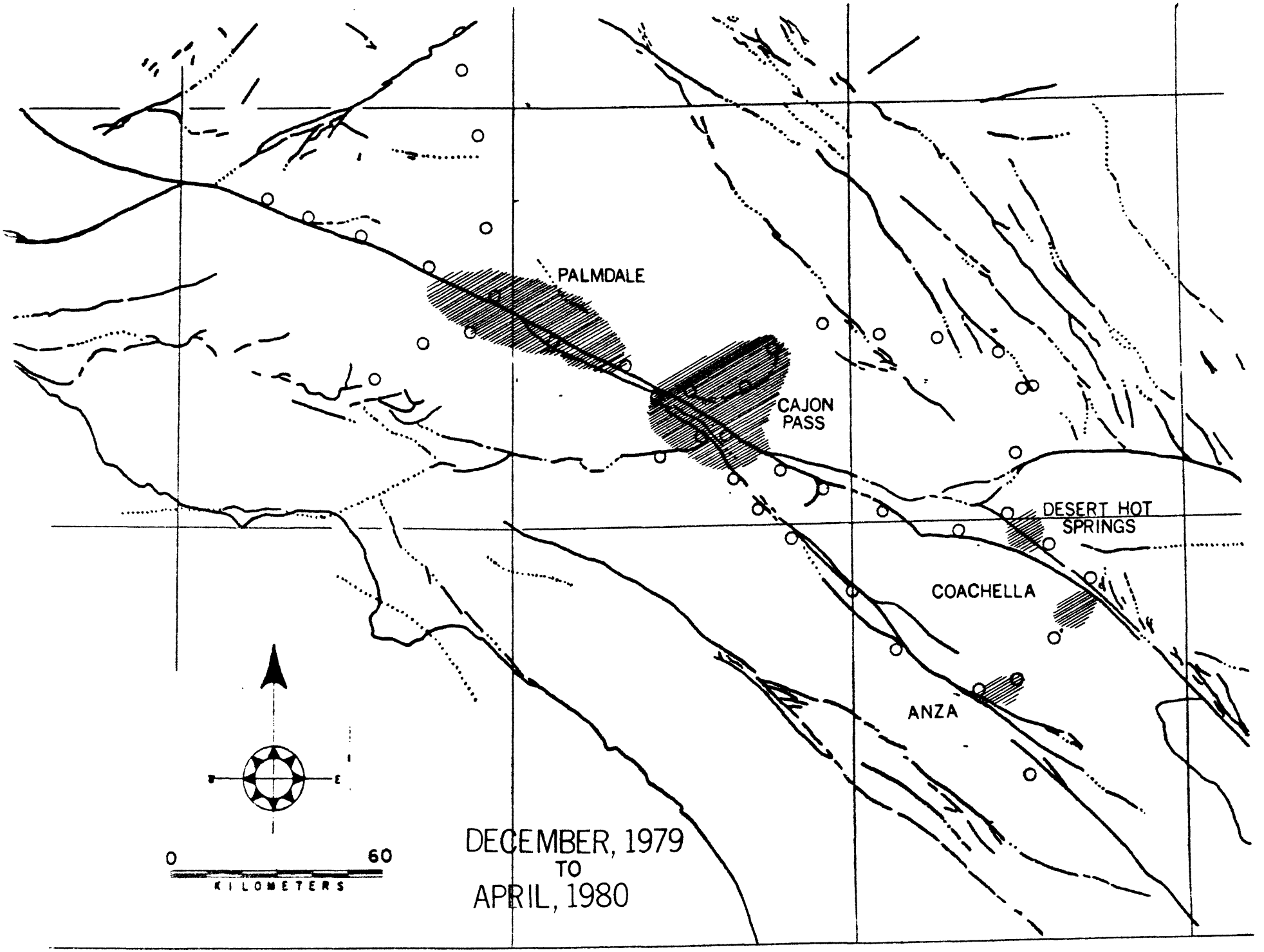
PALMDALE
CAJON PASS
DESERT HOT SPRINGS
COACHELLA
ANZA
0
60
KILOMETERS
DECEMBER, 1979
TO
APRIL, 1980

FIGURE 3

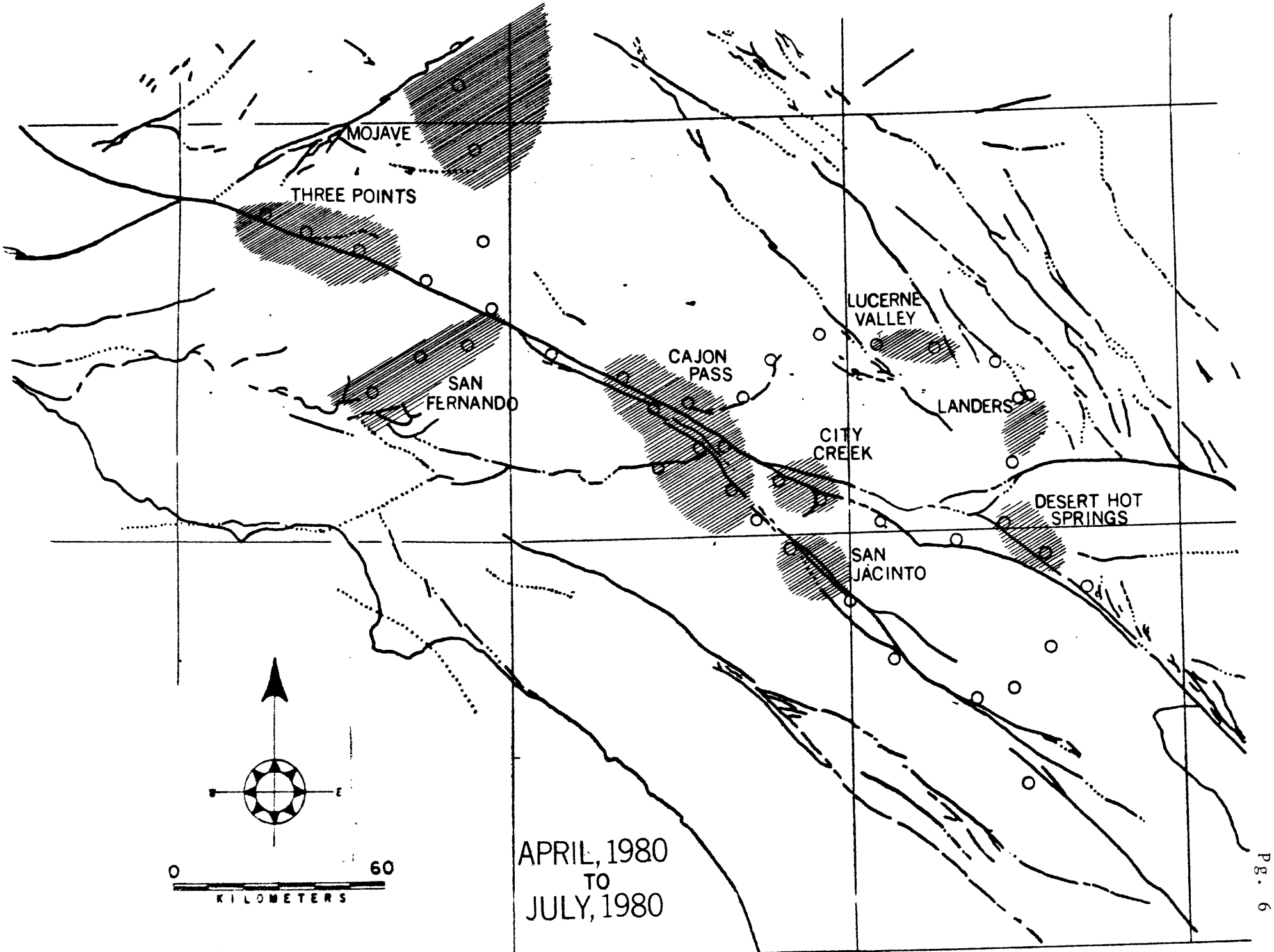
MOJAVE
THREE POINTS
SAN FERNANDO
CAJON PASS
LUCERNE VALLEY
LANDERS
CITY CREEK
DESERT HOT SPRINGS
SAN JACINTO
0
60
KILOMETERS
APRIL, 1980
TO
JULY, 1980

FIGURE 4

The significance of an anomaly is assessed by considering how long the anomaly has persisted, the number of site-pairs involved in the anomaly, and the highest value computed for rate of change within the anomaly.

Figure 2 - Time interval, July 1979 to December 1979.

This map indicates a marked lower overall level of magnetic change due to tectonomagnetic effects when compared to the previous map for the period April 1979 to July 1979. There are only marginally significant anomalies near PALMDALE, WRIGHTWOOD, and CAJON PASS.

Figure 3 - Time interval, December 1979 to April 1980

This map indicates an increase in the rate of tectonomagnetic change over the previous map (Fig. 2). The strongest anomalies are labeled PALMDALE and CAJON PASS. Between the Palmdale and Acton sites a rate of change of +6.7 quarter gammas per 30-day month was computed. This rate of change has been associated with earthquakes at Wrightwood, Landers, and other places in the past. Between the #3 site and the Lytle Creek site a rate of change of +6.3 was similarly computed. Both of these anomalies are considered significant not just because of the rate of change but because each anomaly covers several site-pairs and persists on to the next map. Smaller anomalies are indicated at DESERT HOT SPRINGS, COACHELLA, and ANZA. Each of these is only marginally significant, but the DESERT HOT SPRINGS anomaly does persist on to the next map.

Figure 4 - Time period April 1980 to July 1980

Nine areas of anomalous activity are displayed on this map. The PALMDALE anomaly on the previous map has shifted southward and is labeled SAN FERNANDO on this map. The CAJON PASS anomaly is still present as is the DESERT HOT SPRINGS anomaly. The MOJAVE anomaly re-appears on this map; it was prominent for the same time interval in 1979. Small anomalies are indicated at THREE-POINTS, CITY CREEK, and SAN JACINTO. None of the three were present on the prior map and therefore may be less significant. The LUCERNE VALLEY and LANDERS anomalies were present a year ago, but they are of marginal significance now.

CONCLUSIONS

Three maps are presented identifying regions of anomalous change in the magnetic field believed to be associated with tectonic stress changes. The value of the

research has been verified in part by the close correspondence in time and place between anomalous areas as identified by the experiment and the occurrence of earthquakes.

We have learned that some magnetic anomalies occur prior to an earthquake, and disappear with the occurrence of the earthquake. This conclusion is based upon measurements taken in April and June of 1979 in the Wrightwood area and an August 28, 1979 magnitude 3.7 earthquake in the same area (annual report of October, 1979). It seems reasonable to infer that we have measured coseismic or post seismic magnetic change during the Landers swarm of earthquakes on March 15, 1979 (annual report of October, 1979).

RECOMMENDATIONS

Much has been learned and reported during the years of continuous effort on this project since its inception in 1973. Two or more surveys have been completed each year. It seems desirable that the sequence of data remain unbroken. The program should be continued as follows:

a) Conduct the survey across the entire array in December, 1980.

b) Cooperate with the USGS personnel in relating results of this project with results of other research projects.

c) Make the raw data available to personnel of UCLA and CIRES for their efforts at data enhancement.