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HAS THE EARTH'S MAGNETIC FIELD EVER FLIPPED?

D. RUSSELL HUMPHREYS*

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Abstract

Much paleomagnetic data has been reported in this century suggesting that the earth's magnetic field has reversed its polarity many times in the past. Evolutionists have assumed that the time between reversals must be very long so they use reversal data as evidence that the earth is old. Often creationists are unfamiliar with the depth and variety of the paleomagnetic data and thus do not know whether the reversals were real or not. Until recently they have generally questioned the credibility of the data. Many have made the same assumption as the evolutionists, that reversals could only take place slowly. In a recent paper (Humphreys, 1986a) I have shown that this assumption is not justified, and that rapid reversals occurring during the Genesis Flood would explain the paleomagnetic data nicely. In this paper I review the evidence for reversals in order to show that it is indeed credible.

Introduction

On an early spring day in 1926, a professor from Kyoto Imperial University removed a block of basalt from a Japanese cave. The professor, Motonori Matuyama, had carefully recorded its orientation before taking it out of its natural position. When he brought a compass needle near the block, he found that the block was magnetized with its north pole pointed southward and upwards, nearly opposite the direction of the earth's magnetic field at that time. Matuyama proceeded to collect over a hundred samples from dozens of sites in Japan and Manchuria. He found that the magnetism of the samples fell neatly into two groups; they were either nearly parallel to the earths present field or nearly 180° opposite to it. Other scientists had reported reversed magnetizations (Brunhes, 1906), but Matuyama examined the site strata more carefully. He noticed that none of his reversed rocks came from layers higher than the lower Pleistocene. He decided that the earth's magnetic field was of opposite polarity than today's field when the lower Pleistocene lava was flowing (Matuyama, 1929), a conclusion that made him one of the founding fathers of the new science of *paleomagnetism*, the study of magnetic fields preserved in the geologic strata.

Since that time hundreds of geoscientists have investigated thousands of sites on land and sea, measuring the direction and intensity of magnetization of thousands of rock samples. In any given formation, the magnetic directions are not usually found to be random; instead they cluster within five or 10° around a particular direction. However, only half of the formations have normal directions. The other half are reversed. There are clear correlations in the sequence of reversed / normal strata from sites all over the world. Recently several sites have been found which record reversal transitions in detail, continuously tracking both direction and strength.

A Conflict of Interpretations

On the basis of these data, paleomagnetists have gradually constructed a picture of the earth's field reversing its polarity at irregular times while the geologic strata were forming. They call this view the *field-reversal hypothesis*, as opposed to the view that other things besides a reversal of the field might have caused the reversed magnetizations. Evolutionists (Dalrymple, 1983) and old-earth creationists (Young, 1982) think of these field reversals as occurring over millions of years. They assume that processes in the earth's core have always been ponderously slow, and that it is physically impossible for the field to reverse itself in less than a few thousand years. They point to *archaeomagnetic* (magnetism of pottery, bricks, campfire stones, etc.) evidence for a steady decrease of the field's intensity for the past 1500 years. The decline, they say, is just another reversal which is taking place right now. They support their interpretation with other archaeomagnetic evidence that the field has not steadily decayed for its entire history: thousands of years before Christ, the field fluctuated and then slowly increased to a maximum before beginning to decrease at about 500 A.D. (Merrill and McElhinny, 1983, pp. 101-6). Also see Figure 1.

The evolutionists' interpretation springs from their *dynamo* theories, which try to show that flows of conducting fluid in the earth's core can generate and sustain the magnetic field for billions of years. These

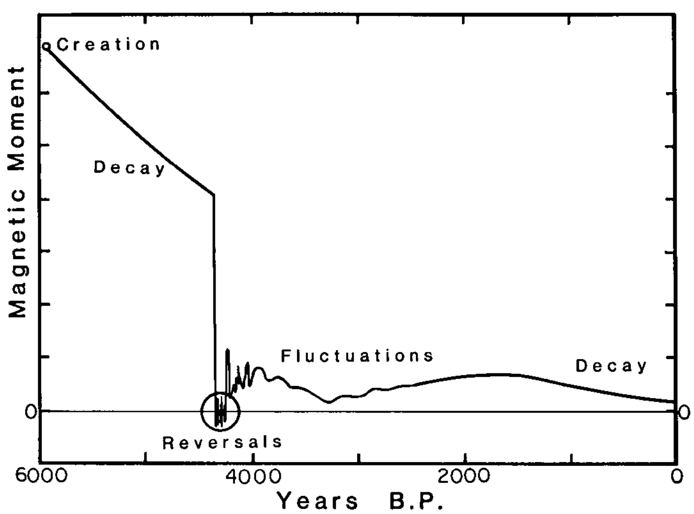


Figure 1. History of the earth's magnetic field, plotted in years before present. By this scenario, the field decayed after its creation, underwent rapid reversals during the Genesis Flood, fluctuated for the next two millenia, and then resumed a steady decay (Humphreys, 1986a).

*D. Russell Humphreys, Ph.D., is a physicist at Sandia National Laboratories, Box 5800, Division 1252, Albuquerque, NM 87185. The Laboratories have not supported this work, and they neither affirm nor deny its scientific validity.

theories are very complex and have problems (Barnes, 1972; Humphreys, 1986a, p. 126; James, Roberts, and Winch, 1980; Inglis, 1981). In contrast, creationists have been developing a much simpler theory, which says that the earths magnetic field is produced by a freely-decaying electric current in the core (Barnes, 1972, 1973; Humphreys, 1983, 1984). Nothing would maintain the current except its own electromagnetic inertia. These fields can last for thousands, but not millions of years. This free-decay theory accounts for the major features of the magnetic fields of the Sun, Moon, Earth, and other planets, whereas dynamo theories have trouble with the same data (Humphreys, 1984, 1986b).

However, critics have pummeled the simple free-decay theory for not taking account of large variations of the earth's field in the past, particularly polarity reversals (Brush, 1982; Dalrymple, 1983; Young, 1982). Until recently the response of many creationists to this criticism has been to discount the paleomagnetic data as being unconvincing (e.g., Barnes, 1972, 1982, 1983, 1984). They seemed to think that field reversals would be incompatible with a young age for the earth. Such thinking makes the very same assumption the evolutionists make: that reversals have to take place very slowly.

Recently I have shown (Humphreys, 1986a) that this assumption is not justified. I showed that rapid reversals are possible according to basic physics, that they are demonstrated by the Sun's presently observed magnetic field reversals, and that a simple mechanism could produce them. In particular, I suggested that strong convection (upwelling caused by heat) in the earth's core could have reversed the earth's field rapidly many times during the year of the Genesis Flood. The reversals I picture would differ from what dynamo theorists imagine: (1) The reversals would dissipate energy, subtracting from the energy in the earth's field rather than adding to it. (2) They would not involve the entire core, but instead only its surface. (3) They would be the result of a single powerful event in the core, rather than a continuing process throughout the history of the field. Figure 1 outlines what I think is the history of the earths magnetic field.

Prior to my paper, young-earth creationists had not done much work toward modifying the free-decay theory, although one letter to this journal opened the question (Montie, 1982). But how convincing is the evidence for reversals? Five years ago I decided to seriously study paleomagnetism and see for myself. I read many books and articles on the subject, spoke with specialists, and gathered samples of my own. Last year I took a graduate-level geology course on paleomagnetism, taught by a recognized expert in that field. It allowed me to get acquainted with the latest laboratory and field techniques, as well as the frank views of an insider on the problems and strengths of paleomagnetic research. I found that the evidence for reversals is much deeper and more varied than I had thought.

Many creationists seem to be as unaware as I was of the massiveness of the data involved. There is some confusion as to exactly what a magnetic field "reversal" is. I will outline the positive evidence for field reversals. Then I will list all of the criticisms of the field reversal hypothesis that I know, along with rebuttals. Finally, I will weigh the various arguments and give my conclusions. This review will not be highly detailed, but it should help an interested reader to get acquainted with the basic ideas and find important references.

A good introduction to the scientific literature is a compilation by Alan Cox (1973) of some of the most important papers from 1929 to 1971, along with interesting introductions and biographical comments. William Glen's history of paleomagnetism, *The Road to Jaramillo* (1982), captures some of the excitement among mainstream earth scientists in the 1960's when paleomagnetism and potassium-argon dating joined to beget a new view of the earth's history, plate tectonics.

What are Reversals?

When a rock forms, either by cooling from a molten state or by hardening of sediments, the earth's magnetic field at the time magnetizes grains of magnetic minerals in the rock, as shown in Figure 2 (Tarling, 1983, pp. 15-75). After formation, the grains resist being remagnetized in other directions. For cooling igneous rocks, this point of resistance happens at a particular temperature called the *Curie* point, which is between 500 and 700°C depending on the mineral involved. A few hundred degrees below the Curie temperature, the magnetization of most minerals is as difficult to change as that of a permanent magnet. For a hardening sedimentary rock, a similar fixation process happens as pressure and heat produce chemical changes. After such processes, the rock has *remanent magnetism,* a magnetic "recording" of the intensity and direction of the earth's field at the time of cooling or hardening. If the field was of reversed polarity at that time and place, we would expect the rock to have a reversed magnetization.

By a field of "reversed polarity," or a "field reversal," I mean simply that a compass needle on the spot at that instant would point south instead of north, about 180° opposite its normal direction. If a magnetic field reversal were to happen today, most creatures would not notice any difference, except for some birds and

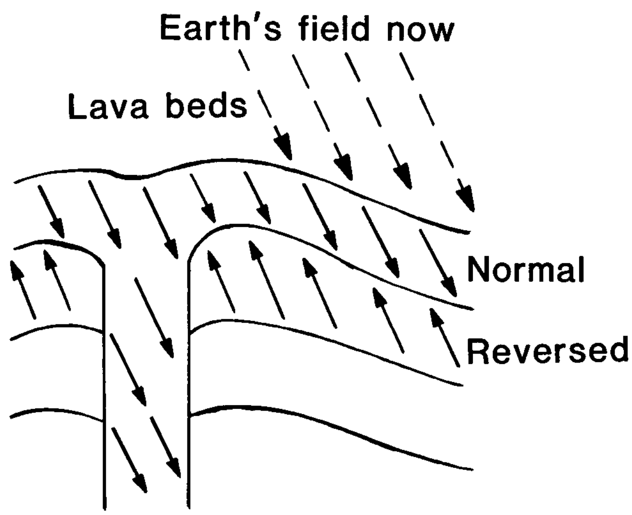


Figure 2. Magnetizations in two successive lava flows. Top flow is magnetized in the same direction as today's field; the flow below is reversely magnetized.

bacteria which seem to navigate by means of the field. The earths rotation axis would not be affected; eskimos would still see the North Star overhead, and the sun would still rise in the east. Gravity would not be affected; we would still weigh the same. But to students of the earths field the difference would be very important, because today there is no place below polar latitudes where the field points south. If at any instant in the past there was just one such place, it would mean that the earth's field at that time was drastically different than it is today.

The existence of a field reversal would not necessarily mean that all of the electric current in the earth's core switched directions. In fact, there are good physical reasons to think that only the topmost layers of the core could participate in reversals (Humphreys, 1986a, pp. 114-6). This would leave the currents and fields in the deeper parts of the core almost unchanged. I have stripped my definition of a field reversal to the minimum. It does not require a massive reversal of all the electric currents in the core. Nor does it require the field to reverse simultaneously over the whole earth.

Evidence for Field Reversals

Here is some of the positive evidence that field reversals have indeed occurred. It is not a complete survey in detail, but rather some general features which I find impressive:

A. Many observations. In the past few decades, there have been countless published studies of reversals. Many of these report thousands of samples measured. As an example of such studies, one survey in Iceland sampled about 900 separate lava flows lying atop one another. The survey team measured the magnetization of over 2000 samples and found at least 60 complete transitions from one polarity to another (Dagley, 1967). This and all of the other studies together represent at least 200,000 measured samples, and possibly as many as a million. Of all the samples measured, about 50 percent are of reversed polarity (the others being normal) (McElhinny, 1973, p. 130). This means that those who would deny the reality of field reversals must explain the existence of anywhere from 100,000 to half a million pieces of rock with reversed magnetization!

B. The variety and extent of the observations. Paleomagnetists have measured fossil magnetism in many different ways and places: igneous and sedimentary rocks, lava flows, clays, lake sediments, deep-sea sediments, cores of rock below the ocean floors, and land and sea magnetic survey profiles. The sea-floor profiles show strong, systematic pattern of deviation from the normal strength of the earth's field, the famous "magnetic anomalies" (Vine and Matthews, 1963; Merrill and McElhinny, 1983, pp. 145-7). Deep-sea drilling cores confirm the existence of reversed polarity rocks in the anomaly regions (Johnson and Merrill, 1978). The anomaly patterns in the Atlantic are roughly symmetric about the mid-Atlantic Ridge. They stretch for 500 km east and west of the ridge, following it south from Iceland nearly 20,000 km, almost to Antarctica. This pattern of "magnetic stripes" thus covers about 2×10^7 km^2 of the Atlantic floor. The other oceans also have anomaly patterns. And although there is much ocean data, *the data from the continents greatly outnumbers the sea floor data* simply because it is easier to gather. Often the land data is of great horizontal extent; it is not unusual to follow a reversed stratum for hundreds of kilometers (McElhinny, 1973, p. 84).

C. The continuity of the observations. Many of the sediment core samples track reversals smoothly from one polarity to the other, in both direction and intensity (Opdyke, Kent, and Lowrie, 1973; Valet, Laj, and Tucholka, 1986). Recently (Bogue and Coe, 1984; Prévot *et al.*, 1985) several continuous lava flows (considered more reliable than sediment studies) have been found which similarly record polarity transitions in detail (Figure 3).

There are many worldwide correlations of unique magnetic events. For example, a thick section of reversed polarity in Carboniferous and Permian strata and a thick section of normal polarity in Cretaceous strata have been seen wherever samples have been taken throughout the world (McElhinny and Burek, 1971). Another example is in deep-sea sediments: all of the uppermost ones show normal polarity, but a few meters downward, they all are of reversed polarity (Tarling, 1983, p. 183). So there appears to be continuity both vertically and horizontally.

Another sort of continuity has to do with the past location of magnetic poles. The inclination (angle of dip from horizontal) and declination (deviation from true north) of a particular sample's magnetization allows the paleomagnetist to calculate roughly where the north (or south) magnetic pole was at the time the sample acquired its magnetization (Figure 4). This is called the *virtual pole* of the site and stratum. The virtual poles of widely-separated Permian sites in North America are within 15° of a particular point in Manchuria (Piper, 1987, pp. 105,301). This agreement among hundreds of sites thousands of miles apart is difficult to explain without all the Permian rocks in North America being (a) laid down at about the same time, and (b) magnetized by the same large-scale field. The virtual poles from other strata in North America center on other paleomagnetic pole locations, or *paleopoles.* Plotting the North American paleopoles in sequence from Permian to Pleistocene shows them following a continuous path, the *polar wander path,* which winds its way from Manchuria to the present north geographic pole (Piper, 1987, p. 302). Polar wander paths from the other continents are similarly continuous.

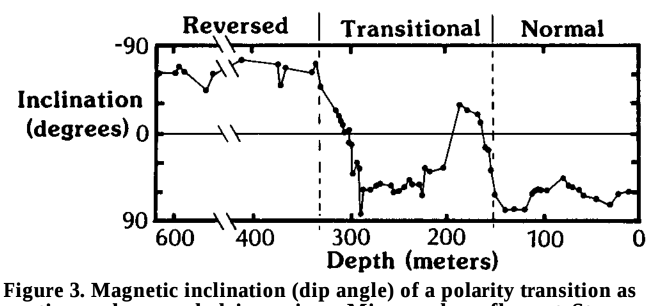


Figure 3. Magnetic inclination (dip angle) of a polarity transition as continuously recorded in a singe Miocene lava flow at Steens Mountain, Oregon (Prévot *et al,* 1985). Declination (deviation from north) and intensity were also measured and also were found to track continuously through the transition. The intensities in the section labeled "transitional" were considerably lower than those in the other two sections.

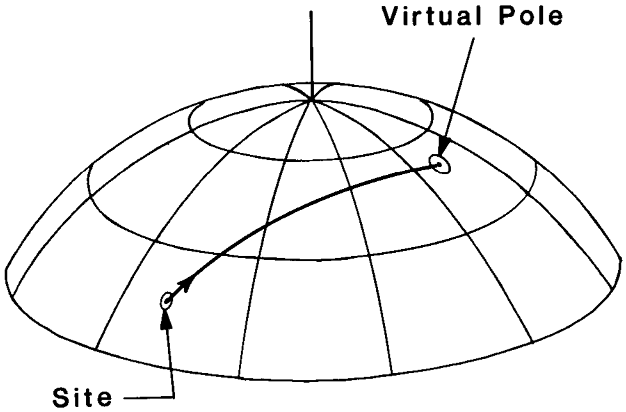


Figure 4. Virtual magnetic pole of a site, determined by the declination and inclination of magnetization at the site. The virtual magnetic poles of most Permian sites in North America are within 15° of a point in Manchuria, the Permian paleopole for North America.

D. The consistency of the observations. Many careful geological studies have been done to check the validity of the field reversal hypothesis, and the results are consistently in favor of the hypothesis. As just one example of such a study, let us consider a survey of rocks heated by lava (Merrill and McElhinny, 1983, pp. 137-9). The purpose was to find out how many rocks could have reversed the polarity of their magnetizations by themselves—self-reversal instead of field reversal (see point 1, next section). When lava intrudes into cracks in rock, it bakes the region around the intrusion. Since the baked rock and the lava cool over approximately the same period of time, they should both acquire magnetization in the same field. Usually the intrusion and baked zone are quite different types of rock. If self-reversals can occur in many types of rock, we would expect to find self-reversing types next to non-reversing types fairly often. In that case, the magnetization of baked zones should frequently be opposite to that of the intrusions. But if self-reversing rocks are rare, most of the baked zones should have the same direction of magnetization as the intrusion (Figure 5). In a survey of 157 such sites, only three had a difference between the baked zone and intrusion magnetizations (Wilson, 1962; McElhinny, 1973, pp. 110-1). This indicates that self-reversals are infrequent, and that most of the reversed-polarity magnetizations we find are from true reversals of the earth's magnetic field.

Even the three discordant cases may be explainable by something other than self-reversal. The Curie temperatures of rocks can differ by as much as a few hundred degrees. In such a case, the baked zone and intrusion would cool through their Curie points at different times, possibly a few days apart. If reversals occurred every week or so, as I suggested in my rapid-reversal hypothesis, then in such situations the two sides of the boundary could have an opposite magnetization. This would be extremely unlikely if reversals took millions of years, but it would happen occasionally if the reversals occurred rapidly. Thus, if chemical and mineralogical studies could eliminate the possibility of self-reversal, the three discordant sites could be evidence for rapid reversals.

However, the main point is that 98 percent of the sites had concordant magnetizations. A reviewer of the work concluded:

> On the basis of the present data, it appears that, at most, one percent of the reversals in igneous and baked rocks are due to mineralogically controlled self-reversals. The evidence in favor of the field-reversal hypothesis is overwhelming (McElhinny, 1973, p. 111).

Criticisms and Answers

In the following sections I have listed all of the criticisms against the field-reversal hypothesis I have been able to find. The leading critic among creationists has been Dr. Thomas Barnes, so I will be citing him frequently. (Even though his views about reversals may be wrong, I think Barnes is correct in asserting that the decline of the earth's field is a free decay, and I respect him for being the first to say so.) Many textbooks on geomagnetism give fairly careful consideration to the validity of the field-reversal hypothesis. A recent one (Jacobs, 1984) is readable, concise, and yet reviews a lot of data on both sides of the question. Another new book (Merrill and McElhinny, 1983) is a good survey of geomagnetism in general, although it is more one-sidedly in favor of field reversals. For more details on methods, an older book (McElhinny, 1973) is good, as are several more recent ones (Collinson, 1983; Tarling, 1983).

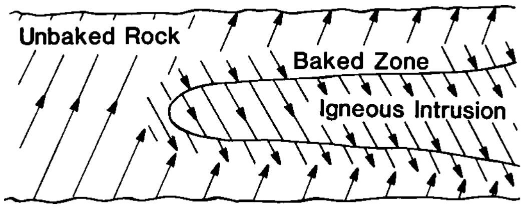
1. Self-Reversals

Criticism: Self-reversals can occur. A French physicist (Neel, 1955) proposed four theoretical ways a rock might show magnetization opposite to the field causing it (Barnes, 1972, p. 49). All of the mechanisms he postulated involve rocks having a particular mixture of two widely different magnetic minerals (Tarling, 1983, p. 182). Some rocks of this type which actually can self-reverse have been synthesized in the laboratory and a few have been found in nature (Nagata, 1952; Ishikawa and Syono, 1963). Recently, rocks of this general class, titanohematites, were found to be somewhat more common than previously thought (Weisburd, 1985).

Answer: Self-reversals are rare. Only a small percentage of natural rocks have the precise proportions of certain magnetic minerals required by Professor Neel's theory (Jacobs, 1984, p. 32; Merrill and McElhinny, 1983, p. 137). Even in the article about titanohematites, Weisburg acknowledged that ". . . magnetite, a material that records the earth's field with great fidelity, was shown to be the dominant magnetic carrier in rocks" (p. 235), and again that there are "relatively few findings of self-reversing minerals in lava beds" (p. 236). Moreover, there is good geological evidence [see (D) and Figure 5] that self-reversals account for less than one percent of the reversal data.

2. Peculiarities in Data

Criticism: Reversals in odd places. Barnes (1972, p. 49) quotes an early book by J. A. Jacobs (1962, pp. 105-6): "all rocks of Permian age have normal polarity." Barnes thought that it was inconsistent that the field might fail to flip only during the time Permian rocks were being laid down. Barnes also quoted a comment by Jacobs (1962, pp. 105-6) that surface lavas along the Japanese coast were normally magnetized in some areas and reversely magnetized in other areas close by. Jacobs apparently felt that the lavas flowed too closely



Baked Zone	N	R	I	R	N
Intrusion	N	R	I	N	R
Number	47	104	3	3	0

Figure 5. Igneous intrusion test for self-reversals. The intrusion bakes a zone around it; when both cool down they are magnetized by the field at the time. If self-reversals are rare, the baked zone and intrusion should have the same magnetization direction in most cases. The table shows the results of a survey of intrusions and baked zones (Merrill and McElhinny, 1983, p. 138). The letters show the polarities of each zone: N = normal, I =intermediate, R = reversed. In only 3 out of 157 cases were the polarities of baked zone and intrusion different, thus indicating that self-reversals are rare.

together in time to record a field reversal taking millions of years to occur, so he raised the question of reversal by other means.

Answer: Peculiarities support field reversals. Since 1962, changes of polarity have been found in Permian rocks, and the most predominant polarity is *reversed* (McElhinny and Burek, 1971; Collinson, 1973, p. 339), not "normal," as Jacobs reportedly said. It is true that Permian layers have considerably less than the average number of polarity flips. Paleocene layers, on the other hand, have considerably more (McElhinny and Burek, 1971). Yet on the average, Permian rocks are not known to be chemically or physically different from Paleocene rocks. The two strata, like all others in the fossil column, differ only in the type of fossils they contain, as creationists have been saying for years (Whitcomb and Morris, 1960, p. 131-5). Therefore it is difficult to explain such a globally consistent difference in the frequency of reversals in the two layers by an internal chemical or physical difference. It is easier to imagine an *external* factor, such as change in the frequency of reversals of the earth's field, or a change in the deposition rate of the strata. As I have pointed out (Humphreys, 1986a, pp. 117-8), the apparent changes in reversal frequency with depth in the fossil column correlate very nicely with inferred changes in sedimentation rate from stratum to stratum. Thus the peculiarities Barnes thought were inconsistent with the field reversal hypothesis actually strongly support it.

As for the lava flows in Japan, it is conceivable that reversals took place much faster than Jacobs thought possible. Then two lava flows could occur within a short time and yet have different magnetizations. McElhinny (1973, pp. 129-30) reported a fair number of "mixed" results, that is, both polarities found within the same formation. Mixed polarities would result whenever different parts of a formation cool or solidify at different times during a reversal. Again, this kind of data could be direct evidence for my rapid-reversal hypothesis (Humphreys, 1986a, p. 121).

3. Magnetization by Lightning

Criticism: Lightning can cause reversed polarities. The large electric currents spreading from a lightning strike can magnetize rocks for many meters around the point of impact. Many points near the strike will then have abnormal polarities (Barnes, 1972, p. 49).

Answer: Lightning affects only small areas. A lightning strike causes random remanent magnetization (in all directions) over just a few square meters. Therefore, it cannot explain the consistent (directions within 5 or 10° of one another) reverse magnetization usually observed on land over many square kilometers (McElhinny and Gough, 1963). Also, paleomagnetists make strenuous efforts (such as drilling deep below the surface of an outcrop) to select samples from locations less susceptible to lightning strikes (McElhinny, 1973, p. 70).

4. Mechanical Stress

Criticism: Stress can disturb magnetizations. Barnes (1972, pp. 49-50) quotes an article saying that mechanical stress on a rock could disturb the direction of its magnetization (Doell and Cox, 1967).

Answer: *Stress does not reverse directions.* In the article Barnes quoted, Doell and Cox consider the possibility that mechanical stress might perturb the direction of magnetization a few degrees. But then they cite (p. 453) an experiment (Stott and Stacey, 1959) which found no such perturbation. No one has ever suggested that stress could completely reverse the magnetization 180° except perhaps in the rare class of rocks that Née1 postulated (point 1).

5. Tectonic Rotations

Criticism: Folding can turn rocks. Upheavals and folding in the earth's crust could physically turn a rock so that its magnetization no longer points in the direction of the field that formed it. A normally-magnetized rock could then appear to be of reversed polarity (Barnes, 1972, p. 50)

Answer: Folding is usually obvious. Any folding or faulting which would turn a south-pointing rock northward would usually affect the entire stratum. The signs of such processes are usually plain even to non-geologists, and magnetic stratigraphers are careful to note such signs, and in fact use them as a test of the stability of magnetizations (McElhinny, 1973, p. 88). At best, only a small percentage of the land-based data could be explained this way.

6. Theories

Criticism: Dynamo theories are incomplete. Barnes correctly points out that evolutionists have no rigorous theory explaining how the earth could have reversed its field (Barnes, 1972, p. 50). If there were no theory to explain the data, the data would be more open to question.

Answer: Creationist reversal theories are possible. The lack of a good evolutionist theory of reversals is not a strong argument against the reality of the reversals. After all, evolutionists do not have a rigorous theory for the main features of the present field, and yet we know the field exists. And, as I have mentioned above, we have the beginnings of a creationist theory of reversals (Humphreys, 1986a).

7. Archaeomagnetic Data

Criticism: Intensity measurements have errors. Barnes (1984, p. 112) cites a Russian compilation of archaeomagnetic measurements (from pottery, etc.) of field intensities at particular localities (Burlatskaya, 1967). He compares these to historical measurements of the earth's magnetic dipole moment over the past 150 years. The *dipole moment* is a measure of the overall strength of the earths magnet; it is best to calculate it from a number of simultaneous measurements all over the globe. Eleven of the 14 archaeomagnetic measurements are within 10 percent of the historical measurement curve, two are within 20 percent, and the last is within 40 percent. Barnes (1984, p. 112) asserts that the discrepancies mean that the archaeomagnetic data are "meaningless."

Answer: Directions are more reliable than intensities. The Russian archaeomagnetic measurements actually appear to be fairly accurate. Intensity measurements at particular locations should differ from the average expected intensity by 10 percent or so, since the intensity of the earths present field can differ by more than that amount from point to point along a given magnetic latitude line. Moreover, the general trend of the archaeomagnetic data for the past 1500 years (Merrill and McElhinny, 1983, pp. 101-6) confirms the decay Barnes pointed out in the historical measurements of the past 150 years. Thus, archaeomagnetic (post-Flood) intensity measurements seem to be fairly reliable. Since (by the young-earth hypothesis) the paleomagnetic (during-Flood) data are only a few thousand years older, one would expect them to be nearly as reliable.

However, the evidence for reversals depends on 180° *direction* changes, not on intensities. One could easily imagine mechanisms whereby magnetizations in rocks could become less intense with the passage of time or by the application of heat and mechanical stress. But directions are harder to change. Barnes (1972, p. 49) himself mentioned an archaeomagnetic study which found good agreement between directions of magnetization in French bricks and actual observations in London and Paris going back to the year 1540 A.D. (Chapman and Bartels, 1961, pp. 135-6). This indicates that paleomagnetic methods are reliable enough to establish the 180° direction changes in reversals.

8. Opinions of a Paleomagnetist

Criticism: An expert had doubts. Barnes (1972, p. 49) quotes a summary of the work of Emile Thellier, a pioneer in paleomagnetism: "[Thellier] concludes that the permanent magnetization of rocks is ill-defined, and gives no safe basis on which conclusions can be arrived at" (Chapmen and Bartels, 1961).

Answer: The expert changed his mind. Chapman and Bartels were summarizing Thellier's thesis, published 50 years ago (Thellier, 1938). Thellier went on to do more research in paleomagnetism for nearly 30 more years. I was not able to get a copy of his thesis, but his opinions later were considerably different from the ones Chapman and Bartels reported. In a 1959 article Thellier reported his measurements of the intensity (not just direction) of the earth's field in the geological past, and he drew conclusions about the past state of the earth's magnetism, in contrast to his reported opinion in 1938. In 1966 Thellier wrote the following about reversals of the earth's magnetic field: "The phenomenon [reversals] that we have described as the first conquest of paleomagnetism remains perhaps the most clear and the most certain of its acquisitions" (Thellier, 1966, p. 180, my translation). So even if Chapman and Bartels correctly summarized Thellier's earlier opinion, it would still only represent the ideas of a graduate student half a century ago. A lot of techniques, such as magnetic "cleaning," were invented after 1938 (Collinson, 1983, pp. 308-59). Thellier's mature opinions should be given more weight than what he thought as he was just beginning his work.

9. Seafloor Magnetometer Surveys

Criticism: Some geologists doubt interpretations. Barnes quoted two geologists' conclusions about seafloor magnetic data: "The so-called magnetic anomalies are not what they are purported to be—a 'taped record' of magnetic events during the creation of the new ocean floor between continents" (Meyerhoff and Meyerhoff, 1972, p. 337).

Answer: The geologists did not deny field reversals. In the article quoted, the Meyerhoffs did not deny the existence of "magnetic anomaly" patterns on the ocean floor, nor did they deny that reversed rocks beneath the floor are probably causing the anomalies. The main thing they were denying was the assertion of plate tectonics theorists that the anomalies are relatively recent: "The main purpose of this paper is to show that the magnetic anomalies are not young features of the ocean basins, and thereby to stimulate new ideas" (p. 337). They stated: "Our conclusion is that the magnetic anomalies are caused by differences in magnetic susceptibility and *by magnetic [field] reversals*" (p. 355, italics mine).

10. Deepsea Drilling Cores

Criticism: Seafloor magnetic data is complex. Studies of seafloor magnetism in the 1970's and 1980's have shown that the magnetic anomaly patterns are actually much more complex than the popular science literature of the 1960's indicates. I have not seen this point mentioned in creationist writings, but it surfaces frequently in verbal discussions. The gist of it seems to be an implication that since the data is complex, it is somehow invalid.

Answer: Seafloor data supports rapid reversals. Deep-sea drilling of the ocean crust in anomaly regions has produced core samples which directly confirm the existence of reversed magnetizations (Johnson and Merrill, 1978; Dunlop and Prévot, 1982). A recent study typifies the large amount of work that has been done in this area (Smith and Bannerjee, 1987). The main confusion is that the drilling has not found nice uniform layers of reversed and normal magnetization such as are found on land. Instead the data suggests that the ocean crust is a hodgepodge of rocks of different polarities, very localized both vertically and horizontally, perhaps on a scale of meters (Figure 6). The area under the anomaly regions would thus have simply a higher percentage of reversed rocks than non-anomaly regions.

Evolutionists have difficulty with this data, since they picture the rocks cooling much faster then the assumed thousand or million-year reversal periods. According to their picture, they should find uniform layers of magnetization. However, if the rate of re-

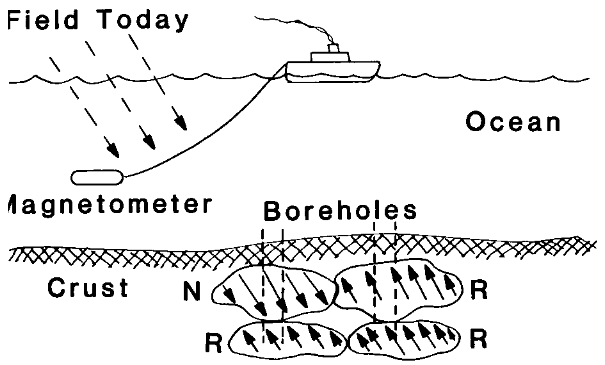


Figure 6. Seafloor magnetizations. Towed magnetometers show strong reductions in the intensity of the earth's magnetic field in "magnetic anomaly" regions. Deep-core samples from the oceanic crust show the existence of reversely-polarized rock beneath the anomaly regions, not in uniform layers, but in a highly localized hodgepodge of reversed and normal rocks.

versals were high, about the same as formation and cooling rates of the new basalt in seawater, much spottier patterns would occur. Imagine two pieces of basalt, A and B, each a meter in diameter, formed at the mid-ocean ridge on a Sunday morning during the Flood. Piece A has more seawater circulating by it and cools through the Curie temperature on Monday, when the field is of normal polarity. On Wednesday, the field reverses direction. By Friday piece B, being right next to A but less exposed to water, finally cools through the Curie point and records a reversed magnetization. Thus we could have two pieces of rock side by side with opposite polarities, But since piece B is more typical of the general area, the overall magnetization is in the reversed direction. Thousands of years later, magnetometers towed over the area record a lower-than normal magnetization. Thus a creationist view of rapid reversals and rapid formation of ocean crust during the Flood can explain this data.

11. Chemical Correlations

Criticisms: Oxidation may correlate with reversals. Barnes did not mention this point, but it has been discussed in mainstream literature. In some locations the iron compounds in reversely magnetized lava appear to be more highly oxidized than in normally magnetized lava (Jacobs, 1984, pp. 34-7). If events in the core (producing the field) were not connected with physical conditions in the crust or atmosphere (producing the oxidation), then the chemistry of the lavas might have caused the reverse magnetization.

Answer: *The Flood could cause correlations.* Further studies in other locations have shown that the correlations of oxidation and magnetization are not found in many places (Watkins and Haggerty, 1968; Kristjansson and McDougall 1982), and some scientists take issue with the correlation, calling it an artifact of the data analysis (Larson and Strangway, 1966; Merrill, 1975). Jacobs (1984, pp. 35-7) reviews both sides of the controversy. However, if there is a correlation, it might be understandable from a creationist standpoint. It is suggested that the Genesis Flood apparently affected the earth's core (Humphreys, 1986a, pp. 117-8, 125-6; Humphreys, 1978) as well as events on the surface of the earth. If the reversals happened during the Flood, it is quite possible that some lava flows could be synchronized with the field reversals.

Conclusion: Weighing the Evidence

Let us consider what evidence we would need in order to say that a field reversal has taken place. In the second edition of his book, Barnes lists criteria which must be met in order to evaluate the earth's dipole moment in the past: we must have accurate intensity and direction measurements from a large number of points over the whole globe, and these must be known to be nearly simultaneous compared to the decay time of the field (Barnes, 1983, p. 124). While this may be possible (in principle) for the archaeomagnetic data, it is much more difficult for the paleomagnetic data, since there are many reversals recorded in the fossil column. Thus, estimates of the dipole moment at various times during the Flood may not be very accurate.

Barnes' criteria are much more stringent than what is needed. We do not need to know the overall dipole moment of the earth at various times to prove that a field reversal has occurred, especially not one of the limited kind I defined in the third section. We need neither intensities, nor very accurate directions, nor simultaneous data from many locations. All we need is evidence that the field at just one point on the earth, at just one instant in the past, was roughly opposite to the normal direction.

Do we have such evidence? Let us consider the criticisms first. Points 2 through 9 of the critique have fairly straightforward answers. Point 10 also seems answerable, although much research remains to be done on the sea floor anomalies. However, one could completely dismiss the seafloor data without doing much damage to the case for reversals. The few occasions of "mixed" polarities (point 2) are explainable in terms of my rapid-reversal hypothesis, and in fact, support it. In my opinion, the most serious criticisms were number 1, the possibility of self-reversal, and number 11, the correlation of oxidation with reversals in some rocks. Theory, laboratory experiments, and geological data all indicate that self-reversing rocks are rare. The correlations are also rare (and disputed), but if they exist, there is a possible creationist explanation for them which allows the existence of field reversals. So it seems to me that we have sufficiently good answers to all critiques.

The positive evidence is strong. If just one of the more than 100,000 reversely-magnetized samples reported was really made by a reversed field, it would prove that a limited reversal has occurred. If the reversely-magnetized samples were only a small percentage of all the samples taken, there might be grounds for suspicion. But fully *half* of all geologic samples having a measureable magnetization are of reversed polarity. The variety, extent, continuity, and consistency of the reversal data all strongly suggest that most of the data is valid, far more than the one genuine sample we need. Therefore, I conclude that polarity reversals of the earth's magnetic field have indeed occurred. We need to understand them.

Acknowledgement

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QUOTE

It is to be remembered that the facts are from God, the explanation from men; and the two are often as far apart as Heaven and its antipode.

These human explanations are not only without authority, but they are very mutable. They change not only from generation to generation, but almost as often as the phases of the moon. It is a fact that the planets move. Once it was said that they were moved by spirits, then by vortexes, now by self-evolved forces. It is hard that we should be called upon to change our faith with every new moon. The same man sometimes propounds theories almost as rapidly as the changes of the kaleidoscope.

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