Geomagnetic and Reversal of Geomagnetic Fields excerpt from Core Publishing ISBN 0-9690-4410-0 1980

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Michael Csuzdi devoted a great deal of his life in private research studying weather and geophysical phenomena. He applied electrical engineering theory to explain super nova storms; cyclones and anticyclones; earth currents, geomagnetic fields and their reversal; and finally displacement of the continents.

These physical phenomena he concluded were all based on the well observed flow of electrons from the earth's molten magma core out to space. This thermionic emission he fully modeled with the well established equations related to electrostatic charge and vacuum tube technology. He concluded it is the immense volume of the earth's combined oceans and continents that makes these small electrical forces of nature grow exponentially into the force of nature of our planet. In later years he applied the same mathematical modeling to explain the continental positions on the earth's moon and the planet Mars based on observed data of the time.

His body of work based on thermionic emission is best understood by the pure physics community rather than the geophysics community that has consistently applied mechanically oriented explanations to observations on Earth. This has limited it's understanding and acceptance. This need not be the case as the concepts and equations are straight forward and easily understood with an open scientific mind.

You have entered this web page based on a key word search that is tied to a subject and explained by Michael Csuzdi's theories. It is hoped that the following chapter taken from this published work with spark interest in the proposed explanation and drive curiosity in reading the complete document. Only then can the wholeness of his thermionic emission theory be fully realized as complete and scientifically accurate.

The goal of this website is to drive further independent review and scientific debate on the theories proposed by Michael Csuzdi. If they can be corroborated then the potential for better weather prediction, earthquake prediction and an unlimited source of clean energy harvesting could be realized.

Please feel free to share any of these documents and links with others as you see fit. The more review and dialogue the better.

6. Generation of the Geomagnetic Field.

Electric current flowing in a wire loop generates a magnetic field whose axis is coincident with the axis of the loop. If a wire loop were placed on the Earth along the equator with the electrons flowing in the direction of the Earth's rotation, the generated magnetic field would be of the same polarity and almost the same shape as those of the geomagnetic field. The Earth's magnetic field has a flux density, B, of about 5×10^{-5} tesla, and this can be generated according to Ampere's law by a single wire loop with a current of

$$I = 2 R B / \mu_o \qquad (6\text{-}1)$$

With a radius of R = 6370 km the required current, I, is 5.07×10^8 amperes. (As an approximation, I assume the overall permeability of the Earth and its environment as equal to that of a vacuum, $\mu_o = 4\pi \times 10^{-7}$ weber/ampere/metre). However, to produce and maintain such a current, a driving voltage and a corresponding constant energy input are required. There are no indications for the existence of the very large voltage gradient and for the very great energy conversion which are necessary for this process in the very lossy material of the Earth. Thus, this mechanism can not work in this form.

R.H. Rowland demonstrated that by mechanically moving free electrons on a circular path, the same magnetic field can be generated as if the electrons were moving in a wire, in the form of an electric current, driven by a voltage.

> "In 1875, Rowland suspended a magnetic needle below a rapidly rotating charged ebonite disc and observed that the needle was deflected. When the rotation of the disc was reversed, the needle was deflected in the opposite direction. Thus a rapidly moving electrostatic charge has a magnetic effect similar to that of an electric current." [34]

Thus, if a number of negative charges (free electrons) were infused in the surface layer of the crust along the equator, the rotation of the Earth would carry them around in a circular path identical to a wire loop. This generates an identical magnetic field to that of the wire loop, but no voltage and no energy input are required, because the electrons are not moving with respect to the molecules of their environment, and do not lose their velocity in friction. This field exists as long as the electrons are there and the Earth rotates. Permanent magnets produce and maintain their magnetism without a constant energy input for an indefinitely long time since their identically aligned orbital electrons rotate in a lossless environment.

The number of electrons necessary to be present in the equatorial crust to produce the magnetic field, can be calculated. To produce 1 ampere current, it is necessary to move 1 coulomb charge (6.4×10^{18} electrons) over a conductor in 1 second. The above calculated 5.07×10^{8} amperes require 3.24×10^{27} electrons to move around in the loop in 1 second. But it takes 24 hours (86,400 seconds) for the Earth to turn once, thus 86,400 times more electrons, 2.80×10^{32} , are needed to produce the same current and its resulting magnetic field. In this form the electrons would be distributed evenly along the 40,000 km length of the equator with a density of 7.0×10^{27} electrons per metre while co-rotating with the Earth.

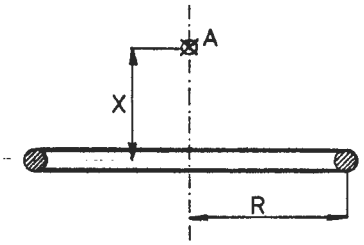


Figure 6-1

The above calculation is only the first approximation to this problem. Equation (6-1) gives the magnetic flux density at the centre of the loop which corresponds to the centre of the Earth in the case of the equatorial electron belt. The quoted flux density of 5×10^{-5} tesla is observed at the surface of the crust, 6370 km from the centre of that loop. Equation (6-2) is a modified version of (6-1), and gives the required current for flux density B at a distance X from the centre of the loop along its axis (Figure 6-1).

$$I = \frac{2\,B}{\mu_o} \frac{(R^2 + X^2)^{\frac{3}{2}}}{R^2} \qquad (6\text{-}2)$$

In this case the required current is 1.43×10^{9} amperes, and the corresponding amount of electrons in the equatorial belt is 7.93×10^{32} .

Further improvement in the calculations is achieved when we consider an even distribution of free electrons over the entire surface of the Earth instead of that single belt along the equator. This is equivalent to a large number of wire loops placed parallel to the equator which cover the entire surface of the Earth from pole to pole (Figure 6-2). The magnetic flux generated by each loop at the observation point A is calculated, and all the results are added

together. Equation (6-2) is solved for B, and I = Q/t is substituted in Equation (6-3). This equation can be used for numerical integration.

$$B = \frac{\mu_o}{2\ t}\ Q\ \frac{R^2}{(R^2 + X^2)^{\frac{3}{2}}} \qquad (6\text{-}3)$$

In this case the total number of electrons required in the crust is 4.22×10^{32} to produce 5×10^{-5} tesla flux density at 1 metre above the surface of the ground. The shape of this magnetic field is now the same as that of the geomagnetic field (except for certain irregularities in the latter).

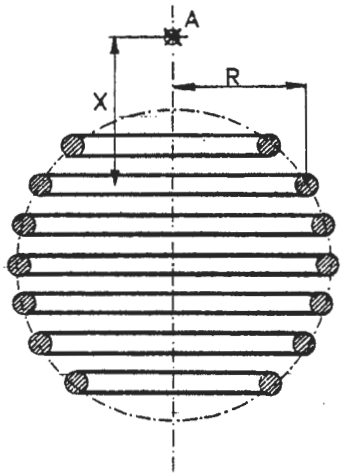


Figure 6-2

The basic idea that the geomagnetic field is generated by negative charges co-rotating with the Earth became evident by the end of the 19-th century, after Rowland demonstrated that mechanical rotation of charges produces a magnetic field similar to that of an electric current. However, it also became evident that the required amount of electric charge would also produce an enormously strong electrostatic field, 2×10^6 volts/metre, over the surface of the Earth, for which there is no evidence. Then, in 1900, W. Sutherland proposed that

> "...if for the moment we imagine the equal and opposite electric charge gathered at the center, it would completely neutralize the electrostatic field due to the surface charge, while being at the center it would fail to affect the magnetic field of the surface charge. Thus by this extreme case we furnish ourselves with an ideal model of the Earth's magnetic field as produced by the rotation of a powerful internal electrostatic field, the magnetic field outside the Earth would be the only external evidence of the existence of the electrostatic field within." [35]

This is a perfectly reasonable assumption, and it is in a complete agreement with the laws of electricity. Furthermore, as Sutherland also suggested, the equal and opposite (positive) charges do not have to be at the centre in order to neutralize the external electric field. If the positive charges have a non-zero rotational radius, they also generate a magnetic field, but its polarity is opposite to that of the field of the negative charges. The only requirement is that the average rotational radius of the positive charges be somewhat smaller. In this case the observable external field is the difference of the two, and since the field due to the negative charges is greater, the polarity of the difference field has the polarity of this field. However, neither Sutherland nor anyone else has suggested any powerful reason, or produced any evidence that charges are actually separated radially, let alone that charges do exist inside the Earth at all. As a consequence, Sutherland's proposal fell into disfavour. Instead, the principle of self-exciting magnetohydrodynamic generator became the target of investigation ever since J. Larmor, in 1924, proposed it, even though much less evidence supports this.

The apparent lack of evidence for the Earth's internal charges, and for their radial separation, has several reasons. The first is the observations by scientists during the early years of electricity, in the seventeenth and eighteenth centuries, that materials are either conductors or insulators. Accordingly, insulators would not carry, or contain, electric charges. This notion has been extended to the free electron after its discovery as the representative of the negative charge. To account for electrical phenomena in insulators the concept of polarization is being used where the atom's electron orbits are supposed to become elongated. The second reason is that samples of the Earth's material, even from deep mines, show no electric charge, not even polarization, when examined in the laboratory. These views were established more than a hundred years ago. However, during the past 100 years a great amount of evidence has been collected in the field of electricity which disprove those early notions. With the improvement in measurements of electrical resistance it has become clear that there are no insulators, all materials conduct electricity, although the range is about 20 orders of magnitude. The discovery of the transistor, in 1948, is a milestone in this respect, when the conductance of electricity, and very specificly, the conductance of free electrons in "insulators", became established and utilized. Since then material in the lower range of conductivity has been called "semiconductors".

The physical size of the electric charges has been established. In his original papers in 1900 and 1903, Sutherland talks about positive and negative electrons. Since then it has been determined that the positive and negative charges, in non-nuclear environment, are considerably different in size. The positive charge appears only in the form of a positive ion, as an ionized molecule, and its diameter

is more than a million times larger than that of the electron which represents the negative charge. Accordingly, electrons easily penetrate solid material, and move in it, while positive ions do not. Thus, if an amount of negative charges were placed in a solid-matter container, the charges would quickly escape through the wall of the container. However, if positive charges were placed in it, they would stay permanently in the container because they can not penetrate the wall. Sutherland's theory can now be expanded by saying that if a mixture of equal quantity of positive and negative charges, a plasma, is present in a central cavity inside the Earth, then the negative charges occupy a larger effectve radius because they penetrate the wall too, that is, the outer rock shell of the cavity. In this case both electrical requirements are met: the equal quantity of the charges neutralize their own electrostatic fields above the surface, and a net magnetic field is generated by the rotation because the effective rotational radius of the negative charges is greater than that of the positive ones.

There is a natural spontaneous process which produces such a plasma. Edison, in 1883, noticed it first (but did not explain) that an electric current flows in the evacuated space between the red hot filament and a cold metal plate in his electric lamp he had been developing. Later, users of this lamp noticed a continual darkening of the glass bulb which turned out to be the deposition of the evaporating filament (cathode). This is known today as thermionic emission. The theory of this process was established by 1923, at least for the electron tube. It has been established that the material of the high temperature cathode breaks up into an equal quantity of positively and negatively charged particles which move away from the cathode by their thermal energy. If there is a colder surface nearby, the plasma deposits is on it, the positive ions and the free electrons recombine into the original, electrically neutral matter of the cathode.

In this process electrons penetrate the glass wall of the electron tube as a result of a developing "negative space charge" which accompanies thermionic emissions. There are several ways of observing this penetration. The operating tube collects more dust than other surfaces nearby. (Electrostatic air cleaners operate on the principle that a negatively charged grid surface attracts dust particles which are positively charged). These actions are most evident on the TV picture tube which almost violently attracts dielectric material (paper, plastics, hair, dust). Also, an electroscope detects the charge from the outside. The only reason why these electrons do not leave the tube permanently is that the positive ions can not move through an intact glass wall, they stay inside, and their positive charge attracts the electrons back, with which they eventually recombine. A very important point in the theory of thermionic emission is that an anode voltage is not necessary for the basic process. It only improves its efficiency when applied. The electrically charged particles obtain their energy for the motion from the thermal energy of the cathode.

There is an operating thermionic cathode inside the Earth. It has been observed for a long time that the ground temperature increases with depth. It has been established that the temperature reaches the melting point of rock (about 1200°C) at a depth between 20 and 50 km below the surface of the continents, and at 5 km below the ocean floor.

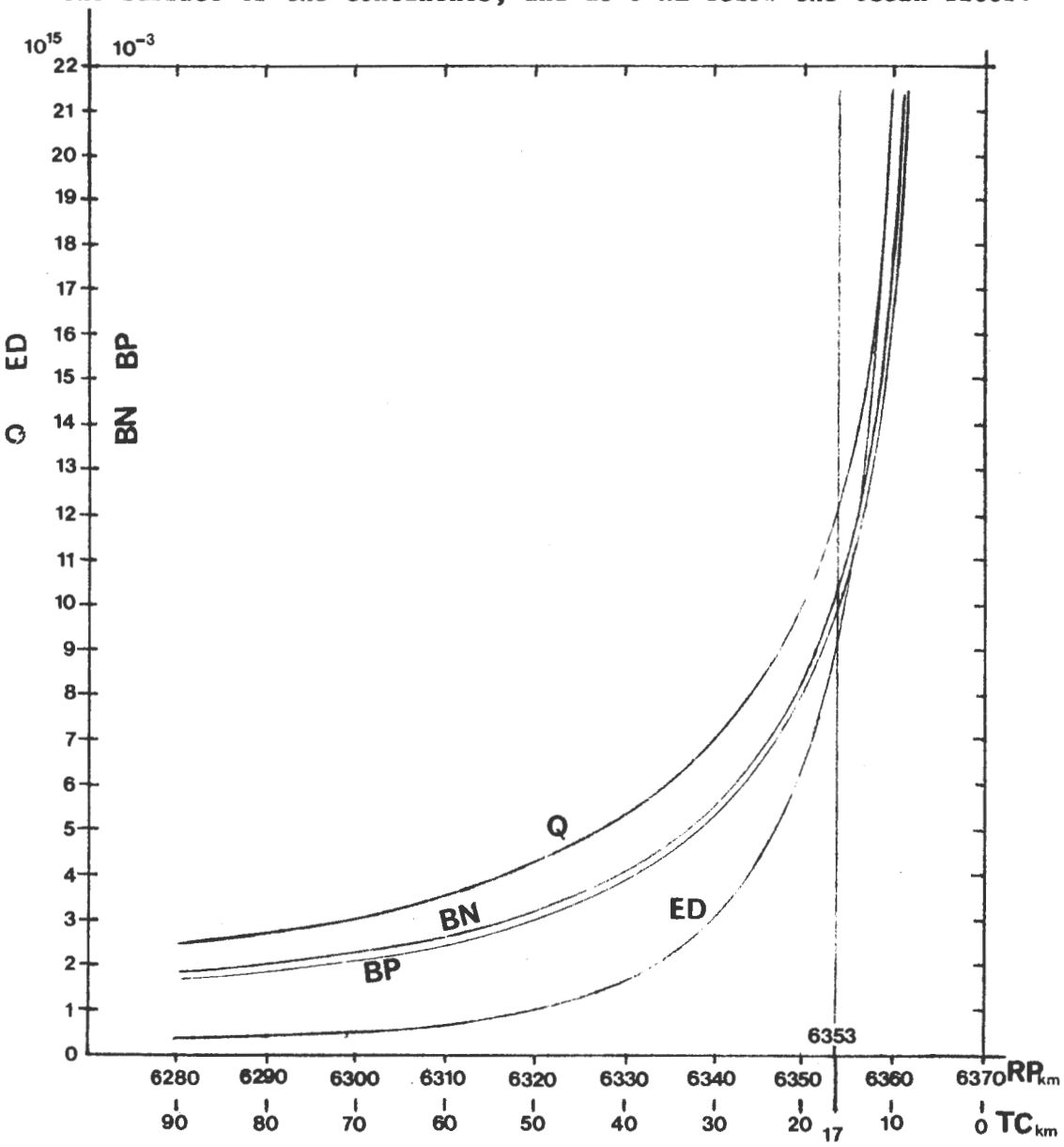


Figure 6-3

Seizmic measurements confirm these values by indicating a sudden change in the state of matter at these depths when the seizmic waves enter the liquid-molten layer below the crust. This layer, called Mohorovicic discontinuity (first observed in 1909), is present virtually at all

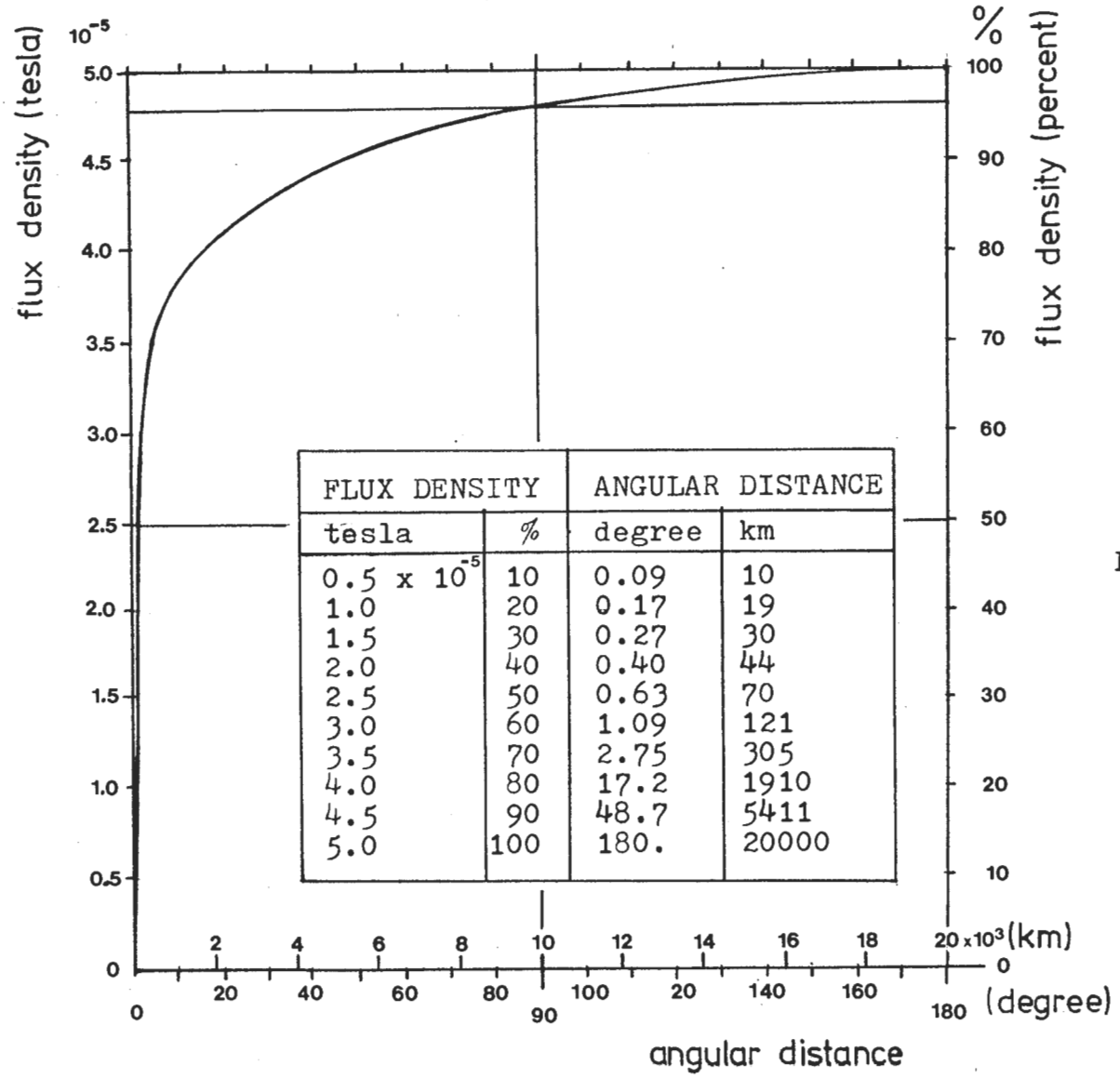
places of the Earth. Thus, the above stated condition of a central cavity inside the Earth with a plasma in it, is met. The Earth has a centrally located source of electric charges, which can be called the magma cathode. The cavity in which the thermionic emission takes place is a spherical layer between the molten surface of the interior and the solid inner surface of the crust above it. From the point of view of the thermionic emission only the surface area and the temperature of the cathode are relevant. The thickness of the molten layer is not. The positive charges are trapped in this cavity while the negative charges are free to penetrate the solid crust above.

RP (km)	TC (km)	Q (Cb)	ED (m^{-3})	BN (tesla)	BP (tesla)
6280	90	2.40×10^{15}	3.40×10^{14}	1.800×10^{-3}	1.750×10^{-3}
6290	80	2.70×10^{15}	4.29×10^{14}	2.029×10^{-3}	1.978×10^{-3}
6300	70	3.00×10^{15}	5.44×10^{14}	2.258×10^{-3}	2.209×10^{-3}
6310	60	3.55×10^{15}	7.49×10^{14}	2.676×10^{-3}	2.626×10^{-3}
6320	50	4.30×10^{15}	1.09×10^{15}	3.247×10^{-3}	3.196×10^{-3}
6330	40	5.35×10^{15}	1.69×10^{15}	4.046×10^{-3}	3.995×10^{-3}
6340	30	7.10×10^{15}	2.98×10^{15}	5.378×10^{-3}	5.328×10^{-3}
6350	20	1.06×10^{16}	6.67×10^{15}	8.042×10^{-3}	7.992×10^{-3}
6353	17	1.25×10^{16}	9.25×10^{15}	9.488×10^{-3}	9.437×10^{-3}
6360	10	2.15×10^{16}	2.71×10^{16}	1.634×10^{-2}	1.629×10^{-2}

Table 6-1

Equation (6-3) allows the calculations of the difference magnetic field above the surface of the ground, and also the free-electron content of the crust, when both the positive and the negative charges produce magnetic field while rotating at different radii. The equation has to be solved twice, first by substituting into R the radius of the negative charges, then that of the positives, and subtracting the results from one another. Figure 6-3 illustrates the required charge Q, the crust's electron density ED. BN is the flux density generated by the negative charges, and BP by the positive charges. These are expressed as functions of the rotational radius of the positive charges RP, or the thickness of the crust TC. The produced difference flux density is always 5×10^{-5} tesla in these calculation. Table (6-1) is the same data in tabular form.

With an average thickness of 17 km, there are 8.0×10^{34} electrons in the crust. The corresponding volume of the crust is 8.64×10^{18} m^3, thus the charge density is 9.25×10^{15} electrons per m^3. This is actually a very small amount of electrons with respect to the number of atoms in the crustal rock, 10^{28} per m^3. Thus, there is only one electron for each 1.1×10^{12} atoms.



FLUX DENSITY		ANGULAR DISTANCE	
tesla	%	degree	km
0.5×10^{-5}	10	0.09	10
1.0	20	0.17	19
1.5	30	0.27	30
2.0	40	0.40	44
2.5	50	0.63	70
3.0	60	1.09	121
3.5	70	2.75	305
4.0	80	17.2	1910
4.5	90	48.7	5411
5.0	100	180.	20000

Figure 6-4

Averaging the crustal thickness into 17 km, when locally this thickness varies from 5 km on the ocean floor to 60 km under large mountains, gives a reasonable approximation for the average magnetic field. But this large variation from place to place has an observable effect on the behaviour of the magnetic field over the Earth. The first

conclusion can be drawn when we calculate the running total during the numerical integration of Equation (6-3). Figure 6-4 shows this in a graphic form. On the calculated model the distance between the two magnetic poles is 22,000 km, like on the Earth, and the point of observation is at one of the poles. The running total shows that 50% of the total flux density at this point is generated by a volume of the globe whose arc length around the observation point is 70 km (0.63° of the 180° angular distance between the poles). The near hemisphere produces 97% of the total flux, thus leaving only 3% for the entire other hemisphere. The "volume of the globe" means the total charge volume of the mass under the said area, including both the negatively and the positively charged layers, thus the effect of surface features are not dominant.

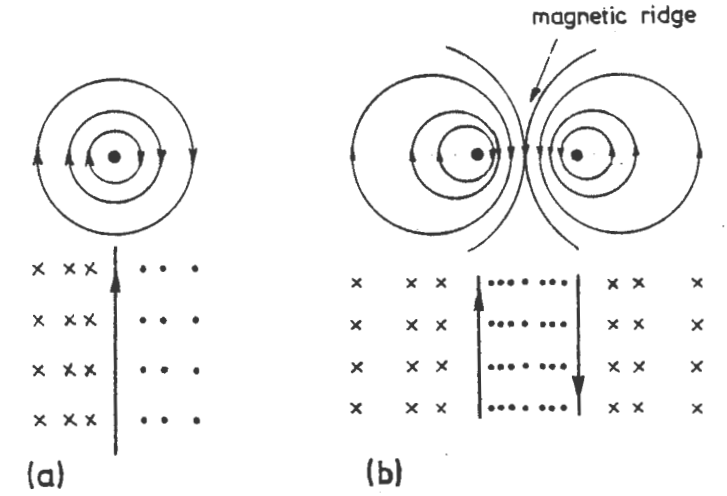
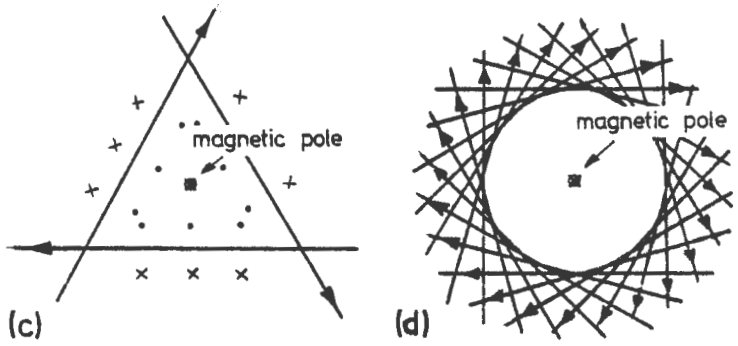


Figure 6-5



The second conclusion can be drawn from a unique property of charge rotation, which does not exist when the field is generated by current loops. In current loops the current is uniform along the loop, thus the generated field is symmetrical about the axis of the loop.

However, in charge rotation the charge distribution does not have to be uniform along the path of rotation. In an extreme case a single lump of charge can be rotated along a radius. Here the magnetic field at every instant is like the one of a straight conductor, that is, it does not have a magnetic pole (Figure 6-5a). The flux density decreases

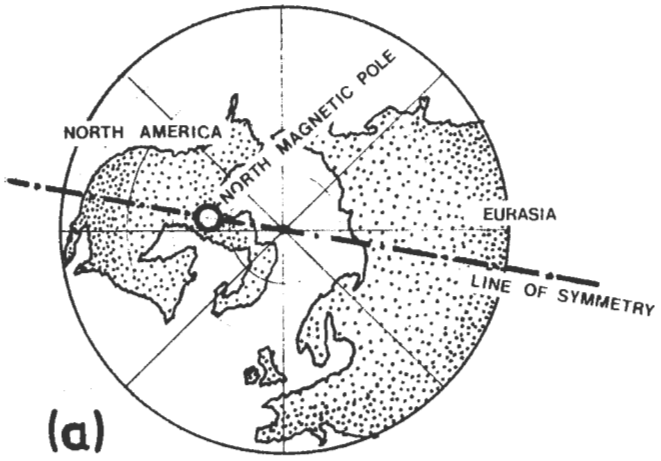
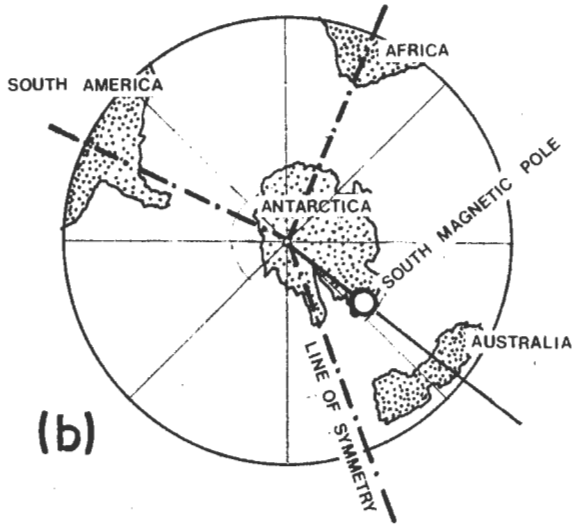


Figure 6-6



with the inverse square of the distance in the direction perpendicular to the velocity. When there are two lumps of charges at 180° apart, at every instant the field is like that of two straight conductors at 2R distance apart, and carrying currents in the opposite direction (b). There is still no pole, but a magnetic ridge between the two conductors. Unequal currents in the two conductors simulate two lumps of unequal charges, and the position of the magnetic ridge shifts away from its central place. The ridge shifts away from the charge or current which generates the stronger field. This system defaults to a

single charge or current form when one charge or current becomes negligible to the other, and the ridge drops to zero at this charge or current.

Finally, when three or more lumps of charge rotate, or three or more conductors carry currents (c,d), forms a pair of real magnetic poles. Here again the position of the pole is controlled by the charge or current ratios. The pole is shifted away always from the side which generates the strongest magnetic field. On the Earth this is manifested in both hemispheres. In the Northern Hemisphere Eurasia and North America are about 180° apart around the rotational axis. In between them are two sections of ocean floor. Thus, there are four lumps of charges along the path of rotation. The volumes of the ocean floors are equal, but the volumes of the two continents are considerably different, thus they represent two unequal lumps of charges. Consequently, the magnetic pole is shifted away from the one which generates the strongest magnetic field: Eurasia. Indeed, the North Magnetic Pole is located 1400 km away from the pole of rotation, inside North America, on the line of symmetry of the two continents (Figure 6-6a).

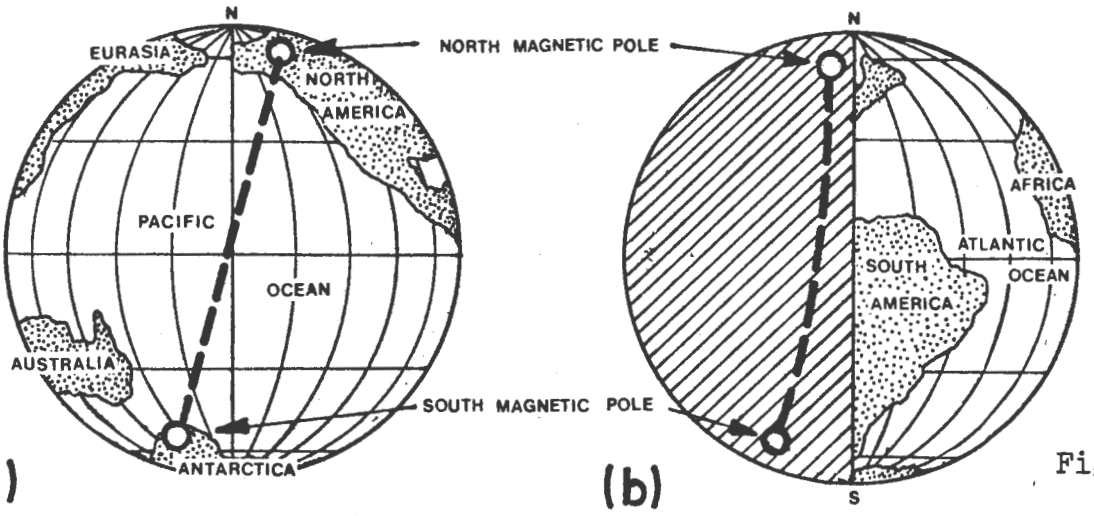


Figure 6-7

In the Southern Hemisphere there are four continents, but Antarctica is centrally located around the rotational pole, thus its effect should be small. With the three remaining continents there are three ocean floors, thus six lumps of charges. The Southern Magnetic Pole is shifted away from between the two largest continents, Africa and South America, towards the smallest, Australia. The shift is 2300 km from the pole of rotation (Figure 6-6b). The small deviation from the exact line of symmetry can be attributed to the larger mass of South America on the Southern Hemisphere, and indeed, the deviation is towards Africa.

The two magnetic poles are interconnected inside the Earth by the magnetic axis. The position of this axis is shifted away from the thickest areas of the crust at each cross-section. Since the crustal thickness widely varies, this axis is curving, it would be better called as a magnetic pole trunk line. It is a characteristic feature of the Earth that the far most continental area is located in one hemisphere, opposite to the Pacific hemisphere. Thus, the pole trunk line must be completely shifted away from the land hemisphere toward the Pacific hemisphere. Indeed, both magnetic poles are entirely on the Pacific side of the Earth (Figure 6-7a). The probable inner layout of the pole trunk line is shown in (b), by removing a quarter section of a solid model-globe.

7. Reversal of the Geomagnetic Field.

Any theory attempting to explain the Earth's magnetic field should equally explain those paleomagnetic observations which indicate that in the Earth's history cooling lava outflows solidified sometimes in the presence of a reverse polarity ambient magnetic field. From these observations the statement has been inferred that the geomagnetic field reversed its polarity several times in the past. This inference is not necessarily true.

The geomagnetic field is the difference of two independently generated magnetic fields, one is by the rotation of positive charges in the magma, and the other is by the rotation of negative charges in the crust. These two magnetic generators can be examined separately.

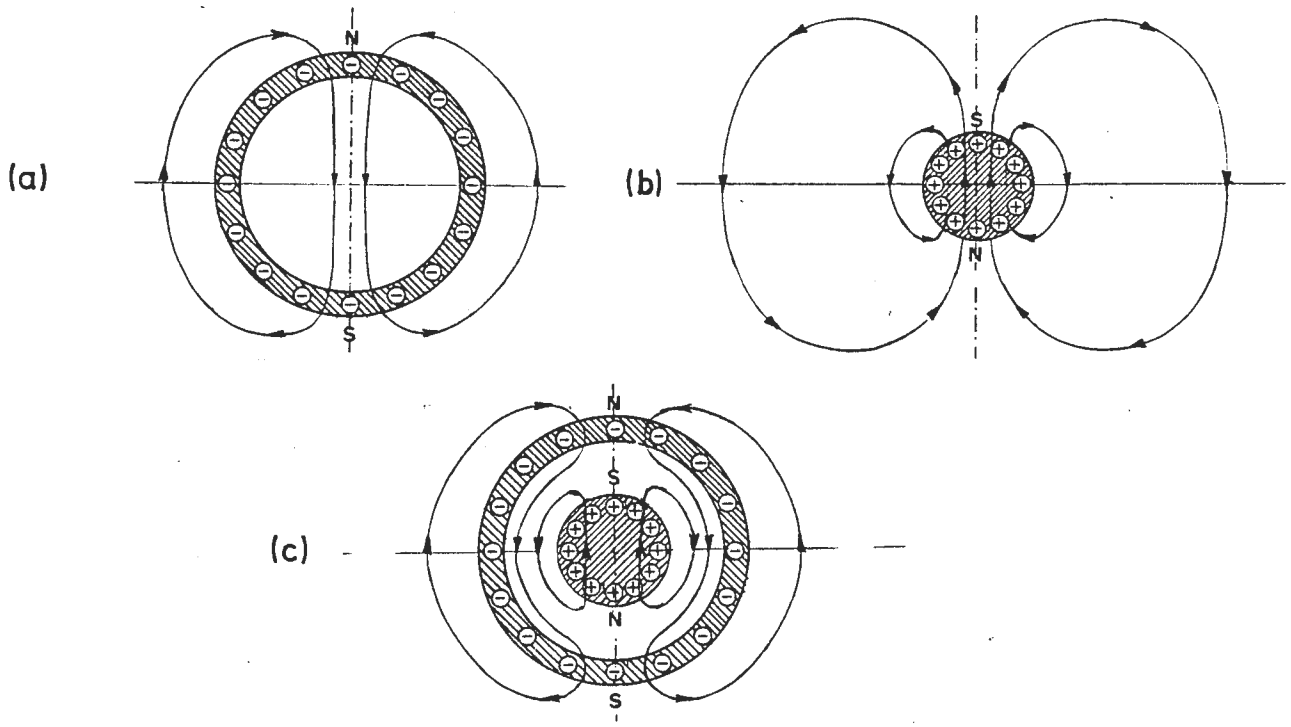


Figure 7-1

Figure 7-1 illustrates them separately, (a) and (b), and also together (c). On the combined view it can be seen from the directions of the lines of force that above the crust the two fields subtract, but below the crust, between the crust and the magma, the two fields add together. This inner field is very powerful. According to Table 6-1, with a 17 km thick crust the negative flux density is 9.488×10^{-3} tesla, and the positive flux density is 9.437×10^{-3}. Their sum, 1.892×10^{-2}, is 378 times as high as their difference, the observed 5×10^{-5} tesla external field. Nevertheless, the direction of this very strong internal field is the same as that of the crust's internal field alone. Therefore, the qualitative properties of the geomagnetic field near to

the crust, below or above it, can be investigated on a model which is a charged spherical shell only, as in Figure 7-1a. In turn, this shell can be replaced by a wire coil (solenoid) either on a spherical or on a cylindrical bobbin (Figure 7-2). This latter one is especially easy to build for an experiment in a size, say, of 50 cm in length and in diameter.

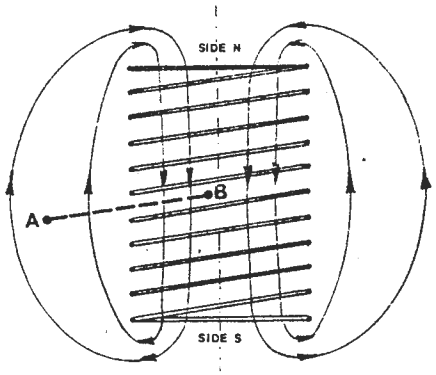


Figure 7-2

In this experiment keep the axis of the coil horizontally, and move a magnetic needle from point A to point B on a path through the layer of the wires. While the needle is still at A it points toward side N, but as it moves through the layer of wires it suddenly turns 180°, and points toward side S thereafter. This turn of the magnetic needle indicates an apparent "reversal" of the polarity of the magnetic field. Of course, this is not a real reversal of the field. Rather, it indicates that the field direction inside the coil, or inside the rotating charged shell, is reversed with respect to that outside of the coil or shell.

In the plane of the wires is the "magnetic neutral zone" which separates the two fields of opposite polarities. In this zone the flux density is zero. There is no deflection force on the magnetic needle here, the needle moves only randomly. This is not an instability of an existing field, but a noise type behaviour when vibration, gravity, or thermal forces, which are usually suppressed by the strong magnetic field, act on the needle. The position of this neutral zone is independent on the intensity of the current, or on the magnetic flux density of the coil. The zone is the result of the folding back of the very same field around the plane of the wires.

A magnetic neutral zone can exist not only within the very same field, as in the above example, but also between two fields of independent origin. Figure 7-3 illustrates one such case when two wire coils generate fields in the same space between them. The coils are oriented in such a way as to generate fields of opposite directions here. A magnetic neutral zone takes shape in this space where the individual

flux densities are equal, and the directions are opposite. In a symmetrical system the plane of the neutral zone (c-c) is at half way between the coils. However, in this setup the position of the neutral zone does depend on the magnetic flux densities of the coils. We can make the neutral zone to move through a magnetic needle of fixed position between the two coils by varying the current in one of the coils, or by moving one of the coils closer or farther from the other coil. In this case an observer of fixed position can observe a "reversal" of the magnetic field. Of course, this is again not a real reversal of the coils' magnetic field. Possible movements of the needle in the neutral zone now includes the stability factor of the magnetic sources. Since the position of the zone depends on the difference of the two fields, a slight variation of one of them causes a variation in the position of the zone.

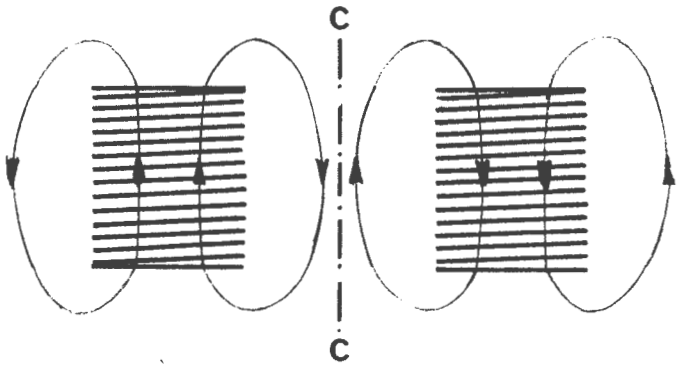


Figure 7-3

The two magnetic generators of the Earth is a concentric arrangement of the above discussed setup of two coils. Figure 7-4 illustrates the resultant fields below and above the crust. The dot-dash line indicates a possible position of the magnetic neutral zone. However, this zone now can move up and down in the crust, depending on the flux densities, or on the density ratio of the two generated magnetic fields, or on the radial positions of the two fields. In the Earth's history the magnetic flux density of certain surface areas changed radically, and this caused the shift of the local magnetic neutral zone in the vertical direction.

A major reason for the change of the surface flux density is the migration of magma in the vertical direction. (Molten matter while inside the Earth is called magma, but it is called lava when it moves over the surface). Melting of the Earth's matter is caused by the heating effect of the decay of radioactive elements. The temperature builds up as the amount of heat accumulates in the ground, but the melting does not take place until the melting point of that particular type of rock has been reached. Different types of rock usually form

layers. When a layer of high melting point rocks melts through, and it is covered by a low melting point layer, a rapid and violent melting takes place in the upper layer. Water steam and gases develop faster than they can escape, and the pressure quickly squeezes the newly generated magma above the surface where it forms a lava lake.

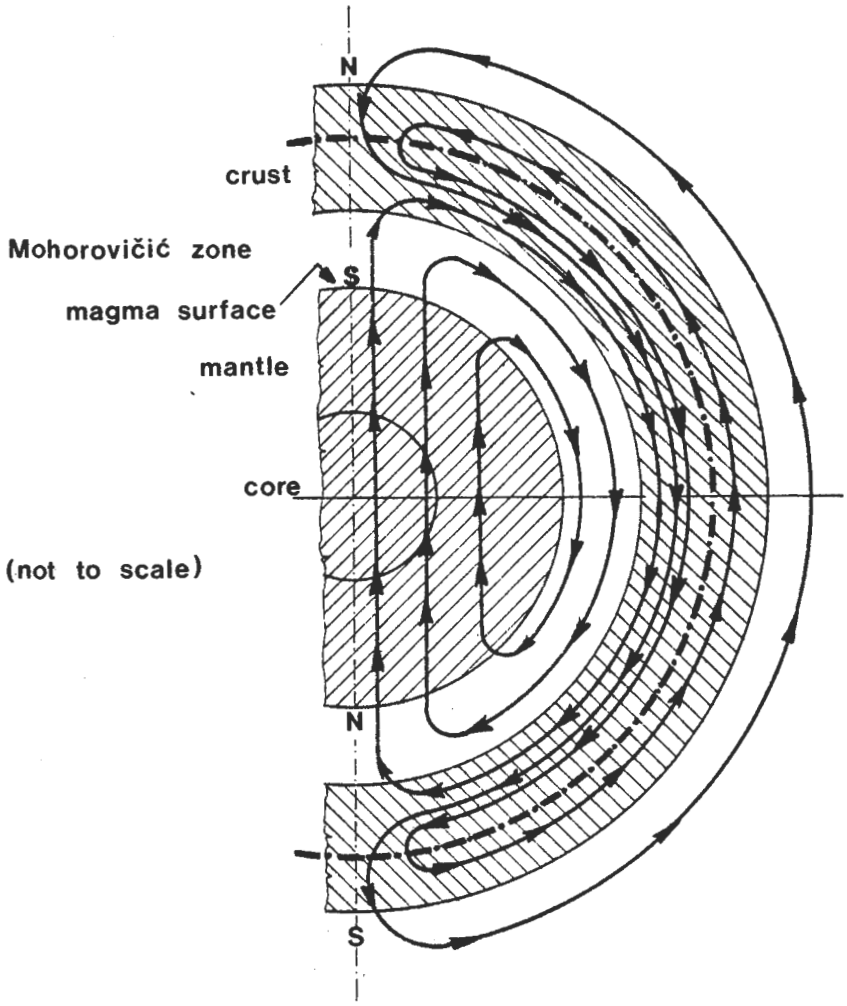


Figure 7-4

However, melting solid rock into magma or lava is converting matter from one type of magnetic generator into the other. A layer of solid rock in the crust is infused with free electrons and it generates the normal polarity magnetic field. But after it melts, it becomes part of the magma cathode, and it generates the reverse polarity magnetic field. Therefore, the flux ratio of the two fields changes. The result is the shift of the magnetic neutral zone in the direction away from the generator which has become more powerful. The neutral zone shifts upward.

The neutral zone is above the surface of the ground when the ambient magnetic field is mostly generated by positive charges of the magma. On the graph of Figure 6-4 I showed that 50% of the flux density at an observation point is generated by an area of 70 km radius. Thus, if the radius of the lava lake reaches about this value, the neutral zone may move over the surface. The polarity of the field below the neutral zone is reversed. Thus an observer at the forming lava lake notes the sudden reversal of the magnetic polarity, but also notes that by the eventual cooling and solidification of the lava the polarity returns to normal. Solidification converts material back to a generator of normal polarity magnetic field.

Ferrous elements in molten rocks record the direction of the ambient magnetic field at the time when their temperature passes the Curie point (about 400°C) during cooling. Their remanent magnetic field freezes in that direction, and does not change again unless the temperature rises once more above the Curie point. When a large and thick lava lake solidifies, a characteristic pattern of the contemporaneous magnetic field remains in the rock along its vertical cross-section in the form of remanent magnetism. At the beginning of the solidification the magnetic neutral zone, depending on the extent of the lava lake, can be below, in, or above the lake. Solidification starts at 1200°C, way above the Curie point, thus the direction of magnetism of the ferrous elements is not yet determined. But the solid layer on the surface is already generating a normal field, thus the neutral zone starts lowering. There is a long delay for the Curie point before it enters the lake, when the surface temperature drops to 400°C. By this time a considerable thickness of solid layer exists, and the original thicknesss of the molten lava is less by the same amount. Thus, for a large and uniform lake the ambient magnetic field at its surface is of normal polarity by the time the Curie temperature sets in. However, if small and thermally isolated veins of the lava lake exist, their temperatures can drop much faster, while the ambient magnetic field is maintained at reversed polarity by the lake. Their remanent polarity therefore, can record reverse field.

The rate of sinking of the neutral zone is not proportional to the thickening of the surface layer. Thus, the Curie temperature may catch up with it. At this point the remanent magnetism records the switching directions of the inclination and the declination. Further down, where the Curie temperature sinks below the neutral zone, the remanent magnetism records a reversed polarity field. Nevertheless, if the cooling still continues, the normal polarity field will eventually occupy this area too, but the remanent magnetism in this area remains in reversed polarity.

In summary, this mechanism allows the following combinations of polarities in lava extrusion of single events. If the volume in the area is small, the polarity remains normal because the neutral zone

does not move over the surface. If the volume is large, the polarity in the uppermost layer of the extrusion is normal, in the lowermost layer it is reversed. In the vicinity of the area small veins may possess entirely reversed polarity because of their fast cooling in the temporarily reversed field. The combination which should never take place is that in a single extrusion a normal polarity layer develops below the reversed layer. This restriction should be contrasted to the current explanation of polarity reversal: that the entire geomagnetic field switched polarity during the cooling of a lava lake entirely by coincidence. A normal polarity epoch existed while the uppermost layer went through its Curie temperature, and a reverse polarity epoch while this temperature existed in the lowermost layer [36]. However, no lava lake should be found whose existence coincided with the return of the normal polarity epoch. In this case the uppermost lavas would be reversed and the lowermost normal.

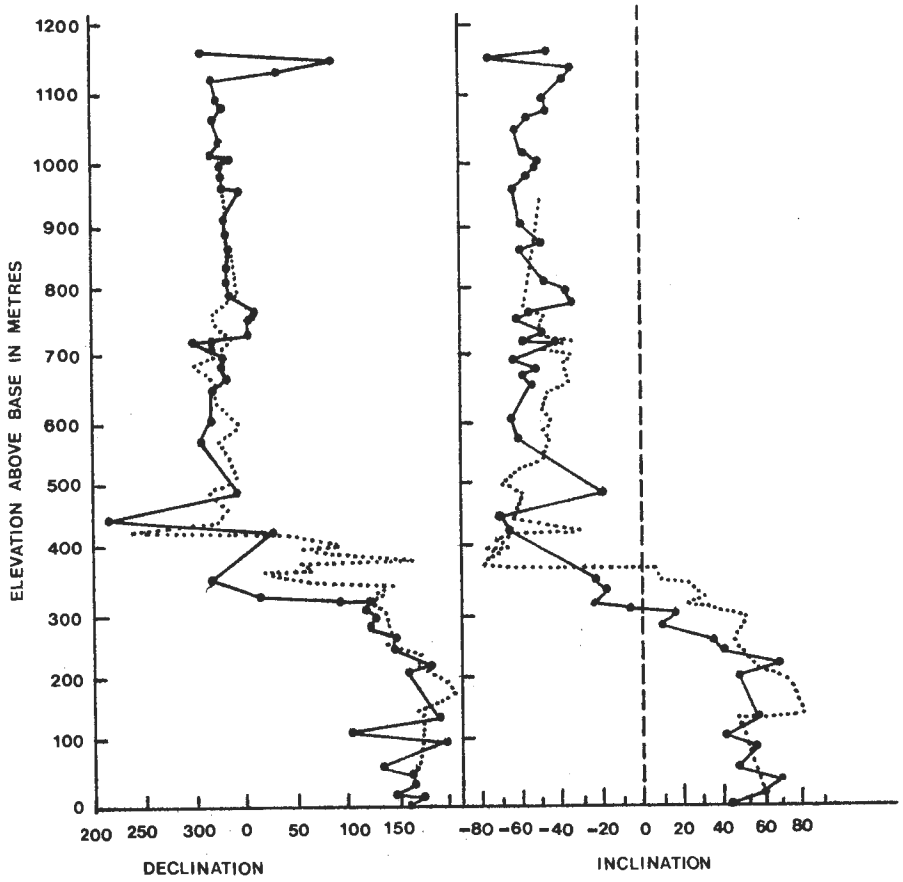


Figure 7-5

The Stormberg lava field in South Africa is an example for the event when a lava lake of large volume developed [37]. This is an area of 33,000 km² (equivalent to a circular area of 102 km radius) where the lava deposit is 1200 m deep. This deposit was drilled through, and the

direction of the remanent magnetic field, its inclination and declination, were determined at several heights (Figure 7-5. The dotted and solid lines represent two sampling areas 120 km apart). Above the 350 m height from its base the deposit is magnetized in the normal direction, below this height it is reversely magnetized. Around the 350 m is the magnetic neutral zone where the inclination and declination switch sign.

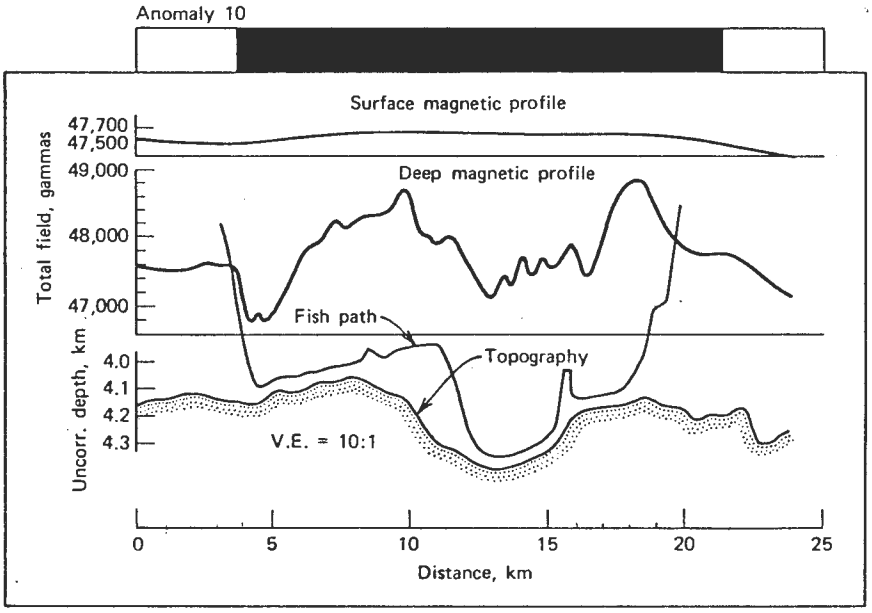


Figure 7-6

Generally, in low-lying areas the probability is greater for finding reverse polarity than in mountains. In a borehole less deep than the thickness of the crust one should always find the live (not the remanent) neutral zone of the geomagnetic field, and the reverse field below. The most extreme case for low-lying areas is the ocean floor. The live geomagnetic neutral zone is permanently above the ocean floor at about 50% of its surface, thus the reverse field is accessible here, between the floor and the neutral zone. Submersible instrument packages towed in this area have been measuring this field. (Geophysicists attribute this reverse field to remanent magnetism of reversely magnetized ore bodies. However, drilling does not produce samples with the required enormous intensity, nor does such rock exist anywhere on the Earth). Figure 7-6 is a magnetic profile measured near the ocean floor by an instrument package called "Fish", in 1967 [38]. This is a traverse across a "magnetic anomaly", as geophysicists call these areas, in the northeast Pacific at a height above the bottom between 35 and 180 metres, 4 km below the surface. This measurement shows all the characteristics of live reversed and normal magnetic fields as the instrument took a cross-section of them as it moved.

The white-black striping is a convention to describe a normal field as black and a reverse field as white. As the instrument moved from the 0 km to the 4 km point it measured 47,600 gammas (4.76×10^{-5} tesla) magnetic flux density of reverse polarity, a value as high as that at the surface of the ocean. At 4.5 km it crossed the neutral zone as indicated by the deep minimum in the flux density, and by the turning of the polarity into the normal direction. From 4.5 km to 22 km it moved in the normal field, and then crossed the neutral zone once again, entering into another area of reverse field. The ocean floor is densely populated with normal and reverse fields in nearly equal areas. Figure 7-7 is a geomagnetic map of a larger area (120,000 km^2) of which Figure 7-6 is a short (25 km) traverse, marked C-C at latitude 32° 25' N just east of 126° W. (Figure 7-7 is after [47]).

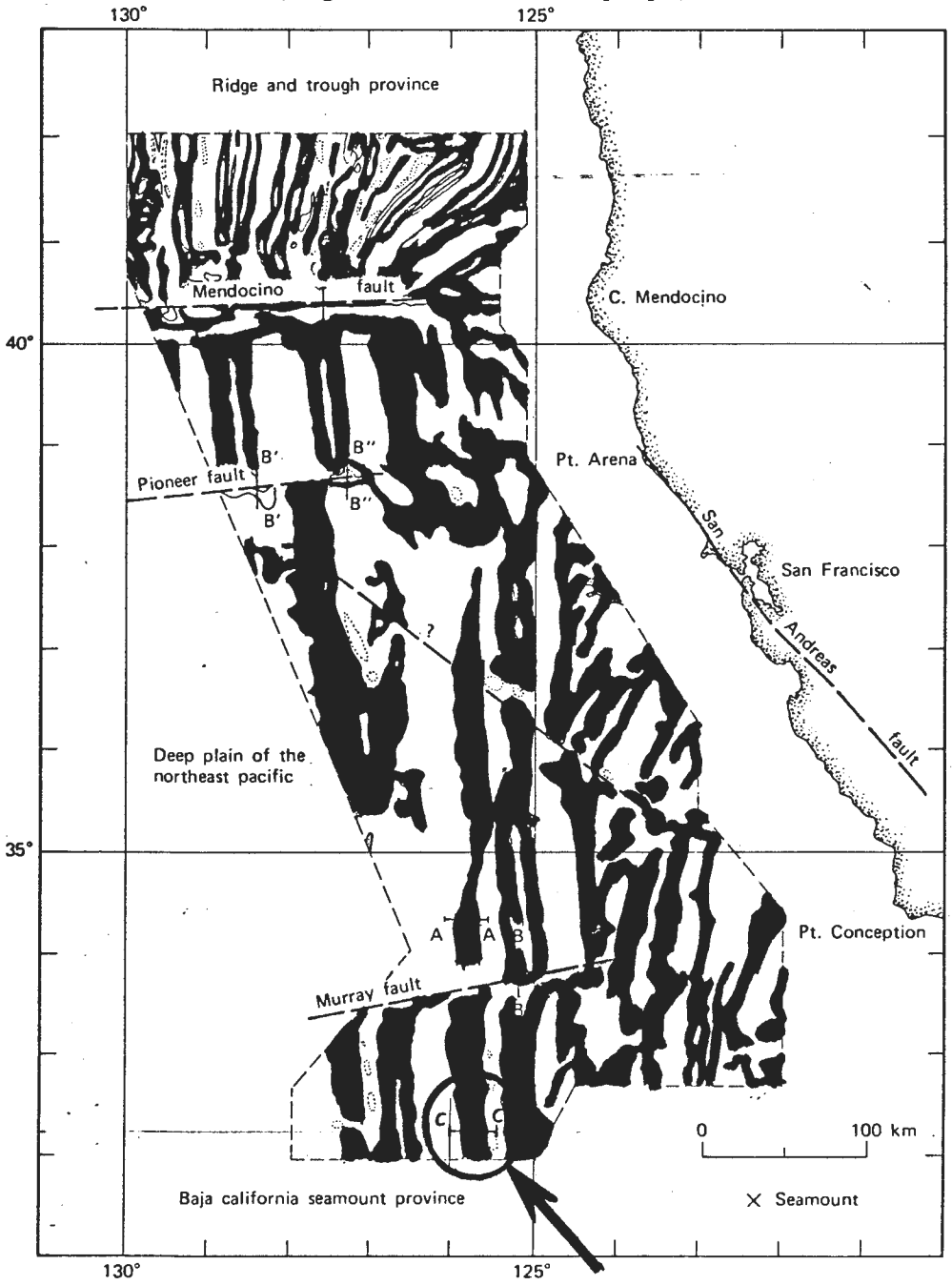


Figure 7-7

Rock samples dredged or drilled at these areas may or may not show the same polarity as the live polarity of the area is. The ocean floor frequently breaks up, especially around the ridges, and the resulting lava flow records the momentary polarity of the geomagnetic field at that particular spot. This field is very much variable since a breakup of the ocean floor can cover an area as large as that of the Stormberg lavas, but the entire cycle passes off in a few hours by the rapid cooling in the presence of the ocean's water. (I discussed the resulting supernova stroms in Chapter 2).

The magnetic profile and the surface profile of the ocean floor do not necessarily coincide because other factors are also involved. Among these are the actual thickness of the floor in the area, but the most important is that a larger area is involved in the production of the local field. According to the example of Figure 6-4, a radius of 70 km produces 50% of the flux density. For the thin ocean floor this radius is different. But when the floor breaks up over large areas the reverse polarity internal magnetic field bursts out like a solar protuberance, and extends upward in the ocean. This reverse field may reach the surface and the atmosphere for the few hours while the breakup lasts. The outbreak of the violent supernova storm is another manifestation of the magma outburst on the ocean floor. It is possible that immediately prior to the storm, and during it, the local geomagnetic field undergoes a polarity reversal. Reports on "magnetic storms", temporary malfunctioning of magnetic compasses and other electric equipment on ships and on airplanes could be attributed to these events. It may add to the confusion under these circumstances that wild deflections of the magnetic needle takes place only during the passage of the neutral zone. When the reverse polarity sets in, the needle becomes stable again, even though at a 180° error. To make bad things worse, the navigator believes the new stable indication of the needle, and notices the apparently wrong bearing, and steers in the opposite direction. This is a literally vicious circle, because the ship will cross the neutral zone again, will turn back again, and will stay in the storm for an indefinite time, even it will follow the course of the storm. Figure 7-8 illustrates this geometry. The shaded area is the storm, the dot-dash line is the magnetic neutral zone. The magnetic polarity is reverse within the circle of the neutral zone, and normal outside. The ship follows a circular route, crossing the neutral zone twice during each round, because the magnetic needle switches 180° each time of crossing in a heavy storm. Only radio-navigation would reveal this, if radio communication is possible at all in a very severe electric storm. But the most important factor is the ignorance of the people involved about the sheer possibility of these events, and this have precluded the objective observation of the real mechanism.

Mysterious disasters, Bermuda triangles, could well be caused by the temporarily reversed local magnetic field. Mythological tales

about the Sirens [40] could be symbolic description of such events as experienced by ancient people. The recent discovery of a geared navigational or mathematical instrument of Greek origin from 80 B.C. [41] suggests that they also could have possessed the magnetic needle. Observation of magnetic reversals on small island on the sea could have furnished them with the fixed reference to identify the surfacing and disappearing reverse field. As we are told, Sirens attracted the attention of sailors, and if they listened to and obeyed the Sirens, then they would be trapped and never released. Sailors liked to listen to their talk as they like to give credit to what their compass says, especially in peril when no other help is in sight. Odysseus studied this situation with the precaution that he had himself tied to the

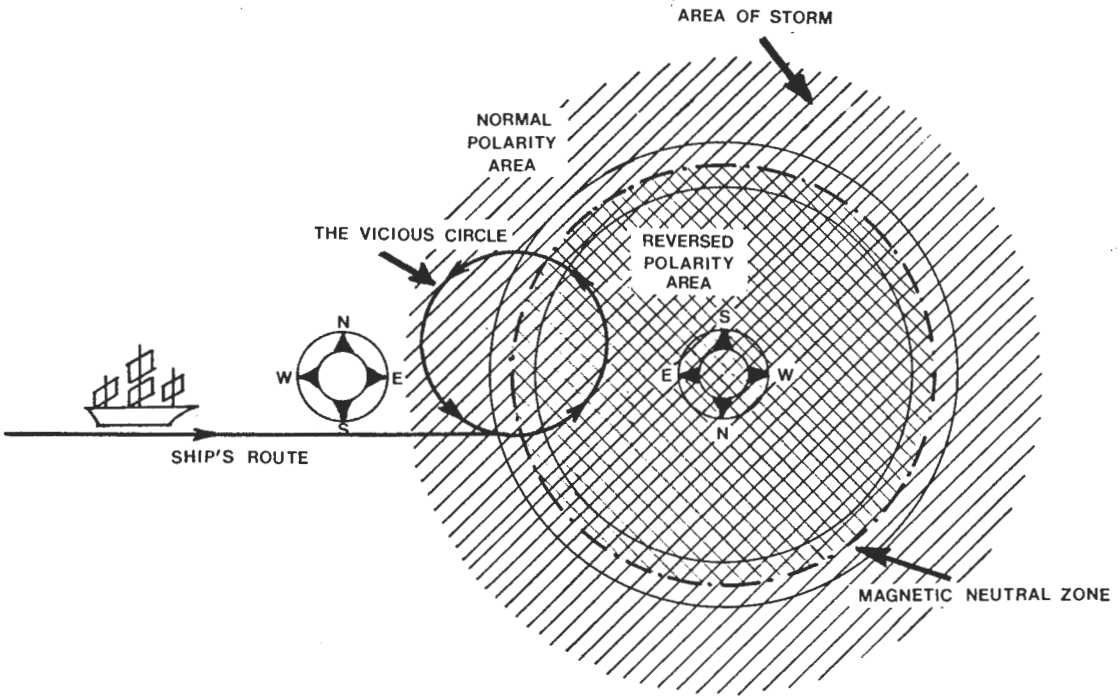


Figure 7-8

shipmast to prevent himself acting on the information received from the Sirens, while he put wax in the ears of his shipmates to prevent them obeying his own instructions. When they reached the area of the Sirens, Odysseus instructed the helmsman to turn the ship according to the information he obtained from the Sirens, and he was deeply convinced about the correctness of it. However, his command was not obeyed, the ship stayed on the original course and escaped the area unhurt. Sirens are well suited to represent the surfacing reversed magnetic field. They emerge from the sea, they resemble something you are familiar with, but they don't do what you expect them do, because they are somehow different. Furthermore, their upper part is the right one and the lower part is the wrong; as the order of magnetic layers. The top one is the normal and the lower is the reversed.

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