Cause and evolution of intraplate orogeny in Australia

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Supplemental data

Location	0 ~ 6 Ma	6 ~ 11 Ma	11 ~ 23 Ma	23 ~ 25 Ma	55 Ma	100 Ma
Western Southeast Indian Ridge	3.10	3.10	2.46	2.46	1.08	-
Eastern Southeastern Ridge	1.90	1.90	1.36	1.36	-	-
Australia Antarctic Discordance	2.10	2.10	1.64	1.64	0.72	-
Papua New Guinea	4.00	4.00	-	-	-	-
Banda Arc	– 2.50	– 2.50	-	-	-	-
Java	– 23	– 23	-23	-23	-	-
New Hebrides	1.30	1.30	-	-	-	-
Solomon	1.00	1.00	-	-	-	-

Sumatra	2.00	2.00	2.00	2.00	-	-
New Zealand	3.00	3.00	2.00	-	-	-
Australian/Pacific plate margin south of New Zealand	1.50	0.75	-	-	-	-
Ontong Plateau	-	-	1.50	1.50	-	-
New Guinea Margin	-	-	-2.00	-2.00	1.00	-
Tasman Sea	-	-	-	-	1.10	-
Coral Sea	-	-	-	-	0.49	-
Northern Trench	-	-	-	-	-2.00	-
Wharton Basin Ridge	-	-	-	-	3.10	2.32
East Gondwanaland Subduction Zone	-	-	-	-	-	-23.00

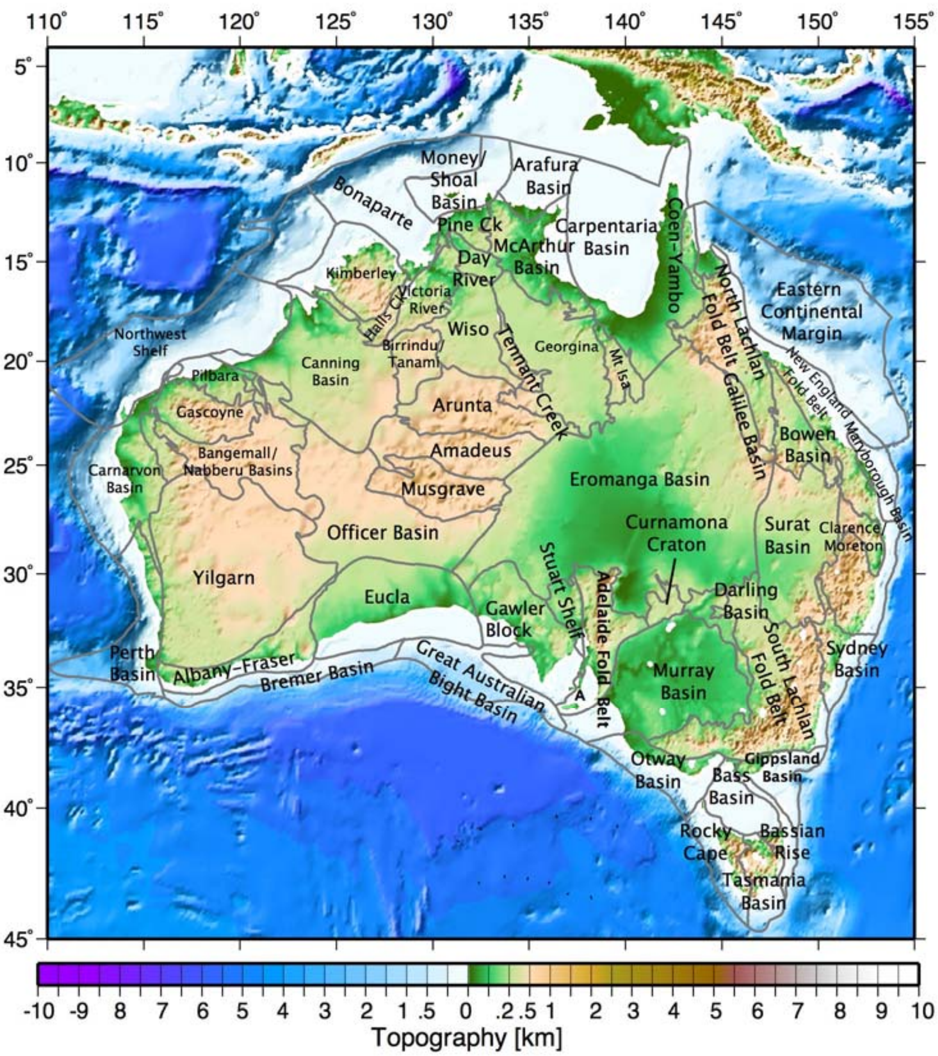
Appendix 1 Forces applied to models with times in millions of years before present. Positive forces are directed towards the interior of the plate. Note: Force magnitudes are 1 x 10^{12} N/m, which is equivalent to a stress of 10 MPa across a plate of thickness 100 km. See reconstructions (Figure 2) for locations of forces.

Geological Province	Effective Elastic Plate Thickness (km)	Flexural Rigidity x $1e^{25}$ N.m	Scaling Factor	Effective Young's Modulus x $1e^{10}$ N/m^2	Refined Effective Young's Modulus x $1e^{10}$ N/m^2	Refined Effective Rigidity x $1e^{25}$ N.m	Refined Effective Elastic Plate Thickness (km)
Adelaide Fold Belt	-	-	-	-	0.30	0.11	49
Stuart Shelf	-	-	-	-	0.80	0.28	68
Arunta Block	88	0.61	0.29	1.74	3.70	1.30	113
Ngalia Basin	88	0.61	0.29	1.74	3.70	1.30	113
Tennant Creek Block	88	0.61	0.29	1.74	3.70	1.30	113
Amadeus Basin	-	-	-	-	0.70	0.25	65
Officer Basin	-	-	-	-	0.70	0.25	65
Eucla Basin	-	-	-	-	0.70	0.25	65
Darling Basin	29	0.02	0.01	0.06	0.20	0.07	42
Murray Basin	29	0.02	0.01	0.06	0.20	0.07	42
Bass Basin	-	-	-	-	0.60	0.21	61
Rocky Cape Block	-	-	-	-	0.60	0.21	61
Tasmania Basin	-	-	-	-	0.60	0.21	61
Bassian Rise	-	-	-	-	0.60	0.21	61
Sydney Basin	-	-	-	-	0.60	0.21	61
Clarence-Moreton	-	-	-	-	0.60	0.21	61

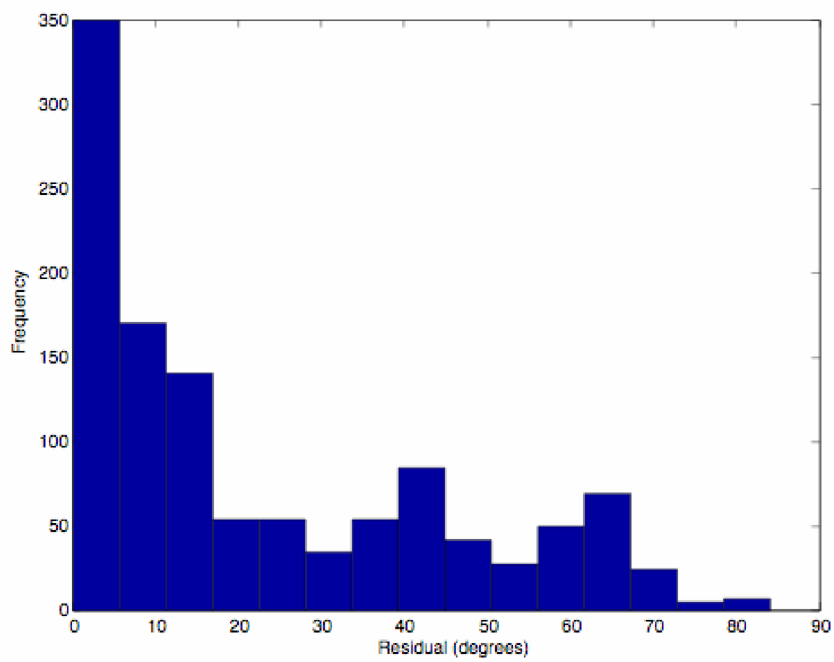
Basin							
Bowen Basin	-	-	-	-	0.60	0.21	61
Marybourough Basin	-	-	-	-	0.60	0.21	61
Galilee Basin	-	-	-	-	0.60	0.21	61
Eromanga Basin	-	-	-	-	0.80	0.28	68
Surat Basin	-	-	-	-	0.80	0.28	68
Gawler Block	92	0.69	0.33	1.97	3.98	1.39	116
Gippsland Basin	-	-	-	-	0.70	0.25	65
Mt Isa Block	134	2.10	1.00	6.00	6.00	2.10	134
Musgrave Block	88	0.61	0.29	1.74	3.74	1.31	114
Coen-Yambo Block	-	-	-	-	5.70	2.00	131
Daly River Basin	-	-	-	-	1.00	0.35	73
Wiso Basin	-	-	-	-	1.00	0.35	73
Georgia Basin	-	-	-	-	1.00	0.35	73
McArthur Basin	-	-	-	-	1.00	0.35	73
Arafura Basin	-	-	-	-	1.00	0.35	73
Carpentaria Basin	-	-	-	-	1.00	0.35	73
North Lachlan Fold Belt	26	0.02	0.01	0.05	0.09	0.03	32
Northwest Shelf	-	-	-	-	0.40	0.14	54

Halls Creek Province	134	2.10	1.00	6.00	6.00	2.10	134
Pine Creek Geosyncline	134	2.10	1.00	6.00	6.00	2.10	134
Bonaparte Gulf Basin	-	-	-	-	0.50	0.18	58
Browse Basin	-	-	-	-	0.50	0.18	58
Canarvon Basin	-	-	-	-	0.40	0.14	54
Otway Basin	-	-	-	-	0.70	0.25	65
Perth Basin	-	-	-	-	0.30	0.11	49
Pilbara Block	132	2.00	0.95	5.71	5.70	2.00	131
Paterson Province	132	2.00	0.95	5.71	5.70	2.00	131
Bremer Basin	-	-	-	-	0.09	0.03	32
Great Australian Bight Basin	-	-	-	-	0.09	0.03	32
South Lachlan Fold Belt	20	0.01	0.00	0.02	0.05	0.02	26
Bangrnall and Nabberu Basins	-	-	-	-	0.70	0.25	65
Gascoyne Block	-	-	-	-	0.70	0.25	65
Canning Basin	-	-	-	-	0.70	0.25	65
Kimberly Basin	-	-	-	-	0.70	0.25	65
Money Shoal Basin	-	-	-	-	0.70	0.25	65
Victoria River Basin	-	-	-	-	0.70	0.25	65

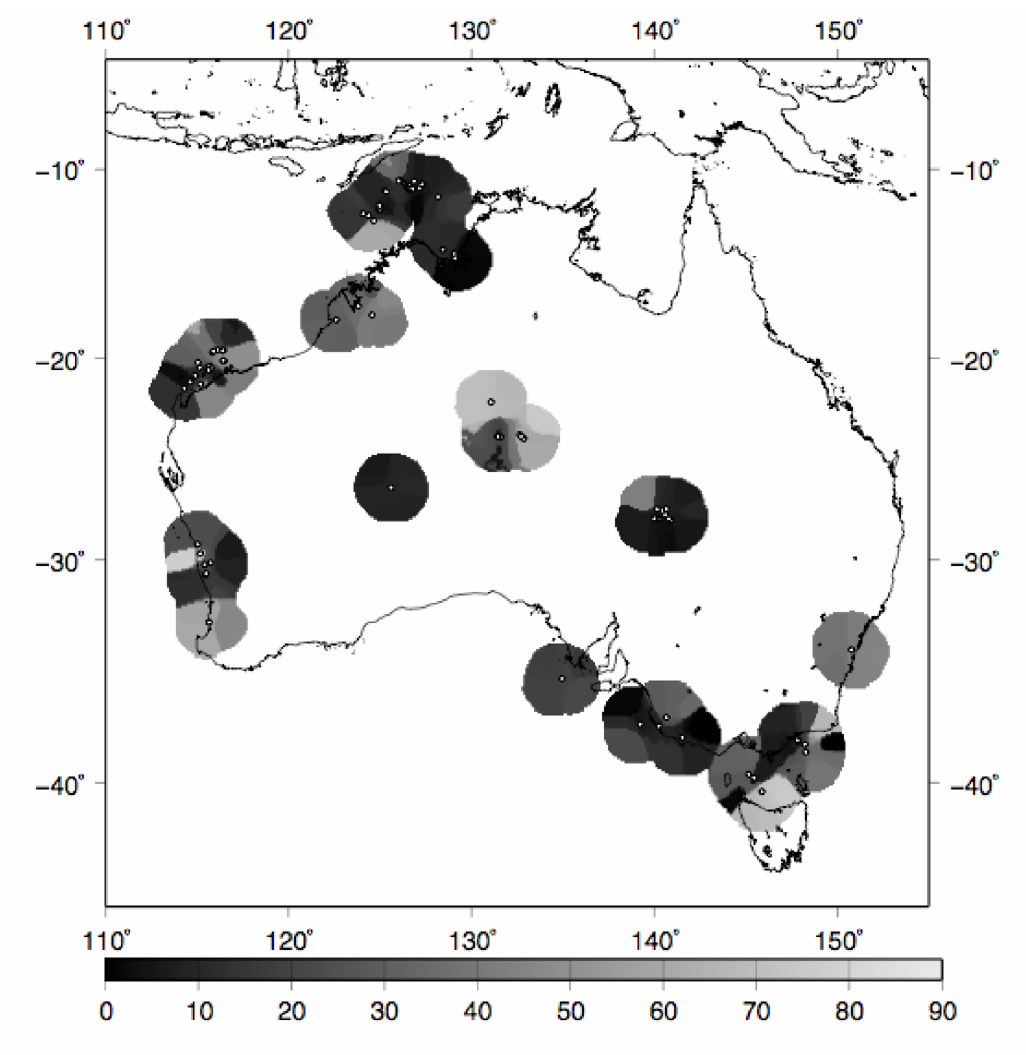
Birrindudu and Tanami Basins	-	-	-	-	0.70	0.25	65
Albany-Fraser Province	132	2.00	0.95	5.71	5.70	2.00	131
Yilgarn Block	132	2.00	0.95	5.71	5.70	2.00	131
Eastern Continental Margin	-	-	-	-	0.02	0.01	19



Appendix 2 Table of initial values for strength estimates of material parameters in columns one and two after Zuber et al. (1989); geological provinces correspond to labels on Figure as part of Appendix 2. Effective Young's modulus represent the value assigned to a material in the model after scaling. Refined values are the values obtained from the optimisation process that give a best fit with observational data and as such represent strengths optimised for the present day stress regime. The significant differences between the initial and refined effective Young's modulus in some regions may represent spatial aliasing in the initial values due to unsuitable window size and spacing used in the effective elastic plate thickness study of Zuber et al. (1989), with most regions representing small spatial areas that may not have been resolved correctly. Given the non-uniqueness of forward modelling and the non-linear interactions between stress directions, magnitudes and rheological provinces, aliasing of these regions in order to achieve the best fit with observed stress orientation overall cannot be ruled out.



Appendix 3 Histogram showing total residual misfit of the “best fit” contemporary model with a median residual misfit value of ~12˚. Modelled σ_H orientations were averaged over a small window whose centre corresponded to the location of a σ_H orientation with A to B quality for various regions over the Australian continent and continental margin. The difference between azimuths of measured and average modelled σ_H orientations then determined the residual misfit.



Appendix 4 Map of residual misfit with 100 km near neighbour interpolated misfit (in degrees) gridded around data points of the Australian Stress Map included in the optimisation process (white circles). Darker colours indicate a better fit between measured and modelled maximum horizontal stress directions. The fit of modelled stress orientations in some regions of Australia, in particular north-eastern Australia, remained unconstrained due to lack of any high quality data. The modelling process is intrinsically skewed towards optimising overall fit where there is the most data, and as such any interpretation using the

modelled results in regions at increasing distance from data points must consider this increasing uncertainty.

Flinders

Time Period	Mean Azimuth	σ_H	σ_h	σ_v	Regime
6Ma - 0Ma	106	29	22	20	R
11Ma- 6Ma	69	26	23	20	R
23Ma - 11Ma	118	42	11	20	SS
25Ma - 23Ma	114	33	11	20	SS
~55Ma	85	34	22	20	R
~100Ma	169	69	-192	20	SS

Gippsland

Time Period	Mean Azimuth	σ_H	σ_h	σ_v	Regime
6Ma - 0Ma	129	28	21	20	R
11Ma- 6Ma	90	26	23	20	R
23Ma - 11Ma	135	45	22	20	R
25Ma - 23Ma	133	36	22	20	R
~55Ma	87	21	19.9	20	SS

Appendix 5 Modelled mean maximum horizontal stress (σ_H) direction and magnitude, modelled minimum horizontal stress (σ_h) magnitude and estimated vertical stress (σ_v) at roughly 1km depth for the Flinders Ranges and Gippsland Basin. Faulting Regime (R = reverse, SS = strike-slip, N = normal). Data for Flinders Ranges and Gippsland Basin averaged over a regions defined by 30°N, 34°S, 138°W, 140°E and 38°N, 39°S, 146°W, 149°E, respectively.