Introduction

In relatively earthquake-free areas we are commonly lulled into believing that the land is static and only weather and the oceans are dynamic. What a brief time scale we inhabit! Yet Norway, through the ages, has been far from passive. Her margins, her mountains and her very blood, petroleum, were formed in the cauldron of Plate Tectonics. Plate tectonics models the complex and dynamic evolution of the Earth through endless ages, and addresses and explains the fascinating history of continents that move, split apart, collide and deform through the processes of sea-floor spreading and subduction. At times, continents have coalesced into very large bodies and even supercontinents, in the process generating vast mountain belts, crustal thickening, extensional collapse and exhumation of high-pressure rocks. The formation and break-up of supercontinents (Torsvik 2003) is the most spectacular demonstration of the extremely dynamic nature of our planet, and some evidence points to a periodicity of about 500 Ma in supercontinent formation during Earth history. The cyclicity of supercontinent amalgamation and dispersal has affected both deep and surficial Earth processes and has driven biological evolution and climatic changes.

Norwegian geology provides a virtual textbook for so many of these geological processes. Originally part of the smaller Archaean and Palaeoproterozoic terrane of Fennoscandia, for about the past 1 Ga, the area now represented by Norway formed the eastern margin of Rodinia (Torsvik 2003). From about 550 Ma, Norway formed the western margin of Baltica (Cocks & Torsvik 2002), then the centre of Laurussia, and finally the northwest of Eurasia, where she remains today. A revised apparent polar wander path and palaeogeographic reconstructions of Norway through time are presented and discussed.
Late Palaeozoic and Mesozoic were overtaken by Early Tertiary sea-floor spreading and continental separation from Greenland at about 54 Ma, creating the modern passive margin (Fig. 1). Events in the earliest time frames were responsible for Norway's ore and industrial mineral deposits, whereas deformation, rifting and sedimentation of the Late Palaeozoic and younger eras created and enhanced the Norwegian offshore hydrocarbon resources.

Norway's earliest times

The oldest parts of Norway were formed in the mists of antiquity. During the Precambrian, Baltica was made up of three terranes: Volgo-Uralia, Sarmatia and Fennoscandia, and all of Norway today overlies the Fennoscandian part of the plate. Fennoscandia can herself be divided into two: a northeastern Archean domain, with rocks dating from 3.5 to 2.7 Ga, and a southwestern Proterozoic zone, with rocks and orogenic belts dating from 2.5 to 1.7 Ga (Bogdanova et al. 2001). To the southwest of the Archean domain the Proterozoic crust of central Fennoscandia was created soon after 1.9 Ga in a series of orogenic events termed the Svecofennian Orogeny (best exposed in neighbouring Finland). Relatively soon afterwards she collided with the previously-combined Volgo-Uralia and Sarmatia to form Protobaltica. Where Fennoscandia (and subsequently Protobaltica) lay before uniting to form part of the supercontinent of Rodinia is quite unknown. How much Protobaltic crust was subducted in subsequent orogenies is also uncertain.

Later Precambrian reconstructions have, for the last decade, been dominated by the postulate of a Neoproterozoic Supercontinent named Rodinia (e.g., Dalziel 1991; Hoffman 1991; Torsvik et al. 1996; Torsvik 2003). The existence of Rodinia was initially based on a postulated linkage between the presently dispersed c. 1 Ga Grenvillian, Sveconorwegian and Kibaran mobile belts. The existence of Rodinia was initially based on a postulated linkage between the presently dispersed c. 1 Ga Grenvillian, Sveconorwegian and Kibaran mobile belts. Laurentia formed the core of this supercontinent (Fig. 2). Norway has traditionally been assumed to face Greenland whilst the Tornquist margin of Baltica faced West Gondwana. However, recent maps show Baltica (Norway) geographically inverted in relation to Laurentia at c. 750 Ma (Hartz & Torsvik 2002; Torsvik
2003), thus linking the Proterozoic Timanian/Baikalian, Avalonian and Cadomian arcs to Baltica in a Pacific-type scenario (Roberts & Siedlecka 2002). From around 800 to 650 Ma, Avalonian-Cadomian arc activity and accretion of Avalonian and related peri-Gondwanan terranes (e.g. Armorica and Perunica) occurred along the Gondwanan margin (Fig. 2), followed by the onset of the main phase of volcanism at about 630 Ma (Murphy et al. 2000). All these events essentially terminated at around 550 Ma, and Baltica terrane amalgamation was then complete. Central Taimyr had collided with Siberia within the Ægir Sea realm (Fig. 3b).

The disruption of Rodinia, already in progress at 750 Ma, and the subsequent formation of Gondwana were marked by the most spectacular mountain-belt building episode in Earth history. No mountain area as extensive as the Gondwana mountains has been constructed on Earth, before or since (Burke et al. 2004). Gondwana formed by 550 Ma, a vast, newly-assembled continent that stretched from polar to equatorial latitudes. Avalonia, Armorica, Perunica (also known as Bohemia) and many other terranes formed part of Gondwana (Fig. 3a). They were affected by the Avalonian-/Cadamian Orogeny that lasted throughout Vendian time and broadly contemporaneous with the Timanian (~ 610-550 Ma) and Baikalian events in Northwest Russia and Siberia. The latter marks the accretion of Central Taimyr with the Siberian craton between 630 and 570 Ma (Vernikovsky 1997).

One part of Norway which was not part of Baltica was the Svalbard Archipelago. In the Proterozoic (Fig. 2) and in Early Palaeozoic times it formed part of the margins of Laurentia (Gee & Teben'kov 2004), which occupies much of modern North America and Greenland. Laurentian warm-water shelly faunas, well known from the area (Fig. 3b), are completely different from those in Baltica in the Early Ordovician (Cocks & Forsey 1982). Svalbard had a very different history from mainland Norway: it can be divided into four separate small terranes separated by strike-slip faults, all of which were active during the development of the Barentsian Caledonides (Gee 2005). However, Svalbard is not considered further here.

The Scandinavian Caledonides and Laurussia

Our modern understanding of the Scandinavian Caledonides has evolved in several revolutionary stages marked, for example, by classic papers such as Størmer (1967) and the book by Strand & Kulling (1972). In these works, the Caledonides were differentiated into foreland, miogeosynclinal and eugeosynclinal facies, and the various nappes were held to derive from these environments. The next major step in advancing our understanding was the overview of Gee (1975). Gee demonstrated that the nappes had travelled considerable distances to their final sites of emplacement, causing much crustal thickening, and that a number of distinct metamorphic breaks could be identified between over-riding nappes and their substrates.

A number of discoveries were made in the late 1970s and early 1980s. The recognition that ophiolites and associated island arcs were represented in Norway (Gale & Roberts 1972, 1974) and constituted important aspects of the stratigraphic/tectonic development (e.g. Sturt 1984) marked a revolutionary conceptual advance in our knowledge of the Scandinavian Caledonides. One should also refer to the tectonostratigraphic subdivision of the Scandinavian Caledonides (Roberts & Gee 1985) in which the rocks are grouped into Autochthon, Parautochthon, and Lower, Middle, Upper and Uppermost Allochthons; providing a logical framework for the nappe complexes (Fig. 1). From the Parautochthon through the lower part of the Upper Allochthon, the nappes all have a bipartite subdivision between basement, recognised as part of Baltica, and cover sequences of Upper Precambrian and Lower Palaeozoic sedimentary rocks. The boundary between the Seve and Köli Nappes of the Upper Allochthon was recognised as
a significant break, the outboard oceanic assemblages (ophiolites and magmatic arcs) first making their appearance in the Koli Nappes. The Uppermost Allochthon comprises exotic elements, including extensive carbonate formations and major batholiths of probable Laurentian affinity (see review in Roberts 2003).

A number of attempts have been made in the direction of describing the development of the Scandinavian Caledonides in a plate tectonic framework. Most of these models, however, adopted a Wilsonian view of the Iapetus Ocean (separating Baltica and Laurentia), relying essentially on a simple opening and closing of oceans along mainly straight and parallel margins. However, more recent literature (Torsvik et al. 1996; Torsvik 1998; Torsvik & Rehnström 2001; Hartz & Torsvik 2002; Cocks & Torsvik 2002; Roberts 2003) shows that, like most convergent margins worldwide, the Caledonide evolution in space and time is not a matter of simple orthogonal tectonics.

In the latest Vendian, Baltica and Siberia were separated by the Ågir Sea (Fig. 3a). The Iapetus Ocean between Baltica and Laurentia probably opened at around this time. In the model of Hartz & Torsvik (2002), Iapetus was initiated at a junction between a rift (Laurentia-Gondwana), a right-lateral fault between Laurentia and Baltica and a trench (inverted Baltica/Gondwana). Iapetus probably reached its widest in Late Tremadoc or Early Arenig times (c. 480 Ma) as indicated from different benthic trilobite faunal provinces (Fig. 3b) and palaeomagnetic data (Cocks & Fortey 1982; Cocks & Torsvik 2002). Palaeomagnetic studies, carried out in the early 1990’s clearly demonstrated that Baltica was upside-down during the Early Ordovician (Fig. 3b), located at mid-southerly latitudes and separated from
From northwest Gondwana and Laurentia by the Tornquist Sea and the Iapetus Ocean. During the Ordovician, Baltica rotated in a counter-clockwise manner towards its present orientation, and by the Late Ordovician, Norway faced Laurentia for the first time (Figs. 3 and 4).

Rifting between Avalonia and Gondwana was the first breakaway of peri-Gondwana terranes, and Avalonia drifted rapidly northward to gain palaeolatitudes comparable with those of Baltica by the Caradoc (Fig. 4a). Tornquist Sea crust was subducted beneath Avalonia and explosive vents associated with Andean-type magmatism in SE England (Pharaoh et al. 1993) supplied Baltica with gigantic Mid-Caradoc ash-falls (e.g. the Kinnekulle K-bentonite) controlled by westerly Ordovician winds. Southwest Baltica records an Ashgillian thermal event that is broadly comparable with the Shelveian event in Avalonia (Torsvik & Rehnström 2003). This event is also contemporaneous with Caledonian low-grade metamorphism in the North Sea (Torsvik 1998) and was probably related to the soft oblique Avalonia-Baltica docking at about the Ordovician-Silurian boundary.

By about 420 Ma, Baltica, Avalonia, intervening terranes and Laurentia had all coalesced to form the new superterrane of Laurussia (Fig. 4b). The Scandian orogenic event (Gee 1975) was marked by oblique collision and deep subduction of Baltican crust beneath Laurentia (Andersen et al. 1991; Torsvik et al. 1996; Eide & Torsvik 1996). Large parts of Laurussia were in tropical palaeolatitudes during the Silurian, with the deposition of substantial carbonate deposits. In southern Norway, preserved today in the Oslo Graben (Cocks & Worsley 1993), there were shallow-marine limestones and deeper-water turbidites offshore of...
them, and these are preserved both onshore and offshore today (Smelror et al. 1997). These areas shallowed up during Wenlock times to be followed by a non-marine 'Old Red Sandstone' facies, the latter indicating the development of molasse-filled basins during upper crustal extension. By the Early Devonian, the Old Red Sandstone facies was developed over a much wider area, extending from central North America to the East Baltic and from the southern Appalachians to Spitsbergen, a distance of over 4,500 km (Friend et al. 2000). In the Oslo region, Old Red Sandstone accumulation (the Ringerike Group) was coeval with Ludlow to Pragian Scandian crustal thickening and later (in Emsian times) with tectonic extension denudation (Gee 2005). However, elsewhere on Baltica the fringing carbonates persisted through all of the Silurian, including the famous reefs of Gotland and Estonia (Fig. 4b).

There has been considerable controversy concerning the nature of the Scandinavian Caledonide orogen. Did it represent one collisional orogeny or was it a polycyclic orogen (reviewed in Roberts 2003) involving several collisions at or close to the leading edge of Baltica? The first, or the more traditional model involves several collisions at or close to the leading edge of Baltica? The first, or the more traditional model involves one major collisional event, the Scandian, in Silurian times, and stems mainly from the classic papers of Størmer (1967) and Gee (1975). Early studies from the

Seiland Igneous Province in Finnmark (Fig. 1) led directly to the hypothesis of the Late Cambrian-Early Ordovician Finnmarkian Orogeny (e.g., Sturt et al. 1978). However, the nature of the Finnmarkian orogenic event remains a subject of much debate: There has been some agreement that it involved arc/continent collision following subduction, and perhaps involved interaction between Baltica and the Kara Block in the Ågir Sea realm (e.g., Cocks & Torsvik 2002). New and partially unpublished isotope dating studies in northern Norway, however, question the existence of the Finnmarkian orogenic concept and will undoubtedly lead to major modification of our understanding of the Scandinavian Caledonides (Corfu et al. 2004; Roberts et al. 2004).

In addition, two more events have been recognized in the Scandinavian Caledonides, namely the Trondheim (Early Arenig, and about 20 million years younger than the Finnmarkian) and the Taconian (Mid-Late Ordovician) events. Both are linked to arc-accretion related events (Roberts 2003); the Taconic event, represented mostly in the Uppermost Allochthon, is argued to have occurred along the margin of Laurentia but is also contemporaneous with the Shelveian event in southern England and the Avalonia-Baltica docking discussed above.

Fig. 5. a) Pangea supercontinent during the Late Permian period (Torsvik 2003; Torsvik & Cocks 2004). The distribution of low-latitude coal deposits (C) and evaporites (E) are indicated. Note that this reconstruction is a Pangea A octupole (15%) reconstruction (Torsvik & Cocks 2004) and differs slightly from the GAD based reconstruction in (b).

b) Pangea A reconstruction (GAD-based). The present ‘sub-African’ slow velocity zone near the core-mantle-boundary was probably situated beneath parts of Laurentia and was centered below the supercontinent. The Siberian Traps (251 Ma) also overlie hotter (?) deep mantle. Continents are draped on shear-wave velocity anomalies near the core mantle boundary (Becker Boschi 2002). The distribution of the Siberian Traps is outlined in red shading (after Burke & Torsvik 2004).
Pangea Assembly

In the Carboniferous, starting at about 330 Ma, Gondwana merged with Laurussia and intervening terranes to form the supercontinent of Pangea (Van der Voo & Torsvik 2001; Torsvik & Van der Voo 2002; Torsvik & Cocks 2004). The Variscan belts of Europe became part of a belt that stretched from the Caucasus to the Appalachian and Ouachita mountains (Matte 2001). The Palaeotethys Ocean, an embayment in eastern Pangea, separated the northern from the southern parts of today’s European collage during the later Palaeozoic (Fig. 5a). The Late Carboniferous and Early Permian were marked by a significant glacial episode which lasted as long as 50 Ma, but also witnessed the formation of the most extensive coal deposits of the Phanerozoic which are very well represented in Europe. These subsequently became the source for one of Earth’s highest reserves of natural gas. Although there are no glacial deposits known from the Late Permian, and the climate was extraordinarily arid, it is noteworthy that low-latitude coal deposits are lacking within Pangea (indicating an arid equator). Conversely, a wet equator is indicated for terranes in the eastern Palaeotethys (South and North China) that were not part of Pangea at this time.

In the Late Permian, Pangea was at her climax. However, minor fragmentation of Pangea had already begun as new oceanic crust was forming the Neotethys Ocean along the eastern margin of Pangea (Stampfli & Borel 2002; Torsvik & Cocks 2004). The existence of a single large landmass and intense magmatism (~251 Ma Siberian Traps and the Emeishan Traps of South China) created climatic and atmospheric conditions that culminated in the Earth’s largest known extinction event near the Permo-Triassic boundary. Consequently, good hydrocarbon source rocks are rare until the Mid Jurassic and onwards (e.g. Upper Jurassic black shales with excellent source potential along the...
Norwegian margin; Brekke et al. 2001), when animal evolution once again flourished, and the break-up of the Pangea supercontinent had developed new shelf and habitat areas.

In the deep Earth, the long-term shielding effect of the Pangea supercontinent over large parts of the underlying mantle probably caused an increase in mantle temperatures and spawned continental doming in the interior of the supercontinent. Heterogeneities near the core-mantle boundary (CMB) observed today under parts of Africa may be the residual effect of supercontinent insulation (Fig. 5b), protecting the Pangea mantle from subduction and cooling (Burke & Torsvik 2004).

**Norway’s latest story**

Since the Late Palaeozoic, and directly linked to the break-up of Pangea, the Norwegian continental shelf experienced multi-phase rifting (e.g., Brekke et al 2001, Mosar et al. 2002), culminating in the separation of Greenland and Norway and the formation of the Northeast Atlantic Ocean in the Early Tertiary at Anomaly 24 time (~54 Ma). From the Late Permian to the Early Cretaceous, the stretching direction between the present-day Norwegian shelf and East Greenland was orientated east-west, oblique to the present coastline (Fig. 6a). During the Late Cretaceous, the rifting direction changed to a more northwest-southeast orientation, more perpendicular to Norway’s present coastline. Plate reconstructions based on Torsvik et al. (2001a) suggest that the main phase of post-Pangea pre-drift extension on the Norwegian-Greenland passive margins took place during the Cretaceous (Fig. 7). This extension can be quantified by the amount of continent-ocean boundary (COB) overlap, but the precise location of the COB and an appropriate plate model are critical requirements for these estimates. In addition, the COB is not a distinct boundary but rather a transition zone, some tens of kilometres wide between true continental and true oceanic crust. Across the Mid-Norwegian shelf to East Greenland, the COB overlap was about 300 km in the Early Cretaceous (Fig. 6b), amounting to a plate tectonic-scale stretching factor ($\beta$) of at least 2. During the latest Cretaceous and earliest Tertiary (~69-56 Ma) the extension rate amounted to ~1 cm/yr. Total extension during this time interval was in the order of 150 km (Fig. 7).

Sea-floor spreading between Greenland and Europe commenced in the Early Tertiary (~54 Ma), post-dating and partly coinciding with vast igneous activity in the UK, Ireland, the Faeroes, Greenland and the West Greenland-Baffin corridor (e.g., Saunders et al. 1997; Skogseid et al. 2000; Torsvik et al. 2001b). Full spreading velocities for the NE Atlantic were ~4 cm/yr during break-up, declining to a minimum of 1.4 cm/yr at Anomaly 13 (~33 Ma). A velocity recovery of approximately 2 cm/yr has followed during the past 20 million years. There is notable misfit (gap) between the southwest Greenland COB and the Eurasian COB (Mosar et al. 2002) at the assumed time of break-up. This implies either that 1) the COB is not properly identified, 2) the plate fit is inaccurate, 3) break-up started a few million years earlier in this sector of the NE Atlantic, or 4) some combination of the above.

Opening of the NE Atlantic took place at three interconnected ridges: Reykjanes, Ægir and Mohrs (Fig. 7). An important change in seafloor spreading occurred with the abandoning of the Ægir Ridge system shortly before Anomaly 13 (~35 Ma) when the Reykjanes Ridge propagated north and west of Jan Mayen (the Kolbeinsey Ridge). Jan Mayen rotated away from Greenland in an anticlockwise manner and shortly after Anomaly 13, the Ægir ridge became extinct, and the Kolbeinsey Ridge became well developed along the western margin of Jan Mayen. From 30 Ma and onwards Jan Mayen became part of the Eurasian plate. Seafloor spreading in the Labrador Sea had ceased by this time and Greenland became part of the North American plate once again.

The North Atlantic Igneous Province (NAIP) is one of several Large Igneous Provinces (LIPs) that have erupted on the Earth’s surface (Eldholm & Coffin 2002). Burke & Torsvik (2004) have recently shown that almost all LIPs of the past 200 My, when reconstructed to the time of their eruption, become concentrated radially above areas of the CMB occupied by the slower parts of the D” zone (the lowest 300-400 km of the mantle). They attribute the generation of LIPs to hotter material that left the D” zone episodically in thermally buoyant mantle plumes that rose to the base of the lithosphere. Because NAIP rocks extend over vast areas, not all of these outcrops can mark the site of the eruption of the Iceland plume. Many must represent material that has propagated horizontally within the asthenosphere from the original plume eruption site (e.g. Marzoli et al. 1999), and into weakened crust, existing rifts or interacted with the spreading ridge (Ito et al. 2003). A sloping base exists near spreading ridges, and if the spreading ridge is less than a few hundred kilometres away from the hotspot (Ito et al. 2003), volcanic eruption will occur at the ridge rather than directly above the plume.

At present, the estimated location of the Iceland hotspot (64.4°N, 341.9°E in Fig. 8a) overlies a shear-wave velocity anomaly of ~0.5% at the CMB. The Iceland plume does not have a hotspot track and past locations can only be estimated from a fixed Indo-Atlantic hotspot frame (Müller et al. 1993) accounting for Labrador rifting and spreading, or a mantle reference frame.
(Steinberger 2004) in which the motion of the Iceland plume in a convecting mantle is considered (Fig. 8a). The latter approach, computed from the SMEAN tomographic model (Becker & Boschi 2002) with a plume initiation age of 80 Ma, is not very different from a fixed Indo-Atlantic reference frame, but generally indicates a westward motion of the hotspot of ~200 km over the past 60 Ma. If mantle reference frames are correct to a first approximation, continents can be reconstructed in an ‘absolute’ sense, and the velocity field for the plates can be calculated (Fig. 8b).

In the Late Cretaceous and the Early Tertiary all plates in the North Atlantic realm were mostly drifting NW or NNW (Torsvik et al. 2001b), but at different relative speeds, with the opening of the Labrador Sea and the NE Atlantic occurring simultaneously. After Anomaly 13, North America and Greenland show similarly NW-directed movements (seafloor spreading ceased in the Labrador Sea) whilst Eurasia (with Jan Mayen, which had rifted off Greenland to join Europe) changed to a NE course (Fig. 8b) compatible with the present motion of Europe. Northwestward movement of Greenland during most of the Tertiary (Fig. 8b) was the important factor in positioning the Iceland plume at the leading edge of Greenland at around 40 Ma, and with focused and well-dated magmatism in East Greenland almost directly above the estimated plume location at that time. The NE plate motion shift for Eurasia is comparable to that of Africa, indicating stronger coupling between Africa and Eurasia, or alternatively is linked with the positioning of the Iceland plume below the spreading ridge, leading to increased local upwelling below the ridge at around 20-30 million years ago, or a combination of these two causes.

Since the opening of the northeast Atlantic at around 54 Ma, Norway has been relatively quiescent. However, she has been uplifted during the Tertiary, and undergone extensive isostatic adjustment during the past 3 million years. Glaciations and regional uplifts have caused deep erosion of the mainland area and the Barents Sea shelf as well as deposition of sediments along the Norwegian-Greenland Sea (Brekke et al. 2001).
Norway's drift story - Finale

In contrast to hotspot/mantle frames, palaeomagnetic data can be used throughout Earth history, but they only constrain latitude and the amount of angular rotation. We can therefore position continents at any longitude we wish by using other geological constraints such as the fossil record (e.g. Fig. 3b). Apparent polar wander (APW) paths represent a convenient way of summarising palaeomagnetic data. In the running mean method palaeomagnetic poles are assigned absolute ages, a time window is selected (e.g., 20 m.y. used in Fig. 9), and then all palaeomagnetic poles with ages falling within the time window are averaged. Figure 9 is the APW path used to reconstruct Norway (Baltica) in Phanerozoic space and time (Fig. 10). The early part of this APW path is based purely on Baltica data (mostly from Sweden) before the Silurian since Baltica was an independent continent. For later times, Baltic data are combined with Laurentian data (Scotland/North America). Finally, all globally available data from 330 Ma onwards are rotated to Norwegian (European) co-ordinates (Table 1), based on data selection and relative fits detailed in Torsvik & Van der Voo (2002) and on work in progress.

The drift history for Norway can be constructed with relatively high confidence since the Cambrian, whilst the older history is more patchy and poorly understood. For the times when Norway was part of the Rodinia supercontinent there exist essentially three undisputed data-sets: (1) Sveconorwegian poles (~ 970-1100 Ma) suggesting low-to-subtropical latitudes for Baltica, (2) the ~ 850-900 Ma Hunnedalen dykes (850 Ma) and the Egersund anorthosites (880-900 Ma uplift magnetizations) in SW Norway indicating high latitudes, and (3) 700-800 Ma sedimentary poles from Northern Norway and Russia that demonstrate equatorial latitudes. During and after Rodinia break-up, Baltica returned to high latitudes (~ 616 Ma). Thus, Norway is known to have experienced a rather tortuous Neoproterozoic and Vendian drift history.

Neoproterozoic (Vendian) glacial deposits are recorded on many continents, some evidently deposited at low latitudes and thereby suggesting that Earth was affected by global glaciation events (e.g., Hoffman & Schrag 2002). In Norway, the Moelv Tillite in the southeast and its correlative the Varanger Mortensnes Formation in the far north (Fig. 10) are poorly dated. However, U/Pb dating of detrital zircons now constrain the
Fig. 9. Lower diagram: Apparent polar wander path (APW) for Norway (Baltica) (cf. text and Table 1). Running mean poles are shown with A95 confidence circles and mean poles older than 480 Ma (on the opposite hemisphere) are listed in Table 1. Top diagram: Latitudinal velocities for Oslo (based on APW path below).

Fig. 10. The drift history for Norway (Baltica) based on the APW path in Figure 9.
deposition of the Moelv Tillite to younger than 620 ± 14 Ma (Bingen et al. 2005). Palaeomagnetic data from the 616 Ma Egersund dykes (Walderhaug & Torsvik, in preparation) demonstrate that Baltica was located at high latitudes during the Varangerian glaciation. These data do not rule out the postulate of a global glaciation (the so-called Snowball Earth), but reject an explanation in terms of changes in Earth’s obliquity since such an explanation precludes high-latitude glaciations. The Varangerian glaciation was probably broadly contemporaneous with Vendian magmatism, metamorphism and tectonic activity (c. 630-550 Ma) in the Timan-Pechora-Rybachy-Varanger region, i.e. the Timanian orogenic event, a period of documented arc/continent along the northeastern margin of Baltica (Gee et al. 2000; Roberts & Siedlecka 2002; Rehnström et al. 2002; Roberts & Olovyanishnikov 2004).

In the Early Palaeozoic, Norway was located at intermediate to high southerly latitudes and rotated almost 180° compared to her present orientation. Late Cambrian and Ordovician times were marked by pronounced counter-clockwise rotation with northward drift during mid Ordovician to mid Silurian times. This culminated with a minor episode of southward movement (Fig. 9) after collision with Laurentia and the formation of Laurussia. Norway was located within the tropics from Late Ordovician to Late Carboniferous times and then drifted northwards into its present location (Fig. 9). Latitudinal velocities for Norway (Oslo) generally indicate velocities below 8 cm/yr. except for a velocity burst (16 cm/yr.) in the Early Silurian, and hence just prior to the Laurentia-Baltica collision.

Sedimentary facies and their contained faunas clearly reflect Baltica’s drift history. In the Cambrian and early Ordovician, when Baltica was at relatively high southerly palaeolatitudes, the characteristic benthic brachiopod and trilobite faunas were not very diverse (Cocks & Fortey 1982). Carbonates, when present (rare), were narrow (c. 4 cm/yr.) in the Early Silurian, and hence just prior to the Laurentia-Baltica collision.

Phanerozoic running mean APW path (south poles) for Baltica (globally from 330 Ma and onwards) and Euler rotation data (Euler longitude is zero for all times) in European co-ordinates. A95=95% confidence circle; N=Number of poles.
porites (Nordkapp Basin with salt deposits at 20–23°N) by the Late Carboniferous (e.g., Roberts et al. 2003). During the Late Permian, southern Norway and the North Sea region entered the subtropics, evidenced by the Zechstein salt deposits (~260 Ma) that were mostly confined to latitudes between 18 and 27°N (arid climate).

Norway’s general northward drift during the last 600 million years witnesses a history from a southerly arctic climate, through equatorial and sub-tropical climates (Late Ordovician through the Triassic), to the present stage of a temperate-to-arctic climate in the northern hemisphere. The drift history was associated with large rotations of Norway, and northward drift was periodically interrupted by short phases of southerly drift.

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