SUPPLEMENTARY MATERIALS

Late Triassic sequence of paleogeographic maps assisted by the GPMDB

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The global database of paleopoles (the GPMDB) was started by Van der Voo and McElhinny (Van der Voo & McElhinny, 1989; but with precursors including Piper, 1988, and Westphal, 1989), continued by McElhinny and Lock (McElhinny & Lock, 1990; Lock & McElhinny, 1991), and later by Pisarevsky (Pisarevsky & McElhinny, 2003, Pisarevsky, 2005). It was suspended by the latter in 2005 due to failure to renew funding for the project by the academic institutions involved.

The present sequence of paleogeographic maps, drafted using the latest existing version (end of 2004) of the GPMDB, is located temporally at the end of the Triassic (about 200 Ma ago). According to the expanding Earth concept (and contrary to plate tectonics theory), it is assumed that the ocean basins were not yet open at this time and only epicontinental seas were present. The first planisphere (radius 6370 Km) shows how according to plate tectonics the vast oceans of the Triassic age, about two thirds of the Earth's lithosphere, would all have been subducted (with an improbably precise mechanism), leaving space for all the younger ocean floor. Another implausible coincidence is that the maximum age of the first seafloor created in the Atlantic is equal to the age of the last seafloor in subduction in the Pacific, representing the Jurassic. Instead, it would be more logical for the Jurassic to be the opening time for all the oceans, including the Pacific.

The reconstructions were all performed using FORTRAN software (Sagnotti et al., 1993; Florindo et al., 1994; Scalera, 1995) bringing the Fisher average for the palaeopoles (Fisher, 1953) of each continent to overlap (or very near to) the north pole of the geographic reticulum. This was performed for all the intermediate reconstructed global maps between the first (plate tectonics and current radius) and the last (terrestrial expansion and radii between 3600 km and 3000 km). For the African and South American continents a single paleopole was traced at minimum radii, as explained in the discussion below. The 0° meridian was always conventionally defined by the modern location of Greenwich in London. The radiuses adopted were: 6370, 6000, 5600, 5200, 4800, 4400, 4000, 3600, 3200, 3000 Km. The ten reconstructions have the dual purpose: 1) of showing how the mutual positions of the continents change with each decrease in radius, thereby constituting further boundary conditions for the subsequent reconstruction with even smaller radius; 2) helping in the choice of radius to attribute to the Upper Triassic Earth.

The selected Upper Triassic GPMDB data are shown in Tables SM-01 to SM-08, and the Upper Jurassic selection (used in Figs. 5 and 6 in the main paper) in Table SM-09, with each data group displayed on a Robinson planisphere (orthophanic projection; orthophanic = "right-appearing"). All GPMDB data extractions were performed under the "*Excludes known secondaries*" condition. In the planispheres that accompany the tables, the sampling sites (bold red dots) and relative paleo-poles (bold red dots) are joined by large-circle segments (in blue). the confidence ellipses are in blue. Fisher's average circle is in red.

The Figures from SM-02 to SM-11 show paleogeographic reconstructions realized for the Upper Triassic period. Paleopoles are shown as Fisher's averages of the group of selected poles listed in the Tables (except at 3200 Km radius for Africa and South America, for which the only reliable pole in the GPMDB is traced). See the following discussion and Fig. SM-01 for explanations and details. The beige colour delimits the Palaeozoic shields. An orthophanic projection developed by the author was used, modifying the Lambert equivalent projection. It was designed with the aim of keeping the two opposite polar areas visible.

The most important things that can be observed about the sequence of globes are:

● **i)** At the lowest terrestrial radiuses (from 4000 to 3000 Km) Africa tends to extend more and more towards the South Pole, eventually reaching it with its Atlantic margin. In doing this it appears to wedge itself towards the south of Antarctica and its Palaeozoic shield with an unavoidable overlap. This indicates that from the Triassic until Recent Africa must have undergone repeated rifting analogous to the current Ethiopian Rift, which has increased the continent's longitudinal extension by about a thousand kilometres. The expanding Earth concept thus has predictive value.

The Upper Triassic African poles seem to be better grouped at a radius of 6370 Km, rather than radii of 3600, 3200, or 3000 Km (see Fig. SM-01, top), but this certainly does not refute terrestrial expansion. It does mean once again that paleogeographic reconstructions must take considerable stretching of the continental surfaces into account, in this case latitudinal. The same best grouping of the poles at the current radius occurs for South America (Fig. SM-01,below) and consequently a similar extension process must have occurred for this continent. Since Africa and South America were in contact until the beginning of the Cretaceous period, it is possible to hypothesize one or more common distension events. This is witnessed by the Jurassic oceanic bands (Larson et al., 1985; Roeser & Rilat, 1982), juxtaposed to East Africa and fragmented in typical manner (Fig. SM-01, top, bottom; in blue), by the presence of volcanic emission traps in South Africa (Karoo) and South America (Paranà) and their relationships with the oceanic chains of Walvis and Rio Grande, and with major alignments of kimberlitic extrusions in southern Africa. All these structures and distension events again testify to the predictive value of the expansion theory.

● **ii)** Antarctica and Australia – in contact as the Earth's radius decreases – are found to fit tightly between Africa and the Americas. When the reconstructions reach the minimum radiuses, Australia is in a position that satisfies the observations in my work on the Pacific conformities (Scalera, 1993). It is simultaneously juxtaposed with its modern eastern edge towards South America, and with New Guinea overlaid with the Californian region. This satisfies two important boundary conditions that, if the expanding Earth theory was false, would be an unlikely double coincidence, also as regards paleomagnetic data.

● **iii)** Asia more than any other continent has undergone insertion of large amounts of so-called juvenile terranes. This peculiar aspect remains unexplained in the plate tectonics scheme. The reconstructions created here show that for an expanding Earth this is instead a necessity. In lesser radius reconstructions Asia must necessarily have a smaller area, which during the course of the Mesozoic and later up to the Recent, has greatly expanded with the insertion of numerous juvenile bands. Once again the expanding Earth scheme has a predictive capacity.

● **iv)** The Siberian Palaeozoic shield must also have undergone rototranslations, which from a position in the Upper Triassic closer to Europe and its shield, have moved it to its current position. This links back to the previous point **iii)** and again supports the predictive capacity of Earth expansion.

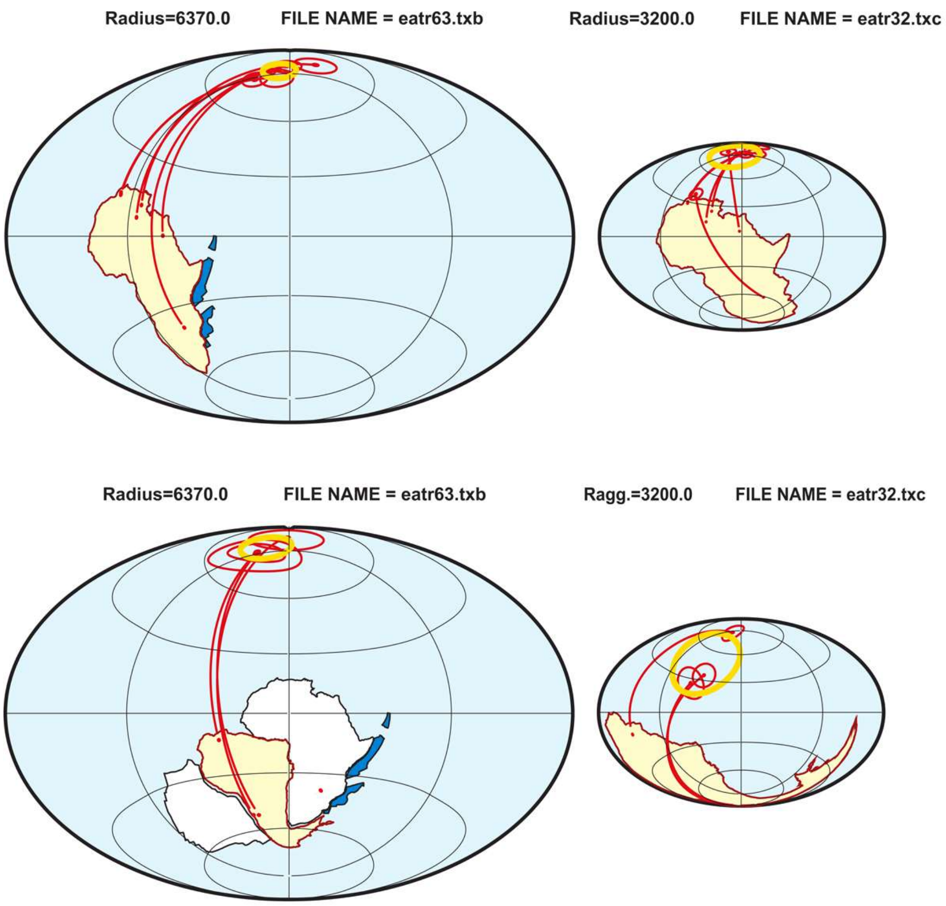

FIG. SM-01 - At the top of the figure the Late-Triassic paleopoles of Africa are shown. We see that the group of paleopoles is more compact (with a small circle of the Fisher's average, in yellow) when traced at the current radius, and less compact (Fisher's average radius about 20°) on a radius of 3200 km. From the group is far a paleopole whose sampling site is located in the southern part of Africa near a branch of the African Rift that runs locally with azimuth near 45°. At the bottom of the figure two paleopoles of South America of the same age, with a sampling site in the southern part of the continent, are seen to depart in the same manner towards the South when traced on a globe of radius 3200 Km. Superficially interpreted this would seem to indicate the unsustainability of the concept of terrestrial expansion. But at the top of the image it is seen that Africa is flanked to the east by Jurassic land. This strip of seafloor (in blue) is fragmented along the meridians in two areas: the first to the north through the expansion of the Red Sea, and further south by the insertion of Cretaceous seafloor. The isochrones show a progressive opening of the seafloor nearly perpendicular to the coast of eastern Africa, from the Lower Jurassic into part of the Cretaceous. The same process of rifting must be assumed to have occurred within the African continent with progressive shifting of the southern paleopole site to the south. Africa and South America were in contact until the end of the Jurassic and the African distension process also affected the nearby South American continent. The opening and enlargement of the Nazca plate further contributed to this process which stretched South America toward the south.

● **v)** Greenland was translated from its usual position in Pangaea depicted in the first reconstruction at the current radius of 6370 Km, to a position with its southern tip closer to Africa. This was for two reasons: the first was to bring the paleopole of Greenland closer to the group of paleopoles of the other continents, from which it departs excessively if the fragment is kept in the traditional position. It is obvious that this would be abandoned if new poles closer to the main group were added to the only reliable one available for the Triassic in the GPMDB. The second reason was so that in reconstructions Europe and its Iberian peninsula offshoot are always overlapped with mobile orogenetic zones (rather than shields) of the African continent. Finally, the left handed transcurrent movement between Africa and Europe that is necessary to account for the opening of the Atlantic Jurassic seafloor, could justify the rotation of the Iberian peninsula.

● **vi)** Europe, North America, Australia and Antarctica must also have increased in surface areas to varying degrees from the Triassic to the Recent.

● **vii)** India is plotted both in the position expected for the plate tectonics Pangaea (with its average paleopole hypothesized as being north), and in a position with its antipole (antipodal pole) facing north. In reconstructions with smaller radii we can see that the latter position, with the Indian east coast facing Asia, becomes necessary, and constitutes a revision of the position assigned to India in a previous work (Scalera, 2001). This east Indian coast formed part of the shores of an ancient Mediterranean, whose vestiges remain today as the Black , Caspian, and Aral Seas. The implausibility of Indian subduction beneath the Himalayas has recently been acknowledged by Khan et al. (2017).

CONCLUSIONS

What appears as a leitmotif in this work needs to be underlined: in addition to ocean floor spread, the continental surfaces must have expanded along bands that are now more difficult to identify compared to the more obvious midoceanic ridges and parallel symmetrical magnetic seafloor anomalies. Both plate tectonics and expanding Earth theories have used current continental profiles for the reconstruction of Pangaea (with the almost unique exception of slight correction for the African Rift, introduced in 2018 by Gurnis *et al*. in a well-known plate tectonics computer program), while this now appears to be completely refuted by reconstructions based on paleopoles. The continents must have been appreciably deformed from one period to the next.

It is therefore necessary to develop a more fully evolutionary view of the Earth's surface, that will require the availability of larger, higher quality databases. For example, a denser latitudinal paleomagnetic sampling of Africa could enable more accurate identification of the continent's deformation bands over geological time. The same applies for South America. Resumption of data collection for the large GPMDB would be highly desirable.

This work must be considered provisional, incomplete and without definitive conclusions. The latter might perhaps be formulated by repeating these reconstructions and carrying out more for subsequent times (Jurassic, Cretaceous, etc.) and earlier (Palaeozoic, Archaean) periods, hopefully with the availability of paleomagnetic data published in the last 15 years. It nevertheless remains highly significant that our incomplete GPMDB already contains strong indications of curvature effects due to an expanding Earth (see point **i)** in the discussion) from the mapping of paleopoles data for Africa and South America.

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Figures

&

Tables

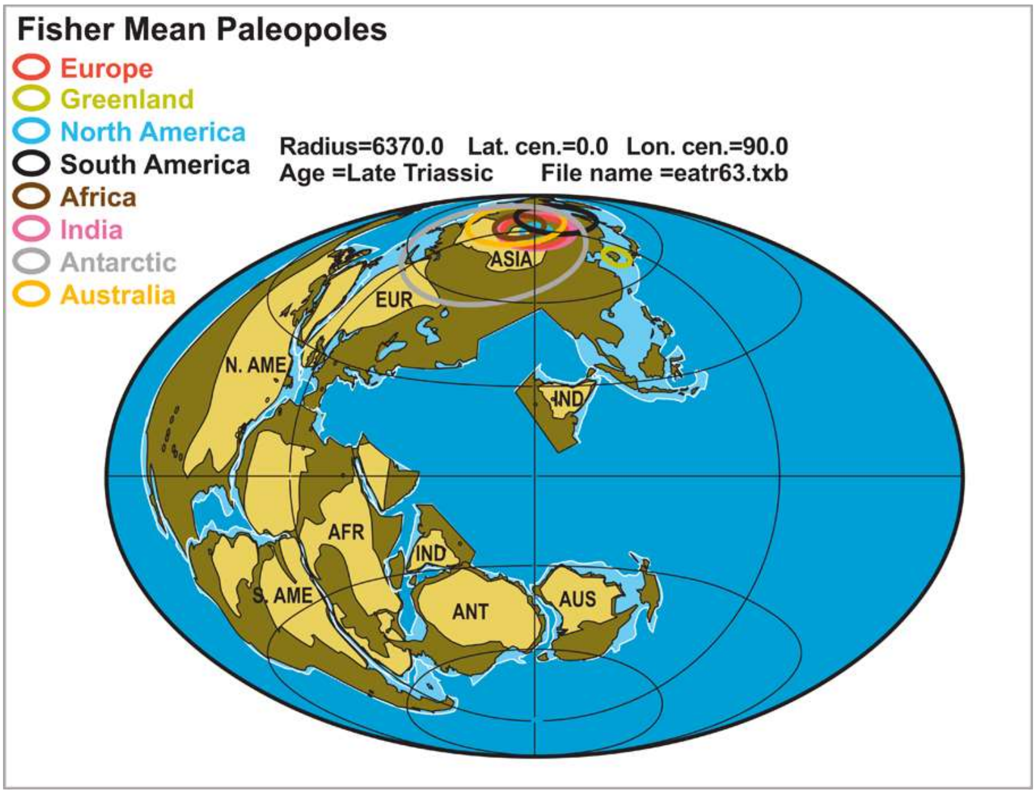


Fig. SM-02 – Upper Triassic Earth, Radius=6370 Km, orthophanic projection (modified Lambert equal-area).

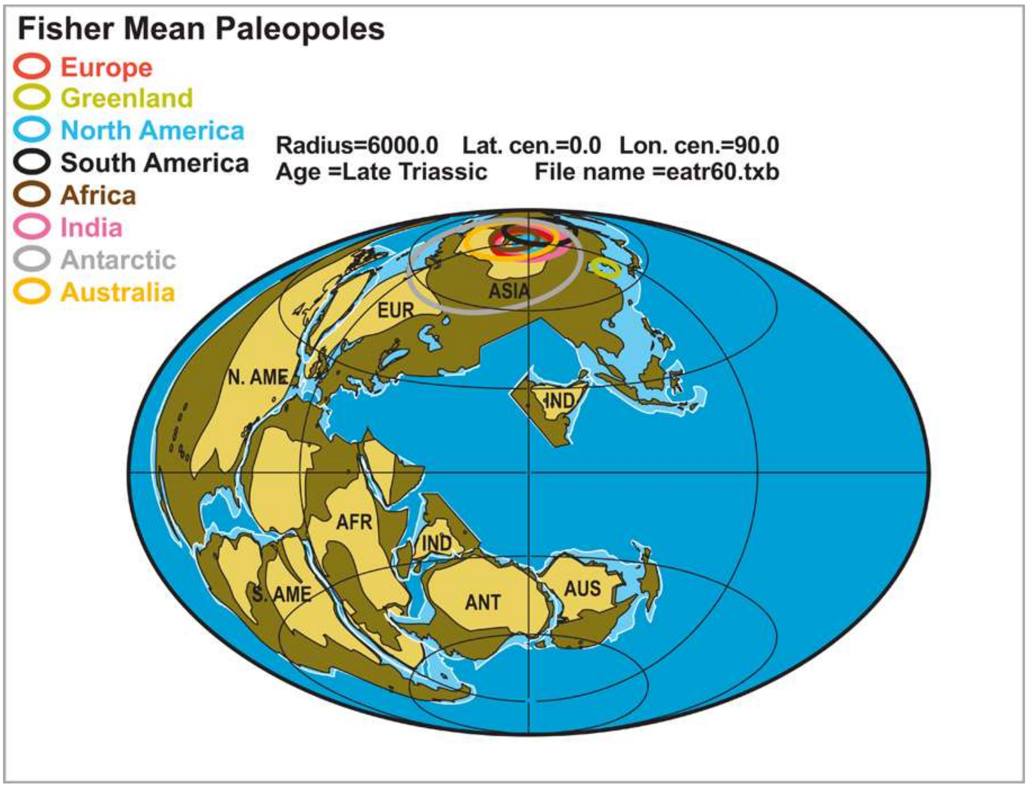


Fig. SM-03 – Upper Triassic Earth, Radius=6000 Km, orthophanic projection (modified Lambert equal-area).

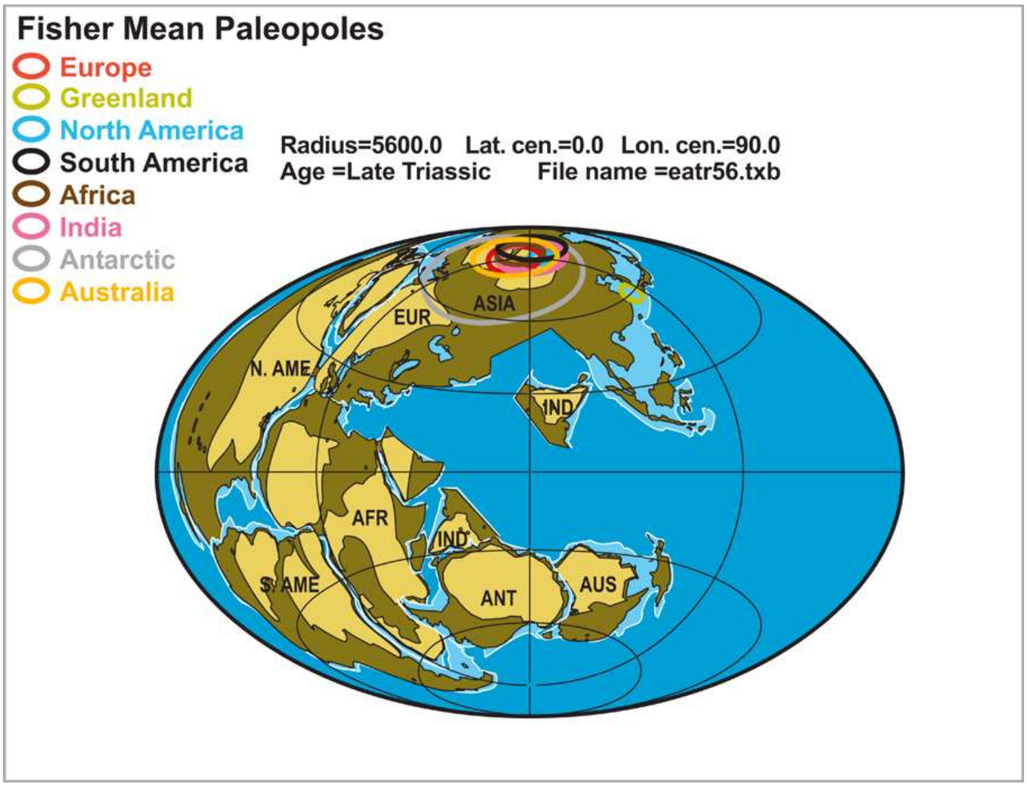


Fig. SM-04 – Upper Triassic Earth, Radius=5600 Km, orthophanic projection (modified Lambert equal-area).

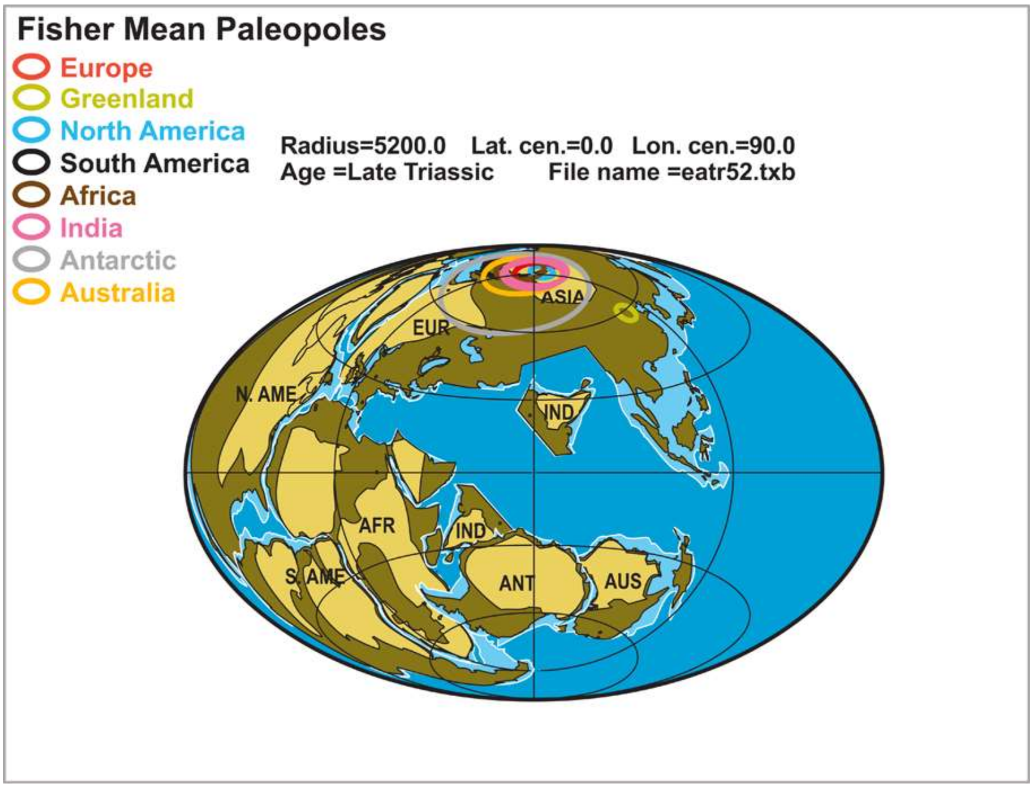


Fig. SM-05 – Upper Triassic Earth, Radius=5200 Km, orthophanic projection (modified Lambert equal-area).

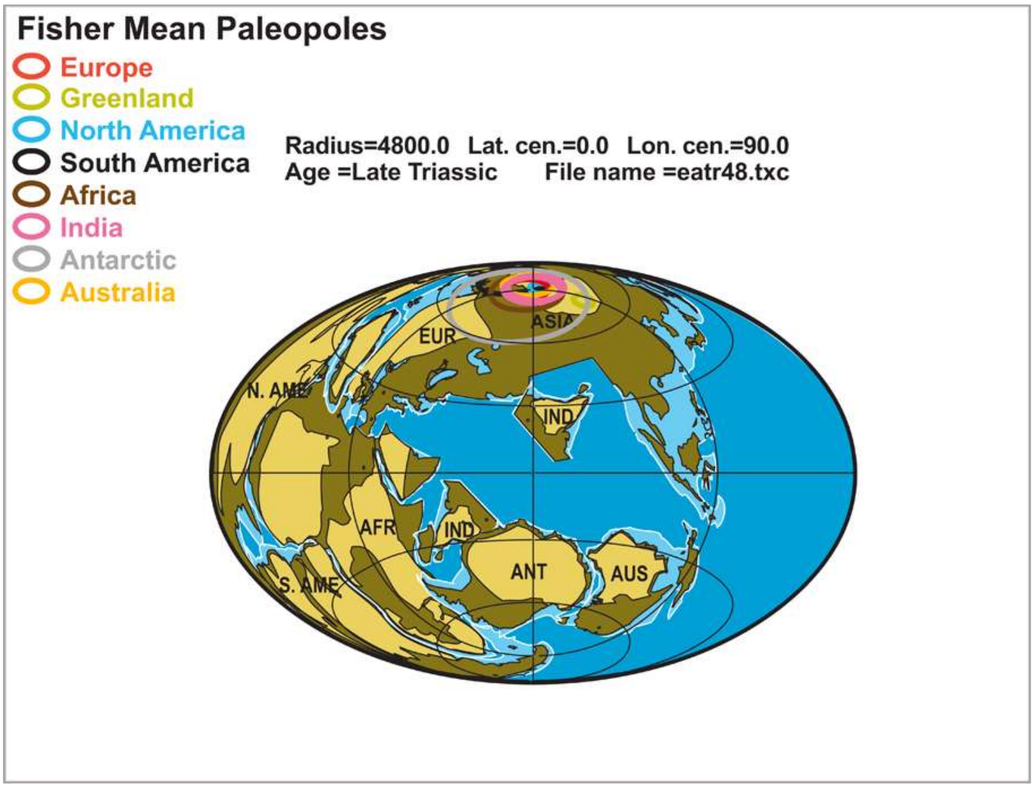


Fig. SM-06 – Upper Triassic Earth, Radius=4800 Km, orthophanic projection (modified Lambert equal-area).

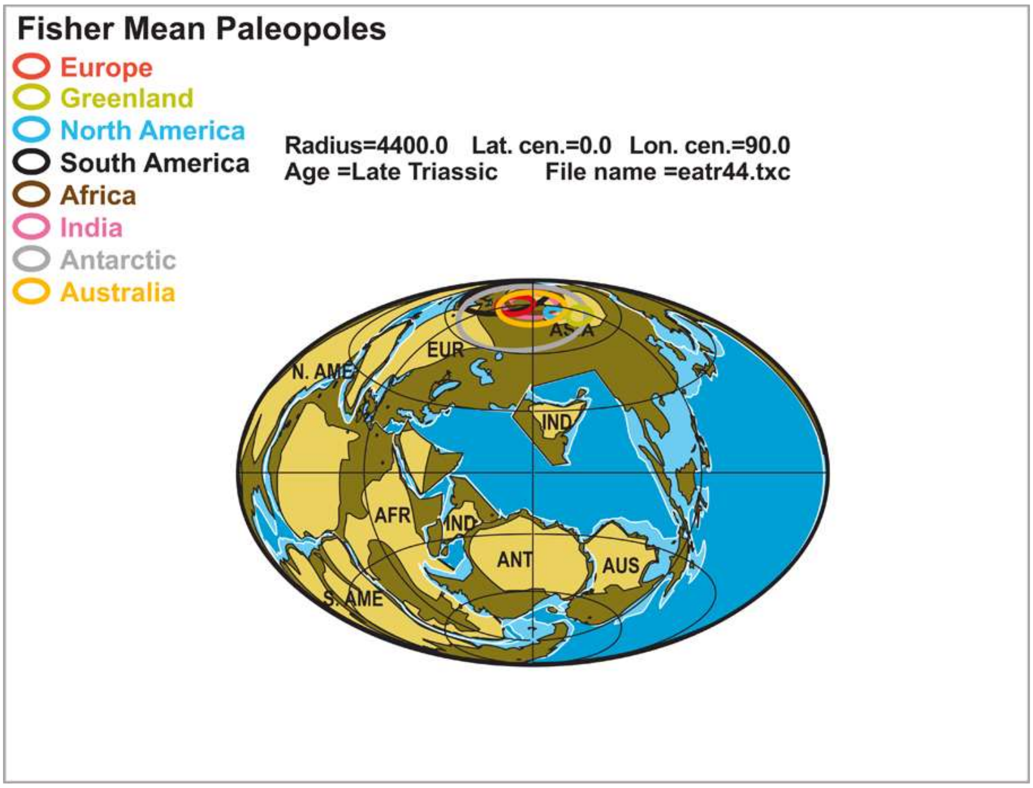


Fig. SM-07 – Upper Triassic Earth, Radius=4400 Km, orthophanic projection (modified Lambert equal-area).

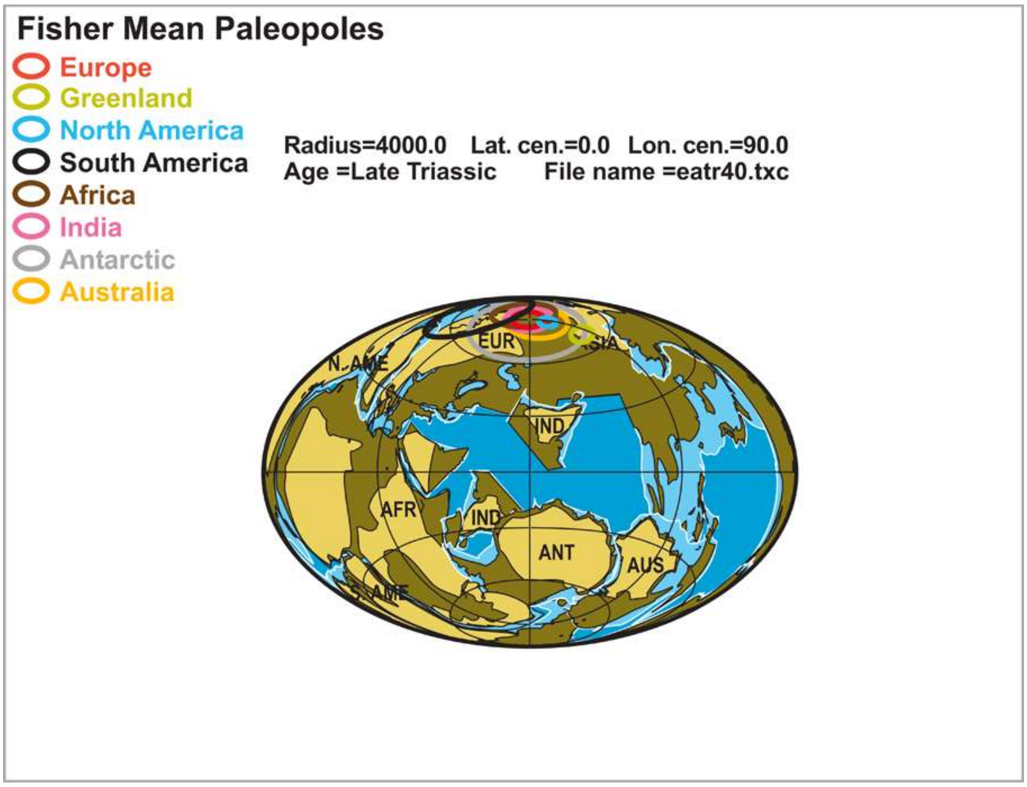


Fig. SM-08 – Upper Triassic Earth, Radius=4000 Km, orthophanic projection (modified Lambert equal-area).

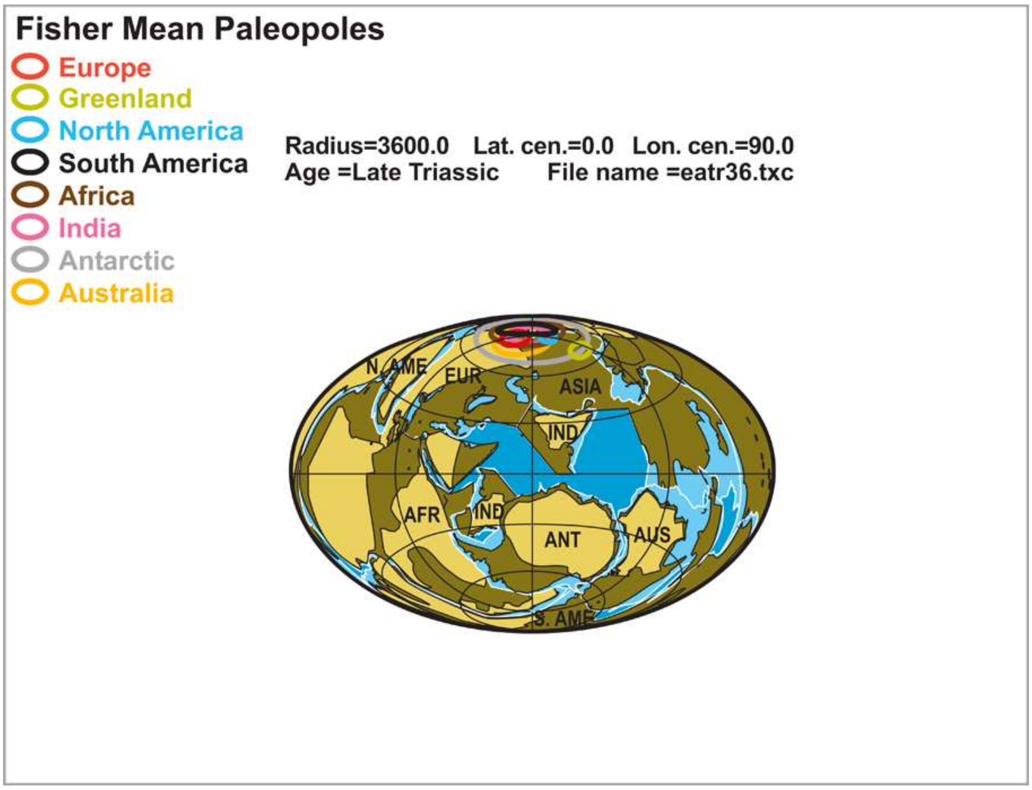


Fig. SM-09 – Upper Triassic Earth, Radius=3600 Km, orthophanic projection (modified Lambert equal-area).

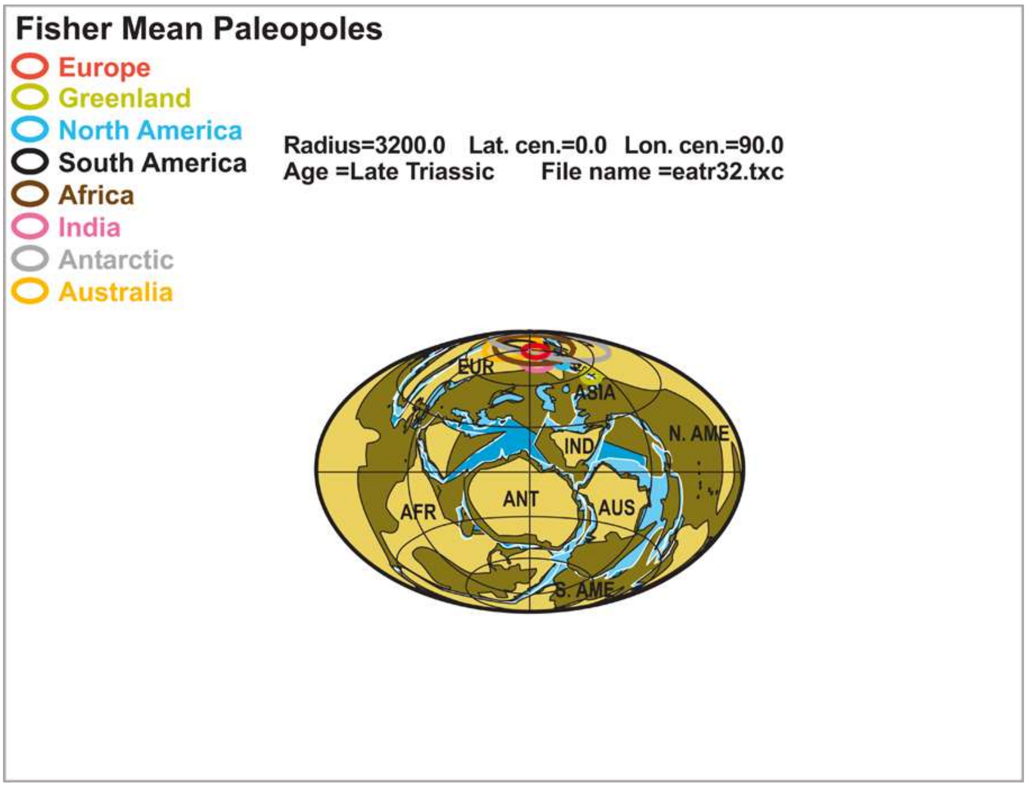


Fig. SM-10 – Upper Triassic Earth, Radius=3200 Km, orthophanic projection (modified Lambert equal-area).

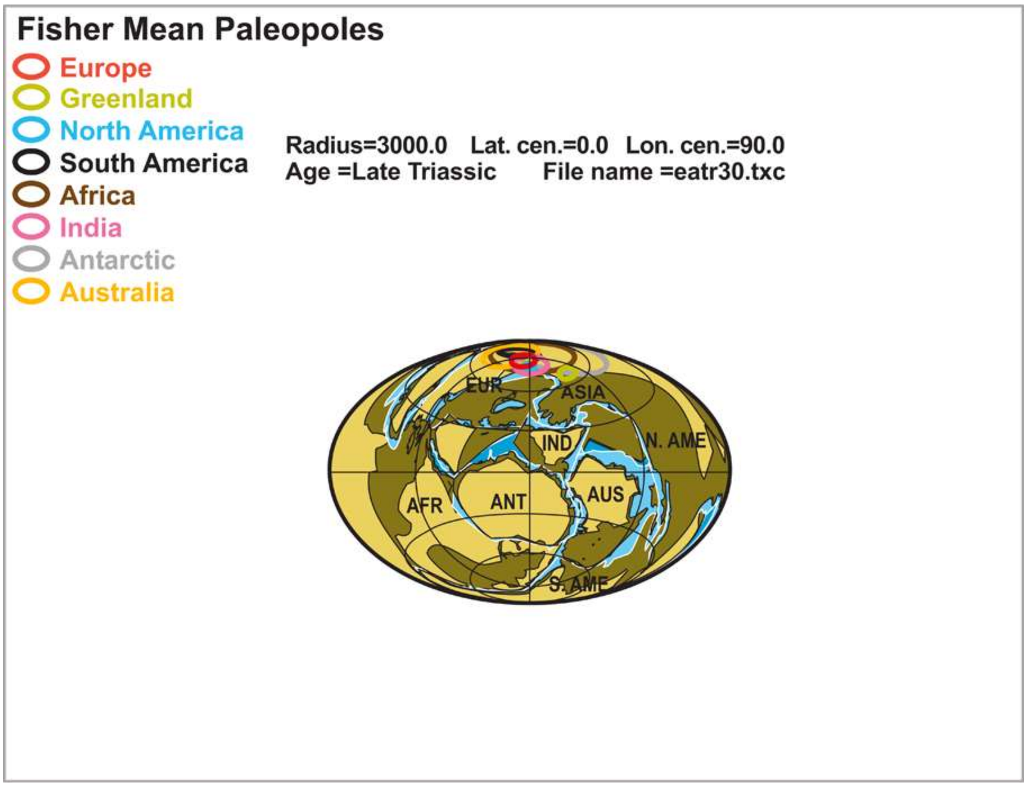
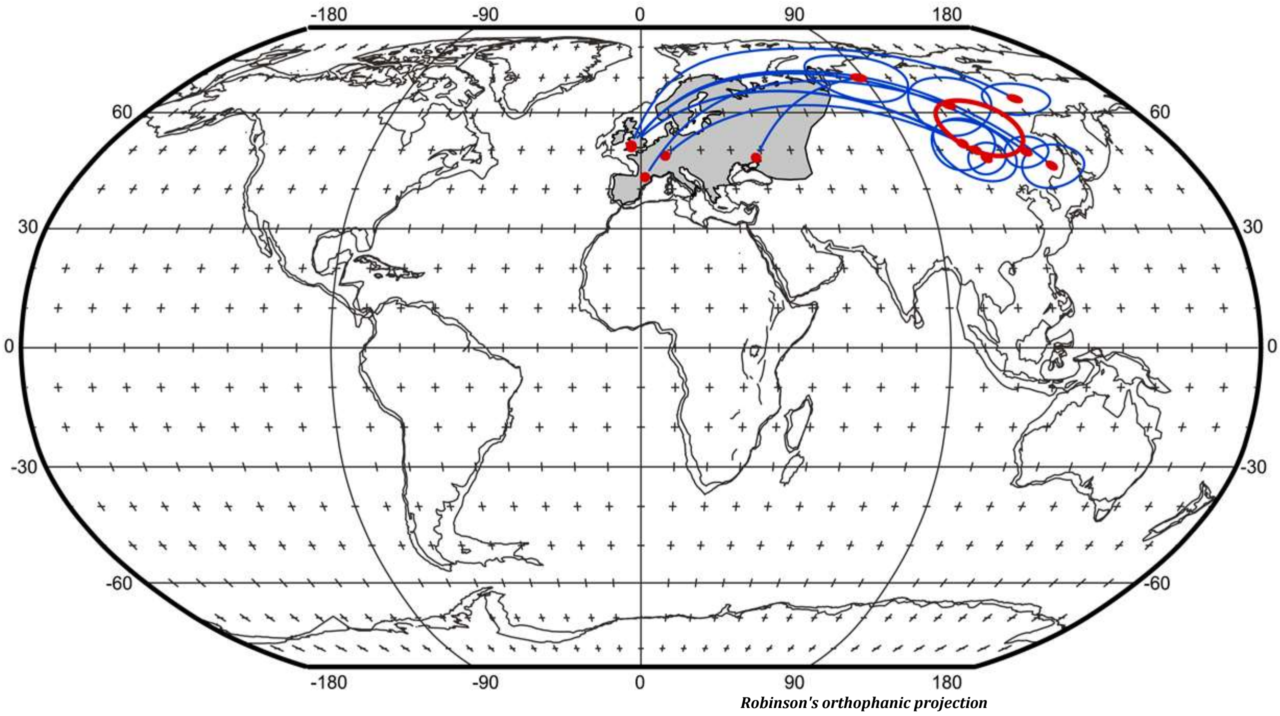


Fig. SM-11 – Upper Triassic Earth, Radius=3000 Km, orthophanic projection (modified Lambert equal-area).

TABLE SM-01

EUROPE – UPPER TRIASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
51.2	-3.3	196 - 204	4.0	6.2	63.9	141.2	4	Hounslow *et al.*	2004
48.5	8.0	200 - 204	8.0	8.0	50.0	112.0	4	Edel & Duringer	1997
51.2	-3.3	200 - 217	5.4	8.3	51.7	108.9	4	Hounslow *et al.*	2004
51.2	-3.3	204 - 217	3.3	5.8	49.6	128.4	4	Briden & Daniels	1999
51.2	-3.3	204 - 217	3.2	5.3	47.9	114.0	4	Hounslow *et al.*	2004
50.7	-3.2	200 - 228	4.6	8.5	46.0	133.9	3	Creer	1959
43.0	1.3	200 - 228	6.1	9.4	62.1	114.2	3	Girdler	1968
48.0	38.0	200 - 228	6.4	7.1	70.0	88.0	2	Rusakov	1971

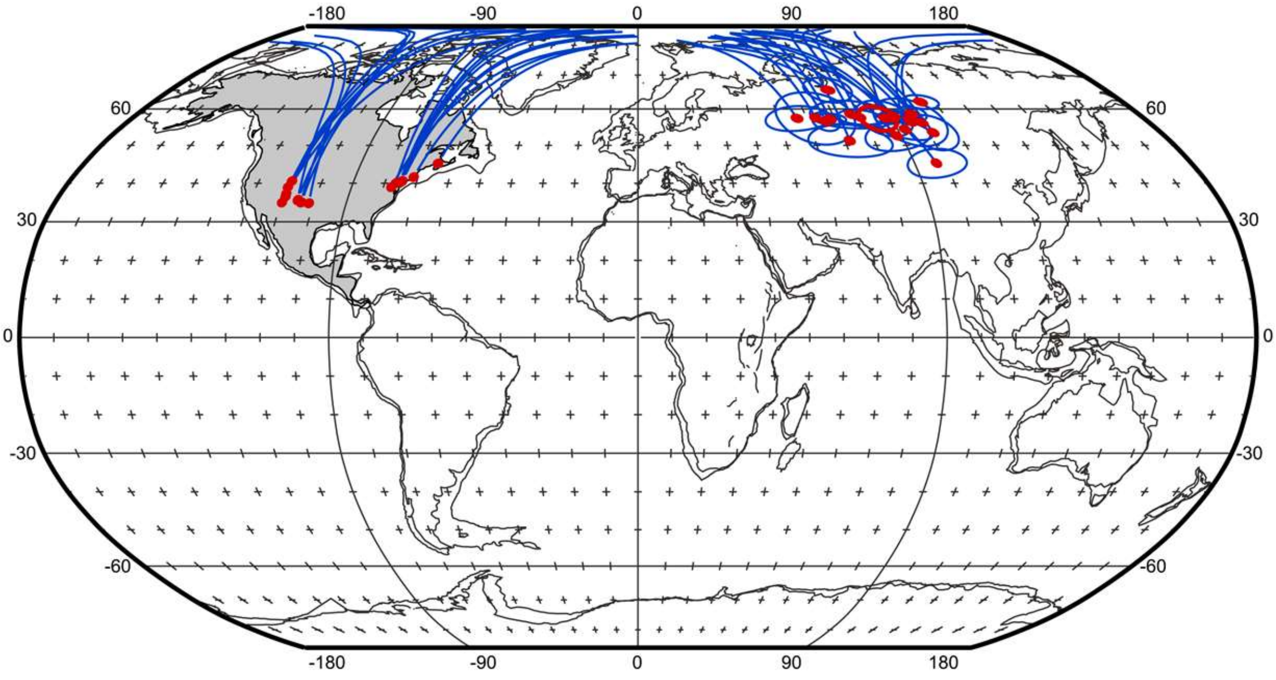


Tab. SM-01 – Upper Triassic GPMDB paleopoles of Europe and their Fisher average (red circle), with the listed data displayed on the Robinson planisphere.

TABLE SM-02

NORTH AMERICA – UPPER TRIASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
39.0	-77.5	194 - 208	3.7	3.7	65.5	73.1	4	Kodama *et al.*	1994
40.6	-74.6	198 - 204	2.1	2.7	58.6	98.4	4	Kent *et al.*	1995
37.26	-109.7	200 - 204	3.3	6.5	57.4	56.6	4	Molina-Garza *et al.*	2003
40.57	-109.6	200 - 204	4.4	8.8	51.3	71.7	4	Molina-Garza *et al.*	2003
40.6	-74.8	190 - 222	1.6	3.1	57.5	90.0	3	McIntosh *et al.*	1985
40.5	-74.6	202 - 210	1.4	2.7	58.0	91.5	4	Kent *et al.*	1995
35.7	-105.3	204 - 210	3.9	7.7	58.5	76.5	4	Molina-Garza *et al.*	1996
40.5	-74.6	204 - 213	1.2	2.4	57.2	96.5	4	Kent *et al.*	1995
39.0	-110.0	204 - 217	7.3	7.3	57.5	63.3	4	Kent & Witte	1993
36.5	-109.5	207 - 217	2.6	2.6	56.5	66.4	4	Bazard & Butler	1991
35.0	-103.9	208 - 217	2.1	4.2	57.7	79.1	3	Reeve &Helsley	1972
35.0	-104.0	210 - 217	5.0	5.0	57.4	87.8	4	Bazard & Butler	1991
40.0	-76.5	200 - 228	2.0	3.0	62.0	105.0	2	Beck	1965
45.2	-65.0	200 - 228	3.6	7.2	45.3	97.1	3	Symons *et al.*	1989
41.6	-71.4	200 - 228	3.7	7.3	52.6	88.4	4	McEnroe	1995
40.3	-74.9	210 - 220	1.1	1.2	56.2	99.9	4	Kent *et al.*	1995
34.8	-101.5	210 - 222	6.6	6.6	56.4	96.3	4	Molina-Garza *et al.*	1995
35.0	-109.9	210 - 222	1.5	3.0	57.2	68.3	4	Steiner & Lucas	2000
40.3	-75.3	210 - 223	4.8	4.8	53.5	101.6	4	Witte & Kent	1989
35.6	-105.3	210 . 228	2.6	5.1	54.3	92.6	4	Molina-Garza *et al.*	1996

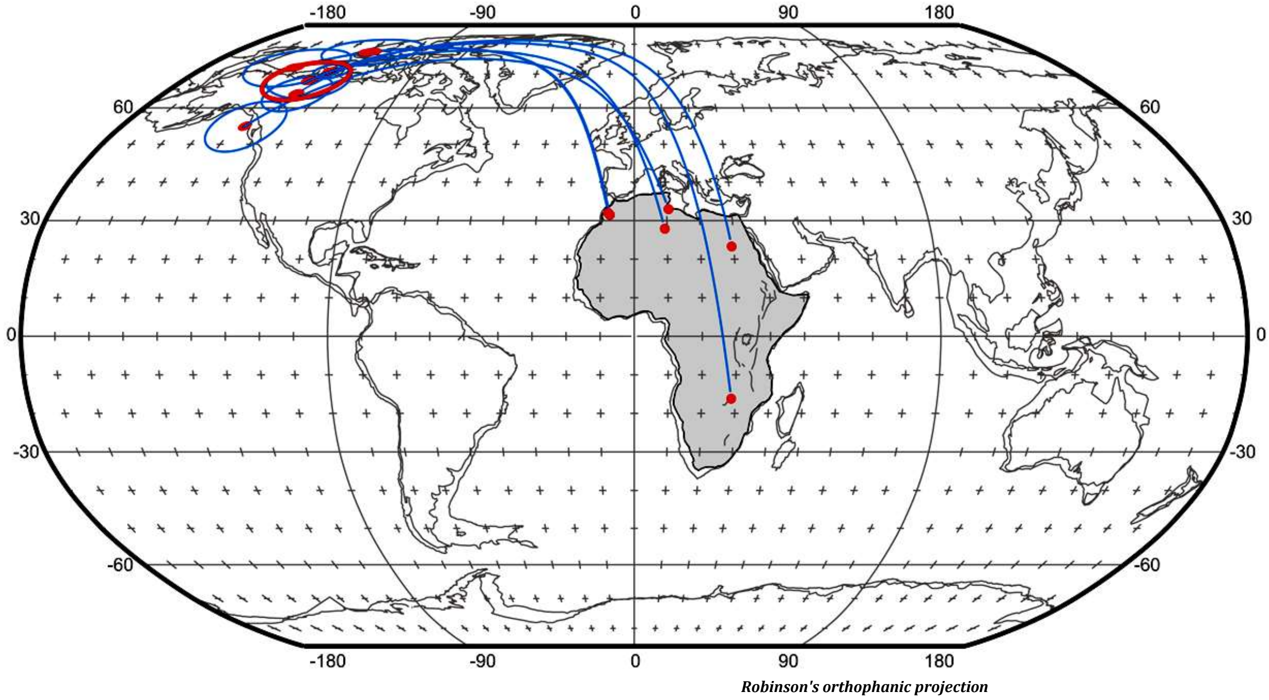


Tab. SM-02 – Upper Triassic GPMDB paleopoles of North America and their Fisher average (red circle), with the listed data displayed on the Robinson planisphere.

TABLE SM-03

AFRICA – UPPER TRIASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
32.0	-8.0	182 - 211	6.0	6.0	72.1	217.7	2	Westphal *et al.*	1979
31.5	-7.5	199 - 201	4.6	4.6	77.2	240.9	4	Knight *et al.*	2004
27.9	9.3	176 - 228	2.3	2.3	70.9	235.1	4	Kies *et al.*	1995
-16.2	28.8	200 - 228	5.0	6.5	68.0	230.5	2	Opdyke	1964
33.0	10.6	200 - 228	6.9	6.9	54.9	223.3	3	Ghorabi & Henry	1991
23.3	29.3	211 - 221	5.1	5.1	64.1	230.7	2	Saradeth *et al.*	1989

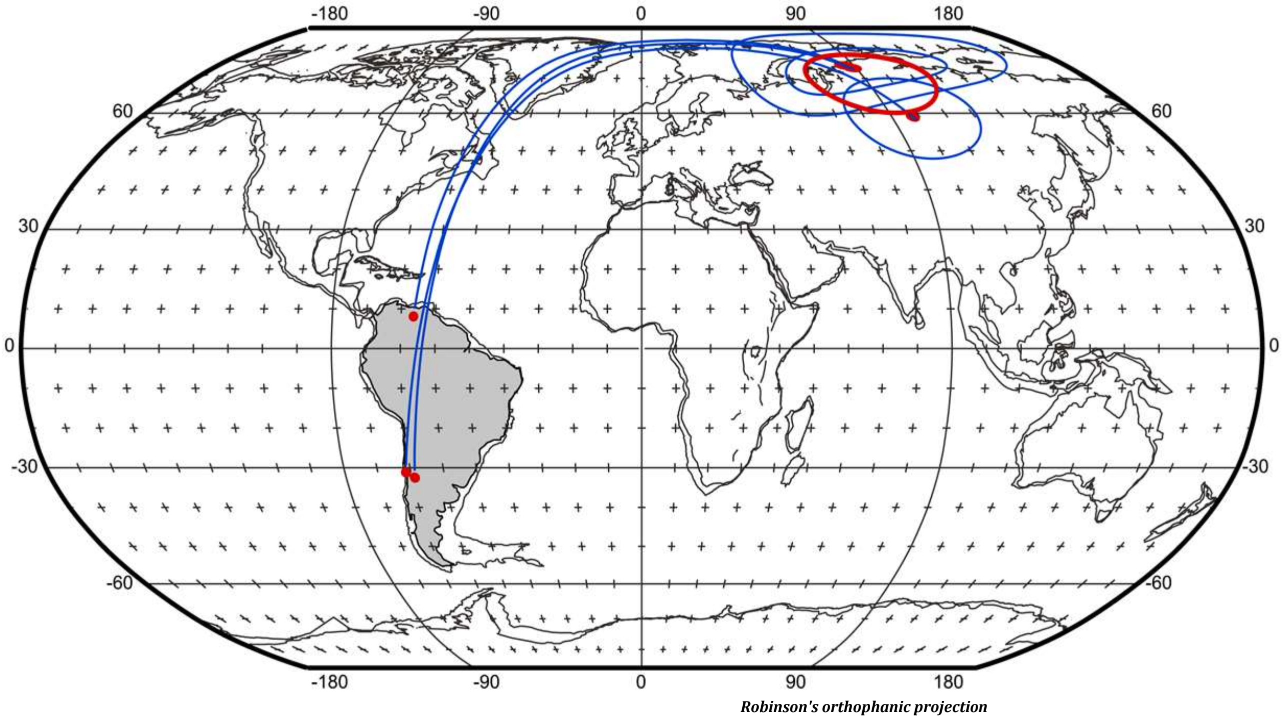


Tab. SM-03 – Upper Triassic GPMDB paleopoles of Africa and their Fisher average (red circle), with the listed data displayed on the Robinson planisphere.

TABLE SM-04

SOUTH AMERICA – UPPER TRIASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
8.1	-66.4	192 - 205	5.8	11.4	73.2	88.5	2	MacDonald & Opdyke	1974
-32.5	-69.1	200 - 228	11.0	18.0	74.0	86.0	2	Valencio	1969
-31.2	-71.5	217 - 228	10.9	12.0	59.0	97.5	4	Forsythe *et al.*	1987

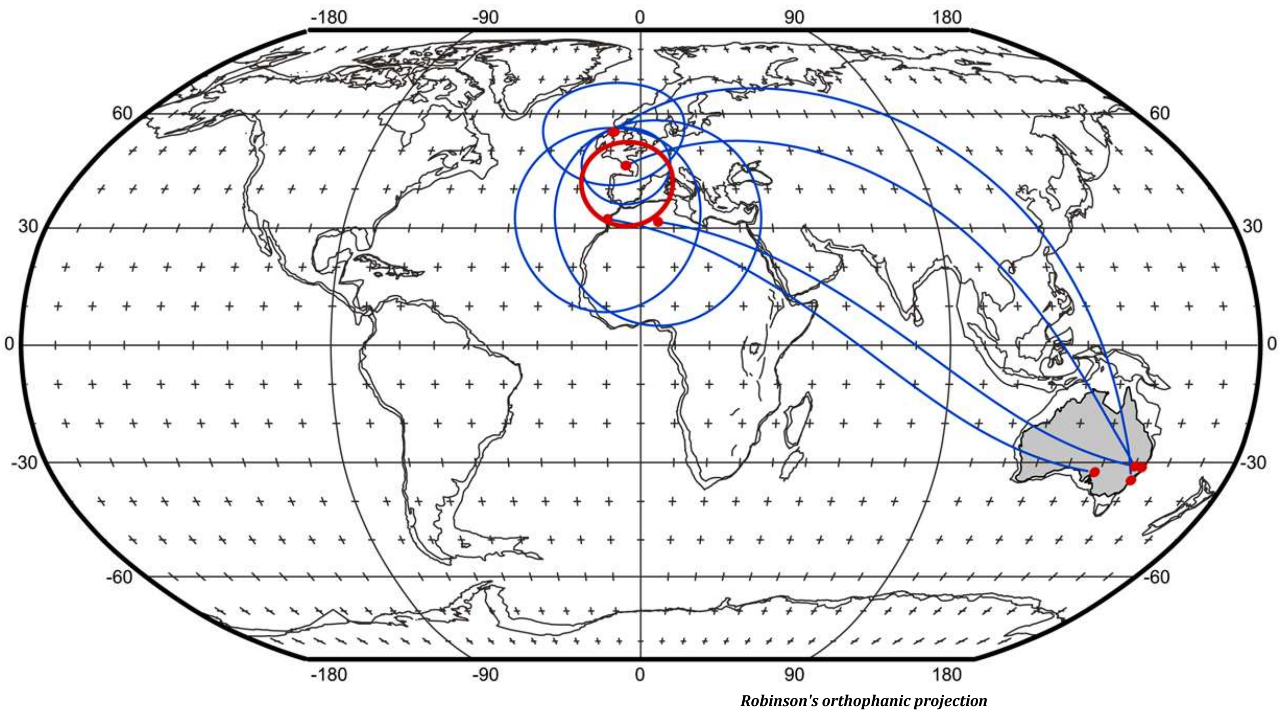


Tab. SM-04 – Upper Triassic GPMDB paleopoles of South America and their Fisher average (red circle), with the listed data displayed on the Robinson planisphere.

TABLE SM-05

AUSTRALIA – UPPER TRIASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
-31.0	150.0	187 - 207	10.0	10.0	46.1	355.2	2	Schmidt	1976
-32.5	138.5	200 - 228	23.8	23.8	32.3	349.9	2	Schmidt *et al.*	1976
-34.6	150.8	190 - 210	14.0	14.0	55.0	350.6	4	Schmidt	1990
-31.3	152.3	200 - 228	26.6	26.6	31.6	5.3	4	Schmidt *et al.*	1994

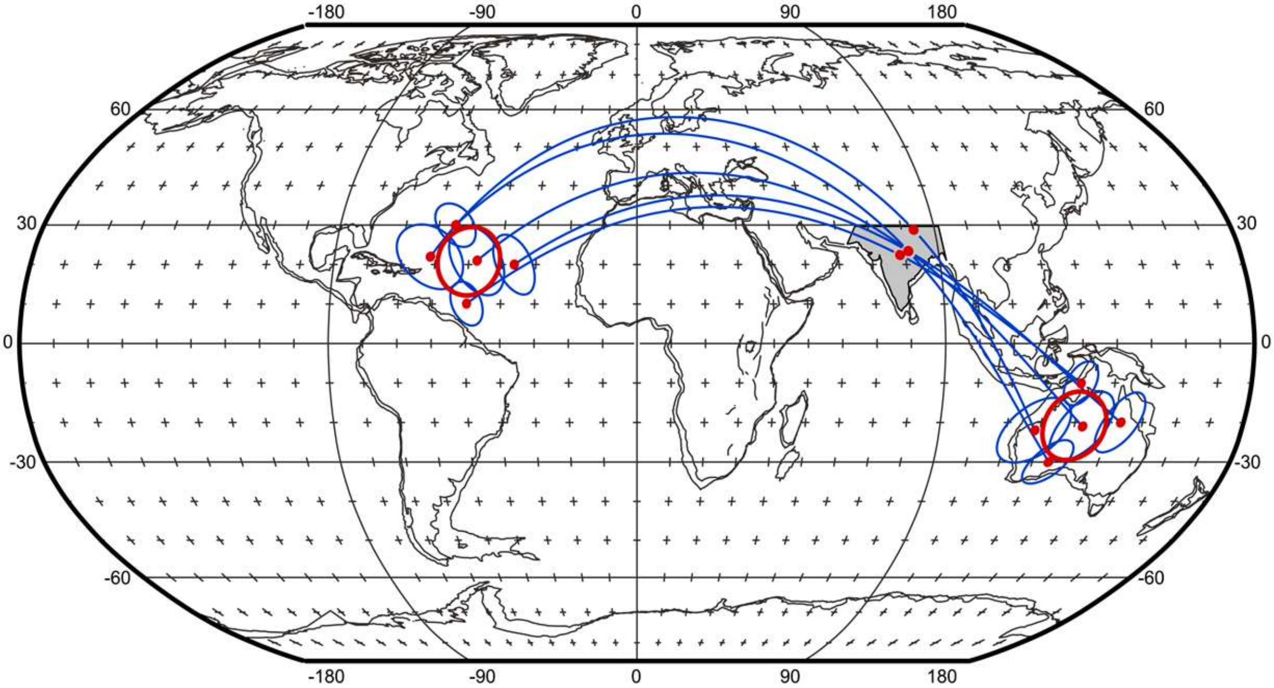


Tab. SM-05 – Upper Triassic GPMDB paleopoles of Australia and their Fisher average (red circle), with the listed data displayed on the Robinson planisphere.

TABLE SM-06

INDIA – UPPER TRIASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
22.4	78.4	176 - 228	4.0	6.1	10.1	310.1	3	Wensink	1968
23.4	81.1	200 - 204	6.1	10.1	21.0	312.5	4	Agarwal	1980
23.4	81.0	200 - 228	4.0	6.8	30.0	305.0	3	Bhalla & Verma	1969
23.4	81.0	210 - 228	4.6	8.5	20.0	323.6	4	Agarwal	1980
28.8	83.7	200 - 204	6.8	10.5	22.0	298.5	4	Klootwijk - Bingham	1980

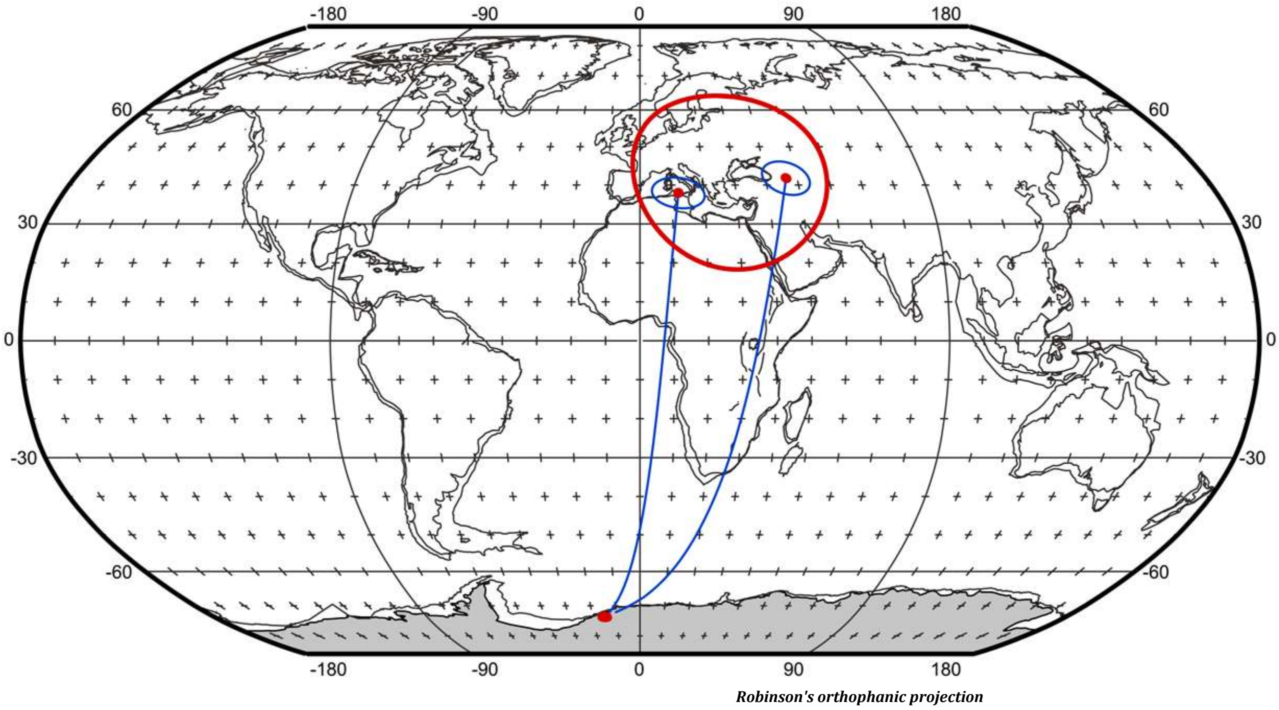


Tab. SM-06 – Upper Triassic GPMDB paleopoles of India, with the listed data displayed on the Robinson planisphere. Indian paleopoles are plotted together with their antipoles (antipode poles), and both groups and their associated Fisher's average (red circles) are alternatively considered in the variable radius paleogeographic reconstructions.

TABLE SM-07

ANTARCTICA – UPPER TRIASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
-73.3	-15.0	160 - 230	4.2	5.6	41.8	46.5	3	Lovlie	1979
-73.7	-14.9	165 - 215	3.9	6.5	38.0	12.0	3	Lovlie & Mitchell	1989

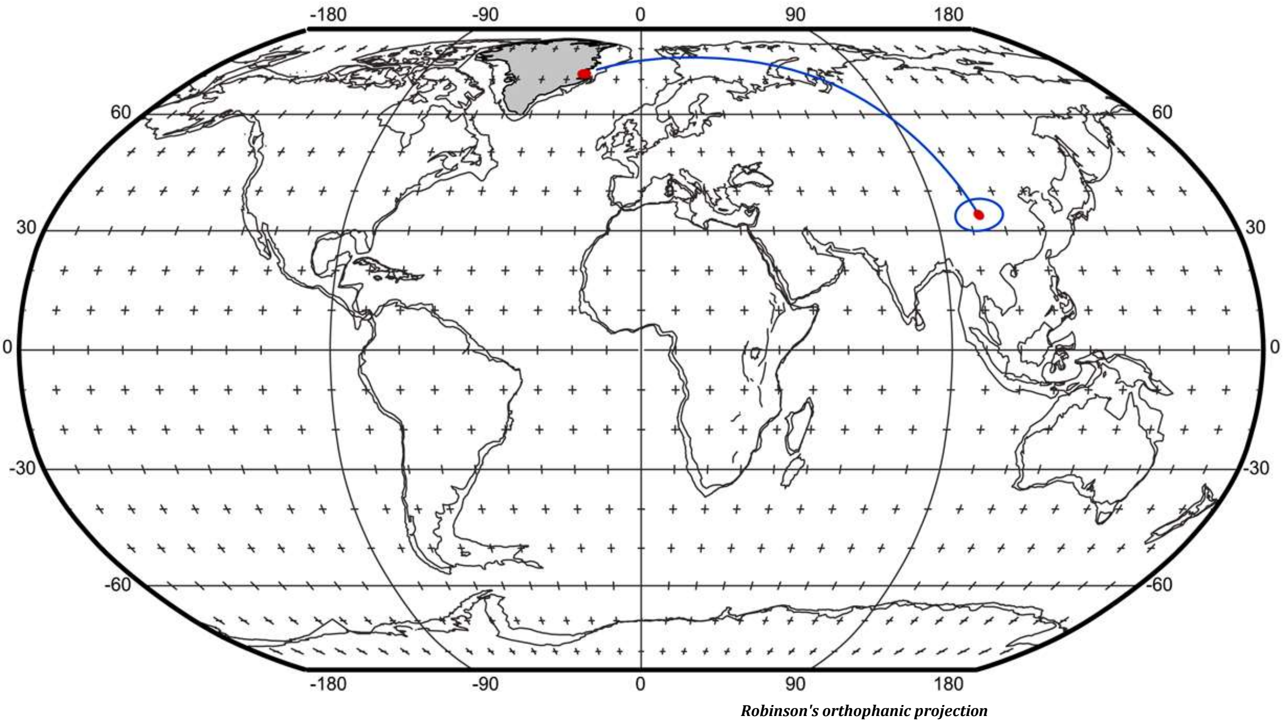


Tab. SM-07 – Upper Triassic GPMDB paleopoles of Antarctica and their Fisher average (red circle), with the listed data displayed on the Robinson planisphere.

TABLE SM-08

GREENLAND – UPPER TRIASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
71.7	-23.4	217 - 228	3.8	6.4	34.0	103.2	2	Reeve *et al.*	1974

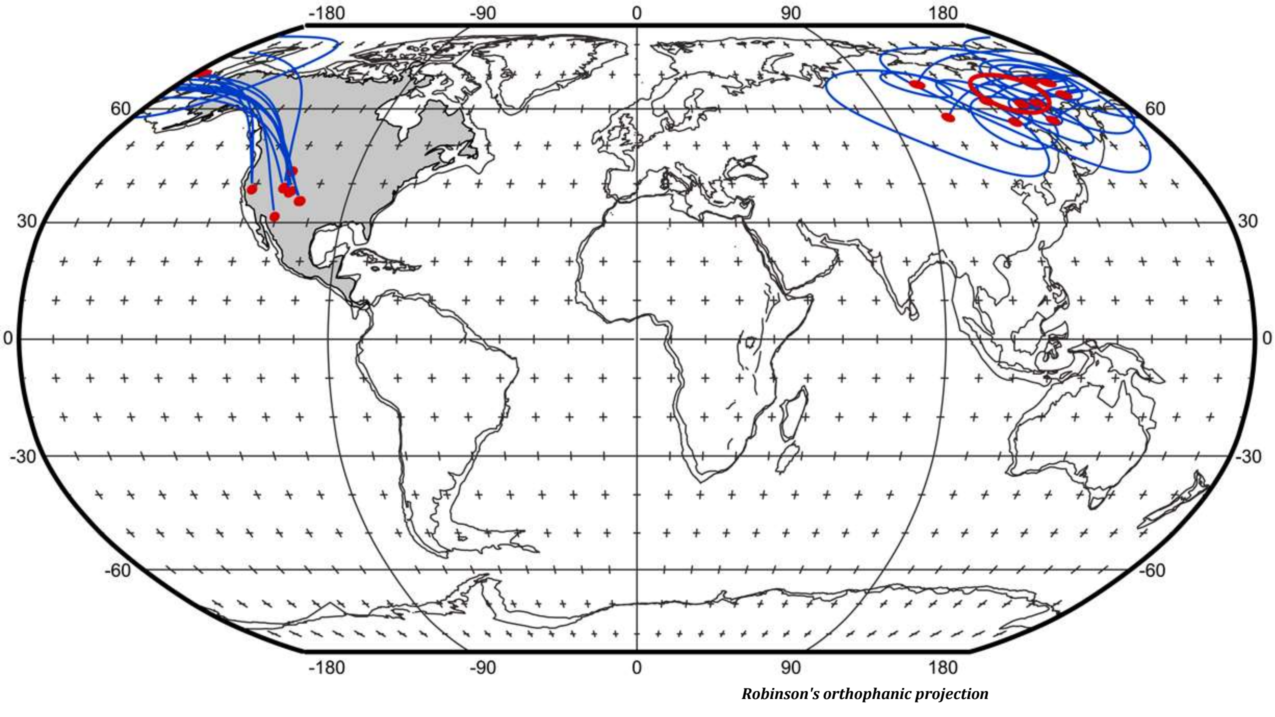


Tab. SM-08 – Upper Triassic GPMDB paleopole of Greenland, with the listed data displayed on the Robinson planisphere. The only Upper Triassic paleopole of Greenland is too far to the South-East, and is not sufficient to draw definitive conclusions. Then, also the position of this continental bloc, that is held in the grip between North America and Europe, is helpful in order to plot paleogeographic reconstructions.

TABLE SM-05

AMERICA – UPPER JURASSIC – ADOPTED GPMDB POLES

Site		Age Window	Confidence Ellipse		Pole		Quality	Authors	Year
Lat.	Lon.	My	Δincl.	Δdecl.	Lat.	Lon.			
31.5	-110.5	149 - 153	4.1	7.4	62.2	130.3	3	Kluth *et al.*	1982
38.5	-120.8	155 - 165	10.6	13.1	70.5	182.6	3	Bogen *et al.*	1985
38.5	-120.8	155 - 165	10.6	19.3	57.6	111.0	3	Bogen *et al.*	1985
39.0	-111.0	162 - 164	2.9	5.0	67.0	109.8	3	Steiner	1978
38.1	-108.2	151 - 161	4.0	6.5	61.4	142.2	3	Steiner & Helsley	1975
38.1	-108.2	146 - 155	3.5	5.0	67.5	161.8	3	Steiner & Helsley	1975
43.2	-110.8	154 - 170	8.0	11.0	64.0	162.0	4	McWhinnie *et al.*	1990
38.8	-111.1	158 - 163	7.2	7.2	56.3	133.4	4	Bazard & Butler	1992
37.7	-108.8	146 - 161	4.8	4.8	68.3	156.2	4	Bazard & Butler	1994
35.5	-104.2	161 - 165	4.1	7.0	56.8	147.4	4	Steiner	2003
35.5	-104.7	161 - 165	12.2	20.0	61.6	148.2	4	Steiner	2003



Tab. SM-09 – Upper Jurassic GPMDB paleopoles of North America and their Fisher average (red circle), with the listed data displayed on the Robinson planisphere. This poles plot refers to the cartographic experiment of Fig. 04 and Fig. 05 of the main paper.