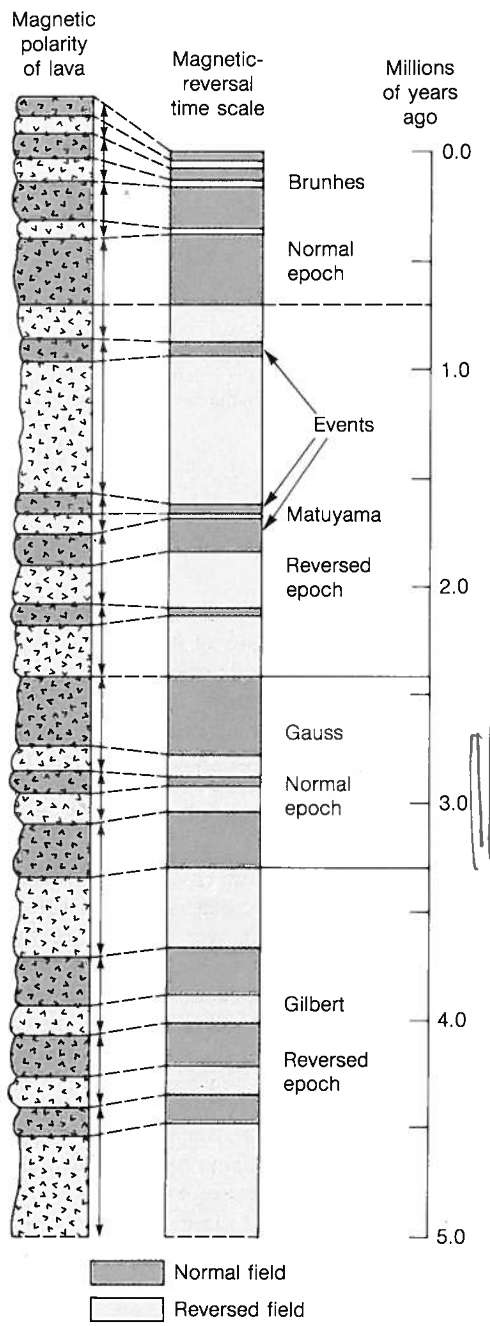

Figure 18-14
Schematic illustration of how magnetic polarities of lava flows are used to construct the time scale of magnetic reversals over the past 5 million years. In no one place is the entire sequence found; the sequence is worked out by patching together the ages and polarities from lava beds all over the world. The radiometric-magnetic time scale has recently been extended to 7 million years.

stratigraphy—can be deduced. The history of reversals going back almost 7 million years has been worked out in this way (Fig. 18-14). It has been found that about half of all rocks studied are magnetized opposite to the Earth's present magnetic field, which implies that the field has flipped frequently over geologic time and that normal and reverse fields are equally likely. Although normal and reverse **magnetic epochs** (each of which is named after a famous magnetician) seem to last on the order of one-half million years, superimposed on the major epochs are transient, short-lived flips of the field, known as **magnetic events,** which may last anywhere from several thousand to 200,000 years. The Australian graduate student mentioned earlier apparently found a new reversal event within the present Brunhes normal epoch.

Just why the field reverses is unknown. We are even uncertain whether the field dies down and builds up again in the opposite direction or simply tilts over. The simple self-exciting dynamo can have either polarity, and perhaps this indicates that the Earth's internal dynamo is easily changeable.

Some specialists on the microfossils of the sea floor have reported a curious correlation between extinctions of certain faunal types and reversals of the field. It is a matter of some concern if the disappearance of certain organisms is related to polarity changes. One explanation that has been advanced is that penetration to the Earth of lethal cosmic rays may be increased when the geomagnetic field is near zero. Most cosmic rays, however, are absorbed by the atmosphere rather than deflected by the magnetic field, so that the effect on life is likely to be small. Perhaps the constituents of the microfauna somehow depend on the magnetic field in their internal biochemical reactions. Perhaps an external common cause, like a large meteorite impact, affects both the fauna and the field. Perhaps the correlation is spurious.

Although the cause of reversals remains for future scientists to explain, their occurrence has made possible an important discovery about the sea floor.

The Sea Floor as a Magnetic "Tape Recorder." During World War II, extremely sensitive airborne magnetometers were developed to detect submarines by their magnetic fields. With slight modification, these same instruments were adopted by oceanographers for towing behind their research ships. Used in this way, the magnetometers measure two things: the main planetary or geomagnetic field (see Fig. 18-5) and the local magnetic disturbance, or **magnetic anomaly,** due to magnetized rocks on the sea floor. The general, broad geomagnetic field could easily be subtracted, leaving a record of a highly variable magnetic anomaly originating in the magnetized rocks beneath the sea. Rocks strongly magnetized in the normal direction would show as a positive anomaly; reversely magnetized rocks would show as a negative anomaly.

Steaming back and forth across the ocean, sea-going scientists discovered amazing magnetic anomaly patterns like the one shown in Figure 18-15. In many areas, the bands of positive and negative magnetic anomalies are linear over hundreds of miles and show an almost perfect symmetry with respect to the central magnetic anomaly. The axis of symmetry coincides with the crest of the mid-ocean ridge. If one folds a map of such anomalies along the ridge axis, he will find that the magnetic bands on one side fall nearly on top of those on the other side, almost like the ink-blot pattern of a Rorschach test. Figure 18-16 shows a magnetic profile across a ridge, which illustrates these features in greater detail. Note the amazing correspondence of the sequence of peaks and troughs of the magnetic-anomaly curve on both sides of the ridge.

This peculiar magnetic pattern puzzled scientists for several years until 1963, when two Englishmen, F. J. Vine and D. H. Mathews, and, independently, two Canadians, L. Morley and A. Larochelle, made a startling proposal. They reasoned that the positive and negative magnetic zones correspond to bands of rock on the sea floor that were magnetized during ancient episodes of normal and reversed magnetism of the Earth's field, and that the magnetic stripes could be used as evidence in support of the theory of

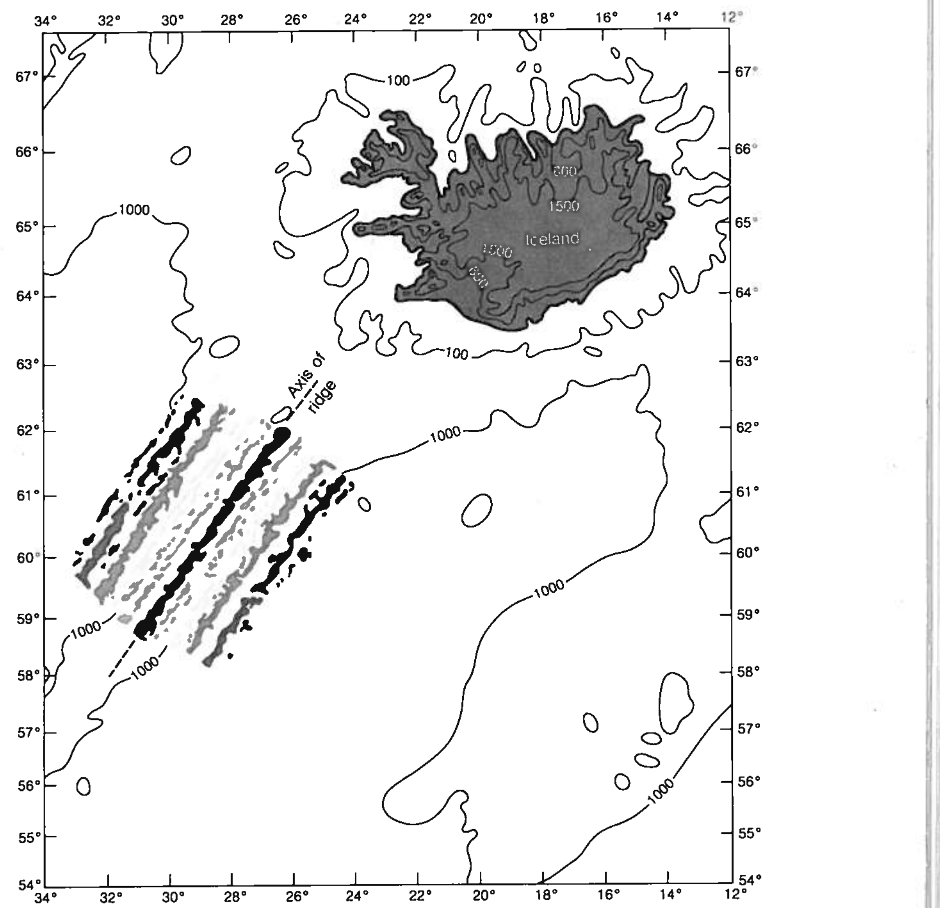

Figure 18-15
Magnetic anomaly pattern associated with the Reykjanes Ridge, a part of the mid-Atlantic ridge southwest of Iceland. The white spaces correspond to rock formations on the sea floor that are reversely magnetized. The strips shown in tones of brown or gray correspond to normal magnetization—that is, similar to the present-day direction. The almost perfect symmetry with respect to the ridge axis is emphasized by the matching tones on opposite sides; the youngest rock is brown and the oldest black, in accordance with the hypothesis of sea-floor spreading. [After "The Origin of the Oceanic Ridges," by E. Orowan, Copyright © 1969, by Scientific American, Inc. All rights reserved.]

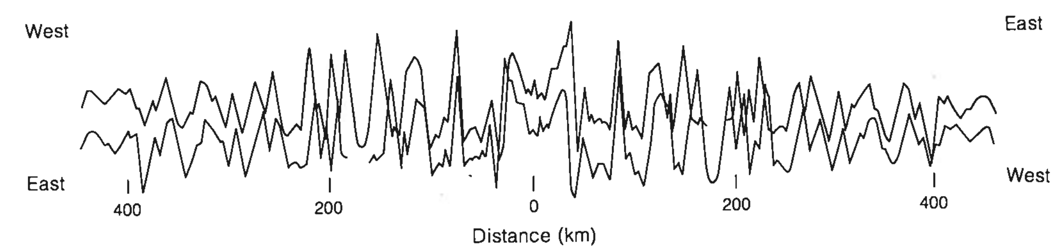

Figure 18-16
Symmetry of the magnetic anomaly of sea floor rocks on both sides of the ridge axis is demonstrated by reversing a record covering about 900 km of both flanks (brown) and superposing it on the record as ordinarily shown (black). [After "Sea Floor Spreading" by J. R. Heirtzler. Copyright © 1968 by Scientific American, Inc. All rights reserved.]