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Critical reappraisal of Late Mesozoic-Cenozoic Central and North Atlantic, Caribbean and Mediterranean evolution

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ABSTRACT

Key words: Geodynamic evolution; Tidal forces; Upper and lower mantle; Differencial rotation; Giant hypocycloid gearing Earth; Extended plate tectonic model; Global tectonic megacycles; Oceanic or Wilson Cycle; Eastwards migrating Pacific basin; Double zip fastener principle; East-Westwards increasing collision ages; Endless collisional mountain belt; Two-lap collisional mountain belt spiral; Eart's history: alternating North and South Pangaea spirals; Pangaea and Gondwana reconstruction; Central and North Atlantic, Caribbean and Mediterranean evolution; Laramide-Cuban/Hispaniolan/Caribbean Andes-Eurekan-Atlas/Alpine belt; Eastern North America-West Africa connection; Clockwise rotation of North America during the Tertiary; Greenland (the Arabia of South America?); Arabia (the Greenland of Africa ?).

(1) The Pacific basin (Pacific area) may be regarded as moving eastwards like a double zip fastener relative to the continents and their respective plates (Pangaea area): opening in the East and closing in the West. This movement is tracked by a continuous mountain belt, the collision ages of which increase westwards.

(2) The relative movements between the Pacific area and the Pangaea area in the W-E/E-W direction are generated by tidal forces (principle of hypocycloid gearing), whereby the lower mantle and the Pacific basin or area (Pacific crust = roof of the lower mantle?) rotate somewhat faster eastwards around the Earth's spin axis relative to the upper mantle/crust system with the continents and their respective plates (Pangaea area) (differential rotation).

(3) These relative West to East/East to West displacements produce a perpetually existing sequence of distinct styles of opening and closing ocean basins, exemplified by the present East to West arrangement of ocean basins around the globe (Oceanic or Wilson Cycle: Rift/Red Sea style; Atlantic style; Mediterranean/Caribbean style as eastwards propagating tongue of the Pacific basin; Pacific style; Collision/Himalayas style). This sequence of ocean styles, of which the Pacific ocean is a part, moves eastwards with the lower mantle relative to the continents and the upper-mantle/crust of the Pangaea area.

(4) Similarly, the collisional mountain belt extending westwards from the equator to the West of the Pacific and representing a chronological sequence of collision zones (sequential collisions) in the wake of the passing of the Pacific basin double zip fastener, may also be described as recording the history of oceans and their continental margins in the form of successive Wilson Cycles.

(5) Every 200 to 250 m.y. the Pacific basin double zip fastener, the sequence of ocean styles of the Wilson Cycle and the eastwards growing collisional mountain belt in their wake complete one lap around the Earth. Two East drift lappings of 400 to 500 m.y. produce a two-lap collisional mountain belt spiral around a supercontinent in one hemisphere (North or South Pangaea). The Earth's history is subdivided into alternating North Pangaea growth/South Pangaea breakup eras and South Pangaea growth/North Pangaea breakup eras. Older North and South Pangaeas and their collisional mountain belt spirals may be reconstructed by rotating back the continents and orogenic fragments of a broken spiral (e.g. South Pangaea, Gondwana) to their previous Pangaea growth era orientations. In the resulting collisional mountain belt spiral, pieced together from orogenic segments and fragments, the collision ages have to increase successively towards the West.

(6) With its current western margin orientated in a West-East direction North America must have collided during the Late Cretaceous Laramide orogeny with the northern margin of South America (Caribbean Andes) at the equator to the West of the Late Mesozoic Pacific. During post-Laramide times it must have rotated clockwise into its present orientation. The eastern margin of North America has never been attached to the western margin of North Africa but only to the western margin of Europe.

(7) Due to migration eastwards of the sequence of ocean styles of the Wilson Cycle, relative to a distinct plate tectonic setting of an ocean, a continent or continental margin, a future or later evolutionary style at the Earth's surface is always depicted in a setting simultaneously developed further to the West and a past or earlier style in a setting simultaneously occurring further to the East. In

consequence, a high probability exists that up to the Early Tertiary, Greenland (the Arabia of South America?) occupied a plate tectonic setting which is comparable to the current setting of Arabia (the Greenland of Africa?). The Late Cretaceous/Early Tertiary Eureka collision zone (Eureka orogeny) at the northern margin of the Greenland Plate and on some of the Canadian Arctic Islands is comparable with the Middle to Late Tertiary Taurus-Bitlis-Zagros collision zone at the northern margin of the Arabian Plate.

INTRODUCTION

In previous papers an extended plate tectonic model was presented by the author (Trurnit, 1984; 1988a, b; 1989; 1991a-d; 1992): the eastward displacement of the Pacific basin relative to the continents and their respective plates (Fig.1) caused by independent and different rotations of the Earth's upper mantle and lower mantle. It was shown that the Pacific basin functions like a double zip fastener (opening towards the East and closing in the West), the eastwards movements of which relative to the continents and their respective plates produce predictable, specific styles of ocean basins, continents, megacontinents, their margins and mountain belts. The styles of geodynamic megastructures observed at present have also existed during the past but with the continents in different locations (plate tectonic settings) and agglomerations. Their evolution is systematic and given the rate of differential rotation in the hypocycloid gearing Earth occurs cyclically during synchronized periods of 200 to 250, 400 to 500 and 800 to 1000 m. y. The evolutionary styles and megastructures are named after the current styles and structures representing them. In the model, the term Pangaea is used for all continental crust, past and present; the terms Tethys (for the Mesozoic/Cenozoic) and Iapetus (for the Late Proterozoic to Middle Paleozoic) are taken as synonymous with the Pacific. A circum-Pacific ring of subduction zones separates a Pacific area with mainly active continental margins from a continental or Pangaea area with intra-Pangaea Oceans (Atlantic, Red Sea/Indic, Arctic Ocean, etc.) and mainly passive continental margins. The Pangaea area in turn is subdivided into a North Pangaea area (at present Laurasia) and a South Pangaea area (at present Gondwana) with the North Pangaea and the South Pangaea continents broadly distributed over the northern and southern hemispheres (Figs.1, 4-6).

While the eastwards directed zip fastener-like closing of the West Pacific basin by N-S directed sequential collisions of the continents from the northern and southern hemispheres (Africa and Europe during the Early Tertiary; India and Asia during the Late Tertiary; Australia and SE-Asia during the present) at the equator behind and to the West of the Pacific and the vanished Tethys is generally accepted by the geoscientific community, an eastwards directed zip fastener-like opening at the front to the East of the Pacific in the form of Mediterranean/Caribbean style rift propagation and polewards withdrawal of the respective continents in the Africa and Europe, South and North America settings is not. This paper emphasizes, that it is

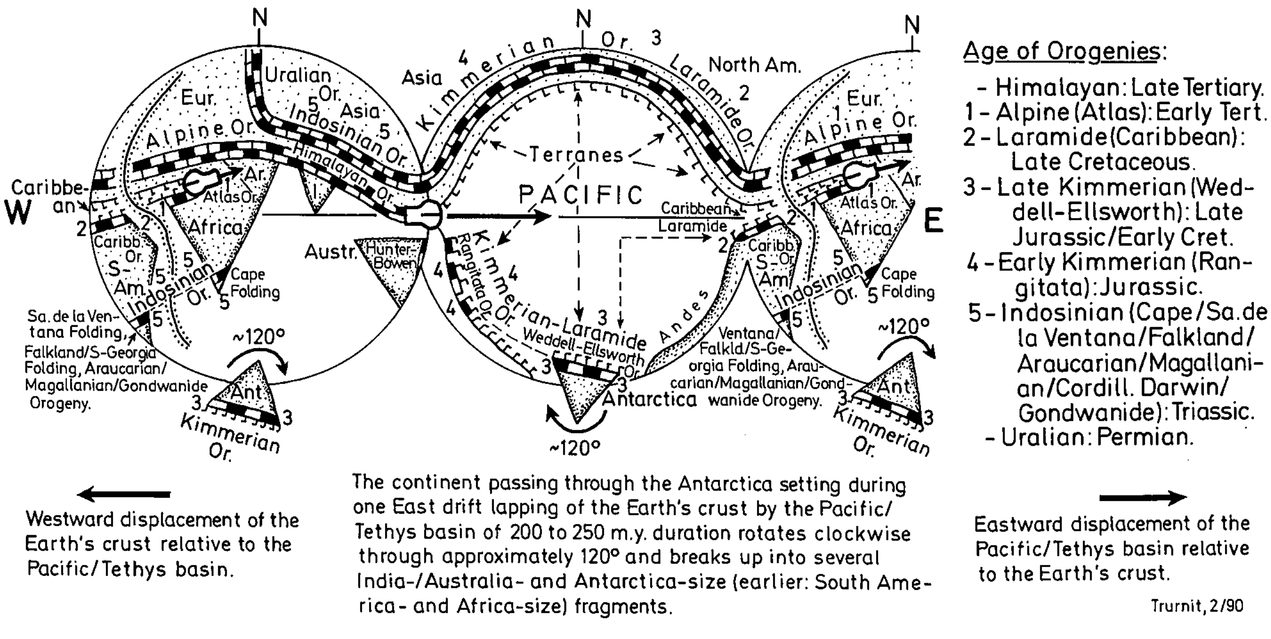

Fig.1 — The Himalayan-Alpine-Laramide-Kimmerian-Indosinian-Uralian North Pangaea collisional mountain belt marking the track of the eastward migrating Pacific basin since the Permian. Fragments from this belt that migrate around the Pacific basin in the South together with the Gondwana (South Pangaea minus Laurentia) continents. Post-collisional formation of tectonostratigraphic terranes.

absolutely necessary to accept the existence of eastwards directed Mediterranean/Caribbean style rift propagation to the East of the Pacific, if global tectonic modelling shall yield any further scientifically valuable results.

In the following, additional constraints are presented for the eastward migrating Pacific basin double zip fastener, with emphasis on data supporting the zip fastener opening of the East Pacific and the western part of the Pangaea area (Mediterranean, Caribbean, Central and North Atlantic settings; North and South America, Europe/Western Asia and Africa, Greenland and Arabia settings). However, in order to preserve the internal consistency of the paper, a minimum of previously presented results must be repeated.

Constraints for the eastward displacement of the Pacific basin and the sequence of ocean styles of the Wilson Cycle relative to the continents and their respective plates

Six geodynamic phenomena point to an eastward displacement of the Pacific basin and the lower mantle (Pacific crust = roof of the lower mantle?) relative to the upper mantle, to the North and South Pangaea areas or to the continents with their respective plates (or else, westward displacement of the upper mantle, the Pangaea areas or continents in relation to the Pacific basin and the lower mantle), the first 5 of which have already been covered in detail in previous publications (Trurnit, 1984; 1988a, b; 1989; 1991 a-d; 1992) and will not be treated here in any detail:

1. The Himalayan-Alpine-Laramide-Kimmerian-Indosinian-Uralian collisional mountain belt starting at the equator to the West of the Pacific, in which the collision ages increase progressively westwards (Fig.1). This endless belt leads westwards into the remote geological past of the Earth. It appears to mark the track of the eastwards migrating Pacific basin.

2. Lateral continental growth by winding the individual laps of the collisional mountain belt in the form of two-lap spirals alternately around North and South Pangaea supercontinents in the northern and southern hemispheres.

3. The contrast between the gentle inclinations of the subduction zones at the Andean style continental margins East of the Pacific and the steep inclinations of the subduction zones at the island arc style margins of the West Pacific.

4. The arrangement of ocean styles in the evolutionary sequence of the Oceanic or Wilson Cycle (Wilson, 1966a, b; Dewey and Burke, 1974) describing the opening and closing of an ocean with subsequent collision of the continental margins and collisional mountain building (Rift/Red Sea style, Atlantic style; Mediterranean/

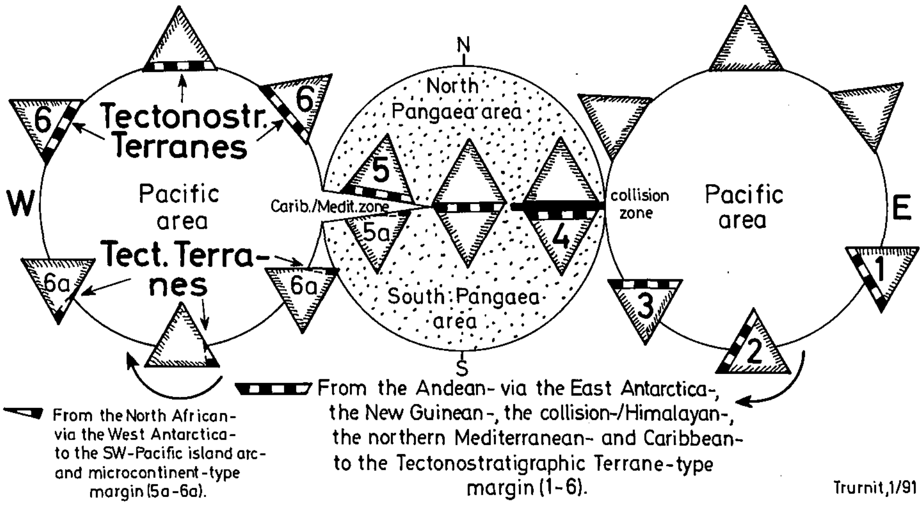

Fig. 2 — Evolution and formation of tectonostratigraphic terranes: continents from the southern hemisphere which had previously collided sequentially at the equator to the West of the eastwards migrating Pacific basin against the continents from the northern hemisphere, should after half an East drift lapping by the Pacific basin have disengaged again from the northern continents in the post-collisional, extensional Mediterranean and Caribbean settings to the East of the Pacific, leaving their former northern margins in the form of tectonostratigraphic terranes attached to the northern continents. These will later migrate westwards around the Pacific basin in the North, accompanied by post-collisional basin-and-range and metamorphic core complex style extensional provinces (tectonic denudation/erosion or extensional unroofing/exhumation and isostatic rise of metamorphic core complexes) (equatorial view).

Caribbean style as eastwards propagating tongue of the Pacific basin; Pacific style, Collision/Himalayas style) from East to West through 360° around the globe. The continental or Pangaea area continuously opens or splits apart at the Pacific bow to the East of the Pacific in the extensional Mediterranean and Caribbean settings (rift propagation towards the East) and continuously closes again at the Pacific stern at the equator in the West (diachronous or sequential collisions) (double zip fastener principle) (Fig.1). What is lost from the Pacific basin in the West through sequential collisions between the respective continents in the Asia and Australia settings, is added to the Pacific basin in the East by eastwards directed progressive openings of a series of Caribbeans and Mediterraneans, withdrawal of the respective continents in the North America and South America, Europe and Africa settings towards the Earth's poles and by the incorporation of a succession of Atlantics/rift oceans formed beforehand in the Pangaea area in the East, into the Pacific (disappearance of Pacific/ Tethys in the West and creation of new Pacific in the East).

5. The phenomenon of the tectonostratigraphic terranes: continents from the southern hemisphere (the hemisphere of the Pangaea breaking up) which had previously collided at the equator to the West of the eastwards migrating Pacific basin against the continents from the northern hemisphere (the hemisphere of the Pangaea forming), should after half an East drift lapping by the Pacific basin, have disengaged again from the northern continents in the tensional, post-collisional Mediterranean and Caribbean settings farther West and to the East of the Pacific, having left their former northern margins in the form of tectonostratigraphic terranes attached to the northern continents. These will later migrate westwards in the North (hemisphere of the Pangaea growing) around the Pacific basin as parts of the collisional mountain belt, accompanied by basin-and-range and metamorphic core complex style extensional provinces (Figs. 1, 2, 6). In comparison with pre-collisional island arcs, tectonostratigraphic terranes are post-collisional crustal fragments (Trurnit, 1988a, b; 1989; 1991b).

6. The switch from Late Cretaceous/Early Tertiary compression in N-S direction to Late Oligocene/Mio-/ Pliocene extension in the same direction in the stress field of the Alpine/Mediterranean/North African and even Northwestern European Region (Fig.3) (Lister *et al.*, 1987; Weijermars, 1987, 1988, 1991; Laubscher, 1988; Trurnit, 1991b). This reversal of stress in N-S direction could have been effected through rotations of the respective continents or areas through the centrifugally induced stress field, the orientation of which is aligned with the spinning Earth's axis and equator (Roland, 1976). However, major rotations of Africa and Europe during the Tertiary have not been recorded paleomagnetically. A second and more probable explanation would be a westward directed shift of the Alpine/Mediterranean area and its accompanying continents in the North and South, away from the collision setting at the equator to the West of the Pacific and in the eastern part of the Pangaea area, by means of an eastward displacement of the Pacific basin relative to the continents of the Pangaea area, towards a more central and finally western setting in the Pangaea area and to the East of the Pacific, where N-S directed extension prevails (Figs.3, 4). Relative to a fixed continent the Pacific basin disappears or "sets" in the East and reappears, returns or "rises" in the West. As a result, the Alpine belt since Late Oligocene/ Early Miocene times was and presently still is stretched in a N-S direction (also in the direction of the orogenic trend above rotating, extensional hotspot regions; e.g. Carpathian, Alpine-Ligurian, Betic knots, loops or vortexes) along low-angle detachment faults (tectonic denudation/erosion, extensional unroofing/exhumation and isostatic rise of metamorphic core complexes) and the Mediterranean area subsided coevally below sea level.

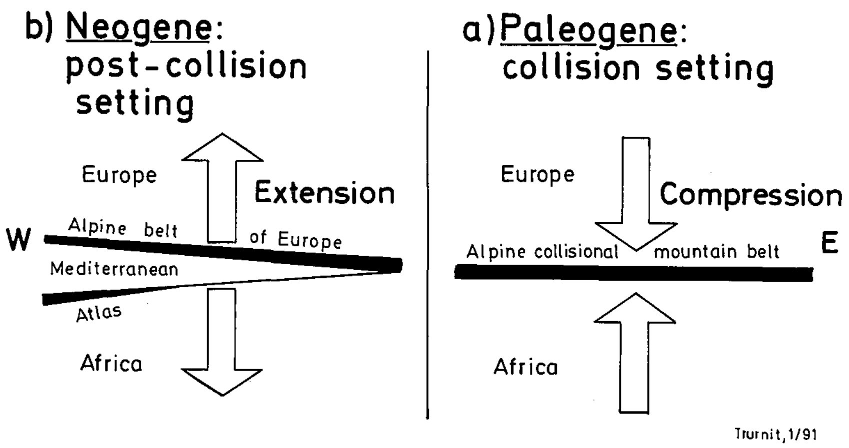

Fig.3 — North-South directed stresses acting on Western Europe and the Mediterranean area during a) the Early Tertiary and b) the Late Tertiary.

Currently it is not generally accepted that Mediterranean and Caribbean style oceans are post-collisional, extensional rift oceans opening in a N-S direction. In the original Wilson Cycle they are depicted as pre-collision style oceans shortly before closing (Wilson, 1966a, b; Dewey and Burke, 1974). That the geoscientific community is still working with an oversimplified, homogeneous, uniaxial global stress field valid for both the West Pacific/Eastern Pangaea and East Pacific/Western Pangaea areas is one of the cruces of global tectonics. The results are misinterpretations of the East Pacific area and the Alpine belt, Caribbean and Mediterranean Oceans to the East of it in the West Pangaea area (the cradle of geosciences!), the latter of which are still regarded by many as being in the process of closing instead of extending and opening again in a N-S direction. Likewise, the continents in the northern

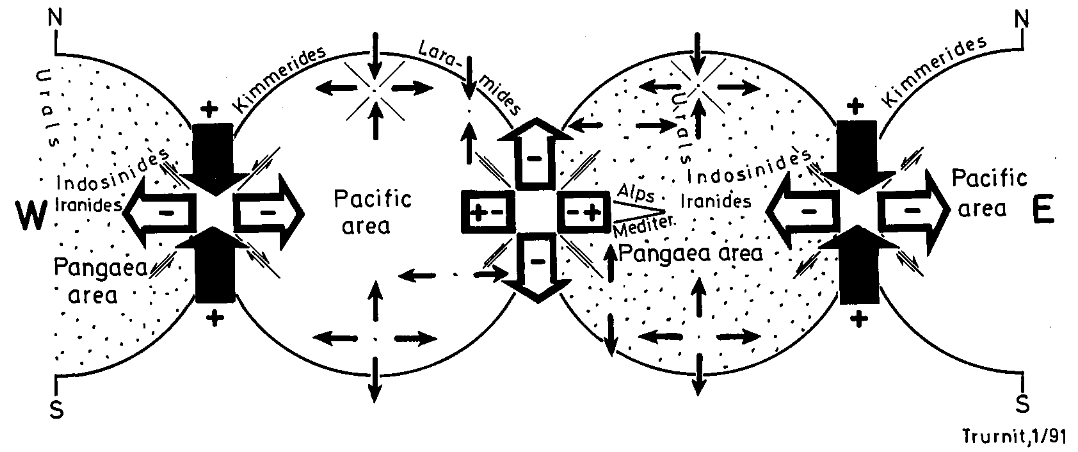

Fig.4 — Generalized, distorted global stress field induced by the combined effects of thermal convection, gravitational, centrifugal and tidal forces.

and southern hemispheres bordering the Mediterranean and Caribbean basins are regarded as still being in the process of colliding in a N-S direction instead of separating again and withdrawing towards the poles (Europe/Africa; North America/South America). Progress in geosciences is thus prevented by incorrectly viewing the East Pacific and the West Pangaea areas.

According to the global stress field induced by the centrifugal force of the spinning Earth (Roland, 1976), vertical tectonic planes orientated parallel to longitude are subject to tension in a W-E direction and to shearing in a diagonal orientation. Arranged in an orientation parallel to latitude/equator, they are subjected to compression in a N-S direction. Plate tectonic planes behave in accordance with that stress field. However, this field is distorted by the eastward displacement of the lower mantle and the Pacific basin relative to the upper mantle/crust and the continents of the Pangaea area (tidal forces). The effects of the centrifugally induced stress field are intensified West of the Pacific (compressional formation of the collisional mountain belt parallel to latitude/equator in a N-S direction and extensional openings of backarc basins parallel to longitude in a W-E direction) but to the East of the Pacific they are weakened, neutralized or reversed (extensional openings of Mediterraneans/Caribbeans and basin-and-range/metamorphic core complex style provinces parallel to latitude/equator in a N-S direction and formation under slight compression of the Cordilleras/Andes parallel to longitude in a W-E direction) (Fig.4). In consequence, the present western margin of North America during the Late Cretaceous Laramide collision/orogeny must have been positioned close to the equator and orientated parallel to latitude/equator to the West of the Late Mesozoic Pacific or Tethys Ocean (Figs.6, 7). Subsequently it must have rotated clockwise into its present orientation.

Analogous to the earlier/younger/past to later/older/future arrangement of ocean styles from East to West through 360° around the globe in the evolutionary sequence of the Oceanic or Wilson Cycle (opening and closing of an ocean) and the collision ages of the individual segments of the Himalayan-Alpine-Laramide-Kimmerian-Indosinian-Uralian collisional mountain belt increasing progressively westwards, the ages of post-collisional extension in this collisional mountain belt and its forelands (Mediterranean/

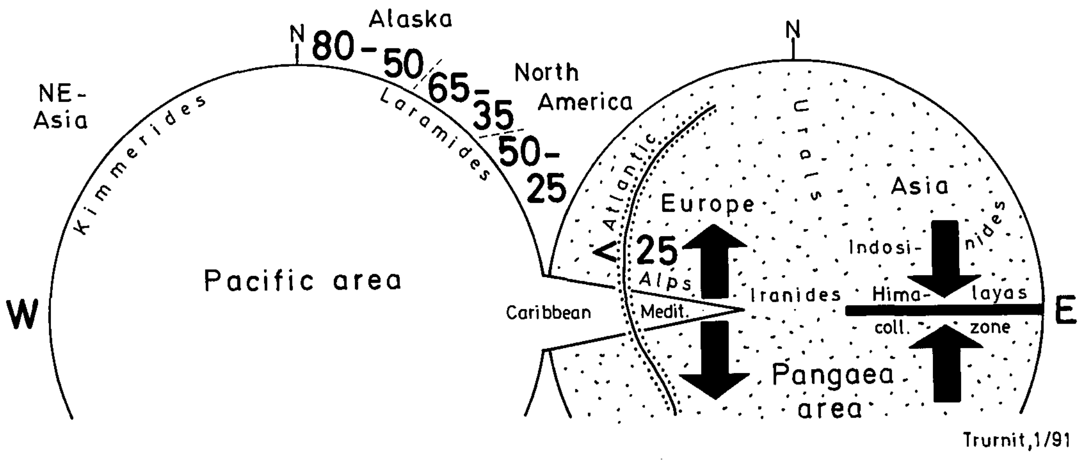

Fig.5 — Initiation and termination of post-collisional extension as well as eastwards propagation of basin-and-range/metamorphic core complex style tectonics within and in the northern forelands of the Alpine-Laramide segment of the North Pangaea collisional mountain belt (in million years).

Caribbean style rifting; basin-and-range style extension; rise of metamorphic core complexes, etc.) also show an increase towards the West (Eisbacher, 1988) (Fig. 5).

The eastward displacement of the Pacific basin and of the sequence of ocean styles of the Wilson Cycle relative to the continents of the Pangaea area demands a slightly higher angular velocity of the convecting lower mantle (Pacific crust = roof of the lower mantle? Two-layer convection only below the Pangaea area?) around the Earth's spin axis, compared with that of the upper mantle-crust system (Nelson and Temple, 1972; Trurnit, 1984 - Fig.6; 1988a - Fig.7; 1988b - Fig.5; 1989 - Fig.5; 1991a - Fig.3; 1991b - Fig.13; 1991c - Fig.3; 1991d - Fig.8; 1992 - Fig. 8). This behaviour of the Earth appears to be caused by the off-centre rotation of the spinning Earth around the gravitational centre of the Earth-Moon (-Sun) system, which moves West through the lower mantle around the Earth's spin axis with the angular velocity of the Earth's tidal bulges.

Pendular movements, rotations and breakup of continents; the reassembly of Gondwana, of South Pangaea and of its collisional mountain belt spiral

One East drift lappping of the upper mantle/crust, of the Pangaea area or of the continents by the Pacific basin, by the sequence of ocean styles of the Wilson Cycle, by the collisional mountain belt or by the lower mantle during the younger history of the Earth lasted 200 to 250 m.y. (shorter going back in time), taken from the differences in age between the overlapping segments of the first completed and older lap (Triassic Indosinian segment of the closed Paleo-Tethys) and the second, still incomplete and younger lap (Tertiary Alpine-Himalayan segment of the closed Neo-Tethys) of the Late Paleozoic-Mesozoic-Cenozoic North Pangaea collisional mountain belt spiral in Asia (Figs.1, 6) (calculated with 250 m.y.: some 16 cm/y or 0,44 mm/d East drift at the equator and growth of the collisional mountain belt behind the Pacific basin towards the East).

The North Pangaea or Laurasia collisional mountain belt leads 1 1/4 to 1 1/3 times westwards around the globe, from the Neogene Himalayas to the Permian Urals. Further to the West and next in age follow the Late Carboniferous European and North American (Marathon-Ouachita-Alleghenian) Variscan mountain belts. Many older collisional mountain belt segments which could be parts of the continuation of the North Pangaea collisional mountain belt in the West, are presently found in the southern hemisphere, some (Appalachians/Caledonides and the Asiatic Caledonides) also in the northern hemisphere. The author of this paper speculated early (Trurnit, 1984; 1988a, b; 1989) about the possibility that the continuation of the North Pangaea collisional mountain belt to the West was originally formed in the southern hemisphere in the form of a South Pangaea collisional mountain belt spiral, that North America belonged during pre-Variscan times to the southern hemisphere (Fig.6), that the Earth's history should be subdivided into alternating North Pangaea growth/South Pangaea breakup eras (Permian to present, etc.) and South Pangaea growth/North Pangaea breakup eras (Late Proterozoic to Middle Paleozoic, etc.) (Fig.6), that the Variscides were a one-sided mountain belt originally formed in a West Pacific island arc, microcontinent and backarc basin setting (Fig.6) and that throughout the Earth's history during Pangaea reorganization eras, Variscan style mountain belts were formed as connections between North and South Pangaea collisional mountain belt spirals (and vice versa). To prove this, a method of correctly piecing together the widely scattered segments and fragments of Gondwana, of the South Pangaea collisional mountain belt and its spiral had to be developed from a detailed analysis of the movements of the North and South Pangaea continents, from the Late Carboniferous onwards. The following passages sum up the results obtained and describe briefly the method developed. Results and method have been presented at length elsewhere (Trurnit, 1984; 1988a, b; 1989; 1991a-d; 1992).

During one East drift lapping by the Pacific basin the continents of the northern and southern hemispheres move differently, in that their margins pass through different sequences of plate tectonic settings:

In the hemisphere of the Pangaea growing (since the Permian the northern hemisphere) the continents face either the equator or the Pacific with the same margin. Otherwise a collisional mountain belt spiral would not form (Figs.1, 6). As the continents move around the Pacific basin in the North, they are subjected to a pendular movement (alternating clockwise and counterclockwise rotations combined with movements between high and low latitudes). The continents in the Europe and North America settings rotate clockwise after the openings of a respective North Atlantic and respective Mediterraneans and Caribbeans (counterclockwise in the southern hemisphere during South Pangaea growth eras) and the continents in the settings of Alaska and Northeast Asia rotate counterclockwise (reverse during South Pangaea growth eras in the southern hemisphere). Due to this behaviour the eastern margin of North America should not be joined to the northwestern margin of Africa in Pangaea reconstructions.

In the hemisphere of the Pangaea breaking up (since the Permian the southern hemisphere) the continents are also subjected to pendular movements between high and low latitudes and additionally rotate through approximately 120° while passing through the southern South America and Antarctica settings (clockwise during the breakup of a South Pangaea in the southern hemisphere - Permian to present; counterclockwise during the breakup of a North Pangaea in the northern hemisphere - Late Proterozoic to Middle Paleozoic) (Figs.1, 6). In the Antarctica setting a continent or plate should rotate in phase with the East drift angular velocity of the Pacific basin and the lower mantle relative to the remainder of the Earth's plates.

Since the Permian, the active Andean style margin of the SE-Pacific evolves from a passive West Africa style, which subsequently develops into an active New Guinea style margin and into the thrust zone of the collisional mountain belt at the equator to the West of the Pacific (Figs. 1, 2, 6). The South American Andes are not an orogen; they are only a one-sided pre-state or forerunner of the two-sided collision zone.

The SW-Pacific island arc/backarc basin/East Australia and later East Africa style margins in the hemisphere of the Pangaea breaking up (since the Permian the southern hemisphere; during the Late Proterozoic and Early to Middle Paleozoic the northern hemisphere) have evolved from passive North Africa/southern Mediterranean, passive northern South America/southern Caribbean or passive West Antarctica style margins, that still might carry fragments from the southern parts of the collisional mountain belt (Figs. 1, 6) (e.g. Atlas, Caribbean Andes of Colombia and Venezuela, West Antarctica, New Zealand - Late Jurassic Rangitata orogen; East Australia - Triassic to Early Jurassic New England/Hunter-Bowen orogen), the main parts of which migrate around the Pacific basin in the form of tectonostratigraphic terranes in the North (Figs. 1, 2, 6), together with and as parts of the collisional mountain belt of the North Pangaea growing since the Permian.

During one East drift lapping of the continents of the Pangaea area by the Pacific basin, a West Gondwana, East Gondwana, South America or Africa style continent will break up into several smaller continents mainly in the southern South America and Antarctica settings: e.g. South Pangaea into Laurentia, West Gondwana and East Gondwana; East Gondwana into India, Australia and Antarctica; West Gondwana into South America and Africa; South America in future into the Fireland-Falkland, the Brazilian and Guayana continents; Africa in future into the South Africa, East Africa and West Africa continents (Fig.6). In addition, in the NE-Africa or NE-South America setting an Arabia/Greenland style continental fragment will break off the Africa or South America style continent along a Red Sea style rift and migrate polewards to become part of the Pangaea growing. Apart from these breakups, one of the three margins of a South America, an Africa, an East Gondwana, a West Gondwana or a South Pangaea style continent is scaled off twice during one East drift lapping by the Pacific basin (Figs. 1, 6): Firstly the North Africa style margin during the separation of an Africa style continent from the collisional mountain belt in the Mediterranean setting. Major parts of this margin remain attached to the collisional mountain belt of the Pangaea growing (tectonostratigraphic terranes; Figs. 2, 6). Only relics of the belt stay with the newly formed passive North Africa style margin (Figs. 2, 6). Secondly the East Australia/SW-Pacific island arc, microcontinent and backarc basin style margin (former North Africa style) (Figs. 2, 6).

Through reverse or counterclockwise rotations of the southern hemisphere continents and reassembled megacontinents from their present orientation back to their Early Mesozoic and Paleozoic orientations and by shifting back North America (Laurentia) South into the southern hemisphere and into its Paleozoic orientations and settings one arrives at the correct reconstruction of the Early Mesozoic Gondwana, of the Late Proterozoic to Middle Paleozoic South Pangaea and of its collisional mountain belt spiral (Fig. 6). This South Pangaea (Gondwana plus Laurentia) and Gondwana reconstruction must satisfy the following requirements: 1. The collision ages in the South Pangaea collisional mountain belt have to increase progressively westwards; 2. The younger lap of the collisional mountain belt has to face the equator, the older lap the South Pole; 3. Analogous to the Permian to present North Pangaea collisional mountain belt, the Late Proterozoic to Middle Paleozoic South Pangaea collisional mountain belt had to be orientated during the whole era of its eastwards growth either in the Pangaea area parallel to the equator or in the southern hemisphere alongside the Paleozoic Pacific or Iapetus Ocean (pendular movements of the South Pangaea continents with the same margins facing either the equator or the Pacific basin; Figs.1, 6). 4. All existing Late Proterozoic to Middle Paleozoic (Early Carboniferous) orogenic fragments and segments which at present are dispersed individually all over the globe, either in the interiors of continents (e.g. Asia) or at the margin of a southern hemisphere continent (e.g. Tuhua orogeny fragment of New Zealand; Pampa and Famatina orogeny fragments of southern South America) have to be accomodated in the reconstructed South Pangaea collisional mountain belt spiral (Figs. 1, 6).

In Figure - 6, the right side of the top illustration depicts the present arrangement of continents around the globe and around the Pacific. On the left side of the top illustration, the North Pangaea collisional mountain belt leads from West of the Pacific westwards from the Neogene Himalayas via the Early Tertiary and Mesozoic segments of the belt to the Urals formed during the Permian. The southern hemisphere continents have been reassembled as the East and West Gondwana megacontinents and rotated counter-clockwise back to their previous orientations during the respective eras in which they were attached to the northern continents and to the North Pangaea collisional mountain belt, between the collisions at the equator to the West of the Pacific/Tethys and before separating anew, East of the Pacific/Tethys in the post-collisional, extensional Mediterranean and Caribbean settings. Below the top continent/ocean distribution scenario for the present in Figure 6, additional scenarios are illustrated for the Late Cretaceous, Jurassic, Triassic, Permian and the Late Carboniferous, in which the progressive East to West/West to East displacement between the continents and the Pacific basin is demonstrated, in which the North Pangaea collisional mountain belt is shown in successively earlier and shorter stages and in which the South Pangaea collisional mountain belt spiral becomes increasingly visible.

The clockwise rotation of North America during the Tertiary; the Late Mesozoic and Early Tertiary setting of the Greenland Plate compared with the present setting of the Arabian Plate

The North America paradox (Atlantic versus Pacific margin: assumed former connection between the eastern margin of North America and the western margin of North

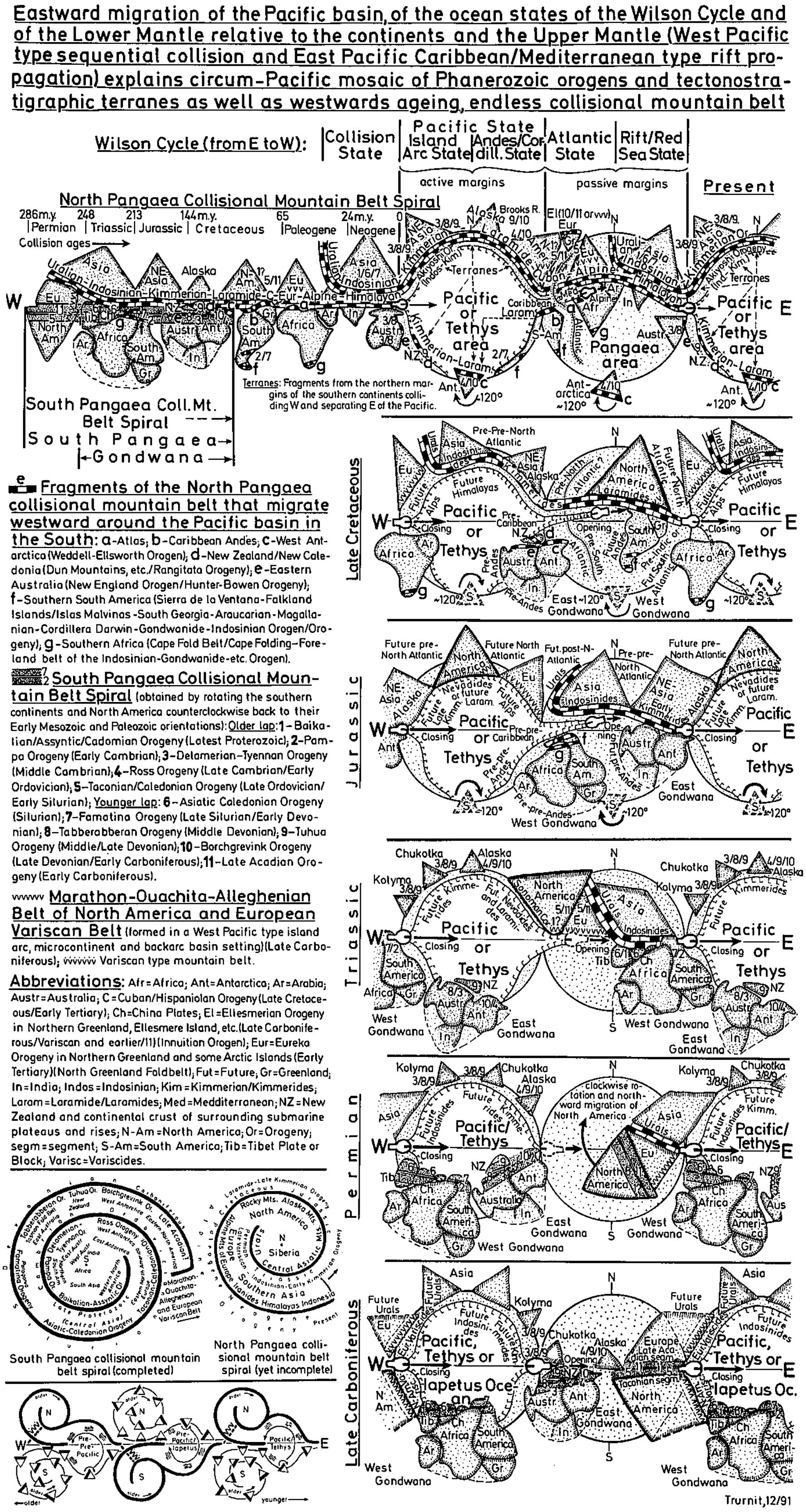

Fig. 6— Global continent/ocean distribution scenarios of the Late Carboniferouse, Permian, Triassic, Jurassic, Late Cretaceous and the Present. Reconstruction of the South Pangaea collisional mountain belt spiral by rotating back the southern hemisphere continents counterclockwise to their Early Mesozoic and Paleozoic orientations in the southern hemisphere. At the left side of the top illustration the South Pangaea/Gondwana continents are depicted after having collided at the equator to the West of the eastward migrating Pacific basin and before separating anew from the northern continents in the extensional Mediterranean and Caribbean settings to the East of the Pacific.

Africa inconsistent with parallel to equator Laramide collision and post-Laramide clockwise terrane/continent rotation) must have resulted from a major error in Central and North Atlantic continent reassemblies that inhibits progress in global tectonics: The "West Africa Connection". Since Wegener (1915), Choubert (1935), Du Toit (1937), Bullard *et al.* (1965) and others reassembled the continents surrounding the present Atlantic Ocean into Pangaea, the single Late Paleozoic/(Early Mesozoic?) supercontinent, in the absence of an alternative model, no one has ever challanged their axiomatic reconstruction apart from minor adjustments. While the former fit between Africa and South America is beyond doubt and that between Europe and North America only needs readjustment, the origin of Greenland is still most obscure (Lefort, 1989) and the presumed former connection between eastern North America and western North Africa requires critical reappraisal.

Geodynamically, a "West Africa connection" appears improbable for the following reasons: 1. According to the distorted global stress field induced by the combined effects of thermal convection and gravitational, centrifugal and tidal forces (Fig.4), a collision between continents from the northern and southern hemispheres (North and South Pangaea) only takes place parallel and close to the equator and only behind and to the West of the eastward migrating Pacific basin (Figs.1, 6). During its formation the Late Cretaceous Laramides collisional mountain belt of present-day Western North America must therefore have been positioned farther South close to the equator and orientated parallel to latitude/equator. 2. In the extra-Pacific or Pangaea area the continents from the northern and southern hemispheres are always connected through a collisional mountain belt which is orientated more or less parallel to equator/latitude and which has collision ages between 0 and up to 100 m.y. (Figs.1, 3, 5, 6). Such young collisional mountain belt does not exist along the North America - West Africa segment of the Atlantic rift ocean. 3. According to the distorted global stress field (Fig.4) the post-collisional disengagements between the continents from the northern and southern hemispheres (North and South Pangaea; Laurasia, Gondwana; etc.) take place only more or less parallel to latitude/equator and only to the East and ahead of the eastwards migrating Pacific basin in the extensional Mediterranean and Caribbean settings (Figs.1, 3, 5, 6). These disconnecting rift oceans form more or less

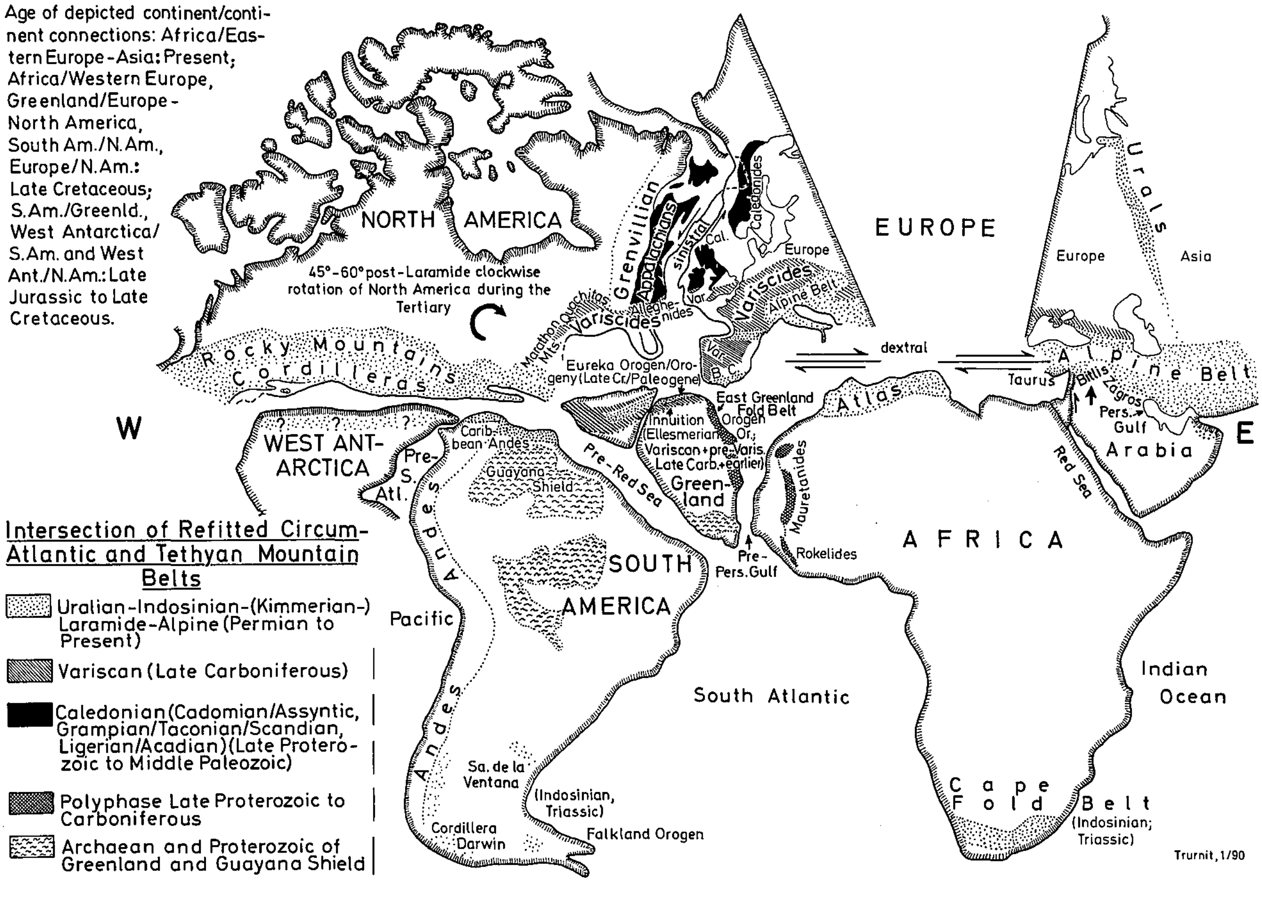

Fig. 7— Center and left side of illustration: Late Jurassic to Late Cretaceous scenarios of the Laramide and Alpine segments of the North Pangaea collisional mountain belt before and during the initial openings of the early pre-Caribbean, the Caribbean and the early Central and North Atlantic Oceans. Center and rigth side of illustration: Late Cretaceous/Early Tertiary and present scenarios; both Greenland (Arabia of South America) and Arabia (Greenland of Africa) appear to have been disconnected from their respective parent continents in similar plate tectonic settings. Clockwise rotation of North America during post-Laramide times from the Early Tertiary onwards subsequent to the initial openings of the Caribbean, Central and North Atlantic Oceans.

parallel to the trend of the orogen/collisional mountain belt, either in the midst of the belt, shifted somewhat equatorwards in the orogen, or in the foreland positioned on a continent of the Pangaea breaking up. During their early evolution, neither the passive western margin of North Africa nor the post-Caledonian passive margin of eastern North America formed as margins of such a parallel to equator Mediterranean style ocean (tongue of the Pacific basin) heralding the approach of the Pacific from the West (Fig. 6).

In the light of the above, it appears impossible that the eastern margin of North America was formerly attached to the western margin of North Africa. Geodynamic considerations support the conclusion that the western margin of North America, presently orientated in a NW-SE direction alongside the NE-Pacific, collided during the Late Cretaceous Laramide orogeny with the northern margin of South America (Caribbean Andes, Cuba, Hispaniola) close and parallel to the equator and to the West of the Late Mesozoic Pacific/Tethys. During the post-Laramide era North America migrated northwards and after having arrived East of the Pacific (polewards withdrawal of Alaska/NE-Asia in the northern and of Antarctica or East Gondwana in the southern hemisphere - Fig. 7), due to the Coriolis force and the drag of the northward migrating Pacific Plate (Trurnit, 1988a - Fig.14) (dextral San Andreas fault strike-slip system), rotated clockwise through 45° to 60° from the Early Tertiary onwards into its present orientation (Figs. 6, 7). The eastern margin of North America should have been positioned in more northerly latitudes und during pre-North Atlantic until early post-Laramide times, should have been connected to the western margin of Europe but not to the western margin of North Africa ("West Africa Connection" a major error!). Numerous paleomagnetic measurements mainly on Tertiary magmatic rocks of Western North America confirm a clockwise rotation of the continent through 45° to 60° during the Tertiary (not explainable alone by local block rotations caused by dextral strike-slip between the western margin of North America and the Pacific Plate, by oblique collisions of terranes or by coastwise transport of tectonostratigraphic terranes along the convex margin of Western North America; Beck, 1976, 1980; Kissel and Laj, 1989). The future detection of suspected former sinistral movements between the eastern margin of North America and the mid-Atlantic Ridge (oblique spreading; ballbearing-like rotations of microplates along the ridge - Hey *et al.*, 1985; slip along major faults off the coast - Sheridan and Grow, 1988), a reinterpretation of the seafloor spreading magnetic anomalies in these realms and a stronger consideration of the fact, that the pattern of latitude-parallel fracture zones to the West of the mid-Atlantic Ridge is less accentuated compared to that pattern to the East of the ridge (Smoot, 1989), might assist in unraveling the North American paradox.

Due to migration eastwards of the sequence of ocean styles of the Wilson Cycle (Figs. 1, 6), relative to a distinct plate tectonic setting of an ocean, a continent or continental margin, a future or later evolutionary style at the Earth's surface is always depicted in a setting simultaneously developed further to the West and a past or earlier style in a setting simultaneously occurring further to the East.

Consequently, in addition to the presumed clockwise rotation of North America during the Tertiary, a high probability exists that Greenland (the Arabia of South America) was formerly connected to northeastern South America and northwestern Africa (Figs. 6, 7). The Late Cretaceous/Early Tertiary Eureka orogen positioned at the northern margin of Greenland and on some of the Canadian Arctic Islands (e.g. Ellesmere Island, etc.), possibly fits in between the Late Cretaceous Laramide Caribbean Andes/ Cuba/Hispaniola orogen in the West and the Early Tertiary Alpine Atlas Mountains of North Africa in the East (southern parts of the Late Cretaceous/Early Tertiary Laramide-Alpine segment of the North Pangaea collisional mountain belt). The (Devonian? to) Late Carboniferous Ellesmerian "orogeny" (Innuition "orogen") in northern Greenland, on Ellesmere Island and other northern Canadian Arctic Islands possibly fits in between the Late Carboniferous Marathon-Ouachita-Alleghenian Variscan belt of southern North America in the West and the Late Carboniferous European and North African Variscan belt in the East (Figs. 6, 7) (Variscides of North Africa part of Europe? - Weijermars, 1987, 1988, 1991).

The East Greenland Fold Belt (Early Paleozoic orogeny) and the polyphase Mauretanides-Rokelides Belt of West Africa (Late Proterozoic, Early to Middle Paleozoic orogenies; Barker and Gayer, 1985; Dallmeyer, 1989) (Figs.6, 7) should be one and the same orogenic belt. Climatic conditions indicating a northward migration of Greenland and attached Canadian Arctic Islands during the Tertiary (coal, petrified forests, subtropical and tropical Eocene fauna and flora) are mentioned by Miall (1984), McMillan (1986), Francis and McMillan (1987), Francis (1990) and others. Greenland (the Arabia of South America) could have drifted North during post-Laramide, Early to Middle Tertiary times into its present-day position from a plate-tectonic setting which corresponds to the present-day setting of Arabia (the Greenland of Africa) to the South of the Tertiary Alpine collisional mountain belt (Figs. 6, 7). Concurrently with the future opening of a post-Central and -North Atlantic Ocean in Eastern Europe or between Europe and Asia, Arabia might probably continue to force its way North through the Alpine belt and the Russian Platform of Eurasia. It should in future arrive at a plate tectonic setting comparable to that presently occupied by Greenland (Figs. 6, 7).

CONCLUSIONS

1. According to the distorted global stress field induced by the combined effects of thermal convection, gravitational, centrifugal and tidal forces, continent/ continent collisions only occur between continents from the northern and southern hemispheres (North Pangaea/ South Pangaea, Laurasia/Gondwana) parallel and close to the equator and only behind and to the West of the

eastwards migrating Pacific basin. Consequently, during its formation the Laramides collisional mountain belt segment at the present western margin of North America must have been positioned close to the equator to the West of the Late Mesozoic Pacific/Tethys and orientated parallel to equator/latitude. North America subsequently rotated clockwise through 45° to 60° into its present orientation, from the Early Tertiary onwards.

2. In the extra-Pacific or Pangaea area the northern and southern hemisphere continents (North and South Pangaea continents) are always connected through a collisional mountain belt which is orientated more or less parallel to latitude/equator and has young collision ages of up to 100 m.y. Due to the absence of such belt along the North America-West Africa segment of the Atlantic rift ocean and this segment not being comparable to a post-collisional Mediterranean style rift ocean heralding the approach of the Pacific from the West, the eastern margin of North America (a part of North Pangaea or Laurasia) could not have been connected to the western margin of North Africa (a part of South Pangaea or Gondwana). The "West Africa Connection" is a major error in Central and North Atlantic continent reconstructions.

3. Due to migration eastwards of the sequence of ocean styles of the Wilson Cycle around the globe, relative to a distinct plate tectonic setting of an ocean, a continent or continental margin, a future or later evolutionary style at the Earth's surface is always depicted in a setting simultaneously developed further to the West and a past or earlier style in a setting simultaneously occurring further to the East. In consequence, a high probability exists that Greenland (the Arabia of South America?) was formerly attached to northeastern South America and western North Africa. During post-Laramide times Greenland must have come from a plate tectonic setting comparable to that presently occupied by Arabia (the Greenland of Africa?).

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