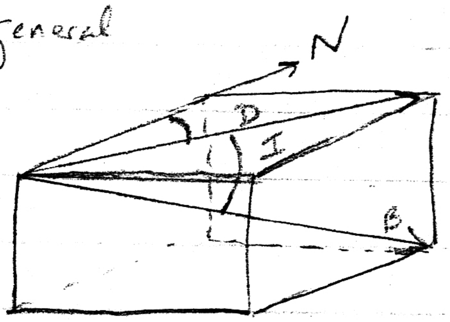
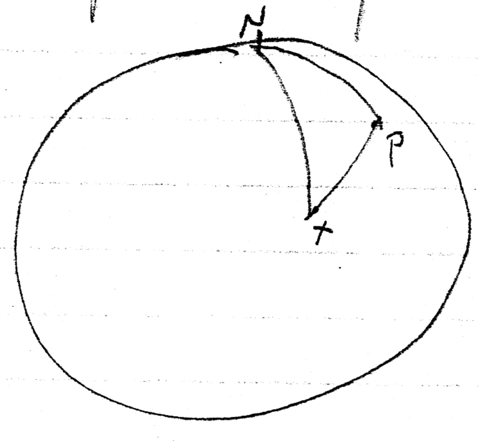
in general



D declination
I inclination

in paleomagnetic work, the assumption is made that D = 0 for the sample when it acquired its magnetization. So the magnetic pole = rotation pole

We want to find the position of the magnetic pole (= rotation pole) when the sample was magnetized in present day coordinates



N = present day north pole
P = paleopole (λ_p, ϕ_p)
x = sample position (λ_x, ϕ_x)
we also measure D and I for the sample

have: λ_x, ϕ_x, D, I want: λ_p, ϕ_p of pole

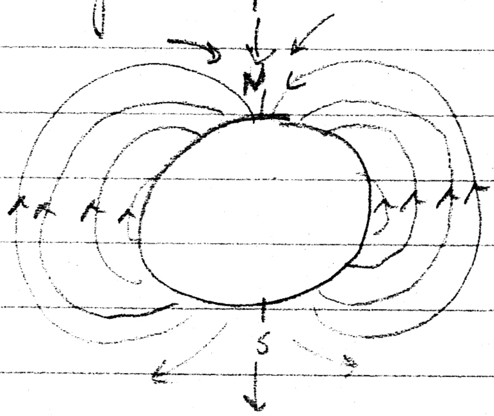
What was the latitude when the sample was magnetized?

$\tan I = 2 \tan \lambda$

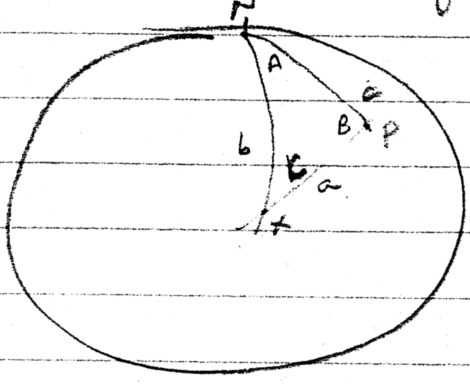
let λ_x, ϕ_x = 47°N, 20°E and I = 30°

then λ = 16°N so sample moved 31° north

can we find the paleolongitude of the sample?
no magnetic field is symmetric about the magnetic pole



We can find the paleopole position under the assumption that declination for the same = 0 at the time of magnetization. Want λ_p, ϕ_p



$b = 90° - \lambda_x$ λ_x = lat of present position

$c = 90° - \lambda_p$

also, the measured declination D = angle C

find λ_p general formula $\cos a = \cos b \cos c + \sin a \sin b \cos A$

we want c = latitude of the paleopole in the present coordinate system

$$\cos c = \cos a \cos b + \sin a \sin b \cos C$$

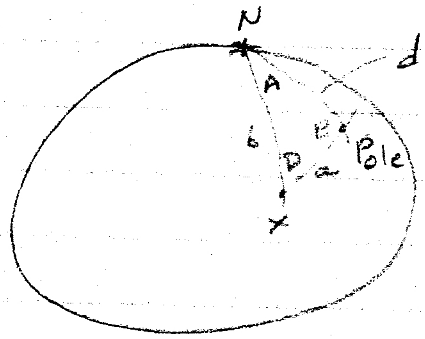
$$\cos(90° - \lambda_p) = \cos(90° - \lambda)\cos(90 - \lambda_x) + \sin(90° - \lambda)\sin(90° - \lambda_x)\cos D$$

or $\sin \lambda_p = \sin \lambda_x \sin \lambda + \cos \lambda_x \cos \lambda \cos D$

have λ, λx and angle D so we can solve for λp

then, use another formula to compute the paleolongitude ϕ_p

$$\frac{\sin a}{\sin A} = \frac{\sin d}{\sin D}$$



A is the angular difference between the longitude of the pole, ϕ_p, and the longitude of the sample, ϕ_x

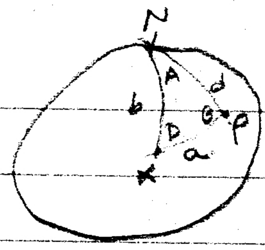
a = 90° − paleolatitude of the sample

d = 90° − paleolatitude of the pole

$$\sin A = \frac{\sin a \sin D}{\sin d} = \frac{\sin(90-\lambda)\sin D}{\sin(90-\lambda_p)}$$

$$\sin(\phi_p - \phi_x) = \frac{\cos \lambda \sin D}{\cos \lambda_p}$$ for $\sin \lambda \geq \sin \lambda_p \sin \lambda_x$

$$\sin(180 + \phi_p - \phi_x) = \frac{\cos \lambda \sin D}{\cos \lambda_p}$$ $\sin \lambda < \sin \lambda_p \sin \lambda_x$



example:

we have:

measurements on a basalt flow at present position
(47°N, 20°E)

remnant magnetization $I = 30°$, $D = 80°$

find the paleopole latitude + longitude

1) find the latitude of the sample when it was magnetized (we already did this):

$\tan I = 2 \tan \lambda$ $\quad \tan 30° = 2 \tan \lambda$

$\lambda = 16°N$

2) find paleolatitude of the pole $\quad \lambda = 16$, $D = 80$

$\lambda_x = 47$

use $\sin \lambda_p = \sin \lambda_x \sin \lambda + \cos \lambda_x \cos \lambda \cos D$

$= \sin 47 \sin 16 + \cos 47 \cos 16 \cos 80$

$\lambda_p = 18°$

longitude of paleopole: here $\sin \lambda = \sin 16 = 0.276$

$\sin \lambda_p \sin \lambda_x = \sin 18 \sin 47$

$= 0.226$

since $\sin \lambda > \sin \lambda_p \sin \lambda_x$ use

$\sin(\phi_p - \phi_x) = \cos \lambda \sin D / \cos \lambda_p$

$$\sin(\phi_p - \phi_x) = \frac{\cos 16 \sin 80}{\cos 18}$$

$$\sin(\phi_p - \phi_x) = .9953$$

$$\phi_p - \phi_x = 84.5^\circ \qquad \phi_p = 104.5^\circ$$

This gives one point on the polar wander curve appropriate for the age of the sample