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PHANEROZOIC PALEOENVIRONMENT AND PALEOLITHOFACIES MAPS. MESOZOIC

Mapy paleośrodowiska i paleolitofacji fanerozoiku. Mezozoik

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Abstract: The paper presents the detailed plate tectonic, paleogeographic, paleoenvironment and paleolithofacies maps for eight Mesozoic time intervals. The most significant Triassic convergent event was the Indosinian orogeny, the collision of Indochina and Indonesia with South China, and consolidation of Chinese blocks. The continued northward drift of the Cimmerian continents corresponded with the closing of the Paleotethys and opening of the Neotethys Ocean. Plate tectonic activity around the Triassic-Jurassic boundary caused paleogeographic and paleoclimatic change, which triggered mass extinction. The rifting in the Atlantic during the Early Jurassic was followed by Middle and Late Jurassic spreading. Cretaceous was the time of the farther spreading of Central Atlantic, as well as origin of South Atlantic and Indian oceans. These events were leading to the maximum dispersion of continents during Phanerozoic times.

Key words: Triassic, Jurassic, Cretaceous, plate tectonics, paleogeography, mass extinction

Treść: Artykuł przedstawia szczegółowe mapy obrazujące tektonikę płyt, paleogeografię, paleośrodowisko i paleolitofacje ośmiu mezozoicznych przedziałów czasowych. Mapy te dotyczą przedziałów czasowych w obrębie triasu, jury i kredy. Głównym konwergentnym wydarzeniem w okresie późnego triasu była orogeneza indochińska, czyli kolizja Indochin i Indonezji z południowymi Chinami, oraz konsolidacja bloków chińskich. Postępujący w kierunku północnym dryft płyt kimeryjskich spowodował zamykanie oceanu Paleotetyda i otwieranie się oceanu Neotetyda. Aktywna tektonika płyt na granicy triasu i jury spowodowała zmiany paleogeograficzne i paleoklimatyczne, które wywołały masowe wymieranie gatunków fauny i flory. Rifting Atlantyku centralnego w okresie wczesnej jury poprzedził środkowojurajski i późnojurajski spreding tego oceanu. W kredzie nastąpił dalszy spreding Atlantyku centralnego, jak również narodziny Atlantyku południowego i Oceanu Indyjskiego. Wydarzenia te prowadziły do największego w fanerozoiku rozproszenia kontynentów.

Słowa kluczowe: trias, jura, kreda, tektonika płyt, paleogeografia, masowe wymieranie

INTRODUCTION

The aim of this paper is the presentation of paleogeographic maps of the world, containing paleoenvironment and paleolithofacies details. In the previous papers (Golonka *et al*. 1994, Golonka 2000, 2002, Golonka & Bocharova 2000, Golonka & Ford 2000) the author presented global paleogeographic maps or details of selected regions (Golonka *et al*. 2000, 2003a, b, 2006, Ford & Golonka 2003). Similar maps were presented before (Golonka 2006) but they covered only Late Triassic and Early Jurassic time slices. Now, the author attempts to cover the entire Phanerozoic in four papers. This paper is dealing with Triassic (two time slices), Jurassic (three time slices), and Cretaceous (three time slices). The papers covering Paleozoic and Cenozoic will follow soon. The maps were constructed using a plate tectonic model, which describes the relative motions between approximately 300 plates and terranes. The detailed reconstruction methodology was described previously in Golonka *et al*. (2003b) paper. The rotation file was presented in Golonka (2007) paper, online version, the appendix. The facies were assembled according to rules established during the production of Phanerozoic reefs map (Kiessling *et al*. 1999, 2003) and also presented by Golonka *et al*. (2006) and Golonka (2007).

MAP DISCUSSION

Early Triassic

The supercontinent Pangea (Fig. 1) existed during the Triassic time (Golonka 2000, 2002). It was surrounded by the Panthalassa Ocean. The continued northward drift of the Cimmerian continent constituted the main Early Triassic global tectonic event. The rifting of the Cimmerian plates (Şengör 1984) occurred during latest Carboniferous-Permian time (Golonka 2000, 2002, Golonka & Ford 2000). These plates drifted from Gondwana north toward Eurasia during Triassic time (Figs 1–3). This movement caused the closing and progressive consumption of the Paleotethys oceanic crust and the opening of the Neotethys Ocean. Large carbonate platforms (Fig. 2 on the interleaf, Fig. 3) developed along the Neotethys and Paleotethys margins as well as on the Cimmerian plates (Dercourt *et al*. 1993, Philip *et al*. 1996, Şengör & Natalin 1996, Golonka & Ford 2000, Zharkov & Chumakov 2001, Philip 2003, Golonka 2004, 2007). Carbonates were limited to a narrow equatorial belt, separating the Paleotethys and Neotethys, and to narrow platforms, along convergent margins of Western Pangea (Kiessling *et al*. 1999, 2003, Golonka 2000, Golonka & Ford 2000). Following the Permian-Triassic extinction, biogenic communities were revived by the Middle Anisian (Kiessling *et al*. 1999, Flügel 2002). Rifting and block-fragmentation in the Tethys played an important part in this revival. The carbonate platform included blocks of the margin of the Circum-Mediterranean Area, Iranian, Qiangtang, Indonesian blocks, the South Chinese plate, and the southern margin of the Scythian plate and margins of Arabia (Figs 2, 3). Dolomitization occurred quite commonly on the carbonate platforms. According to Flügel (2002), Triassic reefs were formed not only in the Tethys but also in the western and eastern parts of the Panthalassa (Paleo-Pacific) Ocean. They originated on shelves of enigmatic tectonostratigraphic terranes in the western and eastern Panthalassa Ocean. These terranes are posted on figure 1.

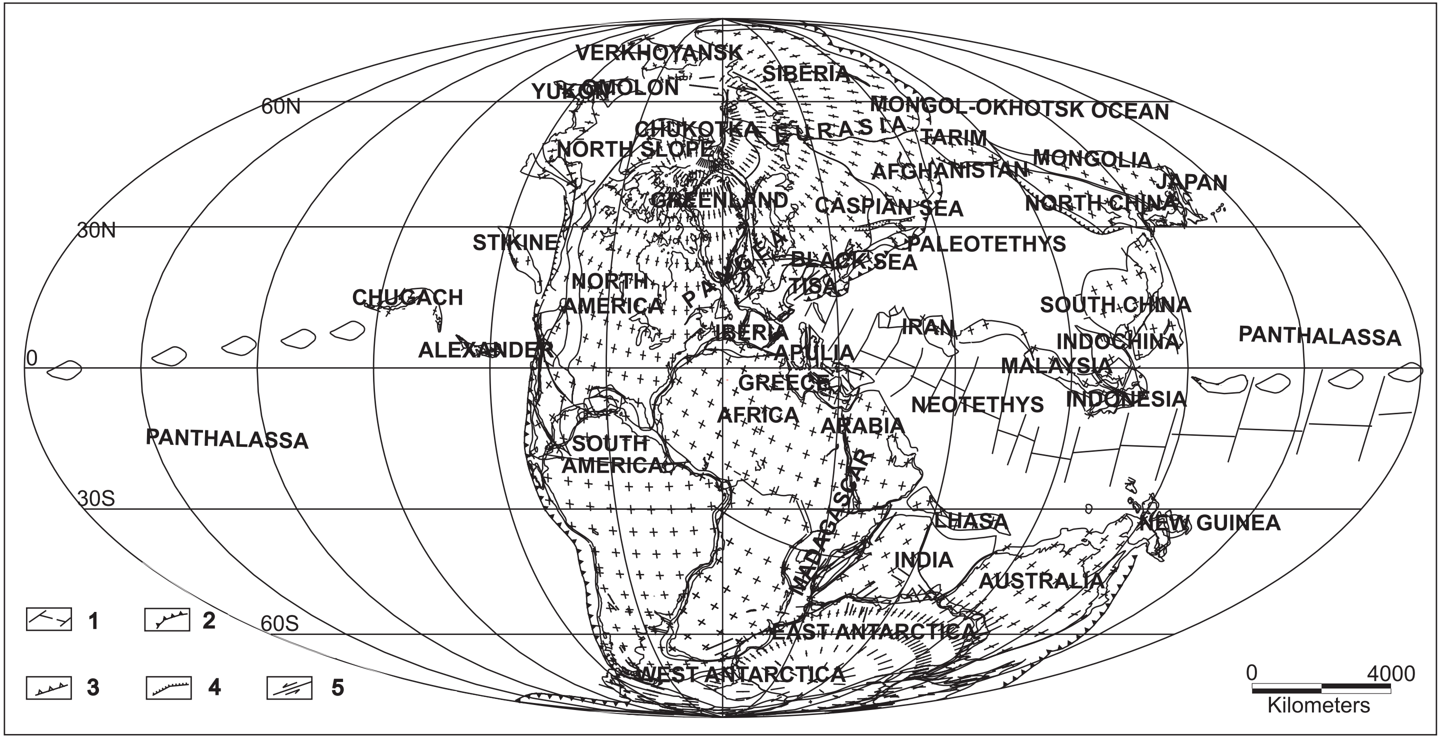

Fig. 1. Plate tectonic map of the Early Triassic (plates position as of 237 Ma). Modified from Golonka (2002): 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault

Fig. 1. Mapa tektoniki płyt wczesnego triasu (pozycja płyt 237 milionów lat temu). Zmieniona wg Golonki (2002): 1 – centrum spredingu oceanicznego i uskok transformujący, 2 – strefa subdukcji, 3 – nasunięcie, 4 – uskok normalny, 5 – uskok przesuwczy

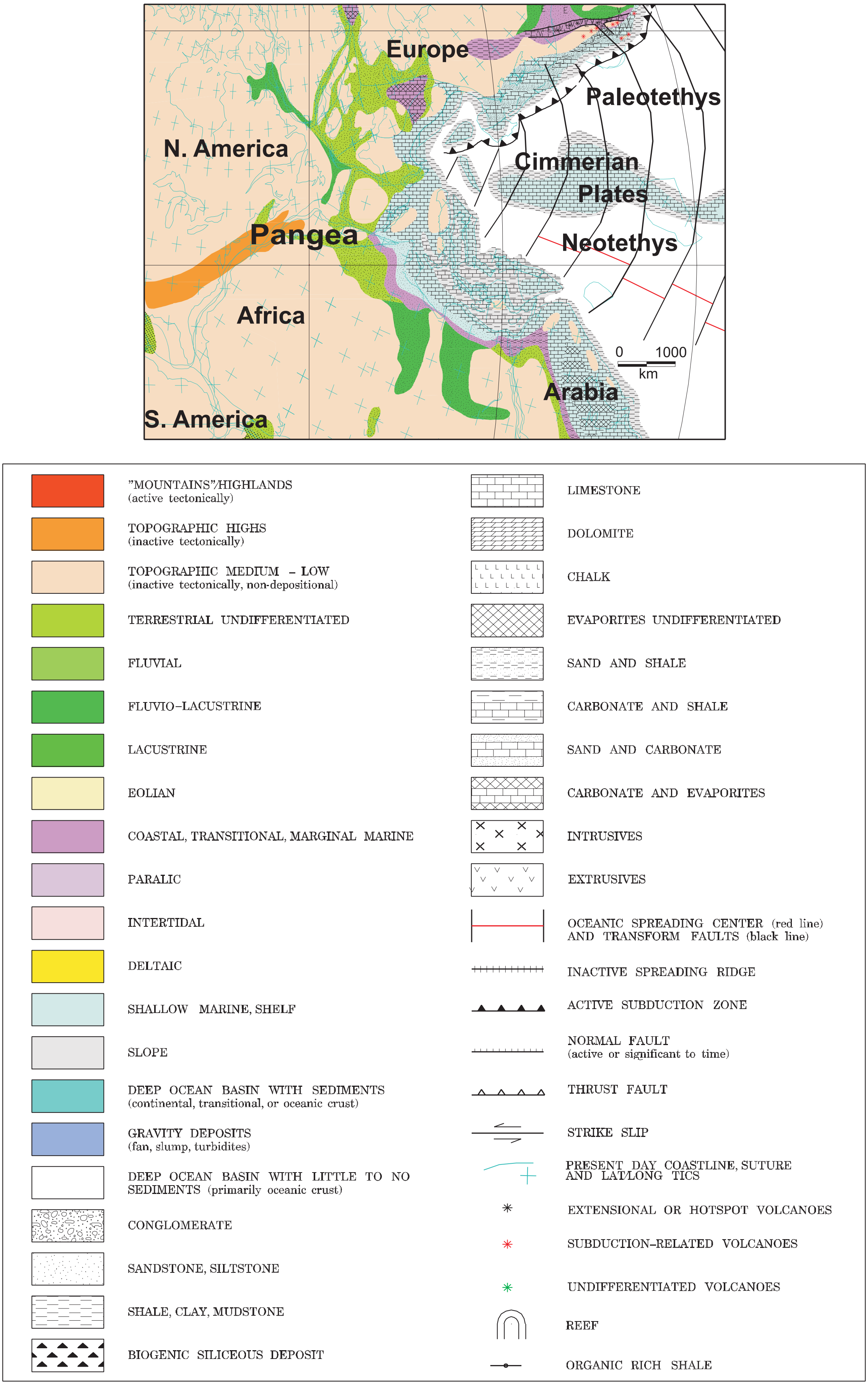

Fig. 2. Plate tectonic, paleoenvironment and lithofacies map of the western Tethys, future Central Atlantic and adjacent areas during Early Triassic time. Explanations to figures 2–5, 7–10, 12–15, 17–20, 22–25, 27–30, 32–35, 37–40. Qualifiers: B – bauxites/laterites, C – coals, E – evaporites, F – flysch, Fe – iron, G – glauconite, M – marls, O – oolites, P – phosphates, R – red beds, Si – silica, T – tillites, V – volcanics

Fig. 2. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Tetydy, przyszłego centralnego Atlantyku oraz obszarów sąsiednich we wczesnym triasie. Objaśnienia do figur 2–5, 7–10, 12–15, 17–20, 22–25, 27–30, 32–35, 37–40. Oznaczenia literowe: B – boksyty/lateryty, C – węgle, E – ewaporyty, F –f lisz, Fe – żelazo, G – glaukonit, M – margle, O – oolity, P – fosfaty, R – utwory czerwone, Si – krzemionka, T – tillity, V – utwory wulkaniczne

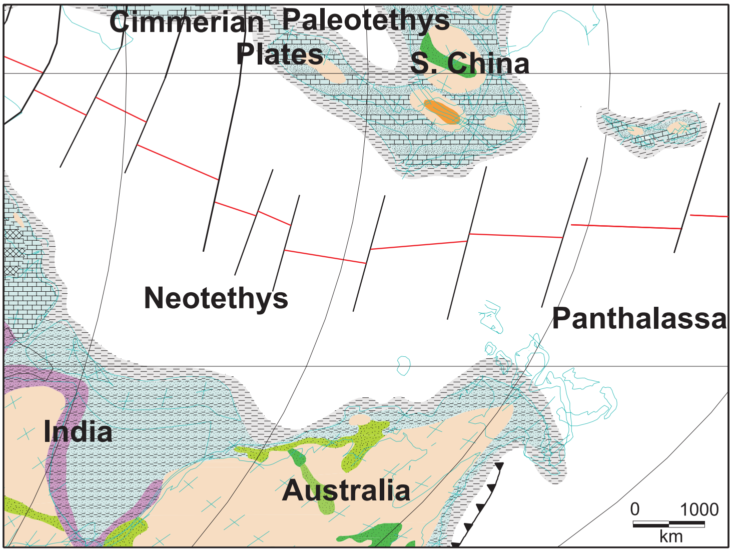

Fig. 3. Plate tectonic, paleoenvironment and lithofacies map of the eastern Tethys and adjacent areas during Early Triassic time

Fig. 3. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Tetydy oraz obszarów sąsiednich we wczesnym triasie

The relationship between Panthalassa terranes and Cimmerian plates is being postulated. During the Permian-Triassic, the Panthalassa terranes drifted perhaps northward from Gondwana and now are attached to Asia and the western North America (Flügel 2002). Their exact origin, evolution and time of accretion is a subject of controversies and long lasting debate (see e.g. Taylor *et al*. 1984, Engebretson *et al*. 1985, Panuska 1985, Debiche *et al*. 1987, Zonenshain *et al*. 1990, Beck 1992, Şengör & Natalin 1996, Keppie & Dostal 2001, Belasky *et al*. 2002).

In the Western Tethys area, the carbonate platforms were formed, which covered the margins of Western and Central Europe, as well as several plates between Europe and North Africa (Fig. 2). The Permian-Triassic back-arc rifting, related to the north-dipping Paleotethyan subduction developed along the southern margin of Eastern Europe and Asia (Kazmin 1991, Golonka 2004). This rifting was active in the future Caspian Sea (Figs 1, 2). The continental and marginal marine sediments with evaporites and volcanics were deposited in this area (Zonenshain *et al*. 1990, Dercourt *et al*. 1993, 2000, Nikishin *et al*. 1996, 1998a, b, Zharkov & Chumakov 2001, Brunet *et al*. 2002, Golonka 2004). The Vardar-Transilvanian Ocean separated the Tisa (Bihor-Apuseni) block from the Moesian-Eastern European Platform (Golonka 2004). The position of the Vardar, Transilvanian and Meliata Oceans, the position of the Tisa unit, and its role the Mesozoic evolution of the Western Tethys area are still speculative and the subject of lively discussion (see e.g. Golonka *et al*. 2000, 2003b, Csontos & Vörös 2004, Golonka 2004 and references therein, Haas & Péró 2004). For example, according to Haas & Péró (2004), Tisa was situated somewhere between Moesia and Carpathian plates, while Stampfli *et al*. (2001) placed it West of Carpathians. Rifting and oceanic type of basin opening could have occurred in the Mediterranean (Figs 1, 2). According to Golonka (2004), a narrow branch of the Neotethys separated the Apulia-Taurus platform from the African continent. This branch also included the Proto-Eastern Mediterranean area. The Apulia platform was connected with European marginal platforms (Fig. 2). A large evaporite platform was located on the Arabian plate (Golonka & Ford 2000). Marine clastic sedimentation prevailed in the north India and Australia (Cook 1990, Golonka & Ford 2000) margins (Fig. 3).

The North China plate was already sutured during the Permian time to the Amurian (Mongolia) terranes (Yin & Nie 1996, Golonka 2000, 2002). The south dipping subduction, which existed prior to this collision along the North China plate, jumped south forming the north-dipping subduction along the northern coast of eastern part of the Paleotethys. The Indonesian part of the Cimmerian continent and southern China drifted northward, and folded inward toward the northern Chinese plates (Metcalfe 1994) (Figs 1, 3). During the Late Permian, the South China plate began collision with the North China block (Yin & Nie 1996, Golonka 2002). This collision continued during the Triassic (Figs 1, 4). The collisional Permian-Triassic events resulted in granites known from the Mongolia-North China (Chen *et al*. 2000, Wu *et al*. 2002).

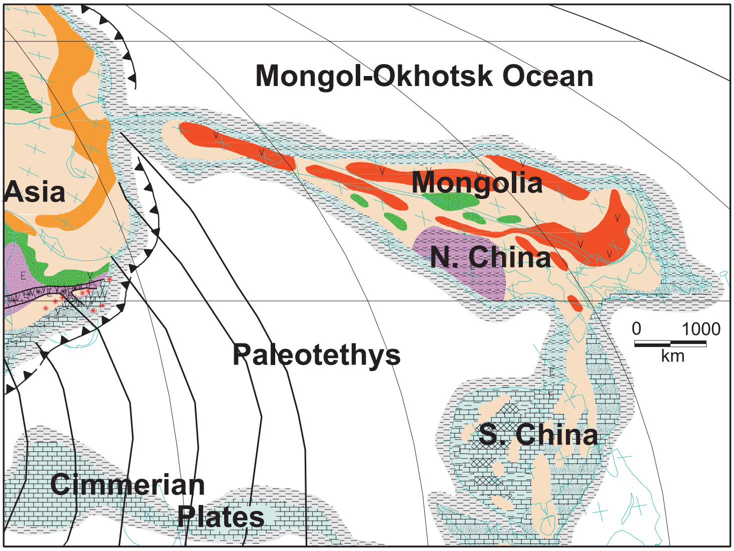

Fig. 4. Plate tectonic, paleoenvironment and lithofacies map of Paleotethys, Chinese plates and adjacent areas during Early Triassic time

Fig. 4. Mapa tektoniki płyt, paleośrodowiska i litofacji Paleotetydy, płyt chińskich oraz obszarów sąsiednich we wczesnym triasie

Consolidation of the North China and Amuria blocks left open the Mongol-Okhotsk Ocean – large embayment of Panthalassa between Amuria and Laurasia (Figs 1, 4) (Zonenshain *et al*. 1990, Golonka 2000, 2002, Golonka & Ford 2000, Kravchinsky *et al*. 2002). Active subduction existed along the margin of this ocean dipping cratonward toward East Siberia.

Indochina and Indonesia were sutured to the South China and Qiangtang block and approached the Eurasian margin (Golonka *et al.* 1994, 2007, Golonka 2000, 2002). Carbonate deposits, clastics and evaporites covered the South China plate (Ronov *et al.* 1989), while siliciclastic sedimentation prevailed on North China and Mongolia (Fig. 4). According to Tong & Yin (2002), South China contains various stratigraphic sequences of different paleogeographic facies, ranging from paralic clastics to deepwater turbidite via shelf carbonate facies. The Indochina and Indonesia suturing with South China resulted in the uplift of parts of South China during the Middle Triassic (Tong & Yin 2002).

Subduction zones originated during the Late Paleozoic along the coasts of Pangea forming the Pangean Rim of Fire (Golonka 2000, 2004, Golonka & Ford 2000). This Rim of Fire was active also during the Triassic and Jurassic causing active volcanism, terrane accretion, and back-arc basin development. The rifts developed in the Gulf of Mexico area, and in maritime Canada (Golonka 2000). In northwestern Africa, Western Europe, and the proto-North Atlantic area, the Late Paleozoic fracture system was reactivated (Ziegler 1982, Doré 1991, Nikishin *et al.* 2002). The North Sea rift system underwent development, together with the formation of the Polish/Danish Aulacogen. The continental siliciclastic sedimentation prevailed in these areas (Figs 1, 2).

The early stage of the Pangea breakup was probably associated with plate reorganization, like shifts from convergent to divergent plate tectonics (Golonka 2000, 2002). Crustal snap-back with uplift and inversion was followed by collapse of the crust. Rifting in Siberia was perhaps caused by pulling effect of the subduction zone, which existed along the margin of the Mongol-Okhotsk Ocean dipping cratonwards towards East Siberia (Fig. 4).

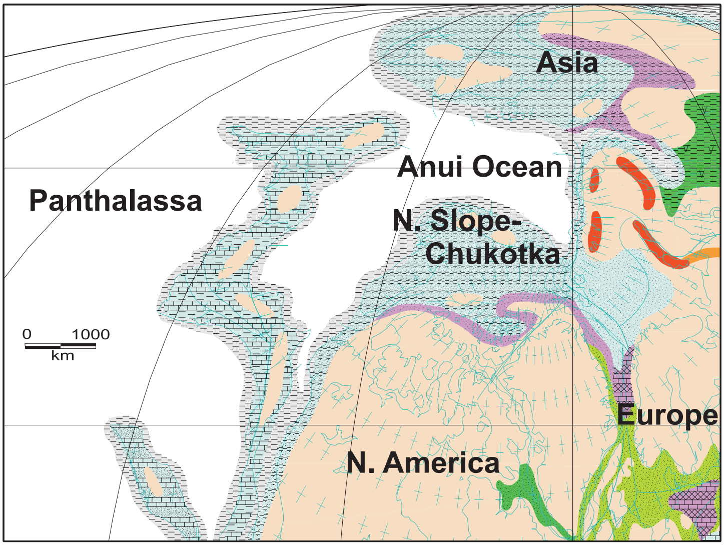

Fig. 5. Plate tectonic, paleoenvironment and lithofacies map of the northwestern Laurasia and adjacent areas during Early Triassic time

Fig. 5. Mapa tektoniki płyt, paleośrodowiska i litofacji północnozachodniej Laurazji oraz obszarów sąsiednich we wczesnym triasie

The sea between the Taimyr and Siberia was an extension of the Anui Ocean (Fig. 5), which existed between the Chukotka-North Slope of Alaska and Verkhoyansk terranes (Zonenshain *et al*. 1990, Şengör & Natalin 1996, Golonka 2000, 2002, Golonka *et al*. 2003a). The episode of very strong, hot spot related, flood basalt eruptions in the Western Siberian basin (Zonenshain *et al*. 1990) began towards the end of the Late Permian, within an extremely short period from 255 to 245 Ma. During 10 million years, 1 200 000 km^3 of basalts were extruded; the bulk of the Siberian lavas erupted within one million years at 250 Ma (Golonka 2000). The largest body of the flood basalts covers the Tunguska flood basalt province, located on the Siberian craton. There are magmatic activities in Siberia and adjacent part of Central Asia connected with the Tunguska super plume: Kuznetsk basalts, age Induan, basalts of Verkhoyansk-Viluy region, and Central Kazakhstan volcanics (Nikishin *et al*. 2002). The last collisional events of the Uralian orogeny took place during the Triassic and Early Jurassic time, in the Pay-Khoy-Novaya Zemlya area (Zonenshain *et al*. 1990, Nikishin *et al*. 1996, Puchkov 1997). The conclusion of the Uralian orogeny was accompanied by uplift of the adjacent areas of Eastern Europe and Western Siberia. The Late Carboniferous-Triassic collision between Siberia and the Kara Sea platform (may be part of Laurussia) in the Taimyr Peninsula was perhaps an extension of the Uralian collision (Ziegler 1982, Nikishin *et al*. 1996, Golonka *et al*. 2003a). According to Torsvik & Anderson (2002), Taimyr deformation happened most probably during the Late Triassic.

A stable marine shelf existed on the northern North America and Asia margins (Golonka *et al*. 2003a) (Fig. 5). Sedimentation in this area was primarily controlled by eustatic sea level changes. Triassic restricted-marine shelf basins (e.g. Alaska, Sverdrup, and Barents Sea) contain black shales that have source rock potential (Leith *et al*. 1993, Golonka *et al*. 2003a). Shoreface to offshore bar sandstones occurred in this passive margin sequence during regressive sea level fluctuations. These sandstones thin and become very discontinuous basinward. Low sea level, aridity and rifting resulted in the widespread continental clastic deposits with red beds and evaporites in Central and Western Europe (Figs 1, 5) during the Early Triassic (Ziegler 1982, Ronov *et al*. 1989, Golonka & Ford 2000, Golonka *et al*. 2003a). Marginal marine environment with clastic deposition existed in the seaway between Europe and Greenland (Stemmerik 2000, Golonka *et al*. 2003a).

Late Triassic

Rifting between North America and Gondwana continued during Late Triassic (Golonka 2000, 2002, Golonka & Ford 2000) (Figs 6, 7). According to Ford & Golonka (2003), during the early rifting phase in this area, extension was accompanied by strike-slip faulting and blocks rotation. Continental rifts were filled with the clastic deposits. Numerous interior clastic depositional systems contain abundant red beds (Ziegler 1988, Withjack *et al*. 1998, Golonka & Ford 2000, Kutek 2001) as well as fluvial deposits. Continental siliciclastics (Buntsandstein), mostly marine carbonates (Muschelkalk), and mixed siliciclastics, carbonates and evaporites (Keuper) formed the Central European Triassic tripartite facies sequence (Köppen & Carter 2000). Subsidence in this area led to the accumulation of sediments reaching up to 4000 m in central Poland (Köppen & Carter 2000, Kutek 2001, Golonka 2007). Continental rifting occurred (Fig. 7) between northern Europe and Greenland.

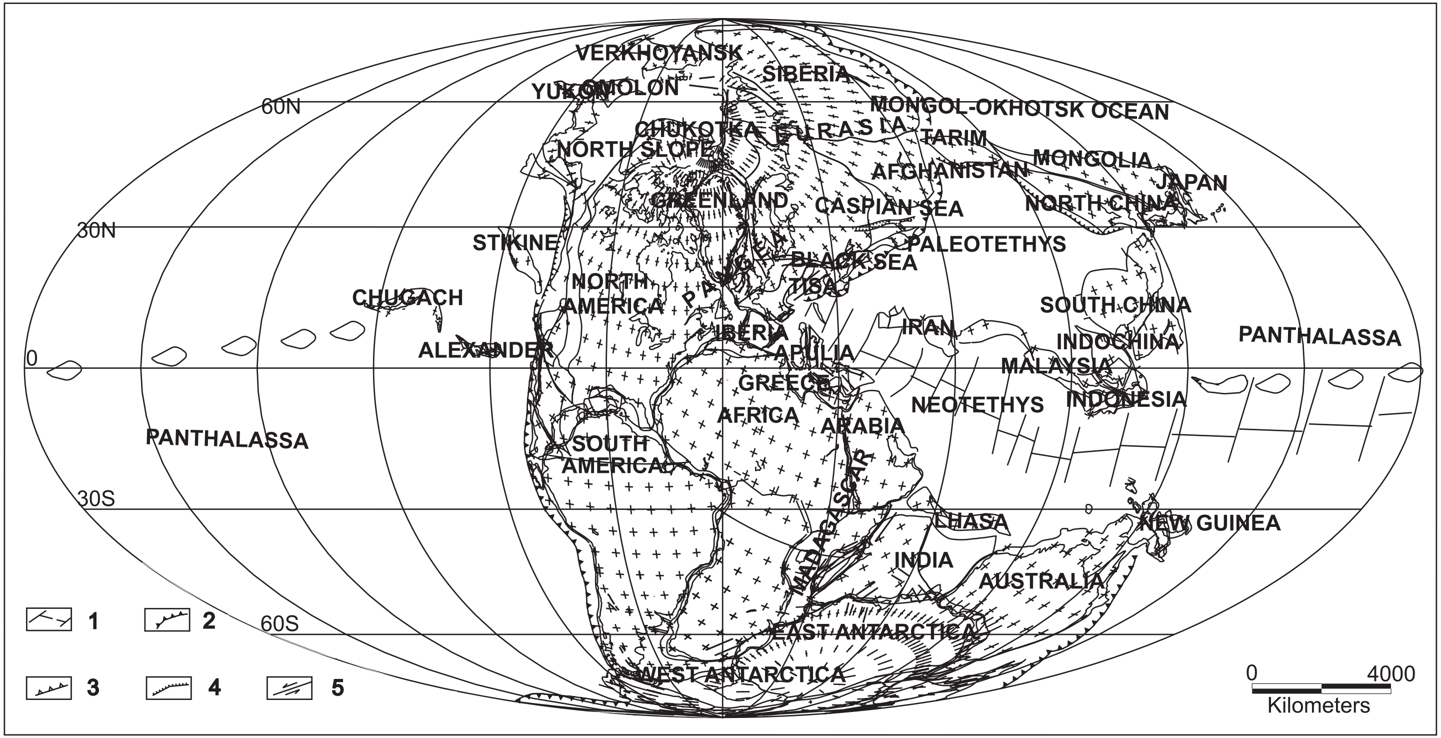

Fig. 6. Plate tectonic map of the Late Triassic (plates position as of 224 Ma). Modified from Golonka (2002, 2007): 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault

Fig. 6. Mapa tektoniki płyt późnego triasu (pozycja płyt 224 milionów lat temu). Zmieniona wg Golonki (2002, 2007): 1 – centrum spredingu oceanicznego i uskok transformujący, 2 – strefa subdukcji, 3 – nasunięcie, 4 – uskok normalny, 5 – uskok przesuwczy

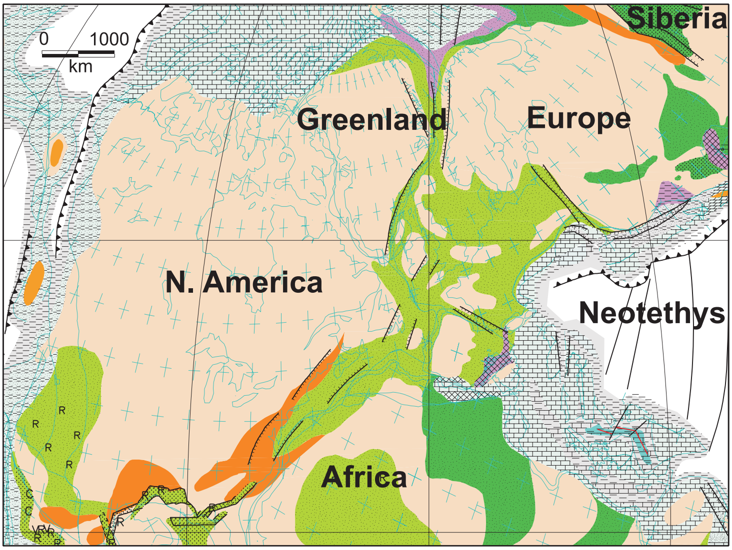

Fig. 7. Plate tectonic, paleoenvironment and lithofacies map of the western Tethys, future Central Atlantic and adjacent areas during Late Triassic time. Modified from Golonka (2007)

Fig. 7. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Tetydy, przyszłego centralnego Atlantyku oraz obszarów sąsiednich w późnym triasie. Zmieniona wg Golonki (2007)

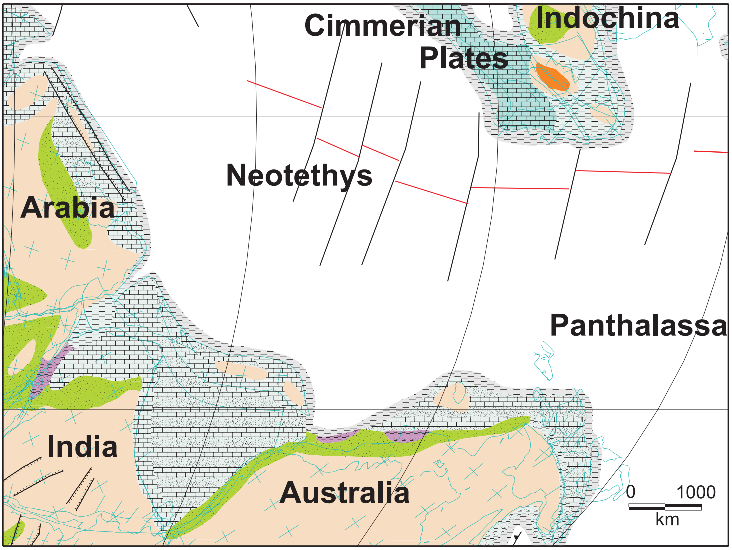

Fig. 8. Plate tectonic, paleoenvironment and lithofacies map of eastern Tethys and adjacent areas during Late Triassic time. Modified from Golonka (2007)

Fig. 8. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Tetydy oraz obszarów sąsiednich w późnym triasie. Zmieniona wg Golonki (2007)

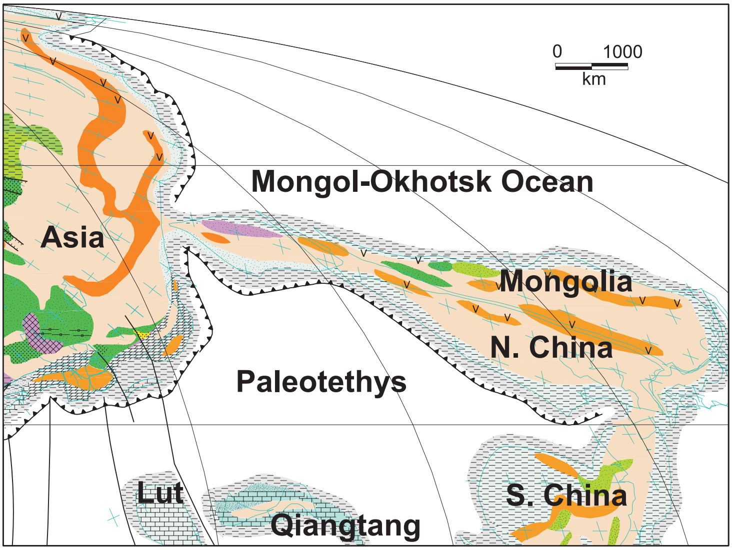

Fig. 9. Plate tectonic, paleoenvironment and lithofacies map of the Paleotethys, Chinese plates and adjacent areas during Late Triassic time. Modified from Golonka (2007)

Fig. 9. Mapa tektoniki płyt, paleośrodowiska i litofacji Paleotetydy, płyt chińskich oraz obszarów sąsiednich w późnym triasie. Zmieniona wg Golonki (2007)

The Pangea rift systems extended from Newark and Central Europe through the North Atlantic, to the Barents shelf and Arctic Alaska (Golonka *et al.* 2003a, 2006). These rifts were filled with red continental clastics reflecting arid climate. Carbonate deposits dominated in the Arctic area north of Canada (Ronov *et al.* 1989, Golonka *et al.* 2003a). Fine-grained clastics were common in the western North America basins as well as on enigmatic terranes in the Panthalassa Ocean (Fig. 7).

The Neotethys was widely open during the Late Triassic time (Ricou 1996, Golonka 2000, 2007, Golonka *et al.* 2003b). Drift of Cimmerian plates narrowed the Paleotethys (Figs 6–9). Microplates collided with the southern margin of Eastern Europe and Central Asia. Compressional events were recorded in a major deformations of the Fore-Caucasus, Mangyshlak and Southern Kopet Dagh (northwestern Iran), Herat area in Afghanistan, and in the Pamir Mountains between the CIS and Afghanistan (Golonka 2004). In the western Tethys area, several blocks of the Cimmerian provenance (Şengör 1984, Şengör & Natalin 1996) collided with the Eurasian margin in the so-called Early Cimmerian orogeny (Zonenshain *et al.* 1990, Golonka 2004). The Calcareous Alps and Inner Carpathians formed the marginal platform of Europe. The Eurasian platform, east of Poland, was dissected by rift systems. The Moesian block, the Western and Eastern Pontides, the Transcaucasus, and the South Caspian blocks were located between this rifted zone and the remnants of Paleotethys.

Shallow-water platform limestones and dolomites with algal/coral-dominated reefs developed on the platform of Cimmerian microplates, Neotethys and Paleotethys margins. Many of the western Tethyan reefs were located on these platforms. A large carbonate platform, which contained many Upper Triassic reefs, was spreading from Apulia to the Taurus zone (Dercourt *et al*. 1993, 2000, Kiessling *et al*. 1999, Flügel 2002, Golonka 2007). This zone was connected with the Alpine-Inner Carpathian carbonate platforms, containing abundant reefs (Kiessling *et al*. 1999, Flügel 2002). Dolomitization of the platform limestones was common. Dolomites were widespread in Southern Europe and Central Asia. The Neotethys margins of Greater India, Arabia and Australia (Figs 7, 8) were occupied by mixed carbonate-clastic facies (Cook 1990, Alsharhan & Magara 1994, Golonka & Ford 2000, Golonka 2007).

The most significant Triassic convergent event was the Indosinian orogeny (Figs 6, 8, 9), the consolidation of Chinese blocks with Indochina and Sibumasu. The partial amalgamation of Indochina and South China took place during Paleozoic time. The Indosinian orogeny concluded this process, leading to the formation of Asia continent. The idea of Indosinian orogeny was formulated during the last century and derived from the geological studies in Vietnam (Golonka *et al*. 2006). The deformational events affected entire Indochina plate as well as adjacent part of South China plate. The post-suturing plutons were emplaced along the suture zone and on the adjacent plates. According to Yin & Nie (1996), the Late Triassic was also the time of the collision of South Chinese and North Chinese plates and a generation of sutures and mountain belts in this area. Siliciclastic shallow marine shale sedimentation covered the western part of South China plate (Ronov *et al*. 1989), while the central and eastern parts were uplifted. The collisional Triassic events continued on between North China and Mongolia (Fig. 9). Volcanics and collisional granites were common in both parts of the newly formed plate (Chen *et al*. 2000, Wu *et al*. 2002) as well as on the Siberian margin of the Mongol-Okhotsk Ocean.

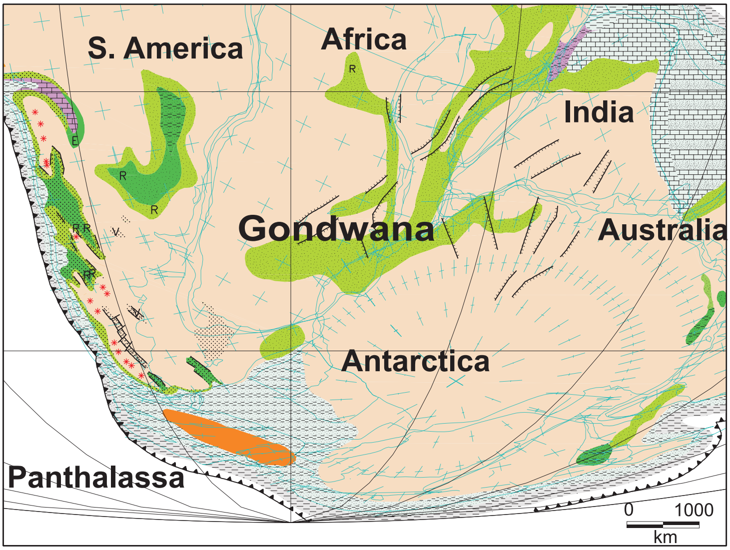

Fig. 10. Plate tectonic, paleoenvironment and lithofacies map of the western Gondwana and adjacent areas during Late Triassic time. Modified from Golonka (2007)

Fig. 10. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Gondwany oraz obszarów sąsiednich w późnym triasie. Zmieniona wg Golonki (2007)

Basins containing Triassic continental red deposits were located in Gondwana (Fig. 10), in South America, Africa, Antarctica, Madagascar and India (Golonka 2007). Continental extension began between Madagascar and India, within Africa, as well as in isolated areas in South America (Macdonald *et al*. 2003).

Early Jurassic

The time around the Triassic-Jurassic boundary marked the very important extinction event (e.g. Simms & Ruffell 1989, 1990, Hallam 1990, 1995, McRoberts & Newton 1995, Hallam & Wignall 1997, 1999, Palfy *et al*. 2000, Wignall 2001, Flügel 2002, Flügel & Kiessling 2002, Huynh & Poulsen 2005, Tanner *et al*. 2005). According to Flügel & Kiessling (2002), this mass extinction ranges fourth in the "Big Five" in terms of taxonomic loss, because more than 50% of the marine genera and about 80% of the species went extinct (Hallam 1995). Reef communities were especially affected (Flügel 2002, Flügel & Kiessling 2002, Leinfelder *et al.* 2002).

From the plate tectonic and paleogeographic point of view, the following events could have influenced the extinction of biotas:

- The closure of Paleotethys and assembly of the Asian part of Pangea (Golonka 2000, 2002, 2004). This event caused the origin of new subduction zone along the Neotethys margin (Figs 11–14), first in its western, later in the eastern part. The Neotethys went from spreading to subducting phase. The new volcanic arcs were born along the subduction line.
- The break-up of Pangea in the future Central Atlantic area and transition from rifting to drifting phase (Withjack *et al*. 1998, Golonka 2000, 2002, Ford & Golonka 2003).
- The very extensive volcanism and origin of Large Igneous Provinces type of basalts (Golonka & Bocharova 2000, Wignall 2001, Tanner *et al*. 2005) (Figs 11, 15). This volcanism was related to the break-up of Pangea and caused rising amount of atmospheric CO_2 (e.g. Huynh & Poulsen 2005).
- Sea level fluctuation (e.g. Hallam & Wignall 1999, Flügel & Kiessling 2002). Drop of sea-level was related to the assembly of Pangea and was followed immediately by the rise caused by the Pangea break-up. It affected especially carbonate platforms and reefs (Flügel 2002, Flügel & Kiessling 2002).
- Anoxia (e.g. Leith *et al*. 1993, Ettensohn 1994, 1997, Golonka *et al*. 2003a). It was related to the formation of restricted basins and nutrient oversupply caused perhaps by volcanic activity and sea-level fluctuations.

All the above mentioned events are bound together by close relationships. Plate tectonic activity caused paleogeographic and paleoclimatic change, which triggered mass extinction.

During the Early Jurassic all major continents and major plates were sutured (Golonka 2007). Only small terranes drifted within Tethys and in Panthalassa (Fig. 11).

Pangea was under stress during Early Mesozoic times (Figs 1, 6, 11) due to subduction zones surrounding the supercontinent. The rifting between North America and Gondwana, continued during Early-Middle Jurassic time (Golonka 2000, 2002, 2007, Golonka & Ford 2000, Ford & Golonka 2003).

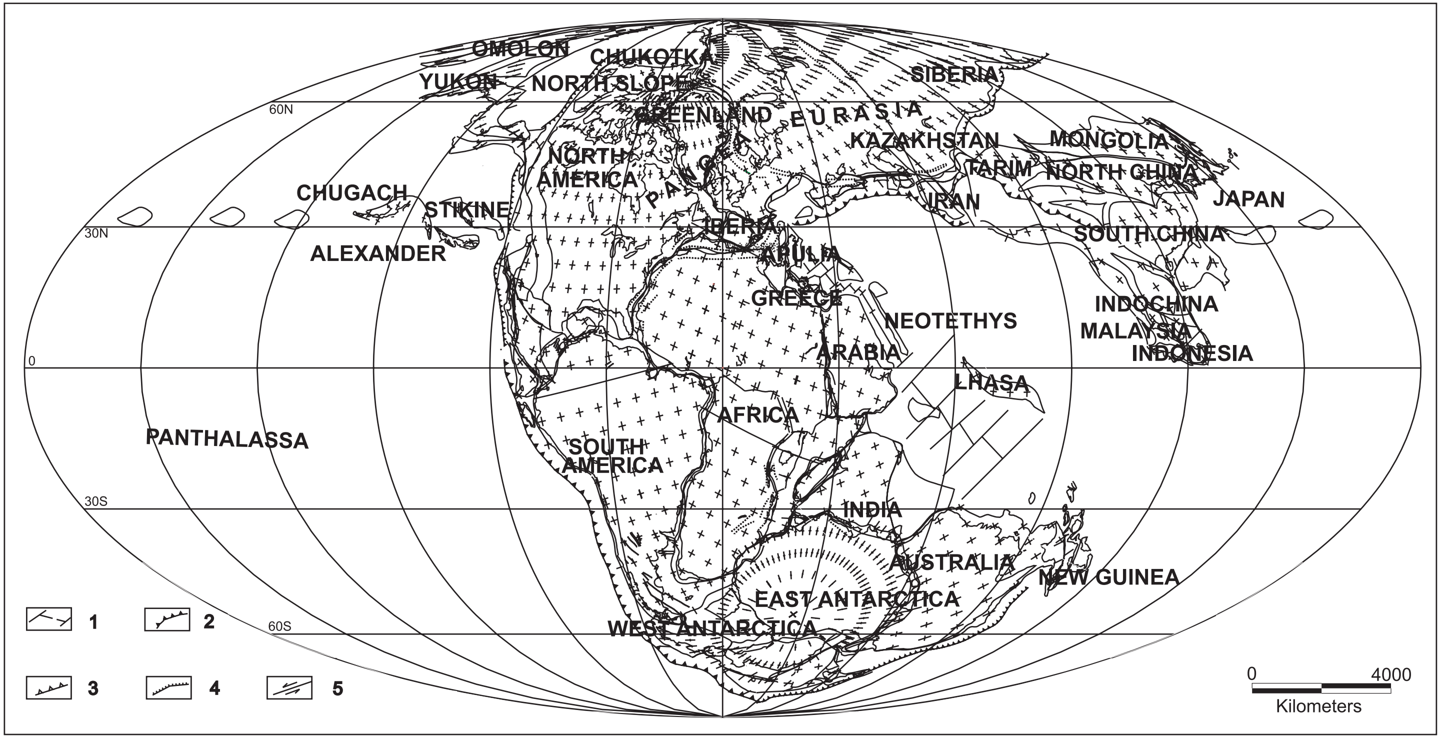

Fig. 11. Plate tectonic map of the Early Jurassic (plates position as of 195 Ma). Modified from Golonka (2002, 2007): 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault

Fig. 11. Mapa tektoniki płyt wczesnej jury (pozycja płyt 195 milionów lat temu). Zmieniona wg Golonki (2002, 2007): 1 – centrum spredingu oceanicznego i uskok transformujący, 2 – strefa subdukcji, 3 – nasunięcie, 4 – uskok normalny, 5 – uskok przesuwczy

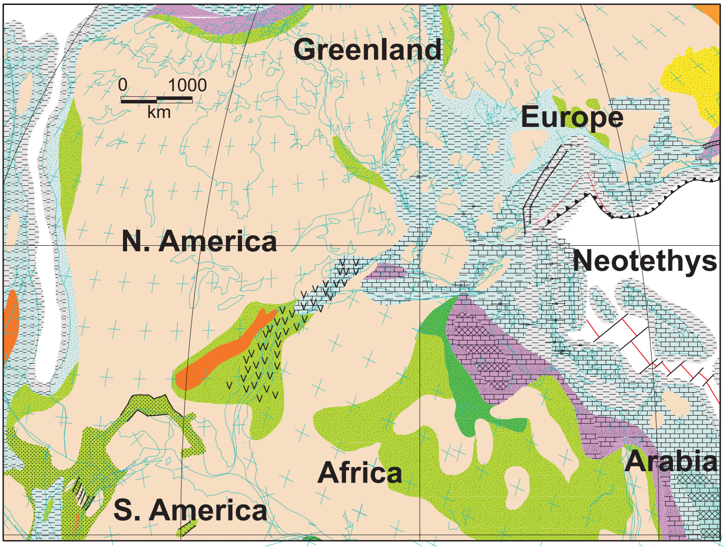

Fig. 12. Plate tectonic, paleoenvironment and lithofacies map of the western Tethys, future Central Atlantic and adjacent areas during Early Jurassic time. Modified from Golonka (2007)

Fig. 12. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Tetydy, przyszłego centralnego Atlantyku oraz obszarów sąsiednich we wczesnej jurze. Zmieniona wg Golonki (2007)

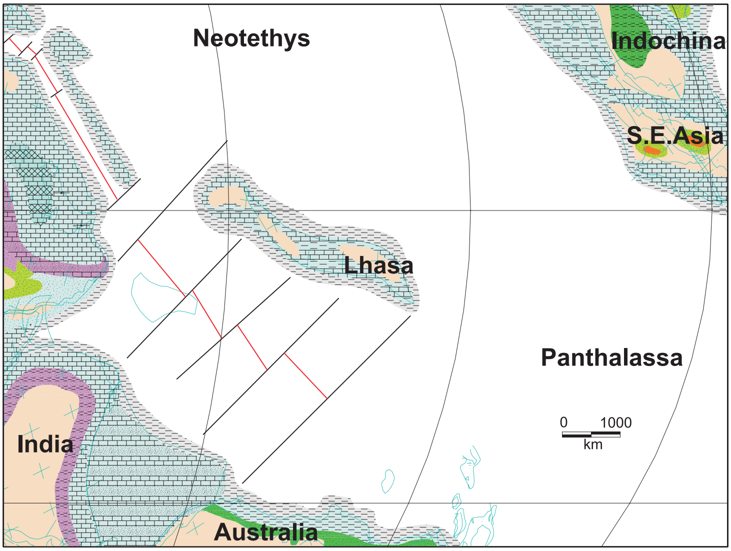

Fig. 13. Plate tectonic, paleoenvironment and lithofacies map of the eastern Tethys and adjacent areas during Early Jurassic time. Modified from Golonka (2007)

Fig. 13. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Tetydy oraz obszarów sąsiednich we wczesnej jurze. Zmieniona wg Golonki (2007)

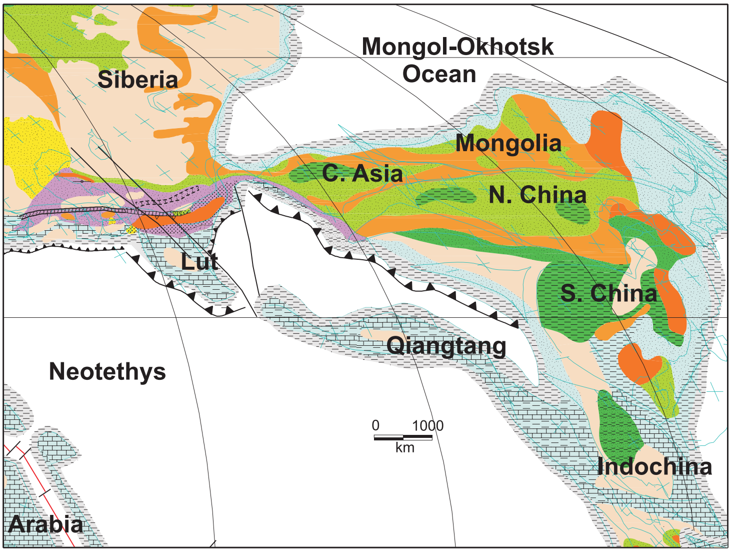

Fig. 14. Plate tectonic, paleoenvironment and lithofacies map of eastern Asia and adjacent areas during Early Jurassic time. Modified from Golonka (2007)

Fig. 14. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Azji oraz obszarów sąsiednich we wczesnej jurze. Zmieniona wg Golonki (2007)

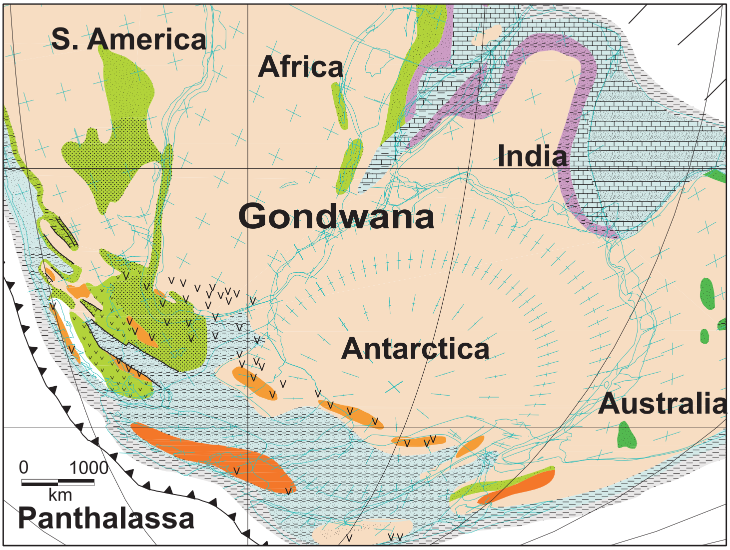

Fig. 15. Plate tectonic, paleoenvironment and lithofacies map of western Gondwana during Early Jurassic time. Modified from Golonka (2007)

Fig. 15. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Gondwany oraz obszarów sąsiednich we wczesnej jurze. Zmieniona wg Golonki (2007)

Continental clastics and volcanics prevailed in the area between Africa and North America. The color of these rocks changed from red to gray along the Triassic-Jurassic boundary due to increased wetness and global transition from oxic to anoxic conditions (Ford & Golonka 2003). Fluvial depositional systems were extensive within interior sag basins and graben rifts (Ziegler 1982, Withjack *et al*. 1998). Delta systems developed where rifts opened onto marine shelves. Rifting continued in the North Sea and in the northern Proto-Atlantic between Norway and Greenland (Ziegler 1988, Doré 1991).

The rifting occurring in the Alps and Carpathians (Neugebauer *et al*. 2001, Golonka 2004) was related to the separation of North America and Gondwana. The subduction zone on the northwestern margins of the Neotethys caused the opening of the back-arc basin, which later formed the Alpine Tethys stretching from Italy to Ukraine (Golonka 2004, 2007). The Pindos Ocean (Robertson *et al*. 1991, 1996, 1998, Golonka 2003a) was spreading between the Gondwana margin and a series of microplates (Figs 12, 13). These plates (Golonka *et al*. 2000, 2003b, Mohajjel *et al*. 2003, Golonka 2007) were drifting northeastward off the Apulia-Taurus-Arabia margin. The Lhasa plate (Şengör 1984, Dercourt *et al*. 1993, Metcalfe 1994, Ricou 1996, Şengör & Natalin 1996, Yin & Nie 1996) also drifted away from Gondwana (Fig. 13). The Qiangtang plate (Fig. 14) approached amalgamated China. The northwestern Neotethys region consisted of numerous blocks covered by carbonate platforms. Adjacent grabens were often filled with black mudstones and organic-rich shale facies. Reef communities were rare at that time (Kiessling *et al*. 1999, Leinfelder 2002). Mixed carbonate-evaporitic facies were deposited in the platform on Arabian Peninsula and on Northern Africa (Fig. 12) margins. Clastic prevailed in the Northern Africa interior (Golonka & Ford 2000). Mixed clastic-carbonate facies were dominant in the northern part of greater India (Fig. 13).

Lacustrine sediments were present in China (Fig. 14) and Australia (Fig. 13). The Mongol-Okhotsk embayment continued to invade Asia from the Panthalassa Ocean, during the Early Jurassic (Golonka 2000, 2007, Golonka & Ford 2000).

Extensive volcanic activity occurred in southern Gondwana (Fig. 15) between approximately 198 Ma and 173 Ma. This volcanics were related to the Karoo rifting, onset of the breakup of Africa, India and Antarctica, and to a large-scale mantle plume (Cox 1992, Golonka 2007). The seafloor spreading in the Western Somali Basin and the Mozambique basin began at 175 Ma (Lawver & Gahagan 1993), opening the East African seaway between Africa and India. According to Geiger *et al*. (2004), the separation of Madagascar occurred in the Late Liassic. This event was related to the opening of the Weddell Sea (Franzese *et al*. 2003, Golonka 2007).

Middle Jurassic

The Central Atlantic was in an advanced drifting stage during the Middle Jurassic time (Withjack *et al*. 1998, Golonka 2000, 2002) (Figs 16, 17). According to Ford & Golonka (2003) passive margin basins formed along the central Atlantic coasts of North America, and Northwestern Africa. Mixed carbonate-clastic sedimentation prevailed (Fig. 17).

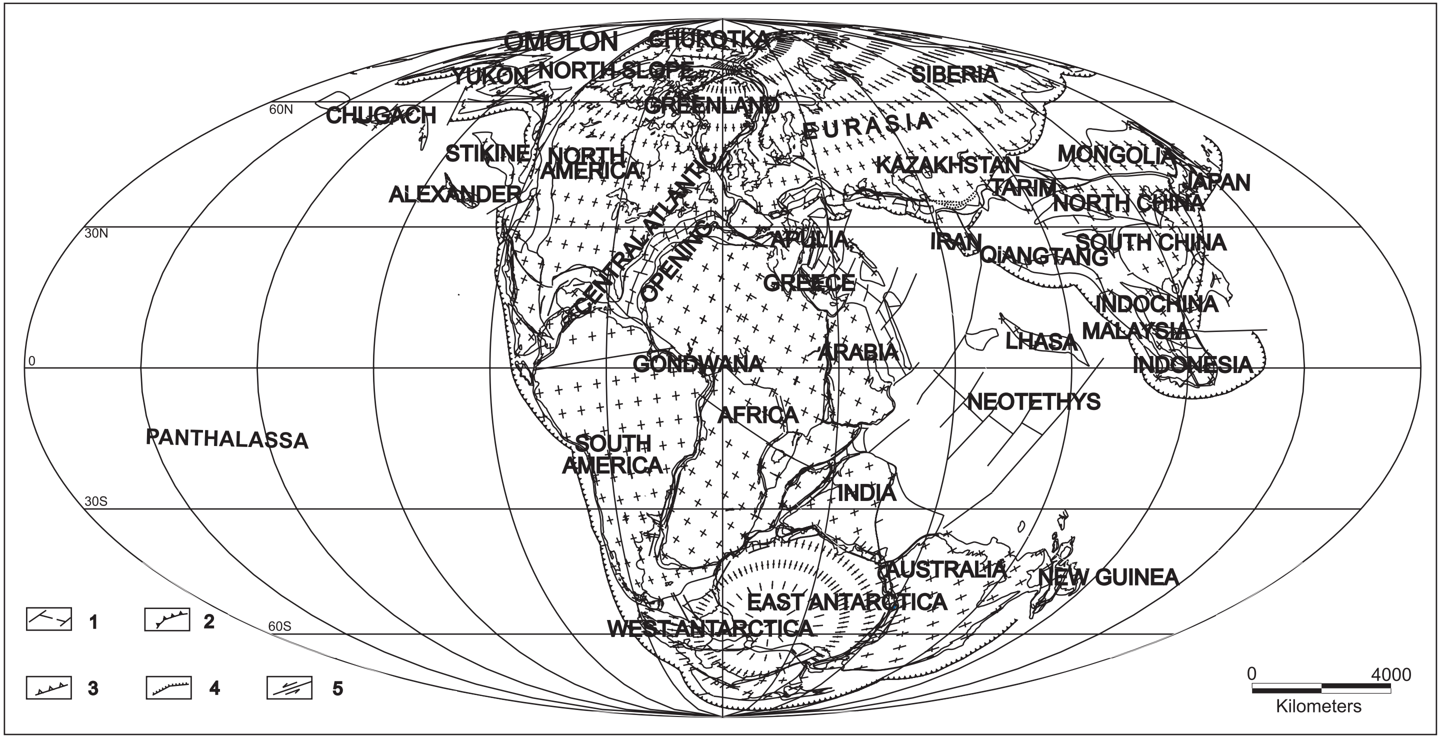

Fig. 16. Plate tectonic map of the Middle Jurassic (plates position as of 166 Ma). Modified from Golonka (2002): 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault

Fig. 16. Mapa tektoniki płyt środkowej jury (pozycja płyt 166 milionów lat temu). Zmieniona wg Golonki (2002): 1 – centrum spredingu oceanicznego i uskok transformujący, 2 – strefa subdukcji, 3 – nasunięcie, 4 – uskok normalny, 5 – uskok przesuwczy

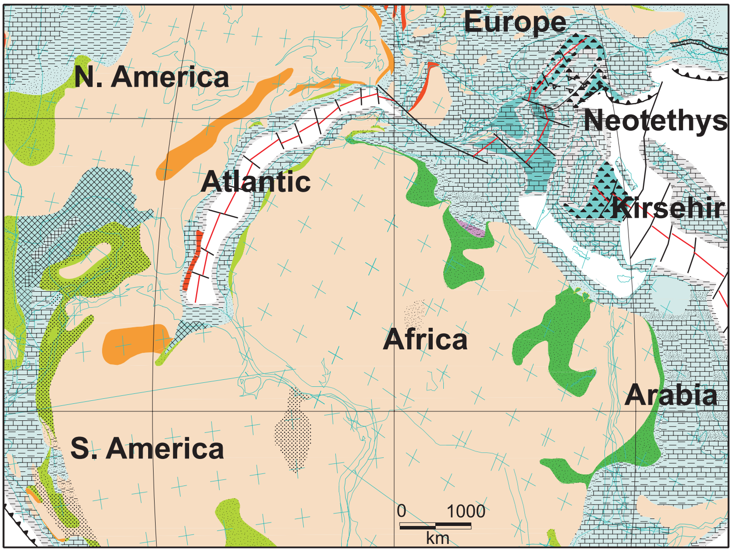

Fig. 17. Plate tectonic, paleoenvironment and lithofacies map of the western Tethys, future Central Atlantic and adjacent areas during Middle Jurassic time

Fig. 17. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Tetydy, przyszłego centralnego Atlantyku oraz obszarów sąsiednich w środkowej jurze

The Alpine Tethys that constitutes the extension of the Central Atlantic system was also in the drifting stage (Golonka 2004). Bill *et al.* (2001) date the onset of oceanic spreading of the Alpine Tethys by isotopic methods as Bajocian. This spreading followed the Early Jurassic rifting stage. Extension of the Neotethys to the northwest into the proto-Mediterranean, produced a connection with the Central Atlantic (Fig. 17). The Ligurian Ocean was opening simultaneously along with the central Atlantic, Penninic Ocean, and Pieniny Klippen Belt Ocean (Dercourt *et al.* 1993, Golonka *et al.* 2000, 2003b, Golonka & Krobicki 2001, 2004). The Inner Carpathian block and the Eastern Alps were moving away from Europe, and at the same time Apulia was moving together with Africa (Golonka 2004). Paleomagnetic data from the Pieniny Klippen Belt Ocean (Lewandowski *et al.* 2004) indicate relatively fast opening of this oceanic domain.

The oceanic realm ended in the triple junction zone in the Ukrainian Eastern Carpathians (Golonka *et al.* 2004). The deepest parts of Alpine Tethys basins are documented by deep water, extremely condensed pelagic limestones, and radiolarites. The shallowest ridge sequences are represented by crinoidal and nodular limestones. The transitional slope sequences between the deepest basinal units and ridge units consist of mixed cherty, limestone and marly facies. The detailed study of the basinal facies (Golonka & Sikora 1981) revealed an enormous condensation of *Nannoconus* limestones and radiolarites (Fig. 17). The basinal units are surrounded by shallow-water carbonate platforms. The northwestern Neotethys region consisted of numerous horst blocks capped by carbonate platforms. Isolated carbonate platforms were associated with the microplates of the northern Neotethys.

Carbonate ramps were large at the southern margin of the Tethyan realm, and smaller as well as more isolated along the northern margin (Philip *et al*. 1996, Golonka 2000). Carbonate platforms, which developed along the Alpine Tethys margins, were also spreading to the cratonic part of Europe (Ziegler 1982). Platform interiors may have been partially dolomitized, particularly in areas associated with evaporite deposits. Carbonate platform developed in the Arabian basins. A vast marine platform became the setting for a well developed carbonate ramp, in which clastic sediments rimmed the western and southern parts of the shallow sea (Alsharhan & Magara 1994) (Figs 17, 18). Rifting continued in the North Sea and in the northern proto-Atlantic (Ziegler 1982, Doré 1991) (Fig. 16). Clastic sedimentation in the deltaic/shallow marine environment (Ineson & Surlyk 2003) in this area provided important sandstone reservoirs. Evaporites were deposited in the Gulf of Mexico area (Ford & Golonka 2003). The connection between Gulf of Mexico and Central Atlantic was perhaps not fully established during Middle Jurassic time (Fig. 17).

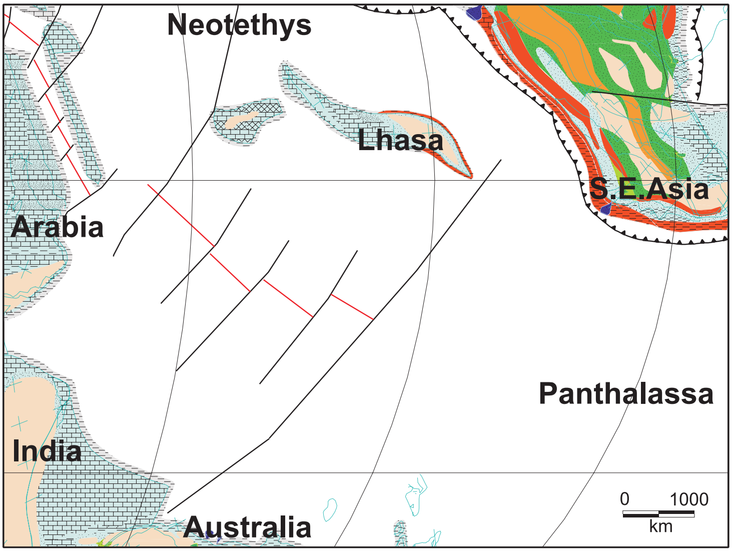

Fig. 18. Plate tectonic, paleoenvironment and lithofacies map of the eastern Tethys and adjacent areas during Middle Jurassic time

Fig. 18. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Tetydy oraz obszarów sąsiednich w środkowej jurze

Advanced seafloor spreading occurred between the Gondwana margin and the Helmand and Lhasa Blocks (Golonka 2000, 2002). The spreading continued between the Arabian-Tauric margin and the Pelagonian, Kirsehir, Sakariya, and Sinandaj-Sirjan blocks (Robertson *et al*. 1991, 1996, Golonka *et al*. 2000, Golonka 2004). All these blocks were covered by carbonate platforms (Figs 17, 18). After a phase of Late Triassic-Early Jurassic compression, the rifting regime was re-established within the Scythian-Turan platform between the Eastern Black Sea and Western Turkmenia and continued through the Middle Jurassic time (Fig. 19).

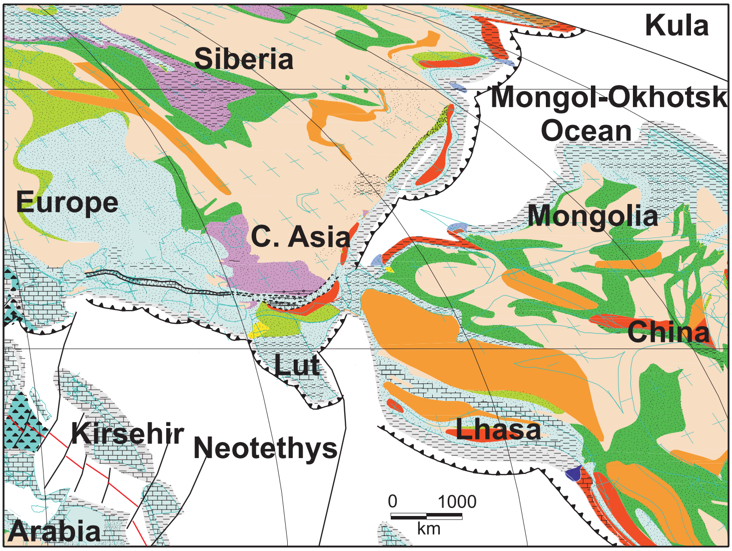

Fig. 19. Plate tectonic, paleoenvironment and lithofacies map of eastern Asia and adjacent areas during Middle Jurassic time

Fig. 19. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Azji oraz obszarów sąsiednich w środkowej jurze

Most of the former rift systems that had developed during the Late Permian-Triassic time were reactivated and new rift systems originated. In the western and central part of the platform, the Early-Middle Jurassic rifting primarily concentrated in the Greater Caucasus basin. Rifting somewhat influenced the Indol-Kuban basin, and the Terek-Caspian trough developed as a subsidiary rift of the Greater Caucasus rift system (Sobornov 1994). In the eastern part of the Scythian-Turan platform, the Early-Middle Jurassic rifting influenced the Amu-Darya and Afghan-Tadjik regions (Golonka 2004).

At that time (Fig. 19), the Mongol-Okhotsk embayment was significantly reduced in size. The main part of the basin was already closed (Zonenshain *et al*. 1990). Continental collision in the western segment of the belt produced an orogenic system of nappes, folds, granitic domes and batholiths. Volcanism, terrane accretion, and back-arc basin development continued along the western margin of North and South America, as well as along the southern margin of Antarctica and Australia (Figs 16, 20). According to Lawver & Gahagan (1993), the terranes of western North America began to collide with North America. Thrusts and transpressional deformations occurred in the western North America. This collision disturbed the westward movement of the North American plate and caused the stress and inversion on the eastern coast of America (Withjack *et al*. 1998).

Rifting was initiated between Australia and Antarctica (Cook 1990). Rifting and spreading began between Antarctica and Africa in the Mozambique Channel and between Madagascar and Africa in the Somali Basin (Rabinowitz *et al*. 1983, Lawver & Gahagan 1993). It is possible, that seafloor spreading likewise occurred in the Weddell Sea. LaBrecque & Barker (1981) propose that the Weddell Sea contains oceanic crust of Middle Jurassic age (Fig. 20).

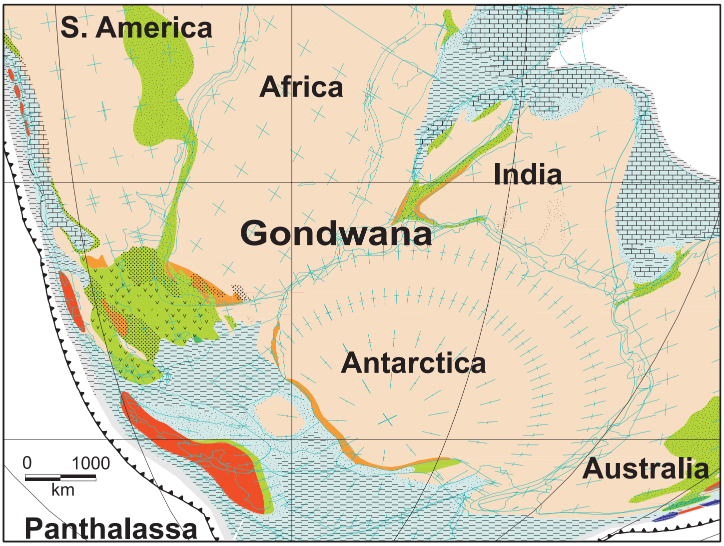

Fig. 20. Plate tectonic, paleoenvironment and lithofacies map of the western Gondwana during Middle Jurassic time

Fig. 20. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Gondwany oraz obszarów sąsiednich w środkowej jurze

According to Franzese *et al.* (2003) the Andean magmatic arc was almost fully developed by this time. According to Macdonald *et al.* (2003), movement of South America was accompanied by the re-organization of crustal blocks in Patagonia, the Falkland/Malvinas Plateau and West Antarctica. This re-organization included clockwise rotation of the Falklands/Malvinas block in an overall extensional regime, which was completed by 165 Ma (Ford & Golonka 2003, Macdonald *et al.* 2003). Continental clastics were deposited in rift basins between the Southern tip of Africa and South America as well as in the Parana Basin (Fig. 20).

Late Jurassic

The drifting stage continued in the Central Atlantic and Alpine Tethys during Late Jurassic time (Golonka 2000, 2002, 2004) (Figs 21, 22). The development of oceanic crust as well as the major phase of seafloor spreading occurred within the Gulf of Mexico (Marton & Buffler 1994, Bird *et al.* 2005). The complex transform fault system developed between Gulf of Mexico and Central Atlantic. Another system of spreading axes, transform faults, and rifts connected the ocean floor spreading in the Central Atlantic and Alpine Tethys. The Tethys rifting continued through the Outer Carpathian area to Polish-Danish graben (Fig. 22). A major Jurassic seaway opened, connecting the Gulf of Mexico and Central America with Southern Europe and the Tethyan branch of the Pacific Ocean (Ford & Golonka 2003). The Late Jurassic corresponds with a period of long-term 1st-order rise in global sea-level (Golonka 2000). The sea-level reached its Jurassic maximum during Kimmeridgian time. Large continental shelves were established on the Tethyan margins, in Europe and in the Arctic (Figs 22–24).

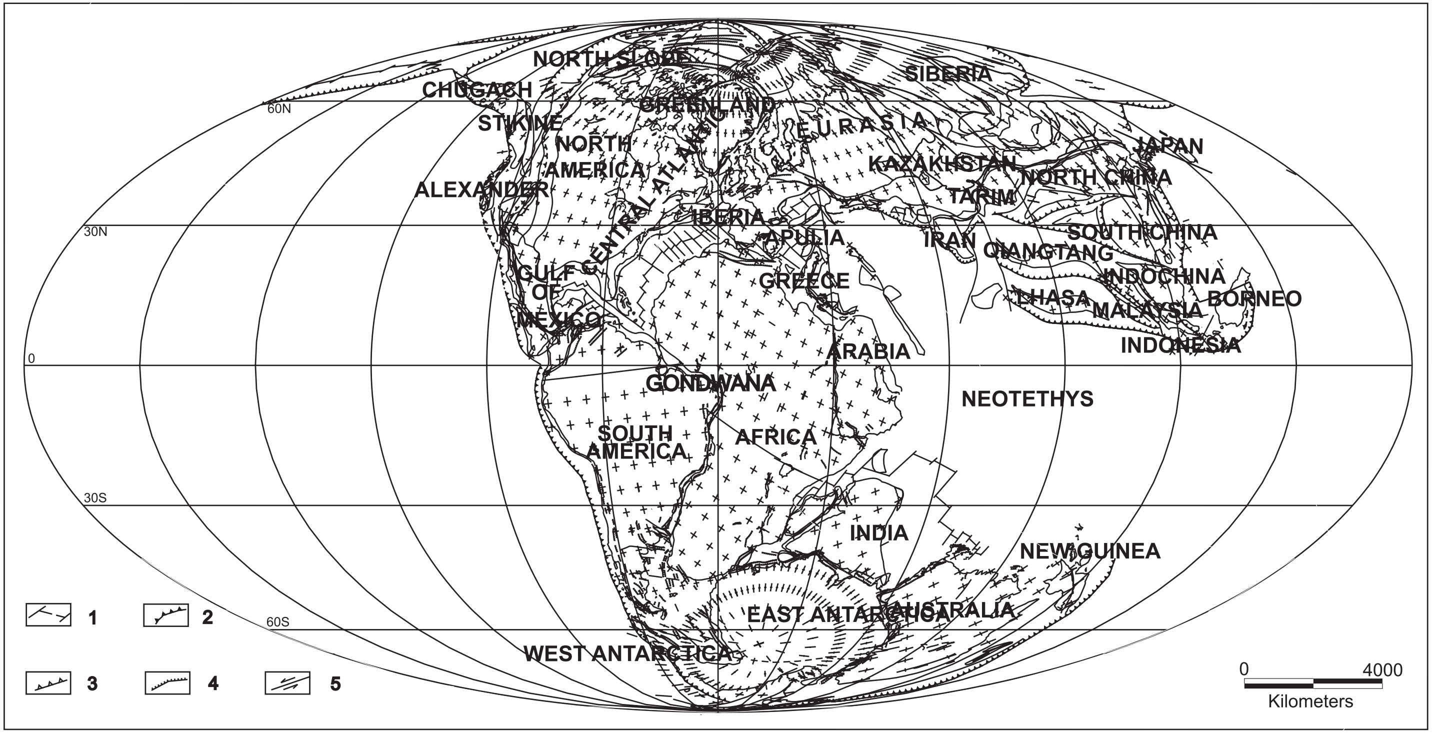

Fig. 21. Plate tectonic map of the Late Jurassic (plates position as of 155 Ma). Modified from Golonka (2002): 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault

Fig. 21. Mapa tektoniki płyt późnej jury (pozycja płyt 155 milionów lat temu). Zmieniona wg Golonki (2002): 1 – centrum spredingu oceanicznego i uskok transformujący, 2 – strefa subdukcji, 3 – nasunięcie, 4 – uskok normalny, 5 – uskok przesuwczy

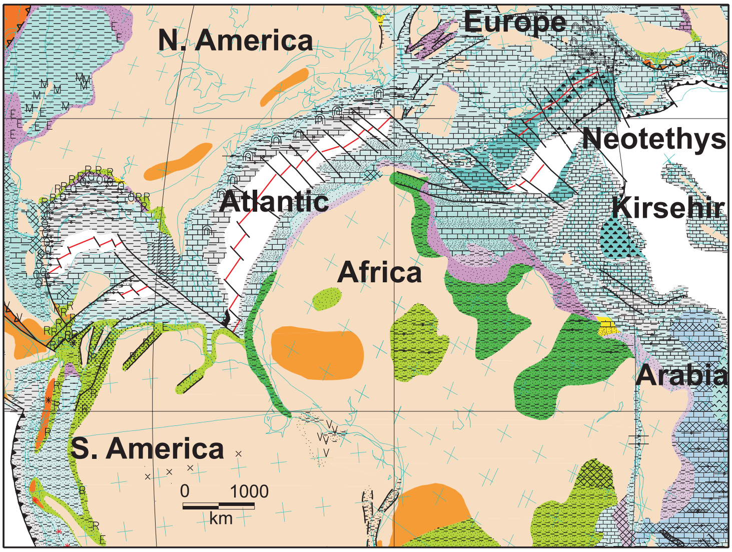

Fig. 22. Plate tectonic, paleoenvironment and lithofacies map of the western Tethys, future Central Atlantic and adjacent areas during Late Jurassic time

Fig. 22. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Tetydy, przyszłego centralnego Atlantyku oraz obszarów sąsiednich w późnej jurze

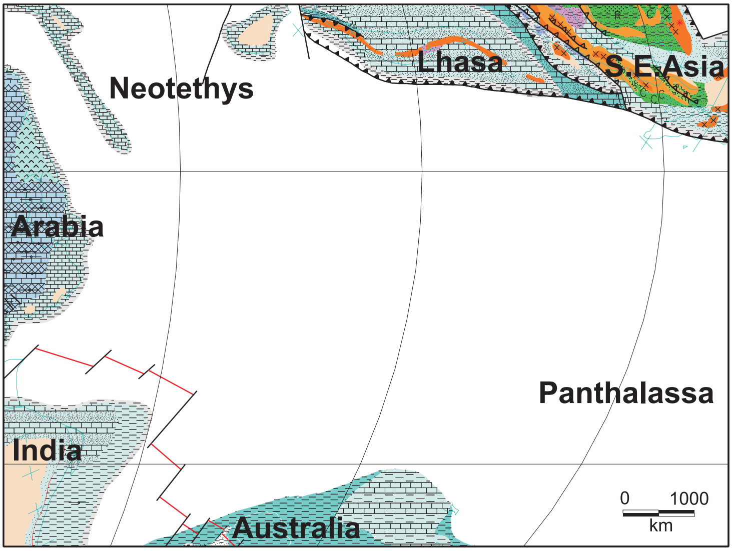

Fig. 23. Plate tectonic, paleoenvironment and lithofacies map of the eastern Tethys and adjacent areas during Late Jurassic time

Fig. 23. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Tetydy oraz obszarów sąsiednich w późnej jurze

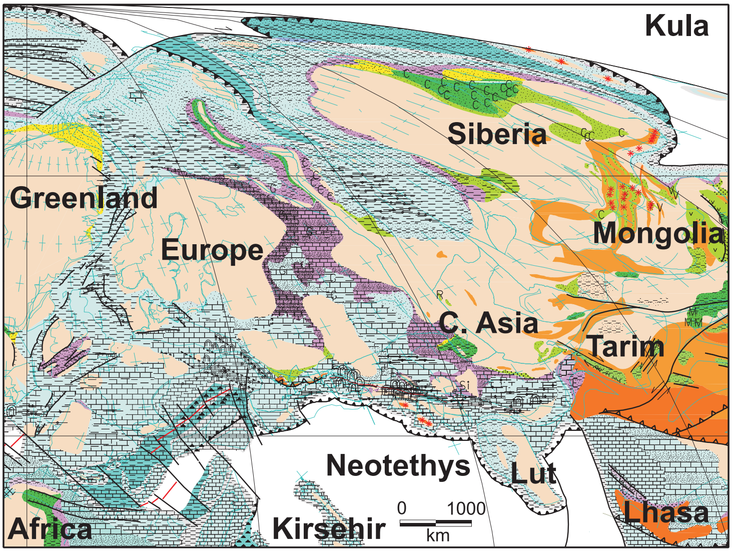

Fig. 24. Plate tectonic, paleoenvironment and lithofacies map of eastern Asia and adjacent areas during Late Jurassic time

Fig. 24. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Azji oraz obszarów sąsiednich w późnej jurze

The Central European rift system continued to the North Sea, Mid-Norway, and the Barents Sea (Golonka *et al*. 2003a). Seaways connected also Tethyan and Boreal (Arctic) realms (Fig. 24).

Carbonate platforms developed during the Late Jurassic on both sides of the Central Atlantic as well as along the Neotethys margins within a band from 35° N to 35° S latitude (Figs 22–24). Ramp-like carbonate depositional profiles predominated. Primary occurrences of major carbonate depositional systems in the Gulf of Mexico were recorded, but also clastic sedimentation was present in this area. A large platform developed in the Cuba-Bahamas-Florida area. Another large carbonate platform was located between Newfoundland and Iberia (Sinclair *et al*. 1993). Oolitic and skeletal grainstones were major components of the shallow-marine carbonate ramps and platforms. Organic reefs composed of corals and sponges were minor depositional components of the carbonate systems. Sedimentation of silica-rich cherty limestones with planktonic algae *Nannoconus* and radiolarians continued during the Late Jurassic within the Alpine Tethys basinal facies (Figs 22, 24). Evaporite-related dolomitization of interior platform carbonates was common. In many marginal Tethyan areas, carbonates gradually changed into evaporites (Ronov *et al*. 1989, Golonka 2000). Carbonate rocks with evaporites were deposited on the Arabian plate providing reservoir rocks and seals for the enormously rich petroleum systems (Alsharhan & Magara 1994). Mixed shallow marine carbonate-clastic facies, deltaic, marginal marine and continental clastics were deposited in North Africa (Ronov *et al*. 1989, May 1991, Dercourt *et al*. 1993, 2000).

In the circum-Arctic region, Late Jurassic deposition was dominated by shales and bituminous black shales (Fig. 24), in contrast to Early and Middle Jurassic coarse clastic deposition (Ulmishek & Klemme 1990, Ettensohn 1994, Golonka *et al*. 2003a). In the Barents Sea, these organic-rich shales were deposited during a period of restricted sea-water circulation which enhanced preservation of organic matter. Similar conditions existed in the North Sea area, West Siberia, and other circum-Arctic regions, like Svalbard, the Sverdrup Basin, Beaufort-Mackenzie area, Alaska North Slope, and Chukchi-East Siberian Basins (Dypvik 1985, Leith *et al*. 1993, Ettensohn 1994). The West Siberian Basin formed a large southward-enclosed marine embayment where the large area was covered by Late Jurassic-Early Cretaceous source rocks. In northern Alaska, deposition of organic-rich Kingak Shale occurred throughout the Jurassic and the earliest Cretaceous (Leith *et al*. 1993).The Mongol-Okhotsk Ocean was closing tightly in the Late Jurassic (Fig. 24), and the collision resulted in the folding and intrusion of granitic batholiths in Mongolia and in the trans-Baikal area (Zonneshain *et al*. 1990). According to Zorin (1999) main collisional episode lasted through the Middle and Late Jurassic. The Late Jurassic, E-W trending fold-and-thrust belt in China, between the eastern Tien Shan and the Liaoning region collision (Yin & Nie 1996), was associated with the Yanshanian orogeny. This orogeny could be related to the closing of the Mongol-Okhotsk Ocean and ongoing compression between the North and South Chinese blocks. The Lhasa block converged with Asia (Ricou 1996). The Lhasa block could have been connected with the Sibumasu block in Southeast Asia (Yin & Nie 1996). The Helmand plate approached Central Asia (Otto *et al*. 1997). The eastern part of the northern branch of the Neotethys narrowed significantly and began to close. A new subduction zone began to develop south of the Lhasa plate. In Southeast Asia, numerous peripheral bulges as well as back-arc and foreland basins developed, that became probable sites of active sediment accumulation (Fig. 23).

Clockwise rotation and southward drifting of southern Gondwana was connected with the continuing, active seafloor spreading in the East African seaway, between India/ Madagascar and Africa (Coffin & Rabinowitz 1988, Golonka 2000, 2004). Continental rifts developed between India and Antarctica, as well as between Australia and Antarctica (Lawver & Gahagan 1993) (Fig. 25). Marine embayments formed at the northern and southern margins of South America. Spreading was active in the Weddell Sea (LaBrecque & Barker 1981, Golonka 2000, 2004). The seaway was formed between Africa, South America and Antarctica-India-Madagascar. This marked the break-up of Gondwana. This was the second stage of the Pangean disassembly. Pre-rift structural lineaments and sags were present between South America and Africa. These structural features became sites for continental and lacustrine sedimentation. The clastic sedimentation prevailed in the marine seaways. Carbonate platform and reefs were present along the South America margin. Reefs reached high latitudes (45° S) in the Patagonia terrane in Argentina (Leinfelder *et al*. 2002).

Extensive subduction, volcanism, and terrane accretion occurred around the Pangean rim, in North and South America. In the western North America, the assemblage consisting of oceanic arcs and wedges collided with the continent during the Nevadean orogeny and the Franciscan formation was accreted onto California (Hamilton 1989, Oldow *et al*. 1989, Golonka 2000). During the collision and obduction of Stikinia (Lawver & Gahagan 1993), the terranes of western North America began to collide with North America resulting in thrusting and transpressional deformations (Ford & Golonka 2002). This collision disturbed the westward movement of the North American plate and caused the stress and inversion on the eastern coast of America (Withjack *et al*. 1998). The other proto-Pacific terranes were perhaps still drifting in the high latitudes. As was mentioned above, their position is very speculative and a subject of hot debate (see e.g. Taylor *et al*. 1984, Engebretson *et al*. 1985, Panuska 1985, Panuska & Stone 1985, Debiche *et al*. 1987, Harbert 1990, Zonenshain *et al*. 1990, Beck 1992, Didenko *et al*. 1993, Şengör & Natalin 1996, Harbert *et al*. 1998, 2001, 2003, Kiessling & Flügel 2000, Johnston 2001, Keppie & Dostal 2001, Belasky *et al*. 2002).

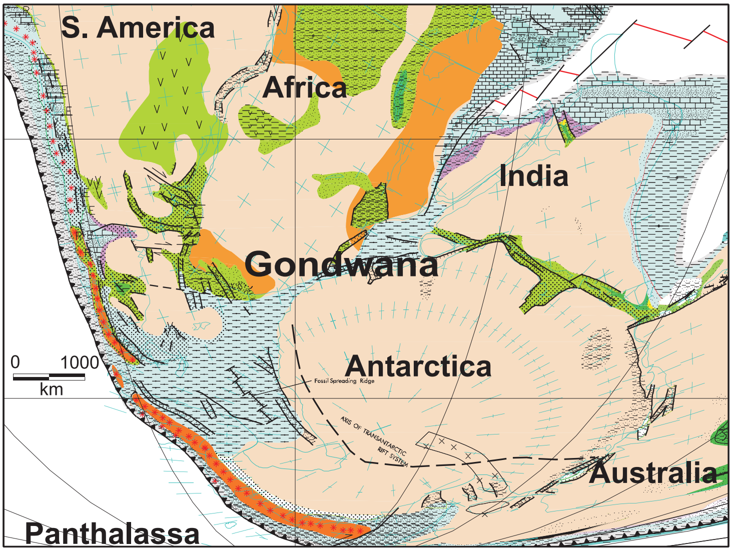

Fig. 25. Plate tectonic, paleoenvironment and lithofacies map of the western Gondwana during Late Jurassic time

Fig. 25. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Gondwany oraz obszarów sąsiednich w późnej jurze

Latest Jurassic-earliest Cretaceous

The latest Jurassic was a time of plate reorganization (Ford & Golonka 2003). The Atlantic began to propagate to the area between Iberia and Canada (Ziegler 1988, Sinclair *et al*. 1993) (Figs 26, 27). Drifting in the Gulf of Mexico ceased by the Late Berriasian or Valanginian (e.g. Ross & Scotese 1988, Marton & Buffler 1994, Bird *et al*. 2005). Sea floor spreading developed in the proto-Caribbean region (Dercourt *et al*. 1993, Ricou 1996). The Alpine Tethys reached its maximum width and stopped spreading (Golonka *et al*. 2000, 2003b, Golonka 2004).

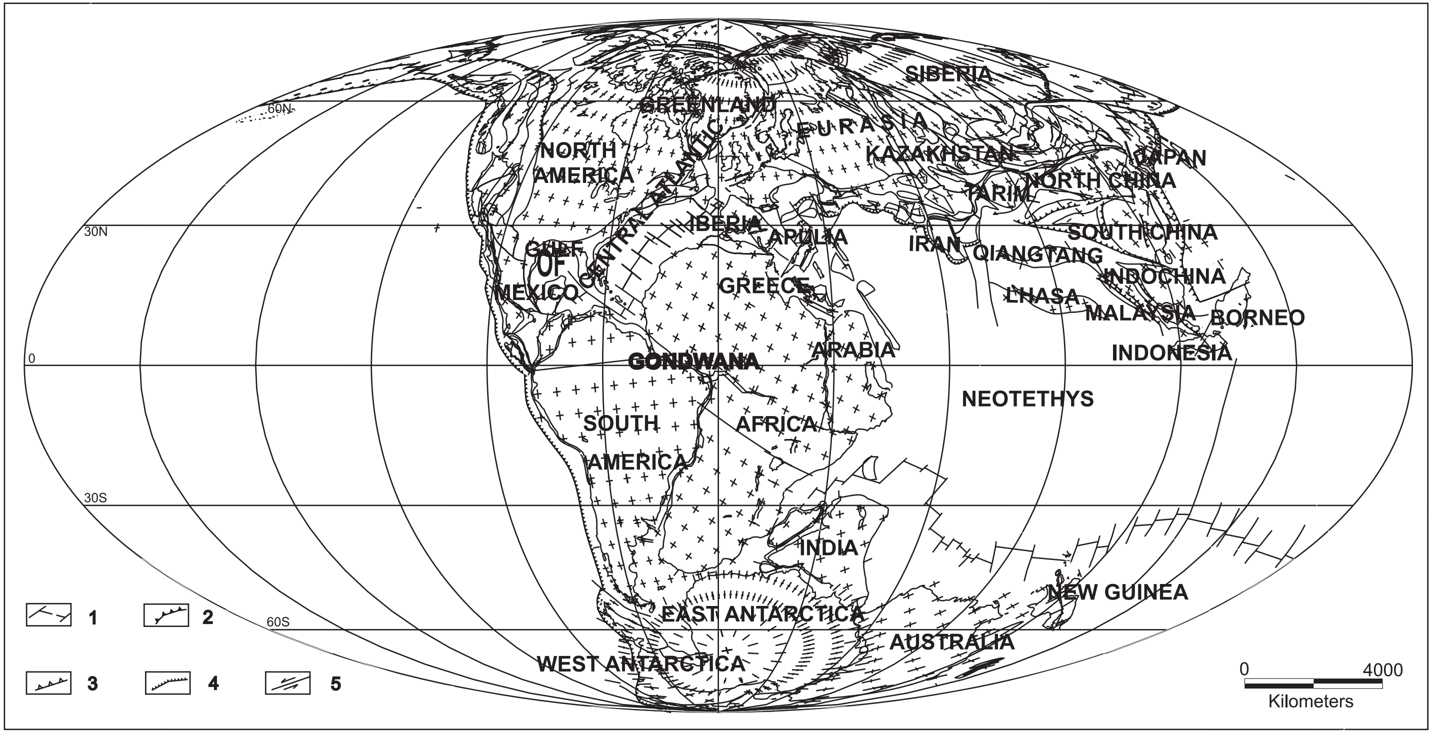

Fig. 26. Plate tectonic map of latest Jurassic-earliest Cretaceous (plates position as of 140 Ma). Modified from Golonka (2002): 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault

Fig. 26. Mapa tektoniki płyt najpóźniejszej jury-najwcześniejszej kredy (pozycja płyt 140 milionów lat temu). Zmieniona wg Golonki (2002): 1 – centrum spredingu oceanicznego i uskok transformujący, 2 – strefa subdukcji, 3 – nasunięcie, 4 – uskok normalny, 5 – uskok przesuwczy

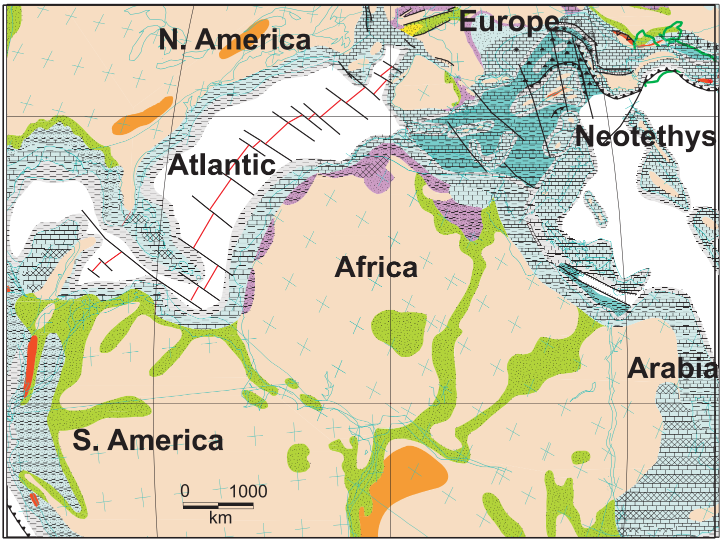

Fig. 27. Plate tectonic, paleoenvironment and lithofacies map of the western Tethys, future Central Atlantic and adjacent areas during latest Jurassic-earliest Cretaceous time

Fig. 27. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Tetydy, przyszłego centralnego Atlantyku oraz obszarów sąsiednich w najpóźniejszej jurze-najwcześniejszej kredzie

Subduction jumped to the northern margin of the Inner Carpathian terranes and began to consume the Pieniny Klippen Belt Ocean (Golonka *et al*. 2000). The latest Jurassic blueschists metamorphic rocks, found as pebbles (exotics) in the Albian flysch in the Pieniny-Magura Basin, indicate existence of a south dipping subduction below the northern margin of the Inner Carpathian plate (Faryad 1997). Detailed explanations of this problem have been described by Golonka & Krobicki (2001). The Tethyan plate reorganization resulted in extensive gravitational faults movement. Several tectonic horsts and grabens were formed, rejuvenating some older faults (Krobicki 1996). The southern part of the North European Platform, north of the Pieniny/Magura realm started to be rifted and the Outer Carpathian basin had developed with the beginning of calcareous flysch sedimentation. The rifted fragment of the European Platform separated this new basin and the Alpine Tethys. The Neotethys extension reached into the Ukrainian Carpathian area establishing connection with the Alpine Tethys in the triple junction zone (Golonka *et al*. 2003b, 2004).

Major carbonate platforms with adjacent deep-water basinal facies occurred around the margins of the Gulf of Mexico, Central Atlantic, Alpine Tethys and eastern Neotethys. The drop of the level decreased the extent of carbonate platforms in Europe and in Central Asia. Reservoir facies within shallow-marine carbonate platforms were mainly grainstones with minimal coral-dominated buildups. In many marginal Tethyan areas carbonates gradually changed into evaporites (Ronov *et al*. 1989, Golonka 2000) (Fig. 28). The carbonate platforms on Tethyan blocks continued their development. The deep-water carbonate-siliceous maiolica facies, with planktonic *Nannoconus* as the main builder (Golonka & Sikora 1981, Golonka 2000), were widespread in the central Tethyan basins. Reefs were common in Tethyan and Atlantic realms (Leinfelder *et al*. 2002).

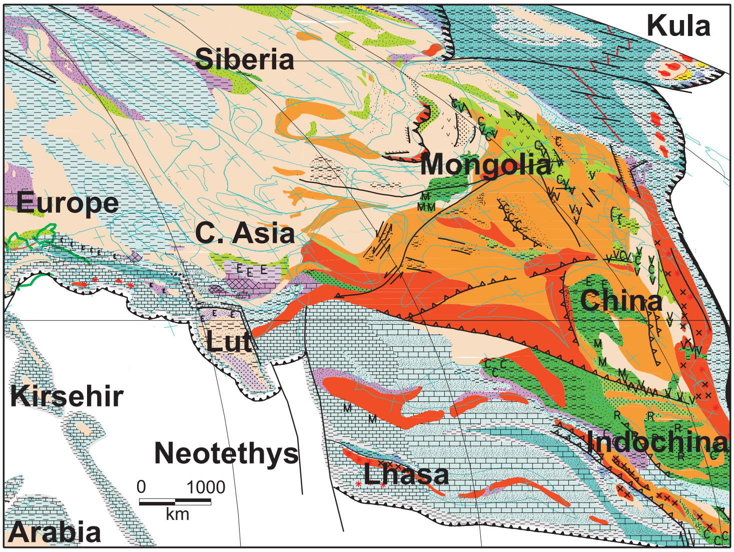

Fig. 28. Plate tectonic, paleoenvironment and lithofacies map of eastern Asia and adjacent areas during latest Jurassic-earliest Cretaceous time

Fig. 28. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Azji oraz obszarów sąsiednich w najpóźniejszej jurze-najwcześniejszej kredzie

During the Tithonian-Berriasian time, rifting started along the northern and eastern margins of the Lut block (Fig. 28). The Turan platform underwent a general uplift in the Kimmeridgian-Tithonian. This uplift is well recorded by changes of the facies from carbonate to evaporite sedimentation (Golonka 2004). The Gaurdak evaporite formation within the Murghab and Afghan-Tadjik basins reaches a thickness of more than 1000 meters. The subduction trench pulling effect along the northern margin of Neotethys, formed the Greater Caucasus-proto-Caspian back-arc basin (Fig. 28), underlain by oceanic crust (Rezanov & Chamo 1969, Zonenshain & Le Pichon 1986, Zonenshain *et al*. 1990, Bazhenov *et al*. 1991, Nadirov *et al*. 1997, Golonka 2004). The collision of the Lhasa block with Asia took place along the Banggong-Nujiang Suture, around the Jurassic/Cretaceous boundary (Metcalfe 1994, Golonka 2000, 2002, 2004, Jolivet *et al*. 2001, Golonka *et al*. 2006). The collision of the Helmand (Afghanistan), with the Turan Platform and South Pamir, Karakorum and Lhasa plates took place approximately about the same time (Otto *et al*. 1997, Golonka 2000, 2004). The eastern part of the northern branch of the Neotethys was closed.

The final closure of the Mongolian-Okhotsk Sea in the Early Cretaceous (Filipova 1998, Golonka 2000, 2002) resulted from the collision of North China and East Siberia (Fig. 28). North China and Siberia became parts of the Eurasian margin adjacent to the Pacific Ocean. Abundant strike-slip tectonics created intermontane basins in China. According to Ren *et al*. (2002), extension was widespread in Eastern China and adjacent areas in the Late Jurassic-Early Cretaceous times. This rifting, which covered an area of more than 2 000 000 km^2 of NE Asia, from the Lake Baikal to the Sikhote-Alin in E-W direction and from the Mongol-Okhotsk fold belt to North China in N-S direction, was characterized by intracontinental rifts, volcanic eruptions and transform extension along large-scale strike-slip faults.

The Atlantic Tethys-North Sea rift system was replaced during the Early Cretaceous by the Eastern Mediterranean, Bay of Biscay-Labrador Sea rift system (Golonka 2000, 2002, Golonka *et al*. 2003a). This tectonic event induced a lowstand in relative sea level that affected the entire North Atlantic and Arctic region (Fig. 29). Repeated faulting during the Early Cretaceous, combined with sea level fluctuations, resulted in several regional hiatuses/unconformities across the region. The North Sea-Poland rifts ceased to expand and from this time can be considered aulacogens (Fig. 29). Rifting in the Arctic was initiated. Narrow transcontinental seaways developed across Europe and the North Atlantic. Present day hot spots of Iceland and Jan Mayen were located in the Late Jurassic time in the vicinity of the Chukchi Borderland. This was a place of the future opening of the Canadian basin (Golonka & Bocharova 2000, Golonka *et al*. 2003a). Rifting in the Arctic region, which was initiated at that time, was caused by mantle convection and upwelling cell, marked by the hot spot volcanics in the Alpha Ridge and Chukchi Borderland. The trench-pulling forces, which consumed the Anui-Anvil Ocean (Zonenshain *et al*. 1990), also played an active role in this rifting event. A system of narrow-margin troughs and exposed rift-shoulder uplifts developed parallel to the Laurasian Margin (Grantz *et al*. 1990, 1998, Golonka & Bocharova 2000, Golonka *et al*. 2003b). The central rift later developed into the Canadian Basin.

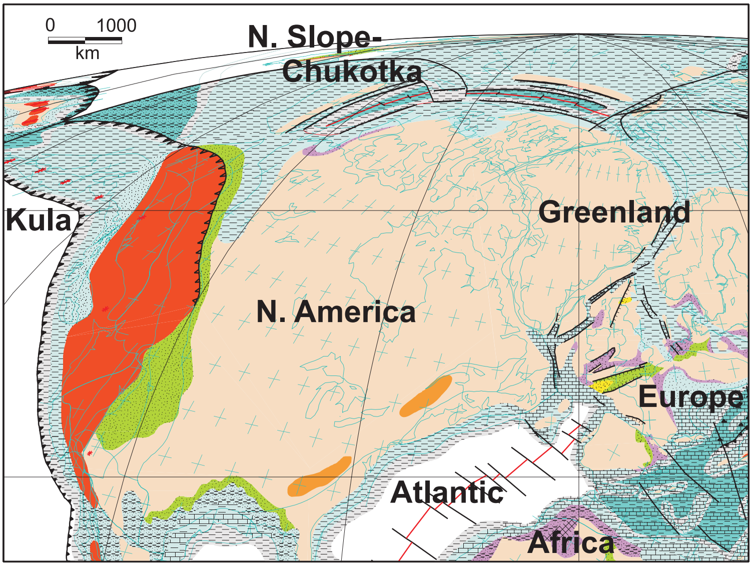

Fig. 29. Plate tectonic, paleoenvironment and lithofacies map of North America and adjacent areas during latest Jurassic-earliest Cretaceous time

Fig. 29. Mapa tektoniki płyt, paleośrodowiska i litofacji Ameryki Północnej oraz obszarów sąsiednich w najpóźniejszej jurze-najwcześniejszej kredzie

Terranes colliding along the western margin of North America and closing of the Anvil Ocean initiated the first thrusting episode of the Brooks allochton in the northern Alaska (Moore *et al*. 1994). The compressional force was translated along a mega-regional shear, which separated the Anvil and Anui oceans. The predominant sediment type during the Early Cretaceous was fine-grained, shallow and deep-water clastics. Coarse-grained clastics and marginal marine sediments were deposited in the marginal parts of the mega-province and during periods immediately following the unconformities. Deep-water fine-grained clastics probably dominated sedimentation in the southern part of the Barents Sea, and in the Mid-Norway and East Greenland areas. Organic-rich sedimentation continued in the circum-Arctic area until the early Valanginian (Golonka *et al*. 2003a).

Gondwana was in the advanced stage of breakup (Lawver & Gahagan 1993, Veevers 1994, 2004, Golonka 2000, 2002) (Fig. 30). Post-rift to drift-stage basins, with marine incursions, existed between Africa and India, Africa and Antarctica .and India and Australia. A narrow transcontinental seaway developed across southern Gondwana (Malvinas/Falklands area). Pre-rift structural lineaments and sags were present between South America and Africa. These structural features became sites for continental and lacustrine sedimentation. According to Richards & Hiller (2000), the North Falkland basin is characterized by fluvial-lacustrine late syn-rift clastic deposits. According to Franzese *et al*. (2003), in western Patagonia, back-arc and intra-arc extension produced the opening of several basins filled with clastic deposits.

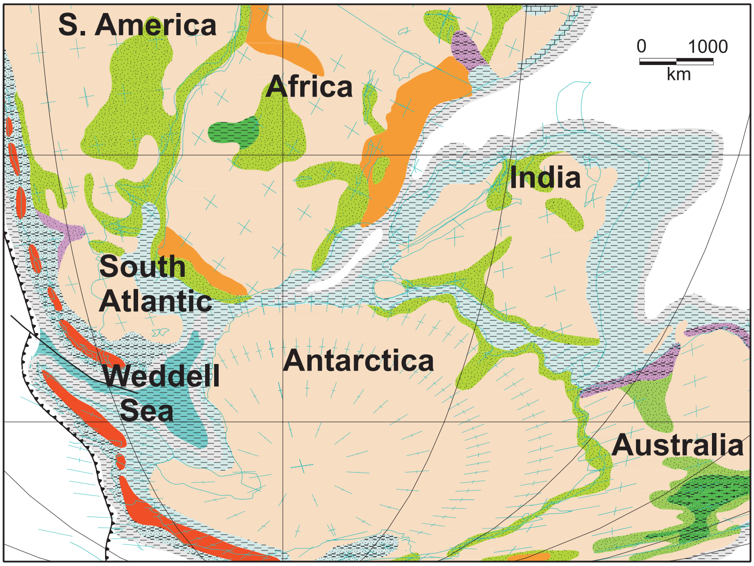

Fig. 30. Plate tectonic, paleoenvironment and lithofacies map of the western Gondwana during latest Jurassic-earliest Cretaceous time

Fig. 30. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Gondwany oraz obszarów sąsiednich w najpóźniejszej jurze-najwcześniejszej kredzie

Early Cretaceous

Pangea and Gondwana were in advanced stage of breakup during the Early Cretaceous (Fig. 31). The Central Atlantic was widely open (Figs 31, 32), propagating towards the area between Iberia and Canada (Ziegler 1988, Golonka & Bocharova 2000, Golonka 2002). Rifting in the Labrador Sea propagated northwards towards the Davies Strait and also, probably, into the southern Baffin Bay (Ziegler 1988).

Repeated faulting during the Early Cretaceous, combined with sea level fluctuations, resulted in several regional hiatuses/unconformities across the North Atlantic, North Sea and Arctic regions (Golonka *et al*. 2003a). The Late Cimmerian unconformity at the transition from Late Jurassic to Early Cretaceous time is recognized in most basins. Other prominent unconformities are seen in the Berriasian-Hauterivian and Aptian. The predominant sediment type during the Early Cretaceous was fine-grained, shallow and deep-water clastics. Coarse-grained clastics and marginal marine sediments were deposited in the marginal parts of the mega-province and during periods immediately following the unconformities. Deep-water fine-grained clastics probably dominated sedimentation in the southern part of the Barents Sea, and in the Mid-Norway and East Greenland areas (Johansen *et al*. 1993, Gustavsen *et al*. 1997, Stemmerik 2000).

In the Alpine-Carpathian area, the Rhenodanubian and Outer Carpathian troughs, situated on partially oceanic crust and partially attenuated continental crust, were opened during the Early Cretaceous time (Fig. 32) (Golonka 2007). To the west, these troughs extended into the Valais Ocean, which entered into a seafloor spreading phase (Froitzheim *et al*. 1996, Marchant & Stampfli 1997), and farther into the area between Spain and France and to the Bay of Biscay (Stampfli 1993, 1996). To the east, the through system was connected with the subsiding Balkan area. The opening of the Outer Carpathian basins is related to the closing of the Pieniny-Magura (North and South Penninic) basin. The Outer Carpathian basin reached its greatest width during the Hauterivian-Aptian time. With the widening of the basin, several subbasins (troughs) began to show their distinctive features.

The Tithonian-Berriasian rifting along the northern and eastern margins of the Lut block was followed by sea-floor spreading during the Barremian-Hauterivian, as well as formation, by the Albian time, of the Sistan Ocean. This ocean is known from the ophiolites in northern Iran (Ricou 1996, Şengör & Natalin 1996). Perhaps all the intra-Iranian basins were opened at that time (Dercourt *et al*. 1986).

Interior continental rifts of Africa remained open during the Early Cretaceous (Ricou 1996, Ford & Golonka 2003). Rifts were rejuvenated in northern Africa between Morocco and Tunisia. Continental coarse- and fine-grained clastics were widespread within the African interior (Fig. 32). The subduction zone between North and South America flipped polarity (Ford & Golonka 2003). A westward dipping subduction developed along the eastern side of the Greater Antilles arc, associated with the creation of blueschists and other metamorphic rocks (Pindell & Tabbutt 1995). The arc began to migrate eastward, consuming the proto-Caribbean oceanic crust, while active seafloor spreading still continued between North and South America (Ricou 1996).

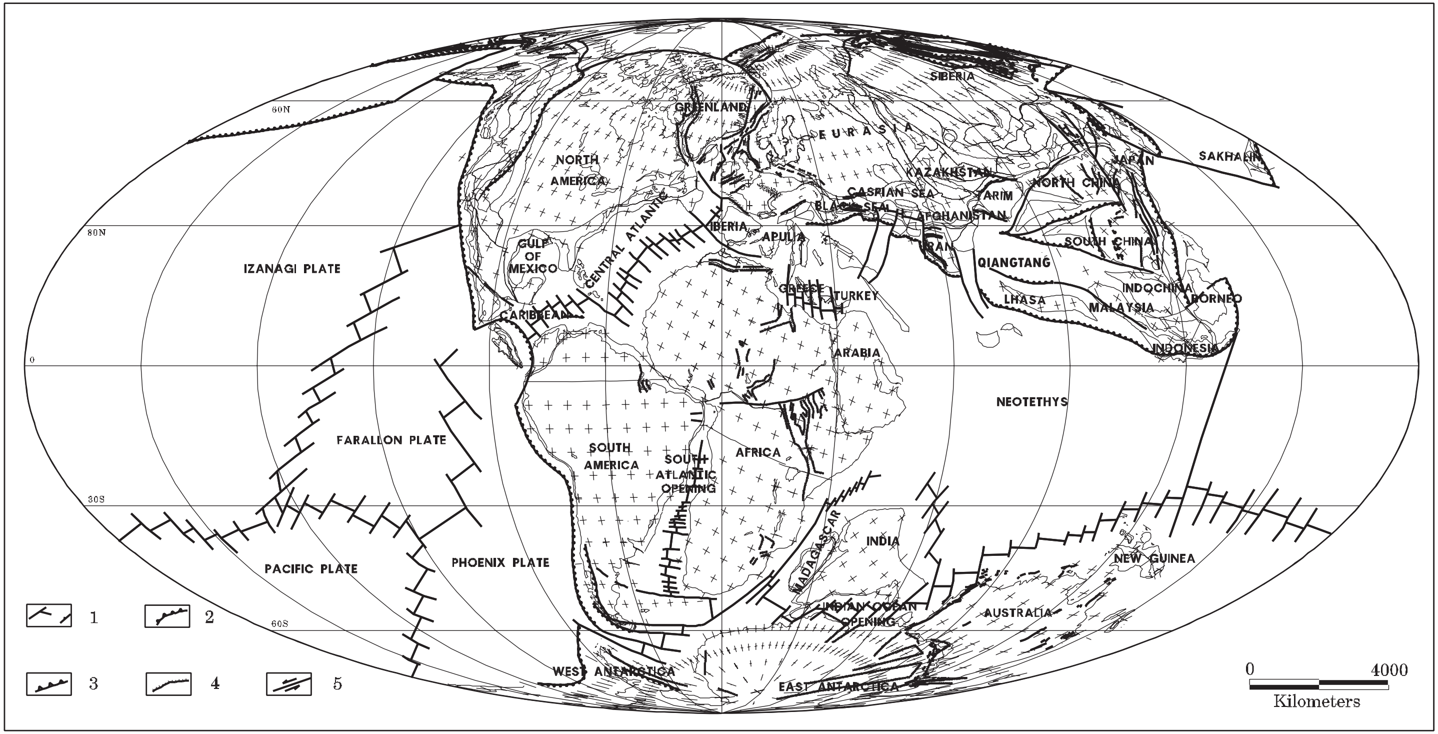

Fig. 31. Plate tectonic map of the Early Cretaceous (plates position as of 112 Ma). Modified from Golonka (2002): 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault

Fig. 31. Mapa tektoniki płyt wczesnej kredy (pozycja płyt 112 milionów lat temu). Zmieniona wg Golonki (2002): 1 – centrum spredingu oceanicznego i uskok transformujący, 2 – strefa subdukcji, 3 – nasunięcie, 4 – uskok normalny, 5 – uskok przesuwczy

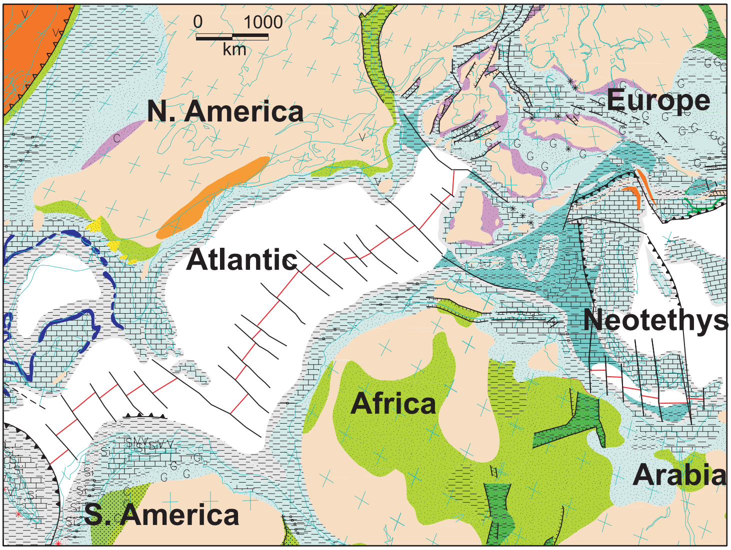

Fig. 32. Plate tectonic, paleoenvironment and lithofacies map of the western Tethys, Central Atlantic and adjacent areas during Early Cretaceous time

Fig. 32. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Tetydy, centralnego Atlantyku oraz obszarów sąsiednich we wczesnej kredzie

In the eastern Tethys, the West Burma terrane was drifting toward South-East Asia (Metcalfe 1994, 1998). Suturing of Lhasa with Central Asia was concluded, but compressional deformations still continued (Golonka 2007). The territory of South China was uplifted with mountains and intermountain basins with red beds, coals and volcanics (Fig. 33). In the Indochina plate, terrestrial clastic sedimentation prevailed with red beds (Golonka *et al*. 2006). Continental clastics with red beds and coals were deposited in Mongolia and southern Siberia. Volcanics were abundant along the eastern coast of Siberia and China. According to Yin & Nie (1996), the formation of the eastern Sichuan fold-and-thrust belt could have been the result of combined thermal weakening, due to the subduction of the Izanagi plate beneath eastern Asia and the compression following the collision of the Lhasa plate and the closure of the Mongol-Okhotsk Ocean (Zonenshain *et al*. 1990, Golonka 2002). Translational movement took place in East Asia (Cox *et al*. 1989, Zonenshain *et al*. 1990, Şengör & Natalin 1996).

The Pacific convergent rim remained very active. Intensive volcanic activity and deformations were recorded within the Rockies, along the western coast of North America (Oldow *et al*. 1989, Pindell & Tabbutt 1995). The North American interior was filled with fine-grained clastics (Fig. 34). Carbonates with rudist reefs were deposited in the Gulf of Mexico area.

Early seafloor spreading began between Antarctica and India as well as between Australia and India (Fig. 35) (Lawver & Gahagan 1993, Ricou 1996, Golonka 2007).

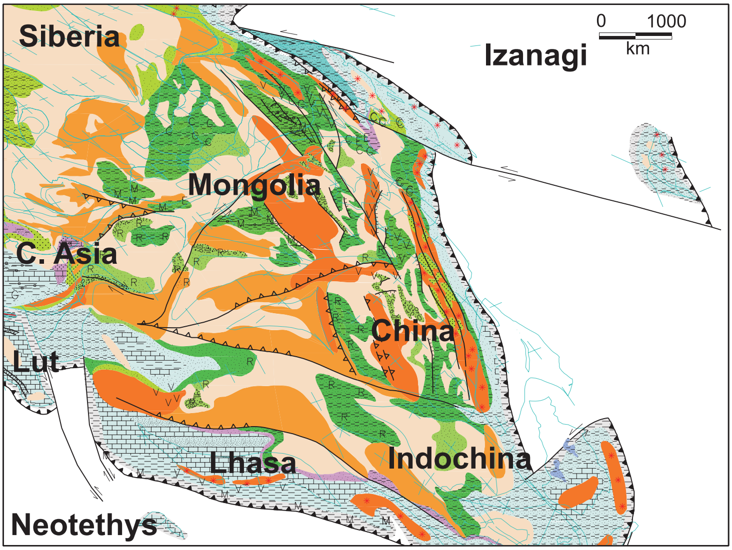

Fig. 33. Plate tectonic, paleoenvironment and lithofacies map of eastern Asia and adjacent areas during Early Cretaceous time

Fig. 33. Mapa tektoniki płyt, paleośrodowiska i litofacji wschodniej Azji oraz obszarów sąsiednich we wczesnej kredzie

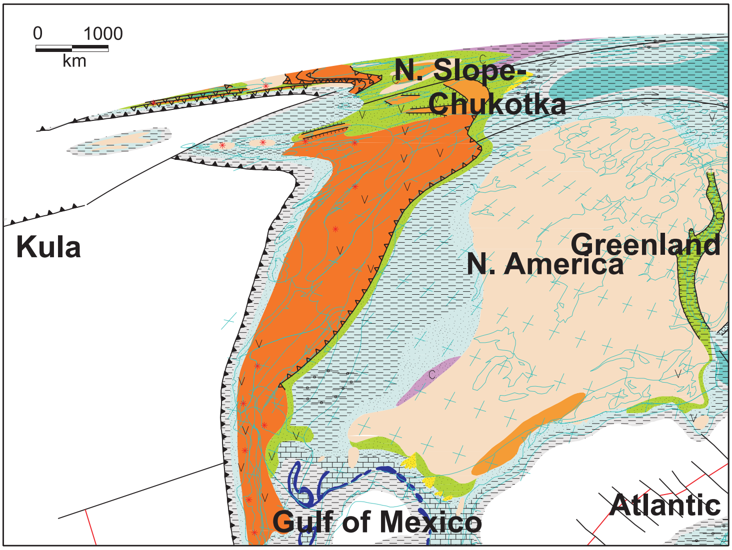

Fig. 34. Plate tectonic, paleoenvironment and lithofacies map of North America and adjacent areas during Early Cretaceous time

Fig. 34. Mapa tektoniki płyt, paleośrodowiska i litofacji Ameryki Północnej oraz obszarów sąsiednich we wczesnej kredzie

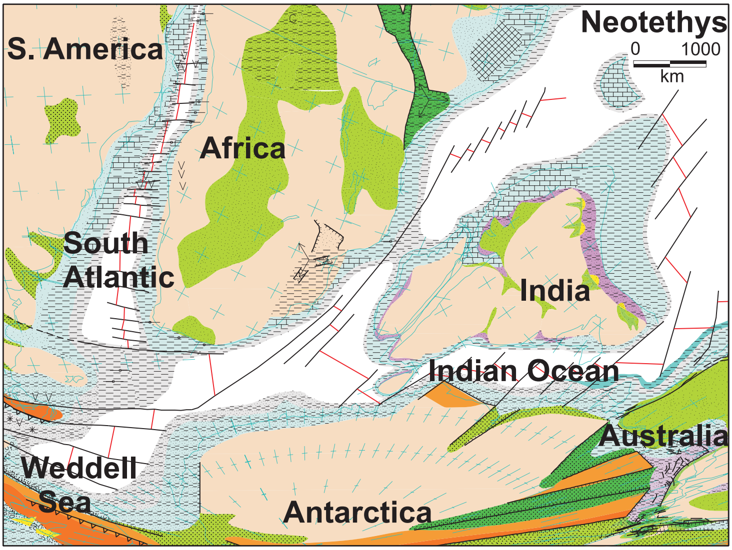

Fig. 35. Plate tectonic, paleoenvironment and lithofacies map of South America, Africa, Australia, India, Antarctica, South Atlantic and Indian Ocean during Early Cretaceous time

Fig. 35. Mapa tektoniki płyt, paleośrodowiska i litofacji Ameryki Południowej, Afryki, Australii, Indii, Antarktyki, południowego Atlantyku oraz Oceanu Indyjskiego we wczesnej kredzie

The pushing force caused by mantle upwelling could explain the initial phase of the northward drift of India (Golonka & Bocharova 2000). The Indian Ocean was born. In a later phase, the Eurasian subduction could have become the major force driving the motion of India (Golonka 2007). Clastics were abundant along the Indian Ocean margins. Some Karoo troughs of southern Africa were rejuvenated (Cadle *et al*. 1993, Guiraud & Bellion 1996, Ford & Golonka 2003). The South Atlantic was open and rifting propagated from this seaway towards the Equator, along the Africa and South America margins (Fig. 33). Volcanics, mixed carbonates and clastics, abundant source rocks and evaporites were deposited in this area.

Late Cretaceous

During the Late Cretaceous, the spreading of the Central and Southern Atlantic continued (Figs 36, 37), with a significant increase in the size of the equatorial Atlantic (Nürnberg & Müller 1991, Ford & Golonka 2003). The Central Atlantic Ocean widened, propagating toward the Labrador Sea. Eastward movement of the Caribbean arc between North and South America, as well as the subduction of the proto-Caribbean oceanic crust beneath the advancing Greater Antilles island arc continued (Ross & Scotese 1988, Pindell & Tabbutt 1995, Golonka & Ford 2003). This arc collided with the Bahama platform during the latest Cretaceous, resulting in the capture of the Caribbean plate and the initiation of subduction along the Panama Arc (Scotese 1991). The trapped Caribbean seafloor had been a part of the Farallon plate of the Pacific (Lawver & Gahagan 1993). Source rocks were abundant along the Atlantic margins in South America, West Africa, and in the Gulf of Mexico area (Fig. 37).

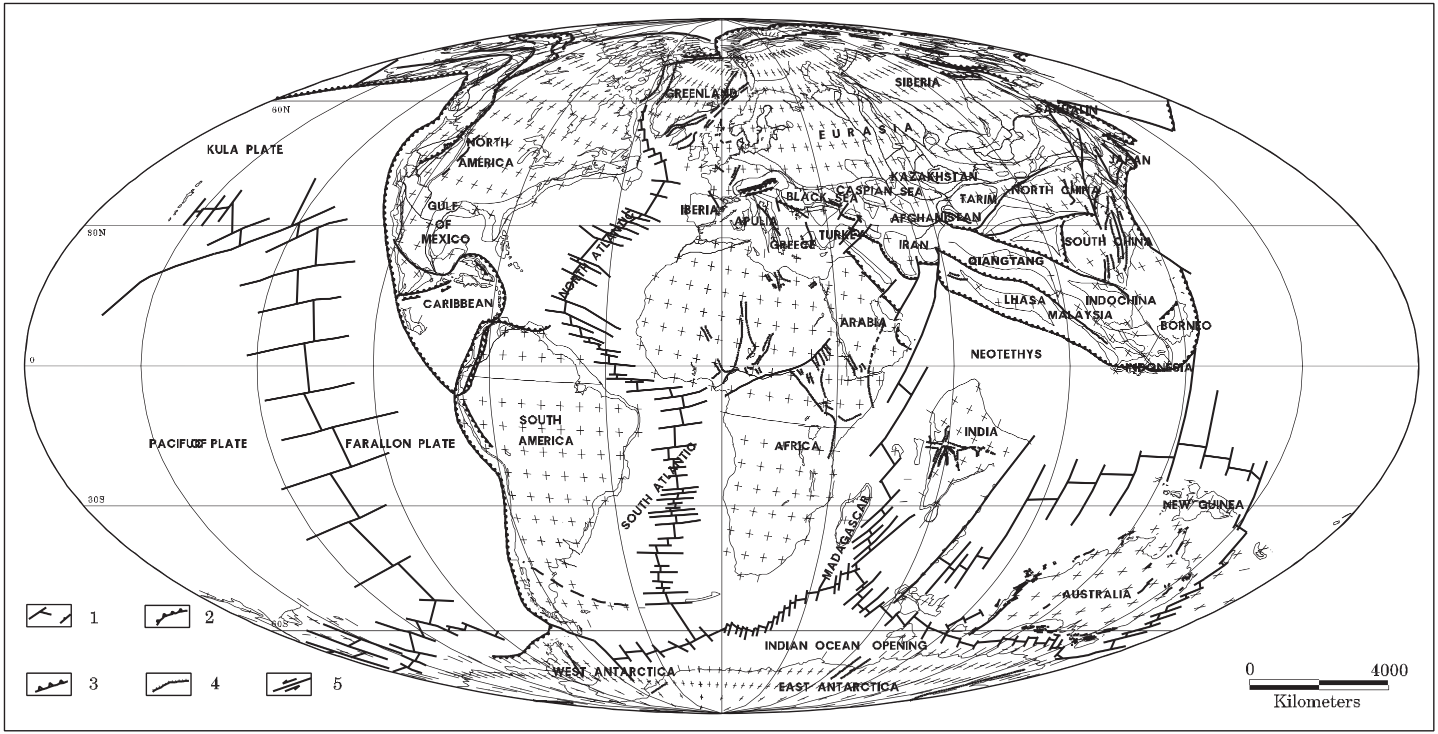

Fig. 36. Plate tectonic map of the Late Cretaceous (plates position as of 90 Ma). Modified from Golonka (2002): 1 – oceanic spreading center and transform faults, 2 – subduction zone, 3 – thrust fault, 4 – normal fault, 5 – transform fault

Fig. 36. Mapa tektoniki płyt późnej kredy (pozycja płyt 90 milionów lat temu). Zmieniona wg Golonki (2002): 1 – centrum spredingu oceanicznego i uskok transformujący, 2 – strefa subdukcji, 3 – nasunięcie, 4 – uskok normalny, 5 – uskok przesuwczy

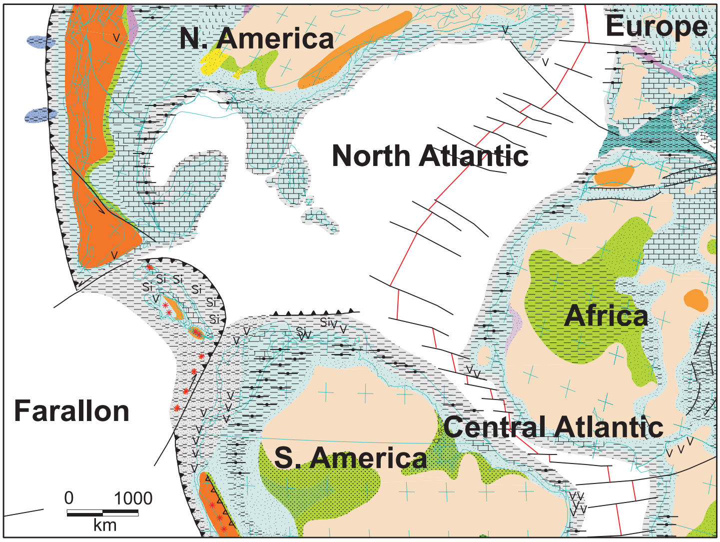

Fig. 37. Plate tectonic, paleoenvironment and lithofacies map of western Tethys, Central Atlantic and adjacent areas during Late Cretaceous time

Fig. 37. Mapa tektoniki płyt, paleośrodowiska i litofacji zachodniej Tetydy, Atlantyku centralnego oraz obszarów sąsiednich w późnej kredzie

According to Metcalfe (1998), by the beginning of Late Cretaceous time, the West Burma (Myanmar) and other small terranes had accreted to Southeast Asia along the Shan Boundary. The subduction dipping toward the continent and Andean-type margines developed along Southeast Asia (Fan 2000). Uplift and continental terrestrial deposition continued within the Indochina and South China territory (Fig. 38) (Golonka *et al.* 2006). Counterclockwise movement of Africa and northward drift of India narrowed the Neotethys Ocean. This reversed the geotectonic process. After reaching the maximum dispersion phase, the continent began to slowly assemble in a new configuration (Golonka 2002).

Spreading continued in the Greater Caucasus-proto-Caspian Ocean (Zonenshain & Le Pichon 1986, Golonka 2004) during the beginning of the Late Cretaceous. According to Nikishin *et al.* (2001), basaltic intrusives of possibly Albian to Turonian ages and Cenomanian olivine basalts are typical for the western part of the Great Caucasus basin. Alkaline basaltic volcanism of Turonian to Santonian age developed along the southern margin of the basin in Georgia (Golonka 2004). Presumably, tensional tectonics in the Great Caucasus lasted until at least the middle Santonian times, as evidenced by its volcanic activity (Nikishin *et al.* 2001). The Jurassic Greater Caucasus-proto-Caspian and Cretaceous western Black Sea oceanic basins were located south of the Scythian-Turan platform. The subduction-related volcanic arcs separated these basins from the Neotethys. The opening was related to the continued northward subduction of the Neotethys. The Greater Caucasus-proto-Caspian Ocean was connected with the Sistan Ocean (Golonka 2004), which separated Lut from Afghanistan and the Kopet-Dagh area (Fig. 39). While the Jurassic deposits in the South Caspian Basin are speculative, the Cretaceous sediments are present in the eastern part of the basin and could be extrapolated towards the central part (Brunet *et al.* 2002).

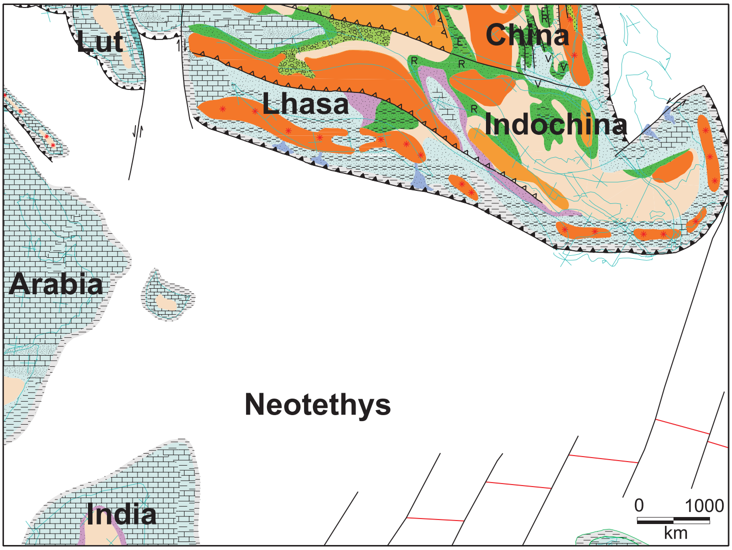

Fig. 38. Plate tectonic, paleoenvironment and lithofacies map of Southeastern Asia, eastern Neotethys and adjacent areas during Late Cretaceous time

Fig. 38. Mapa tektoniki płyt, paleośrodowiska i litofacji Azji południowo-wschodniej, wschodniej Tetydy oraz obszarów sąsiednich w późnej kredzie

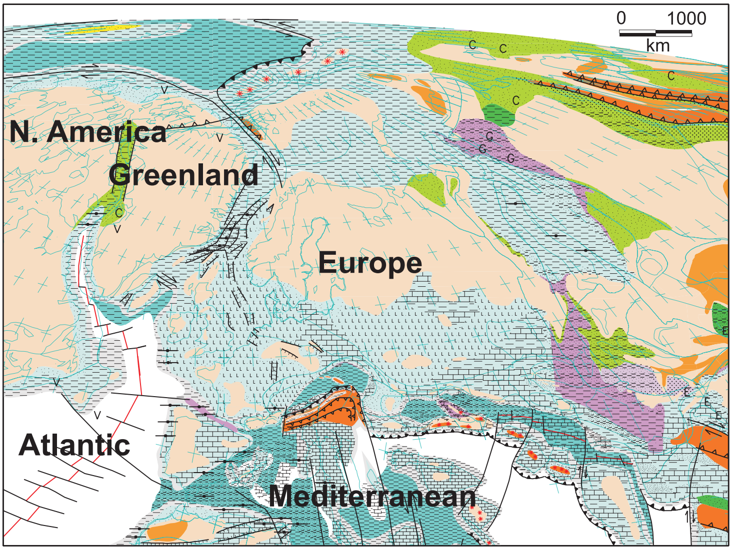

Fig. 39. Plate tectonic, paleoenvironment and lithofacies map of Europe and adjacent areas during Late Cretaceous time

Fig. 39. Mapa tektoniki płyt, paleośrodowiska i litofacji Europy oraz obszarów sąsiednich w późnej kredzie

The rotation of Africa and the renewed spreading in the Eastern Mediterranean caused the Apulian plate to converge with Europe (Golonka 2004). The compressional event in the Inner Carpathians, which began during the Albian time, ended in the Late Turonian (Fig. 39). As a consequence, a complicated nappe structure formed (Golonka 2004). Along with the development of the Inner Carpathian nappes, the for-arc basin was formed between the uplifted part of the Inner Carpathian terrane and the subduction zone. The flysch successions of the Pieniny Klippen Belt were formed in this area. Behind the ridge, another flysch succession was deposited within the back-arc basin.

Most of Europe was covered by a shallow sea. Chalk was widespread in western, central and southeastern Europe during the Late Cretaceous (Fig. 39). Carbonates were still deposited on the platforms within the Mediterranean area.

Deep-water fine-grained clastics probably dominated sedimentation in the Vøring and Møre basins, but the possibility for localized sand deposition is good (Golonka *et al*. 2003). There is also the possibility for the occurrence of organic-rich dark shales, especially during the Turonian Oceanic Anoxic Event although there are no proven Late Cretaceous source rocks. No Upper Cretaceous sediments have been found in Svalbard. Substantial deposition persistent in the Viluy, Khatanga and West Siberian basins (Fig. 39).

Dispersal of the continents and development of the passive margins and rift basins continued in the former Gondwana area. Development of the interior sag basins in South America, Africa, and Asia was associated with the renovation of ancestral failed rifts. The Indian plate continued rapid northeastward movement, opening the Indian Ocean (Royer & Sandwell 1989, Lawver *et al*. 1992). The separation of India from Madagascar began (Fig. 40) (Golonka 2002).

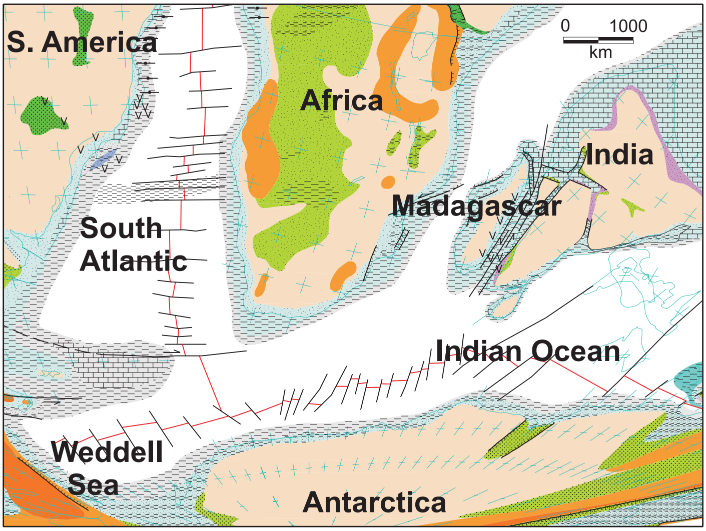

Fig. 40. Plate tectonic, paleoenvironment and lithofacies map of South America, Africa, India, Antarctica, South Atlantic and Indian Ocean during Late Cretaceous time

Fig. 40. Mapa tektoniki płyt, paleośrodowiska i litofacji Ameryki Południowej, Afryki, Australii, Indii, Antarktyki, południowego Atlantyku oraz Oceanu Indyjskiego w późnej kredzie

Clastics and volcanics were redeposited in the newly developed rifts. The onset of seafloor spreading between Australia and Antarctica occurred at 95 Ma (Lawver & Gahagan 1993). Clastic were deposited along the Indian Ocean margins, while carbonates platforms existed in the northern and northwestern India (Fig. 40). Clastics sedimentation with source rocks prevailed on the South Atlantic margins. Volcanics also occurred there. Continental deposits filled the African interior. The basic plate configurations of the Pacific Ocean was formed, with three spreading ridges separating the Pacific plate from three adjacent plates, the Izanagi, Farallon, and Phoenix plates (Fig. 36) (Winterer 1991).

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Streszczenie

Artykuł przedstawia szczegółowe mapy obrazujące tektonikę płyt, paleogeografię, paleośrodowisko i paleolitofacje ośmiu mezozoicznych przedziałów czasowych. Mapy te, które dotyczą przedziałów czasowych w obrębie triasu, jury i kredy, były skonstruowane przy użyciu programów PLATES i PALEOMAP. Dane paleomagnetyczne posłużyły do oznaczenia paleoszerokości geograficznej. Wulkanity znaczące działalność plam gorąca pomagają przy określaniu paleodługości geograficznej. Wykorzystano informacje zawarte w szeregu globalnych i regionalnych pracach. Mapy przedstawiają współczesne linie brzegowe, granice płyt (szwy) oraz wybrane uskoki transformacyjne, osie rozrostu, ryfty, normalne uskoki, nasunięcia, paleośrodowisko i paleolitofacje.

Wzajemne stosunki pomiędzy konfiguracją kontynentów, litofacjami, tektoniką płyt i klimatem, jakie panowały w okresie rozpadu superkontynentu Pangei, otwierania Atlantyku i Oceanu Indyjskiego, wyraźnie zaznaczone są na poszczególnych mapach tworzących spójną serię rekonstrukcji palinspastycznych. Rozkład litofacji jest wyraźnie związany z rozpadem i kontynentów, a także ze zmianami klimatu wywołanymi tektoniką płyt. Rozpad kontynentów i powstawanie oceanów wytworzyło baseny związane z riftingiem i rozwojem krawędzi pasywnych. Zmiany klimatu i wymieranie są związane z reorganizacją płyt i aktywnością pióropuszy płaszcza.

We wczesnym triasie (Fig. 1–5) istniał superkontynent Pangea otoczony przez ocean Panthalassa. Głównym wczesnotriasowym globalnym wydarzeniem z punktu widzenia tektoniki płyt był postępujący dryft płyt kimeryjskich od Gondwany w kierunku Eurazji (Fig. 1–3). Ruch tych płyt powodował zamykanie się oceanu Paleotetyda i otwieranie się oceanu Neotetyda. Wielkie platformy węglanowe utworzyły się na krawędziach Paleotetydy i Neotetydy, jak również na płytach kimeryjskich (Fig. 2, 3). Tworzyły się na nich rafy, budowane przez organizmy skałotwórcze, których odrodzenie następuje w triasie, po wielkim wymieraniu, jakie miało miejsce na pograniczu permu i triasu.

Kontynent Pangea obrzeżony był strefami subdukcji. Działalność wulkaniczna rozwijała się wokół superkontynentu, tworząc tak zwany „ognisty pierścień Pangei”. Ze strefami subdukcji związane było również powstanie naprężeń, które prowadziły do ekstensji, tworzenie się ryftów, a następnie, w okresie późniejszym – do rozłamu superkontynentu. Uwolnienie się naprężeń jest łączone ze wzmożeniem aktywności pióropuszy płaszcza. Towarzyszyły temu ogromne wylewy wulkaniczne na pograniczu permu i triasu na Syberii, tak zwane trapy syberyjskie (Fig. 5). Strefa skierowanej ku północy subdukcji rozciągała się również wzdłuż północnych wybrzeży Paleotetydy. Subdukcja ta spowodowała otwieranie się basenów typu załukowego, rozciągających się wzdłuż południowej krawędzi Europy i Azji.

Północne Chiny były połączone z Mongolią (Fig. 1, 4). Pomiędzy Mongolią a Laurazją znajdował się Ocean Mongolsko-Ochotski, będący odgałęzieniem oceanu Panthalassa. Indochiny i Indonezja były połączone z południowymi Chinami i płytą Qiangtang (Fig. 3).

Ostatnie wydarzenia kolizyjne orogenezy Uralu miały miejsce w triasie i we wczesnej jurze. Deformacje Tajmyru (Fig. 5) związane są również z tą orogenezą. W tym czasie w rejonie późniejszej Arktyki istniał ocean Anui-Anvil, rozciągający się pomiędzy Czukotką, północnym skłonem Alaski a teranami Wierchojańska.

Głównym konwergentnym wydarzeniem w okresie późnego triasu (Fig. 6–10) była orogeneza indochińska, kolizja Indochin i Indonezji z południowymi Chinami oraz konsolidacja bloków chińskich. Dryft płyt kimeryjskich znacząco zwęził Paleotetydę (Fig. 6–9). Na zachodzie szereg płyt zderzyło się z kontynentem Eurazji, wywołując deformacje rejonu Mangyszłaku, Przedpola Kaukazu i południowej strefy gór Kopet-Dagh.

W okolicach granicy triasu i jury nastąpiło wielkie wymieranie gatunków fauny i flory. Następujące procesy związane z tektoniką płyt wpłynęły na wymieranie gatunków:

- zamknięcie Paleotetydy i amalgamacja azjatyckiej części Pangei;
- rozłam Pangei i ryfty na obszarze przyszłego Oceanu Atlantyckiego;
- wulkanizm związany z rozłamem Pangei, wielkie wylewy bazaltowe i uwolnienie znacznej ilości dwutlenku węgla;
- zmiany poziomu morza odzwierciedlające amalgamację i rozpad superkontynentu;
- anoksja związana z powstawaniem basenów dryftowych, aktywnością wulkaniczną i zmianami poziomu morza;

We wczesnej jurze (Fig. 11–15) wszystkie główne kontynenty i płyty wchodziły w skład Pangei. Jedynie drobne terany dryfowały wewnątrz oceanów Panthalassa i Tetyda. Rozpoczęły się narodziny Atlantyku centralnego, którego przedłużeniem jest Zatoka Meksykańska oraz Tetyda Alpejska. Proces ten kontynuował się w jurze środkowej (Fig. 16–20). W wyniku jurajskiego oddzielenia się Gondwany i Laurazji utworzyła się Tetyda Alpejska, to znaczy system Oceanów Alborańsko-Liguryjsko-Pienińskich, który sięgał aż po Karpaty Ukraińskie. Oceany Tetydy Alpejskiej były połączony z Atlantykiem centralnym systemem uskoków przesuwczych, stanowiąc fragment tektonicznego sytemu rozpadu Pangei. System ten sięgał poprzez Polskę, Morze Północne, proto-Atlantyk północny do obszaru Arktyki. W wyniku dyspersji kontynentów tworzyły się nowe platformy węglanowe na szelfach Tetydy i płyt znajdujących się wewnątrz oceanu. Nastąpiło też odrodzenie się organizmów skałotwórczych w tym zespołów rafowych, znacznie przerzedzonych w czasie wielkiego wymierania na przełomie triasu i jury.

Powstawanie oceanów, zapoczątkowane we wczesnej środkowej jurze, kontynuowało się w jurze późnej (Fig. 21–25). Powstała skorupa oceaniczna Zatoki Meksykańskiej. Atlantyk centralny stał się szerokim oceanem. Późnojurajski spreding odspoił też blok Lhasy od Gondwany. Około 160 milionów lat temu terany zaczęły zderzać się z kontynentem Ameryki Północnej. Podczas kolizji Stikini nastąpiła obdukcja materiału teranu w rejonie pasma górskiego Brooks na Alasce, jak również uformowała się formacja San Francisco na terenie Ameryki południowo-zachodniej. Na obszarze Tetydy rozwijały się platformy węglanowe (Fig. 22–24). W tym samym czasie na obszarach wokółarktycznych osadzały się osady klastyczne, wśród nich łupki ze znaczną zawartością substancji organicznej. Łupki bitumiczne osadzają się między innymi w basenach Morza Północnego, przyszłego Atlantyku północnego, Morza Barentsa, Beauforta, zachodniej Syberii.

Rozpoczął się proces rozpadu Pangei, zapoczątkowany przez powstawanie skorupy oceanicznej na obszarze pomiędzy Indiami, Madagaskarem i Afryką.

Na przełomie jury i kredy (Fig. 26–30) nastąpiła generalna reorganizacja płyt. Atlantyk zaczął się rozszerzać między Iberią i Nową Funlandią. Ocean Tetydy Alpejskiej przestał się rozszerzać, kierunek liguryjsko-pieniński został zarzucony, czemu towarzyszyło powstanie strefy subdukcji wzdłuż krawędzi basenu pienińskiego pasa skałkowego. Tworzenie się skorupy oceanicznej w Zatoce Meksykańskiej zakończyło się w beriasie lub valanżynie. Nastąpiło też zamknięcie Oceanu Mongolsko-Ochotskiego. Na obszarze Tetydy wschodniej nastąpiła kolizja płyt Lhasy i Birmy Zachodniej z Eurazją.

We wczesnej kredzie (Fig. 31–35) nastąpił dalszy spreding Atlantyku centralnego, jak również narodziny Atlantyku południowego i Oceanu Indyjskiego. Atlantyk zaczął się rozszerzać pomiędzy Iberią i Nową Funlandią, a następnie w kierunku Morza Labradorskiego i Zatoki Baffina. Otwieranie się Oceanu Arktycznego zostało zapoczątkowane we wczesnej kredzie w basenie kanadyjskim, po czym nastąpiło późnokredowe otwarcie basenu Makarowa.

Spreding i tworzenie się skorupy oceanicznej nastąpiły na obszarze pomiędzy Ameryką Południową i Afryką, a także pomiędzy Antarktyką i Indiami. Otwieranie nowych oceanów prowadziło do największego w fanerozoiku rozproszenia kontynentów.

W późnej kredzie (Fig. 36–40) Atlantyk rozszerzył się. Powstał Atlantyk równikowy, łączący Atlantyk centralny i południowy. Rozszerzył się też Ocean Indyjski, płyta Indii szybko dryfowała w kierunku północnym. Rozpoczął się również dryft Australii w kierunku północnym. Pojawiły się pierwsze deformacje kompresyjne w obszarze alpejskim i karpackim. Ocean Panthalassa przekształcił się w Pacyfik.

Platformy węglanowe istniały w okresie całego mezozoiku na obszarze Tetydy. Kontynentalne skały klastyczne przeważały na obszarach wewnętrznych kontynentów, jak również w ryftach w okresie triasu. Płytkowodne środowiska morskie z węglanowymi osadami klastycznymi przeważały w późnej jurze i kredzie.