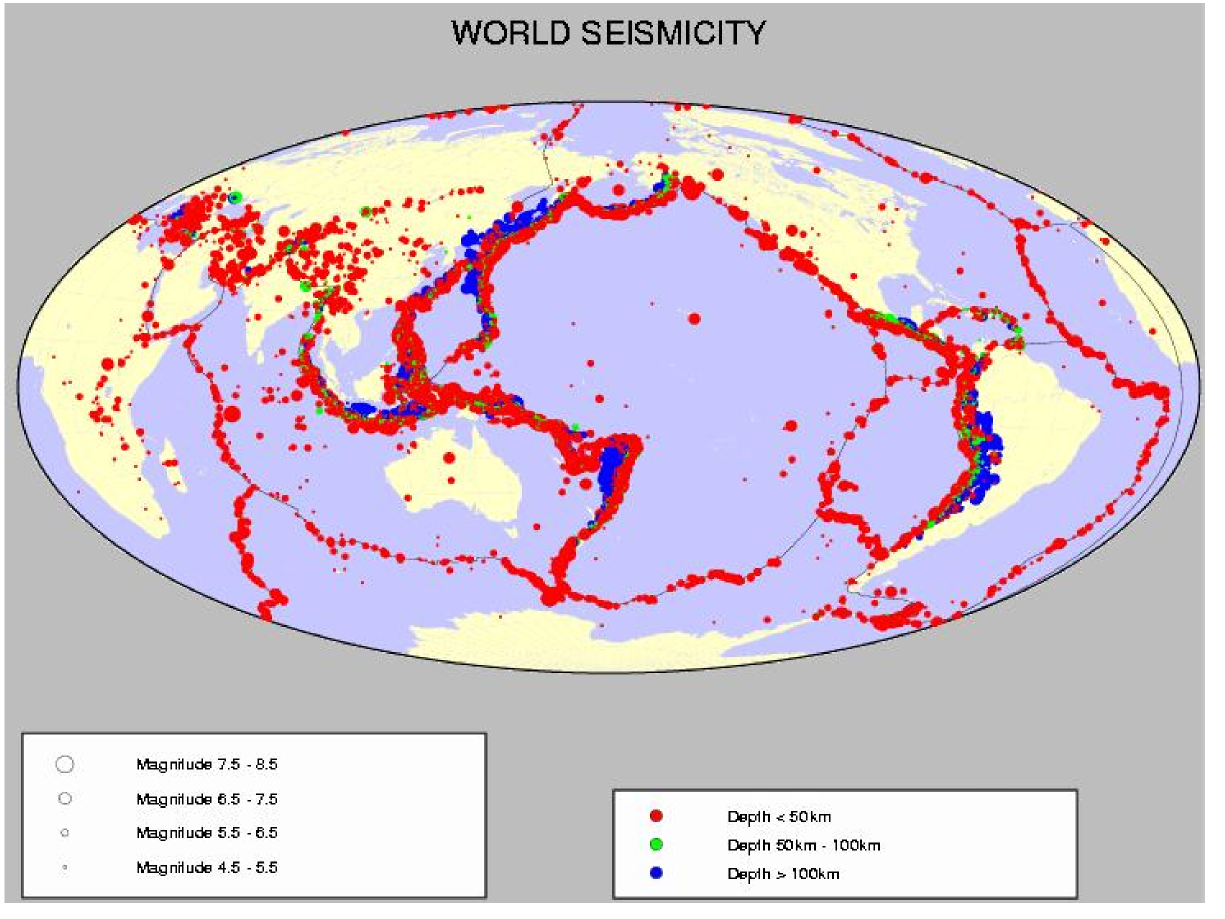
RIGID PLATE TECTONICS

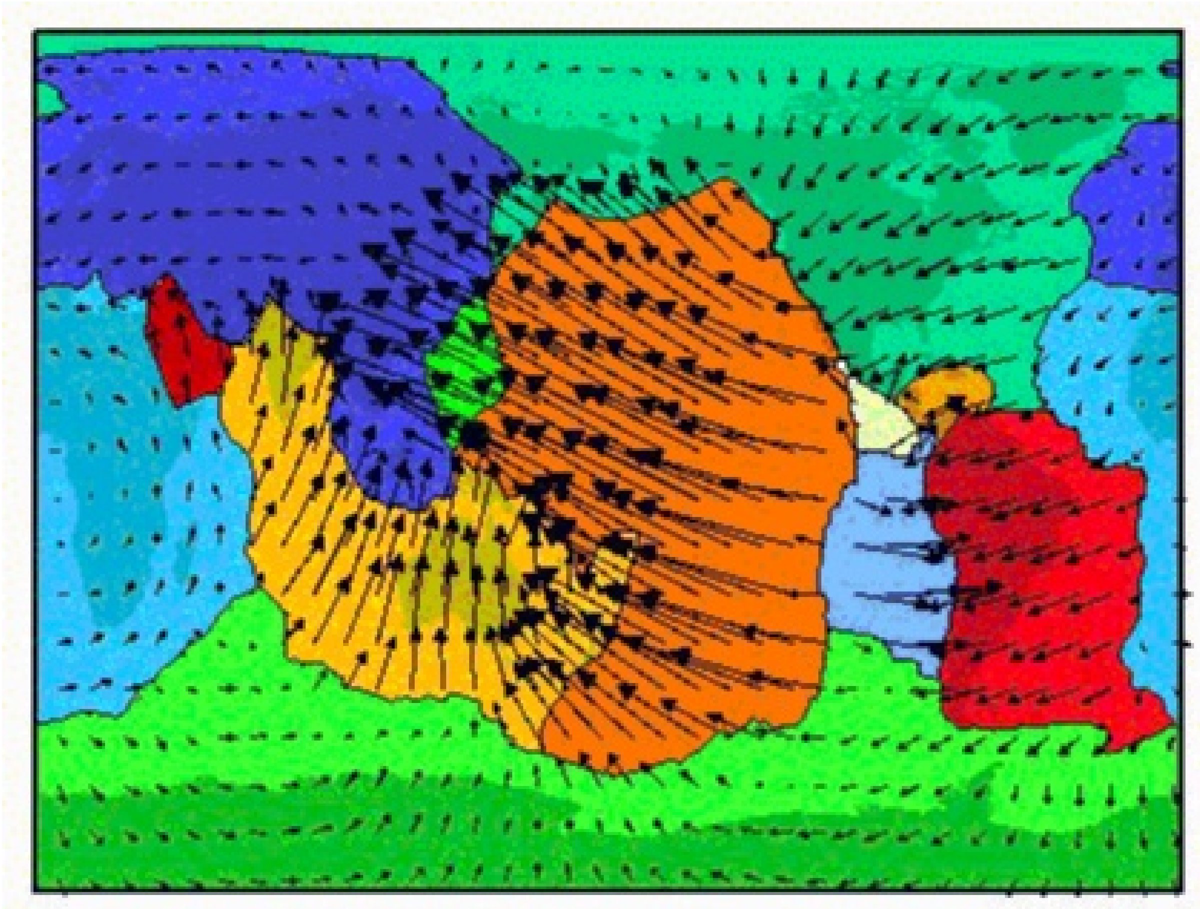
- Plate definition
- Plate motion : Euler pole
- Geological model : Nuvel-1A
- Geodetic model : ITRF
- Rigid plate rotations
- Plate deformation : strain and rotation tensors

World seismicity



The Earth surface is cut by «lines» of earthquakes, separating quite areas, i.e. plates.

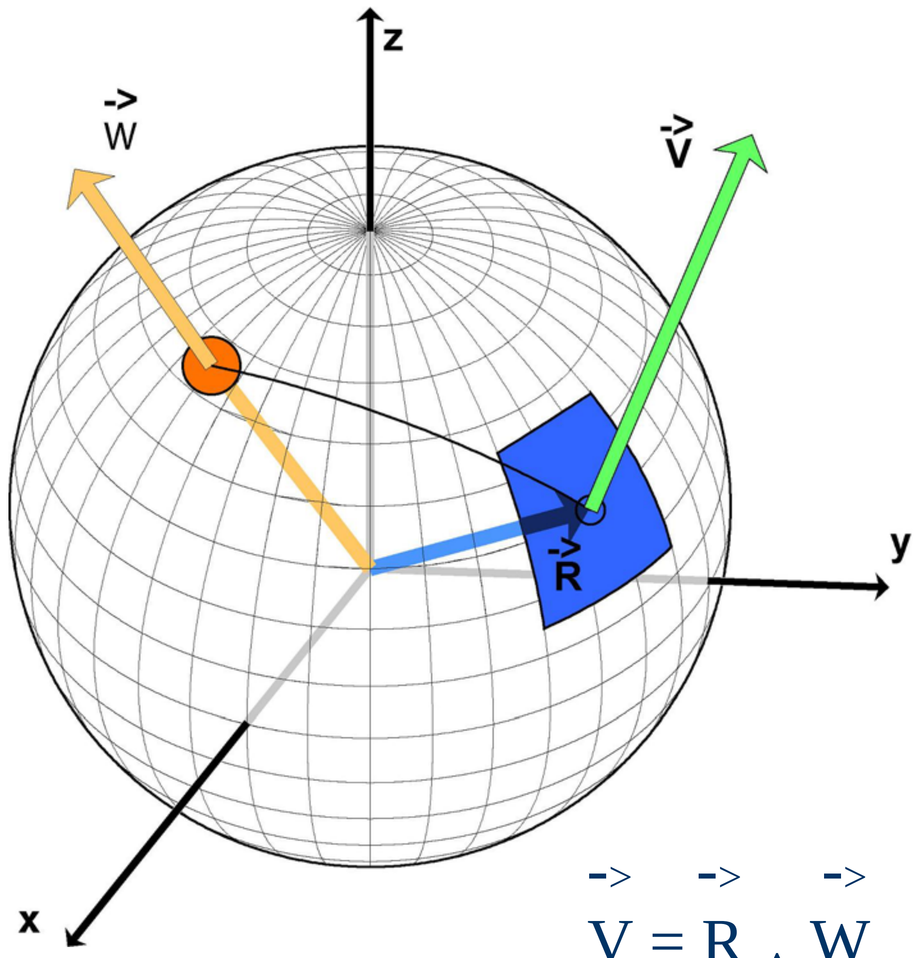
Plate geometry and plate tecctonics



- Pacific
- Eurasia
- North America
- South America
- Africa
- Antarctica
- India-Australia
- Nazca
- Philippine
- Arabia
- Caraibe
- Coco

There are 12 main plates   and they move : it is **plate tectonics**

Rotation on a sphere



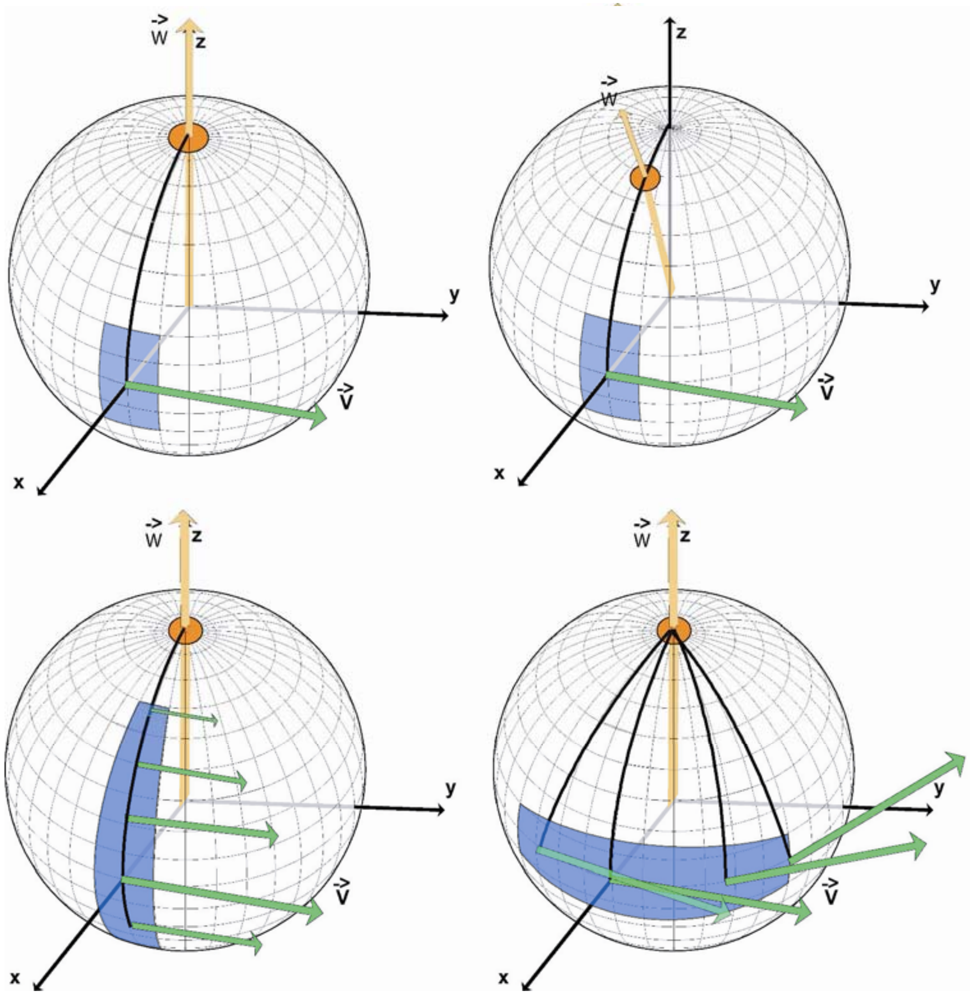
$$\vec{V} = \vec{R} \wedge \vec{W}$$

On a sphere, any translation at the surface is in fact a rotation about an axis crossing the Earth from its center to its surface.

The place at the surface where the axis points is called the **rotation pole**

The amplitude of W is called the **rotation speed**

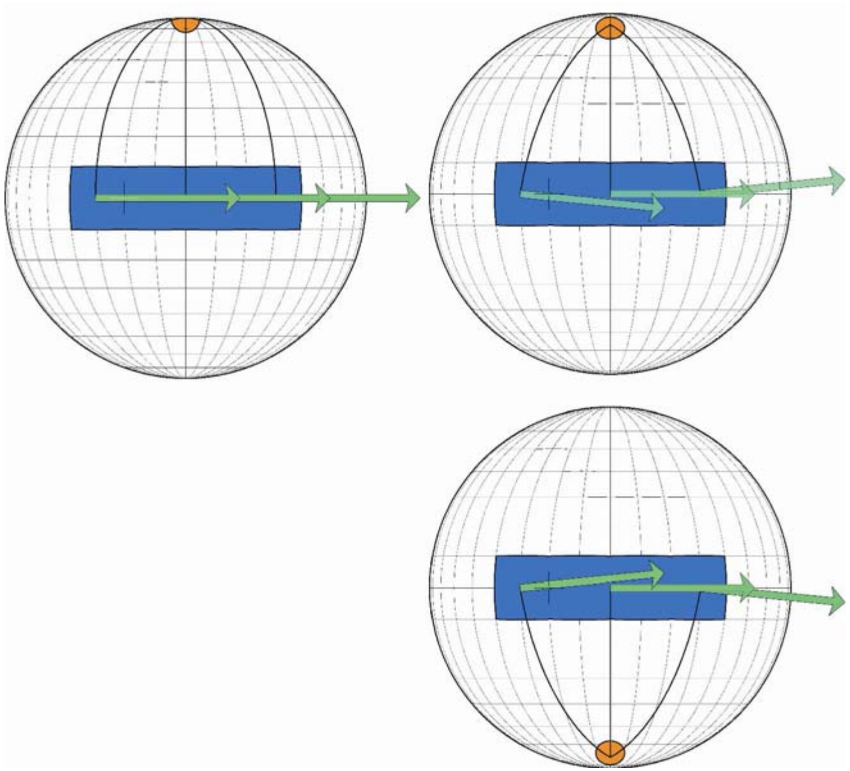
Finding a pole



There is an infinite number of possible poles for only one velocity

=> Only **large plates** have well determined poles

Effect of velocity uncertainty



Slightly different velocities can give very different poles

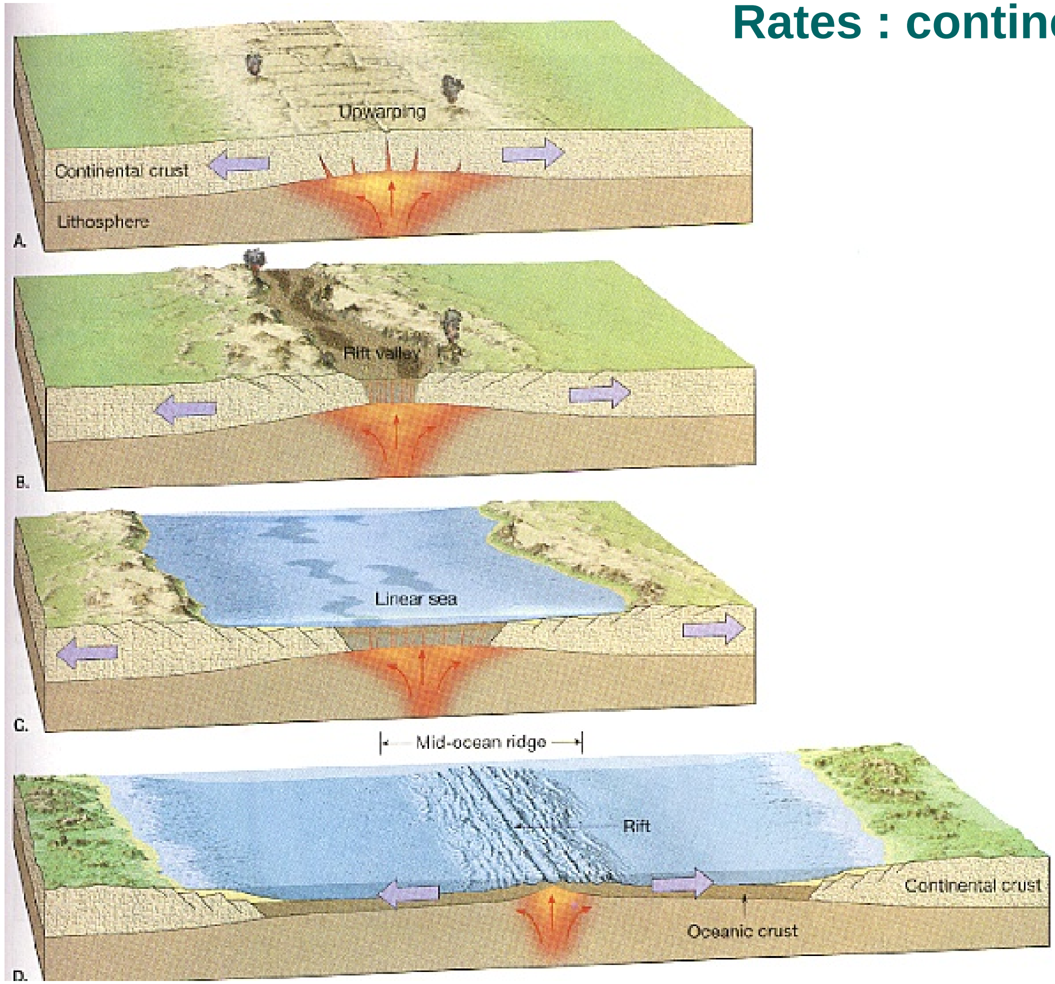
Or reverse :

Very different poles can give quite similar velocities

Pole positions don't matter.
only velocities do !!!!

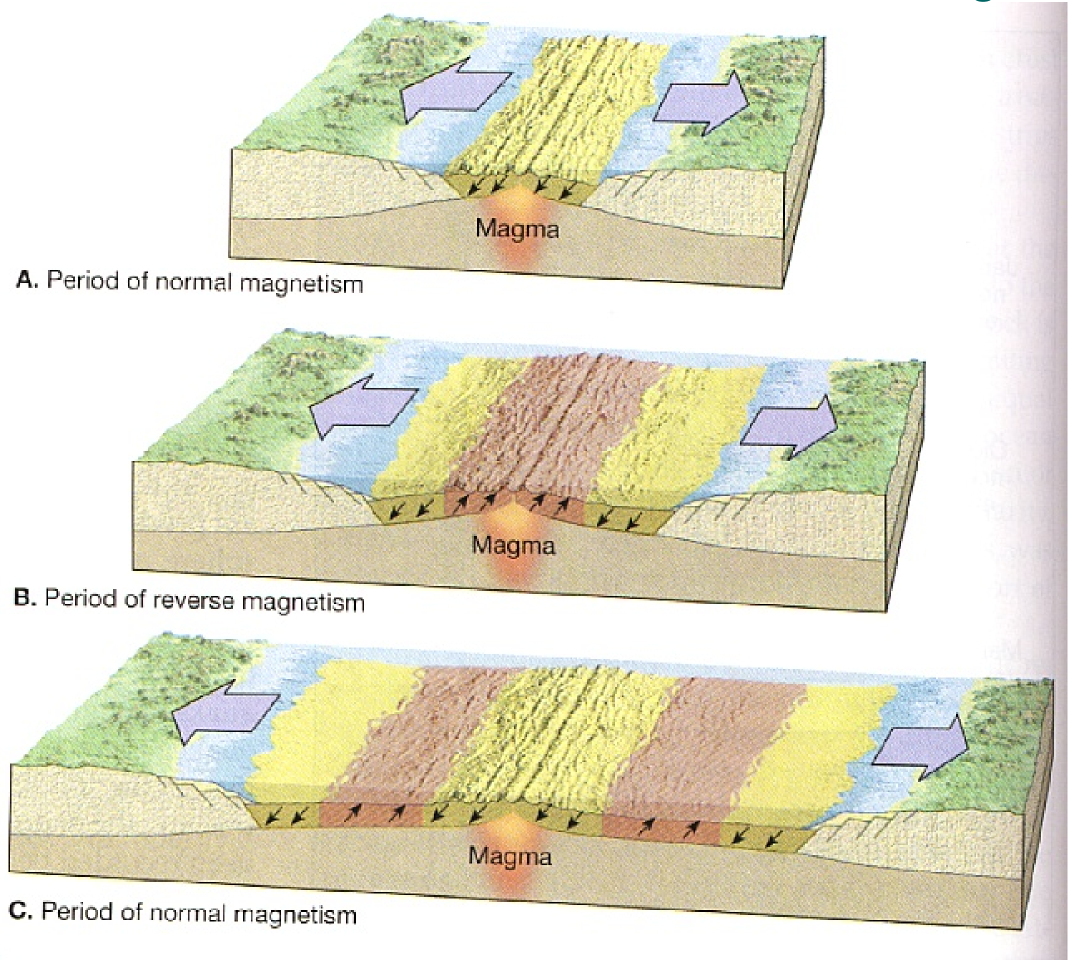
Geological model : how it works

Rates : continental drifting

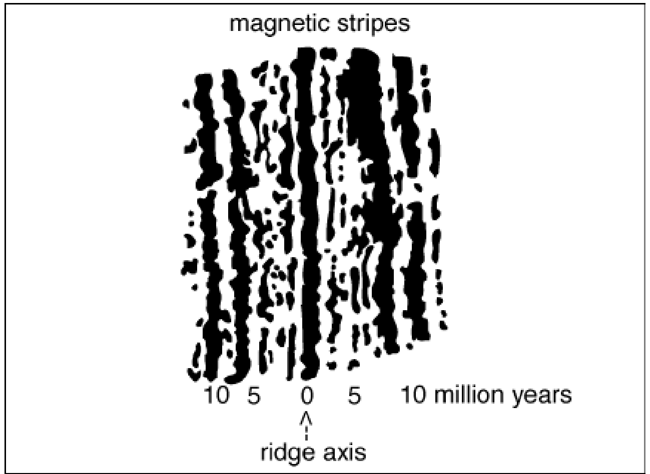


Geological model : how it works

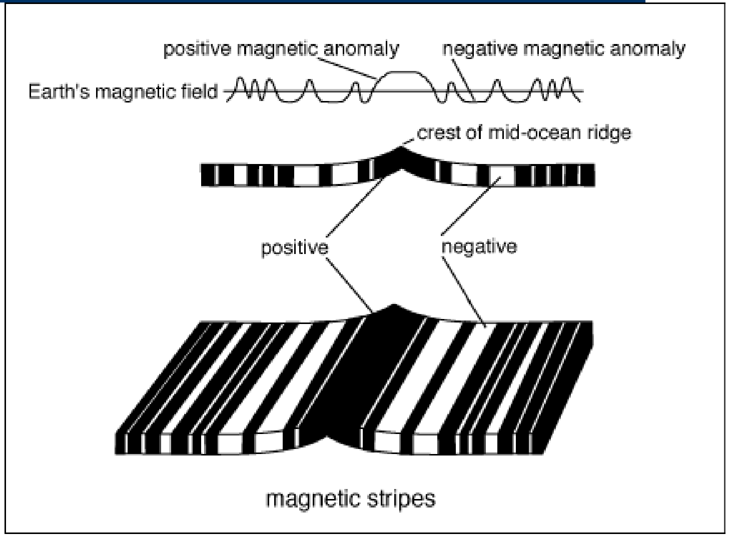
Rates : generation of oceanic crust and sea floor magnetic anomalies

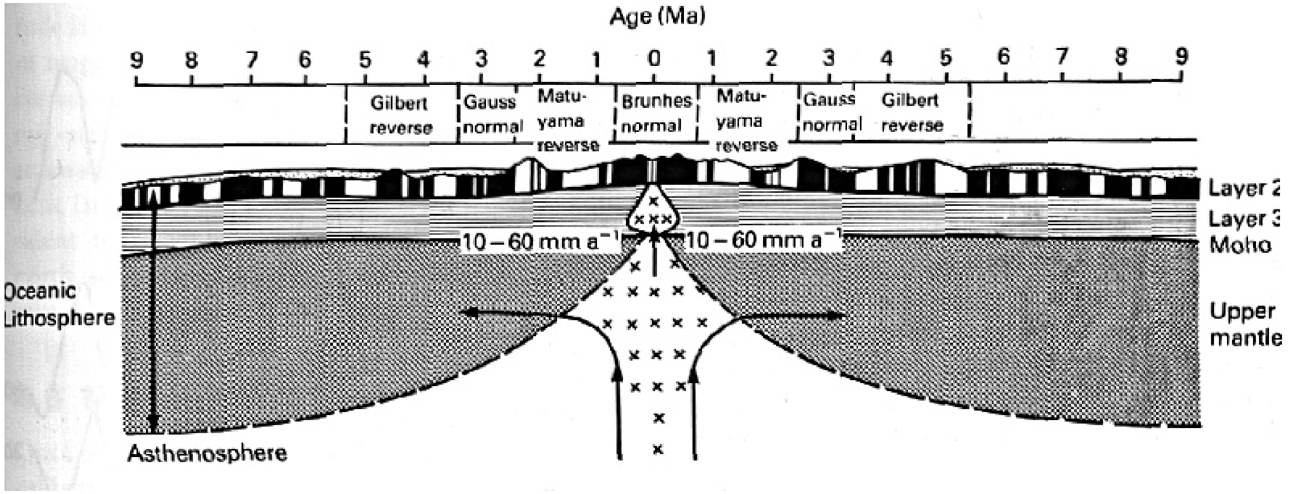


Rates : Vine and Matthews hypothesis



Pattern created by magnetic stripes along the Mid-Atlantic Ridge south of Iceland.





Rates : uncertainties from magnetic time scale

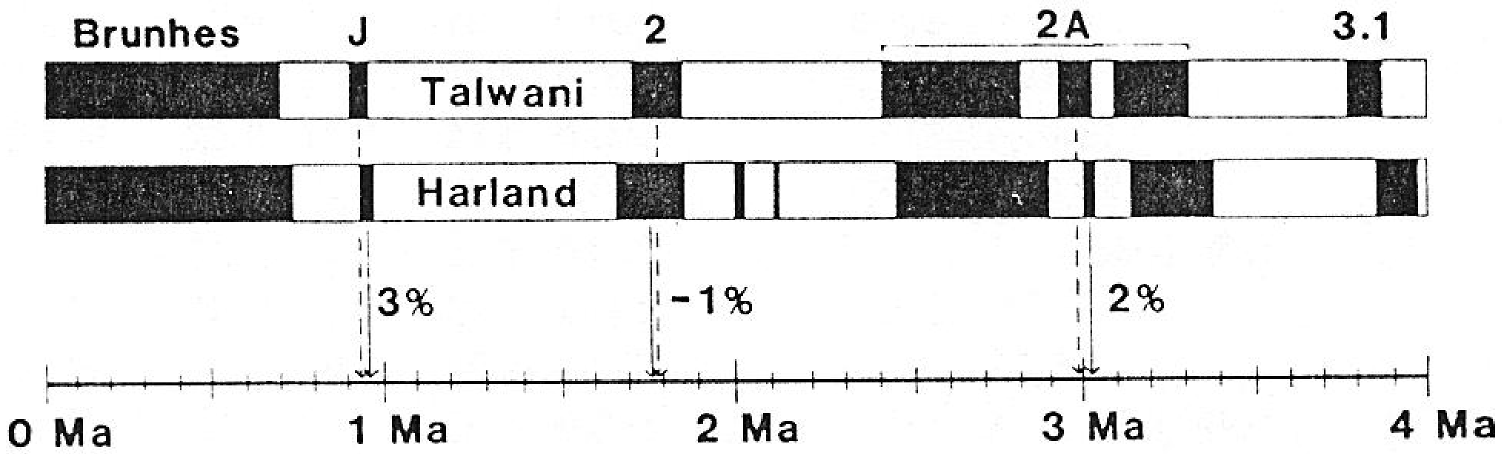
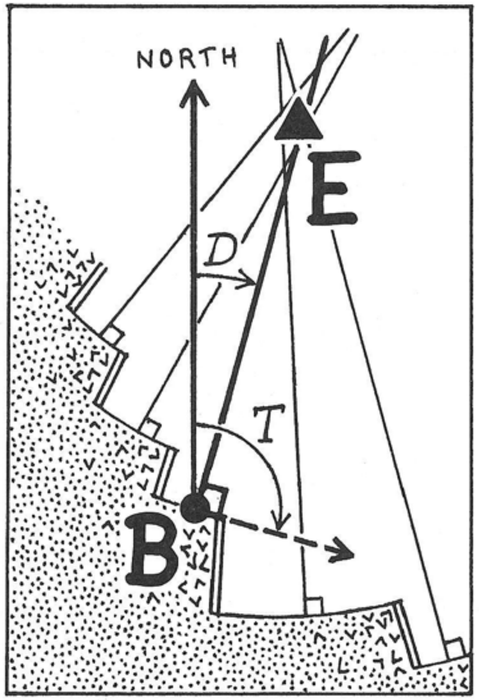


Figure 1. Comparison since 4.0 Ma of the geomagnetic reversal time-scale used here (Harland *et al.* 1982) with the time-scale used by Chase (1978) and Minster & Jordan (1978) (Talwani *et al.* 1971). We determined rates by seeking the best fit to the centre of anomaly 2A, which is 2 per cent older in the Harland *et al.* time-scale than in the Talwani *et al.* time-scale.

Geological model : how it works

directions



$D = T \pm 90°$

Figure 4-1.
Locating an Euler pole **E** from the trends *T* of transforms. Lines nearly intersecting at **E** are great circles perpendicular to the transforms.

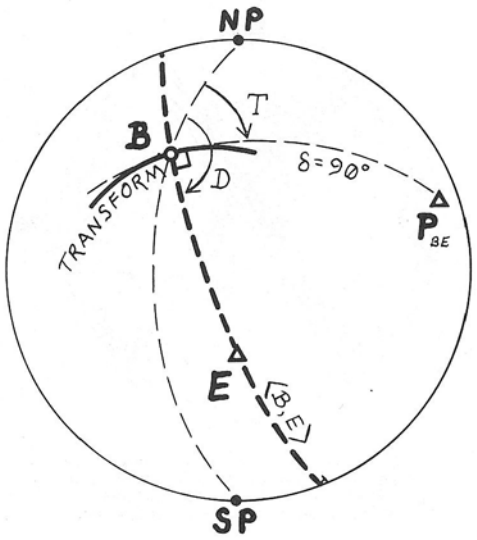


Figure 4-2.
Euler pole **E** is on the great circle perpendicular to the trend of the transform. $\mathbf{P}_{BE}$ is the pole of the great circle <**B**, **E**>.

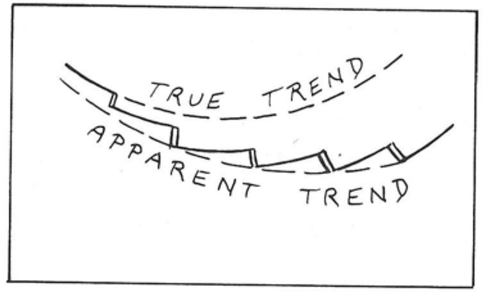
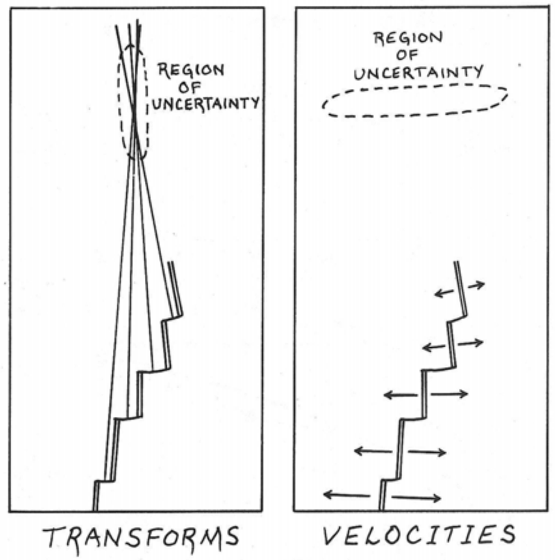


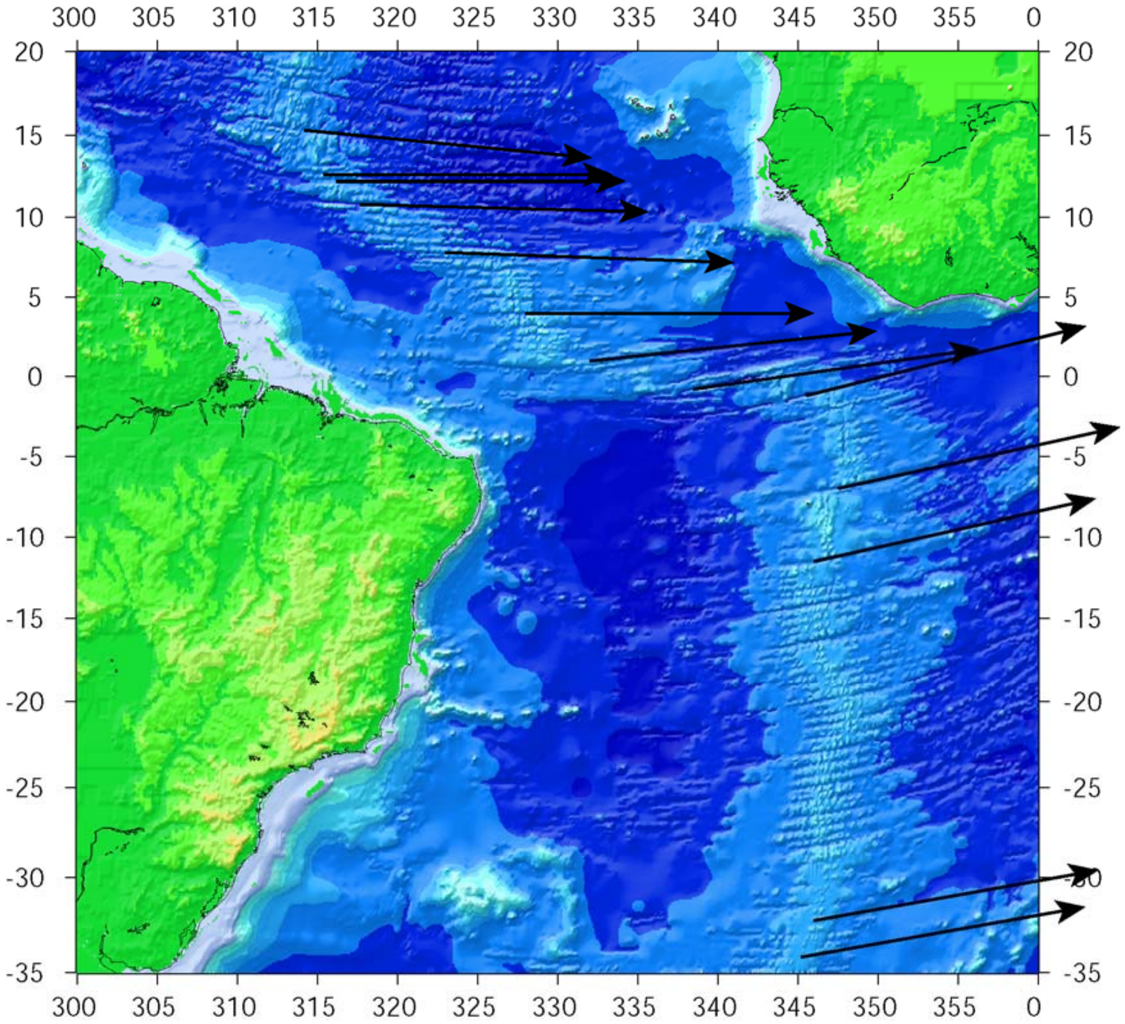
Figure 4-3.
Apparent and true trends of transform system offset by short ridge segments.



Geological model : real data

Transform faults azimuths

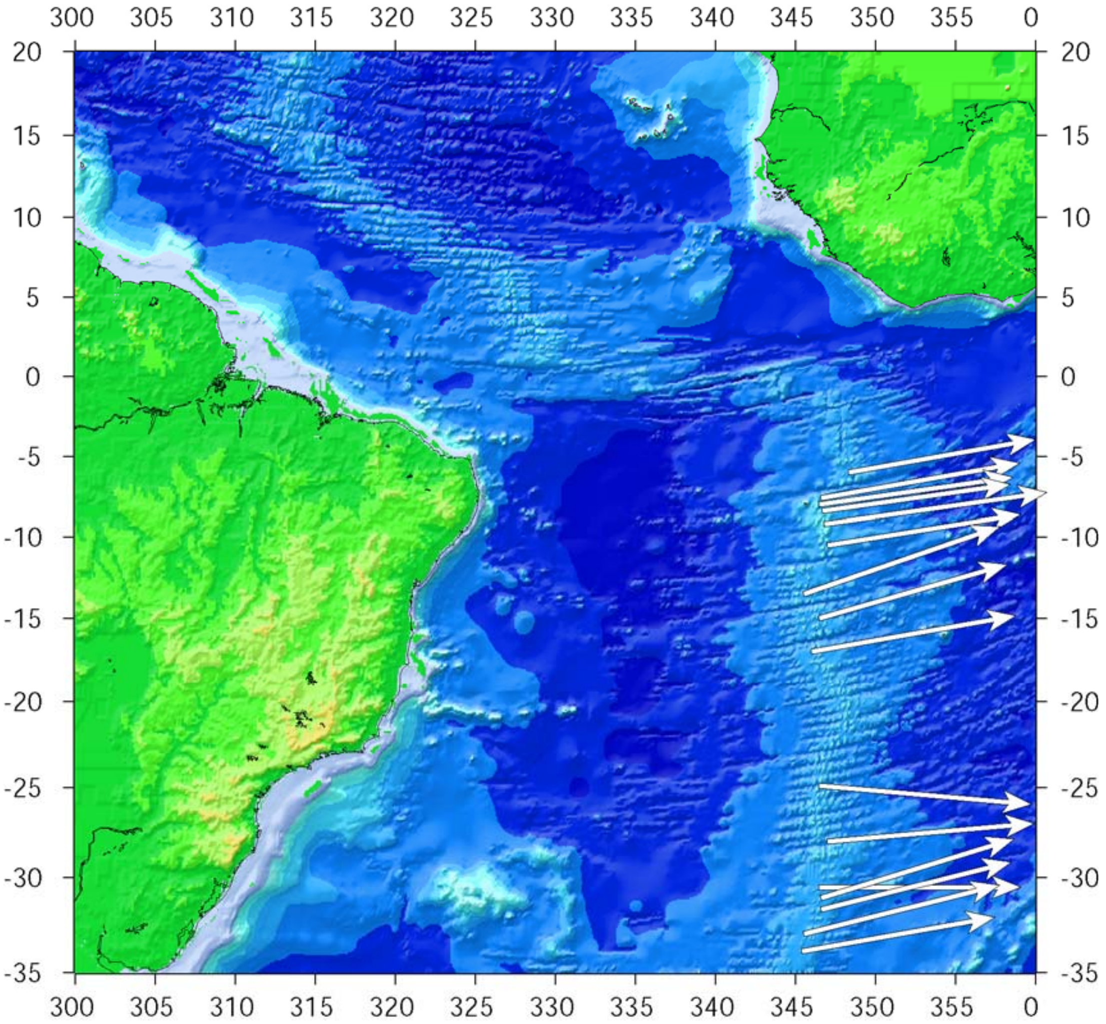
Lon	lat	azimuth
15.3	-45.8	95.5
12.6	-44.6	90.0
12.2	-43.8	90.0
10.8	-42.3	91.5
7.8	-37.0	92.0
4.0	-32.0	90.0
1.0	-28.0	84.0
-0.8	-21.5	82.0
-1.2	-14.5	76.0
-7.0	-12.5	77.7
-11.5	-14.0	77.5
-32.3	-14.0	80.0
-34.2	-14.8	80.0
-54.2	-2.0	65.0



Geological model : real data

Spreading rates

lon, lat, rate, az
-6.0 -11.7 33 10
-7.6 -13.4 35 10
-8.0 -13.5 34 8
-8.4 -13.3 33 8
-9.2 -13.2 39 8
-10.5 -13.0 34 9
-13.5 -14.5 36 19
-15.0 -13.5 34 16
-17.0 -14.0 36 10
-24.9 -13.5 37 -5
-28.0 -13.0 36 5
-30.5 -13.5 35 0
-31.1 -13.4 35 17
-31.7 -13.4 34 14
-33.0 -14.5 35 14
-33.9 -14.6 34 10
-38.5 -17.0 36 10
-40.0 -16.0 36 5
-42.0 -16.0 32 5
-43.0 -16.0 35 5
-54.2 -1.3 28 25
-54.5 -1.1 30 25

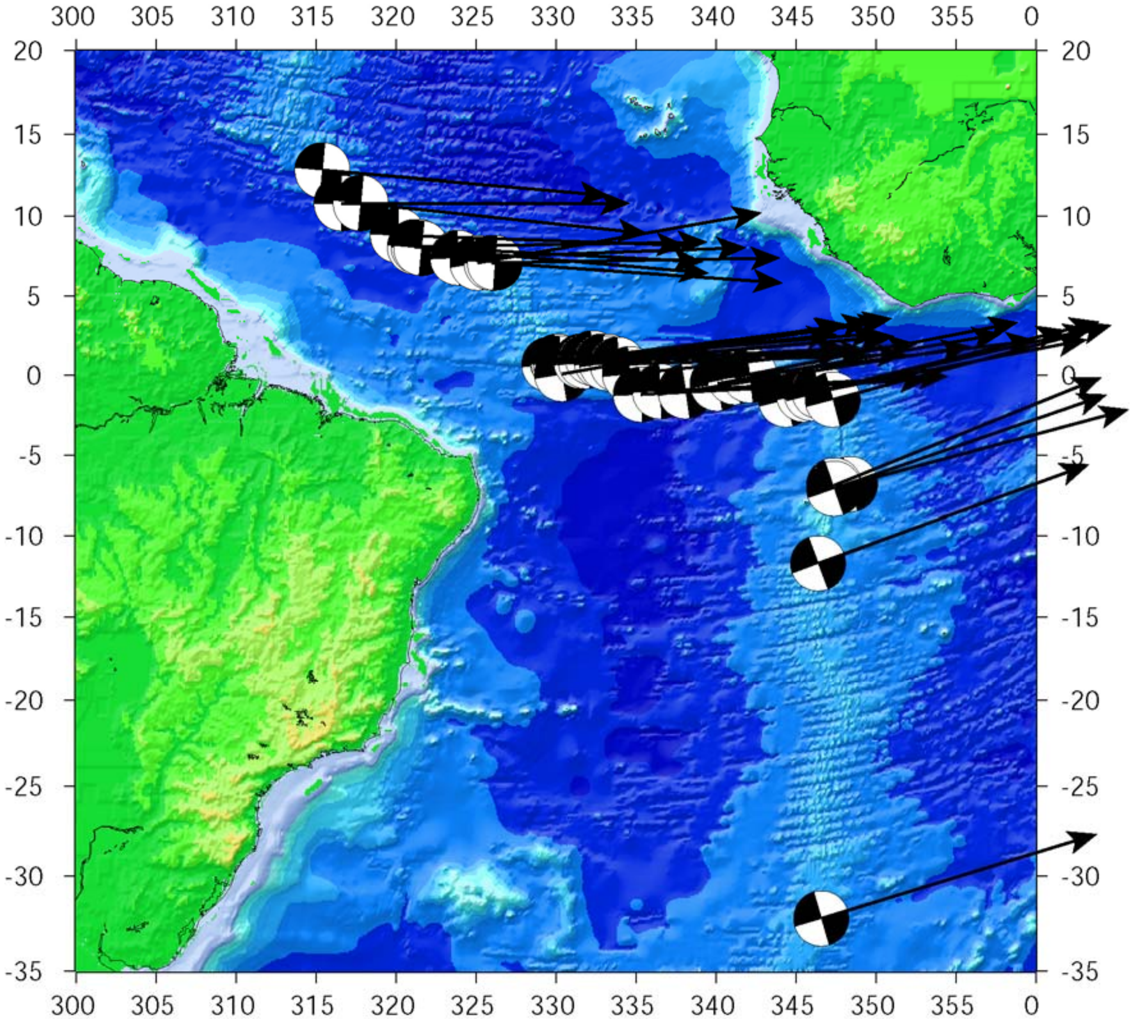


Geological model : real data

Slip vector azimuths

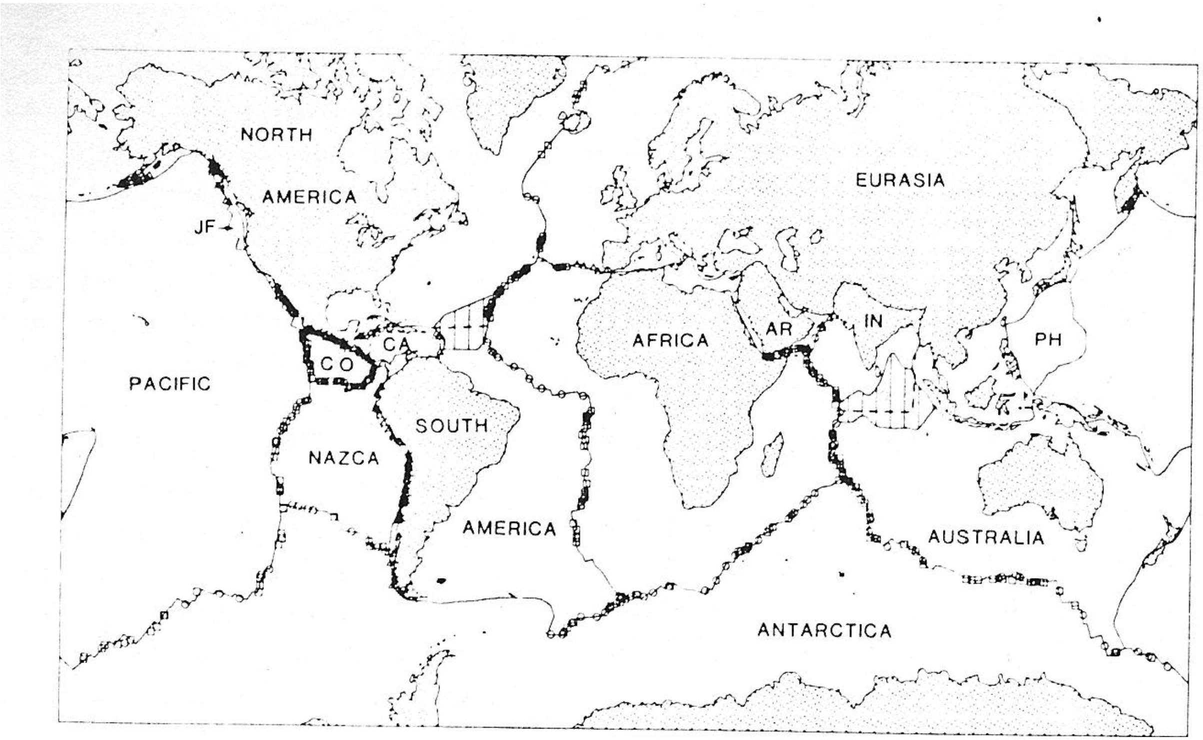
Lon lat azimut
12.8 -44.6 95.0
10.8 -43.4 90.0
10.8 -42.2 96.0
8.8 -39.9 92.0
8.1 -38.8 93.0
8.1 -38.5 89.0
8.0 -38.4 95.0
7.4 -36.1 88.0
7.1 -34.9 80.0
7.1 -34.0 89.0
7.1 -33.8 94.0
0.7 -30.4 84.0
0.9 -29.9 83.0
0.8 -29.8 88.0
0.8 -29.7 87.0
0.1 -29.6 80.0
0.9 -28.4 88.0
0.9 -28.1 82.0
1.1 -27.7 85.0
0.9 -27.1 85.0
0.9 -27.1 82.0
0.9 -26.8 85.0
0.8 -26.8 81.0
0.7 -26.1 88.0
0.1 -25.3 84.0
-1.2 -24.7 87.0
-1.0 -23.5 87.0
-1.0 -21.9 81.0

Lon lat azimut
-0.5 -19.9 80.0
-0.1 -18.8 79.0
-0.0 -17.9 83.0
-1.5 -15.6 76.0
-1.2 -14.5 79.0
-1.1 -14.0 77.0
-1.0 -13.5 76.0
-1.5 -12.7 75.0
-6.8 -11.6 75.0
-6.9 -12.6 68.0
-7.1 -12.6 71.0
-11.7 -13.6 70.0
-32.2 -13.4 73.0
-35.8 -16.0 76.0
-35.5 -16.1 81.0
-47.6 -12.9 76.0
-46.9 -10.8 85.0



Geological model : Nuvel-1A, Demets et al., 1990

Current plate motions, Geophys. Journal. Int., 101, 425-478, 1990



Around 1200 slip vector azimuth, transform fault orientations and spreading rates are compiled in one model for plate motion

Geological model : data table

Table 3. *(continued)*

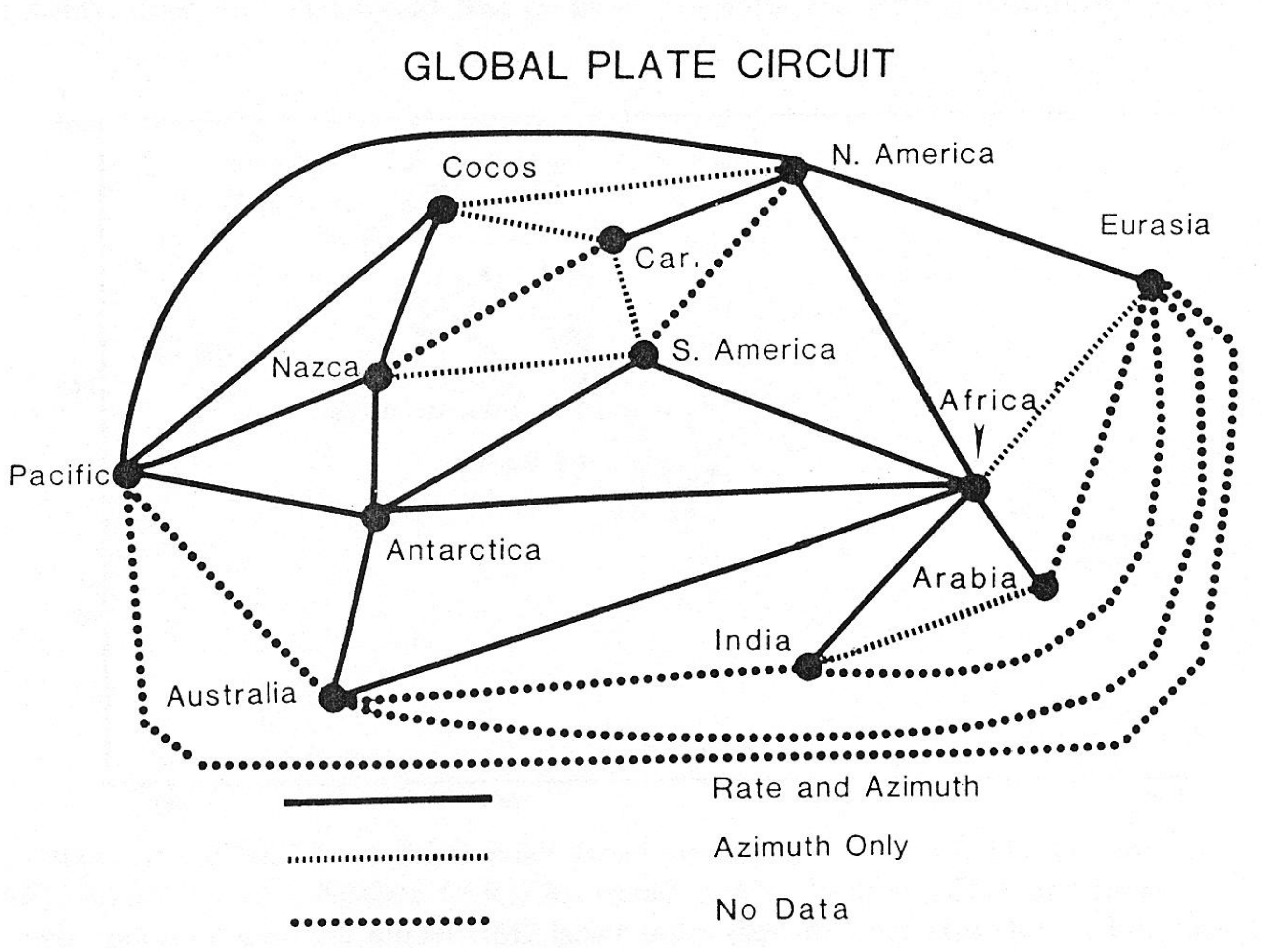
26.90	-44.50	26	4	24.5	0.022	n16e	*Rabinowitz & Schouten* (1985)
26.20	-44.80	22	3	23.5	0.037	n30e	*McGregor et al.* (1977)
25.70	-45.00	24	4	24.2	0.022	n24e	*Rabinowitz & Schouten* (1985)
25.30	-45.40	22.5	2	24.4	0.089	n24e	*Rabinowitz & Schouten* (1985)
25.10	-45.40	24.5	2	24.4	0.090	n24e	*Rona & Gray* (1980)
24.50	-46.10	23	4	24.6	0.023	n23e	*Rabinowitz & Schouten* (1985)
24.20	-46.30	24.5	2	25.1	0.097	n15e	*Rona & Gray* (1980)
23.00	-45.00	25	4	25.2	0.025	n08e	*Rabinowitz & Schouten* (1985)
22.80	-45.00	25	2	25.1	0.100	n04e	*Rabinowitz & Schouten* (1985)
Africa-North America: Transform Azimuths							
35.20	-35.60	104.5	2	103.6	0.203		*Roest et al.* (1984)
33.70	-38.70	104.5	2	103.4	0.216		*Roest et al.* (1984)
30.00	-42.40	101.5	3	102.9	0.100		*Roest et al.* (1984)
23.70	-45.70	98.0	2	102.2	0.220		*Roest et al.* (1984) & *Pockalny et al.* (1988)
Africa-North America: Slip Vectors							
35.43	-36.03	102.0	20	103.6	0.002		CMT 4.29.85
35.41	-36.01	101.0	10	103.7	0.008		CMT 6.06.82
35.35	-36.08	100.0	10	103.7	0.008		*Bergman & Solomon* (1988)
35.14	-35.45	101.0	15	103.6	0.004		CMT 7.14.80
33.79	-38.64	101.0	10	103.4	0.009		*Bergman & Solomon* (1988)
33.78	-38.46	102.0	15	103.4	0.004		CMT 5.07.84
33.69	-38.60	103.0	15	103.4	0.004		CMT 5.03.84
28.74	-43.58	91.0	20	102.8	0.002		*Engeln et al.* (1986)
23.83	-45.94	100.0	10	102.2	0.009		*Bergman & Solomon* (1988)
23.86	-45.57	100.0	10	102.2	0.009		*Bergman & Solomon* (1988)
23.81	-45.44	106.0	15	102.2	0.004		CMT 11.28.81
23.74	-45.17	102.0	15	102.2	0.004		CMT 3.12.77
Africa-Eurasia: Transform Azimuths							
36.90	-23.50	257.0	5	260.2	0.187		*Laughton et al.* (1972)
37.00	-22.60	265.0	3	263.3	0.399		*Laughton et al.* (1972)
37.10	-21.70	265.0	3	266.3	0.384		*Laughton et al.* (1972)
37.10	-20.50	-90.0	7	270.4	0.098		*Laughton et al.* (1972)
Africa-Eurasia: Slip Vectors							
37.75	-17.25	-89.0	25	-79.2	0.022		CMT 10.17.83
37.22	-14.93	-50.0	25	-71.5	0.042		*Grimison & Chen* (1986)
36.96	-11.84	267.0	25	-62.0	0.066		*Grimison & Chen* (1986)
36.01	-10.57	-35.0	25	-57.0	0.092		*Fukao* (1973)
35.99	-10.34	-60.0	25	-56.3	0.098		*Grimison & Chen* (1986)
36.23	-7.61	-35.0	25	-49.8	0.104		*Grimison & Chen* (1986)
Africa-South America: Spreading Rates							
-6.00	-11.70	33	6	34.1	0.018	n10w	*van Andel et al.* (1973)
-7.60	-13.40	35	6	34.4	0.018	n10w	*van Andel et al.* (1973)
-8.00	-13.50	34	2	34.4	0.160	n08w	*Brozena* (1986)
-8.40	-13.30	33	6	34.5	0.018	n08w	*van Andel et al.* (1973)
-9.20	-13.20	39	6	34.6	0.017	n08w	*van Andel et al.* (1973)
-10.50	-13.00	34	3	34.8	0.068	n09w	*Brozena* (1986)
-13.50	-14.50	36	4	35.0	0.034	n19w	*Brozena* (1986)
-15.00	-13.50	34	2	35.4	0.136	n16w	*Brozena* (1986)
-17.00	-14.00	36	3	35.6	0.061	n10w	*Brozena* (1986)
-24.90	-13.50	37	6	34.5	0.013	n05e	*Dickson et al.* (1968)
-28.00	-13.00	36	3	35.7	0.053	n05w	*Dickson et al.* (1968)
-30.50	-13.50	35	3	35.1	0.051	n00e	*Dickson et al.* (1968)
-31.10	-13.40	35	5	35.7	0.019	n17w	*Welch et al.* (1986)
-31.70	-13.40	34	3	35.7	0.052	n14w	*Welch et al.* (1986)
-33.00	-14.50	35	3	35.6	0.051	n14w	*Welch et al.* (1986)
-33.90	-14.60	34	4	35.6	0.029	n10w	*Welch et al.* (1986)
-38.50	-17.00	36	6	35.1	0.013	n10w	*Dickson et al.* (1968)
-40.00	-16.00	36	3	34.7	0.051	n05w	*Loomis & Morgan* (1973)
-42.00	-16.00	32	4	34.4	0.029	n05w	*Dickson et al.* (1968)
-43.00	-16.00	35	3	34.2	0.052	n05w	*Loomis & Morgan* (1973)
-54.20	-1.30	28	5	30.9	0.023	n25w	NGDC Chain 115-4
-54.50	-1.10	30	3	30.8	0.064	n25w	NGDC Chain 115-4
-54.60	-1.00	30	5	30.8	0.023	n25w	NGDC Chain 115-4
Africa-South America: Transform Azimuths							
15.30	-45.80	95.5	3	94.0	0.128		*Roest et al.* (1984)
12.60	-44.60	90.0	3	93.1	0.108		*Collette et al.* (1979)
12.20	-43.80	90.0	3	92.6	0.101		*Collette et al.* (1979)
10.80	-42.30	91.5	2	91.7	0.197		*Macdonald et al.* (1986)
7.80	-37.00	92.0	8	88.6	0.008		*Emery & Uchupi* (1984)
4.00	-32.00	90.0	5	86.0	0.016		*Emery & Uchupi* (1984)
1.00	-28.00	84.0	5	84.1	0.015		*Emery & Uchupi* (1984)
-0.80	-21.50	82.0	2	81.0	0.110		*Belderson et al.* (1984)
-1.20	-14.50	76.0	3	77.8	0.069		*Emery & Uchupi* (1985)
-7.00	-12.50	77.7	2	77.3	0.150		*Brozena* (1986)
-11.50	-14.00	77.5	3	78.2	0.056		*Brozena* (1986)
-32.30	-14.00	80.0	2	78.5	0.098		D. Forsyth (personal communication, 1985)
-34.20	-14.80	80.0	3	78.8	0.042		D. Forsyth (personal communication, 1985)
-54.20	-2.00	65.0	10	71.0	0.006		*Sclater et al.* (1976a)
Africa-South America: Slip Vectors							
15.34	-45.92	97.0	10	94.1	0.012		*Bergman & Solomon* (1988)
15.30	-45.78	98.0	10	94.0	0.011		*Bergman & Solomon* (1988)
15.25	-45.15	97.0	10	93.6	0.011		*Bergman & Solomon* (1988)
14.14	-45.18	100.0	20	93.6	0.003		*Engeln et al.* (1986)
12.84	-44.57	95.0	15	93.1	0.004		CMT 6.09.87
12.05	-43.79	101.0	20	92.6	0.002		*Engeln et al.* (1986)
10.79	-43.51	92.0	10	92.4	0.009		*Bergman & Solomon* (1988)
10.83	-43.43	90.0	10	92.4	0.008		CMT 1.10.85
10.83	-43.23	96.0	20	92.2	0.002		*Engeln et al.* (1986)
10.77	-43.11	92.0	10	92.2	0.008		*Bergman & Solomon* (1988)
10.79	-42.23	96.0	15	91.7	0.003		CMT 3.20.84
10.72	-42.02	97.0	20	91.5	0.002		*Engeln et al.* (1986)
10.72	-41.68	87.0	10	91.3	0.008		*Bergman & Solomon* (1988)
8.80	-39.87	92.0	15	90.3	0.003		CMT 8.13.80
8.05	-38.79	102.0	20	89.6	0.001		*Engeln et al.* (1986)
8.15	-38.76	93.0	10	89.6	0.006		CMT 11.01.84
8.10	-38.55	89.0	15	89.5	0.003		CMT 11.05.78
8.04	-38.39	95.0	15	89.4	0.003		CMT 12.06.81
8.11	-38.09	90.0	10	89.3	0.006		*Engeln et al.* (1986)
7.39	-36.10	88.0	15	88.1	0.002		CMT 4.22.81
7.30	-34.86	85.0	10	87.4	0.005		*Engeln et al.* (1986)
7.08	-34.87	80.0	15	87.5	0.002		CMT 12.24.85
7.10	-34.04	89.0	15	87.0	0.002		CMT 7.26.80
7.07	-33.85	94.0	20	86.9	0.001		CMT 8.30.84
0.67	-30.39	84.0	15	85.3	0.002		CMT 6.22.84
0.86	-29.88	83.0	10	85.0	0.004		CMT 10.12.85
0.83	-29.82	88.0	10	85.0	0.004		CMT 3.20.78
0.77	-29.69	87.0	10	84.9	0.004		CMT 3.20.78
0.11	-29.60	80.0	20	84.9	0.001		CMT 7.24.80
0.82	-28.98	90.0	20	84.6	0.001		*Engeln et al.* (1986)
0.95	-28.43	88.0	10	84.3	0.004		CMT 6.06.85
0.97	-28.29	89.0	20	84.2	0.001		*Engeln et al.* (1986)
0.93	-28.09	82.0	15	84.1	0.002		CMT 9.19.84
1.14	-27.71	85.0	15	83.9	0.002		CMT 6.22.78
0.89	-27.11	85.0	15	83.6	0.002		CMT 11.14.79
0.95	-27.08	82.0	15	83.6	0.002		CMT 11.02.81
0.93	-26.83	85.0	15	83.5	0.002		CMT 7.01.85
0.80	-26.77	81.0	15	83.5	0.002		CMT 6.15.86
0.90	-26.77	88.0	20	83.4	0.001		*Engeln et al.* (1986)
0.87	-26.50	88.0	20	83.3	0.001		*Engeln et al.* (1986)
0.75	-26.14	88.0	20	83.1	0.001		CMT 3.23.86
0.81	-25.45	89.0	20	82.8	0.001		*Engeln et al.* (1986)
0.11	-25.35	84.0	10	82.8	0.004		CMT 11.01.80
-1.19	-24.68	87.0	10	82.5	0.004		CMT 8.12.82
-1.30	-24.30	99.0	20	82.4	0.001		*Engeln et al.* (1986)
-0.99	-23.48	87.0	15	81.9	0.002		CMT 12.08.84
-0.85	-22.13	85.0	20	81.3	0.001		*Engeln et al.* (1986)
-0.97	-21.86	81.0	10	81.2	0.004		CMT 1.03.82
-0.84	-21.81	77.0	10	81.1	0.004		CMT 10.13.83
-0.51	-19.92	80.0	15	80.2	0.002		CMT 12.29.86
-0.50	-19.90	80.0	20	80.2	0.001		*Engeln et al.* (1986)
-0.52	-19.86	77.0	10	80.2	0.005		CMT 4.22.84
-0.58	-19.77	83.0	15	80.1	0.002		CMT 10.09.84
-0.38	-19.55	80.0	15	80.0	0.002		CMT 6.04.85
-0.22	-19.19	79.0	15	79.8	0.002		CMT 6.07.87
-0.32	-19.17	83.0	20	79.8	0.001		*Engeln et al.* (1986)
-0.04	-19.14	77.0	10	79.8	0.005		CMT 5.05.87
-0.13	-18.83	79.0	10	79.6	0.005		CMT 7.07.81
-0.30	-18.60	88.0	20	79.6	0.001		*Engeln et al.* (1986)
-0.14	-18.24	74.0	15	79.4	0.002		CMT 3.12.87
-0.19	-18.03	89.0	20	79.3	0.001		*Engeln et al.* (1986)
-0.02	-17.88	83.0	10	79.2	0.005		CMT 6.24.86

Arabia-India: Fault Trends						
21.00	61.80	30.0	5	27.8	0.459	*Matthews* (1966)
18.00	60.20	23.0	5	22.3	0.534	*Matthews* (1966)
Arabia-India: Slip Vectors						
24.58	66.23	41.0	15	37.5	0.270	*Quittmeyer & Kafka* (1984)
23.79	64.73	28.0	15	34.6	0.176	*Quittmeyer & Kafka* (1984)
21.87	62.32	12.0	15	29.5	0.067	*Quittmeyer & Kafka* (1984)
20.91	62.44	26.0	15	28.3	0.055	CMT 4.7.85
14.94	57.96	23.0	15	16.4	0.171	CMT 12.14.85
14.57	58.09	10.0	15	16.0	0.188	CMT 12.5.81

The motion on some pairs of plates are well constrained because they have oceanic boundaries (e.g. **Africa/South America**).

Others are poorly known (e.g. **Arabia/India**)

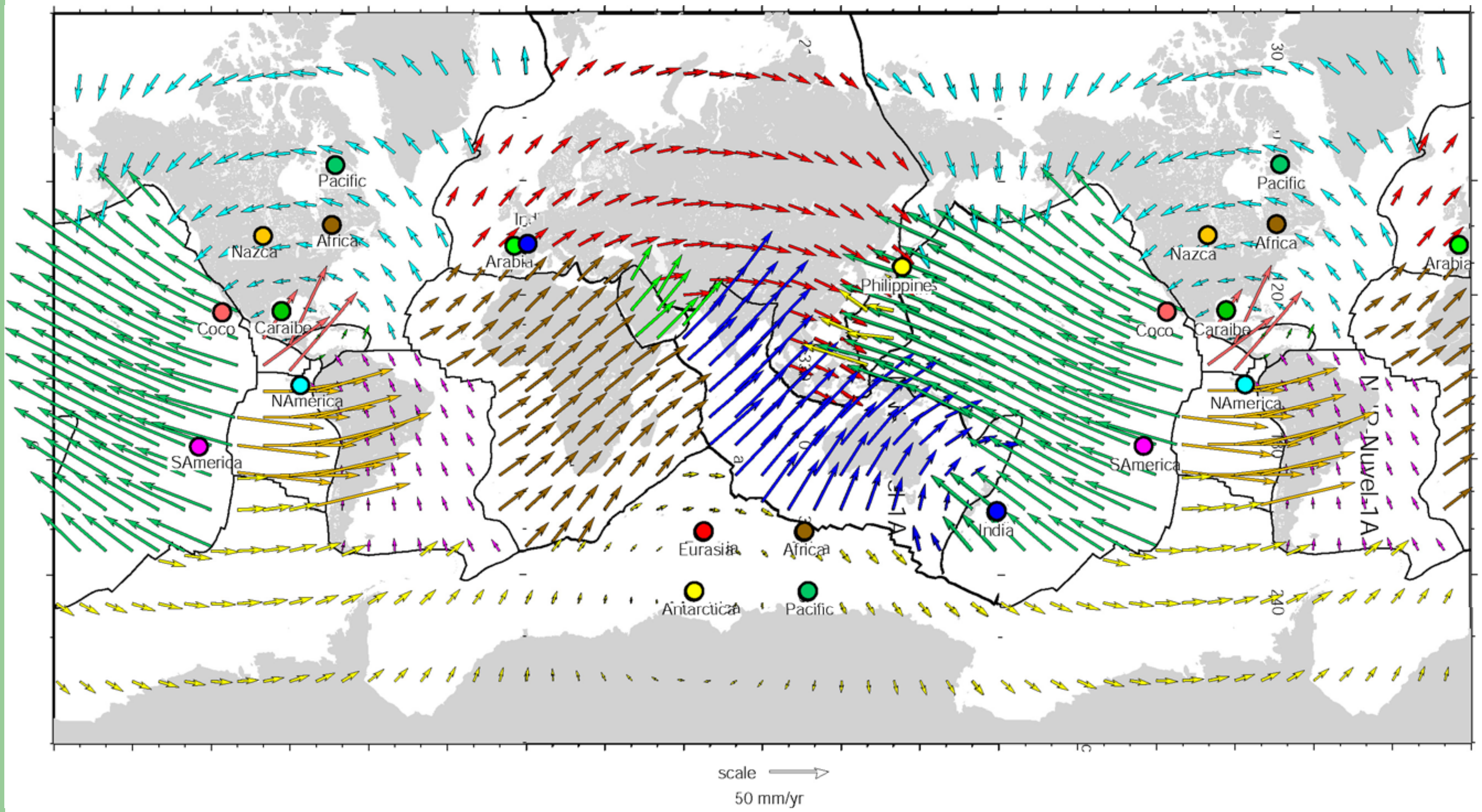
Geological model : closure circuit



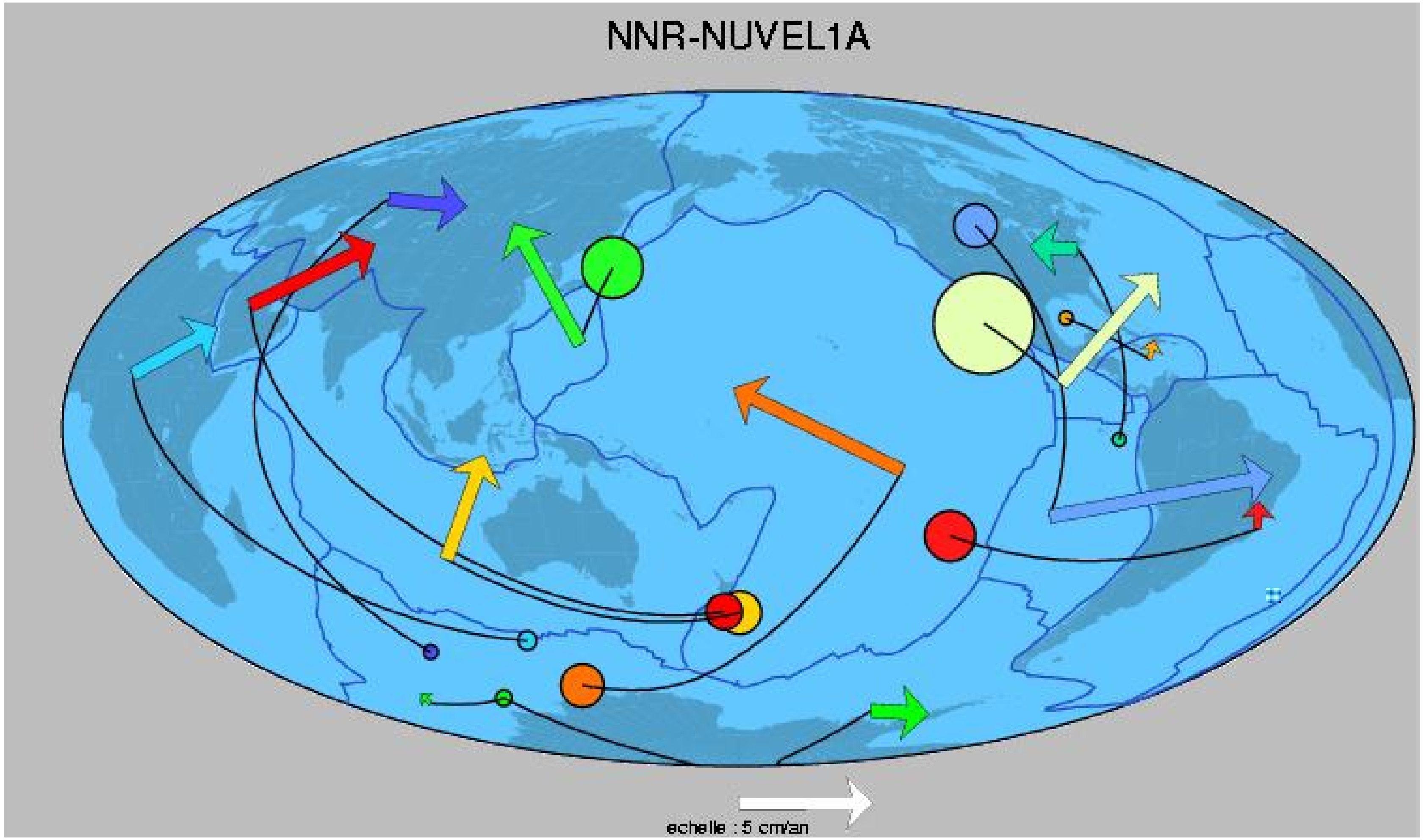
The relative motion of pairs of plate **without data** can be determined through a **circuit** of pairs of plates with data. (e.g. India/Australia is known through Africa, or India/Eurasia through Africa and North America)

The result is of course less well constrained

NNR-Nuvel-1A : velocities

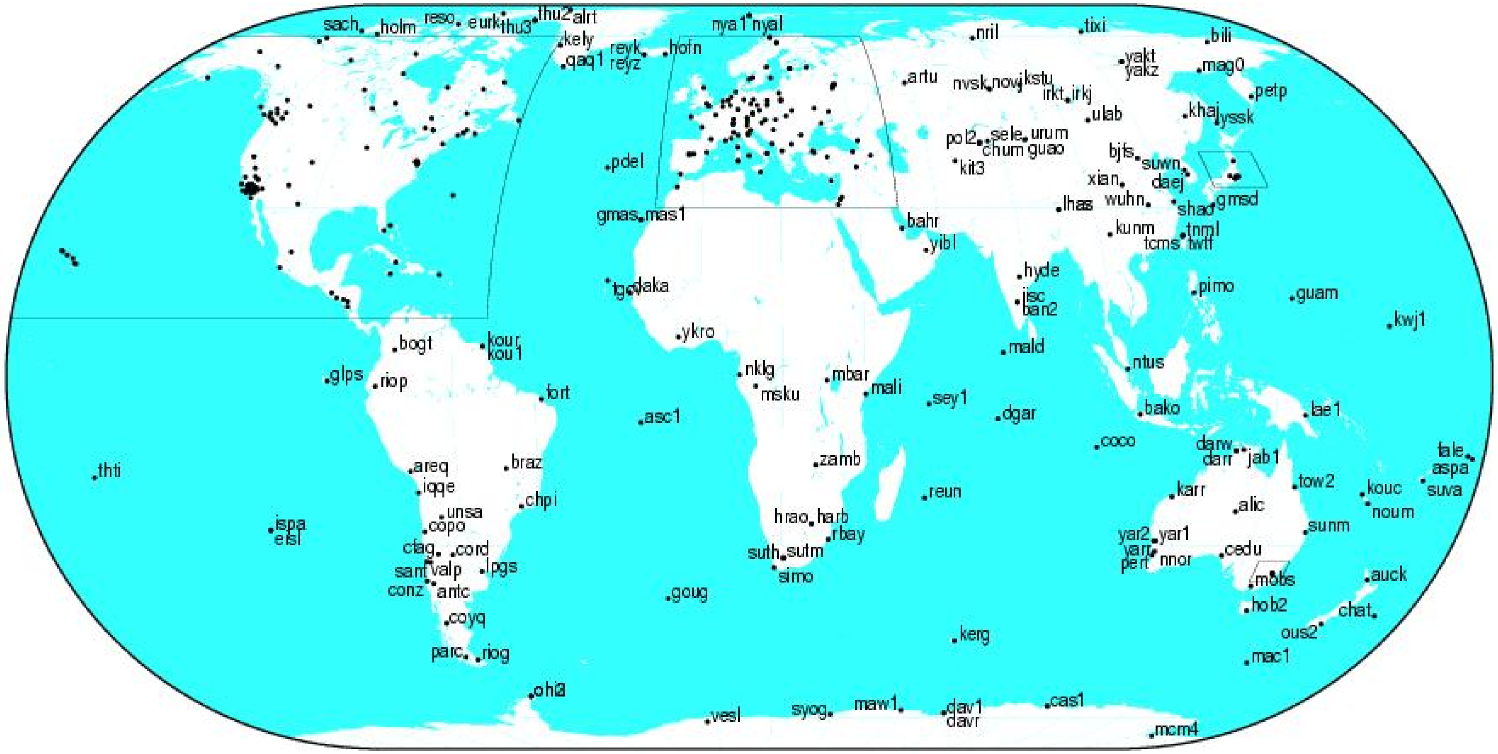


NNR-Nuvel-1A : rotation poles



IGS network

IGS Tracking Network : http://igscb.jpl.nasa.gov



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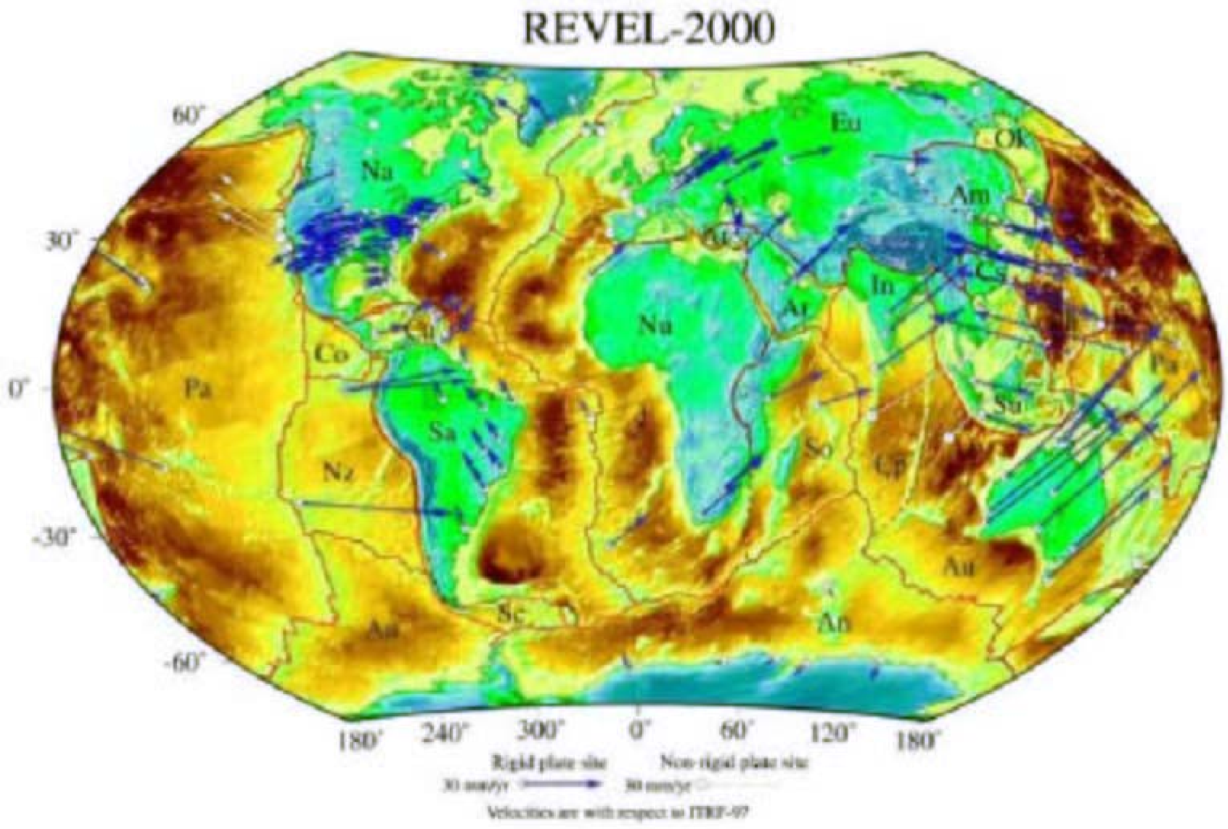
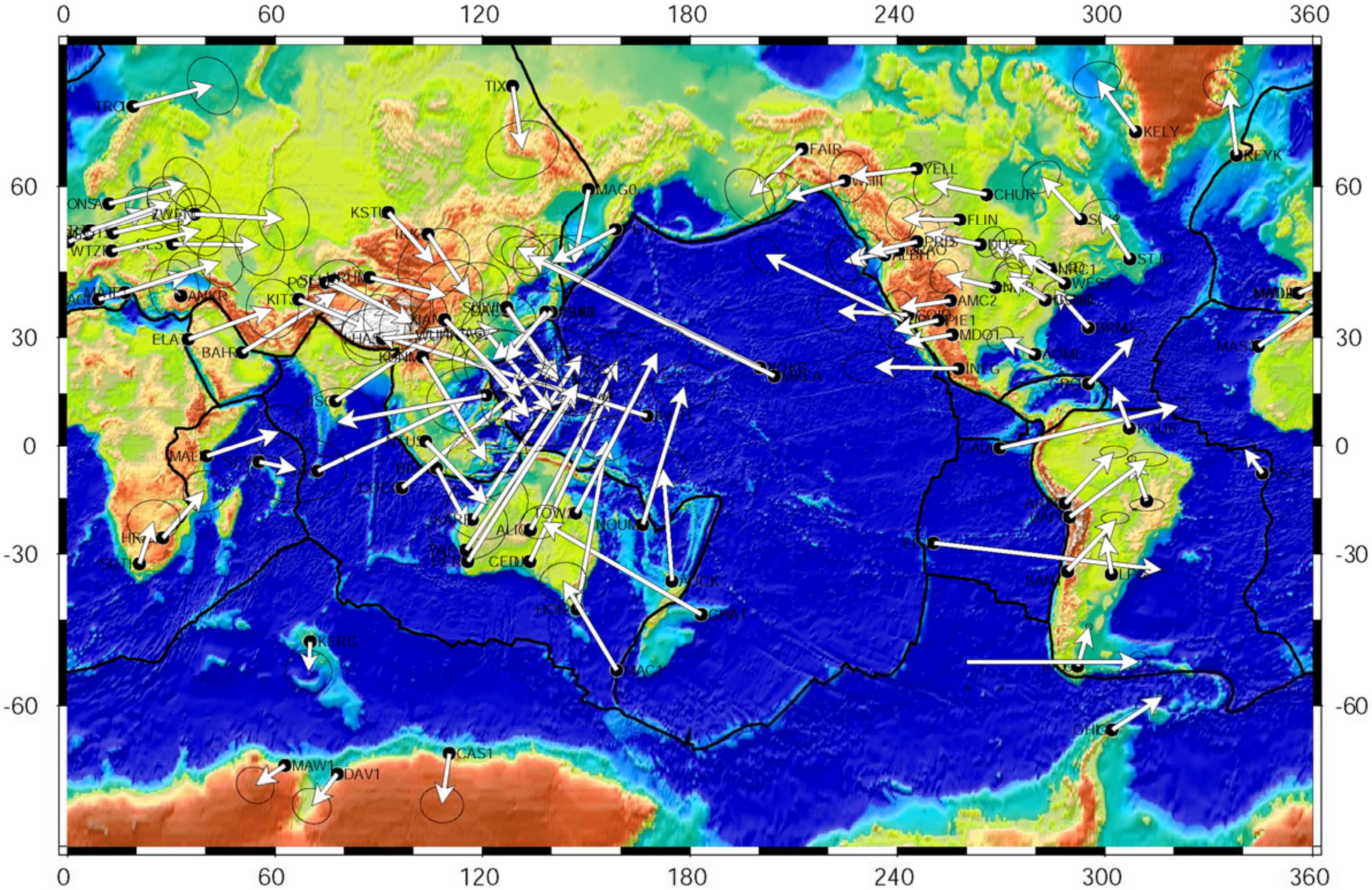
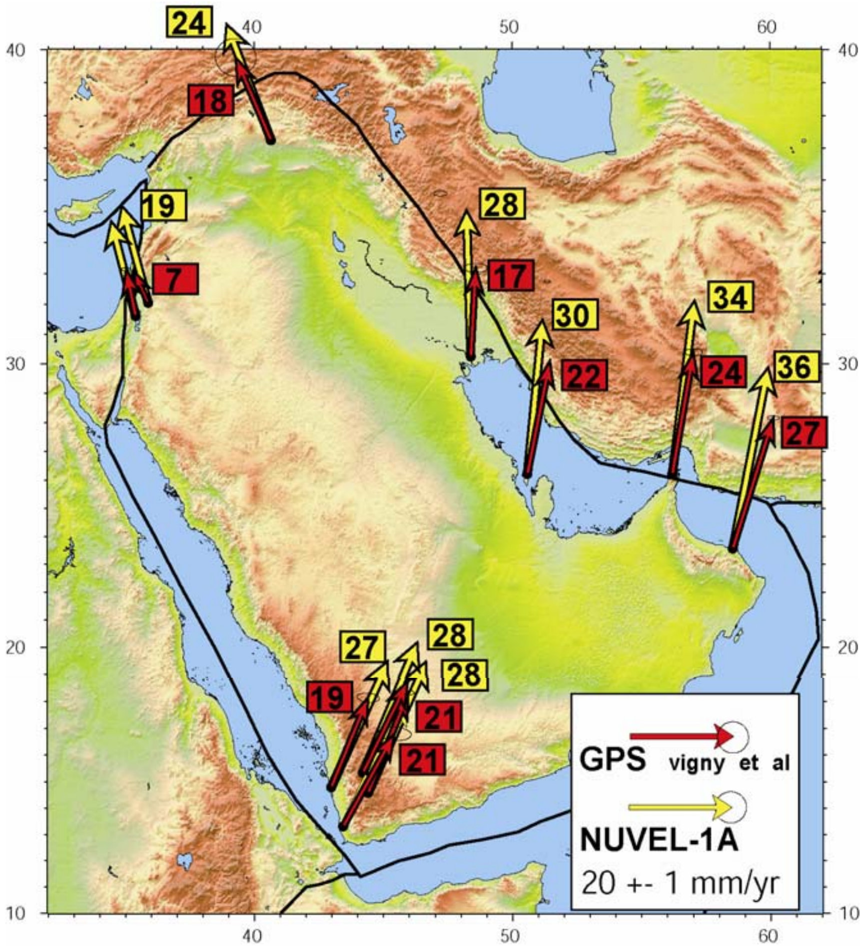
GPS Solutions : Revel, Sella et al. 2002 (ITRF97)

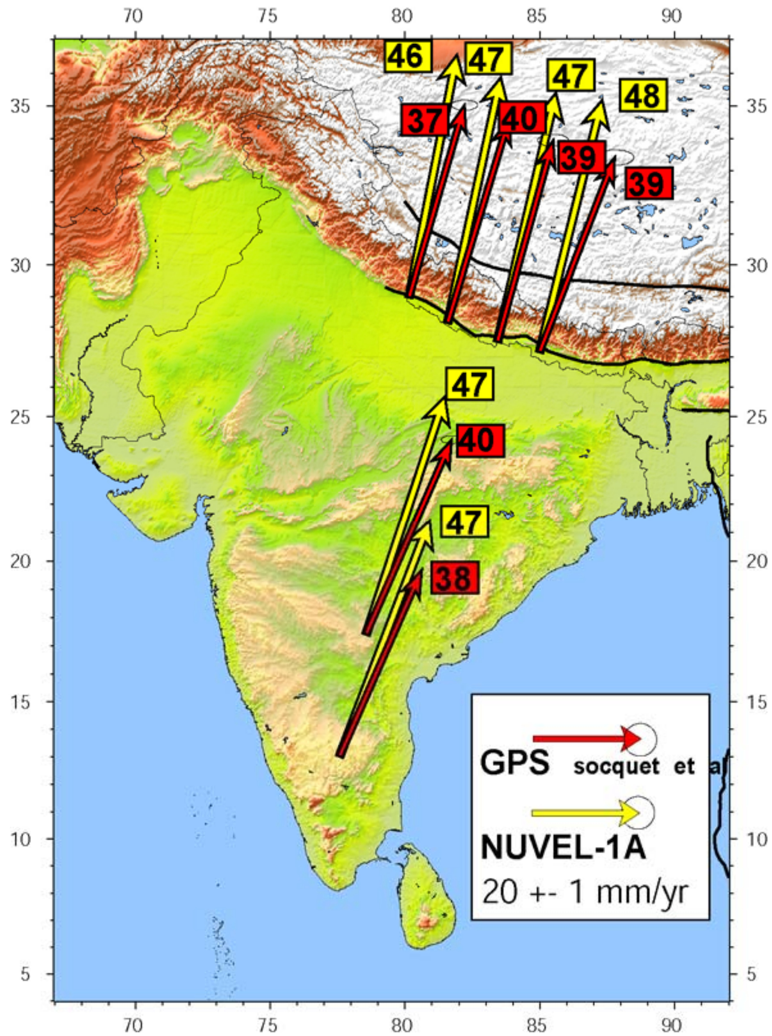


GPS Solutions : ITRF2000, Altamimi et al., 2003

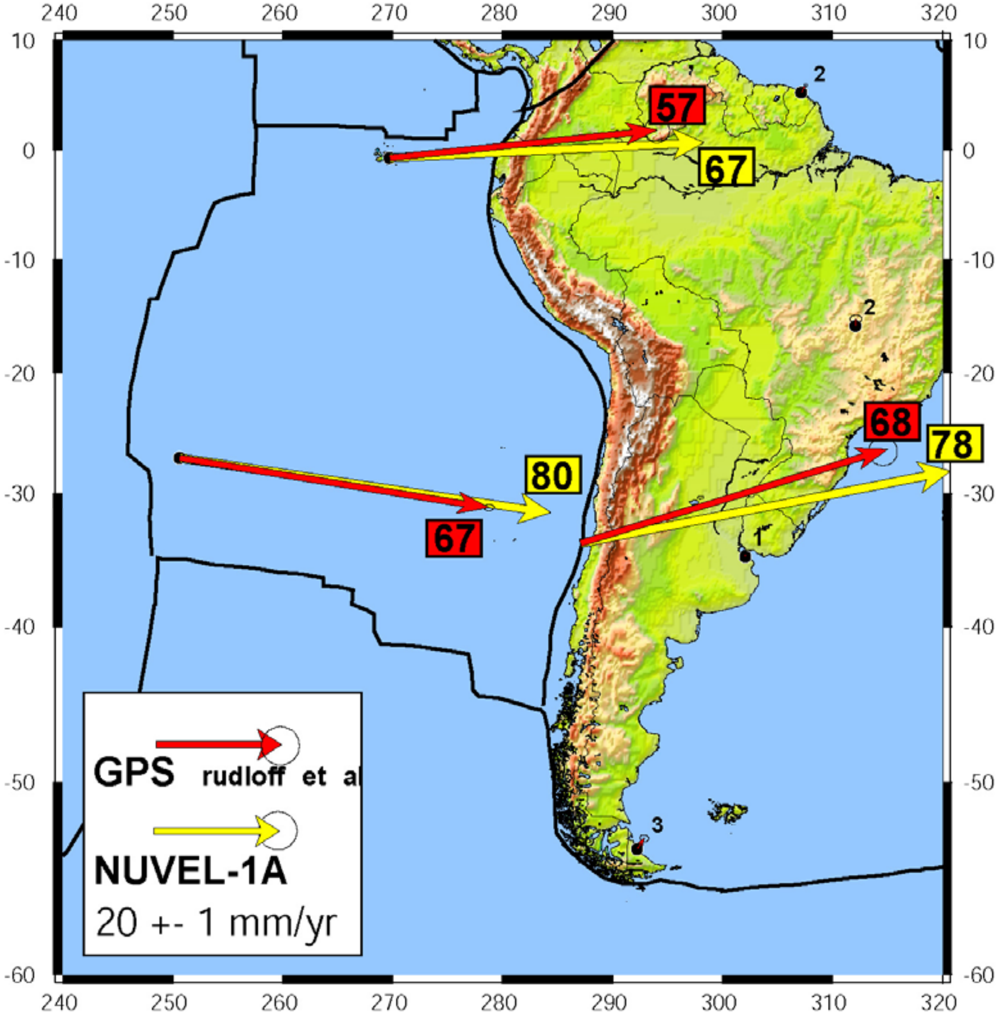


GPS finds Arabia, India and Nazca are slower

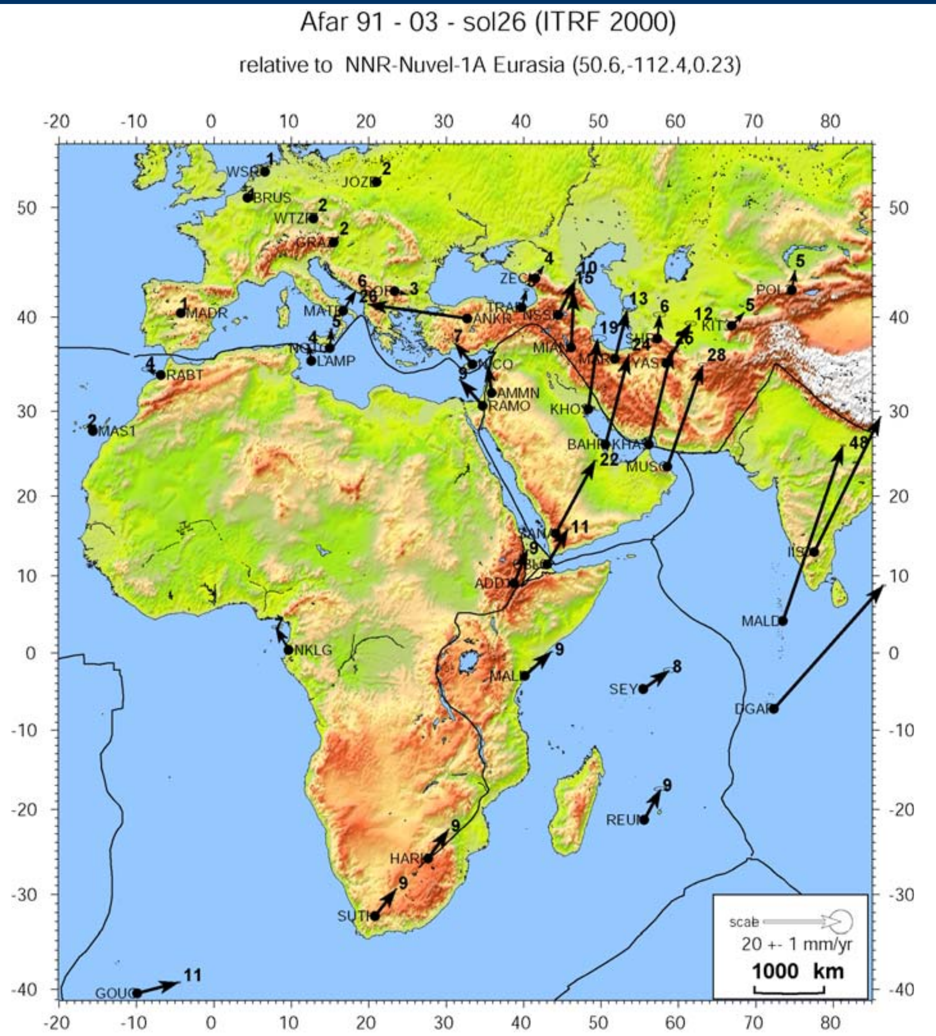




GPS finds Arabia, India and Nazca are slower



Africa Arabia India solution

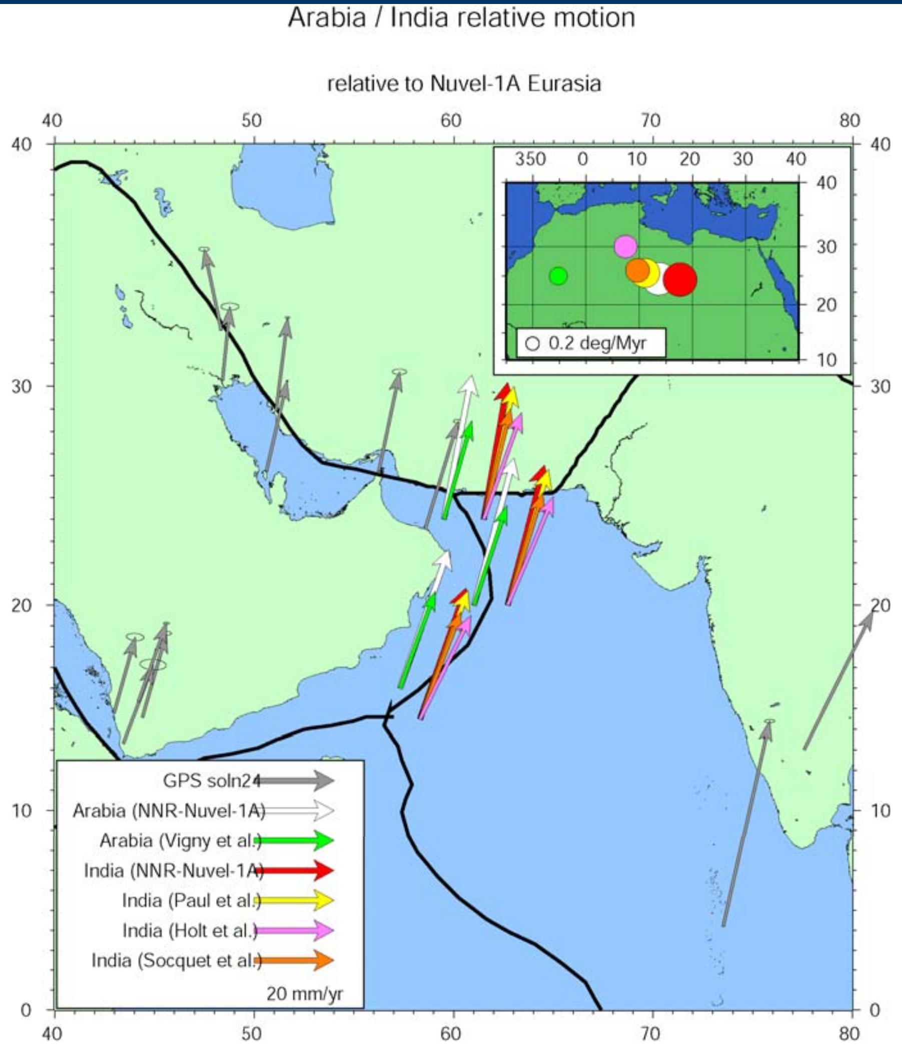


GPS velocities show :

- Africa moving slowly north against Eurasia
- Somalia being separated from Africa
- Arabia moving rapidly North against Eurasia
- India moving even faster north against Eurasia…

…but this does not mean the relative motion of India/Arabia is important

Arabia/India relative motion



The rotation poles of India and Arabia are very close to each other. So the velocity of India is higher than the velocity of Arabia **only because India is further away from the rotation pole**

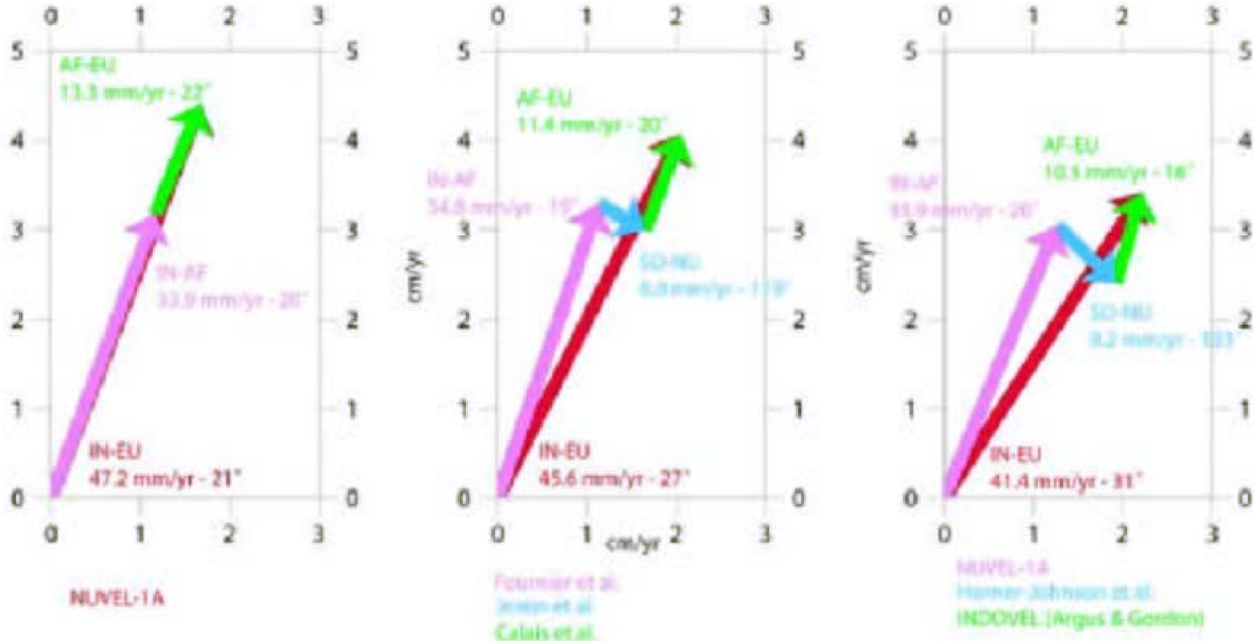
Geological velocities (white & red arrows) on the boundary between Arabia and India are almost identical

GPS determined poles allow to **predict** velocities on this boundary. They should match this condition required by Geology : there is almost no deformation there

India-Africa-Somalia-Eurasia velocity composition

Can we predict the Somalia/Africa motion based on known vectors ?

India/Eurasia velocity
at Bangalore (India)

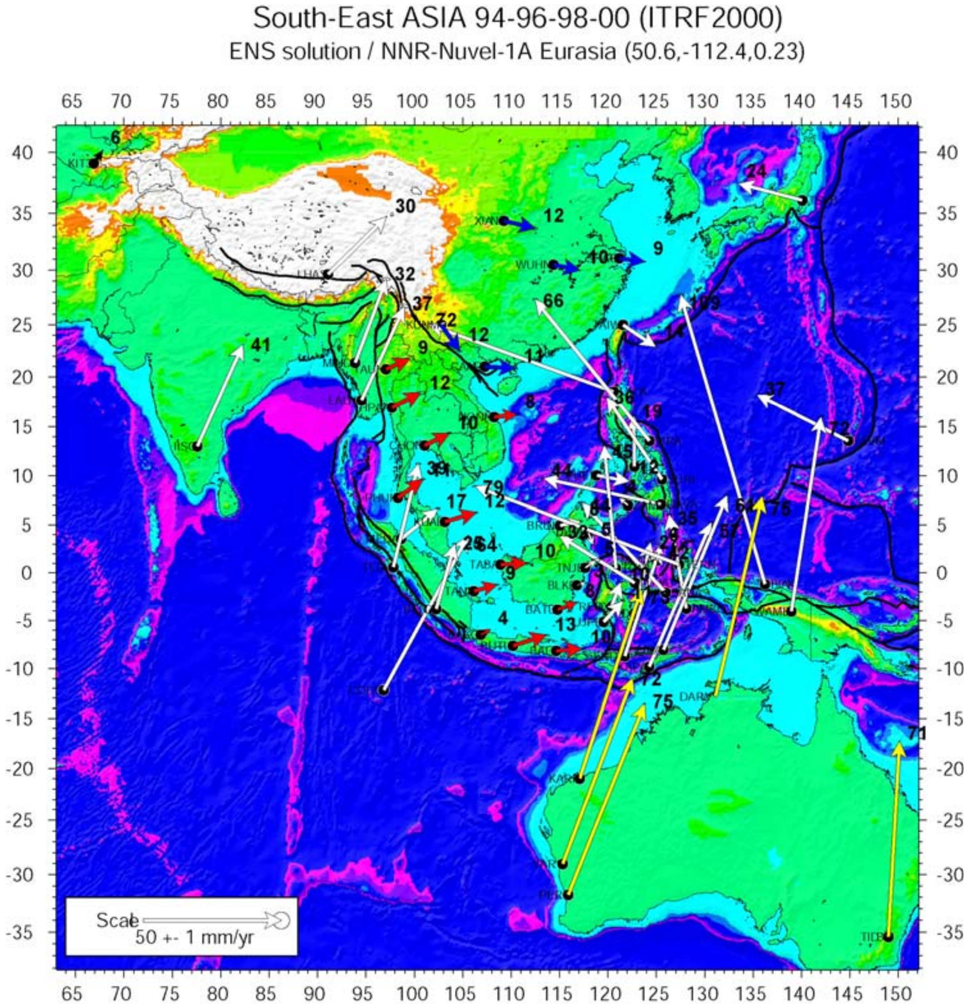


for Nuvel-1A, India/Eurasia is equal to India/Africa + Africa/Eurasia

But India/Eurasia is equal to India/Africa + **Africa/Somalia** +Somalia/Eurasia

Revised Nuvel give high (too high) velocity for Somalia

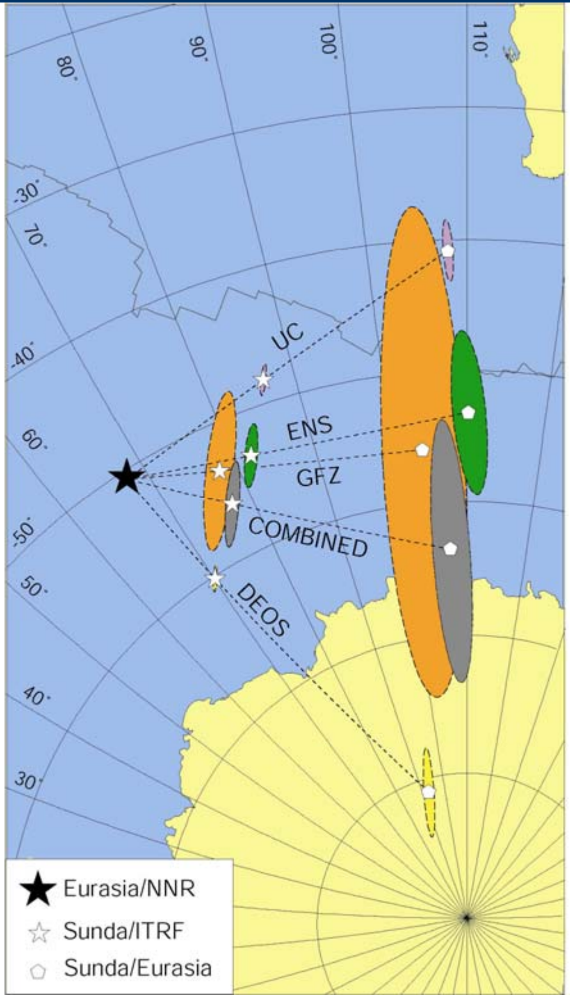
Rigid Sundaland

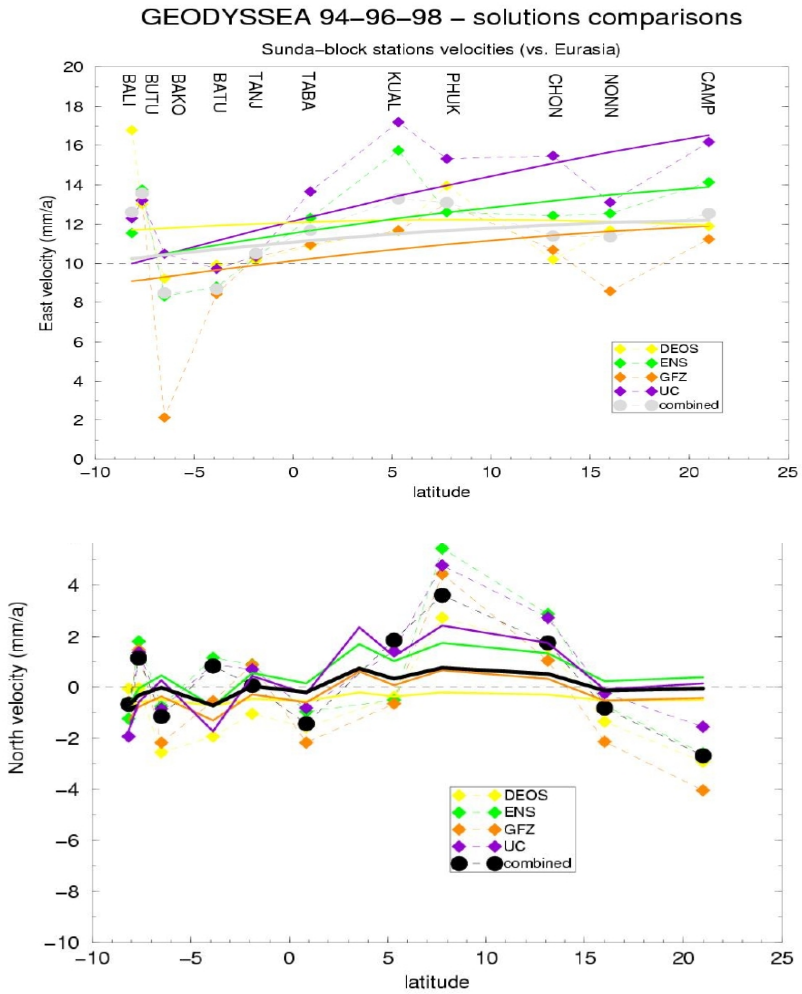


GPS campaigns with more than 60 sites allow to determine that :

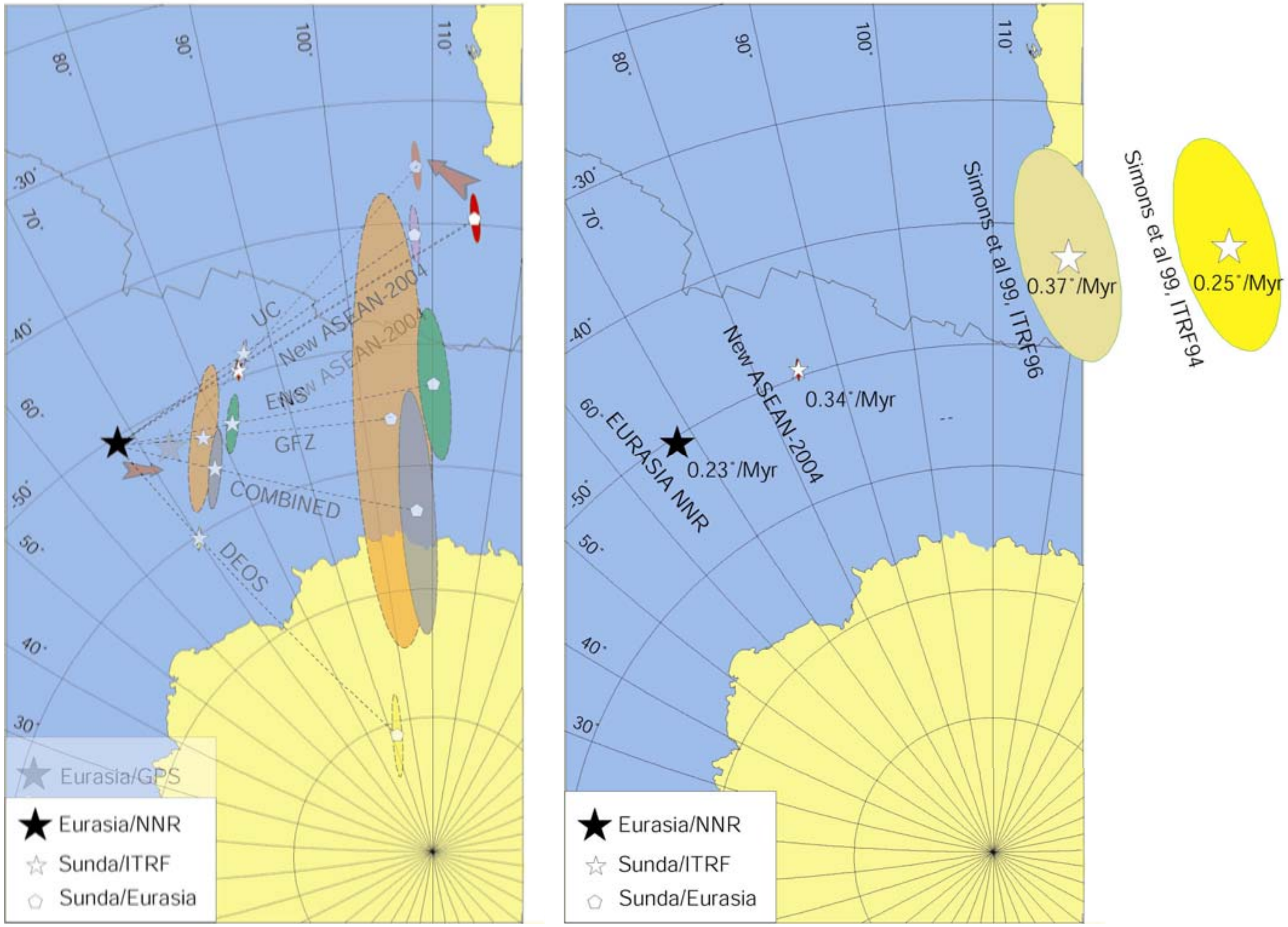
- South-East Asia (red arrows) is an individual block which moves away from Eurasia (black arrows)
- South China (blue arrows) also moves away from Eurasia at around 10 mm/yr eastward

GEODYSSEA poles

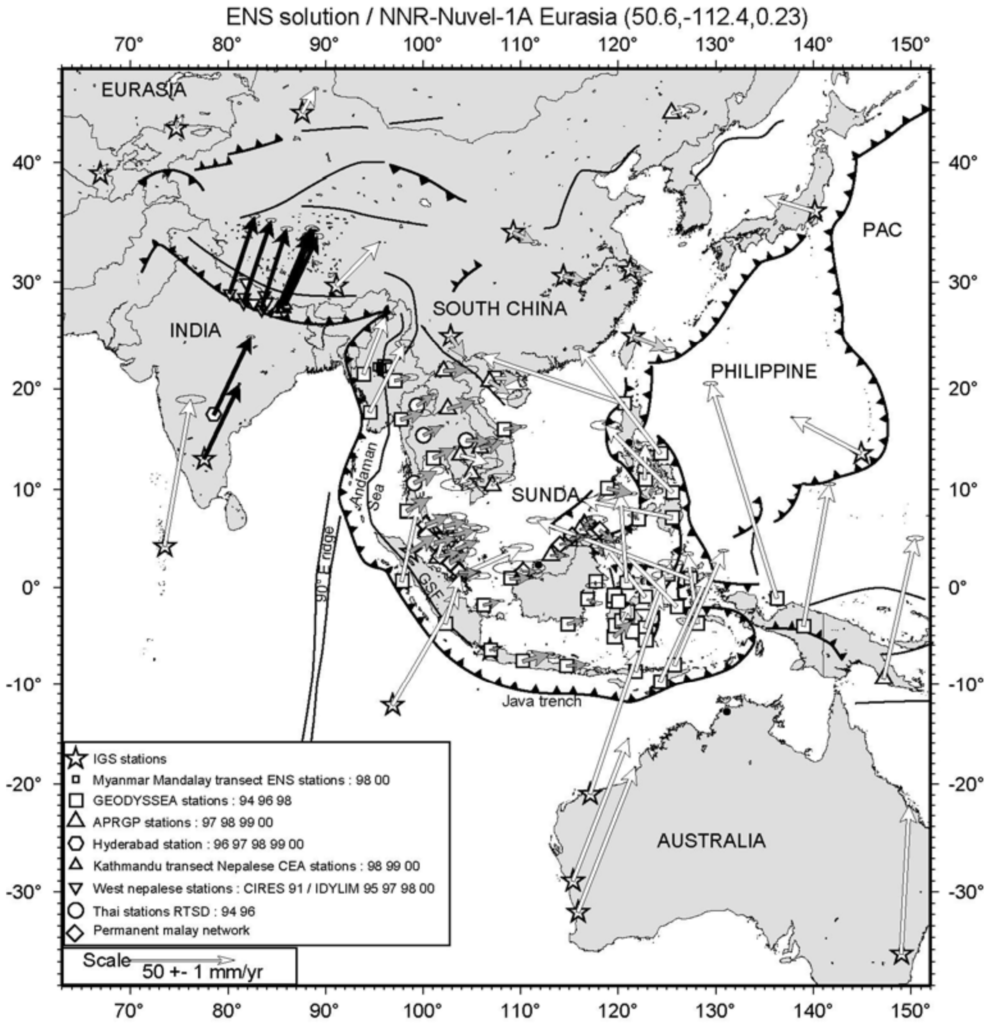




Older GEODYSSEA poles



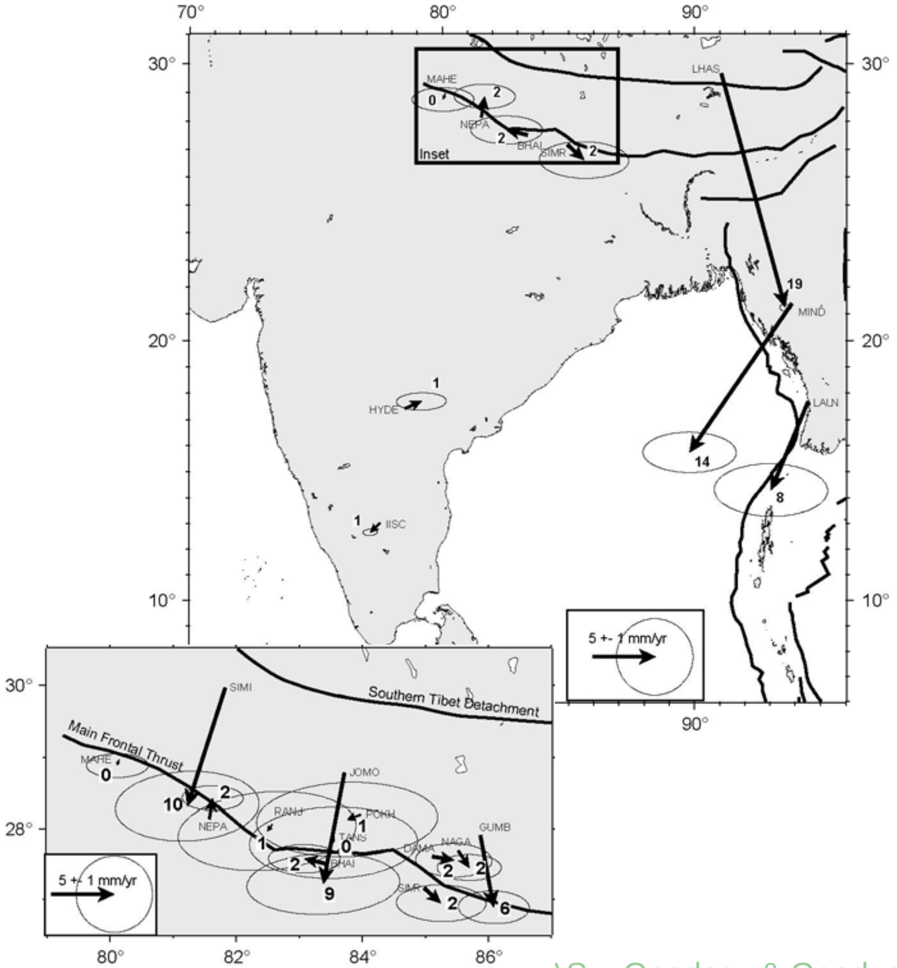
New ASEAN solution

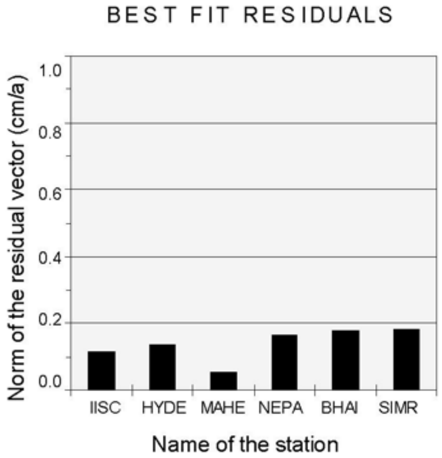


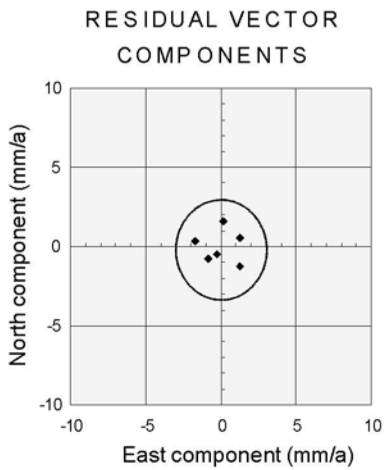
We determine the present-day relative motion between India and Sundaland as well as the horizontal crustal motion within these two plates based on a regional GPS data set including ~190 stations in Asia spanning 11 years. This data set includes GEODYSSEA, APRGP, THAICA, permanent Malaysian network, Nepalese and Indian stations.

Indian residual velocities

Pole positions don't matter … Only residual velocities do





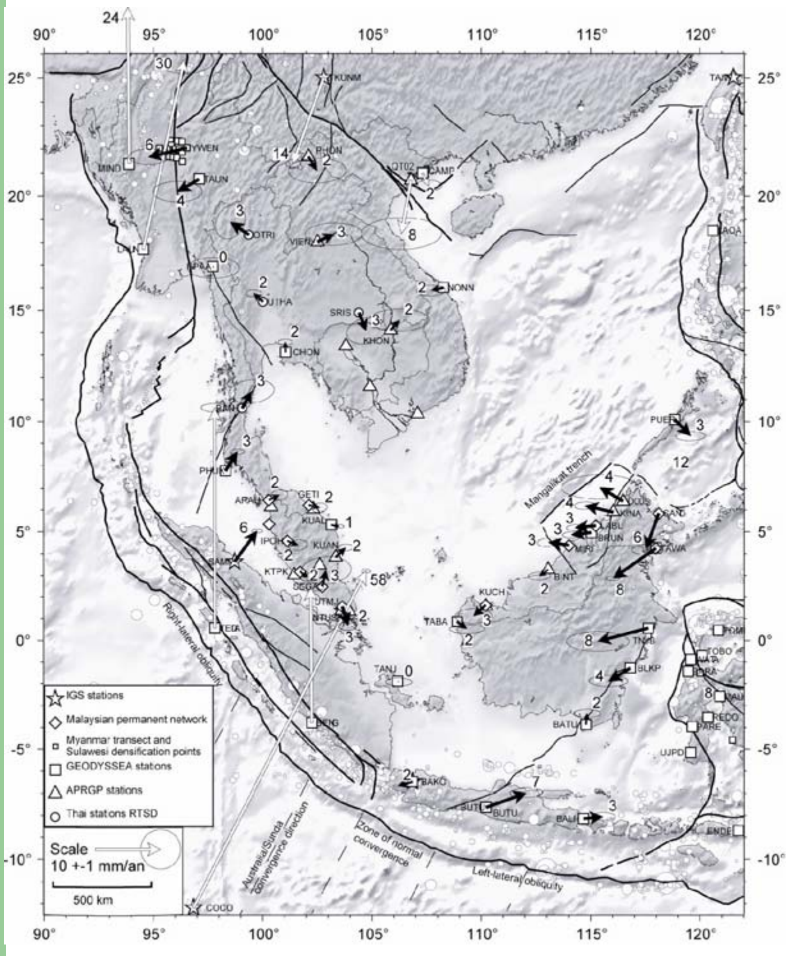


India is a very rigid plate

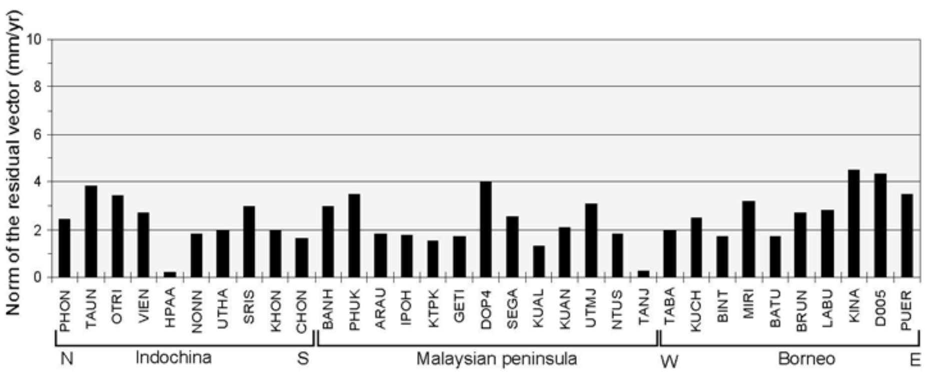
Residual velocities reach the bottom precision of GPS measure-ments

ASEAN Residual velocities

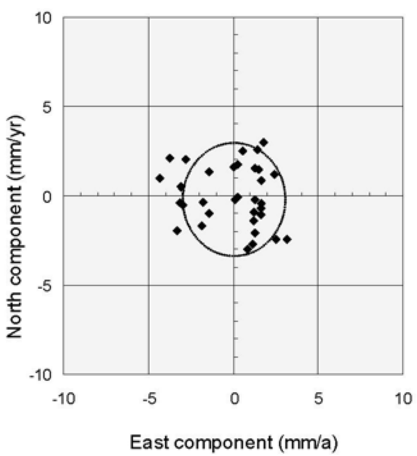
Sundaland is more deformed, at least near its boundaries



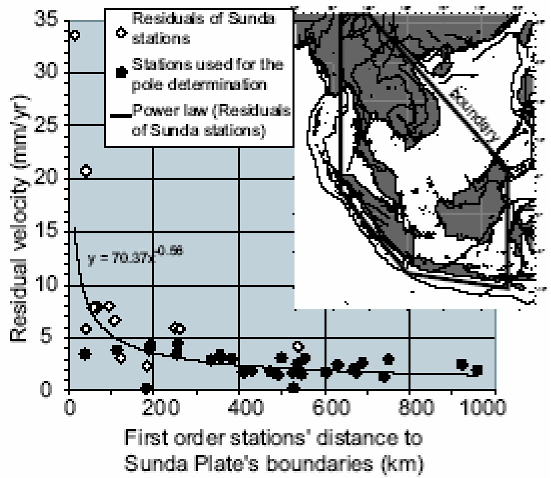
BEST FIT RESIDUALS



RESIDUAL VECTOR COMPONENTS

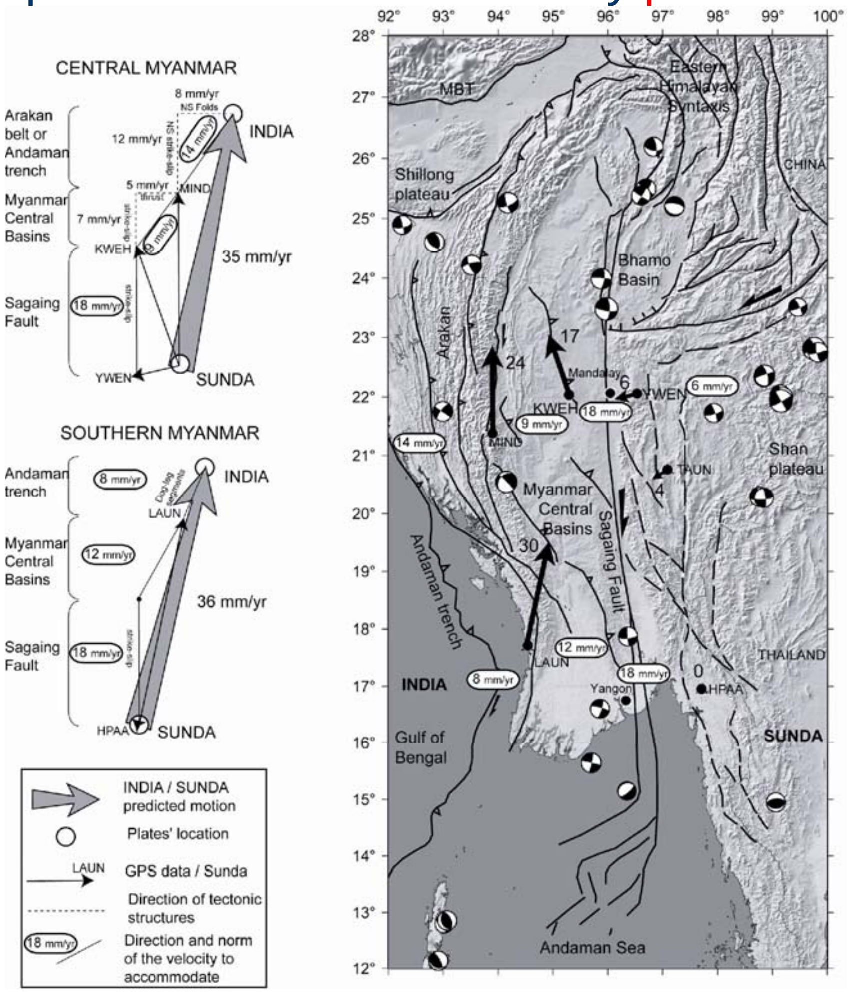


Residual velocities for Sunda stations with respect to their distance to the plate's boundaries



India/Sunda relative motion

Pole positions don't matter….only predicted motions on plate boundary do



Using the measurements we can compute the rotation pole between India and Sundaland

Using the relative pole, we can predict velocities where we don't have measurements

Then we can try to guess what is the motion on geological structures we know but we did not measure

Strain rate and rotation rate tensors (1)

To asses plate deformation :

1. Look at station velocity residuals
2. Compute strain rate and rotation rate tensors

$$\text{Strain} = \frac{\text{Velocity}}{\text{Distance}} = \frac{\text{mm/yr}}{\text{km}} = \% / \text{yr}$$

$$\text{Matrix tensor notation : } S_i^j = d(V_i) / d(x_j) = \begin{vmatrix} d(V_x) / d(x) & d(V_x) / d(y) \\ d(V_y) / d(x) & d(V_y) / d(y) \end{vmatrix}$$

Theory says : [S] = [E] + [W]

	[E]	[W]
	Symetrical	Antisymetrical
	Strain rate	rotation rate

Strain rate and rotation rate tensors (2)

$$[E] = \frac{1}{2}\left([S] + [S]^T\right) = \begin{vmatrix} E_{11} & E_{12} \\ E_{12} & E_{22} \end{vmatrix} \qquad [W] = \frac{1}{2}\left([S] - [S]^T\right) = \begin{vmatrix} 0 & W \\ -W & 0 \end{vmatrix}$$

[E] has 2 Eigen values : ε_1, ε_2

ε_1 and ε_2 are extension/compression along principal direction defined by angle θ (defined as angle between ε_2 direction and north)

$$\varepsilon_1 = E_{11} \cos^2\theta + E_{22} \sin^2\theta - 2\, E_{12} \sin\theta \cos\theta$$

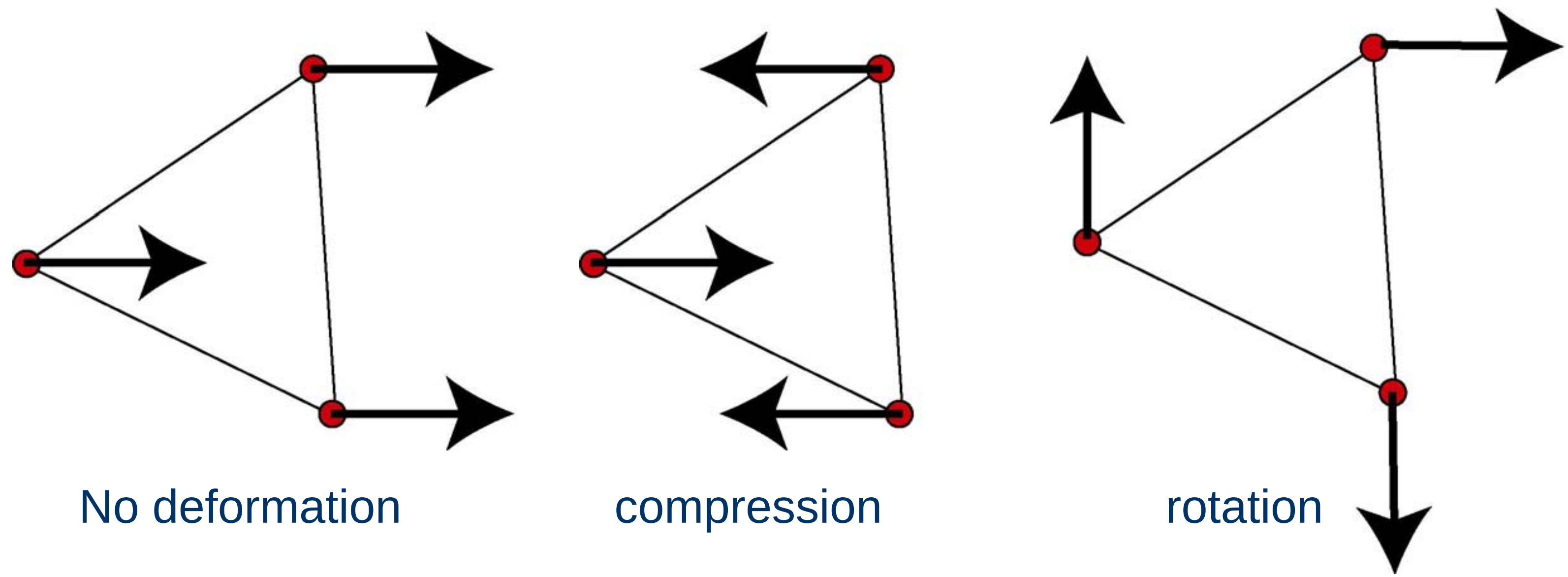
$$\varepsilon_2 = E_{11} \sin^2\theta + E_{22} \cos^2\theta - 2\, E_{12} \sin\theta \cos\theta$$

Strain rate and rotation rate tensors (3)

Minimum requirement to compute strain and rotation rates is :

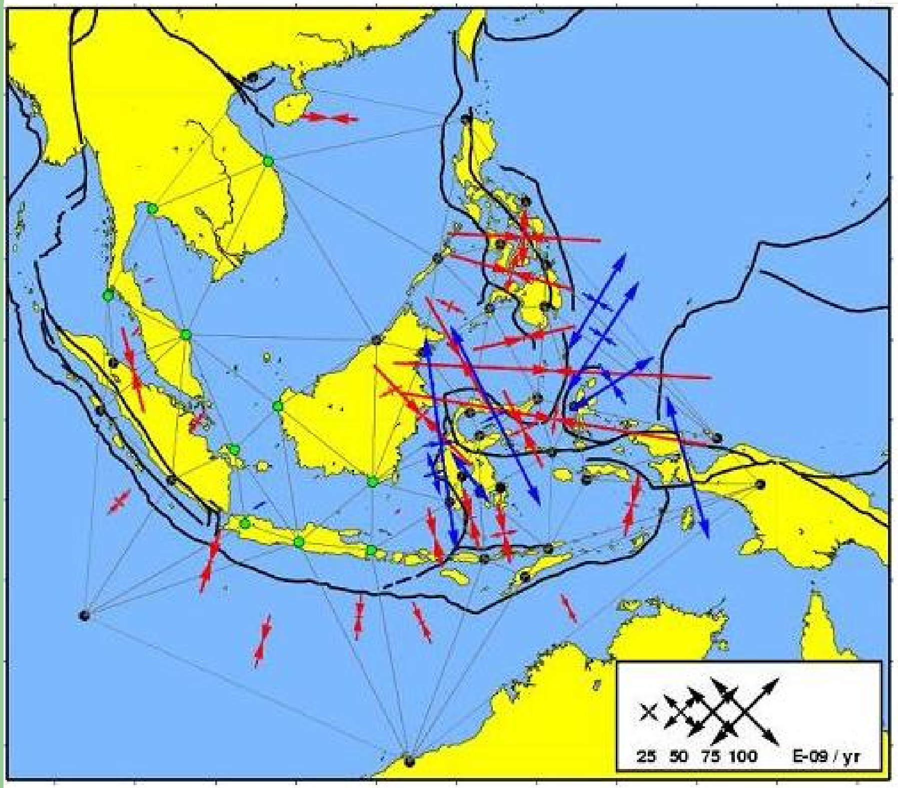
3 velocities (to allow to determine 3 values ε_1, ε_2, and W)

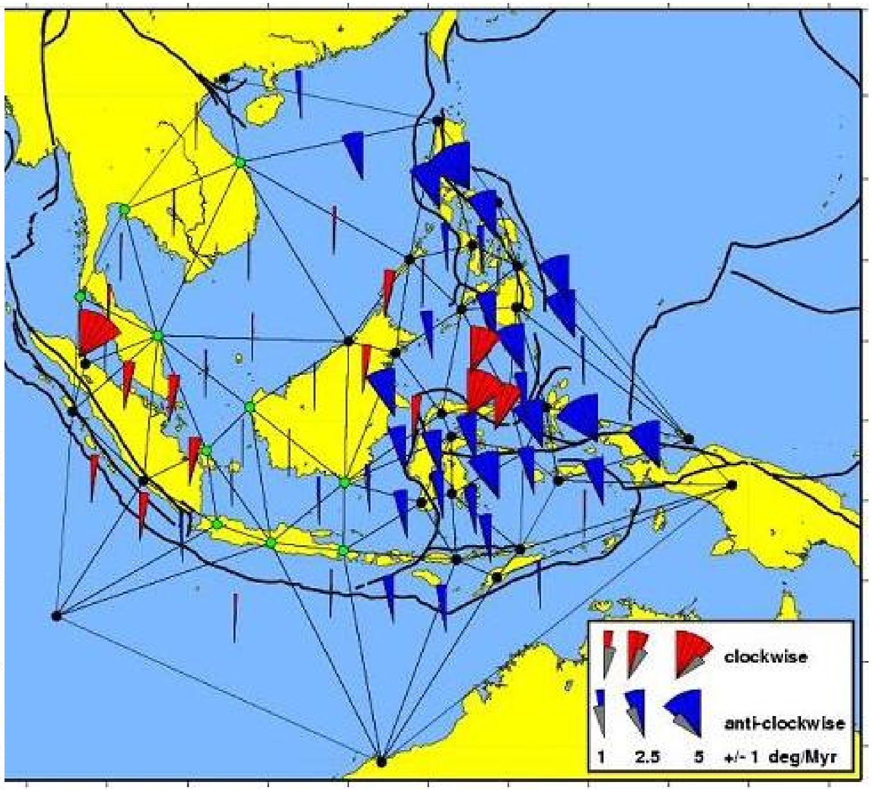
Therefore we can compute strain rate and rotation rate within any polygon, the minimum polygon being a triangle



Strain and rotations are unsensitive to reference frame

Strain and rotation in GEODYSSEA network





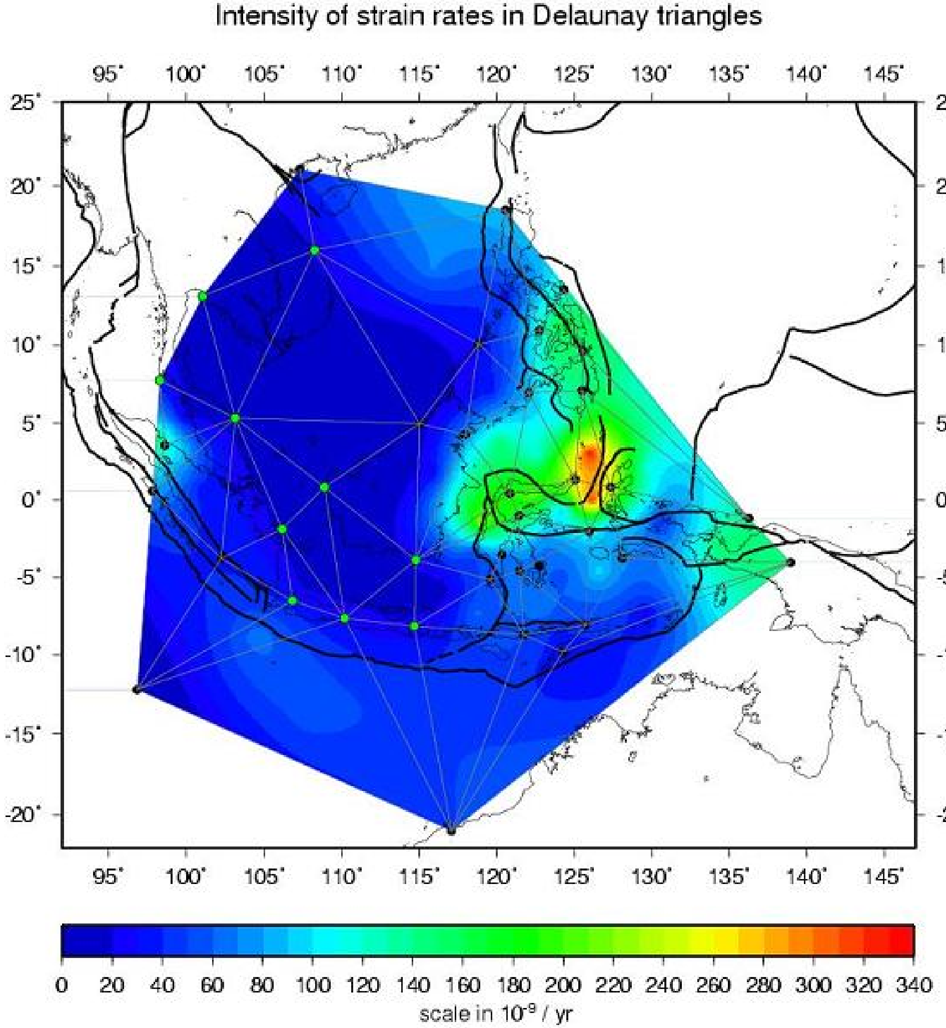
Strains :

extension/compression/strike-slip

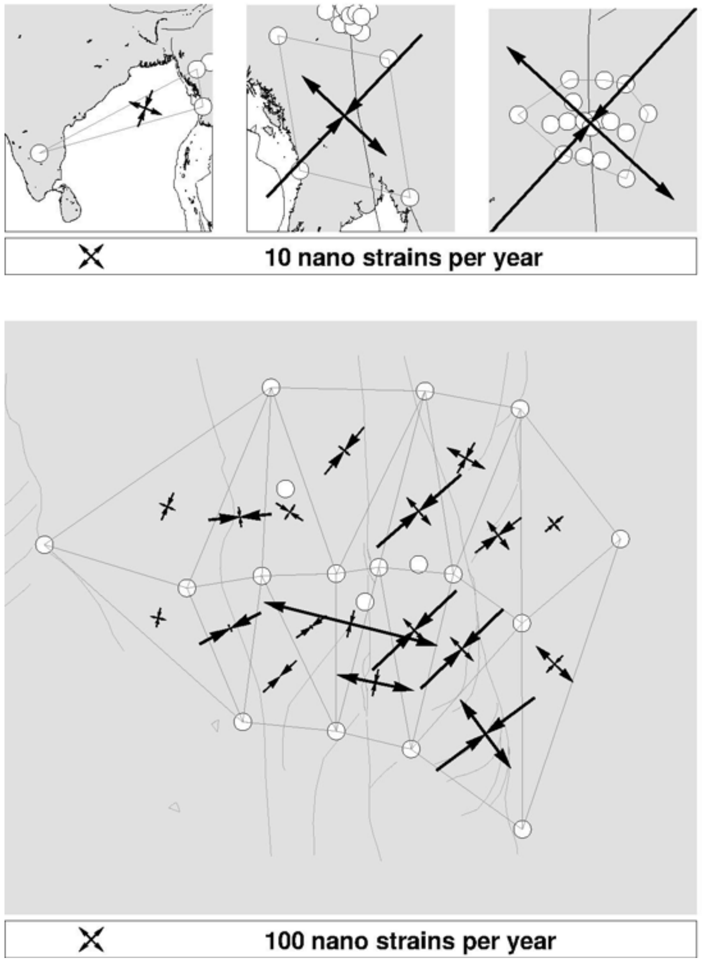
Rotations :

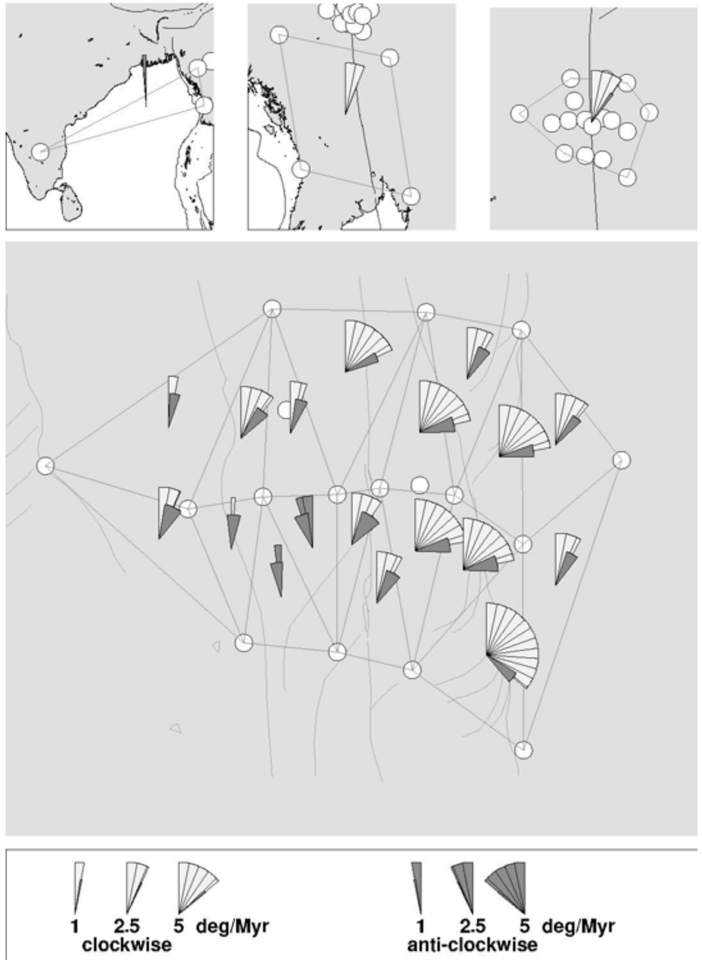
Anti-clockwise/clockwise

Intensity of strain in GEODYSSEA network

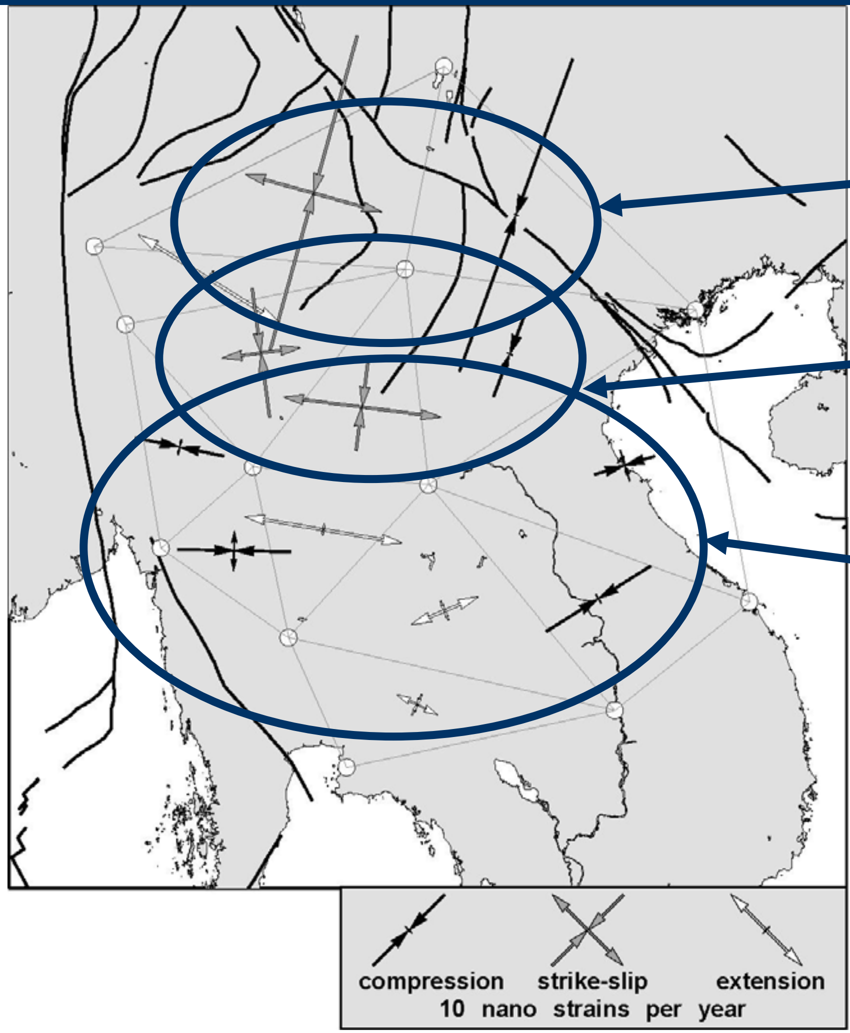


Strain and rotation in Myanmar





Strain in Northern Sundaland (Thailand)

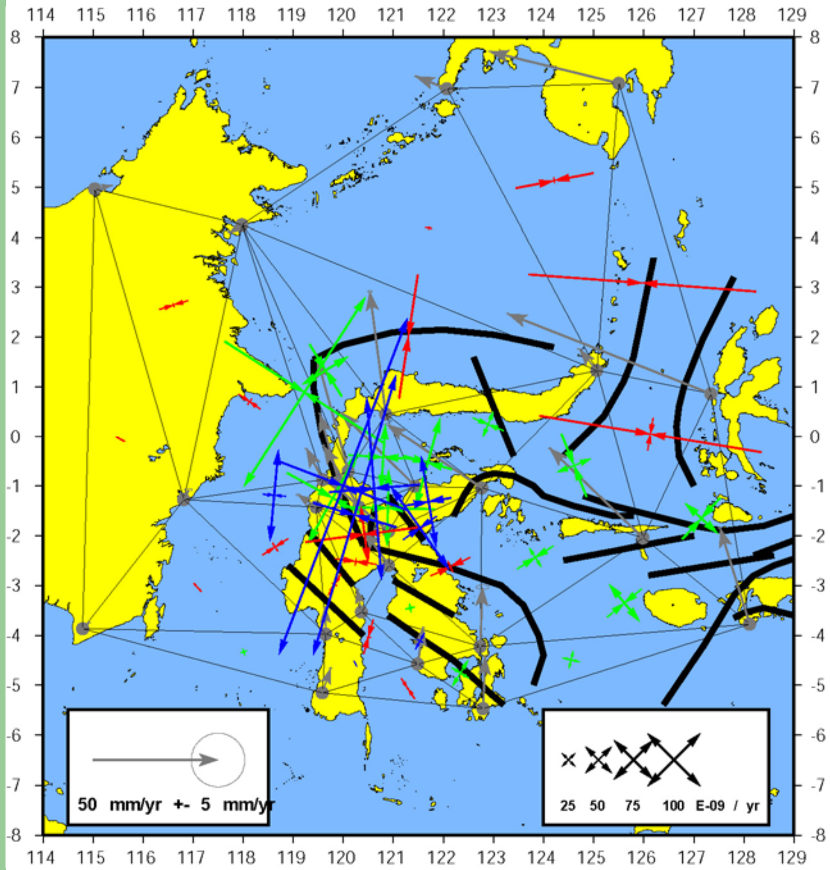


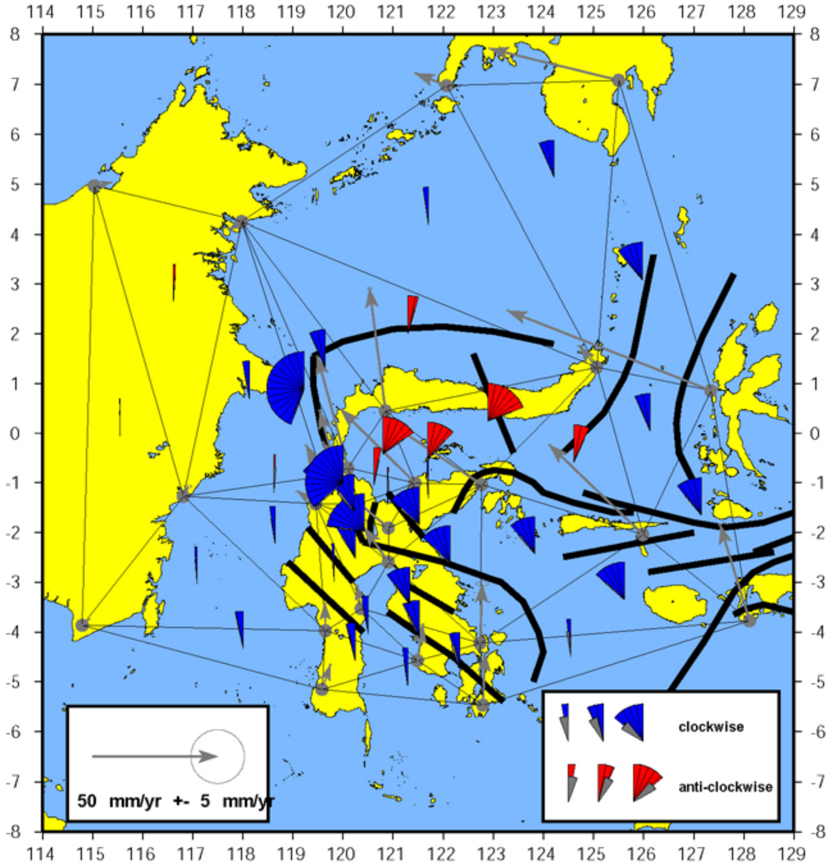
North-South compression in the north

Strike slip deformation in the center

East-West extension in the south

Strain and rotation in Sulawesi network





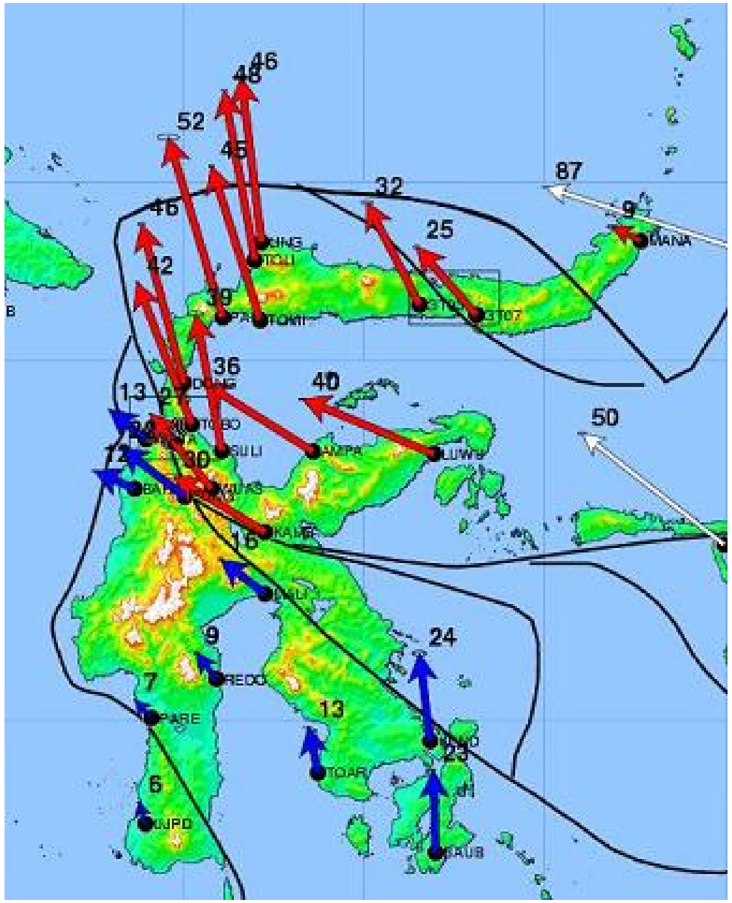
Strains :

extension/compression/strike-slip

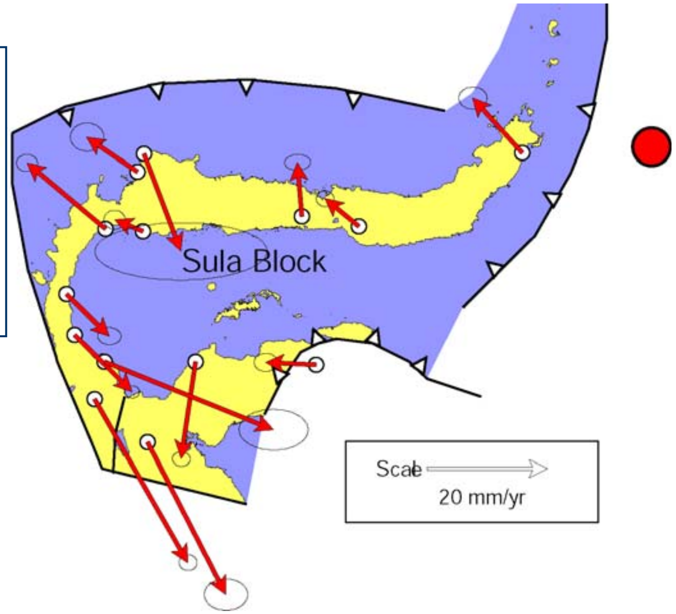
Rotations :

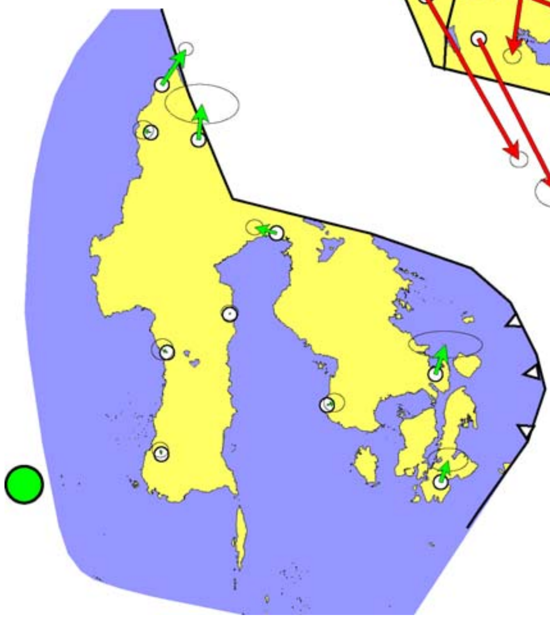
Anti-clockwise/clockwise

Blocks and Internal deformation in Sulawesi



North Sulawesi is highly deformed and pole can be found but leaves high residual velocities





South Sulawesi is not deformed and a pole can be found which leave little residual velocities