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Late Cenozoic intraplate faulting in eastern Australia

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ABSTRACT

The intensity and tectonic origin of late Cenozoic intraplate deformation in eastern Australia is relatively poorly understood. Here we show that Cenozoic volcanic rocks in southeast Queensland have been deformed by numerous faults. Using gridded aeromagnetic data and field observations, structural investigations were conducted on these faults. Results show that faults have mainly undergone strike-slip movement with a reverse component, displacing Cenozoic volcanic rocks ranging in ages from ~31 to ~21 Ma. These ages imply that faulting must have occurred after the late Oligocene. Late Cenozoic deformation has mostly occurred due to the reactivation of major faults, which were active during episodes of basin formation in the Jurassic-Early Cretaceous and later during the opening of the Tasman and Coral Seas from the Late Cretaceous to the early Eocene. The wrench reactivation of major faults in the late Cenozoic also gave rise to the occurrence of brittle subsidiary reverse strike-slip faults that affected Cenozoic volcanic rocks. Intraplate transpressional deformation possibly resulted from far-field stresses transmitted from the collisional zones at the northeast and southeast boundaries of the Australian plate during the late Oligocene-early Miocene and from the late Miocene to the Pliocene. These events have resulted in the hitherto unrecognized reactivation of faults in eastern Australia.

1. Introduction

Intraplate contractional or transpressional deformation is commonly attributed to compressional horizontal stress fields, which are transmitted from the plate boundaries and reactivating pre-existing faults in the plate interiors (Etheridge et al., 1991; Ziegler et al., 1995). The Australian plate, for example, is situated far from the plate boundaries (Fig. 1a) and is commonly assumed to be a relatively stable continent. Nonetheless, there is widespread evidence that late Cenozoic intraplate transpressional deformation affected different parts of Australia, mainly through the reactivation of earlier faults (Keep et al., 2000; Dickinson et al., 2001; Sandiford, 2003b, a; Keep et al., 2007; Hillis et al., 2008). This intraplate deformation has been interpreted to result from the far-field stresses, which were transmitted from the Australian plate boundaries (Hillis et al., 2008; Muller et al., 2012).

One area where the role of late Cenozoic intraplate deformation is less understood is onshore eastern Australia. Major faults in this area have mainly affected late Paleozoic to early Mesozoic rock units (Fig. 1b) (Holcombe et al., 1997b; Babaahmadi and Rosenbaum, 2014), but it is possible that a component of the observed deformation has taken place in the late Cenozoic. This problem can be addressed by focusing on mid-late Cenozoic volcanic rocks, which are widely exposed in eastern Australia (Wellman and McDougall, 1974; Cohen et al., 2007; Knesel et al., 2008; Vasconcelos et al., 2008). Therefore, the recognition of structural observations in these rocks provides an opportunity to investigate the kinematics and intensity of late Cenozoic deformation.

The aim of this paper is to investigate whether evidence for intraplate transpressional deformation is recorded in deformational features within Cenozoic volcanic rocks in eastern Australia. We focus on a number of fault systems in southeast Queensland, and use gridded aeromagnetic data and field observations to analyze the kinematics, magnitude and relative timing of deformation. Finally, we discuss our results in the context of the late Cenozoic geodynamic evolution of the Australian plate.

2. Geological setting

The surface geology of southeast Queensland is dominated by Paleozoic–Mesozoic rock units, which are overlain by Cenozoic volcanic rocks (Fig. 1b). The Paleozoic and early Mesozoic rocks belong to the New England Orogen (Fig. 1b), and mainly consist of (1) Devonian-Carboniferous supra-subduction units (accretionary

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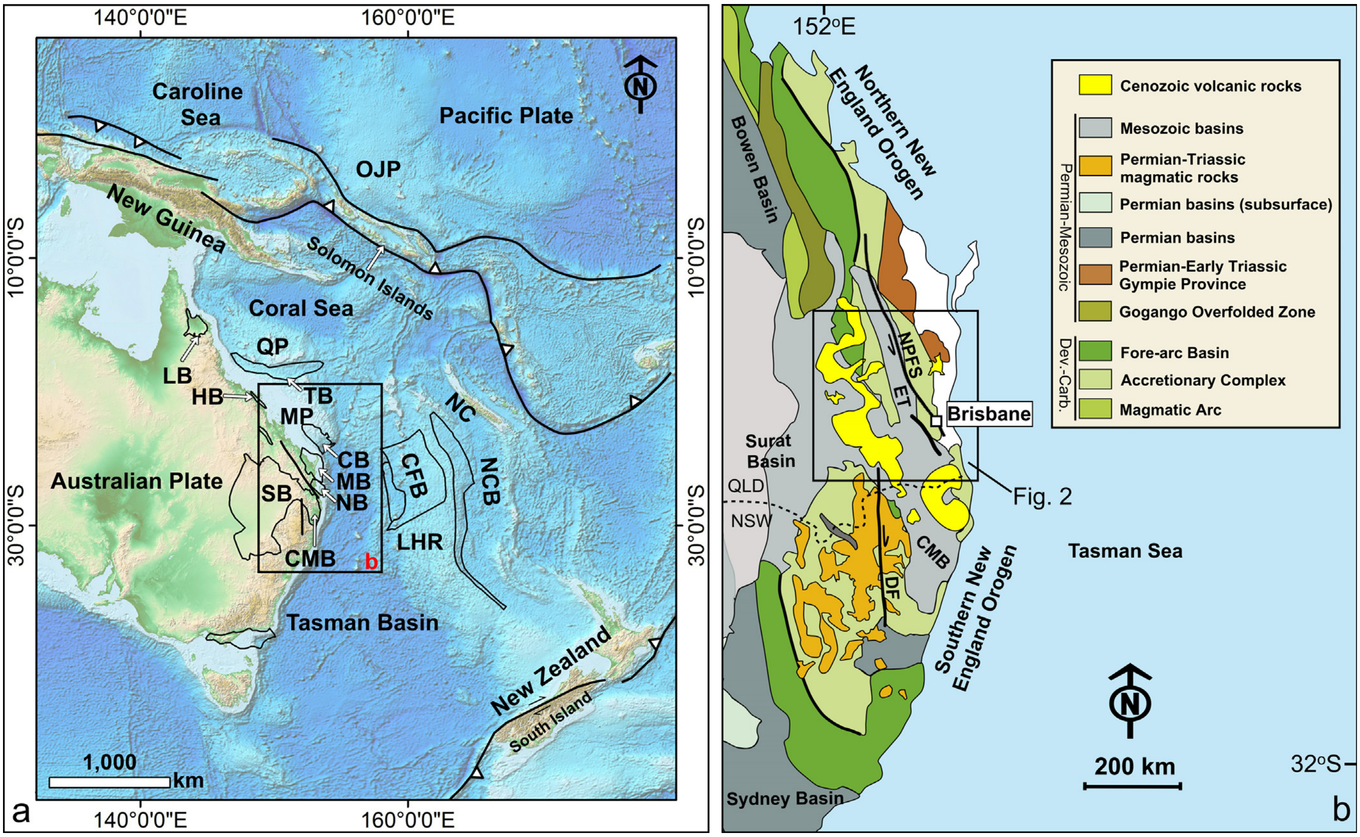

Fig. 1. (a) ETOPO1 digital elevation model of the Australian and Pacific plates (Amante and Eakins, 2009), and a simplified tectonic framework showing Mesozoic sedimentary basins in eastern Australia. CMB, Clarence-Moreton Basin; CB, Caledonia Basin; CB, Capricorn Basin; CFB, Capel and Faust basins; CT, Cato Trough; DB, Duaringa Basin; HB, Hillsborough Basin; LB, Laura Basin; LHR, Lord Howe Rise; MB, Maryborough Basin; MP, Marion Plateau; NB, Nambour Basin; NCB, New Caledonia Basin; NC, New Caledonia; OJP, Ontong Java Plateau; QP, Queensland Plateau; SB, Surat Basin; TB, Townsville Basin. (b) Simplified regional tectonic elements of eastern Australia. DF, Demon Fault; ET, Esk Trough; NPFS, North Pine Fault System.

complex, fore-arc basin and magmatic arc) (Leitch, 1975; Day et al., 1978; Henderson et al., 1993; Holcombe et al., 1997a); (2) early Permian extensional-related sedimentary and magmatic rocks (Korsch et al., 2009a); and (3) Late Permian to Middle Triassic calcalkaline magmatic rocks. The latter formed during episodic contractional events, collectively referred to as the Hunter-Bowen phase, which was intermitted by an interval of back-arc extension in the Early to Middle Triassic that resulted in the formation of sedimentary basins (e.g., Esk Trough; Fig. 1b) (Holcombe et al., 1997b; Li et al., 2012). Late Triassic and younger sedimentary rocks have supposedly been deposited in post-orogenic localized rift basins (Korsch et al., 1989; Holcombe et al., 1997b). The Devonian-Carboniferous subduction-related elements are generally characterized by N- to NNW-strike orientations, but in the southern New England Orogen, the orogen is tightly curved forming an oroclinal structure (Cawood et al., 2011; Rosenbaum, 2012; Rosenbaum et al., 2012).

Late Triassic and younger sedimentary basins have developed in two major episodes. The earlier episode, which occurred in the early Late Triassic, was associated with a major rifting phase that led to the development of the Ipswich and Tarong Basins (Korsch et al., 1989; Holcombe et al., 1997b). Rifting involved bimodal volcanism in southeast Queensland (Holcombe et al., 1997b), accompanied by major normal faults (Babaahmadi and Rosenbaum, 2014). The second episode of basin formation, from the latest Late Triassic to the Early Cretaceous, was associated with thermal relaxation subsidence that gave rise to the development of the Clarence-Moreton, Surat and Maryborough Basins (Korsch et al., 1989; Hill, 1994; Holcombe et al., 1997b; Korsch and Totterdell, 2009). Subsequently, from the Late Cretaceous to the early Eocene, the eastern Australian margin was subject to continental fragmentation accompanying the opening of the Tasman and Coral Seas (Weissel and Watts, 1979; Gaina et al., 1998a, 1998b).

Cenozoic intraplate volcanic rocks are distributed over 3000 km throughout the eastern Australian margin (Wellman and McDougall, 1974). This intraplate volcanism is subdivided into three types: central volcanoes, lava field provinces, and high potassium mafic areas (Wellman and McDougall, 1974). The central volcanoes are mostly basaltic but with some felsic lava flows and intrusions, constructing large volcanoes such as Tweed and Main Range (Fig. 2) (Wellman and McDougall, 1974; Johnson, 1989). These spatio-temporal distribution of the central volcanoes has been attributed to the northward motion of the Australian plate over a stationary hotspot(s) (Knesel et al., 2008). Lava field provinces are mostly composed of extensive and thin basaltic lavas, although in some locations their thickness reaches up to 1000 m (Wellman and McDougall, 1974). High potassium mafic areas are observed in central New South Wales as olivine leucitite (Wellman and McDougall, 1974).

In the study area in southeast Queensland (Fig. 2), mafic and felsic Cenozoic volcanic rocks are mainly associated with large central volcanoes (Wellman and McDougall, 1974; Johnson, 1989). $^{40}Ar/^{39}Ar$ ages of volcanic rocks from this region range from 31 ± 0.8 Ma at Maleny in the north to 20.7 ± 0.5 Ma at Main Range volcano in the south (Fig. 2) (Cohen et al., 2007; Knesel et al., 2008).