Global Correlation of the 223 ka Pringle Falls Event

MICHAEL MCWILLIAMS

Department of Geological and Environmental Sciences, Stanford University, Stanford, California 94305-2115

Abstract

New \(^{40}\text{Ar}^{39}\text{Ar}\) ages link records of anomalous geomagnetic field behavior from western North America and New Zealand, and suggest that a reversal event occurred at 223 ± 4 ka (±1σ). Virtual geomagnetic poles from the Pringle Falls event recorded in both hemispheres lie on a common transition path, suggesting that the geomagnetic field during this interval was dominated by a dipolar component. The Pringle Falls event therefore may be a reverse polarity subchron within the Brunhes Normal Chron.

Introduction

REVERSE POLARITY MAGNETIZATIONS have been reported from within the 0–784 ka Brunhes Normal Chron (Baksi et al., 1992), but their interpretation is controversial. One opinion holds that the Brunhes contains as many as eight short reverse polarity subchrons (Champion et al., 1988; Spell and McDougall, 1992). A contrasting view is that there is no convincing evidence for even a single reverse polarity subchron during the Brunhes (Merrill and McFadden, 1994). In this latter interpretation, the only well documented Brunhes-age geomagnetic events are the Laschamp and Blake reversal excursions, defined as “apparent” reversals produced by relatively strong nondipole field fluctuations. Reversal excursions are distinct from reversal events that are “true” polarity subchrons related to reversals of the dipole field (Merrill and McFadden, 1994).

Some apparent reversals reported in the Brunhes Normal Chron are clearly artifacts that do not record actual geomagnetic field behavior (Verosub and Banerjee, 1977). A real event derived from an accurate geomagnetic field recording must therefore be either a reversal event (which should be essentially synchronous on a global scale) or a reversal excursion (which is unlikely to be either synchronous or global). A significant portion of the Brunhes Chron is characterized by low dipole field strength relative to the present value (Meynadier et al. 1992; Tric et al., 1992; Valet and Meynadier, 1993). A consequence is that an increase in the nondipole/dipole field strength ratio could lead to an increased frequency in the occurrence of reversal excursions but not necessarily reversal events, an argument invoked by those who classify the majority of Brunhes-age events as reversal excursions.

Merrill and McFadden (1994) offered three criteria to discriminate between reversal events and reversal excursions. First, a reversal event should be found at many locations in both hemispheres, with 180° opposite polarity observed at several sites in both hemispheres. Second, a reversal event should be found in different recording media—i.e. sediments and volcanic rocks. Third, evidence from the marine magnetic anomaly record is desirable.

Discrimination between synchronous reversal events and possibly asynchronous reversal excursions also depends critically on the ability to correlate candidate events on a global basis, but correlation is often made difficult in practice because of poor age control. The ~41–45 ka Laschamp event is often thought of as the best documented reversal event/excursion of the Brunhes Chron because anomalous directions of magnetization are observed at widely spaced localities and are indistinguishable in age. The Blake event is less accurately dated than the younger Laschamp event, but it has been observed at many localities. Most other candidate events within the Brunhes Chron are observed at only a single locality and/or have rather poor age control. This paper summarizes geochronological and paleomagnetic data for the Pringle Falls event, recognized here for the first time as a reversal event recorded by sediments and volcanic rocks at distant localities in both hemispheres for which precise age control confirms global synchrony.

Records of the Pringle Falls Event

Western North America

The first detailed records of anomalous geomagnetic field behavior from a sedimentary sequence
MICHAEL MCWILLIAMS

near Pringle Falls, Oregon were originally thought to represent the Blake event (Herrero-Bervera 1989, 1993). New $^{40}$Ar/$^{39}$Ar ages (Fig. 1) from plagioclase in the “D” ash layer at Pringle Falls (Herrero-Bervero et al., 1994) indicate that the Pringle Falls event occurred at $218 \pm 10$ ka, significantly older than the commonly accepted 100–130 ka age for the Blake event. Moreover, the Pringle Falls event is found in sedimentary sequences at Summer Lake, Oregon (Negrini et al., 1988) and at Long Valley, California (Liddicoat and Bailey, 1989; Liddicoat 1990). Figure 2 illustrates the common virtual geomagnetic pole (VGP) paths for the Pringle Falls event recorded at these three localities.

North Island, New Zealand

The Mamaku Ignimbrite is the youngest of the large, sheet-forming ignimbrites of the Taupo Volcanic Zone. Anomalous field directions originally reported from a single site in the Mamaku ignimbrite (Cox 1971) have recently been confirmed (Shane et al., 1994; Tanaka et al., 1996).

Three new $^{40}$Ar/$^{39}$Ar ages from plagioclase from the Mamaku Ignimbrite (Houghton et al., 1995) yield a weighted mean age of $223 \pm 3$ ka (Fig. 1), statistically indistinguishable from an isothermal fission-track age of $230 \pm 12$ ka for the same unit (Shane et al., 1994). Twenty-nine virtual geomagnetic poles (VGPs) for the Mamaku ignimbrite are plotted in Figure 2, along with VGPs from the Pringle Falls event from western North America.

### FIG. 1

$^{40}$Ar/$^{39}$Ar ages from Pringle Falls D ash (top) and Mamaku Ignimbrite (bottom). Filled rectangles indicate steps used to calculate plateau age; uncertainties are $\pm 1 \sigma$. Analytical details can be found in Herrero-Bervero et al. (1994) and Tanaka et al. (1995). Neutron fluence monitor used is Taylor Creek sanidine with an assumed age of 29.92 Ma.
the sedimentary records from North America. This is not unexpected, given the episodic nature of volcanism as opposed to more continuous sedimentation in a lacustrine environment. It is clear from Figure 2 that the VGP paths do not exactly coincide. This too is plausible, inasmuch as there was almost certainly a contribution from the nondipole field, which would produce directions differing slightly at localities around the globe.

The aforementioned criteria for discriminating between reversal events and reversal excursions (Merrill and McFadden, 1994) are exacting, and as a consequence it is not surprising that the authors find no convincing evidence for even a single reverse polarity subchron during the Brunhes. Were the entire reversal time scale judged with the same criteria, many extant polarity chrons would have to be rejected; few polarity transitions older than a few Ma have been observed in multiple rock types and reliably correlated on a global basis, primarily because of imprecise age control.

The available data from the Pringle Falls event meet some, but not all, of the standards established in Merrill and McFadden (1994). The first condition is partially met. Although four sites may not be considered as “many,” they are at least distributed in both hemispheres. The Northern Hemisphere records from Pringle Falls and Long Valley do attain approximately opposite polarity, but the Southern Hemisphere record from New Zealand is punctuated by the volcanic recording process. Discovery of the Pringle Falls event at more localities may completely satisfy this condition in the future. The second condition is clearly satisfied.

Meeting the third condition is perhaps the most difficult. If the Pringle Falls event lasted about 104 years (a reasonable approximation for the minimum time required for a N-R-N polarity transition without any intervening time latched in the R state), the anomaly width adjacent to a ridge spreading at 50 mm/year would be on the order of 0.5 km. Short-wavelength features of about this size have been inferred from the marine magnetic anomaly record, but the only Brunhes-age short event present in a widely accepted version of the polarity time scale (Cande and Kent, 1992) is the ~104 yr Emperor event centered at 498 ka. The Emperor event appears to be present in the marine magnetic anomaly record, but the principal land-based evidence for its existence (Champion et al., 1981) has been retracted (Champion et al., 1988). The original thermoremanent magnetization (TRM) acquired by oceanic basalts upon initial cooling is rapidly altered (Kent and Gee, 1994). If the time scale of the alter-
dipole/dipole field intensity ratio was relatively Blake events occurred during a time when the non-

equivocal. They noted that the Laschamp and the presence of reverse polarity non-dipole/dipole field intensity was relatively
documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evi-

documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evi-
documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evi-
documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evi-

documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evi-

documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evi-

documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evi-

documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evi-

Finally, the Pringle Falls event has been observed in at least as many localities as the Laschamp. Using the criteria outlined in Merrill and McFadden (1994), three well documented geomagnetic events are present in the most recent third of the Brunhes Normal Chron—the Laschamp and Blake events and now the Pringle Falls event.

**Reversal Event or Reversal Excursion?**

Reversal excursions may represent aborted reversals (Hoffman, 1992). If so, they are probably caused by the same physical process as reversal events and the term reversal excursion is superfluous. A contrasting view (Merrill and McFadden, 1994) is that excursions may represent a completely different process that is unrelated to the reversal mechanism and is more likely to occur when the nondipole/dipole field intensity ratio is relatively large. This view is based upon an analysis of the polarity time scale that suggests that the hypothesis of a common stability for the two polarity states cannot be rejected. The presence of reverse polarity subchrons within the Brunhes Normal Chron upsets this model, and as a consequence Merrill and McFadden (1994) have advocated that reversal excursions should not be grouped with reversal events.

The Pringle Falls event clearly qualifies as a well documented excursion, but is it a reversal event? Merrill and McFadden (1994) observed that the evidence for or against excursions as aborted reversals is equivocal. They noted that the Laschamp and Blake events occurred during a time when the nondipole/dipole field intensity ratio was relatively large and the dipole field intensity was relatively low. On these and other grounds, they suggested that these excursions and others should not be treated as aborted reversals.

Detailed studies of polarity transitions have shown that the Brunhes-Matuyama and other transitions in the 0–5 Ma range have two important distinguishing features. First, relative paleointensity records that span the Brunhes-Matuyama well as older polarity transitions show large decreases just prior to the onset of polarity change (Valet and Meynadier, 1993; Menadier et al., 1994; Verosub et al., 1996). Second, VGP paths for the Brunhes-Matuyama and other transitions appear to define a common longitudinal band suggestive of the influence of a strong dipole field component. The Pringle Falls event shares these same two characteristics—a leading paleointensity decrease (Meynadier et al., 1994) and a common VGP path as described here. It therefore seems reasonable to suggest that the Pringle Falls event is, in fact, a reversal event. Whether it should be labeled as a polarity subchron is arguable. One definition (Cande and Kent, 1992) holds that a subchron is defined by a pair of reversals, but the minimum length of the intervening polarity interval is unspecified. Accordingly, a pair of reversal events separated by even a very short time might qualify as a subchron. Regardless of the terminology, the Pringle Falls event may prove useful as a chronostratigraphic marker for the most recent third of the Brunhes Chron.

**REFERENCES**


