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The origins of the intraplate stress field in continental Australia

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Abstract

The ridge push force acting on the Indo-Australian plate exerts a significant torque (8.5×10^{25}N m) about a pole at 30.3°N, 34.5°E. The angular difference between this torque pole and the observed pole of rotation for the plate (19.2°N, 35.6°E) is less than 12° and suggests that the ridge push force plays an important role in the dynamics of the Indo-Australian plate. We have used an elastic finite-element analysis to study the predicted intraplate stress field in continental Australia for four models which employ different boundary conditions to balance the ridge push torque acting on the plate. The modeling indicates that a number of important features of the observed stress field within the Australian continent can be explained in terms of balancing the ridge push torque with resistance imposed along the Himalaya, Papua New Guinea, and New Zealand collisional boundaries segments. These features include N–S-to NE–SW-oriented compression in the northern Australia and E–W-oriented compression in southern Australia. Our analysis also shows that subduction processes along the northern and eastern boundaries provide only second-order controls on the intraplate stress field in continental Australia.

1. Introduction

The Indo-Australian, North American, and South American plates form a group of fast moving "continental" plates [1]. In the North American and South American continents the orientation of the maximum horizontal compression (S_{Hmax}) is well defined and is clearly aligned with both the absolute plate velocity and ridge torque directions [2]. The relatively uniform orientation of S_{Hmax} in these plates reflects, in part, the homogeneous nature of their boundary configurations; namely, both plates have mid-ocean ridges along their trailing (eastern) margins and leading margins involving continental arc-related mountain tracts in South America, and principally strike-slip tectonics in North America [2–5]. While the Indo-Australian plate shares a similar basic plate geometry as the North and South American plates, with a mid-ocean ridge along the trailing margin and a convergent leading margin, the Australian intraplate stress field is not characterized by uniform S_{Hmax} orientation and not readily explicable in terms of any single tectonic process. On the contrary, the S_{Hmax} directions in continental Australia show considerable variation, oriented E–W in southwestern and southeastern Australia, NE–SW along the Northwest Shelf, and N–S in the north. Previous modeling studies of the intraplate stress field concluded that the first-order intraplate stress field is controlled by a large number of tectonic forces acting on the plate, primarily along the northern convergent boundary [6–9]. These studies dif-

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fered substantially in their assessments of the relative contribution of tectonic forces acting along the northern and eastern plate boundaries, particularly along the Java and Sumatra trenches, the Himalaya and Papua New Guinea collisional margins, and the Tonga–Kermadec trench.

In the present study, we postulate that the first-order intraplate stress field in Australia is controlled by the focusing of the ridge push torque along the northern collisional margins and, in particular, along the Papua New Guinea boundary segment. We test this hypothesis by evaluating the predicted intraplate stresses in continental Australia for four successively more complex models of the forces acting on the plate. Our results demonstrate that the observed S_{Hmax} orientation in central and western Australia can be explained by a simple model which balances the ridge push torques with pinned northern collisional segments. Second-order features in the observed stress field, including E–W S_{Hmax} orientations in southwestern and southeastern Australia, are explained by more complex tectonic models which incorporate boundary forces acting along the northern and eastern boundary segments.

2. Sources of tectonic stress and the Australian intraplate stress field

In the present study we have evaluated the predicted intraplate stress field in continental Australia in response to three primary sources of tectonic stress: (1) intraplate sources related to lateral variations in gravitational potential energy of the lithosphere, which includes the ridge push and buoyancy forces, (2) plate boundary forces, and (3) drag forces acting along the base of the plate.

Tectonic forces due to lateral density variations have long been recognized as an important source of intraplate stress and associated deformation [10–24]. These forces act in the cooling oceanic lithosphere along mid-ocean ridges (i.e., ridge push), along continental margins, and in regions of elevated continental lithosphere. In the present study, we refer to these forces collectively as topographic forces. Topographic forces are the best understood of the three major tectonic forces and are well-constrained to range in magnitude from $2–3 \times 10^{12}$ N m^{-1} in the case of ridge push (with a corresponding geoid anomalies of 10–15 m [25]), $1–2 \times 10^{12}$ N m^{-1} for continental margins (with a corresponding geoid anomaly of about 6 m [23,25,26], to almost 6×10^{12} N m^{-1} for continental lithosphere with an elevation of 5000 m [24,26,27].

Continent–continent and continent–arc collisions are likely to impose considerable resistance to plate motion because of the buoyancy of continental lithosphere and hence are likely to be a source of intraplate compression. One constraint on the magnitude of the forces associated with collisional processes is the change of the potential energy associated with the construction of convergent orogens [21]. The potential energy change accompanying growth of convergent orogens is poorly constrained due to our inadequate knowledge of the deep lithospheric density structure and the difficulties involved in measuring continental geoid anomalies. However, the crustal contribution to the excess potential energy of regions of high elevations is proportional to the square of the crustal thickening and is estimated to be in the range of $5–10 \times 10^{12}$ N m^{-1} for the high Himalaya, where crust is approximately double the normal continental thickness [21,23]. In the present study we have used the potential energy formulation discussed in [24] to estimate the forces due to lateral density variations in the lithosphere.

Our calculated torque contributions from the three primary topographic force sources (ridge push, continental margin, and continental topography) are listed in Table 2. In the Indo-Australian plate, the torque due to the ridge push force is more than three times greater than the torque due to continental margin topographic forces and five times greater than the torque due to elevated continental topography topographic forces (Table 2). It is therefore reasonable to expect that the ridge push force will affect the predicted stress field the most.

In comparison to the topographic forces, the magnitudes of collisional and basal drag forces are poorly constrained, with estimates varying by orders of magnitudes [28–30]. For example, the slab pull force is theoretically a few times 10^{13} N m^{-1} for a fully developed slab and potentially produces a large "net" tensional force acting on the plate. However, the extent to which the stresses due to the subducting slab are dissipated by local resistive forces in the subduction zone is not known, and these may significantly reduce the net force due to slab pull acting on the plate. Numerical modeling of the Indo-Australian intraplate stress field has lead to a wide range of postulated values for the magnitude of the forces acting along the subduction zones [6–9], and the relative magnitude of these forces remains highly controversial.

The third class of tectonic force which acts on the plates arises due to the relative motion of the plate over the underlying asthenosphere. This force is often referred to as the "drag force" and may be either resistive or driving in nature. The relative contribution of the drag force to the intraplate stress field is difficult to constrain since the nature of the coupling between the lithospheric plates and the underlying asthenosphere is poorly understood. Because there is little correlation between plate area and absolute plate velocity [28], the nature of the coupling is probably quite complicated. Furthermore, there appears to be little evidence for a strong correlation between the asthenospheric flow pattern due to counter flow and the present-day plate motions [31,32]. In the present study, basal resistive drag is used as needed to balance the net torque acting on the plate [3].

The various tectonic forces acting on the Indo-Australian plate are shown schematically in Fig. 1. The primary collisional boundaries include Himalaya, Papua New Guinea, and New Zealand. Subduction zone forces act along the Java, Sumatra, Solomon, New Hebrides, and Tonga–Kermadec trenches.

The first-order pattern of the regional intraplate stress field in continental Australia is relatively well defined by the stress indicators of the World Stress Map database [33]. Fig. 2 shows the stress indicators located in continental Australia by type and S_{Hmax}

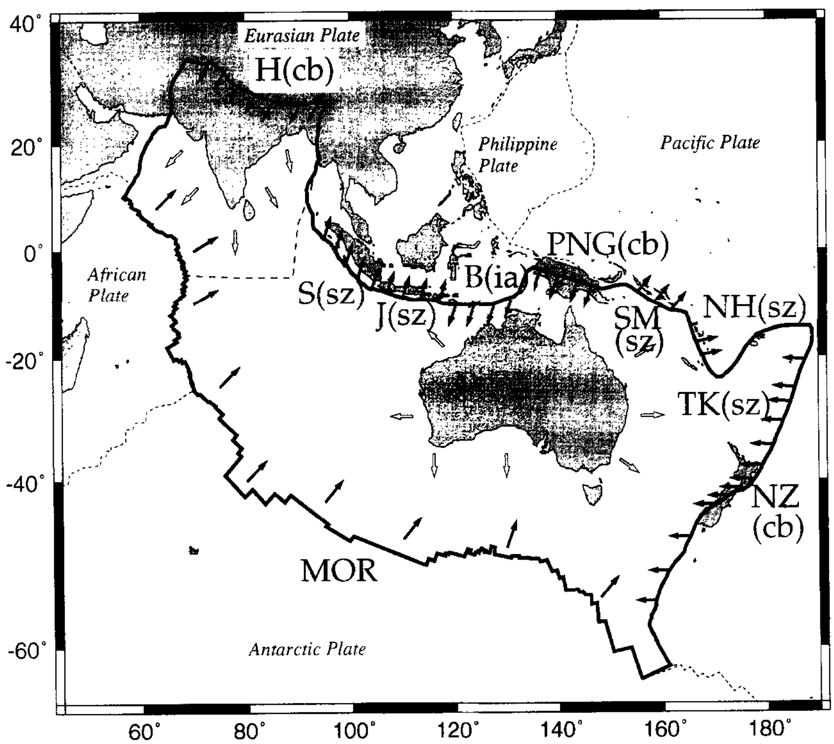

Fig. 1. Indo-Australian plate with boundaries as defined by [1]. *H* = Himalaya; *S* = Sumatra Trench; *J* = Java Trench; *B* = Banda Arc; *PNG* = Papua New Guinea; *SM* = Solomon Trench; *NH* = New Hebrides; *TK* = Tonga–Kermadec Trench; *NZ* = New Zealand; *MOR* = Mid Ocean Ridge. Solid-filled arrows represent the boundary forces acting on the plate. Open arrows represent the forces associated with the continental margins. Note that force arrows are not drawn to scale. The plate boundaries are characterized as *cb* (collisional boundary), *sz* (subduction zone), and *ia* (island arc).

orientation. Despite some considerable scatter the stress field in the Australian continent appears to be characterized by E–W compression in the south, and N–S to NE–SW compression in the north [34–37]. This variation in S_{Hmax} orientation has been related to the resistance of the Indian Ocean–Australian plate to subduction along its northern margin [38], and to the position of Australia relative to the subduction zones along the northern boundary [6,7]. The great Sumba earthquake of 1977 [39], suggests the presence of a large slab pull force acting along the Sunda arc. Along the Northwest Shelf, S_{Hmax} is oriented roughly NE in the Timor Sea region, and nearly E–W in the Barrow–Dampier sub-basin [40–42]. The stress data for continental Australia show a large amount of scatter in the S_{Hmax} orientation, possibly reflecting a strong influence from local sources of stress. These local sources have the greatest effect on stress indicators based on shallow in-situ stress measurements (such as hydraulic fracturing), many of which have been made at depths less than 1 km. Furthermore, stress orientations based on earthquake focal mechanisms may reflect the orientation of pre-existing zones of weakness rather than the contemporary stress field [33]. An analysis of the average S_{Hmax} orientations within 3° × 3° bins [43] confirms the notion that the long wavelength S_{Hmax} trends are oriented E–W in southern Australia and N–S to NE–SW in northern Australia (Fig. 3). Like North America and South America, but unlike the continents on the slower moving plates such as Europe and Africa, the stress field within the interior of the Australian continent is largely compressional. Fig. 2 and Fig. 3 provide information about the observed stress field and constrain the predicted stresses discussed below.

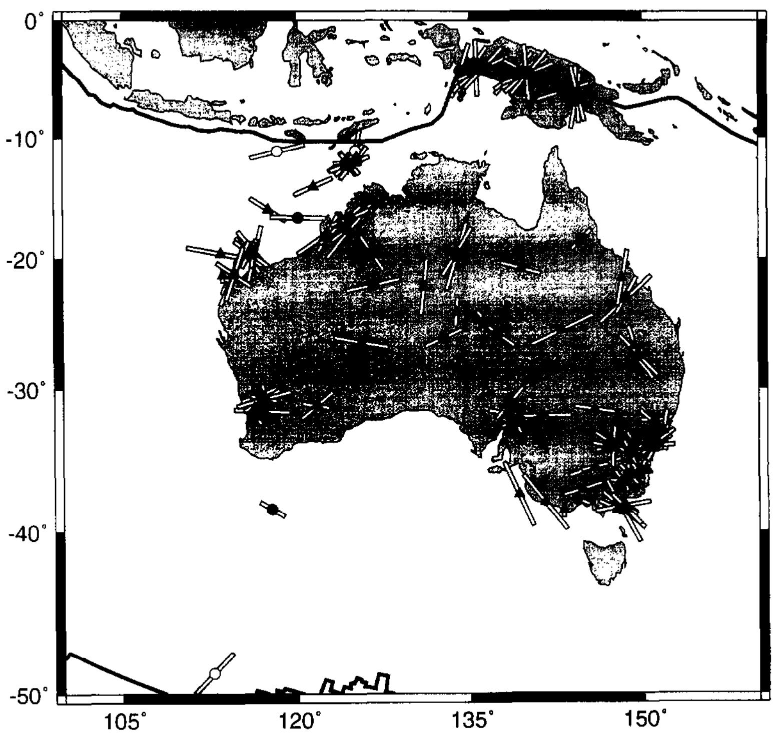

Fig. 2. Stress indicator data for Australia from the World Stress Map database [33]. Circles represent focal mechanisms, squares represent geologic indicators, and triangles represent wellhole data. Solid, open, and grey-shaded stress indicator symbols represent compressional, extensional and strike-slip deformational style, respectively. The length of the vectors, which represent the S_{Hmax} orientations, have been weighted by the indicator quality (A–D) after [33]. Although there is a large amount of scatter in the S_{Hmax} orientations, the stress field is characterized by E–W compression in southeastern and southwestern Australia and by N–S compression in northern Australia.

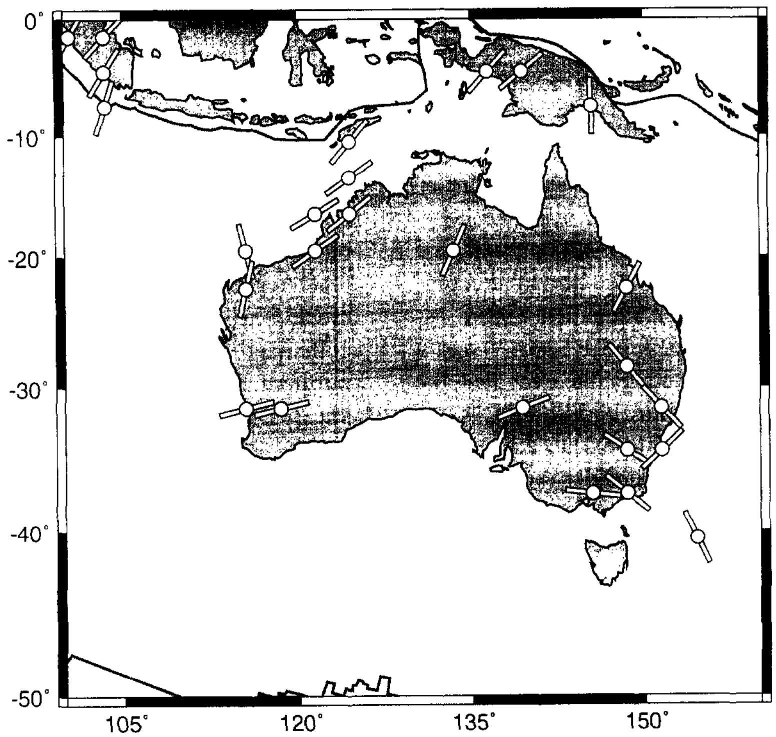

Fig. 3. Average S_{Hmax} orientations within 3° × 3° bins containing two or more indicators [43].

3. Modeling method

Predicted intraplate stresses in continental Australia have been calculated through an elastic finite-element analysis. While the use of an elastic rheology to model whole-plate deformation is obviously an oversimplification, it is justifiable for the modeling of first-order tectonic stresses. Alternative rheologies, such as visco-elastic, are useful for studying how tectonic stresses relax over time. Because the first-order stresses modeled in this study have renewable sources on geologically significant time-scales (e.g., forces due to long-term lateral density variations in the cooling oceanic lithosphere and collisional boundary forces), they can be considered to be in steady state. Thus, we feel the use of purely elastic rheology in this study is a justifiable simplification.

As discussed above, topographic forces, including the ridge push force, are relatively well-constrained. The proximity of the ridge push torque pole and the absolute plate velocity pole suggests that the ridge push torque may be an important driving mechanism for plate motion. Thus, each of the models considered in the present study combines the topographic torques (ridge push, continental margin, and continental topography) with various representations of the boundary forces acting along the northern margin. The magnitudes of the boundary forces acting along the northern collisional and subduction zone boundaries are poorly constrained. Therefore, we adopt the geologically plausible magnitudes listed in Table 2 to represent these forces. We emphasize at the outset that the principal goal of the present study is the evaluation of the relative contribution of these forces to the Australian intraplate stress field and not the determination of the exact magnitude of these boundary forces.

The intraplate stress field for the entire Indo-Australian plate has been modeled using an elastic finite-element analysis. The finite-element grid for the IAP consisted of 2527 constant strain elements composed a network of 1374 nodes, which provides a spatial resolution of about 2° in both latitude and longitude. The sensitivity of the modeled stresses is therefore limited to large-scale topographic features with a wavelength of a few hundred kilometers. The predicted stresses magnitudes are calculated for a lithosphere of constant thickness, assumed to be 100 km. The predicted stresses should be interpreted as the stresses which deviates from the hydro-or lithostatic reference state [44] with the assumption that the vertical stress and any associated horizontal component have been removed. All elements were assigned a Young's modulus of 7×10^{10} Nm^{-2} and a Poisson's ratio of 0.25. Based on the fact that the plate is not accelerating, static equilibrium is assumed. This requires that no net-torque acts on the plate. In the present paper we consider the predicted stress field produced by two sets of boundary conditions which achieve mechanical equilibrium: resistance along the convergent margins and the application of resistive basal drag. In the following sections we describe the stress fields computed for each of these scenarios.

Information about the torque contribution from the various tectonic forces acting on the plate provides a way of quantifying the relative contribution of each to the intraplate stress field. The torque exerted on the plate from a force $\boldsymbol{F}$ is calculated as

$$\boldsymbol{T} = \boldsymbol{r} \times \boldsymbol{F} \tag{1}$$

where $\boldsymbol{r}$ is the radius position vector and $\boldsymbol{F}$ is the force acting on the plate. The total torque acting on the plate is found by integrating $\boldsymbol{T}$ over the surface of the plate. Torque information from the various models evaluated in the present study is listed in Table 2 and Table 3.

4. Modeling results

Four models in the present study were used to evaluate the primary controls on the Australian intraplate stress field. We present the predicted stresses for these models, each of which used a different sets of boundary conditions to balance the torques acting on the plate. A description of the forces applied in each of the models is listed in Table 1. The various force magnitudes and torques are listed in Table 2, and the resulting non-drag torque acting on the plate for each of the four models is listed in Table 3. Predicted stress fields for the models are shown in Fig. 5.

In Model 1, mechanical equilibrium was achieved by homogeneously fixing the entire northern and eastern margin of the plate. This is equivalent to assuming that all of the resistance to the ridge force is transmitted from the Pacific and Eurasia plates to the IAP plate along these boundaries, balancing any tendency for the boundary to be deflected. In this model, no differentiation was made between the collisional and subduction zone boundaries along the northern margin. The orientation of the predicted stresses for Model 1 (Fig. 5a) is characterized by nearly-uniform NE–SW compressive stresses throughout the continental region of Australia. While these predicted S_{Hmax} orientations are consistent with observation in central and northern Australia, they are nearly orthogonal to the observed S_{Hmax} directions in the eastern and western regions. Topographic forces associated with the continental lithosphere have the effect of reducing the magnitude of the compressive stresses from about 18 MPa in the oceanic regions immediately south of Australia, to nearly zero in the continental regions. Although near-zero compressive stress magnitudes in low-elevation continental regions are consistent with potential energy arguments about the ambient state of stress [24], they are inconsistent with the observed stress regimes in continental Australia (Fig. 4). Clearly the homogeneous boundary forces applied in Model 1 are an over-simplification of the forces acting along the northern plate margin.

Model 2 employed a different set of boundary

Table 1
Description of force models

Model	Ridge Push	Collisional Boundaries	Other Boundaries	Drag Force
1	X	P	P	–
2	X	P	F	
3	X	X	F	X
4	X	X	X	X

X = applied force; P = pinned boundary; F = free boundary. Collisional boundaries include Himalaya, Papua New Guinea, and New Zealand (see Fig. 1). Other boundaries include Sumatra, Java, Banda, Solomon, New Hebrides, and Tonga–Kermadec (see Fig. 1).

Table 2
Boundary forces and torque contributions

Force	Magnitude [x10^{12}Nm^{-1}]	Total Torque [x10^{25}Nm]	Latitude [deg]	Longitude [deg]
Collisional Boundaries				
Himalaya	2.0	3.2	0.0 N	172.9 E
Papua New Guinea	2.0	1.9	39.8 S	123.1 W
New Zealand	2.0	2.1	47.2 S	7.9 W
Other Boundaries				
Sumatra	-2.0	1.9	19.0 N	9.6 E
Java	-2.0	2.1	18.7 N	23.7 E
Banda	1.0	1.0	15.7 S	141.8 W
Solomon	-1.0	0.8	39.3 S	102.5 W
New Hebrides	-1.0	0.5	69.7 N	132.1 E
Tonga–Kermadec	1.0	1.3	63.6 S	9.1 E
Non-Boundary Forces				
Ridge Push	—	8.5	30.3 N	34.5 E
Continental Margins	—	2.6	14.7 S	168.3 W
Elevated Continent	—	1.7	18.8 S	169.2 W
Drag (Model 3)	—	4.3	1.8 N	58.3 W
Drag (Model 4)	—	3.8	4.5 N	102.4 W

Positive forces are directed towards the interior of the plate. Note: Force magnitude of 1×10^{12} Nm^{-1} is equivalent to a stress of 10 MPa across a plate of thickness 100 km.

conditions to balance the ridge torque. In this model the three continental collisional boundaries (i.e., Himalayan, Papua New Guinea, and New Zealand) were fixed, while the other plate boundary segments (Sumatra, Java, Banda, Solomon, New Hebrides, and Tonga–Kermadec) were left free. These boundary conditions are equivalent to applying a force along the collisional boundaries proportional to the amount of displacement due to focusing of the ridge push torque along these margins. While still simplistic, these boundary conditions represent a more geologically plausible situation than those of the first model. The predicted stresses for Model 2 (Fig. 5b) differ significantly from those for Model 1. The fixed collisional boundary segments produce considerable stress focusing in northern Australia, resulting in a more pronounced N–S oriented S_{Hmax} in this region. Compressive stresses in this region approach 50 MPa. While the predicted N–S compression in the continental regions is reduced by the topographic forces, the magnitudes still exceed 30 MPa in many regions. While the predicted S_{Hmax} orientations along the Northwest Shelf and in central Australia are consistent with observations, the misfit in southwestern and eastern Australia is still quite large.

Model 3 employs a third set of boundary conditions to represent the forces acting along collisional boundary segments. In this model, a constant force per unit length of boundary segment was applied along the Himalayan, Papua New Guinea, and New Zealand segments (Table 2). The exact amount of this boundary force is poorly constrained, and these values were chosen to represent geologically plausible collisional tractions. No forces were applied along the other northern boundary segments (Table 1). In this model, resistive basal drag was used to balance the net torque acting on the plate, such that a plate velocity of 1.0 cm/yr produced a basal shear stress of 0.1 MPa. This drag force produces a torque contribution of 4.3×10^{25} N m about a pole at 1.8°N, 58.3°W. The predicted S_{Hmax} orientations for Model 3 (Fig. 5c) are consistent with observations throughout continental Australia: E–W in southwestern and southeastern Australia, NE–SW along the Northwest Shelf, and N–S in central and northern Australia. The predicted style of deformation is compressional in central and eastern Australia, where the predicted maximum compression is about 18 MPa. In northern and eastern Australia where topographic forces produce E–W deviatoric tension, the predicted style of deformation is strike-slip.

The representation of the boundary forces applied in Model 3 is still very simplistic, and forces acting along the other boundary segments (i.e., the Sumatra, Java, Solomon, New Hebrides, and Tonga–Kermadec trenches and the Banda arc) should be taken into consideration. Model 4 was used to evaluate the influence of forces acting along these other boundaries on the Australian intraplate stress field. As

Table 3
Non-drag torque for different models

Model	Magnitude [x 10^{25} Nm]	Latitude [deg]	Longitude [deg]
1	5.4	34.9 N	63.9 E
2	5.4	34.2 N	66.5 E
3	4.3	1.8 S	121.7 E
4	3.8	4.5 S	77.6 E

discussed above, the exact magnitude of the forces acting along these boundaries remains highly controversial [5,6]. We have therefore chosen to use equivalent forces (2.0×10^{12} N m^{-1}) acting along both the collisional boundaries (Himalaya, Papua New Guinea, and New Zealand) and the subduction zones (Java and Sumatra) (Table 2). The predicted stresses for Model 4 (Fig. 5d) are very similar to those for Model 3 (Fig. 5c). Non-lithostatic tensional stresses associated with the subduction-zone forces acting along the Java and Sumatra trenches are localized near the trench and have a maximum magnitude of about 25 MPa. Predicted S_{Hmax} orientations in continental Australia show improvement in only one area, southwestern Australia. Compressive stress magnitudes are slightly larger in central Australia, where they approach 25 MPa. Model 4 demonstrates that while subduction zone forces acting along the north Indo-Australian plate boundary may play an important role in the plate-wide intraplate stress field [6–8], they have only a modulating effect on the predicted stresses in continental Australia.

5. Discussion

The modeling presented in this study demonstrates that the first-order features of the intraplate stress field in continental Australia can be explained in terms of the interaction of two governing processes: (1) torques due to topographic forces (mainly due to the ridge push force) and (2) resistance along the collisional boundaries of the Himalaya, Papua New Guinea, and New Zealand. Model 3 (Fig. 5c) clearly shows that the main complexity in the stress field reflects the heterogeneous disposition of the collisional segments along the northern boundaries of the Indo-Australian plate. If this interpretation is correct, it raises important questions about the role of subduction at convergent boundaries in the intraplate

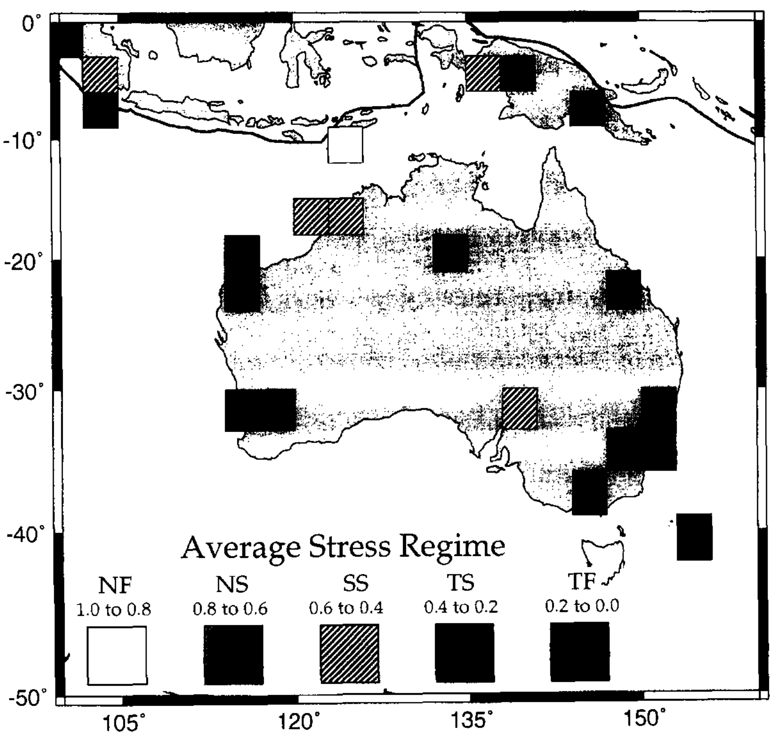

Fig. 4. The average stress regime in continental Australia for 3° × 3° bins containing two or more indicators [43]. Stress regimes correspond to: *NF* = normal faulting; *NS* = normal with strike-slip component; *SS* = strike-slip; *TS* = thrust with strike-slip component; *TF* = thrust faulting.

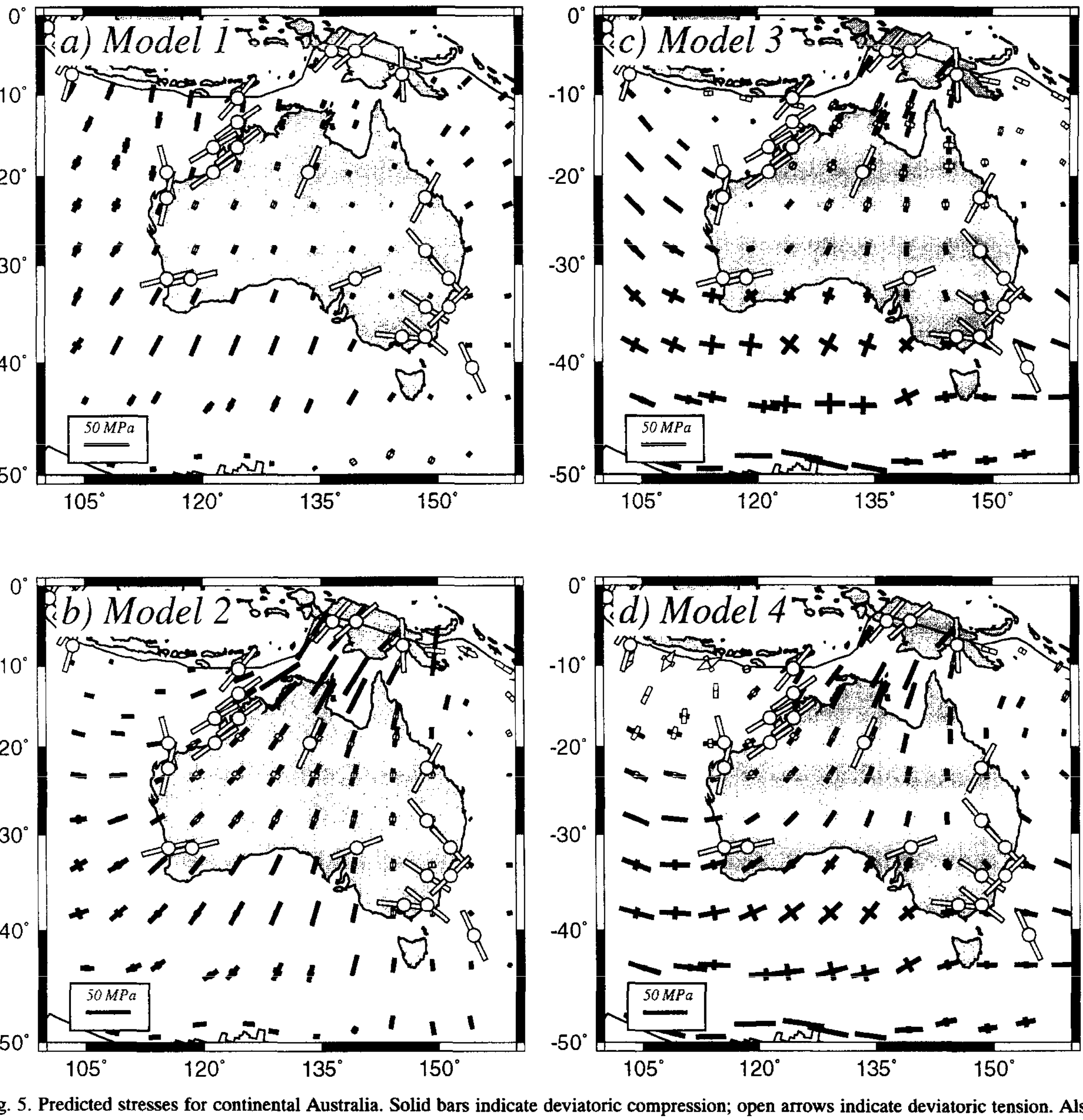

Fig. 5. Predicted stresses for continental Australia. Solid bars indicate deviatoric compression; open arrows indicate deviatoric tension. Also shown are the average S_{Hmax} orientations within 3° × 3° bins from Fig. 4. Force parameters applied for each model are listed in Tables 1 and 3. (a) Model 1: Ridge push torques acting on the plate are balanced by fixing the entire northern and eastern plate boundaries. Predicted stresses throughout continental Australia are compressional (approaching 18 MPa) with S_{Hmax} oriented nearly uniformly NE–SW. (b) Model 2: Ridge push torques are balanced by fixing the collisional boundary segments along the Himalayan, Papua New Guinea, and New Zealand collisional boundary segments. The predicted stress field is dominated by NE–SW compression (approaching 80 MPa) due to focusing of ridge push torque along the Papua New Guinea boundary segment. (c) Model 3: Basal drag is used to balance torque acting on plate from ridge push and collisional boundary forces. Other boundary segments were left free. The predicted stress field is compressional throughout continental Australia (approaching 20 MPa in most regions), with S_{Hmax} varying from NW–SE to E–W in western and southeastern Australia to N–S in the north-central continental regions. (d) Model 4: Basal drag is used to balance torque acting on the plate from ridge push and boundary forces. The predicted stress field is very similar to that of Model 3, suggesting that the primary control on the stress field in continental Australia is exerted by the collisional boundary forces acting along the Papua New Guinea boundary segment.

stress field, namely, that subduction processes provide, at best, a second-order control on the orientation of the Australian intraplate stress field. Other modeling studies have suggested that subduction forces acting along the northern plate margin produce significant tension in the Indo-Australian plate [6–8]. The results of modeling presented elsewhere [9] show that such an effect results in increased stress focusing along the collisional boundaries with a corresponding increase in the predicted stress magnitude but with little reorientation of predicted S_{Hmax} directions. Given the fact that observed S_{Hmax} orientations provide the primary control on the numerical modeling, this suggests that a simple representation of the tectonic forces acting on the plate, such as Model 3, cannot be ruled out on the basis of observation.

Our analysis of the Australian stress field has bearing on an important geodynamic problem concerning the magnitude and origin of the stresses that drive collisional orogens such as the Himalaya. As stated above, the potential-energy changes accompanying the construction of the Himalayan mountains, while poorly constrained, are believed to be of the order of $5–10 \times 10^{12}$ N m^{-1}, requiring shear stresses of the order of 25–50 MPa averaged over a 100-km-thick lithosphere [45]. Moreover, simple calculations show that the potential energy per unit length of elevated continental lithosphere is significantly greater than that of mid-ocean ridges [24]. This large potential energy difference has been used to implicate subduction as an important driving mechanism in plate tectonics. In this context, the important aspect of our modeling has been to illustrate how the focusing of potential energy torques arising from the asymmetric distribution of ridge systems around the Indo-Australian plate boundaries may lead to compressional stresses of the magnitude needed to drive collisional orogens. The main conclusions that stem from the work presented here and which may have important global implications are as follows:

(1) Torques arising from plate-scale potential energy distributions, including ridge push, may provide first-order controls on the in-situ stress field [2], even in plates with complex intraplate stress fields such as Indo-Australia.

(2) The orientation and magnitude of the stresses resulting from plate-scale potential energy distributions may be significantly modified by focusing effects along heterogeneous convergent boundaries. Indeed, in order to develop significant compression within continents it may be necessary that some focusing be present.

(3) The effects of subduction and basal shear are not necessary to explain the first-order characteristics of the Australian stress field (but may influence magnitudes) and thus seem to be second-order features.

Finally, the analysis presented here suggests that the complexity in the Australian stress field, in comparison with other continents such as North America and South America, may simply reflect the heterogeneous convergent boundary conditions operating on the northern and eastern boundary. While the role of the northern boundary of the Indo-Australian plate has long been suspected as being significant, our new interpretation of the origin of the E–W compression in the southeastern Australia further emphasizes the importance of stress focusing at collisional boundaries.

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