individual cloud displacements during several hours on these same dates clearly exhibit motions corresponding to a rotation period of about 5 days (Fig. 1).

The greatly different rotation periods of Venus as determined by both optical and radar observations are difficult to reconcile with one another, for such would require a persistent and widespread planetary wind system having speeds in excess of 300 km/hr with respect to the solid surface; and although the terrestrial jet stream will attain these speeds, it is basically a narrowly confined zonal wind and, therefore, quite different from that observed on Venus. We are, unhappily, confronted with two rather widely divergent rotation periods for the atmosphere of Venus and its solid surface, 5 days and 244 days, respectively. The study of the rotation of Venus continues to produce inconsistencies.

BRADFORD A. SMITH
The Observatory, New Mexico State University, Las Cruces 88001

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Local Geomagnetic Events Associated with Displacements on the San Andreas Fault

Abstract. *The piezomagnetic properties of rock suggest that a change in subsurface stress will manifest itself as a change in the magnetic susceptibility and remanent magnetization and hence the local geomagnetic field. A differential array of magnetometers has been operating since late 1965 on the San Andreas fault in the search for piezomagnetic signals under conditions involving active fault stress. Local changes in the geomagnetic field have been observed near Hollister, California, some tens of hours preceding the onset of abrupt creep displacement on the San Andreas fault.*

The magnetic properties of rocks are sufficiently dependent on stress to suggest that geomagnetic observations could be used to remotely monitor changes in tectonic stress; this method would complement other techniques under investigation in the field of earthquake prediction. This stress-dependent behavior is known as inverse magnetostriction or piezomagnetism and is the consequence of the magnetocrystalline anisotropy of the magnetic minerals, chiefly magnetite, which are present in the rocks.

The magnetic susceptibility and remanent magnetization change with applied compressive stress (*1*). In common igneous rocks the susceptibility parallel to the axis of compression decreases by about 2 percent for an applied stress of 100 bars. The susceptibility at right angles to this applied stress is enhanced by a slightly greater amount (Fig. 1).

The geomagnetic field intensity observed on the surface is a function of the susceptibility and remanent magnetization of the subsurface rocks in the immediate vicinity to the depth of the Curie point isotherm. A change in the subsurface stress should, therefore, by virtue of the piezomagnetic effect cause a change in the observed field intensity. Possible piezomagnetic effects associated with the stress variations of local earth quakes have been reported (*2*) but these observations lacked the repetition and rigorous experimental arrangements necessary to firmly establish their validity.

In order to search for piezomagnetic effects in a seismically active zone, an array of optically pumped rubidium vapor magnetometers (*3*) was established on the San Andreas fault in central California in August 1965 (Fig. 2). The experiment was directed towards recognizing a local change in the geomagnetic field and determining what relationship exists, if any, between such events and seismic or strain events. The magnitude of any observed piezomagnetic effect is determined by the magnitude of the stress change, the unstressed value and stress dependence of the susceptibility, and the usual factors defining a magnetic anomaly. Since the time variation of stress changes in a seismically active area is unknown and the estimated magnitude of the piezomagnetic effect is small

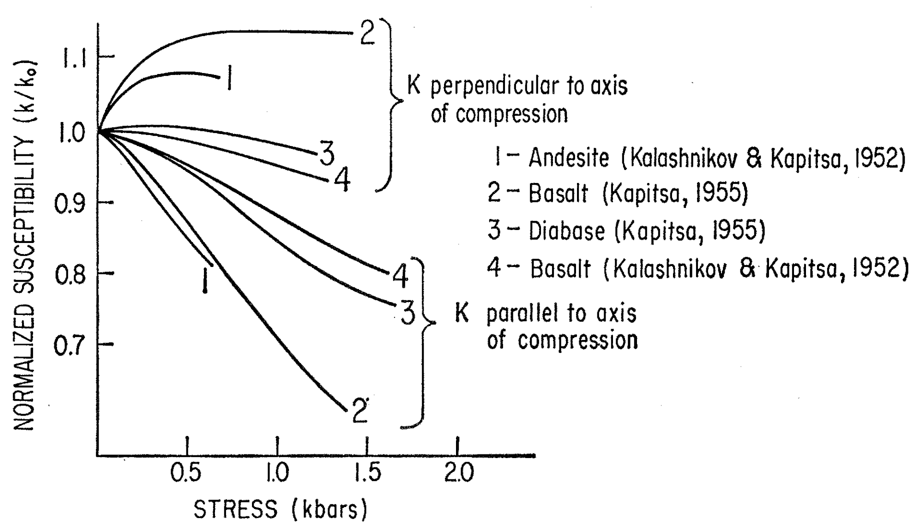

Fig. 1. Experimental data on the variation of magnetic susceptibility of common rocks with applied stress. The susceptibility parallel to the axis of compression decreases with the applied stress whereas the susceptibility perpendicular to the axis of compression is usually initially enhanced. Susceptibility is normalized to susceptibility at zero pressure.

(0.001 to 10 gammas), identification of such effects is obviously difficult.

Recognition of any local change in the field depends almost entirely on the effective removal of the geomagnetic micropulsations which are ten to hundreds of times larger than the expected changes. Two magnetometer sensors near each other sense essentially identical micropulsations since their source is primarily in the ionosphere some hundreds of kilometers distant. The difference in their variations is therefore constant. A local perturbation in the field occurring much closer to one sensor than the other, however, will appear as a change in this otherwise constant difference. The array was therefore operated as a differential array by telemetering the signals to a central location where the differences and total field variations were recorded.

The array has been operating continuously for almost 2 years. During this time, local changes in the observed magnetic field were observed on the Hollister differential record in December 1965 and February, June, July, and October 1966. In every case, and at no other times, abrupt creep displacement of the San Andreas fault, ranging from 0.5 to 4 mm, has occurred in the vicinity of Hollister some tens of hours after the magnetic event. The creep displacement is monitored by several instruments across an unusually localized shear zone which bisects a winery straddling the fault zone (*4*). The displacement, monitored since 1959, exhibits a sporadic behavior in that almost the total average creep of about 1 cm/year occurs at two or three discrete times per year although usually not simultaneously with local earthquakes.

Since the Hollister magnetometer exhibited these tantalizing local changes in the geomagnetic field, the array was reorganized into a denser net centered in the Hollister area in December 1966 (Fig. 3). The objective of the new array was first, to provide redundant magnetometers so that there would be no question as to reality of the observed magnetic variations; second, to obtain more information on the spatial distribution of these local geomagnetic events; and finally, to monitor any possible relative time variations at the different sites.

After the establishment of the new array a local decrease in the magnetic field was observed beginning at 16 hours 30 minutes Greenwich mean time (GMT) on 18 April 1967 (Fig. 4), but this time it was observed on four magnetometers positioned over a span of 25 km. The event appeared simultaneously, within the resolution of the event, at each site, but with different amplitudes and different decay times. The largest event, 2.5 gammas at Stone Canyon, did not return to previous levels for over 90 minutes. The other stations gradually returned to near pre-event values in about 36 minutes. The event was definitely not an ionospheric event because it was not observed at the Stanford site or at the U.S. Coast and Geodetic Castle Rock Observatory. Such differences in intensity at nearby stations are also not observed except accompanying high ionospheric activity when the amplitude of a pulsation is five to ten times larger than the differences.

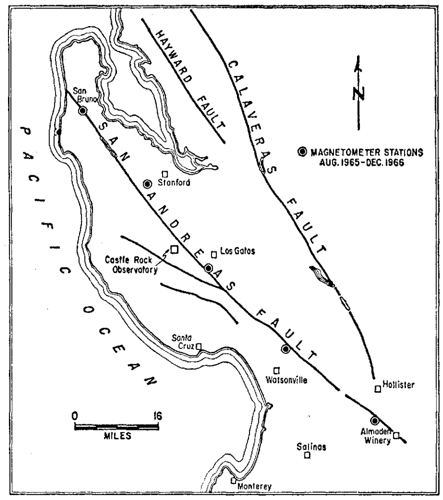

Fig. 2. Location of optically pumped rubidium vapor magnetometers along the San Andreas fault, August to December 1966. The signals are telemetered to Stanford University where four differential recordings are obtained together with the variations of the common reference magnetometer at Los Gatos.

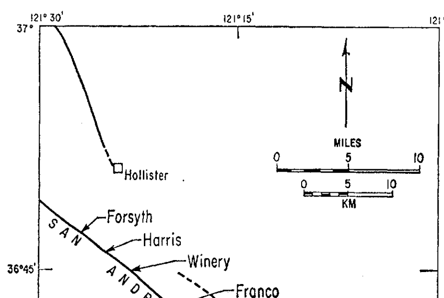

Fig. 3. Location of the present magnetometer array near Hollister, California. The signals from the ESSA Stone Canyon Observatory, the Franco residence, the Harris ranch, and the Forsyth residence are telemetered to the Harris ranch where real time differentials with respect to the arbitrarily chosen reference at Franco are formed.

Creep displacement of about 4 mm occurred over a few minutes' time 16 hours after the observed magnetic event. This was the first large amount of creep observed since early November 1966. Local earthquakes occurred from 20 to 22 April 1967, the largest of which at 16 hours GMT on 20 April had a Richter magnitude of 3.6. This portion of the fault is instrumented by a net of high-gain seismographs and a strain extensometer (*5*). A second local magnetic event was observed on all stations of the array at 16 hours 40 minutes GMT on 29 April 1967, but this event was an increase in field intensity. A similar sequence of magnetic events, creep displacement, and local seismic events was observed in February 1966 when there was only one magnetometer located near Hollister.

If indeed the magnetic events are manifestations of subsurface stress changes, then this will have been the first reported observation of the nature of the time signature of the stress change in a seismically active area. Moreover, the magnetic event was widespread, simultaneous, and without any simultaneously associated creep, strain, or seismic activity. With this evidence, the source of the stress change is believed to be deep, perhaps 10 to 20 km. The lack of immediate accompanying strain and seismic activity could be explained if the stress change were occurring in a ductile region at depth where the hydrostatic stress causes rocks to strain by slow creep or plastic deformation. The stress imposed on the shallower region from 0 to 10 km might require a finite length of time, say 10 to 20 hours, to respond to the new constraint by shear, that is, creep displacement. The local earthquakes could therefore be interpreted as brittle readjustments to the new strain environment and as such are aftershocks of a zero frequency earthquake, that is, creep displacement.

The magnitude of the observed magnetic anomaly is not unreasonable. A magnetic map of this portion of the

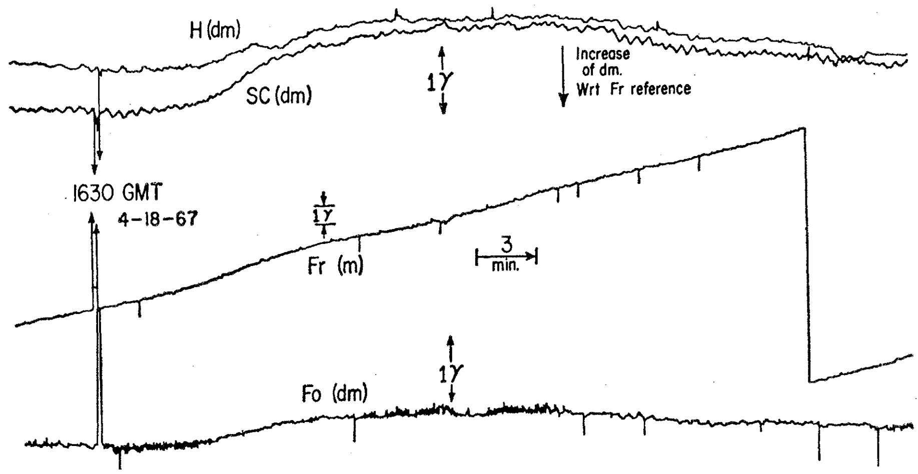

Fig. 4. Local magnetic event observed near Hollister on 18 April 1967 beginning at 1630 hours. Trace moving upward to the right is the reference magnetometer at Franco (*Fr*); the sharp offset is an automatic range adjustment. The other traces are differential magnetometers at the Harris ranch (*H*), Stone Canyon (*SC*), and Forsyth (*Fo*) and represent the amount by which the intensity differs from that at Franco.

San Andreas fault is not available but since the stress change is believed to have occurred at depth, a reasonable magnetic susceptibility would be that of basic rock for which $k \approx 10^{-3}$ cgs unit. Assume a buried sphere tangent to the surface undergoing a stress change of 20 bars. The change in susceptibility in the direction of the applied compressive stress is given by the product of the stress change and the stress sensitivity of the susceptibility (Fig. 1):

$$\Delta k = \frac{-.02}{100 \text{ bars}} \times 10^{-3} \times 20 \text{ bars}$$
$$= -4 \times 10^{-6} \text{ cgs units} \qquad (1)$$

The observed anomaly at the surface from a sphere of radius R of uniform magnetization whose center is at a depth d is

$$\Delta F = \frac{\Delta k\, F(4/3\pi R^3)}{d^3} \approx -0.8 \text{ gamma}$$

where $R = d$ and the total intensity F at Hollister is 50,000 gammas.

It has been pointed out by Brace and Orange (*6*) that the electrical resistivity of rocks is dependent on stress. The telluric current field and its small associated magnetic field will also be dependent on stress. However, it can be shown that for a given stress change the piezomagnetic effect is at least an order of magnitude larger. The ultimate source of the stress change cannot of course be determined without other evidence. The source of the observed ferrimagnetic effects cannot be deeper than the Curie isotherm which is estimated to be 22 km in this region. The signature of the observed piezomagnetic effects appears to follow the logarithmic variation of creep behavior of rocks, lending support to a mechanism of creep or plastic deformation.

Other interpretations of this evidence are perhaps possible, but without positive information concerning the distribution of the strain and stress field at depth, we can only speculate. At the very least, it does appear that stress changes can occur at some depth before their effects are expressed at or near the surface.

SHELDON BREINER
ROBERT L. KOVACH
Department of Geophysics,
Stanford University,
Stanford, California 94305

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Genetic Background and Expressivity of Histocompatibility Genes

Abstract. *A difference in the reactivity of F_1 hybrid female mice to skin grafts from male donors of each of their parental strains suggests that the genetic background can influence the efficacy of the Y antigen to elicit rejection of the graft.*

Although it has been shown that the genetic background of a mouse influences its ability to react against transplantation and other antigens (*1, 2*), there is as yet no direct evidence that genetic factors, other than the specific determinants of transplantation antigens in a donor, can modify the speed of homograft rejection by influencing the expression of these antigens (*3*). Such an effect could be mediated by the ability of non-H (histocompatibility) genes to alter the amount of cellular antigen produced, the availability of the antigen to the hosts' immune system, or the vulnerability of the graft to immune attack, possibly by influencing the sialomucin content of the connective tissue stroma of the graft (*4*). We now present evidence that non-H genes in a skin graft can influence its survival time by affecting the expression of a specific transplantation antigen.

It is now well established that isografts of skin and other tissues in mice are not always permanently accepted when the donor is a male and the recipient is a female (*5*). In this circumstance, rejections seem to be attributable to the association of a histocompatibility factor with the Y chromosome. Although females of different strains vary considerably in the facility with which they react against male isografts, there has been no evidence of variation in the antigenic specificity of the Y factor (*6*). This interstrain diversity in reactivity is apparently dictated by the genotype of the female recipient which determines her capacity to react against male skin (*2*). However, it is conceivable that another factor also contributes to this variability, namely, a genetically determined difference in the expression of the Y antigen. There would be evidence in support of this premise if it could be shown that there are differences in tempo in the reactivities of F_1 hybrid females to skin grafts from male donors of each of their parental strains and, possibly, from F_1 hybrid males.