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Character and kinematics of faults within the turbidite-dominated Lachlan Orogen: implications for tectonic evolution of eastern Australia: Reply

David R. Gray[a,*], David A. Foster[b]

[a]*VIEPS Department of Earth Sciences, Monash University, Melbourne, Victoria, Australia, Australia 3800*
[b]*Department of Geology, University of Florida, PO Box 112120, Gainesville, FL 32611-2120, USA*

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1. Introduction

We thank G.S. Lister (2001) for further focussing comments on the geodynamic significance of deformation and metamorphism in turbidite-dominated orogens such as the Lachlan Orogen of eastern Australia. His comments however, add little to the scientific debate.

Lister questions our 'model' of progressive thickening of an accretionary wedge (see Gray and Foster, 1998, fig. 18) on the premise that; (i) the 'range of models is rather too narrow and simplistic'; and (ii) modern orogens are considerably more complex. These statements fail to recognize that the tectonic interpretation is based on field observations presented in the paper, with timing constrained by an Ar–Ar dataset (see Foster et al., 1998, 1999). Quite simply, the general model that we propose for the accretion and amalgamation of the Lachlan Orogen is the only current model that attempts to incorporate all of the complexities apparent in modern orogenic belts and our current understanding of the geology, structure, and timing in the orogen. These various accomodation mechanisms and processes for Paleozoic orogeny in the Lachlan are summarized in Gray and Foster (1997), Foster et al. (1999) and Foster and Gray (2000). These papers are focussed on the tectonic synthesis of the belt rather than the fault zones that are the focus of the paper under discussion (Gray and Foster, 1998). Some of the key observations that define parts of our model include:

1. Individual thrust systems have leading-imbricate fan geometry (i.e. Cambrian metavolcanics/relicts of ocean crust are exhumed along the leading and frontal faults of each thrust system within Cambrian, Ordovician and Siluro-Devonian turbidites, respectively for the western Lachlan Orogen).
2. Strain gradients and overall shortening necessitate decoupling within oceanic stratigraphy consisting of a turbidite blanket over oceanic basement (Gray and Willman, 1991a,b).
3. Major faults or detachments occur at the turbidite /metavolcanic contact and within the Cambrian oceanic succession which is considered to underlie the turbidites (see Gray, 1997, fig. 8).
4. The Cambrian oceanic succession shows evidence of internal stacking or duplexing (see Gray and Foster, 1998, figs. 7, 9).
5. Within each thrust-system deformation is diachronous and migrates in the direction of thrust transport (see Foster et al., 1998, 1999, fig.9).
6. For the Silurian period the Lachlan Orogen consists of three migrating belts of deformation, essentially thrust-systems in a back-arc oceanic environment (see Gray, 1997; Gray and Foster, 1997, 1998, fig.17; Foster et al., 1999, fig. 8, 2000).
7. Thrust-system geometry requires underthrusting (see Gray and Foster, 2000, fig. 2c).
8. Structural thickening of sediment wedge via chevron-folding and thrusting causes exhumation and subsequent erosion to give sediment cannibilisation (i.e. eroded micas from the Stawell zone are deposited ahead of the prograding sediment wedge in the developing Melbourne Zone depocentre (locally called a 'trough') (see Foster et al., 1999, fig. 9).
9. Illite crystallinity and white mica bo values from the western belt show intermediate pressure metamorphism associated with a low geothermal gradient (see Offler et al., 1998).
10. The leading, frontal faults contain 'Franciscan-like' blueschist blocks within both mud-matrix and serpentinite-matrix melange (see Spaggiari et al., 1998a,b, 1999).

Lister's comments about the deformation style and so-called uniqueness of the orogen display a lack of knowledge

* Corresponding author.
E-mail address: dgray@mail.earth.monash.edu.au (D.R. Gray).

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of the Lachlan Orogen. Lister has no published record of study of the Lachlan rocks. He will certainly argue that this is not a scientific argument, but we feel that this is relevant background to his comment. In Gray and Foster (1998, 2000) we have attempted to show that the Lachlan is not unique in that it has a style of deformation similar to accretionary orogens through the world. These types of orogens seem to be dominated by structures different to orogens dominated by thick continental shelf sediments.

Lister alludes to a 'method of asymptotes' to reinterpret our Ar–Ar dataset published in Foster et al. (1996, 1998, 1999). The method of asymptotes as an interpretive method for Ar–Ar age spectra has never been published anywhere, and therefore has never been peer reviewed by the Ar–Ar community. To make a statement that this method supports 'distinct episodes of deformation and recrystallisation' is therefore unsubstantiated at this point. We again refer readers to our treatment of the geometry, timing and propagation sequence of faults based on a palinspastic restoration for the western Lachlan Orogen (see Foster et al., 1999, fig. 9). Thrust-system dynamics support overall diachronous deformation (cf. Weber, 1981), rather than distinct orogenic episodes related to orogen-scale events. We have argued elsewhere (see Gray et al., 1977; Gray and Foster, 1997) that such an interpretation is an artifact of preservation of deformation in the rock record from a sedimentological and stratigraphic viewpoint. There is no doubt that there are important episodes of more significant deformation, metamorphism, and orogeny in the Lachlan (Foster and Gray, in press). These are all associated with accommodating changing plate interactions that led to closing, extension, and disruption of the back-arc basin.

Lister's discussion of our reply (Gray and Foster, 2000) to the discussion by Taylor and Cayley (2000) on Gray and Foster (1998) is extremely confusing because it implies that we disagree with Taylor and Cayley based simply on their relative experience. This is incorrect. Our disagreement with Taylor and Cayley (2000) is based on our interpretation that the shortening in the western Lachlan (~70% of an originally 1000-km-wide basin) could not have taken place without some underthrusting of the oceanic basement (Gray and Foster, 2000; Foster et al., 1999), and could not simply be intra-plate as they suggest. Our progressive wedge model that Lister refers to is based on the western Lachlan. We have never suggested that there is only one wedge but rather that there are at least three major components to the Lachlan: a western accretionary wedge, a central oceanic arc with a thrust wedge on the west side, and an eastern thrust system and accretionary complex. Furthermore, Lister's comment that "Taylor and Cayley (2000) advocate episodic behavior in a SW Pacific setting, where every large thrust is not synonymous with a subduction zone" is a ridiculous misrepresentation of our original paper (Gray and Foster, 1998). In Gray and Foster (1998) we discuss the nature of more than 20 major fault zones in the Lachlan only one of which is likely to preserve the location of a fossil subduction zone (the Mount Wellington Fault zone).

We reiterate that the original aim of our paper (Gray and Foster, 1998) was to define the nature, geometry and kinematic significance of faults within a turbidite-dominated orogen. We believe that we have done this successfully and ask readers to judge our interpretations for different classes of thrust-systems based on what was presented in that paper, rather than emotional rhetoric and unsubstantiated statements that in our opinion 'muddy the waters' unnecessarily.

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