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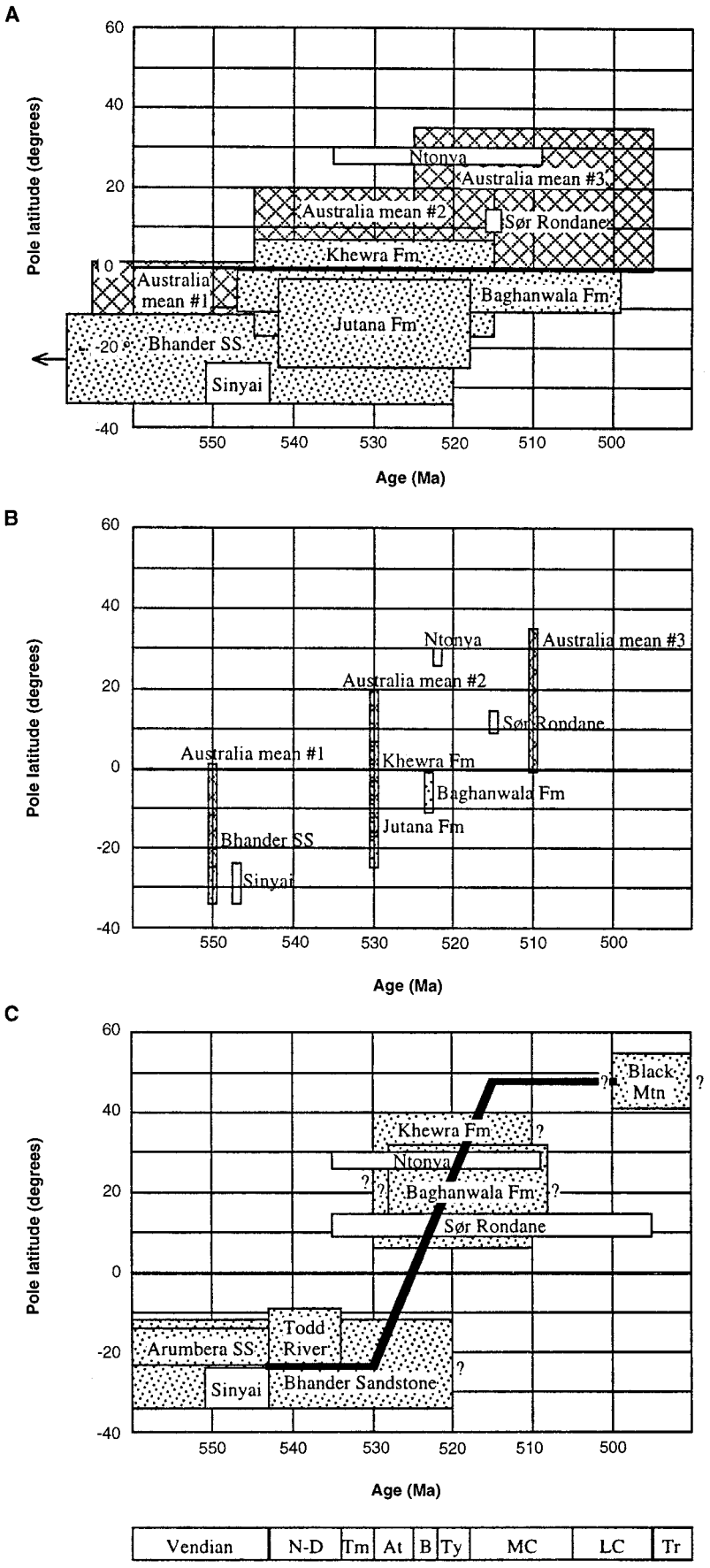

Fig. 1. Comparison of methods used to analyze the Vendian-Cambrian paleomagnetic database from Gondwanaland. For the sake of facility in presentation, diagrams show an oblique projection of the spherically bounded APW curve onto a purely latitudinal ordinate varying with time. Data are presented as rectangles with dimensions from quoted or employed uncertainties in both paleopole latitude (A_{95} or α_{95}) and age. Stippled boxes represent results from sedimentary rocks whose ages depend on use of a calibrated time scale of the fossil record [all boundaries as in the study by Tucker and McKerrow (*13*) except the Vendian-ND boundary at 543 Ma (*14*)]. Mean poles are cross-hatched. N-D, Nemakit-Daldynian; Tm, Tommotian; At, Atdabanian; B, Botomian; Ty, Toyonian; MC, Middle Cambrian; LC, Late Cambrian; and Tr, Tremadocian. (**A**) Data selected according to a study by Meert and Van der Voo; (*15*) (which are presumably the basis for the histogram in figure 1E of the comment by Torsvik *et al*.) are shown at face value. (**B**) Age uncertainties have been eliminated to reflect the nature of the spline-smoothing technique used by Torsvik *et al*. (**C**) Subset of the most reliable data is taken at face value as used in our report (*1*). Queried age limits for some results indicate uncertainties in the paleontological ages of the sampled units, as well as potential revisions to the numerically calibrated Cambrian time scale. Arumbera, Todd River, and Black Mountain results are preferred over the mean poles for Australia derived from a smooth interpolation between those data and others of lesser reliability (*15*). Khewra and Baghanwala poles have been restored to account for ~30° of Neogene CCW vertical-axis rotations in the sampled area [(*16, 17*), which was not done in other studies (*3*, *15*), and 5° of uncertainty has been added to each pole's latitude. The Jutana pole is not included because rotations of its sampled region were estimated only by comparisons with a poorly defined APW path (*17*). Age estimates for the undated but probably Vendian-Cambrian Bhander Sandstone are tentatively accepted from (*15*). The 515 ± 20 Ma age for the Sør Rondane pole is shown as a reasonable 2σ estimate from a compilation of ages (*18*). Thick solid curve indiates the hypothesis of Kirschvink *et al*. (*1*), which appropriately passes through all the uncertainty fields of the data. We (*1*) did not rely on the more problematic or imprecisely dated poles shown in this panel; they are merely shown here to illustrate their compatibility with our earlier conclusions (*1*).

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Polar Wander and the Cambrian

Joseph L. Kirschvink *et al.* (*1*) propose that true polar wander (TPW) occurred during the Cambrian (520 to 535 Ma). This conclusion is based on (i) apparently high drift rates from Gondwana-Laurentia, (ii) an anomalous pole reading from Siberia, and (iii) reinterpretation of polarity from a Vendian pole reading from Baltica. Their intrepretation of Laurentian TPW (*1*) relies exclusively on the contentious Sept Iles Complex result (*2*), which yielded two different poles and seven imprecise Rb-Sr ages (586 to 475 Ma). There are no Cambrian data from Baltica (*3*); a polarity switch of a Vendian pole (*1*) would increase apparent polar wander (APW) path length, but this exercise would have no bearing on Cambrian TPW. Kirschvink *et al.* (*1*) state that the Siberian data are problematic, but this conundrum stems from a single anomalous result (*4*). Excluding this one result, the Siberian data define a gentle APW path (Fig. 1A) from Vendian through Ordovician times (*5*).

A reliable analysis of continental drift-rates or APW rates (Fig. 1, B through D) requires a robust mathematical analysis, but Kirschvink *et al.* (*1*) only quote drift-rates between selected poles or group of poles before stating their conclusions. In arguing that spherical spline analysis (*3*) masks rapid shifts in pole positions, they incorrectly state that the method averages poles over 15- to 20-Ma intervals; the TPW model (*1*) requires that data from all continents must show the same amount of APW between 520 and 535 Ma. Phanerozoic APW rates for Laurentia average 5 cm/year, with peaks in Vendian, Siluro-Devonian, and Jurassic times (Fig. 1B). The Cambrian data show a local minimum. The gap in the Baltic record (580 to 480 Ma; Fig. 1C) requires interpolation beyond reasonable limits and does not shed light on Cambrian TPW. The Siberia data show a local Cambrian maximum (10 cm/year), but considerable higher rates are observed in the Ordovician (Fig. 1D). Analysis of a more complete Gondwana data set [(*6*) and including all the data of (*1*)] shows a high Cambrian APW, but the highest peak occurs in the late Cambrian, outside the proposed TPW period (Fig. 1E). None of the examples show convincing evidence for Cambrian TPW, and rather than "stretching" geodynamic mechanisms, one can fit the data better with conventional plate tectonic systematics (*3*, *7*). Thus, the TPW idea (*1*), while intriguing, is not supported when the most unreliable data are removed from the database.

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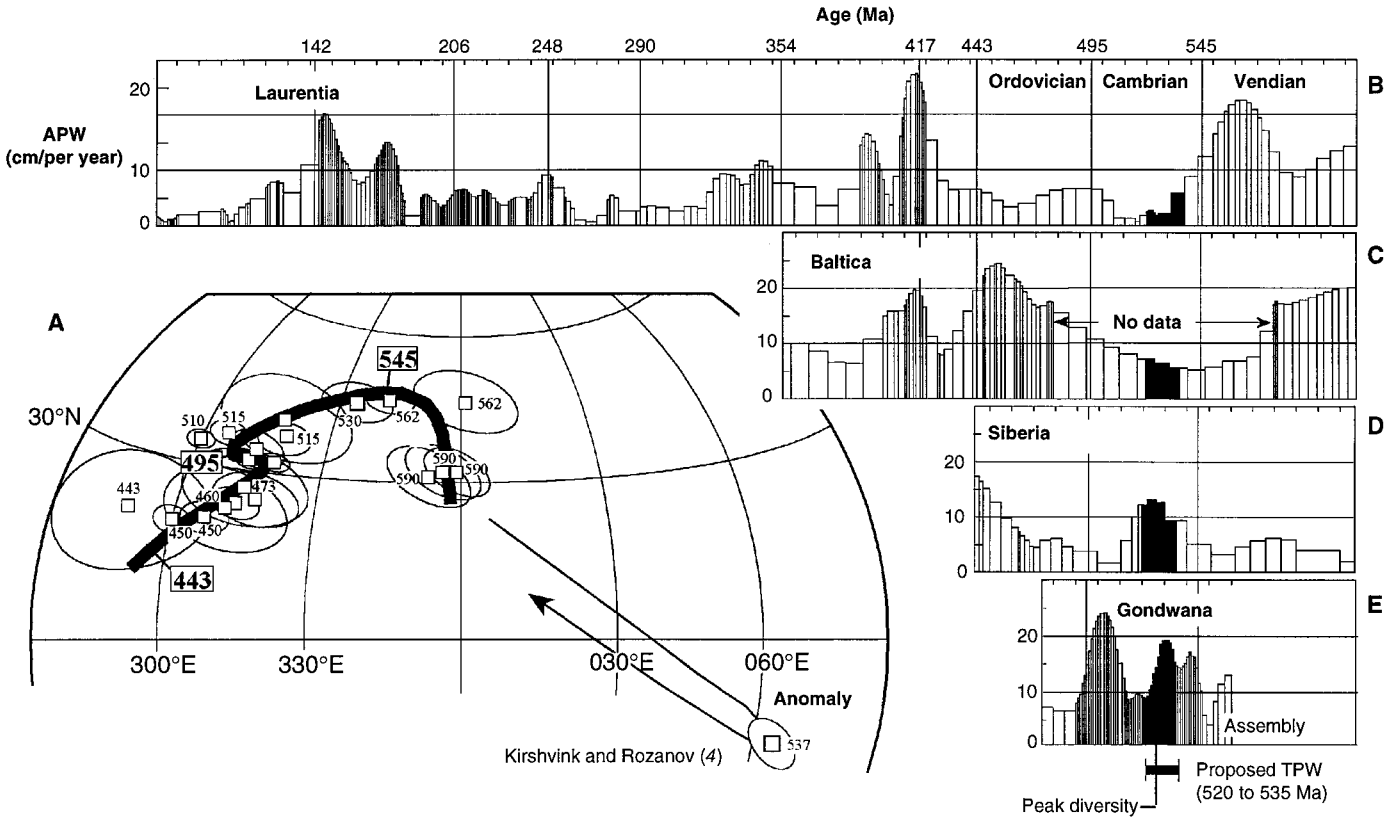

Fig. 1. Palaeomagnetic poles from south Siberia (**A**) plotted with confidence ovals along with a spherical spline (APW) path (*5*). Numbers are mean poles ages (Ma) using the time scale of Tucker and McKerrow (8). Geological boundaries are marked with bold numbers. An anomalous pole is evident (*4*). (**B** through **E**) Calculated APW rates (centimeters per year), based on APW paths for Laurentia, Baltica, Siberia, and Gondwana. Data sources include (*3*) and (*5*–*7*), with Lower Paleozoic ages adjusted to the time scale of Tudur and McKerrow (*8*). Inadequate or no data-coverage indicated by wide APW bars and may be entirely interpolated (for example, that of Baltica between 580 and 480 Ma). APW bars within the proposed TPW interval (520 to 535 Ma), which have been said to bracket peak generic diversity (*1*), are shaded.

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6. J. G. Meert and R. Van der Voo, *J. Geodynam.* **23**, 223 (1997).
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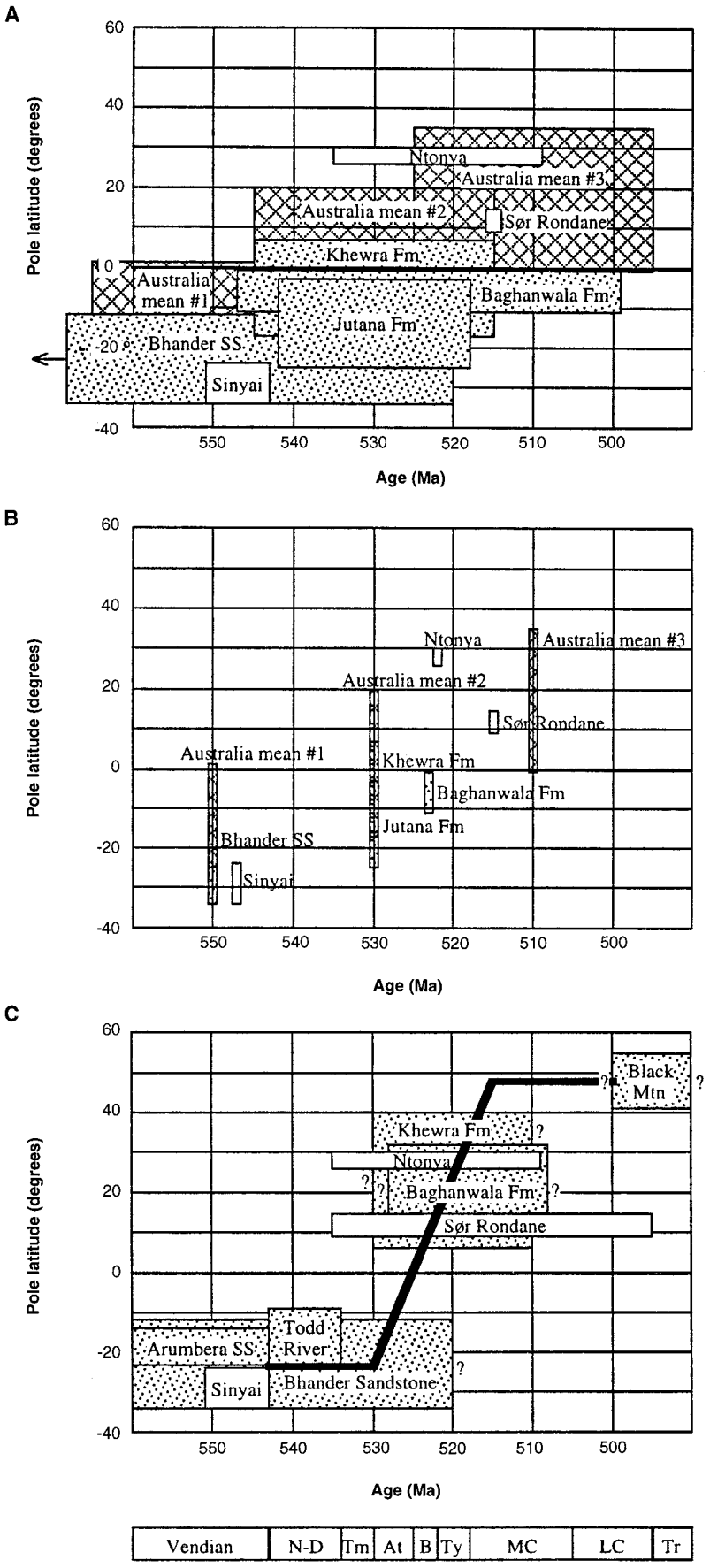

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