Plate kinematics

For calculations dealing with the whole Earth we use a coordinate system in which the origin is at the centre of the Earth. Axis 1 or x points towards the intersection of the equator and the Greenwich meridian, 2 or y is towards the intersection of the equator and 90°E, and 3 or z = is towards the north pole. Longitudes east are positive angles, west are negative.

Geographic coordinates converted to vector form

Components for Earth radius vector **r** at latitude λ longitude ϕ where r = 6370 km

$r_1 = r\cos(\lambda)\cos(\phi)$

$r_2 = r\cos(\lambda)\sin(\phi)$

$r_3 = r\sin(\lambda)$

Components for a unit north arrow $\hat{\mathbf{N}}$ at latitude λ longitude ϕ

$N_1 = -\sin(\lambda)\cos(\phi)$

$N_2 = -\sin(\lambda)\sin(\phi)$

$N_3 = \cos(\lambda)$

Components for a unit east arrow $\hat{\mathbf{E}}$ at longitude ϕ

$E_1 = -\sin(\phi)$

$E_2 = \cos(\phi)$

$E_3 = 0$

Paleomagnetism

Magnetic inclination related to latitude:

$$\tan(I)=2\tan(\lambda)$$

where I = inclination, λ=latitude.

Spreading half-rate related to age of magnetic anomaly $v=w/(t_1-t_2)$

where v = spreading half-rate, w=distance from ridge, t_1, t_2*=ages of anomalies.*

Vector circuit for Euler poles

For any three plates A, B, C, if ${}_A\boldsymbol{\Omega}_B$ signifies rotation of plate B relative to plate A then ${}_A\boldsymbol{\Omega}_B+{}_B\boldsymbol{\Omega}_C+{}_C\boldsymbol{\Omega}_A=\mathbf{0}$ *where* ${}_A\boldsymbol{\Omega}_B$ *signifies motion of B relative to A*

Vector circuit for triple junction

At a triple junction involving plates A, B, C, plate motion vectors obey ${}_A\mathbf{v}_B+{}_B\mathbf{v}_C+{}_C\mathbf{v}_A=0$ *where* ${}_A\mathbf{v}_B$ *signifies motion of B relative to A*

Euler poles for 24 plates

in "Pacific Plate" reference frame. (Poles from the model MORVEL; DeMets et al. 2010, Geophys.J.Int. ***181,*** *1-80)*

		Rotation relative to Pacific Plate		
Plate		Lat°N	Long°E	ω deg/Myr
Amur	AM	65.9	-82.7	0.929
Antarctica	AN	65.9	-78.5	0.887
Arabia	AR	60	-33.2	1.159
Australia	AU	60.1	6.3	1.079
Caribbean	CA	55.8	-77.5	0.905
Cocos	CO	42.2	-112.8	1.676
Capricorn	CP	62.3	-10.1	1.139
Eurasia	EU	61.3	-78.9	0.856
India	IN	61.4	-31.2	1.141
Juan de Fuca	JF	-0.6	37.8	0.625
Lwandle	LW	60	-66.9	0.932
MacQuarie	MQ	59.2	-8	1.686
North America	NA	48.9	-71.7	0.75
Nubia	NB	58.7	-66.6	0.935
Nazca	NZ	55.9	-87.8	1.311
Philippine Sea	PS	-4.6	-41.9	0.89
Rivera	RI	25.7	-104.8	4.966
South America	SA	56	-77	0.653
Scotia	SC	57.8	-78	0.755
Somalia	SM	59.3	-73.5	0.98
Sur	SR	55.7	-75.8	0.636
Sundaland	SU	59.8	-78	0.973
Sandwich	SW	-3.8	-42.4	1.444
Yangtze	YZ	65.5	-82.4	0.968

Rate of plate motion at a point on boundary

In vector terms, slip vector for motion at any point on a plate boundary between plates *A* and *B:*

${}_A\mathbf{v}_B = {}_A\boldsymbol{\Omega}_B \times \mathbf{r}$

where: **r** *is the radius vector of the Earth at the point on the plate boundary and*

${}_A\boldsymbol{\Omega}_B$ *is the plate rotation vector*

North component of ${}_A\mathbf{v}_B$ is given by $v_N = {}_A\mathbf{v}_B \cdot \hat{\mathbf{N}}$

East component of ${}_A\mathbf{v}_B$ is given by $v_E = {}_A\mathbf{v}_B \cdot \hat{\mathbf{E}}$

Alternatively, for a point at angular distance θ from the Euler pole

$v=\omega R\sin\theta$

where R is the radius of the Earth (6370 km), ω is the rate of rotation in radians per million years, and v is the rate of slip in km per million years (or mm per year)

Note: sign conventions here follow the convention used by most geophysicists but not the text Earth Structure by Van der Pluijm & Marshak (2004)