Chapter 10: Paleomagnetism Homework Solutions

1. **The declination of a lava is 8°. Give at least two possible explanations for why it is not zero?**
   a) The block has been rotated
   b) The magnetic pole when the block was magnetized does not coincide with the rotational pole
   c) The block has been tilted
   d) There has been secondary remanent magnetism

2. **What are true north, geographic north, magnetic north?**

   True north and geographic north are the same and are aligned with the Earth's spin axis. Magnetic north is where the magnetic axis of the Earth intersects with the Earth's surface.

   They would be the same if the layers (interfaces) are flat and continuous.

3. **Explain what these test for and how they differ: (a) Fold test, (b) Conglomerate test, (c) Baked contact test?**

   a) Fold test checks whether the magnetic remanence was caused before or after the folding.
   b) Conglomerate test checks whether the magnetic remanence was caused before or after the deposition of the clasts.
   c) Baked contact test checks magnetic remanence was caused before or after the intrusion reheated the rock.

4. **You wish to travel due north; you have only a magnetic compass to provide a bearing, but you know that for your location the magnetic inclination is +5° and the declination is 8°. Then with respect to the direction of your compass needle, which of the following should you choose?**

   Declination is by definition the direction to true north. Thus, travel 8° W of magnetic North.

5. **When a particular sample was thermally demagnetized, its intensity increased up to 250°C, after which it decreased. Why was this?**

   The rock had secondary remanence that was opposite to the primary remanence which resulted in diminishing the overall remanent magnetic field. As thermal demagnetization occurred, the secondary remanence was removed (washed), increasing the total field in the process. As the temperature continues to increase, the primary demagnetization is removed progressively through the range of blocking temperatures.

6. **The Earth's magnetic field is similar to the field that would be produced by a huge bar magnet at its center. Give two reasons why it cannot be a magnet.**
   a) Below depths of 15-20 km, the Earth's temperature is above the Currie Point (~600°C)
   b) A simple bar magnet cannot produce field reversals.

7. **Which of the following relations between blocking temperature, T_b, and Curie Temperature, T_c, is correct?**

   ii) T_c is always less than T_b.

8. **If you wished to identify the magnetic mineral in a rock, would it be more useful to measure it Curie or blocking temperature?**

   Blocking temperatures are a range for all the different domain walls, impurities, etc. of a particular mineral. However, Curie temperature is characteristic of a mineral. Thus, measuring the Curie temperature would allow determination of the magnetic minerals present.

9. **Two rocks have the same iron content, yet their remanent magnetizations differ in strength. Give at least three reasons why the strength of the remanence of a rock does not depend just on its iron content?**

   a) Magnetic field variation due to latitude.
   b) Grain size affects domain stability
   c) Different secondary remanence history
   d) Different chemical formula, i.e., magnetite, hematite, maghaemite all have different saturation remanence.

10. **The declination and inclination of rocks from the western end of an island a few kilometers long are 20° and +30°, whereas the declination and inclination of rocks from the eastern end are 35° and +30°. What explanation can you offer?**

    Since they have the same inclination, most likely the two rocks were magnetized at the same latitude. However, since their inclinations are different, they have different poles, most likely because of relative rotation between the two. Another explanation is that the island is made up of two distinct accreted blocks.

11. **An American geologist, finding on arrival in New Zealand that his compass does not rotate freely, blames the airline for damage in transit. But there could be another explanation. Explain.**

    Because the Earth's magnetic field is a vector and since the field lines almost always intersect the Earth's surface at an inclination that is different than zero, compasses are manufactured so that they spin freely at the latitude which they are intended to be used in. This is accomplished by weighting the needle to counteract the effects of the inclination. In the southern hemisphere, the inclination is negative, while in the northern hemisphere, the inclination is positive, resulting in incorrect weighting of the needle.

12. The equation $\tan I = 2\tan\lambda$ **is used to calculate paleolatitudes. What assumptions are made in this equation? How valid are they likely to be?**

a) We have assumed that the Earth's magnetic field is a dipole, which in turn means that the source volume of the magnetic field is far from the surface of the Earth. This is generally a pretty good assumption

b) We have also assumed that the magnetic pole and the geographic pole are the same. This is only true for time averaged measurements which would eliminate the secular variation of the Earth's magnetic field.

13. A rock magnetized when it was 20° S of the equator has drifted to 20° N today. Its inclination differs from that of its present position by which of the following angles?

Calculate the difference:

$$I_1 = \tan^{-1}\left[2\tan\left(-\lambda_1\right)\right] = \tan^{-1}\left[2\tan\left(-20^o\right)\right] = -36.05^o$$

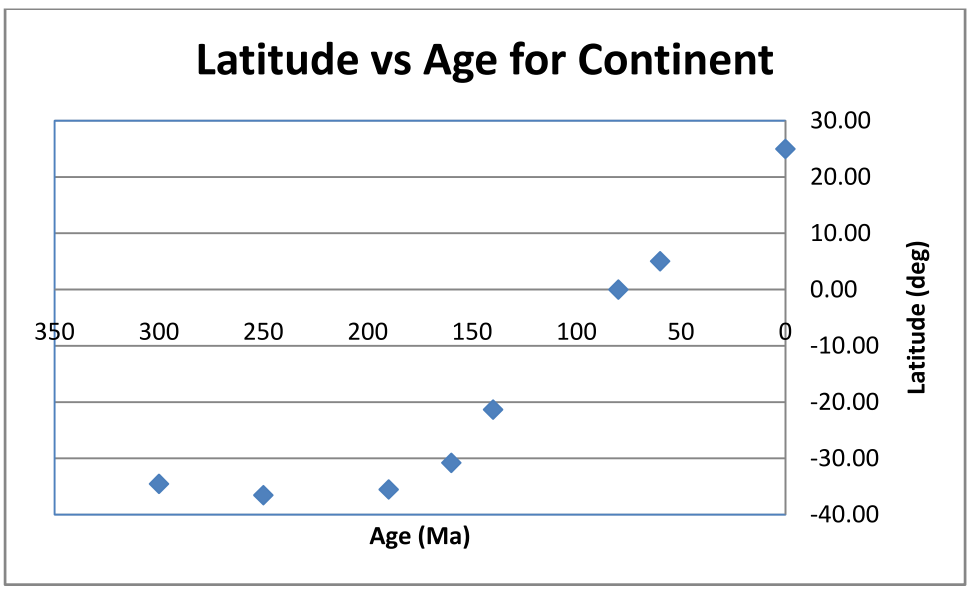
$$I_2 = \tan^{-1}\left[2\tan\left(+\lambda_2\right)\right] = \tan^{-1}\left[2\tan\left(+20^o\right)\right] = +36.05^o$$

$$\Delta I = I_2 - I_1 = 36^o - \left(-36^o\right)$$

$$\Delta I = 72^o$$

14. **A small area of continent has rocks of a range of ages. Their paleomagnetic directions were measured, giving the data below (dates are accurate to about ±4 Ma, paleomagnetic directions to ±2°). Plot the paleolatitudes against time. What can you deduce about the continent?**

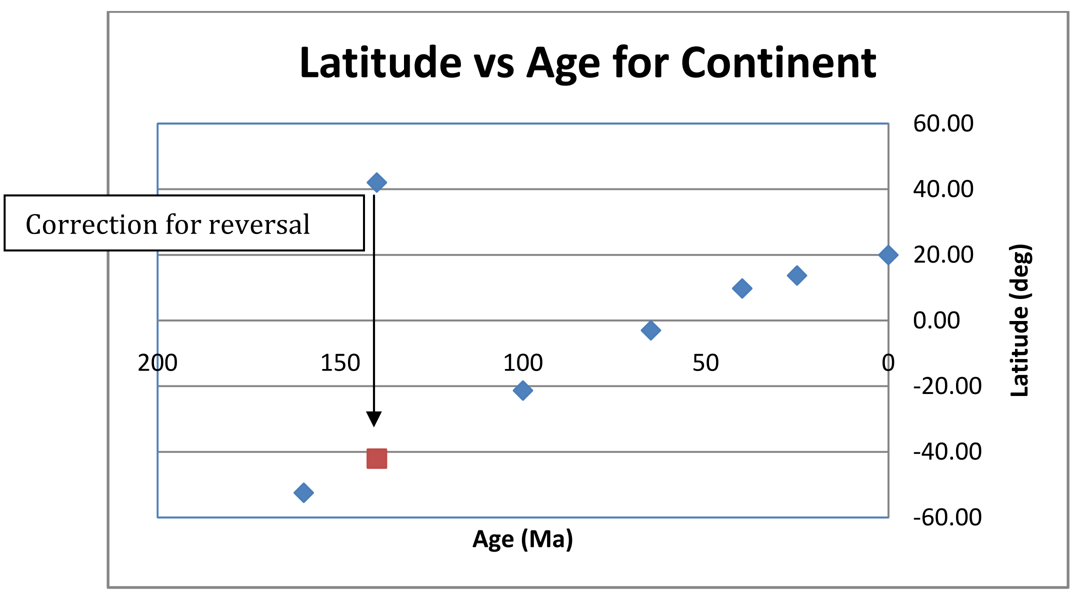
Age (Ma)	Inclination (deg)	Latitude (deg)
300	-54	-34.54
250	-56	-36.55
190	-55	-35.53
160	-50	-30.79
140	-38	-21.34
80	0	0.00
60	10	5.04
0	43	25.00



The continent moved from the southern hemisphere northward at a relatively constant rate beginning around 170 Ma.

15. **A small area of continent has rocks of a range of ages. Their paleomagnetic directions were measured, giving the data below (dates are accurate to about ±4 Ma, paleomagnetic directions to ±2°). Plot the paleolatitudes against time. What can you deduce about the continent?**

Age (Ma)	Declination	Inclination (deg)	Latitude (deg)	
0	0	36	19.96	
25	6	26	13.71	moving N, slight rotation to 6°
40	10	19	9.77	moving N, slight rotation to 10°
65	10	-6	-3.01	moving N, slight rotation to -3°
100	10	-38	-21.34	moving N, slight rotation to -21°
140	190	61	42.05	polar reversal
160	10	-69	-52.49	
140	190	-61	-42.05	corrected for polar reversal



16. **A sandstone has been cut by a 2-m-wide basaltic dyke. For each of the following results, is it likely that either the magnetizations of dyke or of the sandstone are primary?**
    a) **Samples of sandstone from within a few tens of centimeters of the dyke have the same direction of magnetization as the dyke, but not of the sandstone several meters from the contact.**
    b) **All of the samples of dyke and sandstone have the same direction**

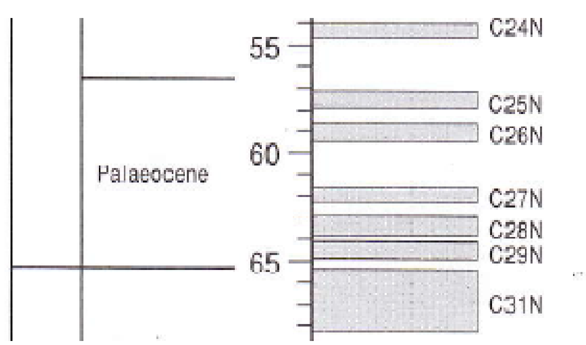
    a) Dyke probably has primary remanence. Sandstone far from the dyke may also have primary remanence from when it was deposited, but is impossible to check. Sandstone near the dyke has secondary remanence
    b) Since both are same, both probably have secondary remanence.

17. **A lava is cut by a dyke, both of late Jurassic age. Samples were taken from two sites in the dyke and also from the lava remote from the dyke. How do you account for the results tabled below?**

    Since the declination of the dyke is ~180° from the lava, and because the inclinations have same magnitude, but opposite sign, this is consistent with the dyke being emplaced in the lava during a polar reversal with the block remaining at the same latitude.

18. **What can you deduce from the information given about the age or duration of eruption of a succession of lavas, for each of the following two cases?**
    a) **They are of Paleocene age and display the polarities succession N, R, N.**
    b) **They are of Campanian age, and all of the lavas are normally magnetized except for a few at the base**

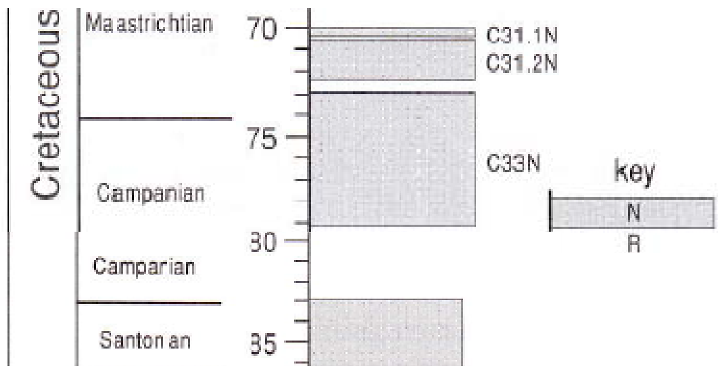
    a) Minimum duration is the minimum length of an R period, ~0.25 Ma, Maximum duration is the maximum span of NRN, ~3Ma. Could have happened at any time during Paleocene.



    In the Paleocene, I see two NRN sequences with the following age spans: 1) 57-59.5 Ma; 2) 61.8-65 Ma.

b) Based on same argument of (a), minimum duration is the minimum length of an R period, only one in Campanian, ~4 Ma. The maximum is any time during the Campanian, ~9 Ma and would have had to overlap the time 79 Ma.

Alternative: Since the rock doesn't (explicitly) contain a 'sandwich (NRN)', the minimum interval would be small to zero. If the succession is not uniform in time, it could span the entire Campanian.



With only a few at the base, the age is probably less than 80 Ma.