Tectonophysics 352 (2002) 335–348
TECTONOPHYSICS
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The Taimyr fold belt, Arctic Siberia: timing of prefold remagnetisation and regional tectonics

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Received 29 August 2001; accepted 9 April 2002

Abstract

Late Precambrian and Palaeozoic platform sediments from the Central–South Taimyr Peninsula (Arctic Siberia) are all remagnetised. The remagnetisation is prefold and is related to thermal remagnetisation caused by Taimyr Trap magmatism. The remagnetisation age is estimated to 220–230 Ma and, hence, is considerably younger than the ca. 251 Ma age for the main body of Siberian Trap flood basalts. The folding that affected the Taimyr region platform sediments also included the Taimyr "Traps," hence, relegating Taimyr deformation to post-Mid Triassic time, and most probably, to a Late Triassic age. This shows that whilst thrusting terminated in the Urals during the Permian, crustal shortening continued in Taimyr, Novaya–Zemlya and the South Barents Sea, well into the Mesozoic.

Keywords: Taimyr; Arctic Siberia; Palaeozoic; Palaeomagnetism; Remagnetisation

1. Introduction

The Taimyr Peninsula of Arctic Siberia has traditionally been divided into three main parts: North, Central and South Taimyr. North Taimyr, together with Severnaya Zemlya (Fig. 1a–b), contains the Kara microcontinent that is suggested to have collided with Siberia (Central and South Taimyr) during the Late Palaeozoic Uralian Orogeny (Vernikovsky, 1996, 1997). Central Taimyr has been defined by the presence of an accreted terrane (Faddey Terrane) with ophiolites (800–740 Ma) and its collision with South Taimyr was suggested to have occurred at around 600–570 Ma. The sedimentary succession of Central and South Taimyr records the development of a stable platform from the Upper Riphean to the late Carboniferous (Vernikovsky, 1997); the platform sequence unconformably covers the accreted Faddey Terrane of Central Taimyr and was used to provide an upper age limit for the timing of amalgamation of the Central and South Taimyr units. The change in the Central–South Taimyr depositional environment from that of stable platform to a foreland basin setting with continental sandstone deposition has been related to the Late Palaeozoic to Early Mesozoic collision of the amalgamated Central–South Taimyr blocks with the Kara microcontinent.

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PII: S0040-1951(02)00274-3

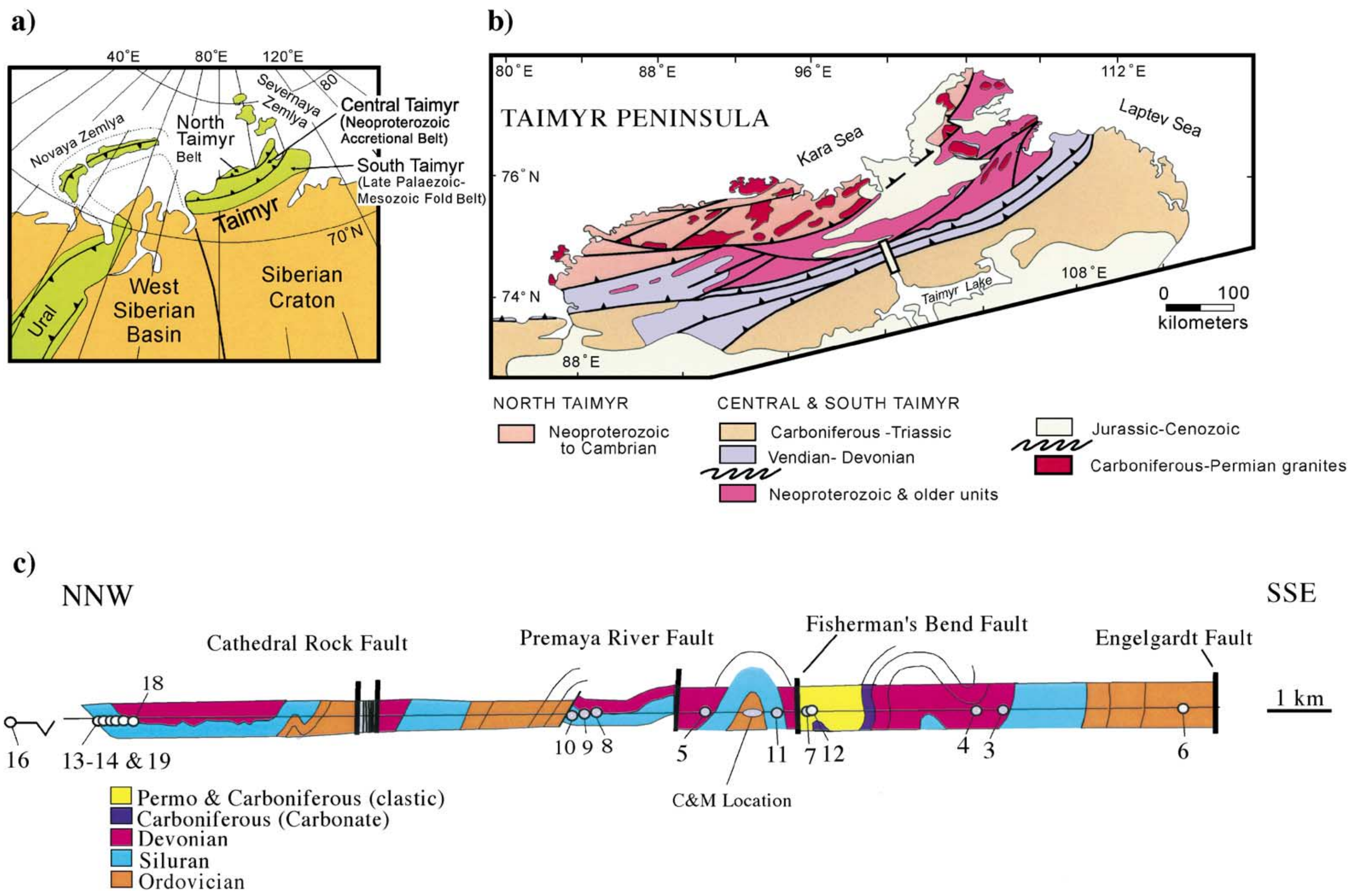

Fig. 1. (a) Geological and location map of Arctic Siberia and adjacent areas (after Metoelkin et al., 2000). (b) Geologic map of Taimyr (after Vernikovsky, 1997). Sampling profile in (c) shown as rectangle (north of Taimyr Lake). (c) Palaeomagnetic sampling profile. Structural profile after Inger et al. (1999). C&M location = Late Ordovician brachiopods locality of Cocks and Modzalevskaya (1997).

In the scenario described above, Central and South Taimyr were part of Siberia from Late Precambrian times and represented the passive margin (present coordinates) of the Siberian continent during most of the Palaeozoic. A different scenario for the arrangement and position of Central and South Taimyr has been forwarded by Cocks and Modzalevskaya (1997); they argue that Ashgill brachiopod fauna (Fig. 1c) in Central Taimyr show links with brachiopod fauna in Sweden and, therefore, that Central Taimyr belonged to Baltica in the Late Ordovician. Brachiopods studied by Cocks and Modzalevskaya (1997) were presumed to belong to Central Taimyr, but we stress that no geological evidence (see also Inger et al., 1999) supports a Palaeozoic suture between Central and South Taimyr. If indeed present, an older suture (ca. 600–570 Ma) between Central and South Taimyr is now completely concealed below the passive-margin de-

Table 1
Sampling details and site mean statistics

Site	Stratigraphic age	St/Dip	C	N	α_{95}	k	Dec	Inc	TDec	TInc
11	Basaltic dyke	148/83 *	H	12	2.8	247	339.8	– 60.0	327.5	– 60.6 *
7	Carboniferous–E Permian	244/82	L	11	8.2	32	355.7	81.9	337.0	0.5
12	Carboniferous–Permian	270/84	L	15	11.8	12	301.3	78.5	350.2	0
4	Devonian III	239/74	H	9	7.7	46	332.5	7.9	337.5	– 65.9
			L	5	11.8	43	288.5	78.8	321.7	7.4
3	Devonian I–II	239/77	H	9	7.2	52	332.9	25.3	334.7	– 51.5
			L	5	17.2	21	329.6	72.5	329.2	– 4.5
5	Devonian I–II	255/52	H	7	2.8	463	340.9	– 18.1	333.7	– 69.8
			L	3	8.1	234	356.2	60.5	350.6	8.9
8	Lower Devonian I–II	37/11	H	12	1.9	538	94.6	– 85.1	328.0	– 82.7
			L	5	20.7	67	51.2	77.7	86.2	71.6
9	Upper Silurian II	8/10	H	6	7.7	76	25.3	– 84.7	309.2	– 80.2
18	Devonian I–II	46/30	H	8	2.9	365	159.4	– 67.3	271.2	– 77.4
14h	Mid–Upper Silurian	67/41	H	4	11.6	63	149.5	– 75.2	341.3	– 63.6
14c	Mid–Upper Silurian	57/37	H	5	3.3	537	161.1	– 66.7	305.6	– 74.7
14b	Mid–Upper Silurian	62/39	H	3	5.1	587	169.2	– 70.3	315.8	– 69.1
14a	Mid–Upper Silurian	67/40	H	7	3.5	296	167.5	– 69.9	326.7	– 69.5
19	Mid–Upper Silurian	55/40	H	18	4.3	66	157.6	– 59.5	292.6	– 78.1
13f	Silurian (Wenlock–Ludlow)	61/47	H	5	9.3	69	142.8	– 37.0	102	– 81.3
13d	Silurian (Wenlock–Ludlow)	46/41	H	5	4.7	263	160.4	– 58.4	268.5	– 72.9
13c	Silurian (Wenlock–Ludlow)	47/41	H	5	2.8	773	158.2	– 64.4	288.5	– 70.9
13b	Silurian (Wenlock–Ludlow)	55/46	H	5	7.6	103	146.2	– 61.9	323.2	– 72.1
13a	Silurian (Wenlock–Ludlow)	51/40	H	5	2.3	1131	155.6	– 59.0	283.5	– 77.7
10	Lower Silurian	68/38	H	7	3.4	314	171.9	– 52.6	257.5	– 81.5
6	Ordovician II	233/85	H	7	8.9	47	327.8	18.8	334.1	– 65.7
			L	6	7.7	76	334.9	84.3	324.2	– 0.6
16	Riphean	188/20	H	5	13.9	31.4	308.8	– 62.9	352.8	– 76.0
	Site means (in situ)		H	19#	24.1	2.9	172.0	– 83.9		
	Bedding corrected (positive fold test)				4.9	47.2			318.6	– 75.0
	(pole: 49.6°N, 128.8°E dp/dm = 8.2/8.9)									
	Site means (in situ)		L	7#	8.6	50.2	341.6	78.7		
	(pole: 81.0°N, 328.6°E dp/dm = 15.4/16.3)									
	Bedding corrected (negative fold test)				29.0	5.3			338.4	11.3

Mean sampling coordinates 75.2°N and 100°E. St/Dip = strike/dip bedding (* strike/dip of dyke); C = component (L = low unblocking, H = high unblocking); N = samples (#sites); α_{95} = 95% confidence circle; k = precision parameter; Dec/Inc = mean declination/inclination (in situ); Tdec/TInc = mean declination/inclination tectonically corrected; Pole = palaeomagnetic pole; dp/dm = semiaxes of the cone of 95% confidence about the pole.

posits of Late Precambrian and younger age. We determine a Palaeozoic distinction between Central and South Taimyr to be confusing, and refer to the entire study area as Central–South Taimyr.

2. Rationale and sampling details

Baltica and Siberia have quite different Palaeozoic apparent polar wander (APW) paths for most of the Palaeozoic (Torsvik et al., 1996; Smethurst et al., 1998) and this originally prompted us to test the Cocks and Modzalevskaya (1997) hypothesis via detailed studies of Palaeozoic sediments from Central–South Taimyr (Fig. 1b–c). However, as shown later, the Taimyr rock record suffered complete remagnetisation in Triassic times that has clouded our original research intentions but, nevertheless, has cast an interesting light on the geological evolution of the Taimyr Peninsula and aspects of Arctic palaeogeography. In addition to remagnetisation problems, most Ordovician sequences (except site 6) proved unsuitable for palaeomagnetic sampling (fissile-fractured) and we focused our sampling on Silurian, Devonian and Carboniferous–Early Permian sites in a ca. 20 km N–S profile along the Taimyr River (Fig. 1b–c, Table 1). We also sampled four sites of Late Riphean stromatolitic carbonates 12–15 km to the north of the main sampling area. Ordovician to Devonian sites included limestones and dolomites whilst the Carboniferous–Early Permian were sampled in sandstones.

All sequences are folded on a NE–SW fold axis (mean 067°), but with little evidence for penetrative deformation and only rare cleavage. Folding along this axis also deforms magmatic rocks (‘Taimyr Traps’) immediately to the south of our study area. No internal unconformities are observed in the Palaeozoic strata. A few dykes cut the folded strata, and we examined one of these at site 11 (Fig. 1c). This dyke truncates folds at a high angle, but is affected by minor brecciation along its margins and may, thus, be late syntectonic. Structural details and tectonic interpretations along our sampling profile in Fig. 1c are detailed in Inger et al. (1999) and we confine our structural descriptions below to those issues with direct relevance to the palaeomagnetic results.

3. Laboratory experiments

The natural remanent magnetization (NRM) was measured with a 2G DC SQUID. Stability of NRM was tested by thermal and alternating field (AF) demagnetisation. Characteristic remanence components (ChRc) were calculated with least square regression analysis.

NRM intensity for the sediments varied between 15 and 0.01 mA/m but the majority of the samples yield intensities below 1 mA/m. Only one of the Upper Riphean sites (site 16) yielded directionally stable palaeomagnetic data (Table 1). Thermal and AF demagnetisation yield similar directional results; most samples show minor, low unblocking components with steep positive inclinations due NNW (in situ coordinates). This component (denoted L) is typically removed at around 250 °C or in AF fields below 10 mT (Fig. 2A–C) and characteristically constitutes 10–20% of the total NRM. Exceptions are sites 3 and 4 (Fig. 2D), where the L component is more dominant; from two sites (sites 7 and 12; both Permo-Carboniferous sandstones), a high unblocking component was not identified due to directional instability at high temperatures, or high AF fields. Component L (normal polarity) fails a fold-test at the 95% confidence level (Table 1), in situ site means plot close to the present day field, and component L is, therefore, considered as a present/recent viscous remanent magnetisation, and is not further elaborated.

High unblocking components (component H) have maximum unblocking temperatures at around 550–580 °C (Fig. 2A) and suggest magnetite as the prime remanence carrier. AF stability is typically achieved up to 120–160 mT (Fig. 2B and C). Within-site grouping of component H is extremely good (α_{95} often < 5° and k>500; Table 1). In situ site mean directions are distributed along a NW–SE girdle that closely mimics the distribution of bedding poles (Fig. 3a). Bedding-corrected H-component site means cluster and have NW declinations with steep negative inclinations (Fig. 3b). H-components pass a fold-test at the 95% confidence level (Fig. 3c) and they are, thus, prefold in origin.

The tested dyke from site 11 (Fig. 1c) yields variable NRM intensities (58 ± 73 mA/M), but all samples yield exemplary single-component magnet-

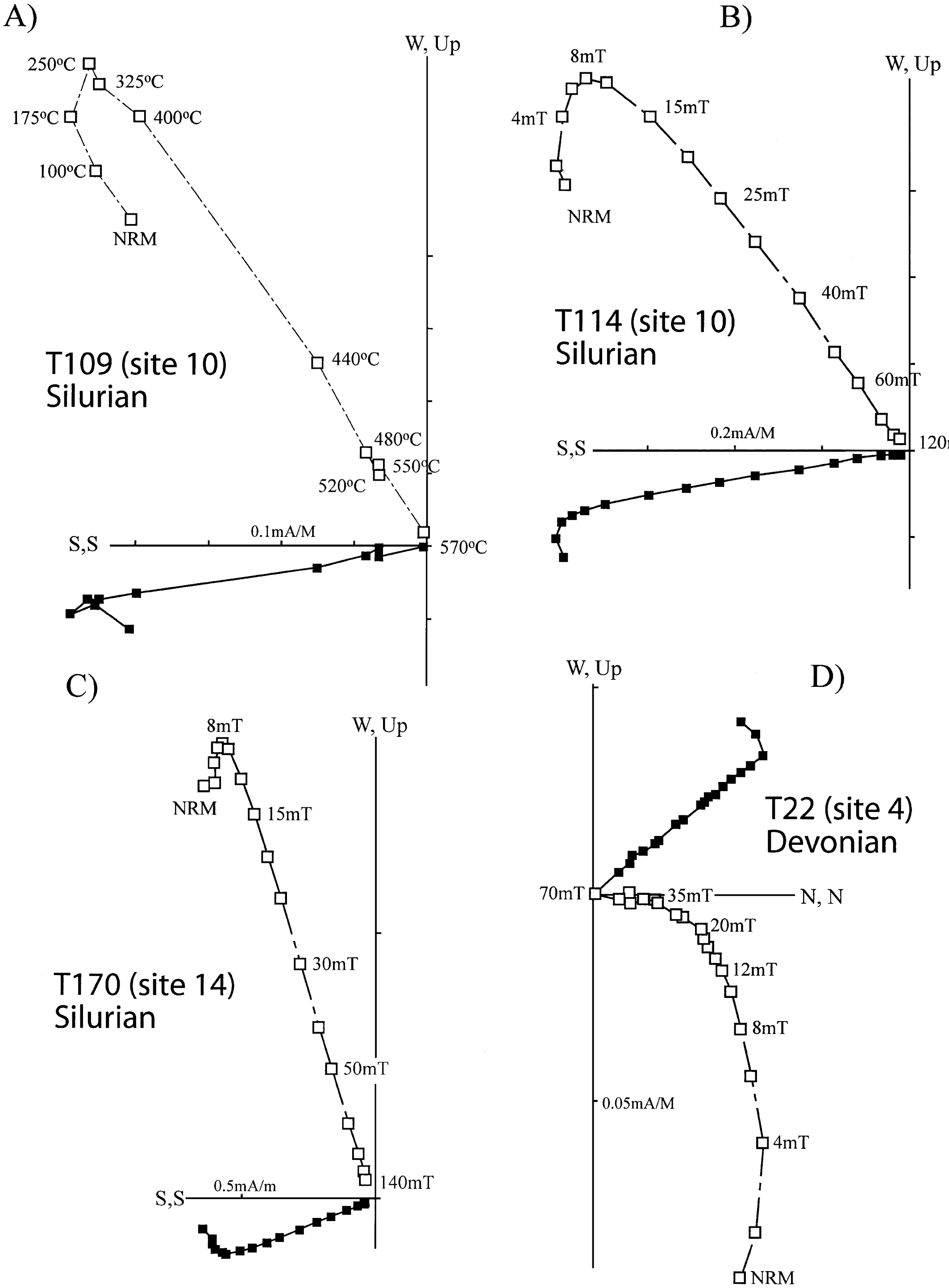

Fig. 2. Examples of thermal (A) and alternating field demagnetisation (B–D) of Silurian and Devonian platform limestones from Central–South Taimyr. All data shown in in situ coordinates. In Zijderveld plots, open (solid) symbols denote point in the vertical (horizontal) plane.

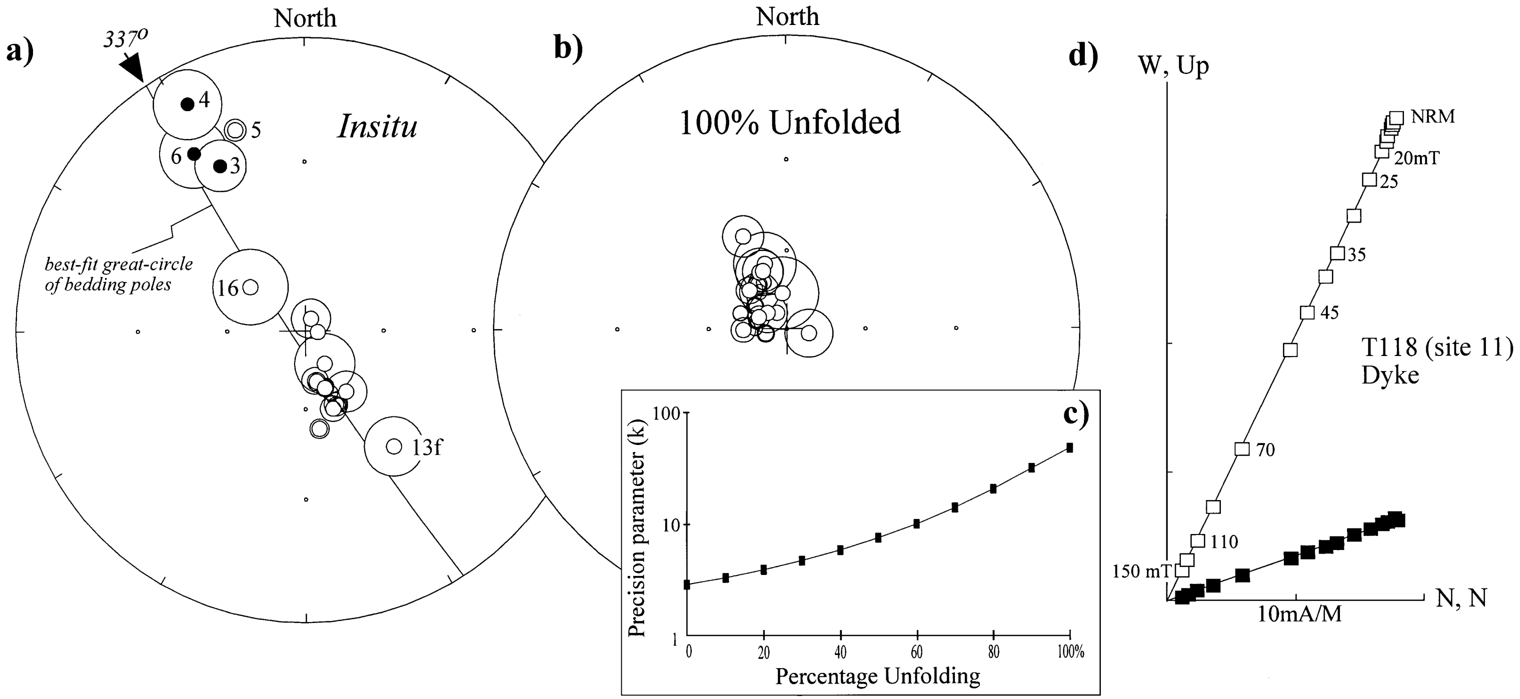

Fig. 3. (a) Late Riphean–Palaeozoic site means (in situ) with α_{95} confidence circles (H components). (b) Bedding-corrected site means (100%). (c) Stepwise fold-test showing the variation in precision parameter k as function of percentage unfolding. (d) Example of AF demagnetisation of a site 11 dyke sample. In stereoplots, open (closed) symbols represent negative (positive) inclinations.

isations with NW declinations and steep negative inclinations (Fig. 3d).

4. Origin and age of prefold magnetisation

The H-component is prefold, but all site means converged to a common mean direction, independent of rock age (Fig. 3b, Table 1); these features testify to a prefold *remagnetisation*. The alternative (i.e. primary remanences), would implicate no APW or magnetic reversals for the entire 250–300 million year time-span of sediment deposition; we do not consider either of these latter two interpretations seriously. The remagnetisation matches palaeomagnetic directions from volcanics and intrusives in Taimyr (Fig. 4a; Table 2); we find it obvious to relate the complete remagnetisation in Taimyr to a regional thermal event, probably of Triassic age (see below). While Site 11 dyke magnetisations have somewhat shallower inclinations than the Taimyr sediments (Fig. 4a), the dyke magnetisation itself must be regarded as a geomagnetic spot-reading. The dyke is probably late syntectonic whilst the Taimyr sediments record a prefold magnetisation.

The Taimyr Traps were or have been assumed to be comagmatic with the Siberian Traps (Fig. 4b), the largest known igneous province in the world, and temporally linked to the massive Permo-Trassic extinction event at ca. 251 Ma (Kamo et al., 1996;

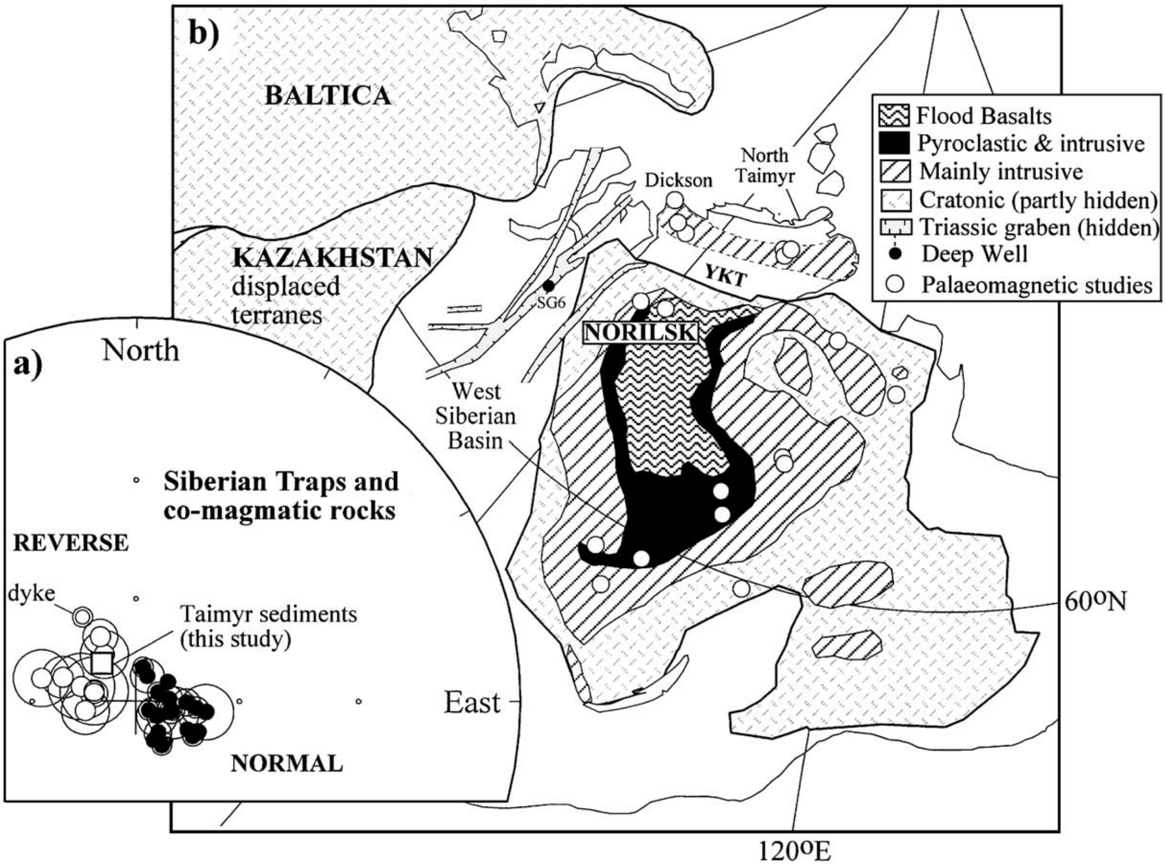

Fig. 4. (a) Comparison of the Taimyr sediment magnetisation with the Siberian Traps (poles listed in Table 2) recalculated to a sampling location of 75.2°N and 100°E. Mean directions are shown with α_{95} confidence circles. Sampling locations are shown in (b). We also show the site 11 dyke magnetisation (in situ). (b) Distribution map of Siberian Traps and assumed comagmatic rocks simplified from Sharma (1997) and Gurevitch et al. (1995). SG6 = Tyumenskaya Well, West Siberian Basin.

Table 2
Palaeomagnetic poles from Siberian Traps and assumed comagmatic rocks (243–251 Ma) and 248–253 Ma Siberian platform poles used in the compilation by Smethurst et al. (1998)

	α_{95}	Glat.	Glon.	Plat.	Plon.	GPDB
Norilsk Region						
Tuffolavova series	4	69	88	62	134	2030
Ivakinsk and Kayerkansk groups	7	69	88	61	173	1990
Ivakinsk and Kayerkansk groups	4	69	88	60	152	1990
Norilsk region intrusives	4	69	88	57	128	1990
Norilsk region intrusives	8	69	88	38	164	1990
Syverminskaya, Mokulaevskaya suites	4	69.5	91	498	146	3044
Siberian traps, Tungus synclise	8	69.5	91	45	149	1985
Taimyr Region						
West Taimyr volcanics	3	72.8	86	43	129	2078
Siberian traps, Western Taimyr (Q=7)	10	72.9	84	59	150	2832
Dixon island intrusions	5	73.5	81	38	122	2078
Central Taimyr volcanics	7	74.9	100.5	46	124	2021
Eastern Taimyr basalts (Q=6)	8	75.2	100	59	145	R1
Eastern Taimyr sills (Q=6)	3	75.2	100	47	1226	R1
Miscellaneous						
Siberian traps, Angara river	2	57	101	61	141	880
Angara region intrusives, Angara	3	58.5	99	49	128	968
Tuffogenic group, Angara river	3	59	103	52	116	880
Siberian traps, Lena river	3	59.5	112	76	130	880
Lena region tuffs, Lena	4	70	123.5	49	143	1988
Siberian traps, Lower Tunguska river	3	62.5	108	63	138	880
Siberian traps, Lower Tunguska river	5	63.5	107	76	142	880
Tuffogenic group, Lower Tunguska river	6	63.5	107	51	127	880
Sytykan and Aikhal Sills, Yakutia	4	66	111.8	53	163	3041
Siberian traps, Anabar–Udzha	6	72	114	44	157	1988
East Siberian traps (Q=6)	10	66	111.6	53	154	R2
Siberian platform poles (248–253 Ma)#						
Markha region volcanics and I (Q=5)	5	66	112	51	158	1997
Ygyattin region intrusions (Q=4)	4	64	115	55	141	968
Upper vilyui intrusives (Q=4)	4	66	108	56	168	1986
Upper Markha region intrusion (Q=5)	6	66	111	48	154	968
Lena river sediments (Q=5)	19	73	125	45	136	1964
Mean Siberian traps (N=24)	5.0 *			54.7	140.5	
Norilsk (N=7)	9.7 *			54.0	150.0	
Taimyr (N=6)	9.6 *			49.2	130.3	
Miscellaneous (N=11)	7.7 *			57.7	140.7	
Siberian platform (N=5)#	8.8 *			51.6	150.9	

Palaeomagnetic poles are based on very limited stability testing (only NRM, pilot and/or blanket cleaning except pole marked with quality factor Q (Van der Voo, 1993). N = number of poles; α_{95} = 95% confidence circle (* = A95). Glat./Glong. = geographic latitude/longitude; Plat./Plon. = pole latitude/longitude; Europe–North America reference pole at 250 ± 10 Ma is 51.7°N, 154.8°E, A95 = 2.5; N = 28 (recalculated to European frame from Torsvik et al., 2001). #Data selection of Smethurst et al. (1998). GPDB = Global Palaeomagnetic Data Base Reference Number (REFNO in McElhinny and Lock, 1966). Access database from http://www.ngdc.noaa.gov/seg/potfld/paleo.shtml or http://dragon.ngu.no/Palmag/paleomag.htm. R1 = Walderhaug et al. (2001) and manuscript in preparation; R2 = calculated from Kravchinsky et al. (2002).

Bowring et al., 1998). Palaeomagnetic directions from the Siberian Traps (s.l.) are broadly similar to one another (Fig. 4a), despite the fact that only three datasets (Gurevitch et al., 1995; Walderhaug et al., 2001; Kravchinsky et al., 2002) are properly documented with modern technical and analytical proce-

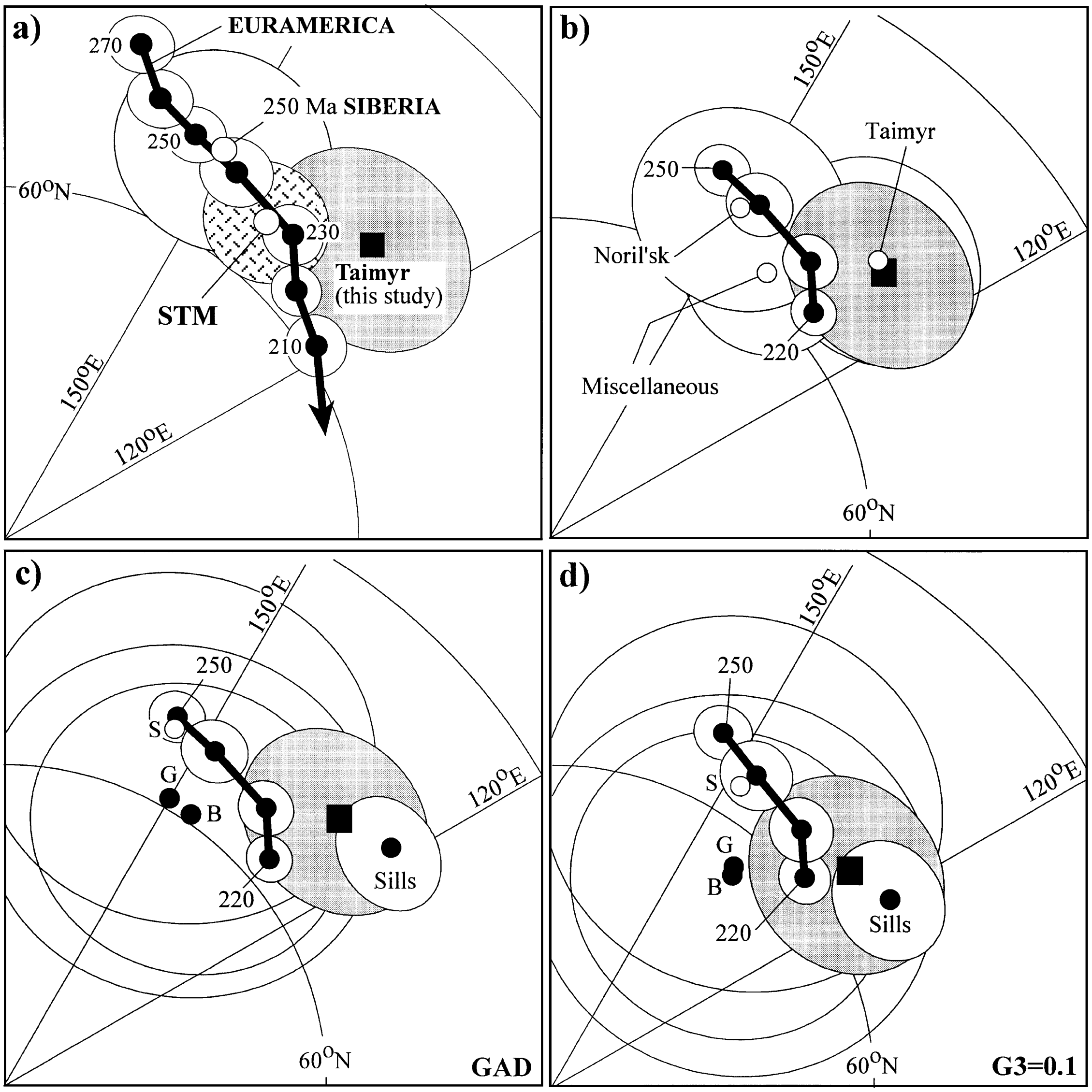

Fig. 5. (a) Euramerica APW path (after Torsvik et al., 2001; in European coordinates) shown along with the Taimyr sediment pole (component H bedding-corrected; Table 1). We also show a mean pole for all Siberian Traps (pole STM), and mean 250-Ma pole of Smethurst et al. (1998) (Table 2). All poles are shown with A95 confidence circle except the Taimyr sediment pole that is shown with d*p*/d*m* confidence ellipsoid. Euramerica APW path is shown in 10-Ma intervals with A95 confidences circles. (b) Siberian Traps separated into mean poles from Noril'sk, Taimyr and Miscellaneous (Table 2), and compared with the Taimyr sediment pole and the Euramerica APW path in (a). (c) The Taimyr sediment pole and the Euramerica APW path as in (a) but compared with only the most recent individual poles (Table 2) derived from the "Siberian Traps." All poles shown with d*p*/d*m* confidence ellipsoids. Pole are as follows: S = East Siberia Traps (Kravchinsky et al., 2002); G = Western Taimyr Volcanics (Gurevitch et al., 1995); B = East Taimyr basalts and Sills = East Taimyr Sills (Walderhaug et al., 2001 and manuscript in preparation). (d) As in (a) but all poles and Euramerica APW path have been recalculated with octupole contributions (G3 = 0.1). Note that Taimyr poles converge toward Mid-Triassic 'ages.'

dures. All our data are of reverse magnetic polarity whilst the Siberian Traps show both polarities (Fig. 4a); we suggest that probably the youngest magmatic outburst(s) in Taimyr remagnetised all the sediments in a reverse-polarity palaeofield.

Practically all reliable isotope ages for the Siberian Traps come from the Noril'sk area (Central Siberia), and Kamo et al. (1996) obtained a U–Pb age of 251.2 ± 0.3 Ma for the Noril'sk-1 intrusion. Noril'sk-1 cuts the lower suites of the flood-volcanic sequence, and recent ages of 252.1 ± 0.4 and 251.1 ± 0.5 Ma (Kamo et al., 2000; Czamanske et al., 2000) are considered to cover the entire duration of Siberian flood volcanism. The paucity of reliable isotope data for areas outside Central Siberia makes correlation to the Central Siberian Traps problematic. Late Permian and Early Triassic ages (Induan stage) have been suggested for the Taimyr Traps (Western Taimyr; Gurevitch et al., 1995), but isotopic ages are urgently needed.

In Fig. 5a, we compare the Taimyr overprint pole with a ca. 250 Ma mean Siberian pole (248–253 Ma poles listed by Smethurst et al., 1998; our Table 2), a Siberian Traps mean pole (Table 2) and a new APW path for Euramerica (Torsvik et al., 2001). Smethurst et al. (1998) did not include any palaeomagnetic results from the Siberian Traps since all of them at that date, except the Gurevitch et al. (1995) data from Western Taimyr, have been subjected to limited, if any, stability testing. The 250 Ma Siberian pole plots close to the 250 Ma Euramerican pole whilst the Taimyr overprint and Siberian Traps mean poles fall closer to the 230–220 Ma segment of the Euramerican APW path (Fig. 5a). Separating the Siberian Traps mean pole into three mean poles (Fig. 5b), namely Norsil'sk (from where high-precision isotope ages were derived), Taimyr and Miscellaneous (Table 2), it now becomes clear that the Noril'sk pole statistically overlaps with the 250 Ma Euramerica mean pole. Conversely, the Taimyr and Miscellaneous poles plot closer to 220–230 Ma, and the Taimyr sediment remagnetisation is practically identical to the Taimyr volcanics and intrusives mean pole.

As noted earlier, the majority of Siberian Traps related rocks have not been subjected to rigorous experimental procedures, and if we only plot studies of modern date, a slightly different picture emerges (Fig. 5c): poles from East Siberia Traps (pole S), Western Taimyr volcanics (pole G) and East Taimyr basalts (pole B) plot closer to the 250 Ma reference pole whilst a pole derived from the East Taimyr Sills is similar to our Taimyr prefold remagnetisation pole, and they both indicate a Mid-Triassic age. A clockwise rotation of ca. 35° can restore the two latter poles to the 250 Ma reference pole, but we find this highly unlikely since the East Taimyr basalt pole (Fig. 5c) comes from the same region (i.e. must also be corrected for the same amount). We also tested for nondipole field contributions (see Van der Voo and Torsvik, 2002) as a possible cause for this apparently young age. Recalculating all poles with octupole contributions reduces the overall scatter in the dataset, but all poles would be further removed from the 250 Ma reference pole, and indeed all the Taimyr poles converge toward Mid-, and perhaps also Late, Triassic reference poles with increased octupole contributions (exemplified with $G3 = 0.1$ in Fig. 5d). Therefore, we propose on the basis of palaeomagnetic data that the Taimyr prefold remagnetisation and the East Taimyr Sills are Mid-Triassic in age.

5. Structural implications: age of folding

The Taimyr remagnetisation predates the main folding event in Taimyr and the sediments were remagnetised while flat-lying (Fig. 6b). This constraint on timing of remagnetisation restricts all deformation and folding in Taimyr (including the Taimyr Traps) to a post-Mid Triassic (post 220–230 Ma) event. An alternative model could follow Inger et al. (1999) who argued for a two-stage evolution of the Taimyr fold belt: (1) Permo-Carboniferous thin-skinned thrusting in northern Central–South Taimyr (Uralian Orogeny) with southern Central–South Taimyr as the distal foreland (Fig. 6a), and (2) Late Triassic folding and dextral strike-slip faulting (Fig. 6c). Stage 1 would probably have to be connected with the initial Late Carboniferous–Early Permian collision of Central–South Taimyr with North Taimyr (Kara) as recorded by syncollisional (ca. 300 Ma) to postcollisional (ca. 264 Ma) granites and metamorphism in North Taimyr (Vernikovsky, 1997). Subduction in such a scenario probably took place beneath North Taimyr (Fig. 6a). This latter model requires that the stratigraphy, or at least the majority of our sampling sites, were fairly

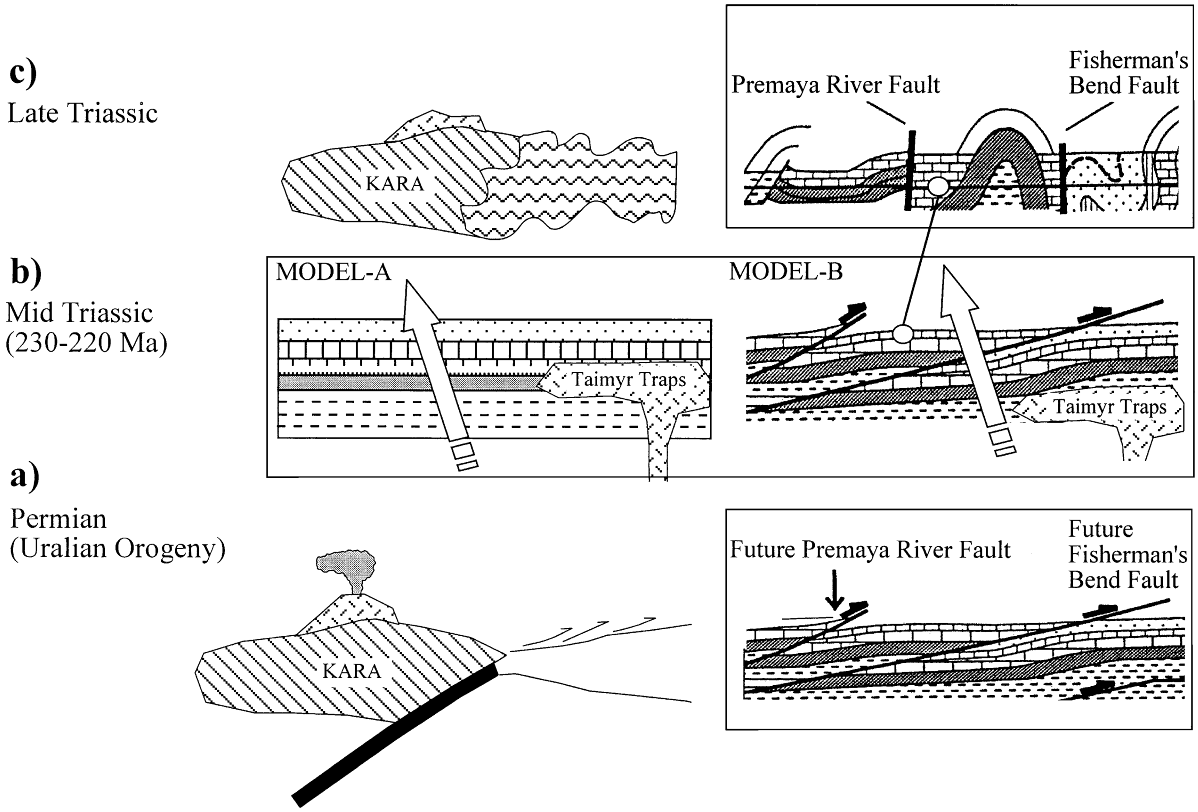

Fig. 6. (a) Permian or Late Carboniferous collision of Central–South Taimyr with North Taimyr (Kara) with thin-skinned thrusting in Central Taimyr (after Inger et al., 1999). Subduction beneath North Taimyr is inferred. (b) Mid-Triassic Trap magmatism leading to complete remagnetization of the Taimyr sediments. The Taimyr sediments were remagnetised while practically flat-lying (left-hand model), but the alternative model with an early phase of thin-skinned thrusting is applicable as long as the majority of our sampling sites were fairly horizontal prior to Trap-magmatism. (c) 'Final collision' of Kara block with Central–South Taimyr leading to folding and dextral strike slip faulting, probably in the Late Triassic.

horizontal (exemplified in Fig. 6b) prior to Taimyr Trap-magmatism and the regional remagnetisation event. Independent of the favoured structural evolution—either the one- or the two-stage history—we relate regional remagnetisation to the thermal effects of Taimyr Trap magmatism in Mid-Triassic times.

6. Late Palaeozoic–Mesozoic palaeogeography

During the Late Palaeozoic all continents, except microcontinents within the Palaeo-Neo Tethys realm, converged to form the Pangea Supercontinent (Fig. 7a). Therefore, most published Late Carboniferous–Permian reconstructions show Siberia attached to Pangea at this time (Fig. 7a) and amalgamation of Siberia with Pangea is considered to predate eruption of the Siberian Traps at the Permo-Triassic boundary (ca. 251 Ma). This massive magmatic event is by some considered to be the expression of back-arc extension induced by progressive decay of an eastward-dipping Uralian subduction zone (Ziegler, 1988), whilst others have favored a hot spot origin (Golonka and Bocharova, 2001).

Fig. 7a is a classic equatorially centred Pangea A-type reconstruction (Scotese, 1997) with Siberia located at around 60°N, and sutured to Arctic Baltica/Kazakhstan by the Late Permian. A slightly different reconstruction of the Northern Pangea elements is shown in Fig. 7b. In this reconstruction,

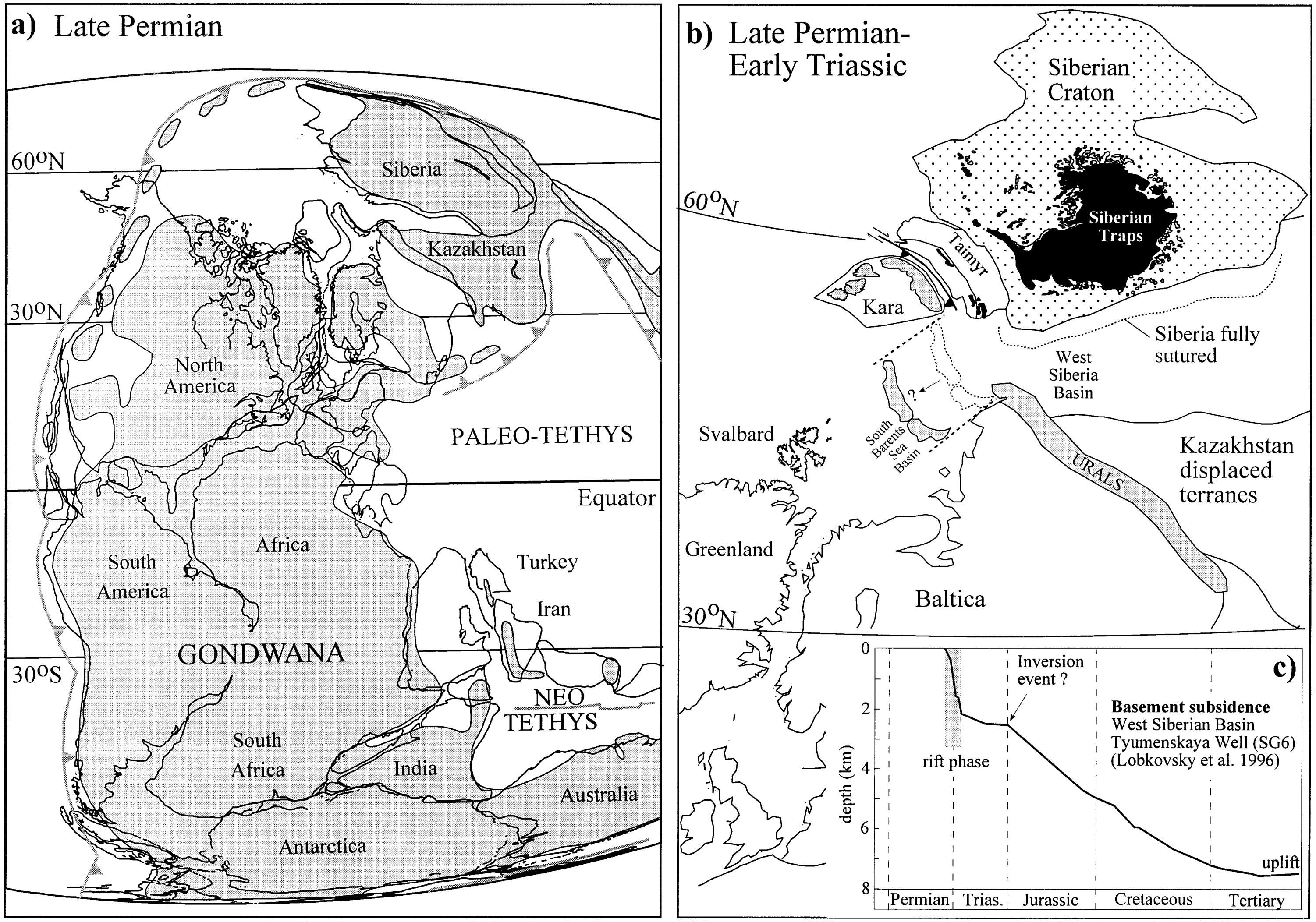

Fig. 7. (a) Late Permian reconstruction (simplified from Scotese, 1997). (b) Palaeoreconstruction at ca. 250 Ma. Pangea A type reconstructions using a 250-Ma mean pole of Torsvik et al. (2001). Siberian craton reconstructed after ca. 250 Ma data listed by Smethurst (1998) (Table 2). Taken at face value, the Siberian craton plot 150 km north of Baltica (not statistically significant). Siberian Traps reconstructed to 250 Ma are shown as black areas/patches. (c) Basement subsidence curve from deep-well SG6, West Siberian Basin (see location in Fig. 4b). Note possible inversion event at the Triassic–Jurassic boundary followed by regional subsidence.

Europe (including Baltica), North America, Svalbard and Greenland are reconstructed according to Torsvik et al. (2001) at 250 ± 10 Ma (their model II). Late Palaeozoic–Mesozoic palaeomagnetic data are not available for the Kara Block, and for reasons of diagram simplicity we show the Kara Block connected to Eurasia. The Central–South Taimyr region, attached to the Siberian Craton, is reconstructed with the ca. 250 Ma mean pole of Smethurst et al. (1998); this mean pole (Fig. 5a; Table 2) produces the smallest latitudinal misfit (150 km) between Baltica and Siberia (Fig. 7b).

If the reconstruction in Fig. 7b has any substance, then post-Mid Triassic shortening/dextral shortening must have occurred between Central–South Taimyr and the Kara Block. Compression is also expected within the West Siberian Basin (WSB). While the Late Palaeozoic–Mesozoic tectonic evolution of the WSB is poorly understood and tectonic information is only available from deep wells and geophysics, subsidence curves from the WSB suggest the main rift phase at the Permo-Triassic boundary (Lobkovsky et al., 1996) with a possible inversion event at the Triassic–Jurassic boundary (Fig. 7c). Inversion was again followed by regional subsidence. Late Triassic inversion also occurred in the Eastern part of the South Barents Sea Basin (Otto and Bailey, 1995) and Pay–Khoy (Nikishin et al., 1996) in the Polar Urals. Otto and Bailey (1995) further suggested that Novaya Zemlya represents an allochthonous body (stippled outline in Fig. 7b) thrust westward into its present position during the Late Triassic. On the Taimyr Peninsula, folding and dextral strike-slip faulting is clearly post-Mid Triassic in age (Fig. 6c). While we stress that a latitudinal offset of 150 km (Fig. 7b) is below the resolution of palaeomagnetic data, the Early Mesozoic tectonic history in the Arctic regions make it clear that some tectonic deformation or reactivation between Baltica and Siberia must have taken place at this time. The most important event probably occurred in the Late Triassic.

During the Carboniferous, Euramerica was rotating clockwise while undergoing northerly drift (Gurnis and Torsvik, 1994; Torsvik et al., 2001), but the climax of the Uralian Orogeny near the Permo-Carboniferous boundary coincides with the onset of counter-clockwise rotation; this may very well have resulted by impinging of Kazakhstan terranes and later, West Siberia, with NE Europe (Nikishin et al., 1996). Counter-clockwise rotation persisted until the Late Triassic–Early Jurassic when the bulk of tectonic deformation ceased in the Arctic regions. The Late Triassic also coincided with systematic changes in the continental configuration in northern Pangea (Torsvik et al., 2001).

7. Conclusions

(1) Due to extensive remagnetisation in Taimyr, our study does not shed direct insight into the hypothesis that Central–South Taimyr was part of Baltica during the Palaeozoic (Cocks and Modzalevskaya, 1997). If this palaeogeographic hypothesis has substance, a post-Mid Triassic suture must be hidden beneath the Mesozoic and Tertiary strata of the Yenisey–Katanga Basin (Fig. 4b).

(2) High-temperature components from the Taimyr sediments pass a fold-test at high statistical significance, but all site means converge to a common mean direction, independent of rock age; hence, the sediments were remagnetised prior to folding. This stresses the fact that fold-tests only provide relative age constraints. In our case, a remagnetisation was identified since we studied the entire Taimyr stratigraphy.

(3) The pretectonic sedimentary remagnetisation matches palaeomagnetic directions from the Taimyr Traps (notably East Taimyr Sills) and is, therefore, related to this regional thermal event. Palaeomagnetic data suggest an age at around 220–230 Ma, and magmatism in Taimyr could therefore, at least in part, be considerably younger than that of Central Siberia Traps.

(4) The Taimyr remagnetisation is prefolding. The sediments were remagnetised while flat-lying in Mid-Triassic time, restricting all deformation and folding in Taimyr to a post-Mid Triassic event. An alternative model with an early (Late Palaeozoic) phase of thin-skinned thrusting (Inger et al., 1999) is applicable only as long as the majority of our sampling sites remained fairly horizontal prior to Trap-magmatism.

(5) Taimyr folding is estimated to be Late Triassic and shows that whilst thrusting terminated in the Urals during the Permian, crustal shortening continued in Taimyr, Novaya–Zemlya and the South Barents Sea. In Taimyr, folding and deformation took place at brittle/high-crustal conditions.

Acknowledgements

NFR, NGU, INTAS and VISTA are thanked for their financial support. Discussions with E.A. Eide and H.J. Walderhaug and comments from M. Westphal and M.L. Bazhenov are greatly appreciated.

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