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Analysis of a Permo-Triassic polarity transition in different absolute reconstructions of Pangaea, considering a model with features of the present Earth magnetic field

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Abstract
The main objective of this paper is to show that the distribution of transitional palaeomagnetic data recorded at 250 Ma are in agreement with simulated data that depend on the sampling site, using a model that considers features of the Present Earth magnetic field. The analysis was performed comparing simulated reversals with the Permo-Triassic polarity transition recorded in the Siberian Trap Basalts. The palaeomagnetic data were corrected according to the Palaeo-latitude and Palaeo-longitude of Siberia (absolute reconstruction) at 250 Ma using hotspot tracks. To obtain the motion of Siberia relative to hotspots from the Present time back to 250 Ma, three different Pangaea models were considered (Pangaea A, Pangaea A2, Pangaea B). In spite of the uncertainties associated with the use of hotspot frameworks and Pangaea configurations, both the modelled and recorded data show a remarkable fit when absolute reconstructions of Pangaea A and A2 configurations are performed. The agreement between both simulated and recorded data suggests that similar features to that of the Present Earth magnetic field could have been involved in reversals since the Permo-Triassic.

Key words *Permo-Triassic – Pangaea – absolute reconstruction – Earth magnetic field – polarity transition*

1. Introduction

Different rock types are capable of recording the directions of the Earth's Magnetic Field (EMF). Through these records, we know that the dipolar component of the geomagnetic field periodically inverts its polarity. Our knowledge on what happens as the field reverses comes from the evaluation of transition palaeomagnetic records. The earliest analysis of geomagnetic polarity reversals was that determined for the Jurassic Stormberg volcanic rocks of Lesotho in Southern Africa (van Zijl *et al.*, 1962). However, most studies of this intriguing process of the EMF have used Cainozoic data (see Coe and Glen, 2004), because transitional records are difficult to determine in older lithologies; as these rocks have probably undergone more geological processes that resulted in remagnetizations resetting total or partially the original data.

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On the other hand, for all of geological time (including the Cainozoic) transition records depend on the capabilities of rocks to act as natural magnetic recorders. Lava flows are considered to record the most accurate spot readings of the geomagnetic field (Hoffman, 1992) but due to the episodic nature of eruptions, their transition records can be discontinuous or multiple lava flows can be emplaced over a shorter time span compared with the rate of variation of the EMF, in which case the flows will preserve redundant records of this field (Prévot and Camps, 1993). Sedimentary rock sequences can be *quasi*-continuous records but they become magnetized by physical and chemical processes of relatively long duration that occur from the deposition of the sediment till the diagenesis. Magnetic directions of sedimentary rocks considered as transitional records could be, indeed, artefacts and not real readings of the EMF (Langereis *et al.*, 1992).

In spite of these problems, longitudinal confinements of Virtual Geomagnetic Poles (VGPs) of Cainozoic transitional records were interpreted as representative of geomagnetic behaviours (Clement, 1991; Laj *et al.*, 1991; Hoffman, 1992; Love, 1998) and different geodynamo models have been suggested to explain Cainozoic polarity transitions. Hoffman (1992) has suggested that inclined dipolar reversal states of the EMF have dominated Cainozoic reversals. Gubbins and Coe (1993) and Gubbins (1994) provided an explanation to link longitude-confined VGP paths to variations in the magnetic flux on the Earth's core surface based on a model proposed by Gubbins (1987). Glatzmaier *et al.* (1999) simulated a suite of reversals which examples were presented by Coe *et al.* (2000); the most interesting of these simulated reversals is that produced by the tomographic geodynamo model where the heat-flux at the core-mantle boundary is patterned on the large-scale variation of seismic velocity from tomographic studies of the lowermost mantle.

As indicated above, transition records for reversals older than the Cainozoic are much more difficult to determine and there are no specific models to explain the polarity transitions of the EMF during the Mesozoic or Palaeozoic times. However, reliable transition records of those times can be analyzed considering the models proposed for the Cainozoic and then, speculate about the mechanisms that manage Mesozoic or Palaeozoic reversals.

A recent study by Heunemann *et al.* (2004) provided reliable directions and intensities for a reversal of the EMF recorded in the Permo-Triassic (*ca.* 250 Ma) Siberian Trap Basalts. Heunemann *et al.* (2004) corrected the corresponding VGPs of the recorded directions for a Permo-Triassic palaeo-geography of Siberia and invoked two alternatives, based on the models presented by Coe *et al.* (2000) and Hoffman (1992), to account for the characteristic features observed in their data. It is noteworthy that the Euler rotation pole used by Heunemann *et al.* (2004) is just to determine the Palaeo-latitude of Siberia at 250 Ma (Smethurst *et al.*, 1998) but not the palaeo-longitude of this continental block at that age.

This paper compares simulated reversals determined by the model proposed by Gubbins (1994) with the Permo-Triassic polarity transition recorded in the Siberian Trap Basalts. Palaeomagnetic data were corrected in accordance with the Palaeo-latitude and Palaeo-longitude of Siberia at 250 Ma using hotspot tracks as has been done for the analysis of the Jurassic transition recorded in the Stormberg Lavas (Vizán and Van Zele, 1995; Prévot *et al.*, 2003). To obtain the motion of Siberia relative to hotspots from the Present back to 250 Ma, several relative reconstructions from a variety of sources were used assuming that three different models of Pangaea are valid for 250 Ma (Pangaea A, Pangaea A2, Pangaea B). Remarkable agreements between the simulated and recorded transitional data were obtained after latitude and longitude palaeo-geographic corrections, especially if Pangaea A and A2 models were used.

2. Discussion on the data and methodologies

The analyzed palaeomagnetic data were compiled from table 2 of Heunemann *et al.* (2004). The extremely high lava productivity makes the Siberian Trap Basalts a possible continuous record for the palaeo-directions of the EMF. According to Heunemann *et al.* (2004) its stratigraphically lower section contains three successive flows of reversed polarity followed by flows that record a transitional state of the EMF. The upper section shows normal polarity and a group of directions that is tentatively interpreted by Heunemann *et al.* (2004) as an excursion. Analysis in this paper concentrates on data that record the transitional state (considering also those three data of reverse polarity in the lower section and some of normal polarity of the upper section). Data belonging to the possible excursion as interpreted by the same authors were not analyzed. The transitional record shows a clustering of data that may be explained as a rapid succession of lava flows; however the palaeo-intensity results indicate that this phenomenon has a geomagnetic cause as several independent field states are recorded (Huenemann *et al.*, 2004).

This paper uses the geomagnetic polarity reversals mechanism proposed by Gubbins (1994) to analyze the transitional record of the Siberian Trap Basalts, because it is based on the configuration of EMF at the core surface derived from historical records (Gubbins, 1987) and has the interesting feature that for the same reversal, different paths of VGPs are predicted at different measurement sites (see Gubbins, 1994; his figs. 12 and 13). The present work analyses whether the VGPs simulated by Gubbins' model are comparable to the cluster of VGPs recorded in the location of the Siberian Trap Basalts at about 250 Ma.

Hotspot models were used to determine palaeo-latitudinal and palaeo-longitudinal corrections in our analysis. Whether hotspots move slowly enough with respect to one another to provide a useful reference frame to make absolute reconstructions has been the subject of discussion (*i.e.* Torsvik *et al.*, 2002). For some workers hotspot models are not very reliable, but others use them in tectonics and geomagnetic models. Absolute reconstructions, for the last 120 Ma, for Africa based on a moving hotspot reference frame, have been recently suggested by O'Neill *et al.* (2005) Many tectonics and geomagnetism studies (*i.e.* Engebretson *et al.*, 1985; Besse and Courtillot, 2002; Prévot *et al.*, 2003) have used an earlier model that considered that hotspots are reasonably fixed and form a convenient reference frame to determine absolute motions of Africa for the last 200 Ma (Morgan, 1983). Hotspot tracks have been recognized by Zonenshain *et al.* (1985) to calculate a clockwise rotation of Siberia from 130 to 280 Ma. This paper used all three of these hotspot models and also determined if an absolute reconstruction of the sampling site based on these models, gives a better agreement between simulated and recorded data.

In order to determine the motion of the sampling site with respect to the hotspots it is necessary to perform a relative reconstruction of Eurasia with Africa at Present geographic coordinates using a reconstruction of Pangaea at 250 Ma. However, after more than 25 years of discussions among palaeomagnetists, there is no general consensus about the configuration of Pangaea during the Late Palaeozoic-Early Mesozoic. It is generally agreed that the Pangaea configuration proposed by Wegener (1922), named Pangaea A and quantified by Bullard *et al.* (1965), was the starting point for the break up of this super continent in the Middle Jurassic. However, Palaeomagnetic Poles (PPs) of Gondwana and Laurasia for the Late Carboniferous to Middle Triassic cannot be reconciled with this reconstruction and show a systematic discrepancy that could be due to different factors such as inclination shallowing in sediments, unrecognized overprints that have not been removed during demagnetization, underestimation of rock ages (Rochette and Vandamme, 2001; McElhinny, 2004; Van der Voo and Torsvik, 2004). This systematic misfit between PPs has also been interpreted in geodynamic or geomagnetic terms. Briden *et al.* (1971), Van der Voo and Torsvik (2001) and Torsvik and Van der Voo (2002) propose that a possible explanation for this disagreement is the existence of persistent non-dipolar (octupolar) fields. Many other workers have invoked different reconstructions of Pangaea called Pangaea B (*i.e.* Morel and Irving, 1981; Torcq *et al.*, 1997; Muttoni *et al.*, 2003; Rakotosolofo *et al.*, 2005) and Pangaea A2 (*i.e.* Van der Voo and French, 1974; Van der Voo *et al.*, 1976; Smith and Livermore, 1991) to produce an agreement between the Laurasia and Gondwana PPs. Pangaea A2 is not very different from Pangaea A and the transition of one to another, involves a small dextral mega shear of about 500 km but the transformation of Pangaea B to Pangaea A involves a large dextral mega shear (of 4000-3500 km). Muttoni *et al.* (1996) proposed the evolution of Pangaea from Pangaea B to A2 during the mid-Permian and from A2 to A during the Late Triassic.

The polarity transition analysis presented here also determined which Pangaea model gives the better agreement between the transition data produced using the Gubbins (1994) model and the data recorded from the Siberian Trap Basalts.

3. Palaeoreconstructions of the palaeomagnetic data recorded in Siberian Trap Basalts

The sections studied by Heunemann *et al.* (2004) are located in the Listvjanka (69°28′N, 88°43′E) and Icon/Abagalakh river valleys (70°22′N, 90°04′E). For the present study the geographic localities were averaged and the palaeomagnetic data were normalised to 69°55′N, 89°23′E. The geographic coordinates of this locality in the Permo-Triassic were determined from a mean Siberian Trap PP using the different models of Pangaea and hotspot frameworks mentioned above.

We considered a PP that is the mean of four entries as a representative pole position for the Siberian Trap Basalts. The four entries are 1) a mean Siberian Trap pole at 54.7°N/140.5°E given in Torsvik and Andersen (2002); 2) Global Palaeomagnetic Database (GPMDB)-REFNO 2832 (59°N/150°E), see also Gurevitch *et al.* (1995); 3) a pole from Gurevitch *et al.* (2004: 54.6°N/146°E); 4) a pole from Heunemann *et al.* (2004: 57.1°N/148.2°E). The geographic coordinates and the Fisherian statistical parameters of the mean PP are: Lat = 56.4°N, Long = =146.0°E, A95 = 3.5°, K = 677.9. This mean PP is quite similar to that obtained with 3 entries by Van der Voo and Torsvik (2004) for the Siberian Traps (Lat = 56°N, Long = 150°E, A95 = 6°). In our case the mean PP includes the pole yielded by the stable reverse and normal directions of the sections that recorded the transition (Heunemann *et al.*, 2004) and then the A95 is reduced from 6° to 3.5°.

Recently Van der Voo and Torsvik (2004) compared their mean Siberian Trap pole with the mean Gondwana PP for 250±10 Ma of Torsvik and Van der Voo (2002) in a Pangea A configuration assuming that Siberia formed part of Eurasia at *ca.* 250 Ma (Smethurst *et al.*, 1998;

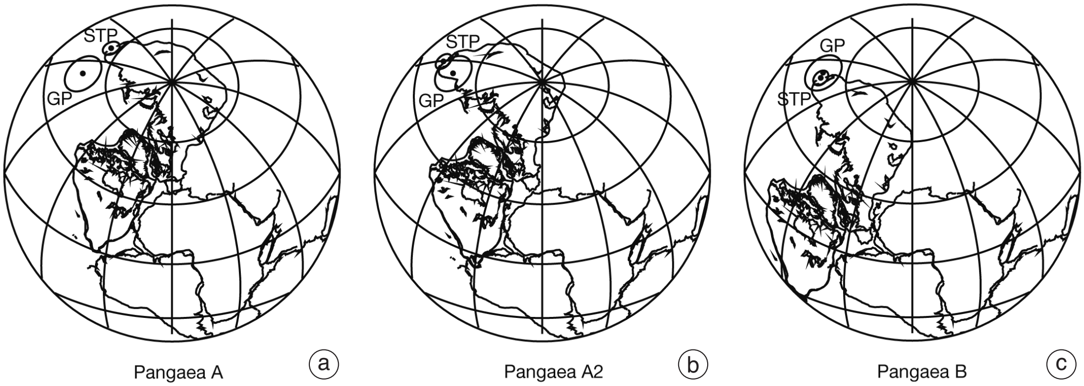

Fig. 1a-c. Comparison of Gondwana mean palaeopole (GP) for 250 ± 10 Ma and Siberian Trap mean palaeopole (STP) in different Pangaea reconstructions with Central Africa held fixed at present geographic coordinates. a) Pangaea A model, notice the discrepancy between the mean palaeopoles. b) Pangaea A2 model, the mean palaeopoles are indistinguishable at 95% of confidence level, although there is a great circle distance of about 9° between them. c) Pangaea B model, the mean palaeopoles get the better fit. A supposed mega-shear of about 3700 km is required to pass from this Pangaea configuration to a Pangaea A model (the starting point of the break up of this super-continent during Middle Jurassic time).

Table I. Rotation poles for the sampling site in Pangaea A model.

Euler pole	Latitude (°N)	Longitude (°E)	Rotation (degree)	Reference
1) Eurasia relative to North America	88.5	27.7	–38	Bullard *et al.* (1965)
2) North America relative to NW Africa	66.95	–12.02	75.55	Klitgord and Schouten (1986)
3) NW Africa relative to Central Africa	12.23	19.01	3.44	Schettino and Scotese (2005)
4) Africa relative to hotpots (0 to 120 Ma)	17.03	–27	–29.72	O'Neill *et al.* (2005)
5) Africa relative to hotpots (120 to 200 Ma)	31.38	3.4	32.18	Morgan (1983) (*)
6) Eurasia relative to hotspots (200 to 250 Ma)	85.03	252.46	25	Zonenshain *et al.* (1985) (**)
7) True Polar Wander	0	187.46	28.15	(***)

(*) Stage pole calculated using the Euler poles of 120 Ma and 200 Ma of Morgan (1983).
(**) The geographic coordinates of this Euler pole (now at 54°N, 104°E) were calculated for 200 Ma in Pangaea A model.
(***) Rotation about an equatorial Euler pole to account for the displacement of the rotation (palaeomagnetic) axis with respect to core/mantle boundary (Cox and Hart, 1986).

Torsvik *et al.*, 2001). Van der Voo and Torsvik (2004) noted that using these poles there is still a continental overlap of 1000 km if Pangea A is used.

This paper also compare the new Siberian Trap mean PP with a Gondwana PP for 250 Ma ± 10 Ma in three models of Pangea (A, A2 and B, see fig. 1a-c). Thirteen poles for the stable parts of Gondwana continents compiled by Torsvik and Van der Voo (2002) were combined with the reconstruction parameters for Gondwana continents recently proposed by Schettino and Scotese (2005). These new reconstruction parameters were used noting that Torsvik and Van der Voo (2002) were not entirely satisfied with published Gondwana fits. The resulting mean Gondwana PP in Present Central Africa geographic coordinates is based on a conventional Fisherian calculation; its geographic coordinates and statistical parameters are: Lat = = 48.4°N, Long = 249.3°E, A95 = 8.4°, K = 25.6.

The comparison was made with Central Africa held fixed and transferring the Siberian Trap pole to the geographic coordinates of this continental block through a plate circuit (Euler poles 1, 2 and 3 in table I). The first rotation of the Siberian Trap pole was to reconstruct the continent of Laurasia «closing» the north Atlantic through the movement of Eurasia towards North America. For this reconstruction the Bullard *et al.* (1965) Euler pole was used because Van der Voo (1990) and Torsvik *et al.* (2001) have demonstrated that this reconstruction gives best agreement between Late Carboniferous-Late Triassic European and North American PPs. The second rotation of the Siberian Trap pole used the reconstruction parameter of Klitgord and Schouten (1986) from North America to northwest Africa, which belongs to a model of Pangaea A. Finally the pole was transferred from northwest Africa to Central Africa using the reconstruction parameters of Schettino and Scotese (2005). Figure 1a shows Gondwana and Siberian Trap PPs in Central Africa geographic coordinates using the Pangaea A configuration. The PPs do not fit, they are distinguishable at 95 % of confidence level and the great circle distance between them is of 15.2°.

To compare both mean PPs with a model of Pangaea A2, the Siberian Trap pole was rotated using also the finite pole of rotation of Van der Voo and French (1974) «closing the Gulf of

Table II. Rotation poles for the sampling site in Pangaea A2 model.

Euler pole	Latitude (°N)	Longitude (°E)	Rotation (degree)	Reference
1) Eurasia relative to North America	88.5	27.7	−38	Bullard *et al.* (1965)
2)North America relative to NW Africa	66.95	−12.02	75.55	Klitgord and Schouten (1986)
3) NW Africa relative to Central Africa	12.23	19.01	3.44	Schettino and Scotese (2005)
4) Rotation to close the Gulf of Mexico	17.38	−8.91	16.13	Van der Voo and French (1974) (*)
5) Africa relative to hotpots (0 to 120 Ma)	17.03	−27	−29.72	O'Neill *et al.* (2005)
6) Africa relative to hotpots (120 to 200 Ma)	31.38	3.4	32.18	Morgan (1983) (**)
7) Eurasia relative to hotspots (200 to 250 Ma)	69.17	268.5	25	Zonenshain *et al.* (1985) (***)
8) True Polar Wander	0	187.03	44.17	(****)

(*) Re-calculated considering the reconstruction parameter of Klitgord and Schouten (1986) for North America relative to NW Africa and the rotation parameter of Schettino and Scotese (2005) for NW Africa relative to Central Africa.

(**) Stage pole calculated using the Euler poles of 120 Ma and 200 Ma of Morgan (1983).

(***) The geographic coordinates of this Euler pole (now at 54°N, 104°E) were calculated for 200 Ma in Pangaea A2 model.

(****) Rotation about an equatorial Euler pole to account for the displacement of the rotation (palaeomagnetic) axis with respect to core/mantle boundary (Cox and Hart, 1986).

Mexico». Figure 1b shows the PPs of Gondwana and Siberian Traps transferred to Central Africa geographic coordinates (Euler poles 1, 2, 3 and 4 in table II) in a Pangaea A2 configuration. The great circle distance between the mean PPs is of 9.1°; however there is an overlap between the 95% confidence level intervals and the 4 poles of Siberian Trap Basalts share a common mean at 95% confidence (McFadden and Lowes, 1981) with Gondwana PPs.

To compare Gondwana and Siberian Trap mean PPs with a model of Pangaea B, a finite pole of rotation to obtain the motion of North America relative to Central Africa was calculated using the analysis of Morel and Irving (1981) and the reconstruction parameters of Klitgord and Schouten (1986) and Schettino and Scotese (2005). This rotation parameter has its pole at Lat = 36.2°N, Long = 04.0° W, and an angle of rotation = 77.35° (counter clockwise). The relative position between the Atlantic bordering continents obtained with this reconstruction parameter is shown in fig. 1c together with Gondwana and the Siberian Trap mean PPs transferred to Central Africa geographic coordinates (Euler poles 1, 2, 3 and 4 in table III). The great circle distance between these PPs is 2.5° and, obviously, they are undistinguishable at 95% of confidence level.

To perform our transition record analysis, absolute reconstructions of the sampling site were made by considering the Siberian Trap mean PP (as representative of the palaeomagnetic spin axis at 250 Ma), different models of Pangaea and the hotspot frameworks already mentioned.

Firstly we transferred the Siberian Trap mean PP to Present Central Africa coordinates using the reconstruction parameters to build the different models of Pangaea. After that, we rotated the plates and the pole position according to the Euler pole of O'Neill *et al.* (2005) for 120 Ma. Then again we rotated the plates and the pole po-

Table III. Rotation poles for the sampling site in Pangaea B model.

Euler pole	Latitude (°N)	Longitude (°E)	Rotation (degree)	Reference
1) Eurasia relative to North America	88.5	27.7	–38	Bullard *et al.* (1965)
2) North America relative to NW Africa	66.95	–12.02	75.55	Klitgord and Schouten (1986)
3) NW Africa relative to Central Africa	12.23	19.01	3.44	Schettino and Scotese (2005)
4) Transition from Pangaea A to B	–25.79	47.49	35.79	Morel and Irving (1981) (*)
5) Africa relative to hotpots (0 to 120 Ma)	17.03	–27	–29.72	O'Neill *et al.* (2005)
6) Africa relative to hotpots (120 to 200 Ma)	31.38	3.4	32.18	Morgan (1983) (**)
7) Eurasia relative to hotspots (200 to 250 Ma)	59.77	314.62	25	Zonenshain *et al.* (1985) (***)
8) True Polar Wander	0	198.77	47.9	(****)

(*) Re-calculated considering the reconstruction parameter of Klitgord and Schouten (1986) for North America relative to NW Africa and the rotation parameter of Schettino and Scotese (2005) for NW Africa relative to Central Africa. The motion of North America relative to Central Africa in a Pangaea B model can be determined through a cumulative rotation including the reconstruction parameters 2), 3) and 4).
(**) Stage pole calculated using the Euler poles of 120 Ma and 200 Ma of Morgan (1983).
(***) The geographic coordinates of this Euler pole (now at 54°N, 104°E) were calculated for 200 Ma in Pangaea B model.
(****) Rotation about an equatorial Euler pole to account for the displacement of the rotation (palaeomagnetic) axis with respect to core/mantle boundary (Cox and Hart, 1986).

Table IV. Absolute reconstructions of Eurasia in different Pangaea types and geographic coordinates of the sampling site at 250 Ma.

Pangaea type	Absolute reconstruction Euler poles			Sampling site	
	Lat °N	Long °E	Angle (°)	Lat °N	Long °E
A	58.37	85.38	66.89	62.46	63.08
A2	59.09	86.34	68.49	62.46	64.97
B	42.15	71.89	45.89	62.46	36.10

sition, using a stage Euler pole for the time span between 120 and 200 Ma (lat = 31.38° N, long = = 3.4° E, and an angle of counter clockwise rotation = 32.18°) calculated from the reconstruction parameters proposed for Africa by Morgan (1983). To perform the rotation of the plates relative to hotspots from 200 to 250 Ma, we used Mongolian hotspot tracks that indicate that Siberia rotated 75° in a clock wise direction from 280 to 130 Ma about an Euler pole that is now located at 54°N, 104°E (Zonenshain *et al.*, 1985). We transferred this pole to its geographic position at 200 Ma in accordance with the different Pangaea models and using the hotspot frameworks of O'Neill *et al.* (2005) and Morgan (1983). Assuming Siberia rotated at a constant velocity, we proposed a rotation of 25° of this continent between 200 and 250 Ma. The mean Siberian Trap PP and the plates were then rotated using the corresponding Euler poles for each Pangaea model accounting for the movement of Siberia relative to the hotspot track between 200 and 250 Ma.

Finally we calculated the displacement of the rotation (palaeomagntic) axis with respect to the hotspot frameworks for every Pangaea model and rotated all the plates about the equatorial

Euler pole that belong to each case. The rotation poles to obtain the absolute reconstructions of the sampling site at 250 Ma in different versions of Pangaea are listed in tables I, II and III. These poles are numbered in the sequential order that should be followed to perform the reconstructions. The cumulative rotation for all the movements described before has different reconstruction parameters for the different Pangaea models. In table IV are listed the Euler poles for the absolute reconstruction of Siberia in Pangaea A, A2 and B and the corresponding palaeogeographic coordinates of the sampling site at 250 Ma.

4. Analysis of the transitional record and discussion

The analysis was carried out comparing calculated and recorded data. The behaviour of the EMF is currently analyzed by plotting the VGPs as computed by palaeomagnetic directions. However, a VGP is calculated assuming a dipole model, which is at variance with the strong non-dipolar field expected during a reversal (*i.e.* Gubbins and Coe, 1993). For this reason we have analyzed not only the computed VGPs but also their directions. The simulated data were determined according to the geographic coordinates of the measured site at 250 Ma for the different absolute reconstructions of Pangaea configurations using one of the models of Gubbins (1994).

Gubbins (1994) developed two models (E and W) assuming the structure of the transitional field is substantially non-dipolar. Since the reversal recorded in the Siberian Trap Basalts is from reverse to normal and according to the path of its transitional VGPs, the model W was adopted to simulate the transitional record. Figures 2, 3, 4 and 5 compare modelled and recorded data; declinations, inclinations and palaeointensities are represented *versus* the latitude of the corresponding VGPs. Notice that unfortu-

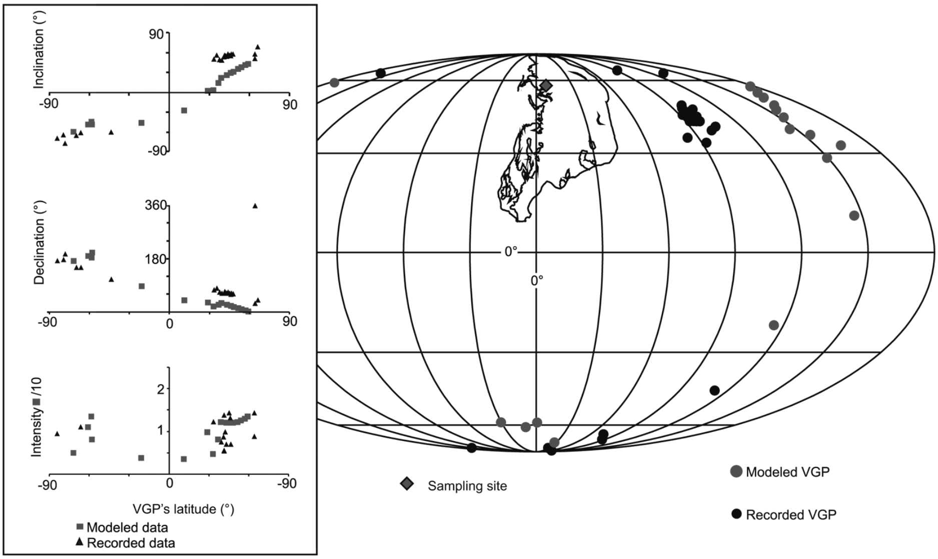

Fig. 2. Modelled and measured data of the polarity transition recorded in Siberian Trap Basalts. The data have just a palaeo-latitudinal correction according to the reconstruction parameter of Smethusrt *et al.* (1998) also used by Heunemann *et al.* (2004). The transitional modelled and recorded data form similar VGPs clusters however they do not agree.

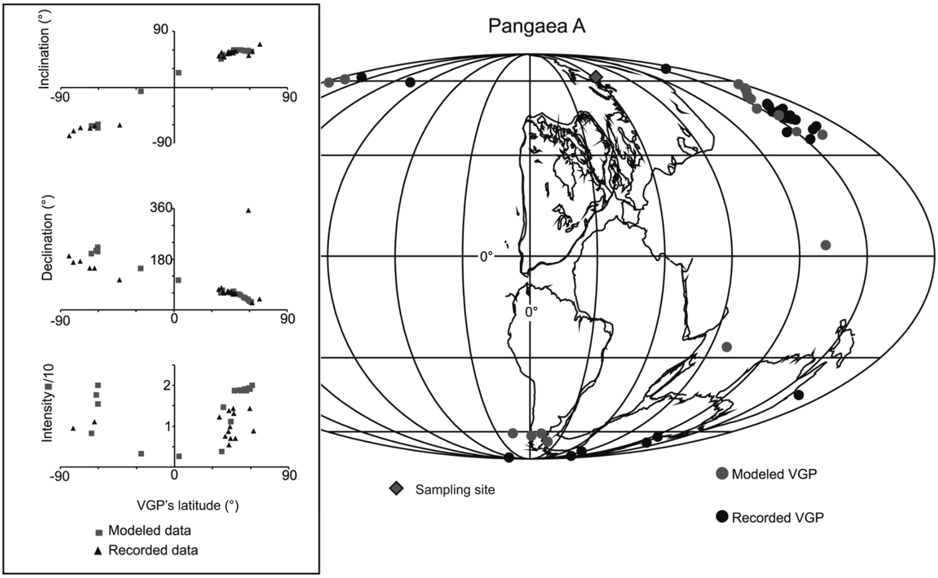

Fig. 3. Modelled and measured data of the polarity transition recorded in Siberian Trap Basalts in an absolute reconstruction of Pangaea type A configuration. The palaeo-latitudinal and palaeo-longitudinal corrections were done on the basis of hotspots frameworks and the mean Siberian Trap palaeopole. Notice the remarkable fit between both the modelled and recorded data.

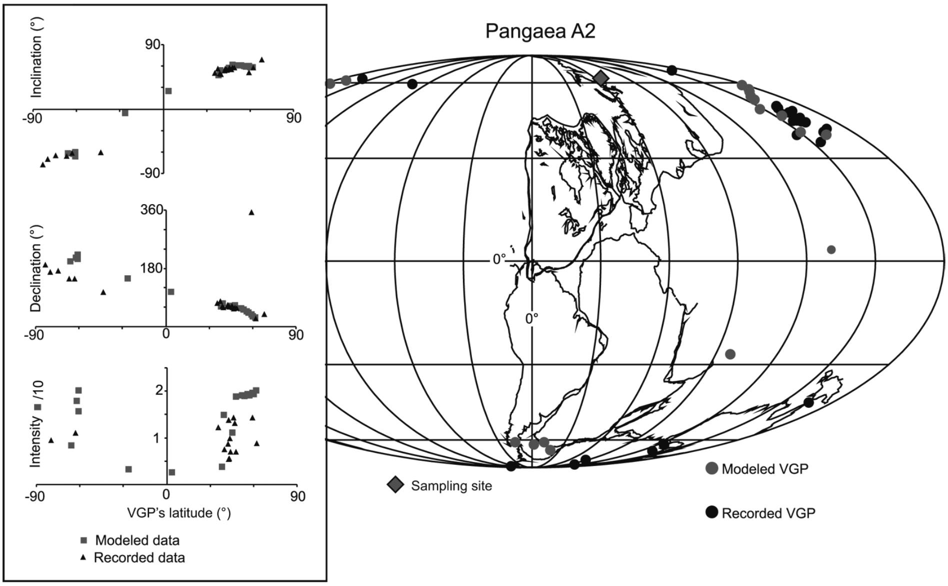

Fig. 4. Modelled and measured data of the polarity transition recorded in Siberian Trap Basalts in an absolute reconstruction of Pangaea type A2 configuration. The palaeo-latitudinal and palaeo-longitudinal corrections were done on the basis of hotspots frameworks and the mean Siberian Trap palaeopole. Notice the remarkable fit between both the modelled and recorded data as in fig. 3.

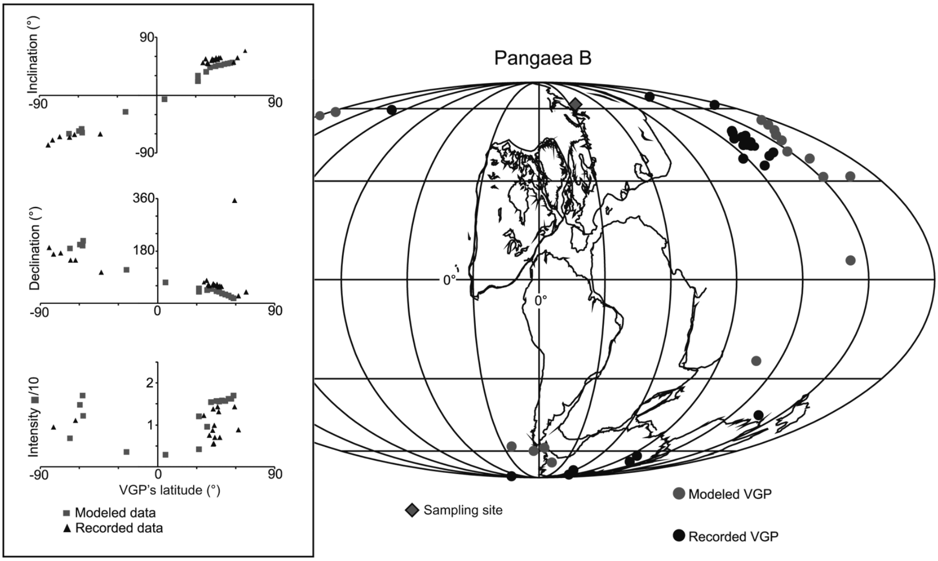

Fig. 5. Modelled and measured data of the polarity transition recorded in Siberian Trap Basalts in an absolute reconstruction of Pangaea type B configuration. The palaeo-latitudinal and palaeo-longitudinal corrections were done on the basis of hotspots frameworks and the mean Siberian Trap palaeopole. The modelled and recorded data are similar but they do not get as good fits as in A or A2 Pangaea models (figs. 3 and 4).

nately Heunemann *et al.* (2004) could not determine the corresponding palaeointensites for all the recorded palaeomagnetic directions.

Figure 2 shows the modelled and recorded data after the palaeo-latitudinal reconstruction of Smethrust *et al.* (1998) that was also used by Heunemann *et al.* (2004). Figures 3, 4 and 5 show the data in the different Pangaea models after the palaeo-latitudinal and palaeo-longitudinal reconstructions based on the mean Siberian Trap PP and the hotspot frameworks.

In all analyzed reconstructions there is a good fit between the modelled and recorded inclinations meanwhile the fit between the declinations is better for data which VGPs are in the north hemisphere.

In all the cases the modelled transitional data show a cluster of VGPs in the north hemisphere as that represented by the recorded transitional data. Both transitional clusters are better grouped in the models of Pangaea with palaeo-latitudinal and palaeo-longitudinal (absolute) reconstructions (compare fig. 2 with figs. 3, 4 and 5).

Pangaea A and A2 models show better fits between the transitional VGPs clusters than does the Pangaea B model (compare fig. 3 and 4 with fig. 5).

5. Conclusions

An analysis of the reversal recorded in the Siberian Trap Basalts suggests that similar features to those considered by Gubbins (1994) could have driven even reversals in the Permo-Triassic.

In spite of the uncertainties associated with the hotspot frameworks and Pangaea configurations, the modelled and recorded data show a better fit when both palaeo-latitudinal and palaeo-longitudinal reconstructions are considered.

Pangaea A and A2 show remarkable fits between the recorded and modelled clusters of transitional VGPs. Pangaea B, shows the best fit between the mean Siberian Trap PP and a Permo-Triassic Gondwana PP but has fewer geological arguments in favour for 250 Ma (Hallam, 1983; Irving, 2004) and does not show as good fit between the recorded and our modelled transitional clusters of VGPs.

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