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Does the Manning Orocline exist? New structural evidence from the inner hinge of the Manning Orocline (eastern Australia)

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A B S T R A C T

The map-view structure of the southern New England Orogen in the eastern Gondwanan margin is characterised by four tight orogenic-scale curvatures: Texas, Coffs-Harbour, Manning and Nambucca oroclines. Here we focus on the geometry of the Manning Orocline and examine whether the inner-arc area of the oroclinal structure is expressed within the accretionary wedge rocks of the Tablelands Complex. Our observations from the Tablelands Complex (Armidale–Walcha area) show that rocks were subjected to penetrative deformation (D_1), which resulted in a regional slaty cleavage (S_1) and related isoclinal folds. This was followed by subsequent deformation (D_2) associated with minor gentle folds. In a larger scale, the steeply dipping S_1 structural fabric shows a continuous map-view curvature, thus defining a macroscopic fold structure. We interpret this macroscopic fold as the expression of the Manning Orocline within the accretionary wedge complex. This interpretation is consistent with the contorted spatial distribution of other tectonic elements (serpentinite belt, forearc basin terranes and early Permian granitoids), which independently define the structure of the Manning Orocline. Our new structural data support the existence of the Manning Orocline and the quadruple oroclinal geometry of the whole southern New England Orogen. The origin of these oroclines is attributed to multiple stages of bending, possibly associated with an earlier phase of curvature during slab rollback (in the early Permian), followed by a subsequent (middle-late Permian) episode of contractional deformation that tightened the oroclinal structure.

1. Introduction

Curved mountain belts, normally referred to as oroclines, have fascinated many geologists since the pioneering work by Carey (1955). Such large scale structures are recognised in both ancient and modern orogens, and have important implications on mountain building processes (Capitanio et al., 2011), the development of extensional backarc basins (Rosenbaum and Lister, 2004b), and the nature of magmatism (Gutiérrez-Alonso et al., 2011). However, the exact mechanisms responsible for oroclinal bending remain controversial with proposed models involving along-strike variations in propagating thin-skinned thrusts (Marshak, 1988, 2004), slab rollback (Rosenbaum and Lister, 2004a; Morra et al., 2006), large-scale drag folding associated with strike-slip faults (Kamp, 1987), indentation of irregular rigid blocks (Rumelhart et al., 1999) and orogenic-scale buckling (Johnston, 2008; Gutiérrez-Alonso et al., 2012; Weil et al., 2013).

The late Palaeozoic to early Mesozoic New England Orogen in eastern Australia (Fig. 1) is one of the most contorted orogens in the world (Glen and Roberts, 2012; Rosenbaum, 2012; Rosenbaum et al., 2012), but there are still major uncertainties with regard to the exact geometry of the oroclines and their tectonic evolution. Current geometrical models (Fig. 2) involve two oroclines (Texas and Coffs-Harbour oroclines) (Lucas, 1960; Korsch, 1981a), three oroclines (+Manning Orocline) (Korsch and Harrington, 1987), or four oroclines (+Nambucca/Hastings Orocline) (Rosenbaum, 2010; Glen and Roberts, 2012). To the north, both the Texas and Coffs-Harbour oroclines are defined by the curvature of the bedding and dominant structural fabric (Korsch and Harrington, 1987; Lennox and Flood, 1997; Li et al., 2012a). The existence of the Manning Orocline farther south is more controversial (e.g. Offler and Foster, 2008), and is mainly supported by the map-view curvature of an early Palaeozoic serpentinite belt (Korsch and Harrington, 1987), Devonian to Carboniferous forearc basin terranes (Glen and Roberts, 2012), and an early Permian belt of granitoids (Rosenbaum, 2010; Rosenbaum et al., 2012) (Fig. 2). Limited palaeomagnetic data from forearc basin rocks surrounding the Manning Orocline are not conclusive, but generally support the existence of the orocline (Geeve et al., 2002; Klootwijk, 2009; Cawood et al., 2011b; Mochales et al., 2012). The existence of a fourth orocline (Nambucca/Hastings Orocline) has recently been suggested based on the map-view curvature of early Permian granitoids and the Palaeozoic serpentinite belt, and the folding within the Hastings Block (Fig. 2) (Rosenbaum, 2010; Glen and Roberts, 2012; Rosenbaum, 2012; Rosenbaum et al., 2012).

One of the major uncertainties with regard to the structure of the Manning Orocline arises from the lack of field evidence supporting

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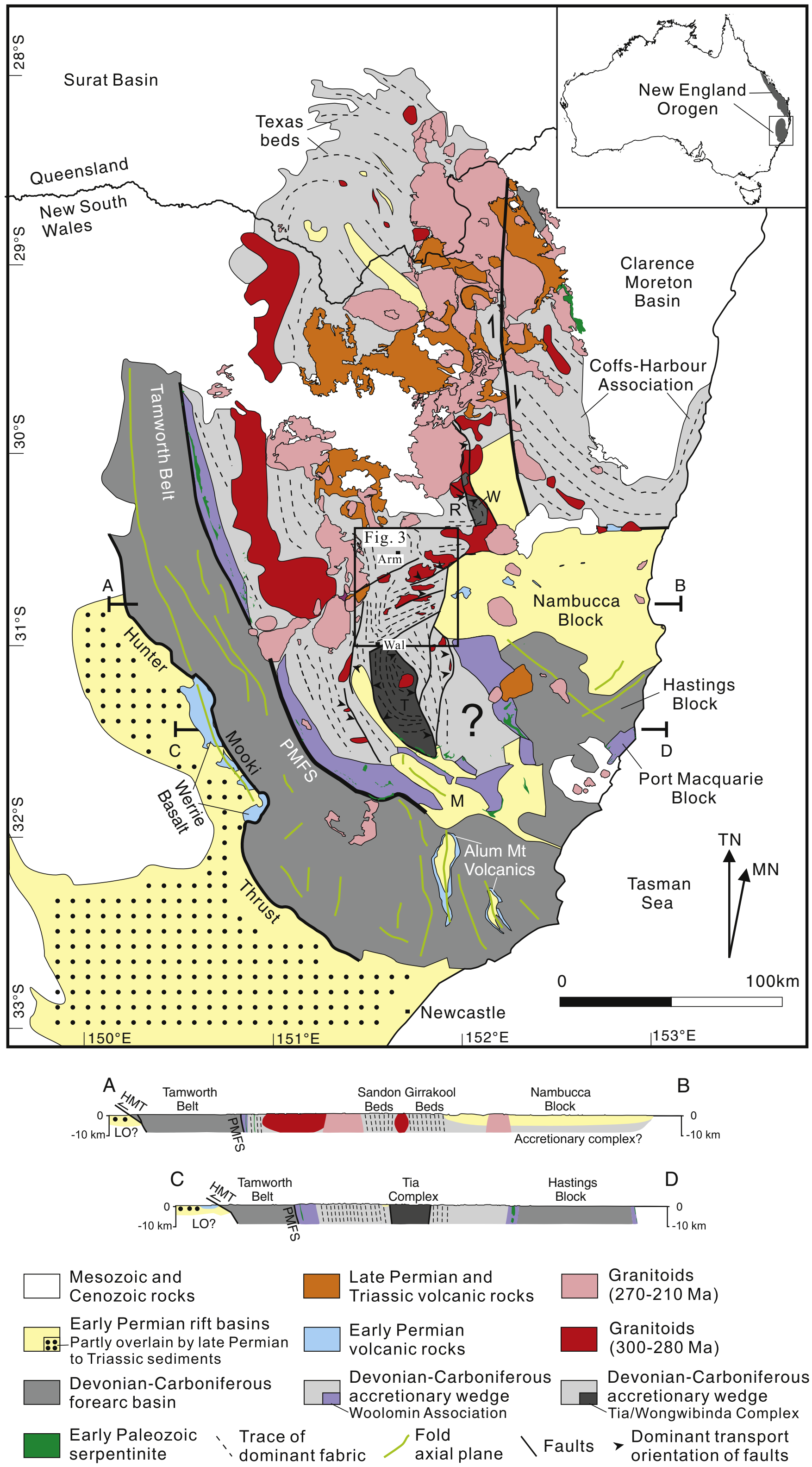

Fig. 1. Geological map and inferred cross sections in the southern New England Orogen. The simplified geological map is modified based on 1:250,000 geological and metallogenic map sheets (Singleton, Newcastle, Tamworth, Hastings, Manilla, Dorrigo-Coffs Harbour, Inverell and Grafton). Inferred cross sections are partly after Guo et al. (2007), Korsch et al. (1997) and Dirks et al. (1992a). The form lines of the dominant structural fabric are based on Binns et al. (1967), Dirks et al. (1992a), Farrell (1988, 1992), Li et al. (2012a), Korsch and Harrington (1987), and this study. Note that for the Tia Complex and Wongwibinda complexes we plotted the D_3 and D_1 fabric, respectively (see the discussion in Section 4.1). Fault structures and related transport directions in the Tablelands Complex are after Landenberger (1996) and Brown (2003). Fold structures in the Tamworth belt and Hastings Block are after Korsch and Harrington (1981) and Glen and Roberts (2012). Fold structures in the early Permian Manning Basin are after Jenkins and Offler (1996). The spatial distribution of the Woolomin Association is after Korsch (1977). T: Tia Complex; W: Wongwibinda Complex; R: Rockvale Block; M: Manning Basin; PMFS: Peel Manning Fault System; HMT: Hunter Mooki Thrust; LO: Lachlan Orogen; Arm: Armidale; Wal: Walcha.