

# ***Interactive comment on “Migration of Reflector Orientation Attributes in Deep Seismic Profiles: Evidence for Decoupling of the Yilgarn Craton Lower Crust” by Andrew J. Calvert and Michael P. Doublie***

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Comment 1: Dip and strike are local measurements, and relation between strike and different strain regimes is not immediately obvious, requiring further justification.

Response 1: The reviewer makes a good point about the individual estimates of strike being local in nature. We have modified the statement identified as p2 l4, and added an explanatory paragraph at the start of section 3.3 to discuss how similar strike estimates across a larger crustal domain can be indicative of a larger scale tectonic process.

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Comment 2: What is the nature of the trade-off between dip and strike, and what are the uncertainties?

Response 2: For an individual CDP there is usually a trade-off between local dip and strike values due to the limited range of available source-receiver azimuths, and this issue has been previously documented by Bellefleur et al. (1997) in their Fig. 4 and Calvert (2017), also in Fig. 4. But as these authors show, this problem can be addressed by including more CDP gathers within the CDP supergather that is used for the analysis, often producing a well-defined global maximum in the estimated semblance; in the case of line YU2, 64 CDP were combined into a single supergather. The methodology section has been expanded to make this clearer. Other than the simple case shown by Levin (1971), it is not possible with a crooked seismic line to produce a simple plot to characterize this trade-off, because the trade-off also depends on the midpoint location, which varies for each trace, in contrast to a straight line. We have, however, taken the approach of estimating the range of angles within 90% of the global semblance maximum to provide an estimate of the relative error for every determined strike value. We have added a display of the error estimated in this way to Figure 2.

Comment 3: 3D migration can be quite informative, can the authors suggest when this might be useful?

Response 3: A general statement on the value of 3D migration has been added at the start of section 2.1, but it is difficult to be more specific, because the value of low fold 3-D migration depends on a number of factors, including the acquisition geometry, signal-to-noise ratio etc. We do state that some form of 3D migration is the desirable goal, and now cite a paper by Nedimovic and West (2003b) that investigates this issue for a Lithoprobe crooked line geometry.

Comment 4: Attribute migration requires further elaboration and explanation for choice of 320 m segment length.

Response 4: A statement has been added to explain and justify the choice of the 320

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m length for the output migrated segment, explaining the method in a bit more detail.

Comment 5: Is attribute migration most suitable for intermediate dips?

Response 5: Migrated dips were restricted to 50 degrees to limit the inclusion of steeply dipping coherent noise, and this is now explained. Dips up to 80 or so degrees can be readily migrated, but it can also become difficult to incorporate steep reflections events into an interpretation when they are out of plane, because they migrate over quite large distances. It should be emphasised that, as noted above, low dip values can usually be estimated accurately when sufficient source-receiver azimuths are present, e.g. with a large enough supergather, along a crooked line. Of course this is not possible when the line is perfectly straight. At very small dips, there may also be a larger error in the strike, but these events can still be migrated, and will not move far due to their low apparent dip.

Comment 6: Change steeply dipping to moderately dipping where appropriate.

Response 6: The text has been modified accordingly.

Comment 7: What is the range of source-receiver azimuths typically required for reasonable orientation estimates, and why is range estimated using a binned measure?

Response 7: The minimum range of source-receiver azimuths required for accurate orientation estimates, 20-30 degrees, is now included. We have also explained in the text that we use a binned estimate of source receiver azimuth range to avoid cases where a large azimuth range is created by a single orthogonal source-receiver pair that will not contribute much to the resolving reflector orientation due to the low signal to noise of a single trace.

Comment 8: Do the uncertainties make the method less useful in the lower crust, and can a plot of the uncertainties in section format be included?

Response 8: We have included an additional display in Figure 2 to show the errors in the estimated strike values for reflections with a semblance greater than 0.005. Al-

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though the display in Figure 2a, includes reflections with errors in strike of less than 30 degrees, it can be seen that many reflections in the lower crust have much lower errors, commonly less than 10 degrees where included in Figure 2a. The method we outline is not limited to particular depth levels of the crust. The effectiveness of the method appears to be controlled mostly by the linearity of the seismic acquisition geometry.

#### References

Bellefleur, G., Calvert, A.J., and Chouteau, M.C.: A link between deformation history and the orientation of reflective structures in the 2.68-2.83 Ga Opatoca belt of the Superior Province, *J. Geophys. Res.*, 102, 15243-15257, doi:10.1029/97jB00505, 1997.

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