ATMOSPHERIC ELECTRIC FIELD OBSERVATIONS, ANIMAL BEHAVIOR, AND EARTHQUAKES

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Observations

Late in 1975, a modest field program was initiated to observe atmospheric electric field along the San Andreas and Calaveras faults in central California. An objective of the program was to detect changes in atmospheric electric field associated with earthquakes and to compare these changes with those observed during storms. Unusual animal behavior reported preceding earthquakes resembles, in many ways, that observed before storm activity. Typical weather - related field changes observed elsewhere are shown in Figure 1. Maximum changes are of the order of ± 10,000 V/m.

The fault-zone program was carried out by Joel Sharp of the USGS using field mills (instruments that measure atmospheric electrostatic field) provided by the Stanford Research Institute. Observations were begun in the winter of 1976 and have continued to the present time. The data are recorded on Rustrak charts at a speed of 1/4" per hour. Full scale range is about 2500 V/m. The field mill locations and periods of operation are tabulated below (Table 1). These periods contain some minor data gaps occasioned by bearing failure of the field mill.

Preliminary analysis of the data has shown the following characteristics:

1. Normal "quiet" field is positive (ground negative) and ranges from 0 to 300 V/m.
2. Rainstorm activity is accompanied by large field fluctuations (> 1250 volts + and -) and reversals, with several reversals often occurring in the course of an hour or two (see Figure 2).
3. A site-dependent diurnal variation ranges from about 200 V/m at St. Francis Retreat to more than 1000 V/m at San Felipe Valley. The diurnal variation is accompanied by high frequency, spikey noise during the daylight hours.

TABLE 1

FIELD MILL SITES IN CENTRAL CALIFORNIA

Site Name	Code	Lat. N	Long. W	Period of Operation
Stone Canyon	STC	36-38.10	121-14.00	12-17-75 to 4-7-76
Melendy Ranch	MEL	36-35.7	121-11.2	1-21-76 to 8-17-76
St. Francis Retreat	SFR	36-49.2	121-29.9	2-5-76 to present
Cienega Valley	ADS	36-43.2	121-21.0	4-7-76 to 6-23-76 8-17-76 to 11-5-76
San Felipe Valley	SFV	37-18.0	121-37.5	6-25-76 to present
Stanford Obs. Primate Lab	SOP	37-24.5	122-13.0	11-9-76 to present

Figure 1. Weather-Related Atmospheric Electric Field Fluctuations

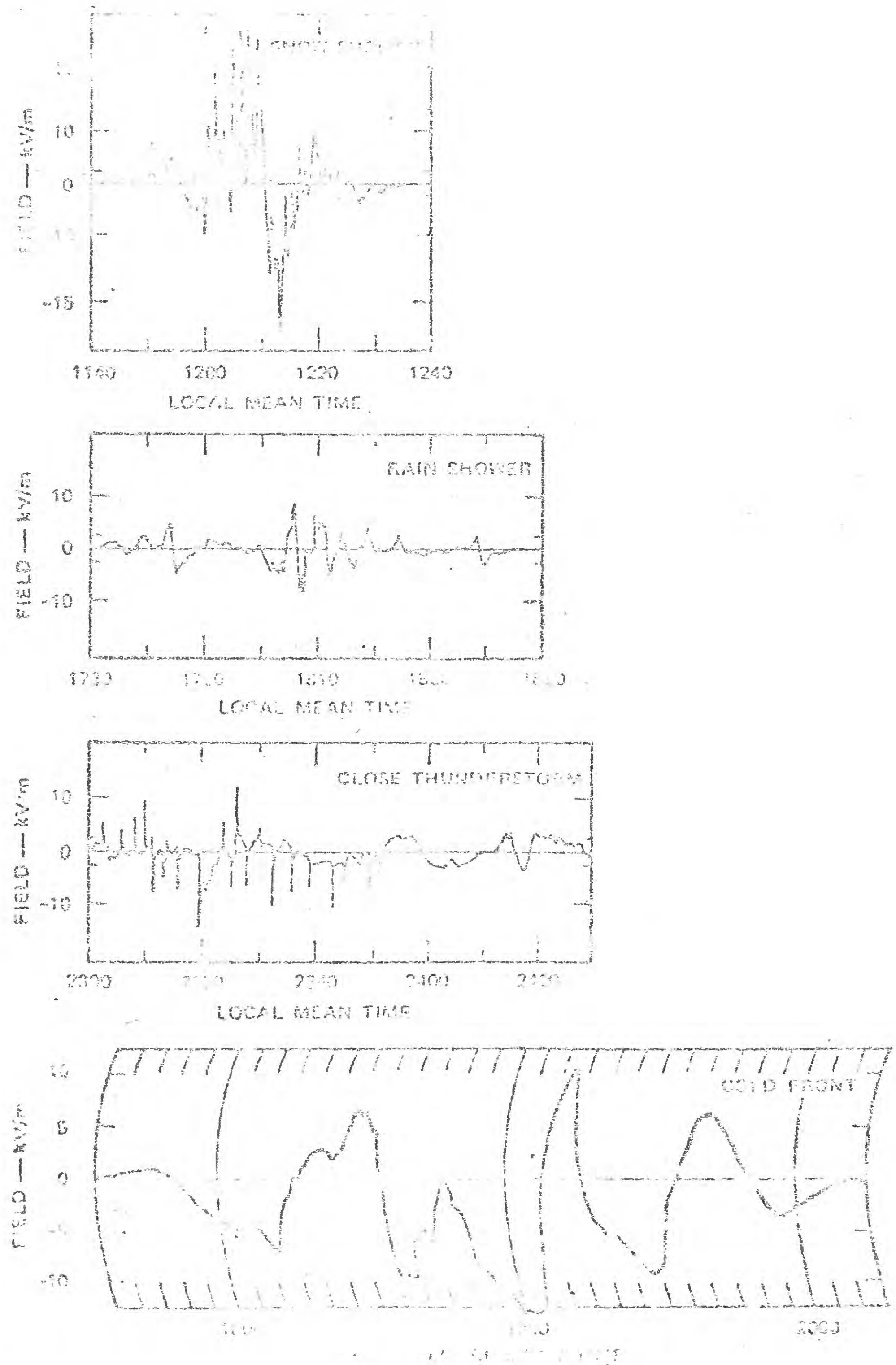
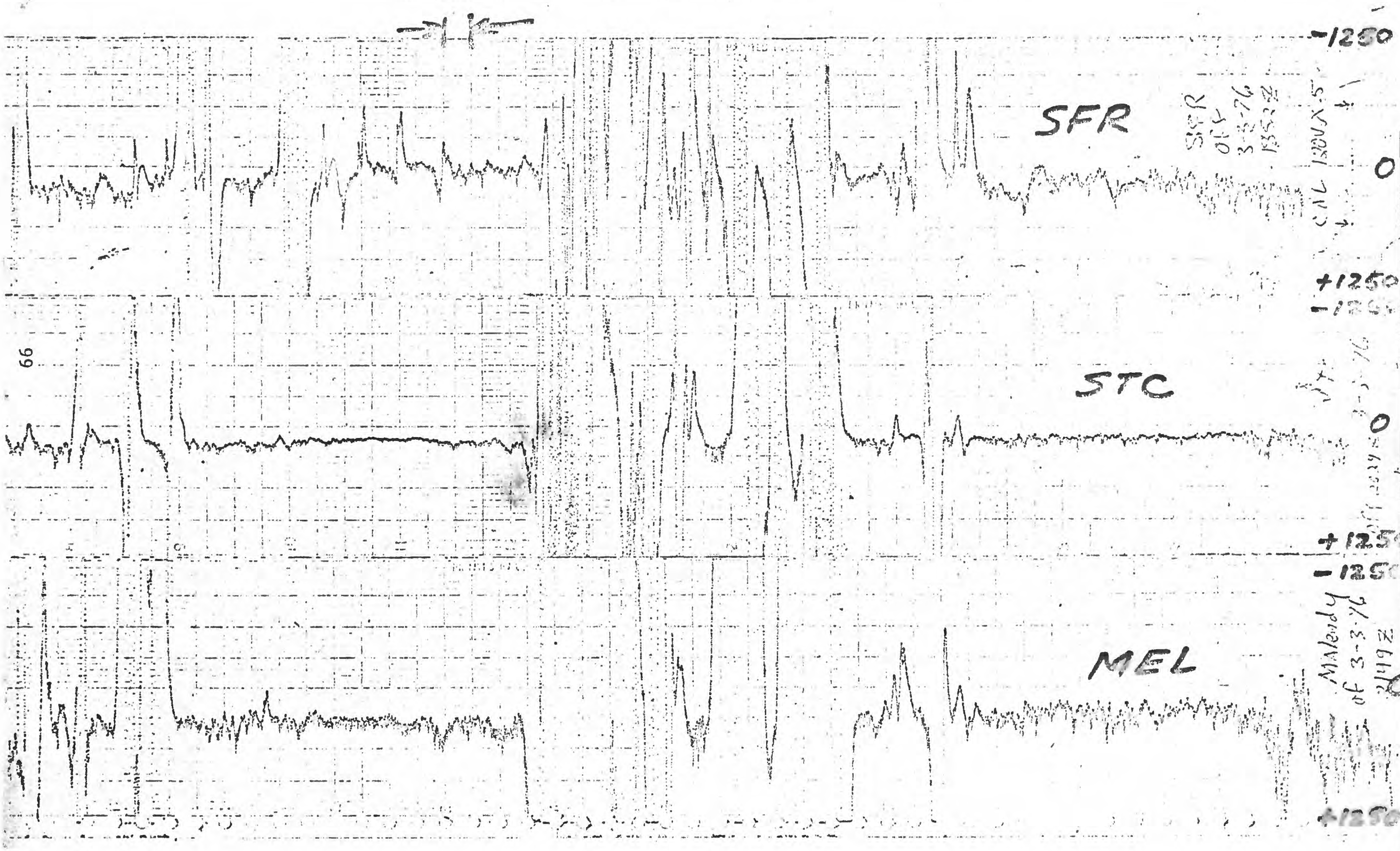


Figure 2. Atmospheric Electric Field Variations During Rainstorm Activity

1 HR. Along the San Andreas Fault.

V/m



4. Several small step-like field decreases at St. Francis Retreat appear to be correlated with abrupt increases in humidity as measured at a nearby weather station. The source of the abrupt change in humidity is not known.

Field Changes and Animal Behavior

Reports of unusual animal behavior preceding earthquakes are sometimes accompanied by reports of mysterious luminosity or lightning (Derr, 1973). Tributsch (1976) has suggested that the piezoelectric effect may be responsible for unusual animal behavior preceding the May 6, 1976 earthquake (M = 6.7) in north-eastern Italy. Finkelstein, et.al. (1973) have concluded that the piezoelectric effect is likely to generate lightining only in circumstances where the rock resistivity is unusually high. A more plausible explanation may be electro-kinetic phenomena induced by ground water flow as discussed by Mizutani, et.al., (1976).

Unusual animal behavior preceding earthquakes may not necessarily by the result of electrostatic field changes, but rather in response to related ionization phenomena and the release of gases associated with creack opening. If gas emission is a factor, the development of sense of smell in many animals is sufficiently advanced over that of humans as to offer an explanation of the apparent superiority of animals in anticipating earthquakes. It is also possible that the human, with constant exposure to pollution and distracting thought processes and activities, is less likely to notice subtle changes in his environment. Human anxiety or depression are nearly always attributed to psychological stress; physical illness to organic disease. Krueger and Reed (1976) have studied the biological impact of small air ion imbalance on mice, rats, and humans. They conclude that the production of serotonin, a powerful neuro hormone, is enhanced by high concentrations of positive ions. The "serotonin irritation syndrome" (migraine, nausea, vomiting, amblyopia, irritability, hyperistalsis, edema, conjunctivitis, congestion of the respiratory tract, etc.) is associated with an increase in positive ions preceding, by 24 to 48 hours, the onset of hot, dry wind conditions. This human condition can be relieved by inhalation of air containing large numbers of negative small air ions. Negative ions have also been found to have a tranquilizing effect on rats and mice.

Air ionization can result from the decay of radioactive material. Pierce (1976) has calculated atmospheric electric field changes which would result from variations in radon release. The changes amount to about 30% of the fair weather field and thus would be on the order of 100 V/m, a value probably too low to alone acount for unusual animal behavior, since field changes of this size are common.

Field Changes And Earthquakes

The only observations of atmospheric electric field during an earthquake sequence of which we are aware were those of Kondo (1968) during the 1966 Matsushiro sequence. He found that significantly more earthquakes occurred at times of decreased electric field than at other times.

During the period of our observations, earthquake activity along the San Andreas and Calaveras faults has been unusually light. Locations of the largest earthquakes to occur near a field mill are shown in Figure 3. One shallow (h = 2.5 km., M = 3.5) earthquake which occurred very near the ADS mill was preceded by a field reversal (Figure 4) at ADS about 24 hours earlier and field reversals just prior to the earthquake at SFR. The ADS signal change is suspected to result from local cultural activity, and an uncertainty in timing makes it impossible to ascertain whether the changes at SFR actually accompanied the earthquake.

Two other earthquakes (M = 3.5, M = 3.8) occurred within a 7-hour period in late October near the SFR mill. These events occurred on two different faults at depths of about 8 km. The electrostatic field at SFR and ADS during

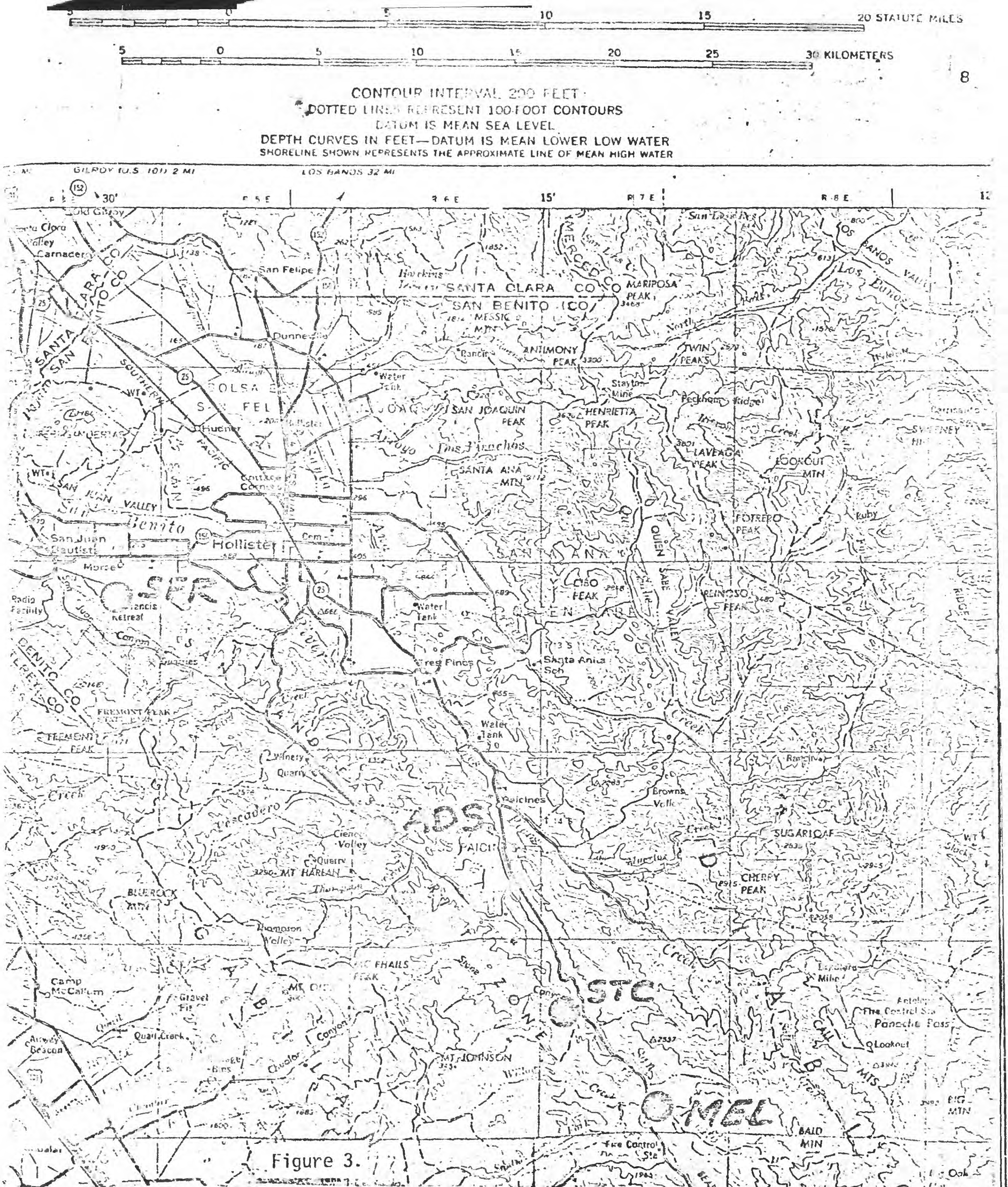


Figure 3.

ld Mill Locations Along the San Andreas Fault and Epicenters of thquakes (M 3.5) During Period of Operation. The epicenters t of the San Andreas Fault are believed to be mislocated and bably occurred nearer the mapped fault trace.

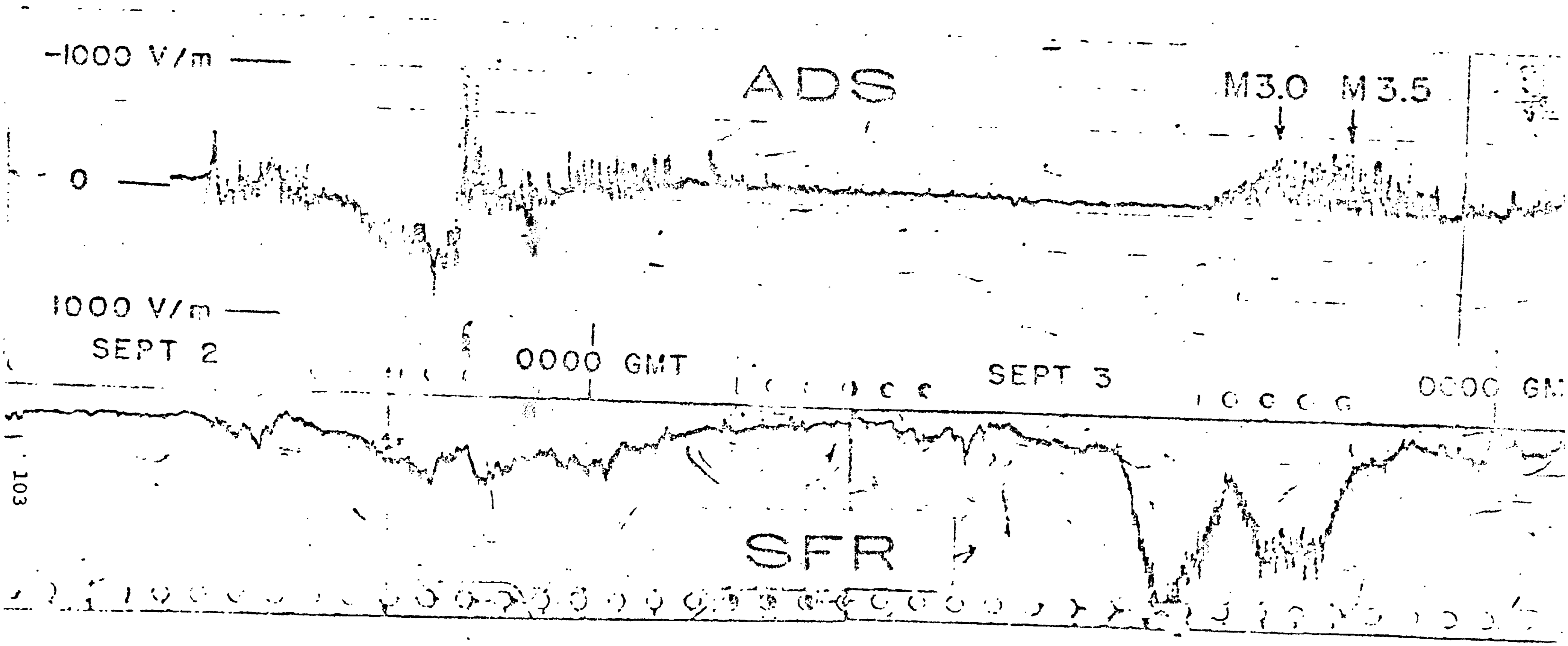


Figure 4. Atmospheric Electric Field Variations Near the Time of a Magnitude 3.5 Earthquake Near the ADS Field Mill. SFR is about 18 km northwest of the earthquake.

the period preceding the earthquakes is shown in Figure 5. Data from a more distant mill at SFV, 50 km north of SFR, is also shown. The storm-like pattern of electric field changes occurring at SFR and ADS the day before the earthquakes does not appear to correlate with any large scale change in weather. However, similar field changes are not unusual enough to allow unequivocal attributions of these changes to some process associated with the earthquake. Additional near observations of larger earthquakes are needed to establish such an association. As soon as any other system (tiltmeters, self-potential, etc.) reports a developing anomaly, the USGS will place the field mills in the expected epicentral region.

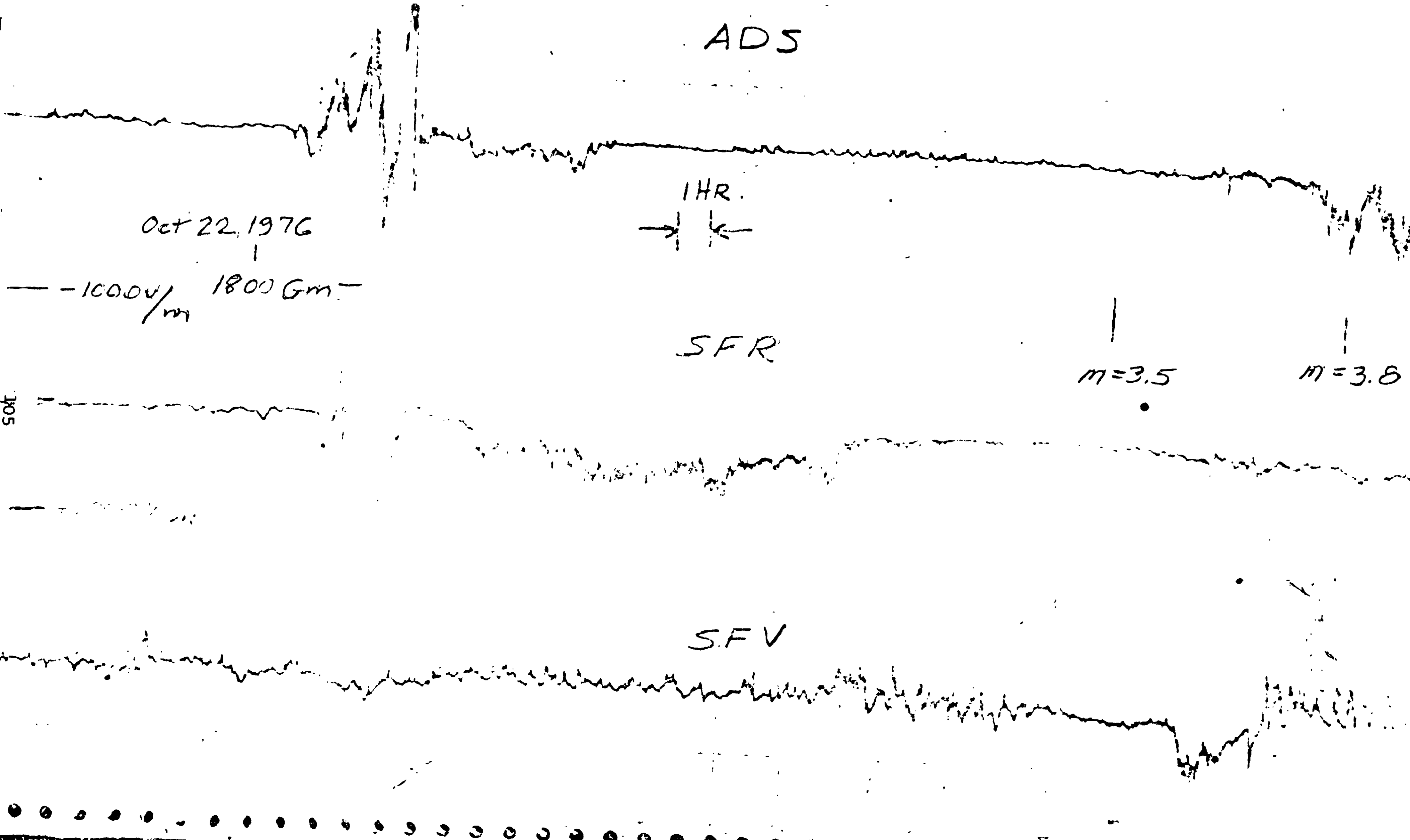


Figure 5. Atmospheric Electric Field Variations Preceding Two Earthquakes Near St. Francis Retreat (SFR). All three instruments are operating at the same sensitivity

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