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12.002 Physics and Chemistry of the Earth and Terrestrial Planets
Fall 2008

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Problem Set #6: Geomagnetism and Paleomagnetism
 due Friday Oct 31 in class

1. Vector component diagrams illustrating progressive demagnetization data for two paleomagnetic samples are shown below. These samples are from volcanic rocks containing magnetite as the dominant ferromagnetic mineral.

(a) Using a protractor to measure angles of line segments in Figure 1a, estimate the direction of the primary remanent magnetization component revealed by this progressive demagnetization experiment.

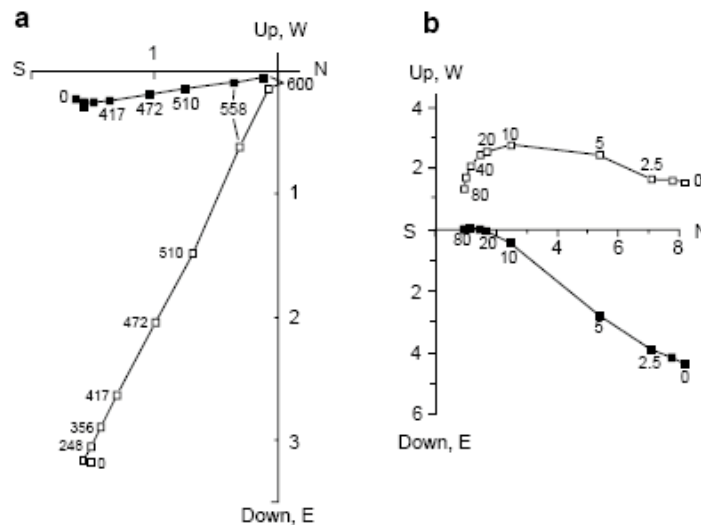


Fig. 1. Vector component diagrams. **(a)** Progressive thermal demagnetization results for a rock sample; the numbers adjacent to data points are temperatures in degrees Celsius; open data points are vector end points projected onto a north-south oriented vertical plane; solid data points are vector end points projected onto the horizontal plane; numbers on axes are in units of 10^{-7} Am^2 . **(b)** Progressive AF demagnetization results for another sample. Conventions and labels as for part **(a)**, except that numbers adjacent to the data points indicate peak AF field (in mT); the NRM of this sample contains a large secondary lightning-induced IRM.

(b) In Fig. 1b, another sample is progressively demagnetized, this time via a method called *alternating field (AF) demagnetization* in which the sample is exposed to alternating magnetic fields of progressively increasing peak amplitude. AF demagnetization is the ideal method for removing overprints from lightning strikes. Applying the same procedure as described above to Figure 1b, estimate the direction of the secondary component of NRM that is removed between AF demagnetization levels 2.5 mT and 10 mT.

2. A paleomagnetic site from a single Oligocene welded ash flow tuff was collected at site location $\lambda_s = 35^\circ\text{N}$, $\varphi_s = 241.2^\circ\text{E}$. The average magnetization direction of the samples at the site has inclination $i = -17.9^\circ$ and declination $\delta = 232.6^\circ$. From these data, calculate the virtual geomagnetic pole (VGP) for this site. Note: The magnetic colatitude, θ , must be a positive number (it is the great-circle distance from the site to the pole). If you obtain a negative number for

$$\theta = \tan^{-1}\left(\frac{2}{\tan i}\right)$$

then

$$\theta = \tan^{-1}\left(\frac{2}{\tan i}\right) + 180^\circ$$

3. Read the attached two classic papers by Keith Runcorn:
- Runcorn, S. K. (1955) Palaeomagnetism of sediments from the Colorado Plateau, *Nature* **176**, 505-506.
- Runcorn, S. K. (1965) Paleomagnetic comparisons between Europe and North America, *Phil. Trans. R. Soc. London A* **258**, 1-12.
- (a) Calculate the magnetization directions (inclination and declination) of the Icelandic basalts, the Supai Shales, and the Springdale Sandstone.
- (b) Figure 1 in the 1965 paper shows the magnetization directions from a single rock formation. Two main magnetization directions were discovered. These rocks have very similar age, yet the locations of the inferred paleopoles are wildly different. How do you explain this?