Vectors and plate motion

Geographic coordinates converted to vector form

Components for a radius vector $\mathbf{r}$ at latitude λ longitude ϕ where R is radius of the Earth

$\mathbf{r}_x = R\cos(\lambda)\cos(\phi)$

$\mathbf{r}_y = R\cos(\lambda)\sin(\phi)$

$\mathbf{r}_z = R\sin(\lambda)$

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

$\mathbf{N}_x = -\sin(\lambda)\cos(\phi)$

$\mathbf{N}_y = -\sin(\lambda)\sin(\phi)$

$\mathbf{N}_z = \cos(\lambda)$

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

$\mathbf{E}_x = -\sin(\phi)$

$\mathbf{E}_y = \cos(\phi)$

$\mathbf{E}_z = 0$

Rate of plate motion at a point on boundary

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)*

Alternatively, in vector terms, slip vector for motion $_A\mathbf{v}_B = {}_A\mathbf{\Omega}_B \times \mathbf{r_i}$

where $\mathbf{r_i}$ *is the radius vector of the earth at the point on the plate boundary and* $_A\grave{\mathbf{U}}_B$ *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 $v_E = {}_A\mathbf{v_B} \cdot \hat{\mathbf{E}}$

Vector circuit for Euler poles

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

where $_A\mathbf{\Omega}_B$ *signifies motion of A relative to B*

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 A relative to B*

Note: sign conventions here follow the text by Van der Pluijm & Marshak (2004)