

Comment on ‘New palaeomagnetic result from Vendian red sediments in Cisbaikalia and the problem of the relationship of Siberia and Laurentia in the Vendian’ by S. A. Pisarevsky, R. A. Komissarova and A. N. Khramov

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1 INTRODUCTION

Pisarevsky *et al.* (2000) document a poorly dated pole from Vendian-age sedimentary rocks in Siberia and argue for a low-latitude position of both Laurentia and Siberia during the interval from 650 to 550 Ma. Their argument is based, at least in part, on a reinterpretation of palaeomagnetic poles from Laurentia because previous studies (e.g. Symons & Chiasson 1991; Meert *et al.* 1994; Torsvik *et al.* 1996) argued for a high latitude position for Laurentia beginning at 580 Ma (perhaps earlier). The new data provided by Pisarevsky *et al.* (2000) are a welcome addition to the Siberian palaeomagnetic database; however, given the broad age range of their result, we feel that the authors over-interpret the extant data in an effort to rescue a controversial positioning of Siberia against the northern margin of Laurentia (Sears & Price 2000; Pelechaty 1996; Hoffman 1991; Dalziel 1997; Condie & Rosen 1994; Frost *et al.* 1998). Therefore, we wish to address the following points in the manuscript that we feel are contentious:

- (1) low palaeolatitude position of Laurentia between 580 and 565 Ma;
- (2) palaeogeographic implications of their proposed fit;
- (3) position of Siberia against northern Laurentia.

2 LATITUDE OF LAURENTIA IN THE LATEST NEOPROTEROZOIC

Symons & Chiasson (1991) argue convincingly that palaeomagnetic data from the Callander Complex indicate Laurentia occupied high latitudes during the latest Neoproterozoic (575 Ma). Their palaeomagnetic study is well documented and, as noted by Pisarevsky *et al.* (2000), contains a dual-polarity magnetization supported by a positive baked contact test. Pisarevsky *et al.* (2000) dismiss this pole with little explanation. Meert *et al.* (1994) presented data from the 564–570 Ma Catoctin volcanics in Virginia that also support a high latitude position for Laurentia at that time. We feel that the Catoctin pole was misinterpreted by Pisarevsky *et al.* (2000) in an effort to ‘rescue’ Laurentia to low latitudes and maintain an already tenuous link to Siberia into the Cambrian (similar to Pelechaty 1996).

Pisarevsky *et al.* (2000) ignore several points related to the argument favouring a primary magnetization for the Catoctin ‘A’ component (Meert *et al.* 1994) arguing instead that the Catoctin ‘B’ component is primary. It is therefore useful to review the *complete* arguments made by Meert *et al.* (1994) for the primary ‘A’ remanence. Pisarevsky *et al.* (2000) correctly point out that the fold test for the ‘B’ component is of higher significance than the ‘A’ component. Folding of the Catoctin volcanic rocks occurred during Taconic deformation between 450 and 470 Ma, so the positive fold test constrains the age of magnetization of both the ‘B’ and ‘A’ components to older than 450–470 Ma. We concluded (Meert *et al.* 1994) that the ‘less-positive’ fold test in the A-component was due to the limited number of sites investigated. Indeed, it is useful to show the stepwise fold test for the A-component (Fig. 1a). The directional improvement upon tilt-correction is obvious from the graph, albeit significant only at the 92 per cent confidence level. The presence of reversals, in the absence of additional data, merely suggests that the magnetization in the rocks spanned at least one interval of field reversal. Both the ‘A’ and ‘B’ magnetizations are dual-polarity. On the basis of these two arguments, Pisarevsky chose the ‘B’ component over the ‘A’ component to represent the primary magnetization.

Our conclusion regarding the primary nature of the A component went beyond that described by Pisarevsky *et al.* (2000). Specifically, we documented a baked contact test for a Catoctin feeder dike intrusive into the Grenvillian-age Pedlar granite at Site 8. Although, our baked contact test was not a ‘classic’ baked contact test due to the limited outcrop at the site, we feel that it provided additional compelling evidence for primary nature of the A-magnetization. The other rationale for choosing the A component as primary was based on the fact that the B component matched a well-known younger direction of magnetization (Late Cambrian age, Fig. 1b; Torsvik *et al.* 1996). Pisarevsky *et al.* (2000) rejected this argument citing the fact that 700–800 Ma poles are also similar to the Cambrian directions and yet are still considered primary. We find this argument weak as many of the studies from these older (700–800 Ma) rocks have palaeomagnetic tests that demonstrate their primary nature while the ‘B’ Catoctin pole does not. The last point is that the A component of magnetization matches *no known*

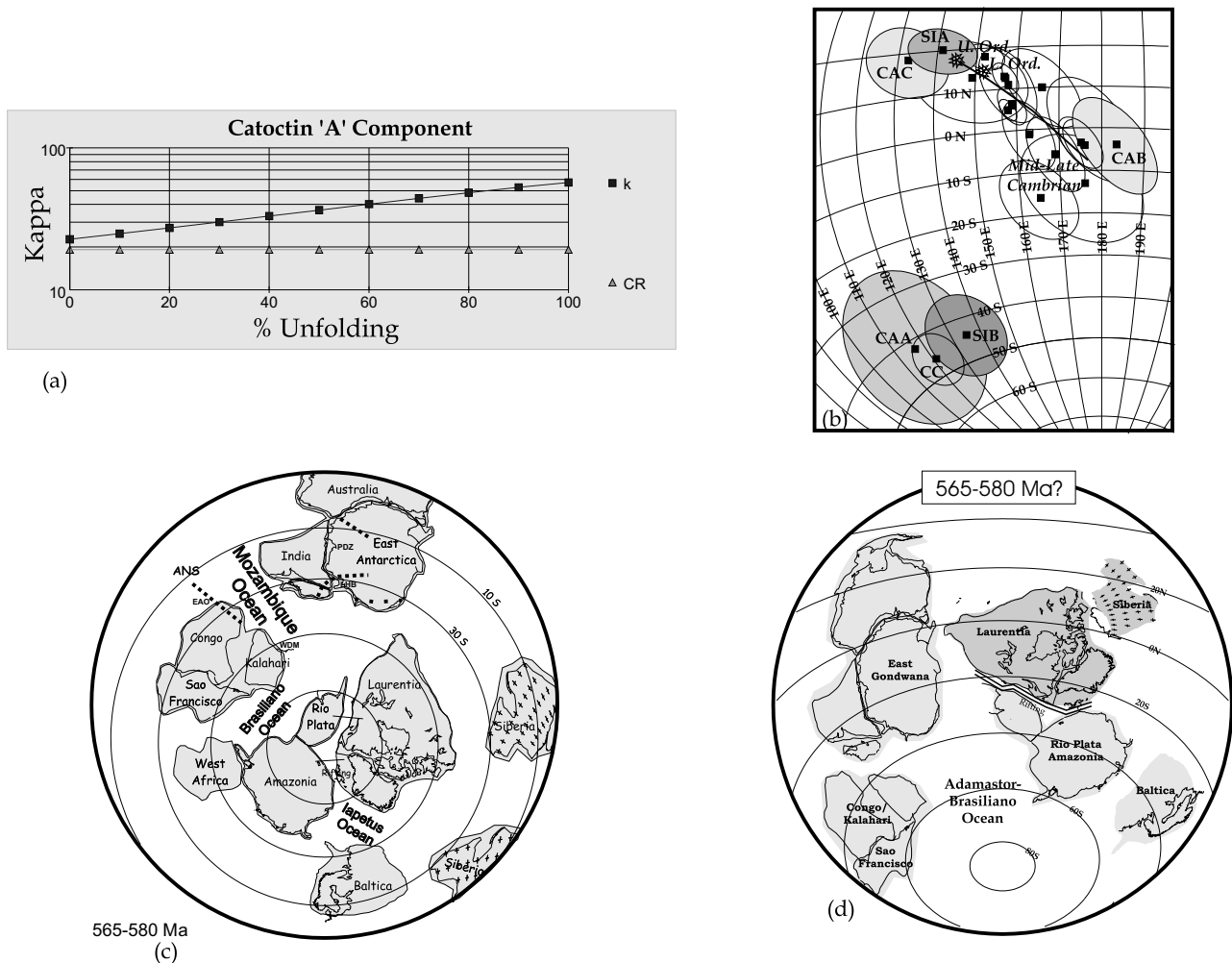


Figure 1. (a) Stepwise unfolding graph for the Catoclin 'A' component that shows the increased grouping of directions upon unfolding. (b) Apparent polar wander path for Laurentia showing the poles discussed in the paper. Light shading represents the poles from the Catoclin study and darker shading represents those from the Sept-Îles study. Pisarevsky *et al.* (2000) argue that the Catoclin 'B' pole (CAB) and Sept-Îles 'A' (SIA) are primary and date to 565 Ma, whereas Meert *et al.* (1994) argue that the Catoclin 'A' (CAA) and Sept-Îles 'B' (SIB) poles are primary. CC represents the 575 Ma Callander Complex pole of Symons & Chiasson (1991). (c) 565–580 Ma reconstruction based on palaeomagnetic poles described in previous studies (see text for details) and the high latitude option for Laurentia. We position Siberia using the palaeomagnetic pole of Pisarevsky *et al.* (2000), but choose the opposite polarity for their pole. (d) Alternative reconstruction at 565–580 Ma using the Catoclin 'B' pole for Laurentia following the suggestion of Pisarevsky *et al.* (2000).

younger poles from Laurentia, is significantly different than the present Earth's field in Virginia and falls near a similar age pole in Laurentia with an unambiguous primary magnetization (the Callander Complex pole, Fig. 1b). We mostly agree with Pisarevsky *et al.* (2000) regarding the Sept-Îles and Long Range poles. We do wish to note one important point regarding the interpretation of the Sept-Îles pole that was not discussed by Pisarevsky *et al.* (2000). The age of the Sept-Îles is now well established by U–Pb dating at 565 ± 4 Ma (Higgins & van Breeman 1998). The age overlaps with ages from the Catoclin volcanic province and therefore, primary poles from both these units should overlap. Pisarevsky *et al.* (2000) argue that both the Catoclin B pole and the Sept-Îles A pole are primary and date to ~ 565 Ma. Fig. 1(b) shows that the Sept-Îles A pole falls some 45° from the Catoclin B pole. Perhaps more importantly, the Sept-Îles A pole falls very close to Ordovician poles from North America and the Catoclin C

pole that is clearly not primary (Fig. 1b, Symons & Chiasson 1991; Meert *et al.* 1994; Tanczyk *et al.* 1987; Torsvik *et al.* 1996). In contrast, the Sept-Îles B pole (corrected for minor tilt as in Symons & Chiasson 1991) is nearly identical to the Catoclin A pole and suggests to us that both magnetizations are the same age. We therefore maintain that the evidence favouring a high-latitude position for Laurentia based on palaeomagnetic data is strong as both the Callander Complex and Catoclin-A magnetizations cannot be dismissed as readily as Pisarevsky *et al.* (2000) maintain.

3 GLOBAL IMPLICATIONS

Although Pisarevsky *et al.* (2000) argued about the primary nature of the magnetizations found in both the Callander and Catoclin rocks, they failed to address some of the tectonic

implications of their proposal. Indeed, we argue that the palaeogeographic implications of their arguments provide a strong rationale for rejecting the low-latitude position for Laurentia. Fig. 1(c) shows a reconstruction for the late Neoproterozoic (580 Ma) based on palaeomagnetic data described elsewhere (Meert & Van der Voo 1997; Torsvik *et al.* 1996; Meert & Van der Voo 1996; Kempf *et al.* 2000). Although the assembly of greater Gondwana was diachronous, most agree that all cratons were in close proximity by 550–530 Ma (Kroner *et al.* 2000; Meert & Van der Voo 1997. Trompette 1997; Torsvik *et al.* 1996). Trompette (1997) and Kroner *et al.* (2000) note collisional events between the Congo-Sao Francisco craton and (a) the Amazonia–Rio Plata cratons and (b) the elements of East Gondwana during the interval during the interval from 650 to 530 Ma. Fig. 1(d) shows an alternative reconstruction based on the premise of Pisarevsky *et al.* (2000) using a low-latitude choice for Laurentia. Except in rare cases, palaeomagnetic data yield a degree of freedom in moving cratons along lines of longitude. Therefore, these reconstructions are flexible in the sense that the relative longitudinal distances between cratons are arbitrary. We merely attempt to reconstruct the globe in a manner consistent with the geological data. Trompette (1997) argues that the Congo–Sao Francisco, Kalahari and Rio Plata cratons had already collided by *c.* 600 Ma, an argument that is difficult to reconcile with the reconstruction in Fig. 1d (based on the Pisarevsky *et al.* 2000 model). In contrast, there is no space or orientation conflict in Fig. 1(c) using the high-latitude option for Laurentia. Furthermore, the proximity of the cratons (Fig. 1c) is consistent with proposed orogenic events in regions of the Mozambique Belt and also closure of the Brazilian Ocean during the interval from 600 to 550 Ma. We make the crucial assumption that rifting along the eastern margin of Laurentia does not commence until sometime post-575 Ma allowing us to position the South American cratons alongside eastern Laurentia. The exact timing of the rift to drift transition is debated (Meert & Van der Voo 1997; Dalziel 1997; Torsvik *et al.* 1996; Cawood *et al.* 2000) but it is difficult to argue on geological grounds for separation prior to 575 Ma.

4 POSITION OF THE SIBERIAN CRATON

Although Pisarevsky *et al.* (2000) and others (see Ernst *et al.* 2000) have argued for a reconstruction of Siberia against the northern margin of Laurentia, both the position and orientation are contentious (Sears & Price 2000). Interestingly, there is not a single unequivocal palaeomagnetic case for placing Siberia against northern Laurentia and the geological arguments for such a position are equally arguable (Sears & Price 2000; Frost *et al.* 1998; Hoffman 1991; Dalziel 1997; Pelechaty 1996; Condie & Rosen 1994). Despite the disagreement over the position and orientation of Siberia, most maintain that the Laurentia–Siberia connection was valid from Mesoproterozoic time until Vendian/Early Cambrian separation. For example, Ernst *et al.* (2000) present data from the Kuonamka dikes at 1503 ± 5 Ma and argued that they are compatible with the position favoured by Dalziel (1997) and Pelechaty (1996); however, the comparison was made using much younger palaeomagnetic poles from Laurentia (<1450 Ma). In addition, the large error (28°) associated with the Kuonamka dike pole allows for the possibility of a fit against western Laurentia as favoured by

Sears & Price (2000). Late Mesoproterozoic data from Siberia (Gallet *et al.* 2000) are equally contentious as they argue that a Siberian connection is possible against northern Laurentia, but the orientation of Siberia in their study (e.g. Rainbird *et al.* 1998) is quite different from that proposed by either Pelechaty (1996) or Pisarevsky *et al.* (2000). It is important to point out that all of these palaeomagnetic comparisons are made by selecting a polarity choice for the palaeomagnetic poles that minimizes the distance between the two cratons. Interestingly, the azimuthal orientation of Laurentia for much of the Neoproterozoic is such that Siberia can (within error) also be placed in a variety of orientations against the western margin of Laurentia (similar to Sears & Price 2000). We therefore feel that Pisarevsky *et al.*'s (2000) attempt to rescue a particular reconstruction by rejecting two palaeomagnetic studies that support a high latitude position for Laurentia is without merit and the high palaeolatitude position for Laurentia between 580 and 565 Ma is preferred.

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