Some Results of an Archaeomagnetic Study on the Secular Variation in the Southwest of North America

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Abstract

Some preliminary data on secular variations of the geomagnetic field are given for the time 600 to 1500 A.D. as determined by archaeomagnetic methods. The inclination of the field has varied from a low of approximately 40 degrees to a maximum of some 60 degrees. Values of declination vary approximately from 10 degrees east of true north to 15 degrees west.

The completed study aims not only to elucidate the trend of secular variation in the Southwestern United States but also to establish a standard scale for the magnetic dating of archaeological ruins in the area for the anthropologist.

In general the baked earth of ancient fireplaces has a stable remanent magnetism which reveals the direction of geomagnetism at the time when it was baked. To trace the trend of secular variation in the past by means of this phenomenon, it is first necessary to work with materials of known age. In this respect, the Southwest has the advantage that suitable materials are obtainable from archaeological ruins which are well dated by the tree-ring method. The use of annual growth rings has effectively been applied to the timbers found at archaeological ruins to determine their cutting dates which may be interpreted by the anthropologist to give the dates of construction of houses or rooms. The age of the archaeomagnetic directions determined from baked earth, however, correspond to the time of baking of the earth. About half of the materials used in the present study were collected from Indian ruins dated by this method at the Laboratory for Tree-Ring Research at the University of Arizona.

Materials used are samples of baked earth collected from fireplaces of dwellings, ceremonial rooms, and also from the baked floors and walls of burnt rooms. Besides these, there is included one set of rock specimens collected from a well dated lava flow. Collecting sites are located in the region from 31° to 38° N. in latitude and from 106° to 112° W. in longitude: most of the sites are in the states of Arizona and New Mexico. The ages of samples obtained so far range from around the beginning of the Christian era to the 17th and 18th centuries, but most of them fall in the period between 600 and 1500 A.D.

Samples are collected as small blocks of baked earth, about 1-1/2 inch on an edge. To obtain these samples, a small block of baked earth is cast in plaster using a cubic brass case which is carefully leveled and oriented to the present magnetic north direction with a magnetic compass set above the case. A comparison of magnetic bearings determined at fireplace and at some distance from it eliminates chances for error in direction from magnetic...
disturbances. In addition, magnetometer measurements made at and away from the sample site noted the presence of any magnetic anomalies. After removing the brass case, the sample is obtained as an accurate cube of plaster having a consistent size for various samples. Six to twelve individual samples were collected from various parts of one fireplace. In all, 25 sets of baked earth samples were obtained from 16 different sites totaling 233 samples including the set of 20 samples from a lava flow. The samples were measured with an astatic magnetometer, and the mean direction and the radius of the circle of confidence at the 95% level were calculated following Fisher's (1953) method.

To check the amount of viscous component and to assess magnetic stability, several samples from each set were subject to a thermal demagnetization treatment at temperatures around 100°C. The change of direction in terms of the angle between the two vectors of magnetization before and after the thermal treatment was mostly less than 3°, but in a few cases it exceeded 7°. For three sets of samples, all samples belonging to a given set were treated by thermal demagnetization experiments. The change of mean direction of magnetization was less than 2.1° and the change in inclination was less than 1.7° and less than 2.3° in declination. The intensity of NRM of the baked earth samples is in general of the order of $10^{-4}$ to $10^{-5}$ emu/cc, and it decreases by 1 to 35% after thermal treatments at 100°C. These preliminary thermal demagnetization tests suggest the contribution of viscous component to be less than 2° and 3° respectively in mean inclination and declination for a set of samples.

Fig. 1 Results of magnetic measurements made on materials from the Southwest of North America.
On Fig. 1 are plotted the results of measurements. Solid lines indicate results from specimens dated by the tree-ring and broken lines show those dated by archaeological evidences. All plotted values of inclination and declination are reduced to Tucson and no correction has been made for any viscous component present. The magnitude of Fisher's radius at the 95% level of significance is shown as a vertical line and a horizontal line indicates the range of age assigned by the anthropological community. In the Southwest, instrumental magnetic observation began in 1910 at the Magnetic Observatory near Tucson. According to the record, the inclination had a maximum value in 1939 and the declination deviated most easterly in 1933. These recent trends of secular variation are also plotted.

The distribution of plotted results of Fig. 1 suggests that the inclination has undergone a secular variation which at least in overall features decreased between 600 and 800, increased after 1000 to reach a maximum value around 1200, and then decreased again at least through 1450. After this time, presumably it had a minimum value, and then increased to present values. To determine the secular variation curve for declination which should be consistent with the curve for inclination, the distribution of plotted results of declination suggests several possible curves and more results are needed before any generalizations can be drawn.

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