An Assessment of Archaeomagnetic Contemporaneity

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RESULTS – MODERN AM DATA

The AM data from each of the modern hearths were compared to that of every other hearth in the dataset (AM pairs) as well as to the IGRF mean pole location (OP) for Tucson in 2005 (AM-OP pairs). The angular distance and probability of the F-test statistic were calculated for each of these AM and AM-OP pairs. Just over 70% of the AM pairs were found to be statistically ‘similar’ (i.e., not statistically different), and the median angular distance between these ‘similar’ hearth pairs was 1.59° (see Table 1 for a summary of the angular distance values for statistically not different (‘Similar’) and different (‘Different’) pairs). The median angular distance between statistically different modern hearths, on the other hand, was 3.52° and the minimum angular distance was 1.82°, which was greater than that of roughly 60% of the ‘similar’ pairs.

Likewise, the AM-OP comparisons revealed that 83% of the hearths were statistically ‘similar’ to the observed location, with a median angular distance of 1.50° and a maximum distance of 4.10°. Intuitively, the interpretation of contemporaneity tests, particularly concerning the degree of true contemporaneity between features, depends on three parameters:

1. the angular distance between two AM directions (or VGP's)
2. the precision of each AM direction
3. the rate of geomagnetic secular variation (SV) at the time of interest

DATA & METHODS

Two sources of data were used to address this problem:

1. Computer Simulations

Simulations were developed to assess how contemporaneity tests play out as a function of angular distance, precision, and SV rate. SV rates were based on modern recordings of the magnetic field in Tucson. To simulate the contemporaneity problem, two ‘features’ were assigned AM directions and precisions. Initially, each feature was assumed to have 8 specimens. Also, the α values for both features were assumed to be the same, either 1°, 3°, 4° or 3°. Using the F-test for comparing magnetic directions (Butler, 1991, p. 150), the angular distance between feature vectors, at which the directions were found to be significantly different at the 95% significance level was calculated. This angle was a linear function of the angle α (Figure 3).

To calculate the angular distance between two features, the AM directions and precisions were first transformed into Fisher distributions (McFadden & Lowes, 1981; see Table 1 for a summary of differences). The latter are mathematical constructs that are based on the precision of each AM direction and the angular distance between the two directions. These data were then submitted to a Monte Carlo simulation process in order to generate a large number of AM directions. The statistical data used to assess the temporal resolution that is possible for contemporaneity tests run under different conditions.

2. Modern AM Data

AM data collected from a suite of 40 modern hearths located in Tucson, AZ were used to assess AM contemporaneity within a single population of directions. These data were collected as part of a collector training workshop, and therefore some degree of collector error should be expected. The α95 values for this dataset ranged from 1° to 4.5°. All 40 hearths were magnetized between September 2004 and November 2005, and therefore should reflect the same average magnetic field. These data were compared to each other and to the IGRF mean pole position for Tucson in 2005.

RESULTS – COMPUTER SIMULATIONS

GEOMAG software was used to calculate the direction of the magnetic field in Tucson at five year intervals from AD 1900-2005. Although these models are superimposed by those contained in IGRF-10, the SV rates calculated should be representative. Figure 1 shows the SV rates calculated as a function of time.

The median rate for these values is 1.37°/year, with a minimum of 0.98°/year, a maximum of 2.53°/year, and an interquartile range of 0.800-1.70°/year.

In Figure 4, these angular differences were translated into age differences using the Tucson SV rates. The medium SV rate was the median value for 20th century Tucson SV; the low and high SV rates are the first and third quartile results in the interquartile range of Tucson SV values. The ordinate value represents the age difference resolvable by a contemporaneity test. Thus, ‘contemporaneous’ AM directions may be as much as 50 years apart for low SV rates and small α values, but 20 years apart, or even more, when the SV rate is slow and/or the α values are high.

SUMMARY:

Although by no means definitive, the results from these analyses offer preliminary guidelines for assessing, understanding, and interpreting archaeomagnetic contemporaneity:

1. The true age of archaeomagnetic features may differ by 50-200 years or more
2. Pairs of different-aged features are more likely to be labeled “contemporary” when they have larger data
3. These data were used to assess the temporal resolution that is possible for contemporaneity tests run under different conditions.

REFERENCES


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Portions of this poster grew out of discussions with researchers working in the American Southwest, including Jeff Eighmy, Bill Deaver, Mark Elson and Jeff Dean. The modern hearth data used in this study was generated through new collectors during the training process. A similar dataset generated by more experienced collectors should reflect a more uniform level of internal consistency.