Available online at www.sciencedirect.com
SCIENCE DIRECT®
Tectonophysics 381 (2004) 235–273
TECTONOPHYSICS
www.elsevier.com/locate/tecto

Plate tectonic evolution of the southern margin of Eurasia in the Mesozoic and Cenozoic

J. Golonka*

Institute of Geological Sciences, Jagiellonian University, ul. Oleandry Str. 2a, 30-063 Cracow, Poland

Received 10 April 2001; accepted 7 June 2002

Abstract

Thirteen time interval maps were constructed, which depict the Triassic to Neogene plate tectonic configuration, paleogeography and general lithofacies of the southern margin of Eurasia. The aim of this paper is to provide an outline of the geodynamic evolution and position of the major tectonic elements of the area within a global framework. The Hercynian Orogeny was completed by the collision of Gondwana and Laurussia, whereas the Tethys Ocean formed the embayment between the Eurasian and Gondwanian branches of Pangea. During Late Triassic–Early Jurassic times, several microplates were sutured to the Eurasian margin, closing the Paleotethys Ocean. A Jurassic–Cretaceous north-dipping subduction boundary was developed along this new continental margin south of the Pontides, Transcaucasus and Iranian plates. The subduction zone trench-pulling effect caused rifting, creating the back-arc basin of the Greater Caucasus–proto South Caspian Sea, which achieved its maximum width during the Late Cretaceous. In the western Tethys, separation of Eurasia from Gondwana resulted in the formation of the Ligurian–Penninic–Pieniny–Magura Ocean (Alpine Tethys) as an extension of Middle Atlantic system and a part of the Pangean breakup tectonic system. During Late Jurassic–Early Cretaceous times, the Outer Carpathian rift developed. The opening of the western Black Sea occurred by rifting and drifting of the western–central Pontides away from the Moesian and Scythian platforms of Eurasia during the Early Cretaceous–Cenomanian. The latest Cretaceous–Paleogene was the time of the closure of the Ligurian–Pieniny Ocean. Adria–Alcapa terranes continued their northward movement during Eocene–Early Miocene times. Their oblique collision with the North European plate led to the development of the accretionary wedge of the Outer Carpathians and its foreland basin. The formation of the West Carpathian thrusts was completed by the Miocene. The thrust front was still propagating eastwards in the eastern Carpathians.

During the Late Cretaceous, the Lesser Caucasus, Sanandaj–Sirjan and Makran plates were sutured to the Iranian–Afghanistan plates in the Caucasus–Caspian Sea area. A north-dipping subduction zone jumped during Paleogene to the Scythian–Turan Platform. The Shatski terrane moved northward, closing the Greater Caucasus Basin and opening the eastern Black Sea. The South Caspian underwent reorganization during Oligocene–Neogene times. The southwestern part of the South Caspian Basin was reopened, while the northwestern part was gradually reduced in size. The collision of India and the Lut plate with Eurasia caused the deformation of Central Asia and created a system of NW–SE wrench faults. The remnants of Jurassic–Cretaceous back-arc systems, oceanic and attenuated crust, as well as Tertiary oceanic and attenuated crust were locked between adjacent continental plates and orogenic systems.

Keywords: Eurasia; Tethys; Plate tectonics; Paleogeography; Mesozoic; Cenozoic

* Tel.: +48-12-266-4294; fax: +48-12-633-2270.
E-mail address: golonka@geos.ing.uj.edu.pl (J. Golonka).

0040-1951/$ - see front matter
doi:10.1016/j.tecto.2002.06.004

1. Introduction

Thirteen time interval maps depicting the Early Triassic through the Neogene plate tectonic configuration, paleogeography and lithofacies of the southern margin of Eurasia between Spain and China have been constructed. The aim of this paper is to provide an outline of the plate tectonic evolution and position of the major crustal elements of the area within a global framework and to show the relationship between the geodynamic evolution of the area and development of the components of basin systems. Therefore, the author has restricted the number of plates and terranes modeled, trying to utilize the existing information and degree of certainty. The author has tried to apply geometric and kinematic principles, using computer technology, to model interrelations between tectonic components along the Eurasian margin and in the surrounding areas. The attached black and white figures (Figs. 6–18) illustrate the plate tectonic evolution of the area. The selected color maps were included into a montage (Fig. 1), which depicts the various environments and lithofacies. The full set of color maps were included into a montage (Fig. 1), which depicts the various environments and lithofacies. The full set of color maps (Figs. 6b–18b) can be viewed in the online version of this paper in ScienceDirect.

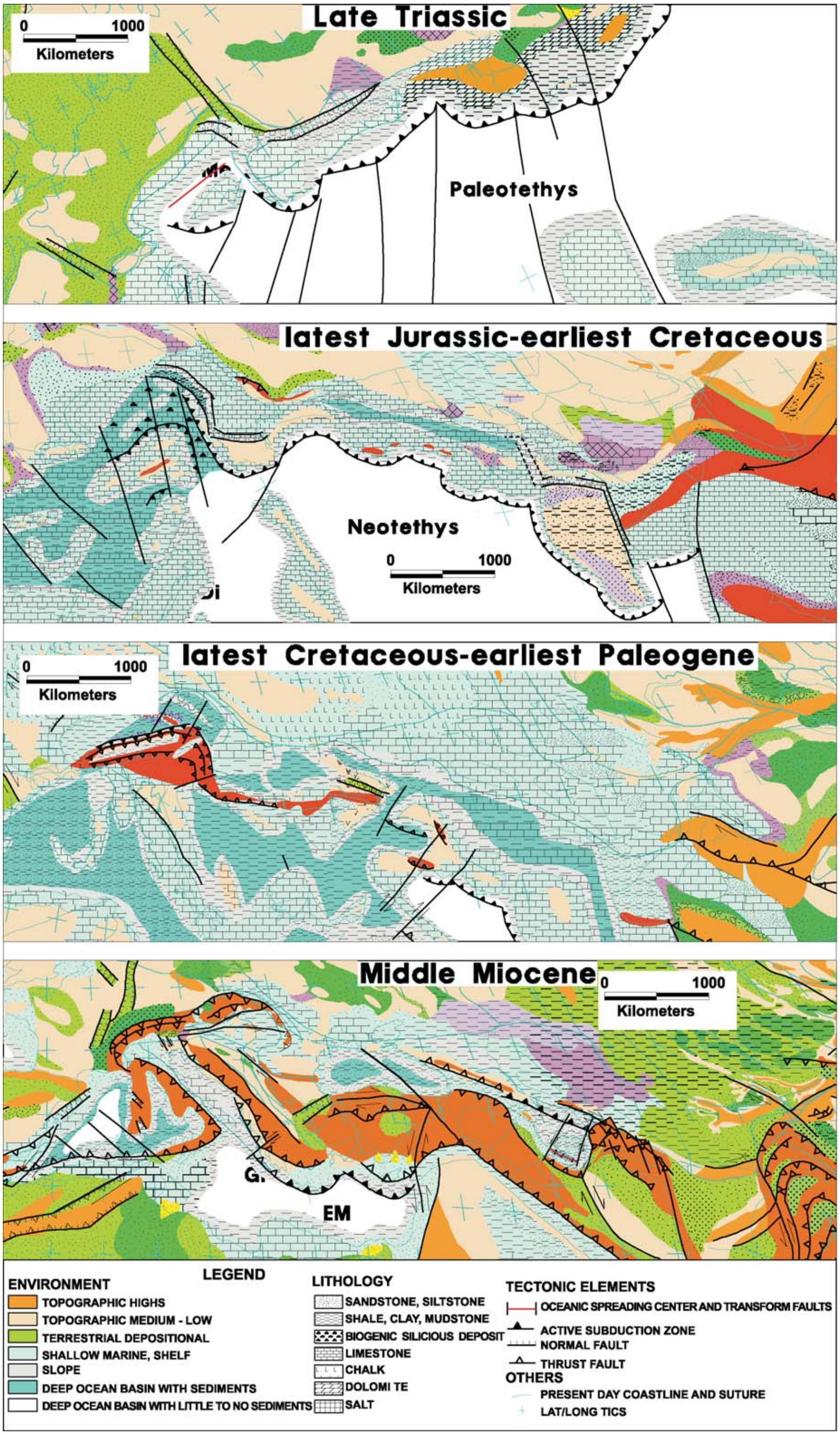
2. Mapping methodology

The time interval maps were constructed according to the following four steps:

1. Construction of base maps using a plate tectonic model. These maps depict plate boundaries (sutures), passive margins, transforms, ridges, plate position at the specific times and outlines of present day coastlines.
2. Review of existing global and regional paleogeographic maps.
3. Posting of generalized facies and paleoenvironment database information on base maps.
4. Interpretation and final assembly of computer map files.

They were constructed using a plate tectonic model that incorporates the relative motions between approximately 300 plates and terranes. This model was constructed using PLATES and PALEOMAP software (see Golonka et al., 1994, 2000; Golonka and Ford, 2000), which integrate computer graphics and data management technology with a highly structured and quantitative description of tectonic relationships. The heart of this program is the rotation file, which is constantly updated, as new paleomagnetic data become available. Hot-spot volcanics serve as reference points for the calculation of paleolongitudes (Golonka and Bocharova, 2000). Ophiolites and deep-water sediments mark paleo-oceans, which were subducted and included into foldbelts. Magnetic data have been used to define paleolatitudinal positions of continents and rotation of major plates (see, e.g., Westphal et al., 1984; Van der Voo, 1993; Besse and Courtillot, 1991; Bazhenov et al., 1991; Besse et al., 1996; Channell, 1996). An attempt has also been made to utilize the paleomagnetic date from minor plates and allochtonous terranes (see, e.g., Patrascu et al., 1992, 1993; Pechersky and Safronov, 1993; Thomas et al., 1993, 1994; Beck and Schermer, 1994; Channell et al., 1992, 1996; Mauritsch et al., 1995, 1996; Feinberg et al., 1996; Krs et al., 1996; Morris, 1996; Kondopolou et al., 1996; Piper et al., 1996; Márton and Martin, 1996; Márton et al., 1999, 2000; Haubold et al., 1999; Muttoni et al., 2000a,b; Grabowski, 2000). The nature of rotation indicated by paleomagnetism measured in sedimentary rocks in allochtonous terranes remains somewhat, sometimes highly, uncertain. It could be caused by the rotation of crustal (basement) elements, rotation of blocks separated by dextral faults (e.g., in Carpathians, Márton et al., 2000) or rotation of thrust sheets (e.g., in Italian Apennines, Muttoni et al., 2000b). Measurement in flysch deposits could also indicate the arrangement of magnetized grains (domains) by turbiditic currents. For example, the magnetic declination of Podhale Flysch in Poland is perhaps an depiction of the sedimentological arrangement of grains (see, e.g., Książkiewicz, 1962) changed by the crustal rotation of the Inner Carpathian plate to the present position. The crustal rotation in a

Fig. 1. Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia Montage of maps for Late Triassic, latest Jurassic–earliest Cretaceous, latest Cretaceous–earliest Paleogene and Middle Miocene. Abbreviations see Fig. 6.


Late Triassic
0 1000
Kilometers
Paleotethys
latest Jurassic-earliest Cretaceous
Neotethys
0 1000
Kilometers
latest Cretaceous-earliest Paleogene
0 1000
Kilometers
Middle Miocene
0 1000
Kilometers
G.
EM
LEGEND
ENVIRONMENT
TOPOGRAPHIC HIGHS
TOPOGRAPHIC MEDIUM - LOW
TERRESTRIAL DEPOSITIONAL
SHALLOW MARINE, SHELF
SLOPE
DEEP OCEAN BASIN WITH SEDIMENTS
DEEP OCEAN BASIN WITH LITTLE TO NO SEDIMENTS
LITHOLOGY
SANDSTONE, SILTSTONE
SHALE, CLAY, MUDSTONE
BIOGENIC SILICIOUS DEPOSIT
LIMESTONE
CHALK
DOLOMI TE
SALT
TECTONIC ELEMENTS
OCEANIC SPREADING CENTER AND TRANSFORM FAULTS
ACTIVE SUBDUCTION ZONE
NORMAL FAULT
THRUST FAULT
OTHERS
PRESENT DAY COASTLINE AND SUTURE
LAT/LONG TICS

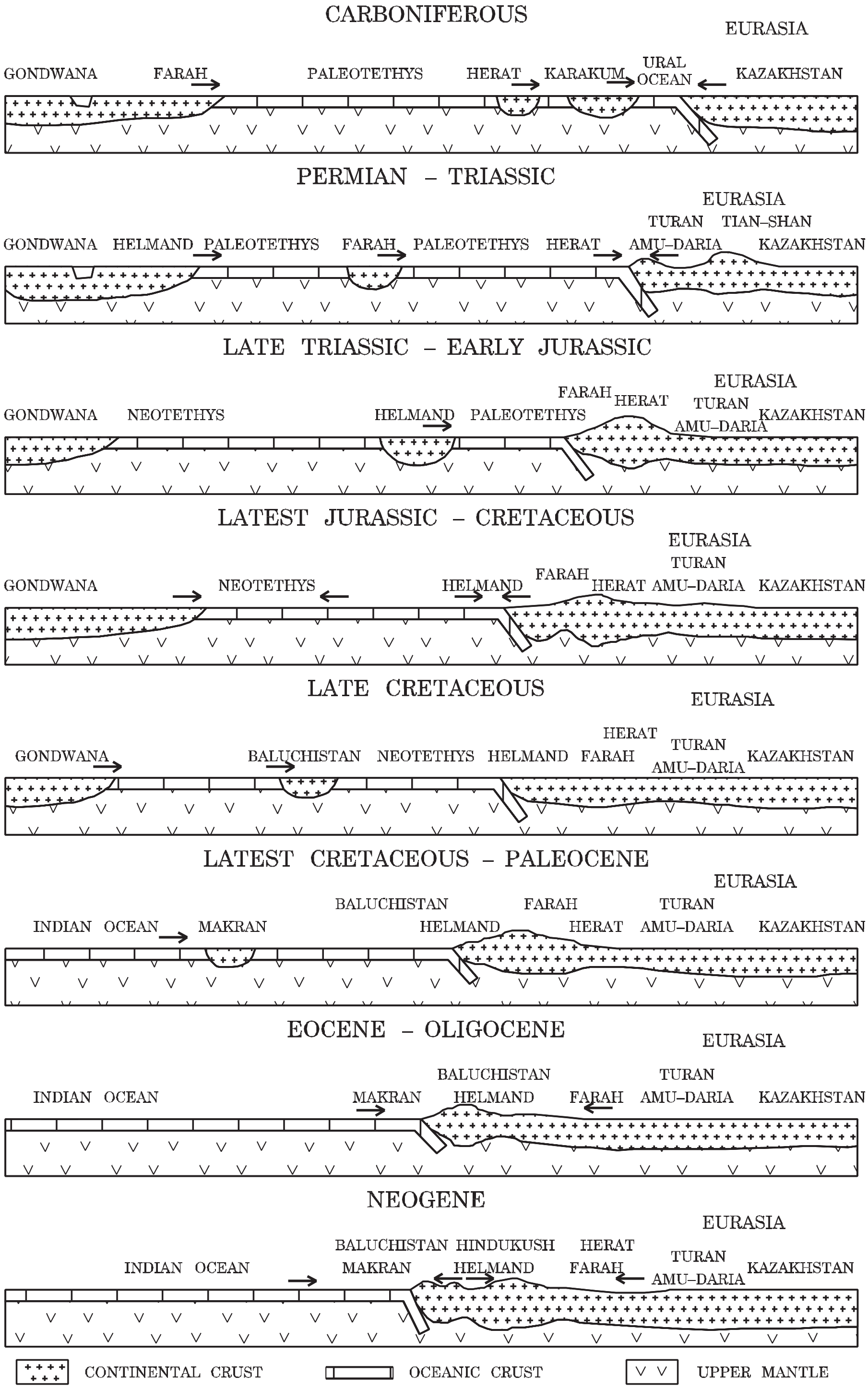


Fig. 2. Plate tectonic profiles. Indian Ocean–Afghanistan–Amu Daria–Kazakhstan.

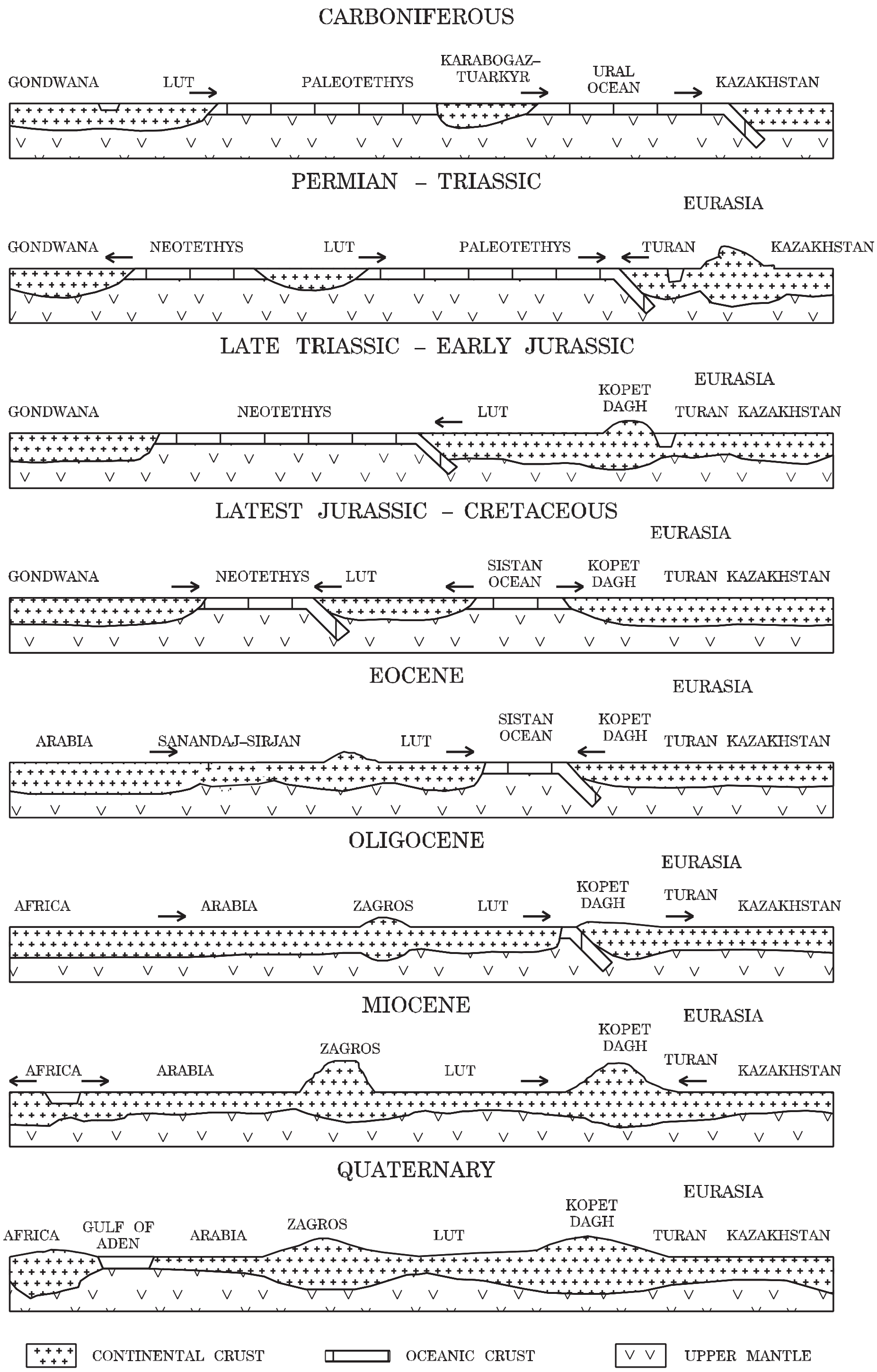


Fig. 3. Plate tectonic profiles. Indian Ocean – Afghanistan – Amu Daria – Kazakhstan.

range of 20–30° agrees with the general geodynamic evolution of the area (Golonka et al., 2000).

Information from several general and regional paleogeographic papers was assessed and utilized (e.g., Ronov et al., 1984, 1989; Vakhrameev, 1987; Vinogradov, 1968a,b; Alekseev et al., 1991; Institute of Tectonics of Lithospheric Plates, 1997; Dercourt et al., 1986, 1993, 2000; Davouzadeh and Schmidt, 1984; Ziegler, 1988, 1989; Robertson, 1998; Nikishin et al., 1996, 1998a,b, 2001; Sengör and Natalin, 1996; Stampfli, 2001; Stampfli et al., 1991, 1998, 2001; Kováč et al., 1998; Zonenshain et al., 1990; Popov et al., 1993; Plašienka, 1999; Neugebauer et al., 2001; Golonka, 2000a,b; Golonka and Ford, 2000; Golonka

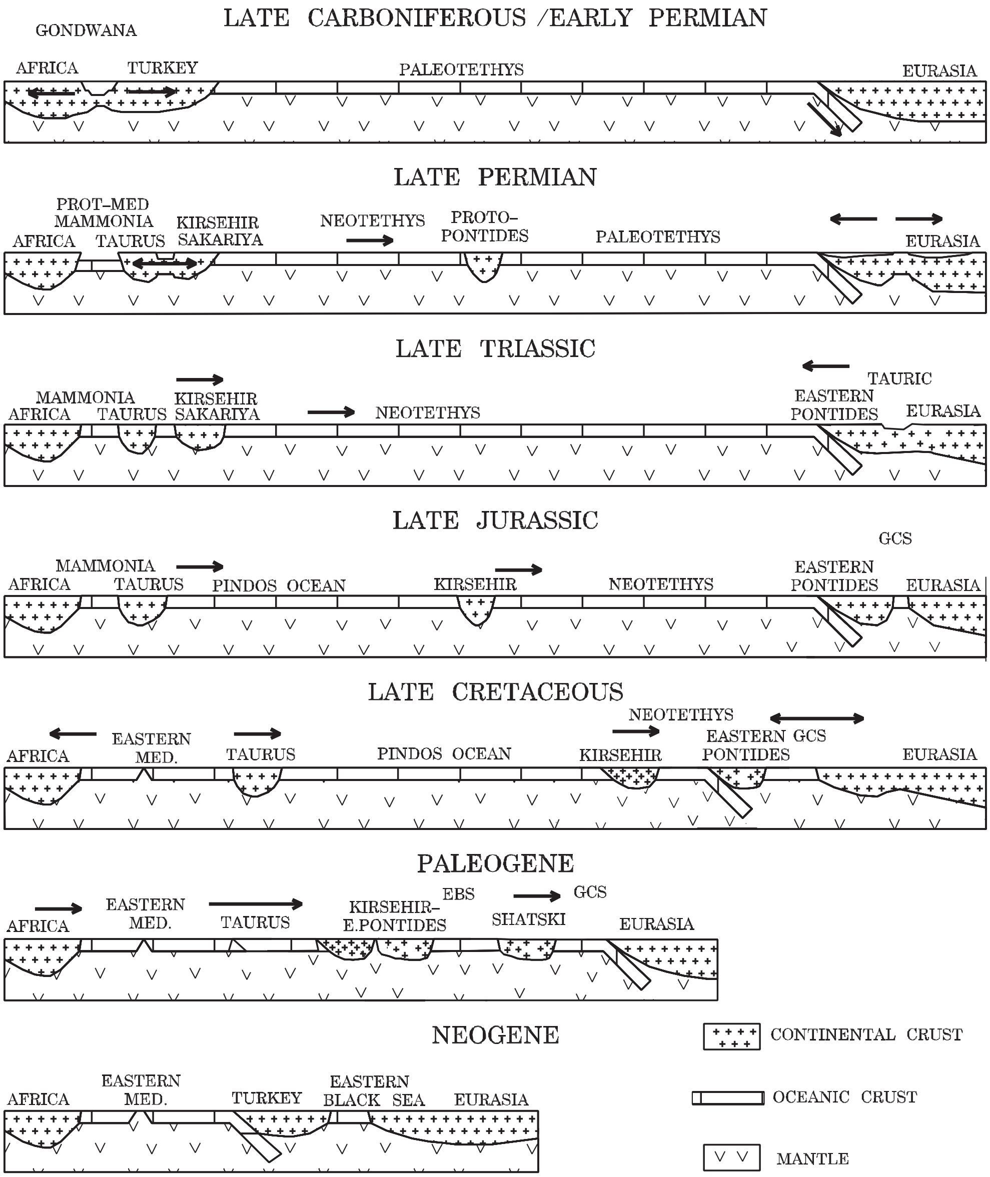


Fig. 4. Plate tectonic profiles. Africa–Eastern Mediterranean–Eastern Black Sea–Eurasia. Abbreviations: GCS—proto-Black Sea–Greater Caucasus–proto South Caspian Sea, EBS—Eastern Black Sea.

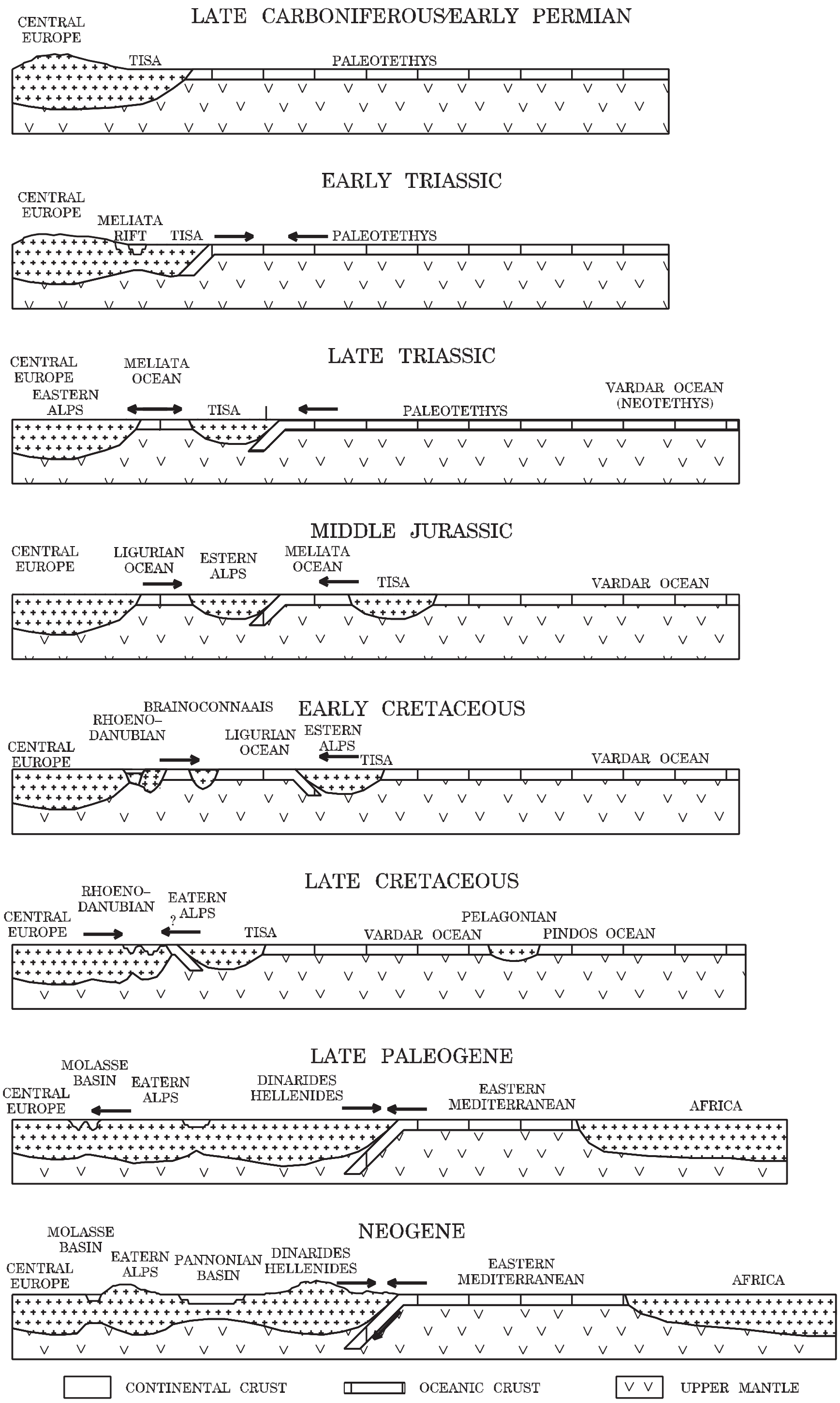


Fig. 5. Plate tectonic profiles. Central Europe–Greece–Eastern Mediterranean–Africa. Arabia–Caspian Sea.

et al., 2000; Brunet et al., 2003). The author also used unpublished maps and databases from the PALEOMAP group (University of Texas at Arlington), PLATES group (University of Texas at Austin), University of Chicago, Institute of Tectonics of Lithospheric Plates in Moscow, Robertson Research in Llandudno, Wales and the Cambridge Arctic Shelf Programme. The plate and terrane separation was based on the PALEOMAP system (see Scotese and Lanford, 1995), with modifications in the Tethys area (Golonka and Gahagan, 1997; Golonka et al., 2000). The calculated paleolatitudes and paleolongitudes were used to generate computer maps in the Microstation design format using the equal area Molweide projection.

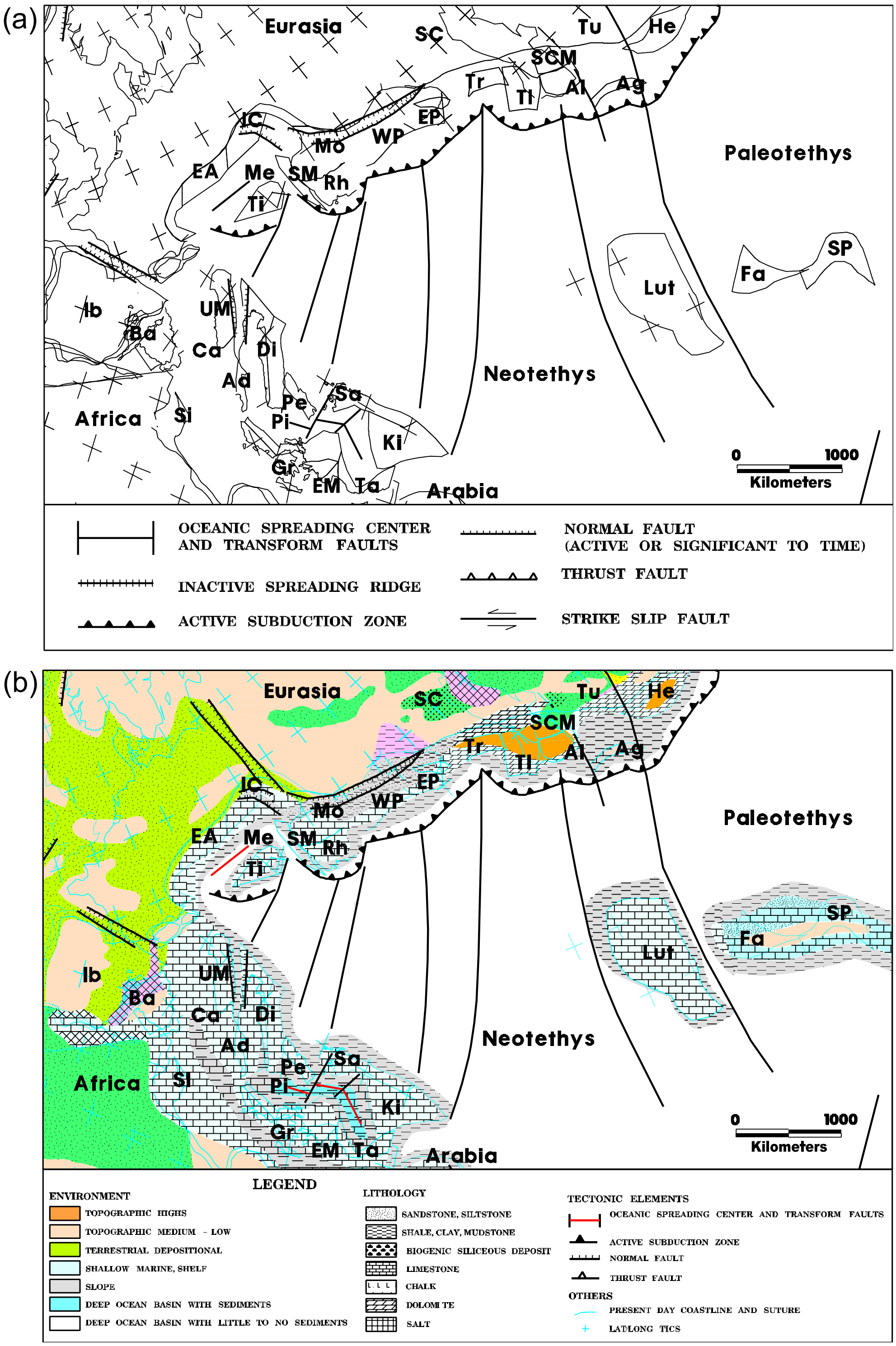
3. Paleogeographic maps: description and discussion

3.1. Permian–Triassic

Many of the continental collisions that occurred in the study area began in the Carboniferous and culminated in the Early Permian. A major part of Pangea was assembled, and a new supercontinent, ringed by subduction zones, moved steadily northwards. The formation of Laurasia reached its main phase during the suturing of Kazakhstan and Siberia with Laurussia (Nikishin et al., 1996; Zonenshain et al., 1990; Ziegler, 1989). The Paleotethys Ocean (Sengör and Natalin, 1996) was situated between the Laurussian (North America, Baltica and Siberia) and Gondwanian (Africa, Arabia, Lut and other Iranian terranes) branches of Pangea (Figs. 2–4). The collision between Gondwana and Laurussia developed the central Pangean mountain range, which extended from Mexico to Poland. Southwards, the mountain system extended to Morocco (Pique, 1989). The Ouachita and Appalachian mountains in North America, Mauretanides in Africa, and Hercynian mountains in Europe and northern Africa (Ziegler, 1989; Golonka, 2000b) form part of this Pangean mountain range. Late Carboniferous events were also marked in the Alps, Carpathians (Vozárová and Vozár, 1992; Dallmeyer et al., 1996; Gawęda et al., 1998; Rakús et al., 1998; Sãndulescu and Visarion, 2000; Kovács et al., 2000; Stampfli, 2001), Italy (Lustrino, 2000) and Rhodopes (Yanev, 1992). The Pontides terranes had also likely been sutured to Eurasia before the Permian (Ustaömer and Robertson, 1997). According to Okay et al. (1996), the western Pontides Paleozoic sequence was folded and possibly thrust-faulted during Late Carboniferous–Permian times. Mountains formed on the northern margin of the Paleotethys, as a result of these events, and were connected with the Hercynian orogen in Europe.

The Calcareous Alps and the Inner Carpathians formed the marginal platform of Western and Central Europe (Fig. 5), while the Scythian–Turan Platform formed the margin of Eastern Europe and Central Asia (Fig. 6). The Scythian–Turan Platform is a name used

Fig. 6. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Late Triassic; plates' positions at 225 Ma. Abbreviations of oceans and plates names for this Figs. 6–18: Ab—Alboran, Ad—Adria (Apulia), Ag—Aghdarband (southern Kopet Dagh), Al—Alborz, Ba—Balearic, Ca—Calabria–Campania, Di—Dinarides, EA—Eastern Alps, EM—Eastern Mediterranean, EP—Eastern Pontides, Fa—Farah, GC—Greater Caucasus, Gr—Greece, He—Herat, Hm—Helmand, Ib—Iberia, IC—Inner Carpathians, Kb—Kabylids, KD—Kopet Dagh, Ki—Kirsehir, La—Ladakh, LC—Lesser Caucasus, Lh—Lhasa, Li—Ligurian (Piemont) Ocean, Ma—Makran, Me—Meliata, Mo—Moesia, NC—North China, NP—North Pamir, OC—Outer Carpathians, PB—Pieniny Klippen Belt Ocean, Pe—Pelagonian plate, Pi—Pindos Ocean, Qa—Qantang, Rh—Rhodopes, Sa—Sakarya, SC—Scythian, SCM—South Caspian microcontinent, Sh—Shatski Rise, Sl—Sicily, SM—Serbo–Macedonian, SP—South Pamir, SS—Sanandaj–Sirjan, SWC—South Western/Kura Caspian Basin, Ta—Taurus terrane, Ti—Tisa, Tl—Talysh, Tm—Tarim, Tr—Transcaucasus, Tu—Turan, UM—Umbria—Marche, WP—Western Pontides, Wt—West Turkmen/Caspian Basin. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Late Triassic; plates position at 225 Ma. Abbreviations of oceans and plates names for (b) and 6 Figs. 7–18: Ab—Alboran, Ad—Adria (Apulia), Ag—Aghdarband (southern Kopet Dagh), Al—Alborz, Ba—Balearic, Ca—Calabria—Campania, Di—Dinarides, EA—Eastern Alps, EM—Eastern Mediterranean, EP—Eastern Pontides, Fa—Farah, GC—Greater Caucasus, Gr—Greece, He—Herat, Hm—Helmand, Ib—Iberia, IC—Inner Carpathians, Kb—Kabylids, KD—Kopet Dagh, Ki—Kirsehir, La—Ladakh, LC—Lesser Caucasus, Lh—Lhasa, Li—Ligurian (Piemont) Ocean, Ma—Makran, Me—Meliata, Mo—Moesia, NC—North China, NP—North Pamir, OC—Outer Carpathians, PB—Pieniny Klippen Belt Ocean, Pe—Pelagonian plate, Pi—Pindos Ocean, Qa—Qantang, Rh—Rhodopes, Sa—Sakarya, SC—Scythian, SCM—South Caspian microcontinent, Sh—Shatski Rise, Sl—Sicily, SM—Serbo–Macedonian, SP—South Pamir, SS—Sanandaj–Sirjan, SWC—South Western/Kura Caspian Basin, Ta—Taurus terrane, Ti—Tisa, Tl—Talysh, Tm—Tarim, Tr—Transcaucasus, Tu—Turan, UM—Umbria–Marche, WP—Western Pontides, Wt—West Turkmen/Caspian Basin.


(a)
Eurasia
SC
Tu
He
SCM
Tr
Tl
Al
Ag
IC
EP
Mo
WP
EA
Me
SM
Rh
Ti
Paleotethys
SP
Fa
Lut
Ib
Ba
UM
Ca
Di
Ad
Sa
Pe
Pi
Africa
Si
Ki
Gr
EM
Ta
Arabia
Neotethys
0 1000
Kilometers
OCEANIC SPREADING CENTER AND TRANSFORM FAULTS
INACTIVE SPREADING RIDGE
ACTIVE SUBDUCTION ZONE
NORMAL FAULT (ACTIVE OR SIGNIFICANT TO TIME)
THRUST FAULT
STRIKE SLIP FAULT
(b)
LEGEND
ENVIRONMENT
TOPOGRAPHIC HIGHS
TOPOGRAPHIC MEDIUM - LOW
TERRESTRIAL DEPOSITIONAL
SHALLOW MARINE, SHELF
SLOPE
DEEP OCEAN BASIN WITH SEDIMENTS
DEEP OCEAN BASIN WITH LITTLE TO NO SEDIMENTS
LITHOLOGY
SANDSTONE, SILTSTONE
SHALE, CLAY, MUDSTONE
BIOGENIC SILICEOUS DEPOSIT
LIMESTONE
CHALK
DOLOMITE
SALT
TECTONIC ELEMENTS
OCEANIC SPREADING CENTER AND TRANSFORM FAULTS
ACTIVE SUBDUCTION ZONE
NORMAL FAULT
THRUST FAULT
OTHERS
PRESENT DAY COASTLINE AND SUTURE
LAT/LONG TICS

by CIS geoscientists to describe the margin of Eurasia between Romania and Afghanistan thought to be formed as result of Late Paleozoic Hercynian and Uralian Orogenies. The North Caspian (Peri–Caspian) Basin constitutes a boundary between the Scythian and Turan parts of the platform (e.g., Zonenshain et al., 1990).

A north-dipping subduction system developed along the Paleotethys margin (Fig. 6). This subduction system played a major role in driving the Late Paleozoic and Early Mesozoic movement of plates in this area. It caused Triassic back-arc rifting in the proto-Black Sea area and along the margins of Scythian–Turan Platform (Zonenshain et al., 1990; Kazmin, 1990, 1991; Nikishin et al., 1998a,b). The Tauric Basin was formed between the Pontides and the Dobrogea–Crimea segment of the Scythian Platform. The Meliata Ocean (Figs. 5 and 6), between the Eurasian margin and the Hungarian Tisa block (Kázmer and Kovács, 1989; Kozur, 1991; Plašienka and Kováč, 1999; Stampfli, 1996, 2001), was geodynamically related to this event. Rifting and fragmentation of separated blocks continued to progress (Ricou, 1996; Golonka and Gahagan, 1997; Golonka et al., 2000). At the same time, the passive margin was formed along the Gondwanian arm of Pangea. The Neotethys Ocean (Fig. 3) originated during the Permian as a result of the Carboniferous–earliest Permian rifting of the Cimmerian plates (see Dercourt et al., 1993; Golonka et al., 1994; Sengör and Natalin, 1996). This ocean had Arabia, Greater India and Australia on one side, and Lut–Farah–South Pamir–Qiantang–Southeast Asia on the other. The spreading was driven by trench-pulling forces, related to the north-dipping subduction, as well as the ridge-pushing forces, related to mantle upwelling, expressed by hot spot activity (Golonka and Bocharova, 2000). The continued northward drift of the Cimmerian continent and the opening of the Neotethys Ocean corresponded with the closing and progressive consumption of Paleotethys oceanic crust.

Rifting and formation of an oceanic type of basin could also have occurred in the Mediterranean, as indicated by the deep water sediments of Sicily (Catalano et al., 1991; Kozur, 1991) Lago Negro (Marsella et al., 1993) and Crete (Kozur and Krahl, 1987), as well as by the Mamonia ophiolites complex in Cyprus (Robertson and Woodcock, 1979; Morris, 1996; Robertson, 1998). The oceanic system was established in Southern and Central Europe during Permian–Triassic times. 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. Its northernmost part was possibly separated from the Umbria–Marche region by a rift. The incipient Pindos Ocean separated the Pelagonian, Sakariya and Kirsehir block from the Ionian–Taurus Platform (Robertson et al., 1991, 1996; Stampfli et al., 1991). The Vardar–Transilvanian Ocean separated the Tisa (Bihor–Apuseni) block from the Moesian–Eastern European Platform (Sãndulescu, 1988; Sãndulescu and Visarion, 2000). There is a possibility of the existence of an embayment of the Vardar–Transilvanian oceanic zone between the Inner Carpathians and the European Platform (Golonka et al., 2000). The exotic material of the Triassic pelagic spotty limestones, which occur as pebbles within Cretaceous–Paleogene gravelstones in the Pieniny Klippen Belt (from the enigmatic so-called Exotic Andrusov Ridge—Birkenmajer, 1988; Birkenmajer et al., 1990) and Magura Unit (Soták, 1986) could have originated in this embayment. The embayment position and its relation to the other parts of the Tethys, Vardar Ocean, Meliata–Halstatt Ocean, Dobrogea rift and Polish–Danish Aulacogen remain quite speculative. According to Rakús et al. (1998), two oceanic units were located south of the Inner Carpathian plate. One was open during the Triassic and closed during the Late Triassic as a result of Early Cimmerian collision. Another, represented by sequences at the classic profile of Meliata in southern Slovakia, opened during the Early–Middle Jurassic as a back-arc basin and closed during the Late Jurassic. The position of the Meliata Ocean, the time of closing and the role of the Tisa unit in the Mesozoic collisional events is still the subject of considerable debate (see Kozur, 1991; Kozur and Mock, 1997; Stampfli, 1996, 2001; Mello, 1996; Rakús et al., 1998; Plašienka, 1999; Hovorka and Spišiak, 1998; Golonka et al., 2000; Wortmann et al., 2001). In the author's opinion, the Meliata–Halstatt Ocean (Kozur, 1991; Kiessling et al., 1999; Golonka et al., 2000) separated the Tisa–Bihor block and the Eurasian margin. The northern Calcareous Alps and

Inner Carpathians formed the marginal platform of Europe (Plašienka and Kováč, 1999).

The most significant Triassic convergent event was the Indosinian Orogeny causing the consolidation of Chinese blocks. According to Yin and Nie (1996), the Late Triassic (220–208 Ma) was the time of collision of South Chinese and North Chinese plates and a generation of sutures and mountain belts in this area. Also, Indochina and Indonesia were sutured to South China and the Qiantang block approached the Eurasian margin (Fig. 7).

In the western Tethys area, Late Triassic collisional events followed an Early–Middle Triassic period of development of basins of back-arc type. Several blocks of the Cimmerian provenance (Sengör, 1984; Sengör and Natalin, 1996) collided with the Eurasian margin in the so-called Early Cimmerian Orogeny. Alborz and the South Caspian Microcontinent collided with the Scythian Platform (Nikishin et al., 1998a,b) at an earlier time (Carnian), while the Serbo–Macedonian block collided with the Moesia–Rhodopes (Tari et al., 1997). The Lut, Farah and South Pamir blocks collided with the Turan Platform during a later phase (Zonenshain et al., 1990; Kazmin, 1990, 1997). The collision of these microplates with the southern margin of Eastern Europe and Central Asia resulted in compressional events which are recorded by major deformations of Permian–Triassic deposits, the formation of the Mangyshlak and Badkhyz–Karabil fold zones (Zonenshain et al., 1990; Gaetani et al., 1998), and the general uplift of the Fore–Caucasus, Caucasus, and Middle Asia regions (Nikishin et al., 1998a,b; Dercourt et al., 2000). The compressional events were recorded in the Southern Kopet Dagh (Aghdarband) area in northwestern Iran (Baud and Stampfli, 1991; Lyberis and Manby, 1999), in the Herat area in Afghanistan and in the Pamir Mountains (Zonenshain et al., 1990) between the CIS, Afghanistan and western China (Tarim). In the northern Carpathians, the Late Triassic–Early Jurassic events are marked by an uplift of the Inner Carpathian plate. In the Late Triassic, shallowing of the basin took place (Kotański, 1961; Mahel et al., 1968) accompanied by deposition of neritic and lagoonal sediments of co-called Carpathian Keuper. Hiatuses were also common in this area, for example in the Czerwone Wierchy facies. Upper Triassic and Lower Jurassic deposits are absent. The Middle Jurassic Bajocian or Bathonian deposits transgressed Middle Triassic limestones (Mahel et al., 1968). In the Javorinska Široka facies, the Upper Dogger beds transgressed the Keuper or the Middle Triassic.

After the collision of the Chinese plates, as well as the Transcaucasus, Alborz and Lut plates in the central Tethyan area, a new northward-dipping subduction zone developed along the northern margin of the Neotethys, south of the accreted continent. Extensive volcanism occurred along this zone.

3.2. Early–Middle Jurassic

The Paleotethys Ocean was closed in the western part of the Tethyan realm in the Early Jurassic (Fig. 7). Subduction developed along the newly formed margin of Neotethys. The north-dipping subduction pulling force led to rifting of a new set of terranes from the passive Gondwanian margin (Golonka, 2000b). At this time, the Lhasa plate (Yin and Nie, 1996; Ricou, 1996; Sengör, 1984; Sengör and Natalin, 1996; Dercourt et al., 1993; Metcalfe, 1994) drifted away from Gondwana. The Neotethys Ocean was divided into northern and southern branches between Tibet and India.

In the western Tethyan realm the Neotethys was subducting under the western part of the Scythian–Turan Platform. The Pindos Ocean to the south (Robertson et al., 1991, 1996) was named after the Pindos Mountains in Greece. It was spreading between the Gondwanian margin and a series of microplates (Figs. 4, 7 and 8). The Pelagonian plate, Kirsehir and Sakarya (Robertson et al., 1991, 1996), and perhaps the Lesser–Caucasus–Sanandaj–Sirjan plates (Adamia, 1991; Golonka et al., 2000) were drifting northeastward. The plates' positions and their relation to the Apulia–Taurus Platform (Dercourt et al., 1993, 2000) remain uncertain.

The Ligurian Ocean, as well as the central Atlantic and Penninic Ocean (Dercourt et al., 1986, 1993; Channell, 1996), were opening during the Early–Middle Jurassic (Figs. 5 and 8). The oldest oceanic crust in the Ligurian–Piedmont Ocean was dated as young as Middle Jurassic in the southern Apennines and in the western Alps by Ricou (1996). Bill et al. (2001) dated the onset of oceanic spreading of the Alpine Tethys by isotopic methods as Bajocian.

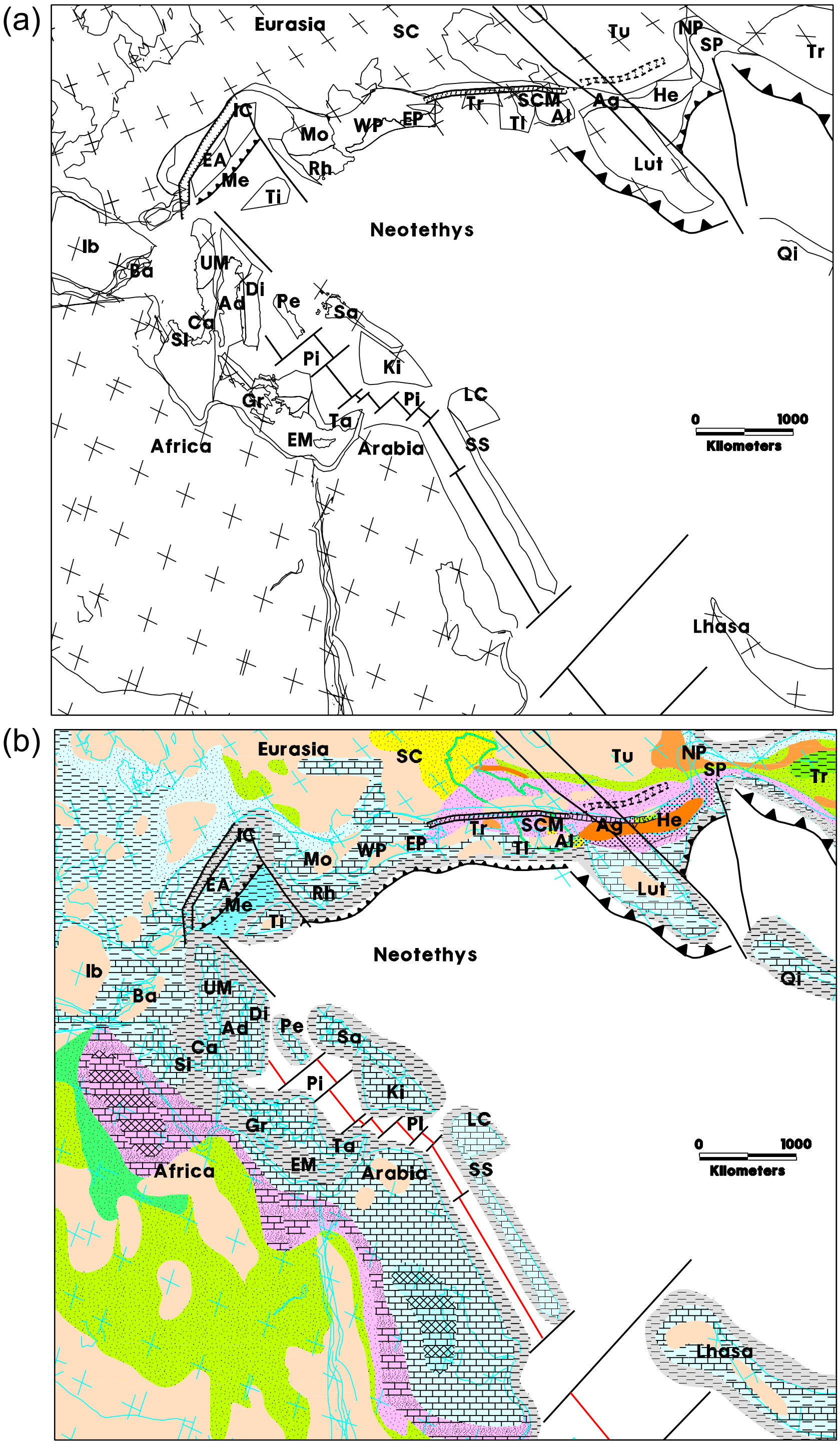


Fig. 7. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Early Jurassic; plates' positions at 195 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Early Jurassic; plates position at 195 Ma. Legend and abbreviations—see Fig. 6b.

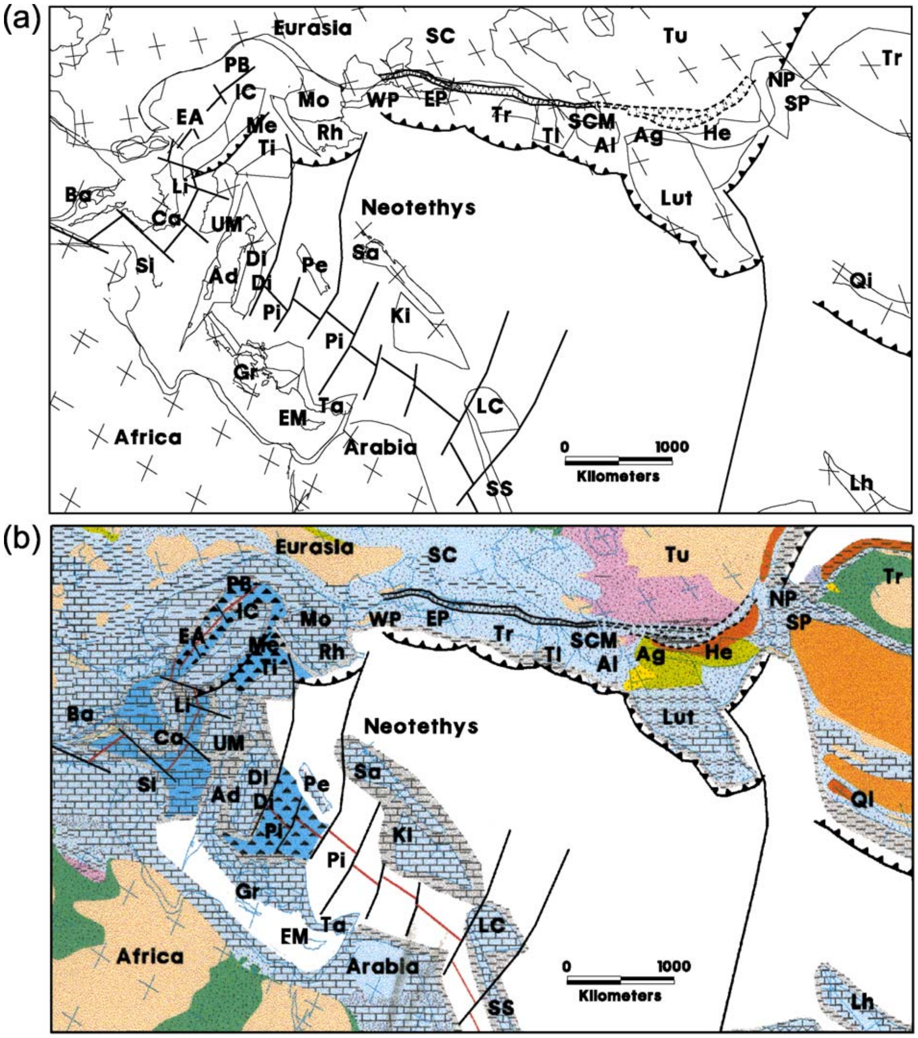


Fig. 8. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Middle Jurassic; plates' positions at 166 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Middle Jurassic; plates position at 166 Ma. Legend and abbreviations—see Fig. 6b.

According to Winkler and Ślączka (1994), the Pieniny data fit well with the supposed opening of the Ligurian–Penninic Ocean. The Central Atlantic was in an advanced drifting stage during the Middle–Late Jurassic (Withjack et al., 1998). Rifting continued in the North Sea and in the northern Proto–Atlantic between Norway and Greenland (Ziegler, 1988; Doré, 1991). The progressive breakup of Pangea resulted in a system of spreading axes, transform faults, and rifts, which connected the ocean floor spreading in the Central Atlantic and Ligurian Sea, to rifting which continued through to the Polish–Danish graben, Mid-Norway and to the Barents Sea (Golonka, 2000b). Tethys was connected with the Polish–Danish graben (Żytko, 1984, 1985) by a transform fault and rift system which preceded the opening of the Outer Carpathian basins.

The Alpine Tethys, that is Ligurian, Penninic and Pieniny Klippen Belt/Magura Oceans, constitute the extension of the central Atlantic system. Stampfli (2001) recently postulated a single Penninic Ocean separating Apulia (Adria) and eastern Alps blocks from Eurasia. The author proposed a similar model for the Pieniny Klippen Belt Basin in the Carpathians. The orientation of the Pieniny–Magura Ocean was SW–NE (see discussion in Golonka and Krobicki, 2001; Aubrecht and Túnyi, 2001). The Pieniny Ocean was divided into the northwestern and southeastern basins by the Czorsztyn Ridge. The deepest parts of both basins are recorded by deep water, extremely condensed, Jurassic–Early Cretaceous pelagic limestones and radiolarites. The shallowest ridge sequences are known as the Czorsztyn succession. In this succession, the Early Jurassic *Posidonia* marls are followed by Middle Jurassic–earliest Cretaceous crinoidal and nodular limestones and Late Cretaceous Ammonitico Rosso and marly facies. The transitional slope sequences between the deepest basinal units and ridge units consist of mixed cherty, limestone and marly facies. Detailed study of the basinal facies (Golonka and Sikora, 1981) revealed an enormous condensation of Nannoconus limestones and radiolarites. The Upper Jurassic–Lower Cretaceous profiles do not exceed more than a dozen or so meters. In extreme cases only two meters were deposited during a time span of 50 myr. Similar conditions could be expected in the other areas of the Tethyan realm, for example in the Caucasus, and, especially in the proto-South Caspian Basin. Profiles of this kind could be easily overlooked in the complicated tectonic setting of the klippen belt. This Jurassic ocean was connected with an older, Triassic embayment of the Vardar–Transilvanian Ocean. A junction of the Tethyan and Atlantic–Ligurian–Penninic–Pieniny Klippen Belt–Magura Ocean existed perhaps in the eastern Slovakian–Ukrainian Carpathians and is represented by the Inačovce–Krichevo unit (Soták et al., 2000).

After a phase of Late Triassic–Early Jurassic compression, a rifting regime was re-established within the Scythian–Turan Platform between the eastern Black Sea and western Turkmenia and continued through to Middle Jurassic times. Most of the former rift systems that had developed during the Late Permian–Triassic were reactivated and new rift systems originated. In the western and central part of the platform, Early–Middle Jurassic rifting was primarily concentrated in the Greater Caucasus Basin. Rifting influenced the Indol–Kuban Basin somewhat and the Terek–Caspian trough developed as a subsidiary rift of the Greater Caucasus rift system (Adamia, 1991; Sobornov, 1994). In the eastern part of the Scythian–Turan Platform, the Early–Middle Jurassic rifting influenced the Amu-Dar'ya and Afghan–Tadjik regions (Clarke, 1994).

In the Middle Jurassic, the Pontides plates (north Turkey) collided with the southern margin of Eurasia, closing the Triassic rift and back-arc system of basins and causing deformations in Crimea and adjacent areas (Zonenshain et al., 1990; Yilmaz et al., 1997). A compressional phase has also been postulated for the Greater Caucasus area at the Aalenian–Bajocian boundary and during the Bathonian (Panov and Guschin, 1987; Koronovsky et al., 1987; Nikishin et al., 1998b). It is not quite clear, whether the Middle Jurassic Caucasus deformations are a result of a collisional event or are related to rifting shoulder uplift. This problem requires further investigation. Compression also took place in Bulgaria (Sengör and Natalin, 1996; Banks and Robinson, 1997). In the Carpathian and eastern Alpine areas, the Meliata–Halstatt Ocean began to narrow (Fig. 5). Subduction polarity is a matter of controversy like many other Meliata issues (see discussion above). Golonka et al. (2000) postulated a northwestward direction of subduction of Meliata oceanic crust under the Inner Carpathian and eastern Alpine plates, related to the southwestward movement of the Carpathian–Alpine plates during the well documented opening of the Alpine Tethys. The movement was accompanied by the Inner Carpathian uplift mentioned above. The postulated Meliata subduction direction also agrees with the general northward subduction under the Eurasian plate in the eastern part of Tethys (e.g., Ricou, 1996; Sengör and Natalin, 1996; Dercourt et al., 2000; Neugebauer et al., 2001). The southward subduction was postulated by Kozur (1991) and followers (e.g., Kozur and Mock, 1997; Hovorka and Spišiak, 1998; Plašienka and Kováč, 1999; Wortmann et al., 2001). This was based on the uplift along the southern margin of Meliata recognized from facies observations. Subduction occurring on the both sides of the Meliata Ocean cannot be excluded.

The central Atlantic was in an advanced drifting stage during the Middle Jurassic (Withjack et al., 1998). The Ligurian Ocean was opening simultaneously with the central Atlantic, the Penninic Ocean and the Pieniny Klippen Belt Ocean (Dercourt et al., 1993; Channell, 1996; Golonka et al., 2000). The

Inner Carpathian block and the eastern Alps were moving away from Europe and, at the same time, Apulia was moving together with Africa (Channell, 1996). A major Jurassic seaway was opened (Ricou, 1996), connecting the Gulf of Mexico and central American area with Southern Europe and the Tethyan branch of the Pacific Ocean. Advanced seafloor spreading occurred between the Gondwanian margin and the Helmand and Lhasa blocks (Golonka, 2000b). Spreading continued between the Arabian–Tauric margin and the Pelagonian, Kirsehir, Sakariya and Sanandaj–Sirjan blocks (Robertson et al., 1991, 1996; Adamia, 1991; Golonka et al., 2000).

3.3. Late Jurassic–Early Cretaceous

During the Late Jurassic (Fig. 9), the Lhasa block converged with Asia (Ricou, 1996). According to Metcalfe (1994), the collision of Lhasa and Qiantang took place along the Banggong suture, approximately at the Jurassic–Cretaceous boundary. The collision of the Helmand block (Afghanistan) with the Turan Platform and Farah–South Pamir plates took place at about the same time (Otto et al., 1997; Golonka, 2000b). According to Kazmin (1989, 1991), the Helmand block was attached to Eurasia along the Varash suture. The northern branch of the Neotethys between Iran and South China—or Mesotethys of Kazmin (1989)—was closed. In the Alpine–Carpathian area in Europe, the subduction of the Meliata–Halstatt Ocean and the collision of the Tisa block with the Inner Carpathian terranes was completed at this time (Froitzheim et al., 1996; Dallmeyer et al., 1996; Plašienka, 1999). The Ligurian–Pieniny reached its maximum width in the latest Jurassic and then stopped spreading (Golonka et al., 1996, 2000). Subduction jumped to the northern margin of the Inner Carpathian terranes and began to consume the Pieniny Klippen Belt Ocean (Birkenmajer, 1986; Golonka et al., 2000). In the western Alpine area in Europe, the movement of the Briançonnais terrane during the Early Cretaceous initiated the closure of the Ligurian Ocean (Stampfli, 1993, 1996), which then entered into its compressional phase (Marchant and Stampfli, 1997).

The Tethyan plate reorganization resulted in extensive fault movement. Several tectonic horsts and grabens were formed, rejuvenating some older, Eo- and Meso-Cimmerian faults. Initial stages of subduction of the oceanic crust of the Pieniny Klippen Belt, under the northern, active margin of the Inner Carpathian plate, may have been related to these movements (Birkenmajer, 1986; Krobicki, 1996). Latest Jurassic blueschists 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 (Fayrad, 1997). Detailed explanations of this problem have been described by Golonka and Krobicki (2001).

The southern part of the North European Platform, north from the Pieniny/Magura realm, began to be rifted. The Outer Carpathian rift (Silesian Basin) had developed with the onset of calcareous flysch sedimentation. The earliest phase of the teschenites extensional volcanism connected with the rifting may have occurred at this time (Książkiewicz, 1977a,b; Narębski, 1990). The rifted fragment of the European Platform separated the Silesian Basin and Pieniny Klippen Belt–Magura Ocean. This fragment is known as the Silesian Ridge (Cordillera). It is known in the Polish Outer Carpathians from exotic rocks only (Książkiewicz, 1962; Burtan et al., 1984), representing Cadomian–Hercynian crystalline basement and Late Paleozoic, Mesozoic and Paleogene sedimentary rocks, mainly carbonates. The western Carpathian Silesian Basin probably extended into the eastern Carpathian Sinaia or "black flysch" Basin and to the southern Carpathian Severin zone (Sãndulescu, 1988; Kräutner, 1996; Kräutner and Krstić, 2001). The Jurassic separation of the Bucovino–Getic microplate from the European plate is perhaps related to this extension. Rifting developed in the Balkan area (Bulgaria), between Moesia and Rhodopes (Tchoumatchenko and Sapunov, 1994). Jurassic extension in the Vardar–Balcanic area preceded flysch sedimentation, during the Tithonian and Early Cretaceous (Bokov and Ognyanov, 1991).

In the area south of the Rhodopes in southeastern Europe, subduction was characterized by northward polarity (Shanov et al., 1992). A northward-dipping subduction system also existed along the southern margin of Eurasia (Fig. 10), between Bulgaria and Lhasa (Ricou, 1996; Kazmin, 1991; Sengör and Natalin, 1996). There is also a possibility that this subduction system continued into the eastern Carpa-

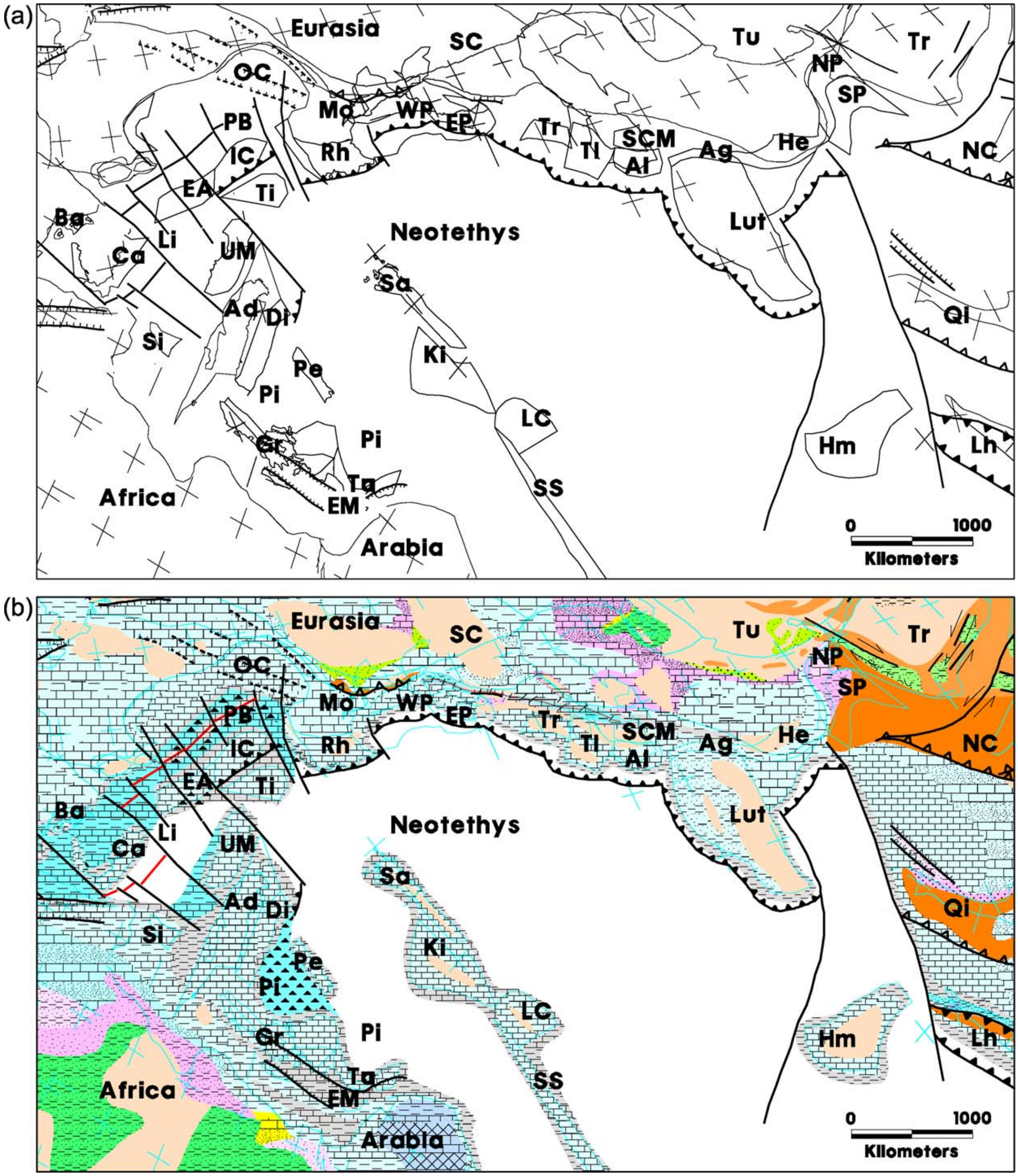


Fig. 9. (a) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Late Jurassic; plates' positions at 152 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Late Jurassic; plates position at 152 Ma. Legend and abbreviations—see Fig. 6b.

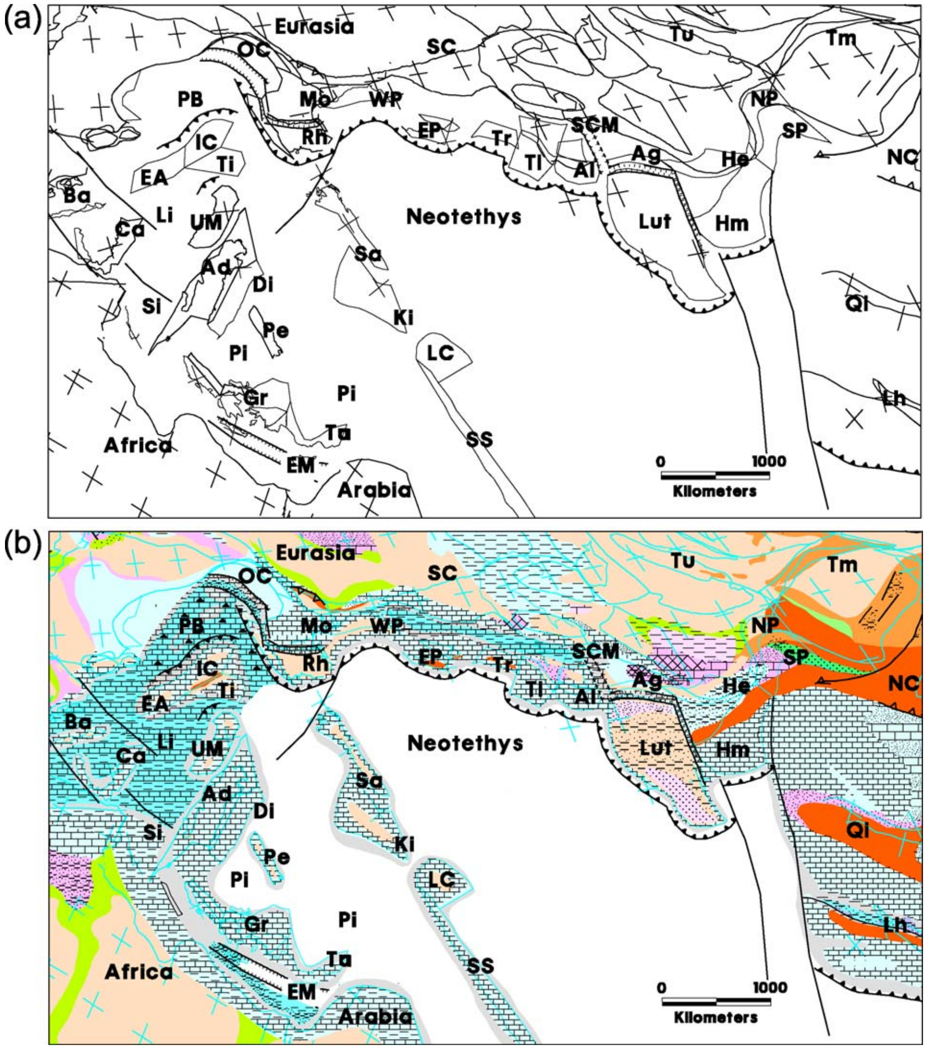


Fig. 10. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during latest Late Jurassic–earliest Lower Cretaceous; plates' positions at 140 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during latest Late Jurassic–earliest Lower Cretaceous; plates position at 140 Ma. Legend and abbreviations—see Fig. 6b.

thian Area, as indicated by volcanic activity (Lashkevitsch et al., 1995).

The Turan Platform underwent a general uplift in Kimmeridgian–Tithonian times, related to the collision of the south-central Afghanistan (Helmand) and Qantang microcontinents with the southern edge of Eurasia (Fig. 3). This uplift is well recorded by facies changes (Vinogradov, 1968a; Kazmin, 1989; Institute of Tectonics of Lithospheric Plates, 1997; Clarke, 1994). Regression of the Jurassic sea during the Kimmeridgian–Tithonian times was manifested by evaporite sedimentation over the uplifted (no deposition) southern margin of the Scythian–Turan Platform. The Gaurdak evaporite formation within the Murghab and Afghan–Tadjik basins reaches a thickness of more than 1000 m. South of this marginal basin in the Afghanistan Farah area Barremian carbonates and Aptian–Albian red beds overlapped with strong angular unconformity a Late Jurassic–Neocomian volcano-sedimentary sequence (Kazmin, 1991). The subduction trench pulling effect, along the southern margin of East Pontides, Transcaucasus, Talysh and Alborz plates formed the Greater Caucasus–Proto Caspian back-arc basin (Fig. 4), underlain by oceanic crust (Rezanov and Chamo, 1969; Zonenshain and Le Pichon, 1986; Zonenshain et al., 1990; Bazhenov et al., 1991; Nadirov et al., 1997).

During Tithonian–Berriasian times, rifting commenced along the northern and eastern margins of the Lut block (Fig. 3). This rifting was followed by sea-floor spreading during the Barremian–Hauterivian as well as formation, by the Albian, of the Sistan Ocean. This ocean is known from ophiolites in northern Iran (Ricou, 1996; Sengör and Natalin, 1996). Perhaps all the intra-Iranian basins were opened at this time (Dercourt et al., 1986).

In the Alpine–Carpathian area, the Rhenodanubian and Outer Carpathian troughs were opened on oceanic and attenuated continental crust during the Early Cretaceous (Figs. 5 and 11) (Winkler and Ślączka,

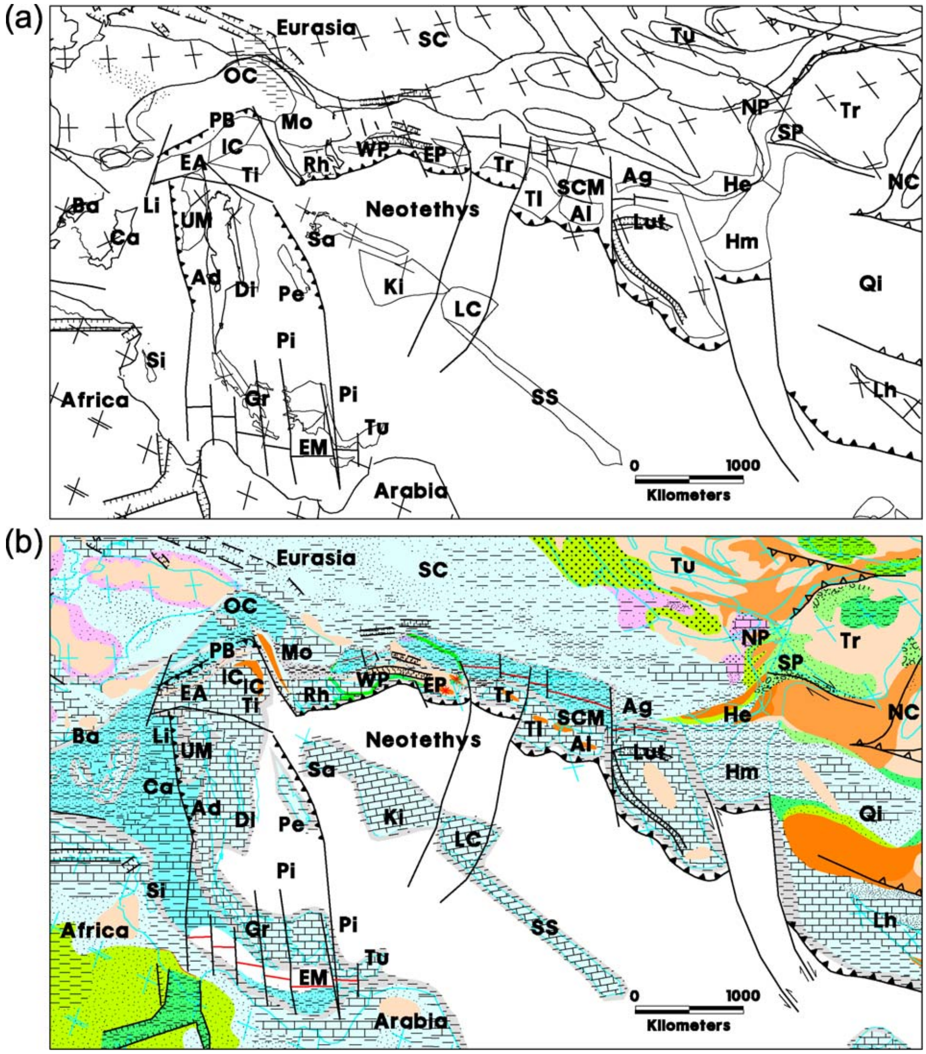


Fig. 11. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia area during latest Upper Aptian–Middle Cenomanian; plates' positions at 112 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the circum-Caspian area during latest Upper Aptian–Middle Cenomanian; plates position at 112 Ma. Legend and abbreviations—see Fig. 6b.

1994; Ślączka, 1996; Golonka et al., 2000). To the west, these troughs extended into the Valais ocean, in which a seafloor spreading phase began (Marchant and Stampfli, 1997; Froitzheim et al., 1996), as well as further into the area between Spain and France and to the Biscay Bay (Stampfli, 1993, 1996). To the east, the trough 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. Traditionally, the Magura Unit is included into the Outer Carpathian realm. However, during Jurassic–Early Cretaceous times the Magura Basin belonged to the Penninic–Pieniny Klippen Belt (Golonka et al., 2000). These two basins show quite different styles of development during the Early Cretaceous: the Pieniny–Magura Basin was closing while Outer Carpathian Basin was opening.

Spreading in the Silesian Basin was accompanied by the main phase of intrusion of teschenites, which occurred during the Hauterivian–Barremian (Lucińska-Anczkiewicz et al., 2000). These intrusions display the features of oceanic islands and were perhaps generated by hot spot activity. It appears as though there were two hot spots in the Carpathian region. The first one, in the western Carpathians, was connected with the Jurassic Żegocina andesites and Early Cretaceous teschenites. Today, western Turkey and northern Aegean volcanics are located at the same latitude and longitude. The second hot spot, in the eastern Carpathians, was connected with the Jurassic andesitic tuffites and Early Cretaceous diabase-melaphyre. Today, the Levantine (e.g., Dead Sea) hot spot volcanics are located at the same latitude and longitude (Burke and Wilson, 1976; Vogt, 1981; Stefanic and Jurdy, 1984; Matyska, 1989; Zonenshain et al., 1991). Golonka and Bocharova (2000) argue for hot spot stability since the end of the Paleozoic. The issue nevertheless remains quite controversial and requires further investigation. The Outer Carpathian Basin reached its greatest width during the Hauterivian–Aptian. With the widening of the basin, several subbasins (troughs) began to show their distinctive features. These subbasins, such as the Silesian, Sub-Silesian, Skole, Dukla and Tarcău, were separated by local uplifts such as the Andrychów zone (Książkiewicz, 1960). The connection of Silesian Basin with Sinaia and the southern Carpathian Severin areas (Săndulescu, 1988) suggests a NW–SE orientation for the basinal axis.

During the Aptian–Albian (Fig. 11), complex tectonics began to take place in the area of the future Alpine belt zone, between Southern Europe and North Africa/Arabia. The Ligurian–Penninic Ocean already entered into its compressional phase during the Hauterivian (Marchant and Stampfli, 1997; Stampfli et al., 1998). South-dipping subduction was active on the southern margin of the Penninic–Pieniny Basin (Birkenmajer, 1986; Golonka et al., 2000). This closure was marked by collisional deformation in the Alps (Froitzheim et al., 1996), the formation of eclogites in Austroalpine units and the earliest Alpine nappes. Thrusting and shortening also occurred in the Inner Carpathians (Plašienka, 1999). Consumption of the Penninic–Pieniny led to the development of an accretionary prism in front of the moving northward and northwestward eastern Alpine and Inner Carpathian plates. In the Albian, synorogenic flysch developed in the Pieniny–Magura Basin (Golonka and Sikora, 1981). The Rhenodanubian flysch could also be related to the formation of the Cretaceous accretionary prism. In the eastern Carpathians the compressional movement started during the Aptian and Albian and the inner part of the Carpathians was folded and thrusted. In front of moving nappes, coarse-grained sediments and olistostromes developed (Săndulescu, 1988).

3.4. Late Cretaceous

The opening of the South Atlantic Ocean occurred in tandem with the drift and counterclockwise rotation of Africa. The Arabian margin of the African–Arabian plate moved northeastwards during the Cretaceous and the western Neotethys narrowed (Fig. 12). The northeastward movement of India led to the narrowing of the eastern Neotethys (Golonka et al., 1994). This reversed the geotectonic process. After reaching the maximum dispersion phase, the continents began to slowly assemble in a new configuration.

The tectonic regime between the Arabian margin and the Sanandaj–Sirjan plate changed from passive to convergent (Ricou, 1996; Sengör and Natalin, 1996; Guiraud and Bellion, 1996). A north-dipping subduction zone under the Sanandaj–Sirjan plate is

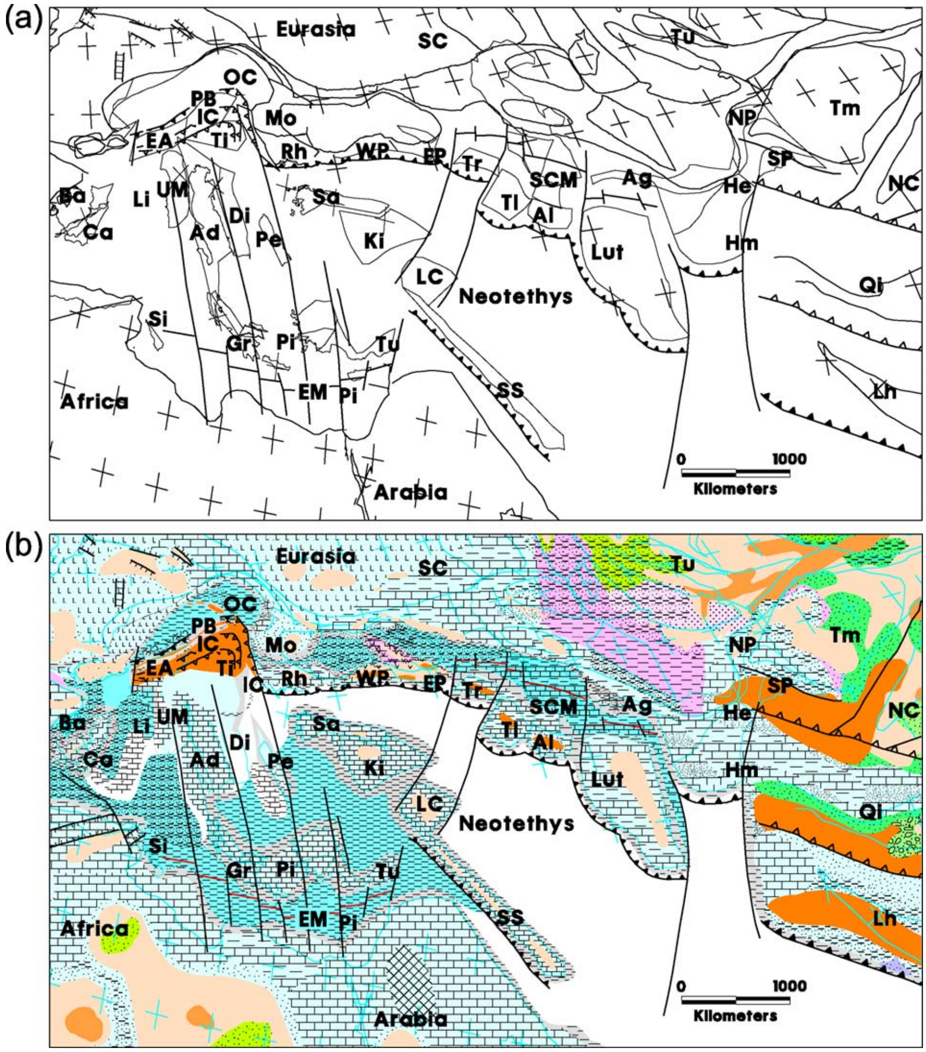


Fig. 12. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Late Cenomanian – Middle Campanian; plates' positions at 90 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Late Cenomanian – Middle Campanian; plates position at 90 Ma. Legend and abbreviations—see Fig. 6b.

marked on the Cenomanian – Middle Campanian map (Fig. 12). It is also possible it had been active since the Jurassic time. The small Kohistan plate collided with Eurasia (Sengör and Natalin, 1996). The rotation of Africa and renewed spreading in the eastern Mediterranean caused the Apulian plate to converge with Europe. The tectonic evolution of the eastern Mediterranean area is a subject of longstanding debate, summarized by Robertson (1998) whose views the author shares. Robertson depicts two phases of oceanic spreading in this area, each marked by a separate ophiolitic complex in Cyprus (Robertson and Woodcock, 1979; Morris, 1996; Robertson, 1998; Garzanti et al., 2000). The first of these, of Permo – Triassic age, was mentioned above. The second, Cretaceous, phase (Dercourt et al., 1984, 1986, 1993) is recorded by Troodos ophiolites and is related to the development of a carbonate platform and volcanism on the Levantine margin (Neev et al., 1976; Cohen et al., 1990; Hirsch et al., 1995; Keeley, 1994). Since continuous spreading from the Triassic (or even Permian) is not very likely (Robertson, 1998), rifting has been indicated on Late Jurassic and Early Cretaceous maps (Figs. 9 and 10) followed by subsequent spreading on the Albian–Cenomanian and Late Cretaceous maps (Fig. 11).

Spreading continued in the Greater Caucasus–proto-Caspian Ocean (Zonenshain and Le Pichon, 1986, Golonka, 2000a) at the beginning of the Late Cretaceous (Fig. 4). According to Nikishin et al. (2001), basaltic intrusives of possibly Albian to Turonian age 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 (cf. Lomize, 1969; Lordkipanidze, 1980; Chaitsky and Shelkoplyas, 1986; Milanovsky, 1991; Koronovsky et al., 1997). Presumably extensional tectonics in the Great Caucasus lasted until at least the Middle Santonian, 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. Subduction-related volcanic arcs separated these basins from the Neotethys. Opening was related to the continued northward subduction of the Neotethys. The Greater Caucasus–Proto-Caspian Ocean was connected with the Sistan Ocean (Golonka, 2000a,b), which separated Lut from Afghanistan and the Kopet-Dagh area (Fig. 3). While the presence of Jurassic deposits in the South Caspian Basin is speculative, Cretaceous sediments are clearly present in the eastern part of the basin and could be extrapolated towards the central part (Brunet et al., 2003). They have also been recognized in mud volcanoes. Moreover, Caspian oils contain elements indicating an origin from Cretaceous source rocks (Abrams and Narimanov, 1997; Guliyev et al., 2001). Indeed, Sengör (1990) proposed the Late Cretaceous as the time of the pull apart opening of the South Caspian Basin.

Africa was moving northwards, closing the gap between its northern margin and the Taurus plate, leading to the Campanian cessation of spreading in the East Mediterranean (Ricou, 1996; Sengör and Natalin, 1996). During Late Cretaceous–Paleocene times (Fig. 13), the Kirsehir and Sakarya plates collided with the Pontides (Yilmaz et al., 1997). This collision closed the northern branch of the Neotethys. The Lesser Caucasus approached the Transcaucasus and Talysh areas. At the end of the Cretaceous or in the Paleogene, the Lesser Caucasus and perhaps Sanandaj–Sirjan and Makran plates were sutured to Transcaucasus–Talysh–Southern Caspian–Lut system (Knipper and Sokolov, 1974; Adamia, 1991; Golonka, 2000a). According to Brunet et al. (2002), the subduction zone below the Lesser Caucasus was locked by the end of the Cretaceous, after the Coniacian obduction of ophiolites in the Sevan–Akera zone (Knipper et al., 2001). Subduction jumped to the Scythian–Turan margin. During the Late Cretaceous, obduction occurred on the northeastern margins of the Arabian plate. This obduction was caused by the convergence of the Sanandaj–Sirjan with the Arabian plate (Ricou, 1996; Guiraud and Bellion, 1996; Robertson and Searle, 1990). The exotic rocks of the Oman ophiolitic nappes reflect different stages of evolution of the Tethyan Ocean and its branches from the Permian until the Cretaceous (Pillevuit et al., 1997). Ophiolites were also obducted in Turkey and emplaced on the Taurus block (Sengör and Natalin, 1996). Oceanic basins between Taurus and Kirsehir remained open.

A compressional event in the Inner Carpathians, which began during the Albian, ended in the Late Turonian. A complicated nappe structure formed as a consequence (Rakús et al., 1998; Plašienka, 1999). Along with the development of the Inner Carpathian nappes, a fore-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.

3.5. Paleocene–Eocene

The Adria (Apulia) plate, together with the eastern Alpine (Austroalpine) and Inner Carpathian blocks, was moving continuously northwards during the Paleogene (Fig. 14). Collision with the European plate began in the Alps at about 47 Ma (Decker and Peresson, 1996). The latest Cretaceous–earliest Paleocene was the time of the closure of the Pieniny Klippen Belt Ocean and the collision of the Inner Carpathians terranes with the Czorsztyn Ridge in the Carpathians (Golonka and Sikora, 1981; Birkenmajer, 1986; Win-

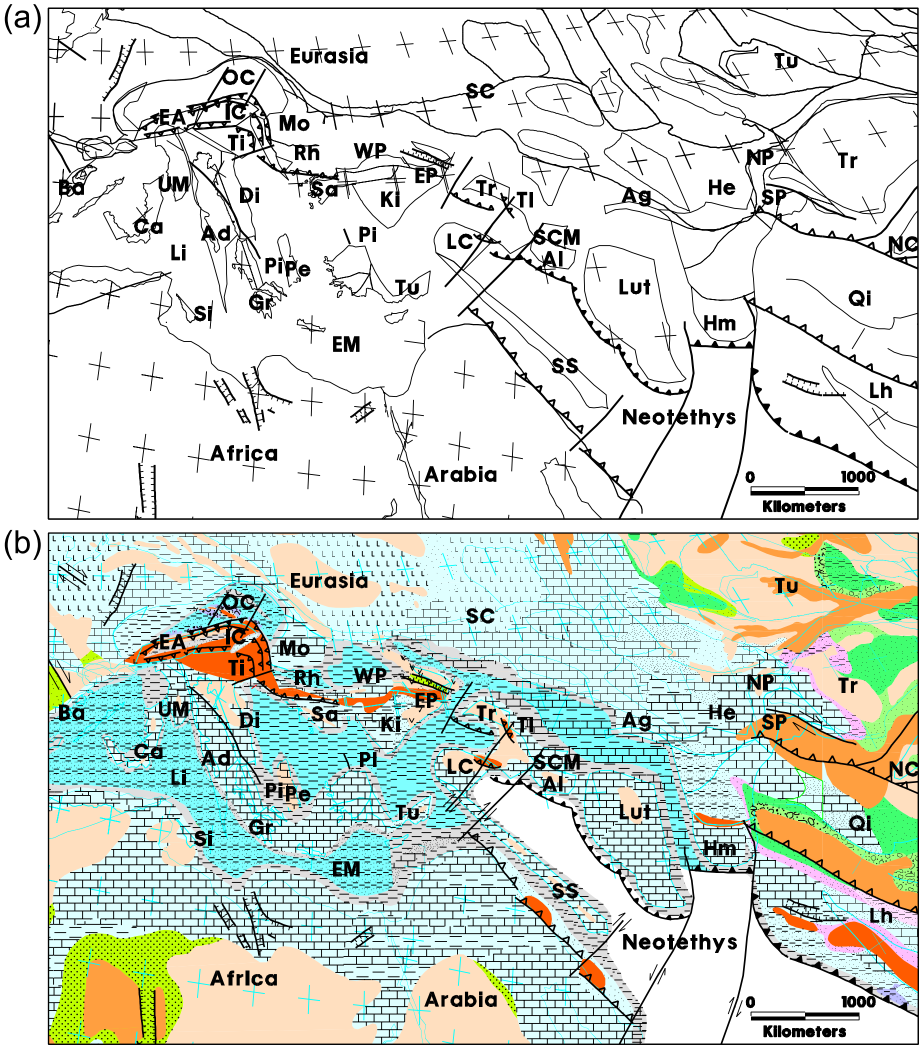


Fig. 13. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Late Campanian–Early Paleocene; plates' positions at 65 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Late Campanian–Early Paleocene; plates position at 65 Ma. Legend and abbreviations—see Fig. 6b.

kler and Ślączka, 1992; Golonka et al., 2000). Primary shortening events in the Balkans occurred in Bulgaria (Sinclair et al., 1997). The Vardar Ocean was closed during Paleocene time (Fig. 5) (Sengör and Natalin, 1996). The Valais Ocean in the Alps finally closed (Froitzheim et al., 1996; Stampfli, 1996). According to Plašienka and Kovač (1999), the Alcapa block was formed at this time by the welding together of the eastern Alps, Inner Carpathian and Tisa as well as smaller terranes, such as the Bükk, Transdanubian or Getic. The main phase of compression and formation of the thrust belt of the Balkanides in Bulgaria occurred during the Eocene (Tari et al., 1997; Sinclair et al., 1997). Closure of the Pieniny Klippen Belt Ocean in the Carpathians also concluded and the Pieniny domain accreted to the Magura Basin (Birkenmajer, 1986; Winkler and Ślączka, 1994). The folding of the Rheno–Danubian zone occurred in the Late Eocene.

Perhaps prior to the Paleocene, the Lesser Caucasus and Sanandaj–Sirjan and Makran plates were sutured

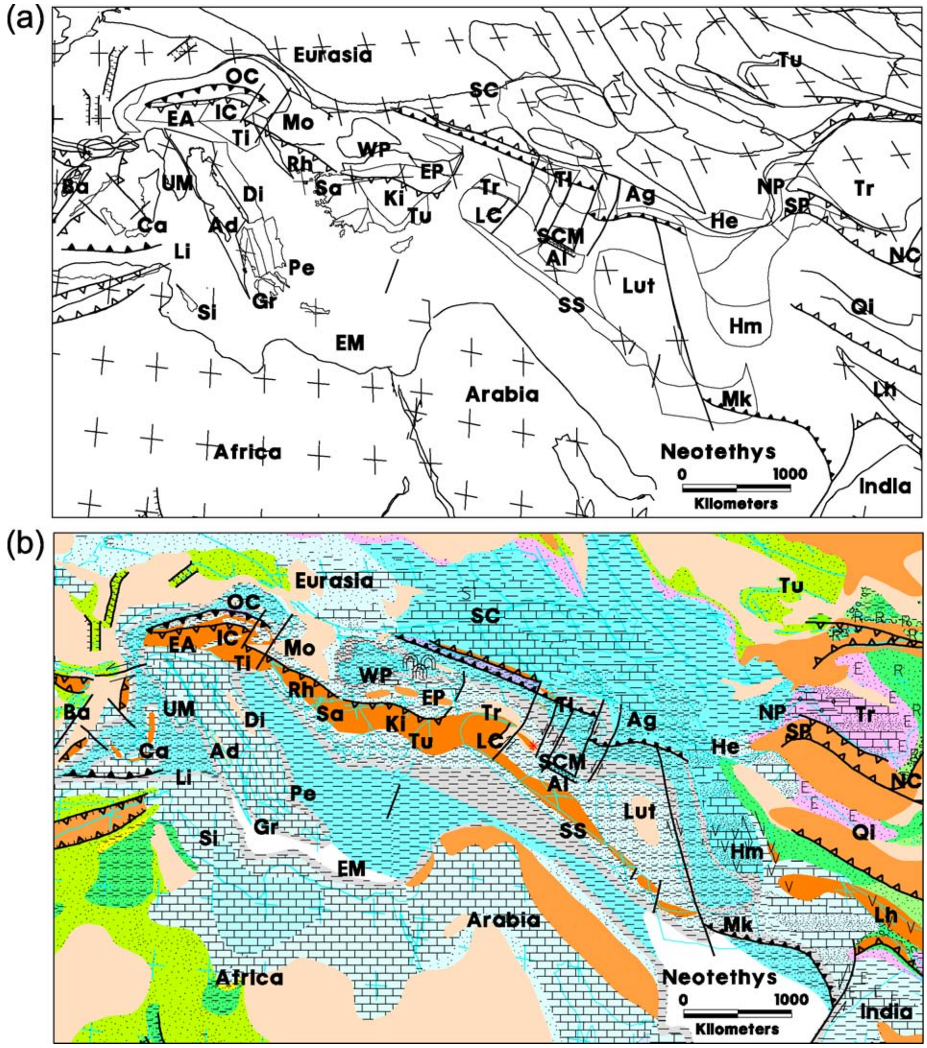


Fig. 14. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Lutetian–Bartonian; plates' positions at 45 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Lutetian–Bartonian; plates position at 45 Ma. Legend and abbreviations—see Fig. 6b.

to the Transcaucasus–Talysh system (Fig. 14). The closure of the Mesozoic Great Caucasus–South Caspian Basin began at this time. The author (see Golonka, 2000a,b; Golonka et al., 2000) attributes this closure to the influence of large plates—Arabian and Lut plates—as well as the development of a subduction zone along the northern margin of the basin. The western segment of this subduction was located along the northern margin of the eastern Black Sea, on the Greater Caucasus area and south off of the Apsheron Peninsula and ridge. A major transform fault system in the western Turkmenistan Basin area separated the eastern and western segments of the subduction complex. This fault system is buried deeply below Neogene sediments of the West Turkmen Basin. The eastern segment of the subduction complex was located along the South Kopet Dagh margin, approximately 200–300 km south of the Apsheron ridge (Fig. 3).

The opening of new Paleogene basins proceeded at the expense of oceanic basins of Mesozoic age.

Some authors (e.g., Robinson et al., 1996; Okay et al., 1996) have suggested that the opening of the East Black Sea Basin was connected with the simultaneous closure of the Great Caucasus Basin. Kazmin (1997) shows on his Maastrichtian map the northward movement of the Shatski rise during the opening of the East Black Sea Basin. The timing of the events is somewhat speculative. Perhaps the Jurassic–Cretaceous oceanic crust of the Greater Caucasus Basin was subducted under the overriding Scythian plate between the latest Cretaceous and the Late Eocene at the same time as the opening of East Black Sea Basin (Fig. 3). The East Black Sea Basin continues eastward to the Ajaro-Trialet and the Talysh basins (Adamia et al., 1974; Shcherba, 1994; Kazmin, 1997; Banks et al., 1997). In the Talysh Basin in southern Azerbaijan, a thick volcanoclastic series with basalts, trachy-basalts, trachy-andesites and andesites is succeeded by flysch with olistostromes. Altogether Paleogene sediments reach a thickness of 10 km (Ali-Zade et al., 1996; Gasanov, 1992, 1996; Brunet et al., 2003). Vincent et al. (2002) link Talysh extension with major extension and ocean spreading within the adjacent South Caspian Basin. Kazmin (1991, 1997) also proposed the Eocene, while Berberian and Berberian (1981), Abrams and Narimanov (1997), and Boulin (1991) proposed the Paleogene as the time of the opening of the South Caspian Basin.

The author has marked a subduction zone on all Paleogene and Neogene maps (Figs. 14–18). The timing of subduction, the role of the trench pulling force, as well as of movement initiation and movement velocity is speculative and is different for different plates. This difference led to the development of several major SW–NE trending strike slip faults, which cut both continental and Jurassic–Cretaceous oceanic crust (Jackson, 1992; Kopp, 1997; Golonka, 2000a). The most important ones are the Araks fault, which separates the Lesser Caucasus block and Transcaucasus block from the Talysh plate, and the Lahijan fault within the Alborz Maintains. The extension of the Lahijan fault, which separated the South Caspian Microcontinent from the Southwest Caspian Basin, is buried deeply below Neogene sediments of the South Caspian Basin, but can be recognized on the deep seismic lines (12 s TWT) as well as on gravity maps.

Beginning in the Eocene, the southeastern part of Turan Plate and the adjacent Afghanistan area was strongly affected by the India–Eurasia collision. The onset of the collision of India with Asia occurred near the Paleocene–Eocene boundary (Gaetani and Garzanti, 1991). According to Searle (1996), this collision may have been diachronous, occurring earlier in northern Pakistan (60 Ma), then in Ladakh–southern Tibet. Metamorphism and crustal thickening reached a peak at about 40 Ma in northern Pakistan, later propagating southwards (Searle, 1996). Oceanic subduction ceased beneath the Indian–Eurasian collision zone. To the south, the Arabian plate slowly converged with Eurasia closing the remnants of the Pindos Ocean along the Sanandaj–Sirjan margin (Zagros suture).

The northward movement of the Transcaucasus block caused the beginning of collision and formation of the Greater Caucasus orogenic belt (Adamia, 1991). Nikishin et al. (2001) attribute the Caucasian Orogeny to the continent–continent collision between the Arabian promontory and the Scythian Platform. This is certainly true for the central part of Great Caucasus between the Black Sea and the Caspian Sea. However, the Caucasus orogenic belt extends from Crimea into the Caspian Sea (Zonenshain et al., 1990; Milanovsky, 1991, 1996; Abrams and Narimanov, 1997; Nikishin et al., 2001). A south verging thrustbelt extends along the margin of Black Sea as far west as Crimea. It is impossible to explain its existence by continent–continent collision between the Arabian promontory and the Scythian plate. Subduction consuming Mesozoic oceanic crust of the Great Caucasus Basin and collision of the Shatski terrane with the Scythian plate seems to be the most logical explanation of the kinematics underlying the formation of the western part of the Caucasus thrustbelt. Philip et al. (1989) also noted differences between the western and eastern part of Great Caucasus. They stated that: “the western Caucasus has followed a style of deformation similar to that of the older subduction, the eastern Caucasus is well engaged in a stage of continental collision”.

3.6. Oligocene–Middle Miocene

Collision continued in the area between Africa and Eurasia (Fig. 15). The cessation of compression

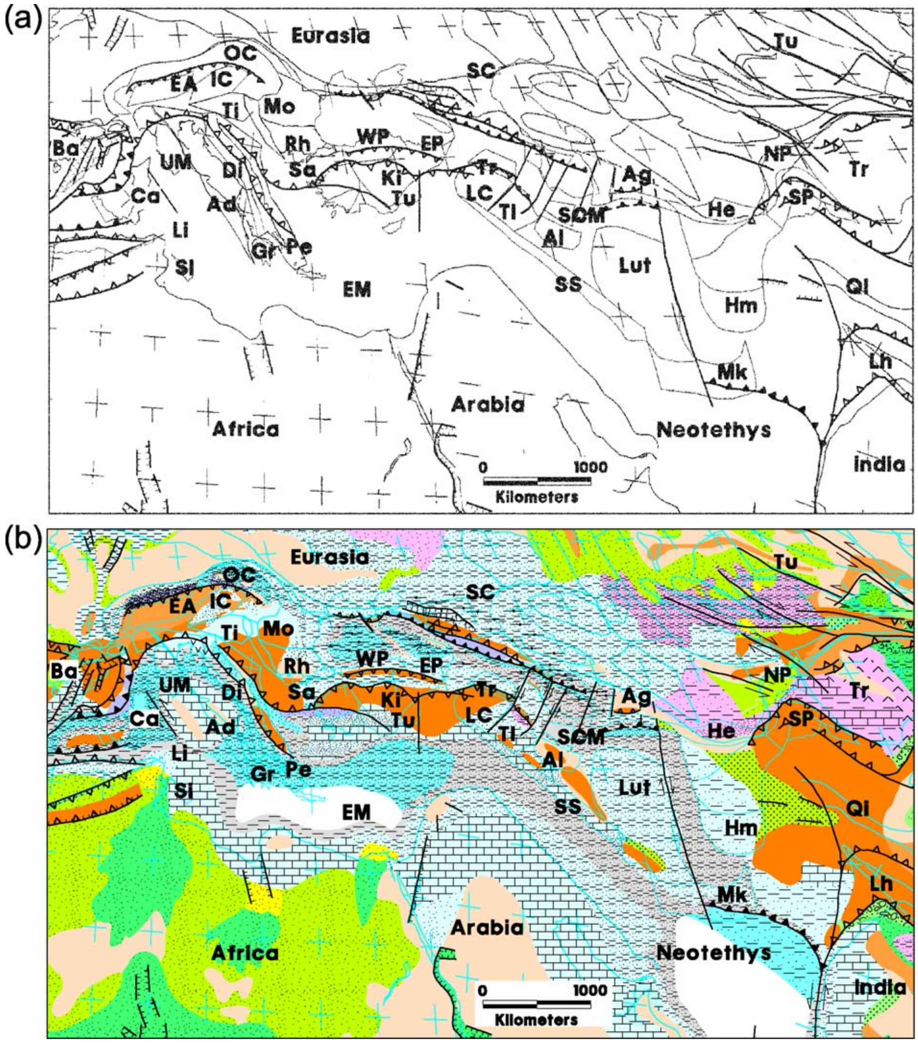


Fig. 15. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Priabonian; plates' positions at 36 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the circum-Caspian area during Priabonian; plates position at 36 Ma. Legend and abbreviations—see Fig. 6b.

of the Bulgarian Balkanides occurred during the Oligocene (Sinclair et al., 1997). The Pindos Ocean was finally closed (Robertson et al., 1991). The collision of Apulia as well as the Alpine–Carpathian terranes with the European plate continued (Decker and Peresson, 1996; Golonka et al., 2000). Metamorphism of the Penninic nappes in the Alps reached peak thermal conditions at about 30 Ma (Kurz et al., 1996). The Calabrian terranes in the western Mediterranean began to move eastwards (Van Dijk and Okkes, 1991).

The Paratethys Sea was formed in Europe and Central Asia, ahead of the northward moving orogenic belts (Dercourt et al., 1993). The Paratethys Sea included orogenic foredeeps as well as remnants of older oceanic basins and epicontinental platforms of the Peri-Tethyan area. There was a transition from flysch to molasse type of sedimentation in the basins in the Alpine–Carpathian (Golonka et al., 2000).

The collision of India and Eurasia continued. Metamorphism and crustal thickening reached their peak in the Zanskar area (Searle, 1996). The subduction zone beneath the Scythian–Turan margin of Eurasia (Sobornov, 1994; Granath et al., 2000; Jackson et al., 2002) produced a trench-pull force which, together with continent–continent collision, influenced the northward movement of the plates between the Black Sea and Afghanistan, the closure of the Greater Caucasus and Sistan oceans, and reorganization of the South Caspian Sea (Golonka, 2000a,b). The Sistan Ocean was closed in eastern Iran, between the Helmand and Lut plates (Sengör and Natalin, 1996). The development of the molasse basins continued in the Himalayan belt foreland (Burbank et al., 1996). The collision and suturing of India to Asia caused extensive strike-slip faulting in Asia (Kopp, 1997). Several blocks were deformed and thrust over the Turan Platform in the Pamir, Afghan–Tadjik and Gissar areas (Fig. 16).

The Sanandaj–Sirjan plate began to thrust over the Arabian Platform, forming the Zagros Mountains (Dercourt et al., 1993). The main cause of thrusting

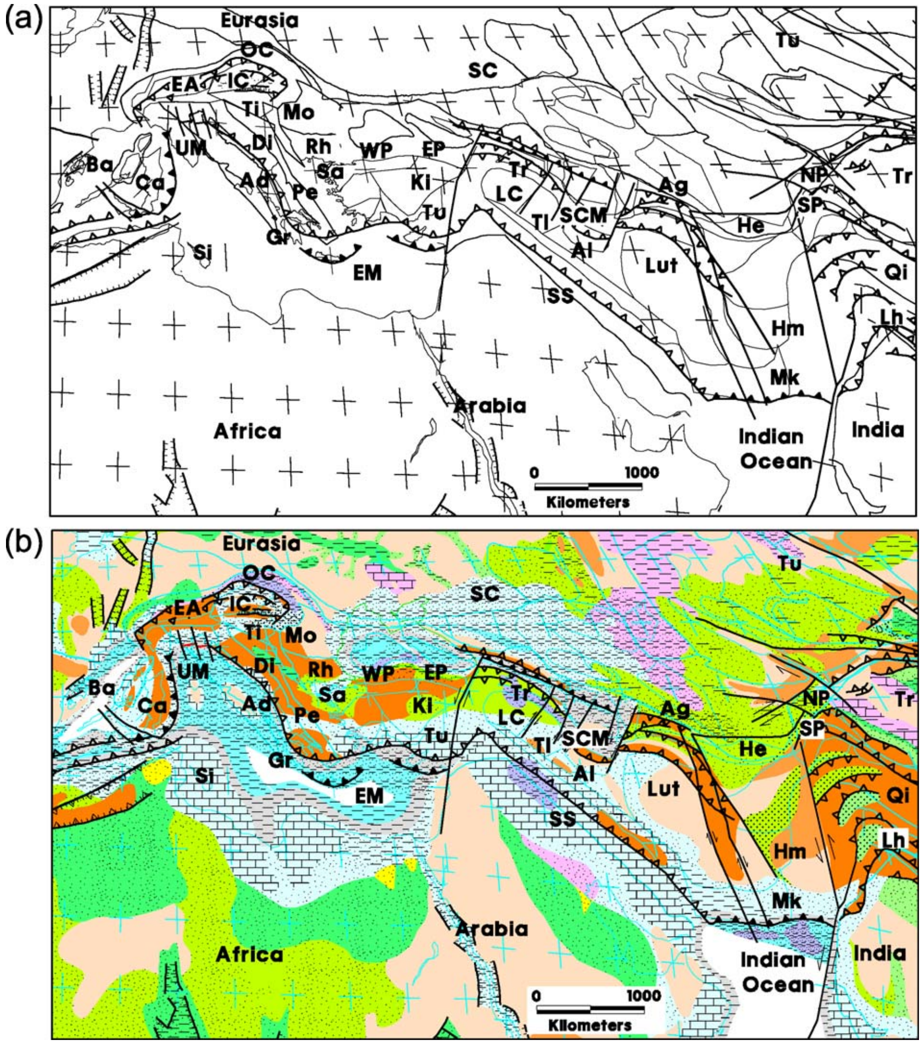


Fig. 16. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Chattian–Aquitanian; plates' positions at 22 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Chattian–Aquitanian; plates position at 22 Ma. Legend and abbreviations—see Fig. 6b.

in the Zagros Mountains, according to Sengör and Natalin (1996), was the counterclockwise rotation of the Arabian plate. The collision of the Lut block with the Turan Platform in Central Asia caused the Kopet Dagh foldbelt to form (Kopp, 1997). The Oligocene–Lower Miocene Maikop Series in Kopet Dagh is folded and thrust together with older Mesozoic and Paleogene rocks.

The South Caspian part of the Greater Caucasus–Sistan oceanic system underwent reorganization during Oligocene–Middle Miocene times. The northward movement of the South Caspian microcontinent resulted in rifting between it and the Alborz plate. This movement could have been linked with subduction. A recent subduction zone exists under the Apsheron ridge (e.g., Priestley et al., 1994; Artemjev and Kaban, 1994; Granath et al., 2000; Knapp et al., 2000; Golonka, 2000a,b; Golonka et al., 2000; Jackson et al., 2002). Its age and origin remains speculative. The Alborz trough in the South Caspian Sea opened, perhaps during or after the Middle Miocene, and extension propagated into the West Turkmen Depression in Central Asia (Golonka, 2000a). The Kopet Dagh folds are unconformably overlain by Upper Miocene, Pliocene and Quaternary deposits of West Turkmen Depression (e.g., Kopp, 1997). The southwestern part of the South Caspian Basin reopened during the Neogene, while its northwestern part was gradually reduced in size. The South Caspian microcontinent or Godin uplift (e.g., Nadirov et al., 1997) separated the southern part of the South Caspian Basin from the northern basin, probably containing remnants of older Mesozoic oceanic crust. The nature of the South Caspian microcontinent is not fully known. It has a different gravity signature than surrounding basinal parts. It could contain elements of continental crust related to the Alborz plate or oceanic plateau basalts. The latter explanation would better fit with observations made by Granath et al. (2000) and Brunet et al. (2003). Seismic lines from offshore Turkmenistan display Kopet Dagh thrusts under the Caspian Sea approximately 50 km from the coast (Tebaldi et al., 2002).

Collisions continued in the area between Africa and Eurasia during the Miocene (Figs. 16 and 17). Thrusting occurred in the Riff area in Africa and the Betic area in the southern Spain, along with collision of the Alboran Sea arc (Morley, 1993; Vissers et al., 1995). Transpressive thrusting in the Balearic margin was related to the displacement of the Alboran block (Vegas, 1992). The Tethyan oceanic crust subducted to the west and northwest and slab-roll back caused back-arc rifting in the Ligurian Sea. Corsica and Sardinia pushed the Umbria–Marche terrane towards a collision with the Apulian block. The Apennine thrust-and-foldbelt began to develop (Pialli and Alvarez, 1997). The Calabrian terranes in the western Mediterranean moved eastwards and southeastwards (Dewey et al., 1989; Van Dijk and Okkes, 1991). The movement of Corsica and Sardinia caused the plates to later push eastwards, resulting in deformation of the Alpine–Carpathian system. This deformation reached as far as Romania (Golonka et al., 2000) and continued throughout the Neogene.

The Apulia and the Alpine–Carpathian terranes were moving northwards, colliding with the European plate, until 17 Ma (Decker and Peresson, 1996). This collision caused the foreland to propagate north. The north to NNW-vergent thrust system of the eastern Alps was formed. Oblique collision between the North European plate and the overriding western Carpathian terranes led to the development of an outer accretionary wedge, the build-up of many flysch nappes and the formation of a foredeep (Kováč et al., 1998; Ślączka, 1996). These nappes were detached from their original basement and thrust over the Paleozoic–Mesozoic deposits of the North European platform. This process was completed during the Upper Tejas I slice in the area of the Vienna Basin and then progressed northeastwards (Oszczypko, 1999; Golonka et al., 2000).

The eastern Mediterranean Sea (Fig. 4) began to be subducted beneath the newly formed Eurasian margin (Vrielynck et al., 1997). The subduction active zone was located north of the Ionian and Levantine basins. The Alboran Sea extensional basin developed in the western Mediterranean behind the arc located between Iberia and northern Africa (Watts et al., 1993; Morley, 1993; Vissers et al., 1995). The first stage of rifting in the Valencia Trough (Vegas, 1992) began. Crustal extension of the internal zone of the Alps started in the Early Miocene, co-eval the ongoing thrusting (Decker and Peresson, 1996). Early to Middle Miocene extension and back-arc type rifting resulted in the formation of the intramontane Pannonian Basin (Fig. 5) in Central Europe (Royden, 1988; Decker and

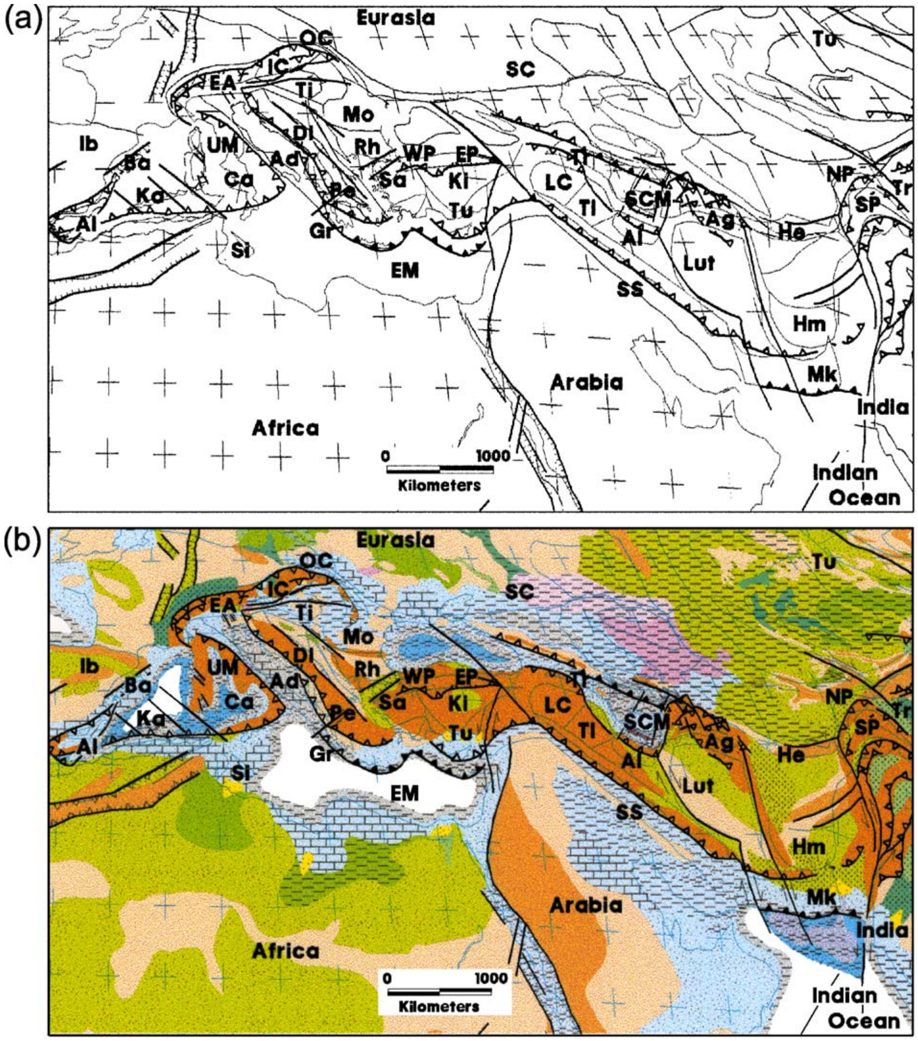


Fig. 17. (a) Paleogeography of the southern margin of Eurasia, between Spain and Central Asia during Burdigalian–Serravallian; plates' positions at 14 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the southern margin of Eurasia, between Spain and Central Asia during Burdigalian–Serravallian; plates position at 14 Ma. Legend and abbreviations—see Fig. 6b.

Peresson, 1996; Tari et al., 1997). A new period of extension began in the Pontides–Sakariya continent in Turkey (Yilmaz et al., 1997).

The collision of India and Eurasia influenced the Central Asia area through the development of far-reaching strike-slip faults. Several blocks were deformed and thrust over the Turan Platform in the Pamir, Afghan–Tadjik and Gissar areas. The Miocene phase of thrusting and folding of the Kopet-Dagh Mountains in Central Asia, with a strong strike-slip component, was a result of the final stage of collision of the Lut plate with Eurasia. The Greater Caucasus Ocean was closed as a result of the collision of the Lesser Caucasus and Transcaucasus blocks with the Scythian Platform, and the Caucasus Mountains began to form (Zonenshain et al., 1990; Kazmin, 1991; Kopp, 1997).

3.7. Late Miocene–Quaternary

Continuation of thrusting occurred in the Riff area in Africa as well as the Betic area in southern Spain

(Fig. 18) due to the collision of the Alboran Sea arc (Morley, 1993). This thrusting temporarily cut off the Mediterranean Sea from the Atlantic, in the Gibraltar Strait area, causing the Messinian salinity crisis. Compressional thrusting continued in the Calabrian Arc, with accompanying strike-slip faulting and change of rotation to the southeast (Dewey et al., 1989; Van Dijk and Okkes, 1991).

The Tyrrhenian Sea (Channell and Mareschal, 1989; Spadini et al., 1995), as well as the Valencia Trough (Vegas, 1992; Torres et al., 1993), went through their main phases of opening. Rifting in the Pantelleria Trough, between Africa and Sicily occurred in the Pliocene and Quaternary. A rift depicted by Casero and Roure (1994) cut the Sicilian-North African thrust front at a right angle. Mosar (personal communication, 2002) explains this rift as a strike-slip cut-off between two plates. A back-arc basin formed in the Aegean area behind the subduction zone. Maximum subsidence took place in the South Caspian area.

The main folding and thrusting phase occurred in northwestern Africa, along with the formation of

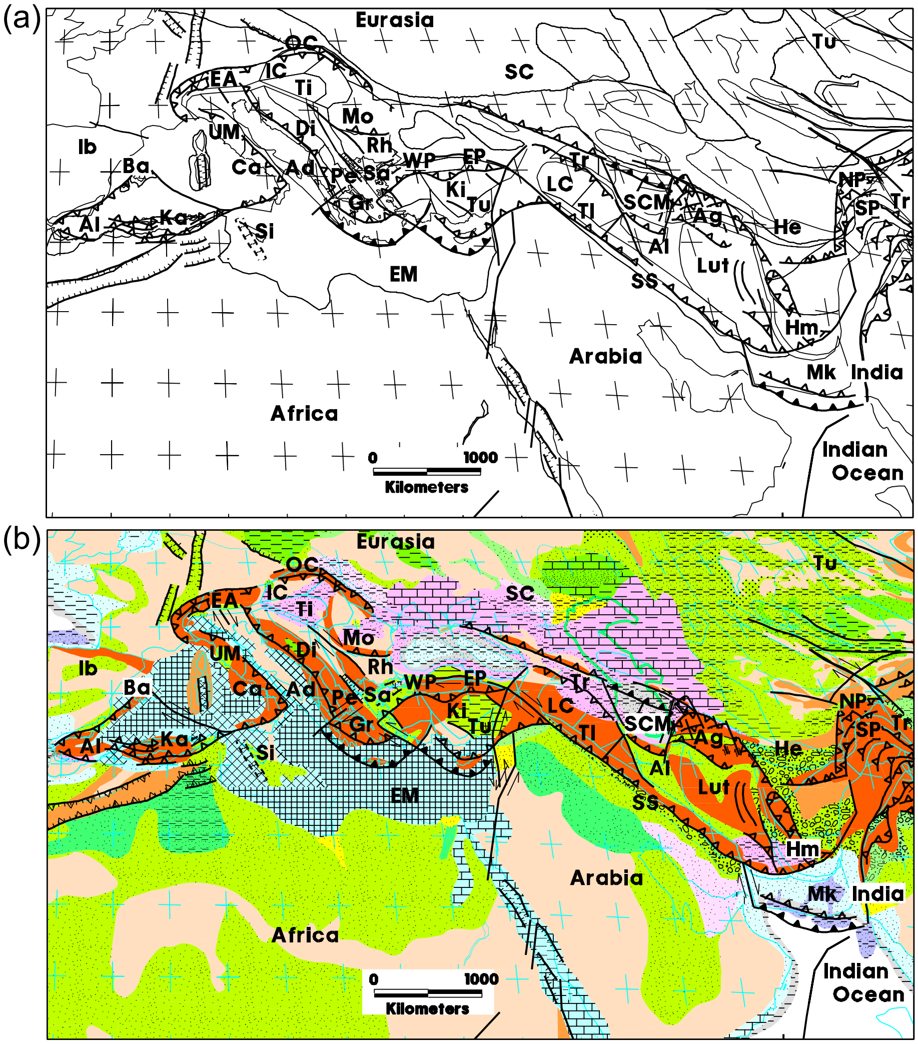


Fig. 18. (a) Paleogeography of the circum-Caspian area during Messinian; plates' positions at 6 Ma. Legend and abbreviations—see Fig. 6. (b) Paleoenvironment and lithofacies of the circum-Caspian area during Messinian; plates position at 6 Ma. Legend and abbreviations—see Fig. 6b.

nappes (Burollet, 1991). Carpathian thrusting progressed east and southeastwards, with a strong element of translation (Golonka et al., 2000). Thrusting was completed during the Pliocene–Quaternary in the Vrancea Mountains in Romania. The eastward movement of the orogen was related to the movement of Corsica and Sardinia and the subsequent opening of the Ligurian and Tyrrhenian Sea. The extrusion caused by collision of the Apulia plate with Europe could have played a role in the eastward movement of the orogen (Decker and Peresson, 1996).

During Pliocene–Quaternary times, the collision of the Indian continent and the Lut plate with Eurasia led to deformation of the Central Asian region (Fig. 18). A system of NW–SE transform faults was developed. These faults controlled the predominant plate tectonic force in the Turan Platform, Kopet Dagh area (Trifonov, 1978; Kopp, 1997; Lyberis and Manby, 1999) and strongly influenced the South Caspian region. Deformation linked with them is observed in the Great Balkhan area, Apsheron ridge, South Caspian area, Alborz Mountains, and the Kura Basin. The N–S strike slip movement system was probably still active, but dramatically reduced. The subduction zone south of the Apsheron ridge became passive perhaps at the end of the Miocene, because of the SE–NW movement of the lithospheric plates. Collision between the South Caspian microcontinent and the Scythian–Turan plate was never concluded. It appears, however, that the Apsheron subduction zone is active again today (Priestley et al., 1994; Artemjev and Kaban, 1994; Granath et al., 2000; Knapp et al., 2000; Jackson et al., 2002). The remnants of the Jurassic–Cretaceous back-arc system, oceanic and attenuated crust in the Cheleken and Southwest Caspian Basin and the Tertiary oceanic and attenuated crust in the Alborz Basin and part of the Southwest Caspian Basin were locked between adjacent continental plates and orogenic systems.

4. Conclusions

1. The Hercynian Orogeny culminated with the collision of Gondwana and Laurussia, whereas the Tethys Ocean formed the embayment between the Eurasian and Gondwanian branches of Pangea. The Eurasian active margin and the Arabian passive margin played a major role in the geodynamic development of the Tethyan area during the Mesozoic.
2. During the Late Triassic–Early Jurassic, several microplates were sutured to the Eurasian margin, closing the Paleotethys Ocean. A Jurassic–Cretaceous north-dipping subduction was developed along this new continental margin, south of the Pontides, Transcaucasus and Iranian plates. This trench-pulling effect of this subduction zone effect led to rifting and creation of the Greater Caucasus–proto-South Caspian Sea back-arc basin, which achieved a maximum width during the Late Cretaceous. Several plates drifted away from Gondwana and docked to Eurasia, during Triassic–Middle Jurassic times.
3. In the western Tethys, separation of Eurasia from Gondwana resulted in the formation of the Ligurian–Penninic–Pieniny Ocean (Alpine Tethys) as a part of the Pangean breakup tectonic system. This Alpine Tethys is an extension of the Middle Atlantic. During Late Jurassic–Early Cretaceous times, the Outer Carpathian rift developed. The opening of the western Black Sea occurred by rifting and drifting of the western–central Pontides away from the Moesian and Scythian platforms of Eurasia, during the Early Cretaceous. The latest Cretaceous–earliest Paleocene was the time of closure of the Ligurian–Pieniny Ocean. The Adria–Alcapa terranes continued their northward movement during Eocene–Early Miocene times. Their oblique collision with the North European plate led to the development of the accretionary wedge of the Outer Carpathians and a foreland basin. The formation of the West Carpathian thrusts was completed by the Miocene. The thrust front was still propagating eastwards in the eastern Carpathians.
4. During the Late Cretaceous, the Lesser Caucasus, Sanandaj–Sirjan, and Makran plates were sutured to the Iranian–Afghanistan plates in the Caucasus–Caspian Sea area. A north-dipping subduction zone jumped to the southern margin of the Scythian-Turan Platform, probably during the Paleogene. The Shatski terrane moved northwards, closing the Greater Caucasus Basin and opening the eastern Black Sea.

5. The South Caspian underwent reorganization during Oligocene–Neogene times. The southwestern part of the South Caspian Basin was reopened, while the northwestern part was gradually reduced in size.
6. The collision of the Indian and the Lut plates with Eurasia caused the deformation of Central Asia and created a system of NW–SE wrench faults. The remnants of the Jurassic–Cretaceous back-arc systems, oceanic and attenuated crust, as well as Tertiary oceanic and attenuated crust were locked between adjacent continental plates and orogenic systems.

Acknowledgements

I would like to express my gratitude to Randell Stephenson for encouragement to present and publish this paper. The presented maps were derived from the Jan Golonka's contribution to the Mobil projects, which encompassed 32 global Phanerozoic paleoenvironment and lithofacies maps, aimed at evaluation of petroleum systems in time and space. The presented version of the regional maps was finalized in 1999–2001 at the Institute of Geological Sciences, Jagiellonian University. I am grateful to Lisa Gahagen from University of Texas at Austin for her help in constructing the regional plates model, as well as to my numerous former Mobil co-workers, especially Dave Ford, Mary Edrich, Paul Frydl, Aart Dronkers, Joel Cline, Wim Burgers, Joel Collins, Jeff Sawlan and Jack Carter. Finally, I would like to thank my academic colleagues Chris Scotese, from the University of Texas at Arlington; Larry Lawver, Ian Dalziel and Mike Coffin, from the University of Texas at Austin; Malcolm Ross from Rice University; Erik Flügel and Wolfgang Kiessling, from the University of Erlangen; Andrzej Ślączka and Nestor Oszczypko from Jagiellonian University; Anatoliy Nikishin from Moscow State University; Marie-Françoise Brunet from University Pierre and Marie Curie, Paris; Natasha Bocharova, Lev Natapov and Vladimir Kazmin, from the Russian Academy of Sciences for sharing their ideas about the paleogeography, paleoclimatology and plate tectonics of this region. By their constructive reviews on a former version of this paper, Anatoliy Nikishin and Jon Mosar greatly helped me to improve it. My gratitude goes to Marta Golonka for editorial improvements and especially to my wife Małgorzata Golonka for patience and cheerful support during the work. This work was partly supported by the grant from the Polish Committee for Scientific Research (KBN grant no. 3 P04D 020 22). It is also a contribution to IGCP 453.

References

Abrams, M.A., Narimanov, A.A., 1997. Geochemical evaluation of hydrocarbons and their potential sources in the western South Caspian depression, Republic of Azerbaijan. Marine and Petroleum Geology 14, 451–468.

Adamia, S.A., 1991. The Caucasus oil and gas province, occasional publications. ESRI, New Series 7 (I–II), 53–74 (Part I).

Adamia, Sh., Gamkrelidze, I.P., Zakariadze, G.S., Lordkipanidze, M.B., 1974. Adjara–Trialeti trough and the problem of the Black Sea origin. Geotektonika N1, 78–94.

Alekseev, M.N., et al. (Eds.), 1991. Paleogeographic Atlas of the Shelf Regions of Eurasia for the Mesozoic and Cenozoic. Geological Institute, Russian Acad. Sci., Moscow. 35 maps, 35 pp. explanatory notes.

Ali-Zade, A.A., Ali-Zade, K.A., Aliyulla, Kh.A., 1996. Region XI. Azerbaijan. In: Krasheninnikov, V.A., Akhmetiev, M.A. (Eds.), Late Eocene–Early Oligocene Geological and Biotic Events on the Territory of the Former Soviet Union: Part I. The Regional Geology of the Upper Eocene and Lower Oligocene. GEOS, Moscow, pp. 112–130 (in Russian).

Artemjev, M.E., Kaban, M.K., 1994. Density imhomogeneities, isostasy and flexural rigidity of the lithosphere in the Transcaspian region. Tectonophysics 240, 281–297.

Aubrecht, R., Túnyi, I., 2001. Original orientation of neptunian dykes in the Pieniny Klippen Belt (western Carpathians): the first results. Contributions to Geophysics and Geodesy 31 (3), 557–578.

Banks, C.J., Robinson, A.G., 1997. Mesozoic strike-slip back-arc basins of the western Black Sea region. In: Robinson, A.G. (Ed.), Regional and Petroleum Geology of the Black Sea and Surrounding Regions. AAPG Memoir, vol. 68, pp. 53–61.

Banks, C.J., Robinson, A.G., Williams, M.P., 1997. Structure and regional tectonics of the achara-trialet fold belt and the adjacent rioni and kartli foreland basins, Republic of Georgia. In: Robinson, A.G. (Ed.), Regional and Petroleum Geology of the Black Sea and Surrounding Region. Memoir, vol. 68. American Association of Petroleum Geologists, Tulsa, Oklahoma, pp. 331–346.

Baud, A., Stampfli, G., 1991. Tectogenesis and evolution of a segment of the Cimmerides: the volcano-sedimentary Triassic of Aghdarband (Kopet-Dagh, north-east Iran). In: Sengör, A.M.C., Yilmaz, Y., Okay, A.I., Gorur, N. (Eds.), Tectonic Evolution of the Tethyan Region. NATO ASI Series. Series C: Mathematical and Physical Sciences, vol. 259, pp. 265–275.

Bazhenov, M.L., Burtman, V.S., Tsyganova, I.V., 1991. Reconstruction of the mesozoic Tethys in the Caucasus. Geotectonics 25, 37–45.

Beck, M.E., Schermer, E.R., 1994. Aegean paleomagnetic inclination anomalies—is there a tectonic explanation? Tectonophysics 231, 281–292.

Berberian, F., Berberian, M., 1981. Tectono-plutonic episodes in Iran. In: Gupta, H.K., Delany, F.M. (Eds.), Zagros. Hindu Kush, Himalaya Geodynamic Evolution. Geodyn. Ser., vol. 3. American Geophysical Union, Washington, DC, pp. 5–32.

Besse, J., Courtillot, V., 1991. Revised and synthetic apparent polar wander paths of the African, Eurasian, North American and Indian plates, and true polar wander since 200 Ma. Journal of Geophysical Research 96, 4029–4050.

Besse, J., Théveniaut, H., Courtillot, V., 1996. Apparent polar wander paths for Northern America, Europe, Africa, Laurussia, and West Gondwana since the upper Carboniferous. In: Nairn, A.E.M., Ricou, L.-E., Vrielynck, B., Dercourt, J. (Eds.), The Oceans Basins and Margin. The Tethys Ocean, vol. 8. Plenum, New York, pp. 71–97.

Bill, M., O'Dogherty, L., Guex, J., Baumgartner, P.O., Masson, H., 2001. Radiolarite ages in Alpine–Mediterranean ophiolites: constraints on the oceanic spreading and the Tethys–Atlantic connection. Geological Society of America Bulletin 113, 129–143.

Birkenmajer, K., 1986. Stages of structural evolution of the Pieniny Klippen Belt, Carpathians. Studia Geologica Polonica 88, 7–32.

Birkenmajer, K., 1988. Exotic Andrusov Ridge: its role in plate–tectonic evolution of the west Carpathian Foldbelt. Studia Geologica Polonica 91, 7–37.

Birkenmajer, K., Kozur, H., Mock, R., 1990. Exotic Triassic pelagic limestone pebbles from the Pieniny Klippen Belt of Poland: a further evidence for early Mesozoic rifting in west Carpathians. Annales Societatis Geologorum Poloniae 60, 3–44.

Bokov, P., Ognyanov, R., 1991. Hydrocarbon prospects in Bulgaria, occasional publications. ESRI, New Series 7 (I–II), 33–51 (Part. I).

Boulin, J., 1991. Structures in southwest Asia and evolution of the eastern Tethys. Tectonophysics 196, 211–268.

Brunet, M.-F., Korotaev, M.V., Ershov, A.V., Nikishin, A.M., 2003. The South Caspian basin: a review of its evolution from subsidence modelling. In: Brunet, M.-F., Cloetingh, S. (Eds.), Integrated Peri-Tethyan Basins Studies (Peri-Tethys Programme). Sedimentary Geology 156, 119–148.

Burbank, D.W., Beck, R.A., Mulder, T., 1996. The Himalayan foreland basin. In: Yin, A., Harrison, T.M. (Eds.), The Tectonic Evolution of Asia. Cambridge Univ. Press, Cambridge, pp. 149–188.

Burtan, J., Chowaniec, J., Golonka, J., 1984. Wstępne wyniki badań nad egzotycznymi skałami węglanowymi z zachodniej części polskich Karpat fliszowych; Preliminary results of studies on exotic carbonate rocks in the western part of the Polish Flysch Carpathians (in Polish, English summary). Biuletyn Instytutu Geologicznego 346, 147–159.

Burke, K.C., Wilson, J.T., 1976. Hot spots on the Earth's surface. Scientific American 335, 46–58.

Burollet, P.F., 1991. Structures and tectonics of Tunisia. Tectonophysics 195, 359–369.

Casero, P., Roure, F., 1994. Neogene deformations at the Sicilian–North African Plate boundary. In: Roure, F. (Ed.), Peri–Tethyan Platform. Éditiones Technip, Paris, pp. 27–50.

Catalano, R., Di Stefano, P., Kozur, H., 1991. Permian circumpacific deep-water faunas from the western Tethys (Sicily, Italy): new evidence for the position of the Permian Tethys. Palaeogeography, Palaeoclimatology, Palaeoecology 87, 75–108.

Chaitsky, V.P., Shelkoplyas, P.A., 1986. Cretaceous subvolcanic, volcano-clastic and volcano-sedimentary rocks of the southern slope of the western Caucasus and Taman. Izvestia Akademii Nauk SSSR. Seria Geologiceskaa 3, 52–61 (in Russian).

Channell, J.E.T., 1996. Paleomagnetism and paleogeography of Adria. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Special Publication-Geological Society, vol. 105, pp. 119–132.

Channell, J.E.T., Mareschal, J.C., 1989. Delamination and assymmetric lithospheric thickening in the development of the Tyrrhenian Rift. In: Coward, M.P., Dietrich, D., Park, R.G. (Eds.), Alpine Tectonics. Special Publication-Geological Society, vol. 45, pp. 285–302.

Channell, J.T., Doglioni, C., Stoner, J.S., 1992. Jurassic and Cretaceous paleomagnetic data from the southern Alps (Italy). Tectonics 11, 811–822.

Channell, J.E.T., Tuysuz, O., Bektas, O., Sengör, A.M.C., 1996. Jurassic–Cretaceous paleomagnetism and paleogeography of the Pontides (Turkey). Tectonics 15, 201–212.

Clarke, J.W., 1994. Petroleum potential of the Amu-Dar'ya Province, western Uzbekistan and eastern Turkmenistan. International Geology Review 36, 407–415.

Cohen, Z., Kaptsan, V., Flexer, A., 1990. The Tectonic Mosaic of the southern Levant: implications for hydrocarbon prospects. Journal of Petroleum Geology 13, 437–462.

Dallmeyer, R.D., Neubauer, F., Handler, R., Fritz, H., Mueller, W., Pana, D., Putis, M., 1996. Tectonothermal evolution of the internal Alps and Carpathians; evidence from $^{40}Ar/^{39}Ar$ mineral and whole-rock data. In: Schmid, S.M., Frey, M., Froitzheim, N., Heilbronner, R., Stuenitz, H. (Eds.), Alpine Geology; Proceedings of the Second Workshop. 2nd Workshop on Alpine Geology. Eclogae Geologicae Helvetiae, vol. 89, pp. 203–227.

Davouzadeh, M., Schmidt, K., 1984. A review of the Mesozoic paleogeography and paleotectonic evolution of Iran. Neues Jahrbuch fur Geologie und Palaontologie. Abhandlungen 68, 182–207.

Decker, H., Peresson, H., 1996. Tertiary kinematics in the Alpine–Carpathian–Pannonian system: links between thrusting, transform faulting and crustal extension. In: Wessely, G., Liebl, W. (Eds.), Oil and Gas in Alpidic Thrustbelts and Basins of Central and Eastern Europe. Special Publications of the European Association of Geoscientists and Engineer, vol. 5. Geological Society, London, pp. 17–21.

Dercourt, J., Zonenshain, L.P., Ricou, L.E., Kazmin, V.G., Le Pichon, X., Knipper, A.L., Grandjacquet, C., Sborshnikov, I.M., Geyssant, J., Lepvrier, C., Pechersky, D.H., Boulin, J., Sibuet, J.C., Savostin, L.A., Soroktin, O., Westphal, M., Bazhenov, M.L., Lauer, J.P., Biju-Duval, B., 1984. Presentation of nine paleogeographic maps at 20,000,000 scale from the Atlantic to the Pamir between Lias and Present. Bulletin de la Societe Géologique de France 8, 637–652.

Dercourt, J., Zonenshain, L.P., Ricou, L.E., Kazmin, V.G., Le Pichon, X., Knipper, A.L., Grandjacquet, C., Sborshnikov, I.M., Geyssant, J., Lepvrier, C., Pechersky, D.H., Boulin, J., Sibuet, J.C., Savostin, L.A., Soroktin, O., Westphal, M., Bazhenov, M.L., Lauer, J.P., Biju-Duval, B., 1986. Geological evolution of the Tethys belt from the Atlantic to Pamirs since the Lias. Tectonophysics 123, 241–315.

Dercourt, J., Ricou, L.E., Vrielynck, B. (Eds.), 1993. Atlas Tethys Paleoenvironmental Maps. Gauthier-Villars, Paris.

Dercourt, J., Gaetani, M., Vrielynck, B., Barrier, E., Biju-Duval, B., Brunet, M.-F., Cadet, J.P., Crasquin, S., Sandulescu, M. (Eds.), 2000. Atlas Peri-Tethys Paleoegeographical Maps, vol. I-XX. CCGM/CGMW, Paris, pp. 1–269. 24 maps and explanatory note.

Dewey, J.F., Helman, M.L., Turco, E., Hutton, D.H.W., Knott, D., 1989. Kinematics of the western Mediterranean. In: Coward, M.P., Dietrich, D., Park, R.G. (Eds.), Alpine Tectonics. Special Publication-Geological Society, vol. 45, pp. 265–283.

Doré, A.G., 1991. The structural foundation and evolution of Mesozoic seaways between Europe and the Arctic. Palaeogeography, Palaeoclimatology, Palaeoecology 87, 441–492.

Fayrad, S.W., 1997. Petrological model for blueschist facies metamorphism in the Pieniny Klippen Belt. In: Grecula, P., Hovorka, D., Putiš, M. (Eds.), Geological Evolution of the Western Carpathians. Mineralia Slovaca Monografia. Státny Geologický Úsyav Dionnýza Stúra, Bratislava, pp. 155–162.

Feinberg, H., Edel, B., Kondopoulou, D., Michard, A., 1996. Implications of ophiolite palaeomagnetism for the interpretation of the geodynamics of northern Greece. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Special Publication-Geological Society, vol. 105, pp. 289–298.

Froitzheim, N., Schmid, S.M., Frey, M., 1996. Mesozoic paleogeography and the timing of eclogite facies metamorphism in the Alps: a working hypothesis. Eclogae Geologicae Helvetiae 89, 81–110.

Gaetani, M., Garzanti, E., 1991. Multicyclic history of the northern India continental margin (northwestern Himalaya). AAPG Bulletin 75, 1427–1446.

Gaetani, M., Balini, M., Vuks, V.J., Gavrilova, V.A., Garzanti, E., Nicora, A., Erba, E., Cariou, E., Cecca, F., Premolli Silva, I., Petrizzo, M.R., Cirilli, M.R., Bucefallo Palliani, R., 1998. The Mesozoic of the Mangyshlak (west Kazakhstan). In: Crasquin-Soleau, S., Barrier, É. (Eds.), Peri-Tethys Memoir 4: Epicratonic Basins of Peri-Tethyan PlatformsMémoires du Muséum National d'Histoire Naturelle, vol. 179, pp. 35–74.

Garzanti, E., Andò, S., Scutellà, M., 2000. Actualisic Ophiolite provenance: the Cyprys case. Journal of Geology 108, 199–218.

Gawęda, A., Kozłowski, K., Piotrowska, K., 1998. Tectonic development of the crystalline basement of the Polish part of the western Tatra Mts. Acta Universitatis Carolinae. Geologica 42, 252–253.

Gasanov, T.A., 1992. The Post-Eocene Nappes of the Talysh zone in the lesser Caucasus. Geotectonics 26, 324–331.

Gasanov, T.A., 1996. Geodynamics of Ophiolites in the Structure of the Lesser Caucasus and Iran. Elm, Baku, pp. 1–454 (in Russian).

Golonka, J., 2000a. Geodynamic evolution of the south Caspian Basin. AAPG's Inaugural Regional International Conference July 9–12, Istanbul, Turkey. Official Program Book. American Association of Petroleum Geologists, Tulsa, Oklahoma, pp. 40–45.

Golonka, J., 2000b. Cambrian–Neogene Plate Tectonic Maps. Wydawnictwa Uniwersytetu Jagiellońskiego, Kraków.

Golonka, J., Bocharova, N.Y., 2000. Hot spot activity the break-up of Pangea. Palaeogeography, Palaeoclimatology, Palaeoecology 161, 49–69.

Golonka, J., Ford, D.W., 2000. Pangean (late Carboniferous–Middle Jurassic) paleoenvironment and lithofacies. Palaeogeography, Palaeoclimatology, Palaeoecology 161, 1–34.

Golonka, J., Gahagan, L., 1997. Tectonic model of the Mediterranean terranes. AAPG Bulletin 8, 1386.

Golonka, J., Krobicki, M., 2001. Upwelling regime in the Carpathian Tethys: a Jurassic–Cretaceous palaeogeographic and paleoclimatic perspective. Geological Quarterly 45, 15–32.

Golonka, J., Sikora, W., 1981. Microfacies of the Jurassic and Lower Cretaceous sedimentarily thinned deposits of the Pieniny Klippen Belt in Poland (in Polish English abstract). Biuletyn Instytutu Geologicznego 31, 7–37.

Golonka, J., Ross, M.I., Scotese, C.R., 1994. Phanerozoic paleogeographic and paleoclimatic modeling maps. In: Embry, A.F., Beauchamp, B., Glass, D.J. (Eds.), Pangea: Global Environment and Resources. Memoir-Canadian Society of Petroleum Geologists, vol. 17, pp. 1–47.

Golonka, J., Edrich, M., Ford, D.W., Pauken, R.B., Bocharova, N.Y., Scotese, C.R., 1996. Jurassic paleogeographic maps of the world. In: Morales, M. (Ed.), The Continental Jurassic. Museum of Northern Arizona Bulletin, vol. 60, pp. 1–5.

Golonka, J., Oszczypko, N., Ślączka, A., 2000. Late Carboniferous–Neogene geodynamic evolution and paleogeography of the circum-Carpathian region and adjacent areas. Annales Societatis Geologorum Poloniae 70, 107–136.

Granath, J.W., Soofi, K.A., Baganz, O.W., Bagirov, E., 2000. Modelling and its implications to the tectonics of the South Caspian basin, AAPG's Inaugural Regional International Conference July 9–12, Istanbul, Turkey. Official Program Book. American Association of Petroleum Geologists, Tulsa, Oklahoma, pp. 46–49.

Grabowski, J., 2000. Palaeo-and rock magnetism of Mesozoic carbonate rocks in the sub-Tatric series (Central West Carpathians) palaeotectonoc implications. Polish Geological Institute Special Papers 5, 1–88.

Guliyev, I.S., Feizulayev, A.A., Huseynov, D.A., 2001. Isotope geochemistry of oils from fields and mud volcanoes in the south Caspian Basin, Azerbaijan. Petroleum Geoscience 7, 201–209.

Guiraud, R., Bellion, Y., 1996. Late Carboniferous to recent geodynamic evolution of the west Gondwanian Cratonic Tethyan margin. In: Nairn, A.E.M., Ricou, L.-E., Vrielynck, B., Dercourt, J. (Eds.), The Oceans Basins and Margin. The Tethys Ocean, vol. 8. Plenum, New York, pp. 101–124.

Haubold, H., Scholger, R., Frisch, W., Summesberger, H., Mauritsch, H.J., 1999. Reconstruction of the geodynamic evolution of the northern Calcareous Alps by means of paleomagnetism. Physics and Chemistry of the Earth. Part A: Solid Earth and Geodesy 24, 697–703.

Hirsch, F., Flexer, A., Rosenfeld, A., Yellin-Dror, A., 1995. Palinspastic and crustal setting of the eastern Mediterranean. Journal of Petroleum Geology 18, 149–170.

Hovorka, D., Spišiak, J., 1998. Mesozoic Meliata ocean dismembered ophiolites. In: Rakús, M. (Ed.), Geodynamic Development of the Western Carpathians. Geological Survey of Slovac Republic, Bratislava, pp. 81–88.

Institute of Tectonics of Lithospheric Plates, 1997. The Paleogeographic Atlas of Northern Eurasia. Russian Academy of Sciences, Moscow.

Jackson, J., 1992. Partitioning of strike-slip an convergent motion between Eurasia and Arabia in eastern Turkey and Arabia. Journal of Geophysical Research 97, 12479–12741.

Jackson, J., Priestley, K., Allen, M., Berberian, M., 2002. Active tectonics of the South Caspian Basin. Geophysical Journal International 148, 214–245.

Kázmer, M., Kovács, S., 1989. Triassic and Jurassic oceanic/Paraoceanic belts in the Carpathian–Pannonian Region and its surroundings. In: Sengör, A.M.C., Yilmaz, Y., Okay, A.I., Gorur, N. (Eds.), Tectonic Evolution of the Tethyan Region. NATO ASI Series. Series C: Mathematical and Physical Sciences, vol. 259, pp. 77–92.

Kazmin, V.G., 1989. Collision and rifting history of the Tethys Ocean. Geotectonics 23, 391–399.

Kazmin, V.G., 1990. Early Mesozoic reconstruction of the Black Sea–Caucasus region. Evolution of the northern margin of the Tethys. Mémoires de la Société Géologique de France, Nouvelle Series 54, 147–158.

Kazmin, V.G., 1991. Collision and rifting in the Tethys ocean: geodynamic implications. Tectonophysics 123, 371–384.

Kazmin, V.G., 1997. Mesozoic to Cenozoic history of the back-arc basins in the Black Sea–Caucasus region, unpublished report 1997. CASP Arctic and Russian Studies III Report 656. Cambridge Arctic Shelf Programme, Cambridge, UK. 70 pp.

Keeley, M.L., 1994. Phanerozoic evolution of the basins of northern Egypt and adjacent areas. Geologische Rundschau 83, 728–742.

Kiessling, W., Flügel, E., Golonka, J., 1999. Paleoreef maps: a comprehensive database of Phanerozoic reefs with graphic presentations. AAPG Bulletin 83, 1552–1587.

Knapp, J.H., Diaconescu, C.C., Connor, J.A., Mcbride, J.H., Simmons, M.D., 2000. Deep seismic exploration of the South Caspian Basin: lithosphere-scale imaging of the world's deepest basin. AAPG's Inaugural Regional International Conference July 9–12, Istanbul, Turkey. Official Program Book. American Association of Petroleum Geologists, Tulsa, Oklahoma, pp. 35–37.

Knipper, A.L., Sokolov, S.D., 1974. Pre-Upper Senonian tectonic sheets in the Lesser Caucasus. Geotectonics 1, 357–361.

Knipper, A.L., Sharaskin, A.Ya., Voznesenskii, A.I., 2001. Ophiolite-clastic breccias of the Lesser Caucasus: structural features and origin. Geotectonics 35, 199–206.

Kondopolou, D., Atzemoglou, A., Pavlides, S., 1996. Palaeomagnetism as a tool for testing geodynamic models in the north Aegean: convergences, controversies and a further hypothesis. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Special Publication-Geological Society, vol. 105, pp. 277–288.

Kopp, M.L., 1997. Lateral escape structures in the Alpine–Himalayan collision belt (In Russian). Russian Academy of Sciences Transactions 506, 1–314.

Koronovsky, N.V., Kozhevnikov, A.V., Panov, D.I., Vishnevsky, L.E., Guschin, A.I., Nikitin, M.Yu., Voronina, A.A., Stafeev, A.N., Panina, L.V., Kopaevich, L.F., Star, M.A., Belyakov, G.A., 1987. The history of geologic development and structure formation of the central part of Terek–Caspian trough. In: Milanovsky, E.E., Koronovsky, N.V. (Eds.), Geology and Mineral Resources of the Great Caucasus. Nauka, Moscow, pp. 147–174 (in Russian).

Koronovsky, N.V., Lomize, M.G., Guschin, A.I., Zarschikov, A.A., Panina, L.V., Romanovskaya, M.A., 1997. Main events in tectonic evolution of the Caucasus segment of the Mediterranean fold belt. Vestnik Moskovskogo Universiteta. Seria 4, Geologia, 5–12 (in Russian).

Kováč, M., Nagymarosy, A., Oszczypko, N., Ślączka, A., Csontos, L., Marunteanu, M., Matenco, L., Marton, M., 1998. Palinspastic reconstruction of the Carpathian–Pannonian region during the Miocene. In: Rakús, M. (Ed.), Geodynamic Development of the Western Carpathians. Geological Survey of Slovac Republic, Bratislava, pp. 189–217.

Kovács, S., Haas, J., Császár, G., Szederkényi, T., Buda, G., Nagymarosy, A., 2000. Tectonostratigarphic terranes in the pre-Neogene basement of the Hungarian part of the Pannonian area. Acta Geologica Hungarica 43, 225–328.

Kotański, Z., 1961. Tectogenesis and paleogeographic reconstruction of the Hig-Tatra chain in Tatra Montains (in Polish, English summary). Acta Geologica Polonica 11, 401–415.

Kozur, H., 1991. The evolution of the Meliata-Halstatt ocean and its significance for the early evolution of the eastern Alps and western Carpathians. Palaeogeography, Palaeoclimatology, Palaeoecology 87, 109–130.

Kozur, H., Krahl, W., 1987. Erster Nachweis von Radiolarien in tethyalen Perm Europas. Neues Jahrbuch fur Geologie und Paleontologie, Abhandlungen 174, 357–372.

Kozur, H., Mock, R., 1997. New paleogeographic and tectonic interpretations in the Slovakian Carpathians and their implications for correlations with the eastern Alps and other parts of the western Tethys: Part II. Inner western Carpathians. Mineralia Slovaca 26, 164–209.

Kräutner, H.G., 1996. Alpine rifting, subduction and collision in the Romanian Carpathians. In: Amman, G., Handler, K.W., Steyrer, H.P. (Eds.), Abstr. VI Symposium für Tektonik Struktur-und Kristallingeologie, 10–15 April 1996. Facultas–Universitätsverlag, Vienna, pp. 230–234.

Kräutner, H.-G., Krstić, B., 2001. Correlation of alpine and pr-alipe structural units within the southern Carpathians and the eastern Balkanides. In: Ádám, A., Szarka, L., Szendröi, J. (Eds.), Pancardi 2001 II. Abstracts. Hunngarian Academy of Sciences, Sopron, Hungary, p. CP1.

Krobicki, M., 1996. Neo-Cimmerian uplift of intraoceanic Czorsztyn pelagic swell (Pieniny Klippen Belt, Polish Carpathians) indicated by the change of brachiopod assemblages. In: Riccardi, A.C. (Ed.), Advances in Jurassic research. 4th International Congress on Jurassic Stratigraphy and Geology. GeoResearch Forum, vol. 1–2, pp. 255–264.

Krs, M., Krsova, M., Pruner, P., 1996. Palaeomagnetism and pa-

laeogeography of the western Carpathians from the Permian to the Neogene. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Special Publication-Geological Society, vol. 105, pp. 175–184.
Książkiewicz, M., 1960. Outline of the paleogeography in the Polish Carpathians. Prace Instytutu Geologicznego 30, 209–231.
Książkiewicz, M. (Ed.), 1962. Geological Atlas of Poland; Stratigraphic and facial problems, vol. 13. Cretaceous and Older Paleogene in the Polish Outer Carpathians. Instytut Geologiczny, Wydawnictwa Geologiczne, Warszawa, Poland. 20 maps, 20 pp. explanatory notes.
Książkiewicz, M., 1977a. Hypothesis of plate tectonics and the origin of the Carpathians. Annales Societatis Geologorum Poloniae 47, 329–353.
Książkiewicz, M., 1977b. Tectonics of the Carpathians. In: Pożaryski, W. (Ed.), Geology of Poland. Tectonics, vol. IV. Wydawnictwa Geologiczne, Warszawa, Poland, pp. 476–604.
Kurz, W., Neubauer, F., Genser, J., 1996. Kinematics of Penninic nappes (Glockner Nappe and basement-cover nappes) in the Tauern Window (eastern Alps, Austria) during subduction and Penninic–Austroalpine collision. Eclogae Geologicae Helvetiae 89, 573–605.
Lashkevitsch, Z.M., Medvedev, A.P., Krupskiy, Y.Z., 1995. Tectonomagmatic Evolution of Carpathians (in Russian). Naukova Dumka, Kiev, pp. 1–113.
Lomize, M.G., 1969. Volcanism of the North-Western Caucasus and Its Connection with Tectonics. Moscow Univ. Press, Moscow, pp. 1–220 (in Russian).
Lordkipanidze, M.B., 1980. Alpine Volcanism and Geodynamics of the Central Segment of the Mediterranean Fold Belt. Metsniereba, Tbilisi, pp. 1–162 (in Russian).
Lucińska-Anczkiewicz, A., Ślączka, A., Villa, I.M., Anczkiewicz, R., 2000. $^{39}Ar/^{40}Ar$ dating of the teschenite association rocks from the polish outer carpathians. Special Paper-Mineralogical Society of Poland 17, 241–242.
Lustrino, M., 2000. Phanerozoic geodynamic evolution of the circum-Italian realm. International Geology Review 42, 724–757.
Lyberis, N., Manby, G., 1999. Oblique to orthogonal convergence across the Turan Block in the post-Miocene. AAPG Bulletin 83, 1135–1160.
Mahel, M., Buday, T., Cicha, I., Fusán, O., Hanzlíkowá, E., Chmelík, F., Kamenický, J., Koráb, T., Kuthan, M., Matějka, A., Nemčok, J., Picha, F., Roth, Z., Seneš, J., Scheibner, E., Stráník, Z., Vaškovsky, I., Žebera, K., 1968. Regional geology of Czechoslovakie: Part II. The West Carpathians. Geological Survey of Czechoslovakia, Praha, 1–723.
Marchant, R.H., Stampfli, G.M., 1997. Subduction of continental crust in the western Alps. Tectonophysics 269, 217–235.
Marsella, E., Kozur, H., D'Argenio, B., 1993. Monte facito formation (Scythian–Middle Carnian). A deposit of the ancestral lagonegro Basin in southern Apennines. Bollettino del Servizio Geologico d'Italia 119, 225–248.
Márton, E., Martin, P., 1996. Large scale rotations in north Hungary during the Neogene as indicated by palaeomagnetic data. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Special Publication-Geological Society, vol. 105, pp. 153–173.
Márton, E., Mastella, L., Tokarski, A.K., 1999. Large counterclockwise rotation of the inner west Carpathian Paleogene Flysch—evidence from paleomagnetic investigations of the Podhale Flysch (Poland). Physics and Chemistry of the Earth. Part A: Solid Earth and Geodesy 24, 645–649.
Márton, E., Kuhlemann, J., Frisch, W., Dunkl, I., 2000. Miocene rotations in the eastern Alps—palaeomagnetic results from intramontane basin sediments. Tectonophysics 323, 163–182.
Matyska, C., 1989. Angular symmetries of hotspot distributions. Earth and Planetary Science Letters 95, 334–340.
Mauritsch, H.J., Scholger, R., Bushati, S.L., Ramiz, H., 1995. Palaeomagnetic results from southern Albania and their significance for the geodynamic evolution of the Dinarides, Albanides and Hellenides. Tectonophysics 242, 5–18.
Mauritsch, H.J., Scholger, R., Bushati, S.L., Xhomo, A., 1996. Palaeomagnetic investigations in northern Albania and their significance for the geodynamic evolution of the Adriatic Aegean realm. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Special Publication-Geological Society, vol. 105, pp. 265–275.
Mello, J., 1996. Meliaticum—geological development, position and relation to surrounding units. Geologicke Práce. Spravy 101, 42–43.
Metcalfe, I., 1994. Late paleozoic and mesozoic paleogeography of eastern Pangea and Tethys. In: Embry, A.F., Beauchamp, B., Glass, D.J. (Eds.), Pangea: Global Environment and Resources. Memoir-Canadian Society of Petroleum Geologists, vol. 17, pp. 97–111.
Milanovsky, E.E., 1991. Geology of the USSR: Part 3. Moscow University Press, Moscow, pp. 1–272 (in Russian).
Milanovsky, E.E., 1996. Geology of the Russia and Adjacent Areas (Northern Eurasia). Moscow Univ. Press, Moscow, pp. 1–448 (in Russian).
Morley, C.K., 1993. Discussion of origins of hinterland basins to the Rif-Betic Cordillera and Carpathians. Tectonophysics 226, 359–376.
Morris, A., 1996. A review of paleomagnetic research in the Troodos ophiolite, Cyprus. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Special Publication-Geological Society, vol. 105, pp. 311–324.
Muttoni, G., Gaetani, M., Budurov, K., Zagorchev, I., Trifonova, E., Ivanova, D., Petrounova, L., Lowrie, W., 2000a. Middle Triassic paleomagnetic data from northern Bulgaria: constraints on Tethyan magnetostratigraphy and paleogeography. Palaeogeography, Palaeoclimatology, Palaeoecology 160, 223–237.
Muttoni, G., Lanci, L., Argnani, A., Hirt, A.M., Cibin, U., Abrahamsen, W., Lowrie, W., 2000b. Paleomagnetic evidence for a Neogene two-phase counterclockwise tectonic rotation in the northern Apennines (Italy). Tectonophysics 326, 241–253.
Nadirov, R.S., Bagirov, B.E., Tagiyev, M., Lerche, I., 1997. Flexural plate subsidence, sedimentation rates, and structural development of the super-deep south Caspian Basin. Tectonophysics 14, 383–400.
Narębski, W., 1990. Early rifts in the evolution of western part of the Carpathians; geochemical evidence from limburgite and teschenite rock series. Geologicky Zbornik 41, 521–528.

Neev, D., Almagor, G., Arad, A., Ginzburg, A., Hall, J.K., 1976. The geology of the southern Mediterranean Sea. Bulletin-Israel, Geological Survey 68, 1–47.

Neugebauer, J., Greiner, B., Appel, E., 2001. Kinematics of the Alpine–west Carpathian orogen and palaeogeographic omplications. Journal of the Geological Society (London) 158, 97–110.

Nikishin, A.M., Ziegler, P.A., Cloething, S., Stephenson, R.A., Furne, A.V., Fokin, P.A., Ershov, A.V., Bolotov, S.N., Koraev, M.V., Alekseev, A.S., Gorbachev, I., Shipilov, E.V., Lankrejer, A., Shalimov, I.V., 1996. Late Precambrian to Triassic history of the east European Craton: dynamics of sedimentary basin evolution. Tectonophysics 268, 23–63.

Nikishin, A.M., Cloetingh, S., Bolotov, S.N., Baraboshkin, E.Y., Kopaevich, L.F., Nazarevich, B.P., Panov, D.I., Brunet, M.-F., Ershov, A.V., Il'ina, V.V., Kosova, S.S., Stephenson, R.A., 1998a. Scythian platform: chronostratigraphy and polyphase stages of tectonic history. In: Crasquin-Soleau, S., Barrier, E. (Eds.), Peri-Tethys Memoir 3: Stratigraphy and Evolution of Peri-Tethyan Platforms. Mémoires du Muséum national d'Histoire Naturelle, vol. 177, pp. 151–162. Paris.

Nikishin, A.M., Cloetingh, S., Brunet, M.-F., Stephenson, R.A., Bolotov, S.N., Ershov, A.V., 1998b. Scythian Platform and Black Sea region: Mesozoic–Cenozoic tectonic and dynamics. In: Crasquin-Soleau, S., Barrie, E. (Eds.), Peri-Tethys Memoir 3: Stratigraphy and Evolution of Peri-Tethyan Platforms. Mémoires du Muséum national d'Histoire Naturelle, vol. 177, pp. 163–176. Paris.

Nikishin, A., Ziegler, P.A., Panov, D.I., Nazarevich, B.P., Brunet, M.-F., Stephenson, R.A., Bolotov, S.N., Korotaev, M.V., Tikhomirov, P.L., 2001. Mesozoic and Cenozoic evolution of the Scythian Platform–Black-Sea–Caucasus domain. In: Ziegler, P.A., Cavazza, W., Robertson, A.H.F., Crasquin-Soleau, S. (Eds.), Peri-Tethys Memoir 6: Peri-Tethyan Rift/Wrench Basins and Passive Margins. Mémoires du Muséum national d'Histoire Naturelle, vol. 186, pp. 295–346. Paris.

Okay, A.I., Satir, M., Maluski, H., Siyako, M., Monie, P., Metzger, R., Akyüz, S., 1996. Paleo- and Neo-Tethyan events in northwestern Turkey: geologic and geochronologic constraints. In: Yin, An, Harrison, T.M. (Eds.), The Tectonic Evolution of Asia. Cambridge Univ. Press, Cambridge, pp. 420–441.

Oszczypko, N., 1999. From remnant ocean basin to collision-related foreland basin—a tentative history of the outer western Carpathians. Geologica Carpathica 50, 161–165.

Otto, S.C., Tull, S.J., Macdonald, D., Voronova, D.L., Blackbourn, G., 1997. Mesozoic–Cenozoic history of deformation and petroleum systems in sedimentary basins of Central Asia; implications of collisions on the Eurasian margin. Thematic set; habitat of oil and gas in the former Soviet Union. Petroleum Geoscience 3, 327–341.

Panov, D.I., Guschin, A.I., 1987. Structural–formational tectonic subdivisions of the Great Caucasus region for the Early and Middle Jurassic time, and the local Early–Middle Jurassic stratigraphy. In: Milanovsky, E.E., Koronovsky, N.V. (Eds.), Geology and Mineral Resources of the Great Caucasus. Nauka, Moscow, pp. 124–139 (in Russian).

Patrascu, S., Bleahu, M., Panaiotu, C., Panaiotu, C.E., 1992. The paleomagnetism of the Upper Cretaceous magmatic rocks in the Banat area of south Carpathians—tectonic implications. Tectonophysics 213, 341–352.

Patrascu, S., Seclaman, M., Panaiotu, C., 1993. Tectonic implications of paleomagnetism in Upper Cretaceous deposits in the Hateg and Rusca Montana Basins (South-Carpathians Romania). Cretaceous Research 14, 255–264.

Pechersky, D.M., Safronov, V.A., 1993. Palinspastic reconstruction of the mountaneous Crimea position in the Middle Jurassic–Early Cretaceous from paleomagnetic data. Geotectonika 1, 96–105.

Philip, H., Cisternas, A., Gvishiani, A., Gorshkov, A., 1989. The Caucasus: an actual example of the initial stages of continental collision. Tectonophysics 161, 1–21.

Pialli, G., Alvarez, W., 1997. Tectonic setting of the Miocene Northern Apennines; the problem of contemporaneous compression and extension. In: Montanari, A., Odin, G.S., Coccioni, R. (Eds.), Miocene stratigraphy; an integrated approach. Developments in Palaeontology and Stratigraphy, vol. 15, pp. 167–185.

Pillevuit, A., Marcoux, J., Stampfli, G., Baud, A., 1997. The Oman Exotics: a key to the understanding of the Neogene geodynamic evolution. Geodynamica Acta 10, 209–238.

Piper, J.D.A., Moore, J.M., Tatar, O., Gursoy, H., Park, R.G., 1996. Palaeomagnetic study of crustal deformation across an intracontinental transform: the North Anatolian Fault Zone in northern Turkey. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Geological Society Special Publication, vol. 105, pp. 299–310.

Pique, A., 1989. Variscan terranes in Morocco. In: Dallmeyer, R.D. (Ed.), Terranes in the Circum-Atlantic Paleozoic orogens. Geological Society of America Special Paper 230, 115–129.

Plašienka, A., 1999. Tectonochrology and Paleotectonic Model of the Jurassic–Cretaceous Evolution of the Central Western Carpathians. Veda, Bratislava.

Plašienka, A., Kováč, M., 1999. How to loop Carpathians—an attempt to reconstruct Meso–Cenozoic palinspastic history of the Carpathian orocline. Geologica Carpathica 50, 163–165.

Popov, S.V., Akhmetov, M.A., Zaporoshets, N.I., Voronina, A.A., Stolyarov, A.S., 1993. History of eastern Paratethys in the Late Eocene–Early Miocene: stratigraphy (in Russian). Geological Correlation 1, 10–39.

Priestley, K., Baker, K., Jackson, K., 1994. Implications of earthquake focal mechanism data for the active tectonics of the south Caspian Basin and surrounding regions. Geophysical Journal International 118, 111–141.

Rakús, M., Potfaj, M., Vozárová, A., 1998. Basic paleogeographic and paleotectonic units of the western Carpathians. In: Rakús, M. (Ed.), Geodynamic development of the western Carpathians. Geological Survey of Slovac Republic, Bratislava, pp. 15–26.

Rezanov, I.A., Chamo, S.S., 1969. Reasons for absence of a 'granitic' layer in basins of the South Caspian and Black Sea type. Canadian Journal of Earth Sciences 6, 671–678.

Ricou, L.-E., 1996. The plate tectonic history of the past Tethys Ocean. In: Nairn, A.E.M., Ricou, L.-E., Vrielynck, B., Dercourt, J. (Eds.), The Oceans Basins and Margin. The Tethys Ocean, vol. 8. Plenum Press, New York, pp. 3–70.

Robertson, A.H.F., 1998. Mesozoic–Tertiary tectonic evolution of the easternmost Mediterranean area: integration of the marine and land evidence. In: Robertson, A.H.F., Richter, C., Camerlenghi, C.A. (Eds.), Proceedings of the Ocean Drilling Program, Scientific Results, vol. 60, pp. 723–782.

Robertson, A.H.F., Searle, M.P., 1990. The northern Oman Tethyan continental margin: stratigraphy, structure, concepts and controversies. In: Robertson, A.H.F., Searle, M.P., Ries, A.C. (Eds.), The Geology and Tectonics of the Oman Region. Special Publication-Geological Society, vol. 49, pp. 3–25.

Robertson, A.H.F., Woodcock, N.H., 1979. Mamonia complex, southwest Cyprus: evolution and emplacement of a Mesozoic continental margin. Geological Society of America Bulletin 90, 651–665.

Robertson, A.H.F., Clift, P.D., Degnanand, P., Jones, G., 1991. Paleogeographic and paleotectonic evolution of eastern Mediterranean Neotethys. Palaeogeography, Palaeoclimatology, Palaeoecology 87, 289–344.

Robertson, A.H.F., Dixon, J.E., Brown, S., Collins, A., Morris, A., Pickett, E.A., Sharp, I., Ustaomer, T., 1996. Alternative tectonic models for the Late Palaeozoic–Early Tertiary development of Tethys in the. Eastern Mediterranean region. In: Morris, A., Tarling, D.H. (Eds.), Paleomagnetism and Tectonics of the Mediterranean Region. Special Publication-Geological Society, vol. 105, pp. 239–263.

Robinson, A.G., Rudat, J.H., Banks, C.J., Wiles, R.L.F., 1996. Petroleum geology of the Black Sea. Marine and Petroleum Geology 13, 195–223.

Ronov, A., Khain, V.E., Balukhovski, A.N., 1989. Atlas of Lithological Paleogeographical Maps of the World: Mesozoic and Cenozoic of the Continents. USSR Academy of Sciences, Leningrad.

Ronov, A., Khain, V.E., Seslavinski, K., 1984. Atlas of Lithological Paleogeographical Maps of The World: Late Precambrian And Paleozoic of the Continents. USSR Academy of Sciences, Leningrad.

Royden, L., 1988. Late Cenozoic tectonics of the Pannonian basin system. In: Royden, L., Horváth, F. (Eds.), The Pannonian Basin: A Study in Basin Evolution. American Association of Petroleum Geologists Memoir, vol. 45, pp. 27–48.

Săndulescu, M., 1988. Cenozoic Tectonic History of the Carpathians. In: Royden, L., Horváth, F. (Eds.), The Pannonian Basin: A Study in Basin Evolution. American Association of Petroleum Geologists Memoir, vol. 45, pp. 17–25.

Săndulescu, M., Visarion, M., 2000. Crustal structure and evolution of the Carpathian–western Black Sea area. Romanian Geophysics 7, 228–231.

Scotese, C.R., Lanford, R.P., 1995. Pangea and the Paleogeography of the Permian. In: Scholle, P.A., Peryt, T.M., Ulmer-Scholle, D.S. (Eds.), The Permian of Northern Pangea. Paleogeography, Paleoclimate, Stratigraphy, vol. 1. Springer Verlag, Berlin, pp. 3–19.

Searle, M.P., 1996. Cooling history, exhumation and kinematics of the Himalaya–Karakorum–Tibet orogenic belt. In: Yin, An, Harrison, T.M. (Eds.), The Tectonic Evolution of Asia. Cambridge Univ. Press, Cambridge, pp. 110–137.

Sengör, A.M.C., 1984. The Cimmeride orogenic system and the tectonics of Eurasia. Special Paper-Geological Society of America 195, 1–82.

Sengör, A.M.C., 1990. A new model for the Late Paleozoic–Mesozoic tectonic evolution of Iran and implications for Oman. The Geology and Tectonics of the Oman Region. Special Publication-Geological Society 49, 797–831.

Sengör, A.M.C., Natalin, B.A., 1996. Paleotectonics of Asia: fragment of a synthesis. In: Yin, An, Harrison, T.M. (Eds.), The Tectonic Evolution of Asia. Cambridge Univ. Press, Cambridge, pp. 486–640.

Shanov, S., Spassov, E., Georgiev, T., 1992. Evidence for existence of a paleosubduction zone beneath the Rhodopean massif (Central Balkans). Tectonophysics 206, 307–314.

Shcherba, I.G., 1994. Paleogene basin of the Caucasus. Bulletin Moskovskovo Obshchedelenyia Ispytatelei Prirody Otdel Geologicheskiy 69, 71–80 (in Russian).

Sinclair, H.D., Juranov, S.G., Georgiev, G., Byrne, P., Mountney, N.P., 1997. The Balkan Thrust Wedge and Foreland Basin of Eastern Bulgaria: Structural and Stratigraphic Development. In: Robinson, A.G. (Ed.), Regional and Petroleum Geology of the Black Sea and Surrounding Regions. Memoir-American Association of Petroleum Geologists, vol. 68, pp. 91–114.

Ślączka, A., 1996. Oil and gas in the northern Carpathians. In: Wessely, G., Liebl, W. (Eds.), Oil and gas in Alpidic thrustbelts and basins of Central and Eastern Europe. Special Publications of the European Association of Geoscientists and Engineer, vol. 5. Geological Society, London, pp. 187–195.

Sobornov, K.O., 1994. Structure and petroleum potential of the Dagestan thrust belt. Canadian Society of Petroleum Geologists Bulletin 42, 352–364.

Soták, J., 1986. Stratigraphy and typology of the Upper Triassic development in outer units in the West Carpathians (reconstructions from redeposites localised in the Silesian Cordillera area). Knihovnicka Zemny Plyn a Nafta 31, 1–53.

Soták, J., Biroň, A., Prokešova, R., Spišiak, J., 2000. Detachment control of core complex exhumation and back-arc extension in the East Slovakian Basin. Slovak Geological Magazine 6, 130–132.

Spadini, G., Cloething, S., Bertotti, G., 1995. Thermo-mechanical modeling of the Tyrrhenian Sea: lithospheric necking and kinematic of rifting. Tectonophysics 14, 629–644.

Stampfli, G.M., 1993. Le Briançonnais, terrain exotique dans les Alpes? The Briançonnais, exotic terrane in the Alps? Eclogae Geologicae Helvetiae 86, 1–45.

Stampfli, G.M., 1996. The intra-Alpine terrain; a Paleotethyan remnant in the Alpine Variscides. In: Schmid, S.M., Frey, M., Froitzheim, N., Heilbronner, R., Stuenitz, H. (Eds.), Alpine geology; Proceedings of the Second Workshop: 2nd Workshop on Alpine Geology. Eclogae Geologicae Helvetiae, vol. 89, pp. 13–42.

Stampfli, G.M. (Ed.), 2001. Geology of the western Swiss alps—a guide book. Mémoires de Géologie (Lausanne), vol. 361, pp. 1–195.

Stampfli, G., Marcoux, J., Baud, A., 1991. Tethyan margins in space and time. In: Channell, J.E.T., Winterer, E.L., Jansa, L.F. (Eds.), Palaeogeography, Palaeoclimatology, Palaeoecology, vol. 87, pp. 373–409.

Stampfli, G.M.M., Mosar, J., Marquer, D., Marchant, R., Baudin, T., Borel, G., 1998. Subduction and obduction processes in the Swiss Alps. Tectonophysics 296, 159–204.

Stampfli, G.M., Mosar, J., Favre, P., Pillevuit, A., Vannay, J.-C., 2001. Late Palaeozoic to Mesozoic evolution of the western Tethyan realm: the Neotethys–East Mediterranean basin connection. In: Ziegler, P.A., Cavazza, W., Robertson, A.H.F., Crasquin-Soleau, S. (Eds.), Peri-Tethys Memoir 6. Peri-Tethyan Rift/Wrench Basins and Passive Margins, vol. 186. Mémoires du Muséum National d'Histoire Naturelle, Paris, pp. 51–108.

Stefanic, M., Jurdy, D.H., 1984. The distribution of hot spots. Journal of Geophysical Research 89, 9919–9925.

Tari, G., Dicea, O., Faulkerson, J., Georgiev, G., Popov, S., Stefanescu, M., Weir, G., 1997. Cimmerian and Alpine stratigraphy and structural evolution of the Moesian Platform (Romania/Bulgaria). In: Robinson, A.G. (Ed.), Regional and petroleum geology of the Black Sea and surrounding regions. Memoir-American Association of Petroleum Geologists, vol. 68, pp. 63–90.

Tchoumatchenko, P., Sapunov, I., 1994. Intraplate tectonics in the Bulgarian part of the Moesian Platform during the Jurassic. Geologica Balcanica 24, 3–12.

Tebaldi, E., Bertello, F., Bocca, P., Roviello, A., 2002. Petroleum Geology of the Caspian Basins. 2 Day International Conference, 10–11 April 2002. The Geological Society, Burlington House, London (Abs.).

Trifonov, V.G., 1978. Late Quaternary movements of western and central Asia. Geological Society of America Bulletin 89, 1059–1072.

Thomas, J.C., Perroud, H., Cobbold, P.R., Bazhenov, M.L., Burtman, V.S., Chauvin, A., Sadybakasov, E., 1993. A paleomagnetic study of Tertiary formations from the Kyrgyz Tien-Shan and its tectonic implications. Journal of Geophysical Research—Solid Earth 98, 9571–9589.

Thomas, J.C., Chauvin, A., Gapais, D., Bazhenov, M., Perroud, L.H., Cobbold, P.R., Burtman, V.S., 1994. Paleomagnetic evidence for Cenozoic block rotations in the Tadjik depression (Central Asia). Journal of Geophysical Research—Solid Earth 99, 15141–15160.

Torres, J., Bois, C., Burrus, J., 1993. Initiation and evolution of the Valencia Trough (western Mediterranean); constraints from deep seismic profiling and subsidence analysis. In: Stephenson, R.A. (Ed.), Crustal controls on the internal architecture of sedimentary basins. Tectonophysics, vol. 228, pp. 57–80.

Ustaömer, T., Robertson, A., 1997. Tectonic–sedimentary evolution of the north tethyan margin in the central pontides of northern Turkey. In: Robinson, A.G. (Ed.), Regional and petroleum geology of the Black Sea and surrounding region. Memoir-American Association of Petroleum Geologists, vol. 68, pp. 255–290.

Vakhrameev, V.A., 1987. Cretaceous paleogeography of the U.S.S.R. Palaeogeography, Palaeoclimatology, Palaeoecology 59, 57–67.

Van der Voo, R., 1993. Paleomagnetism of the Atlantic, Tethys and Iapetus. Cambridge Univ. Press, Cambridge.

Van Dijk, J., Okkes, M., 1991. Neogene tectonostratigraphy and kinematics of Calabrian basins; implications for the geodynamics of the central Mediterranean. Tectonophysics 196, 23–60.

Vegas, R., 1992. The Valencia trough and the origin of the western Mediterranean basins. Tectonophysics 203, 249–261.

Vincent, S.J., Allen, M.B., Ismail-Zadeh, A., Flecker, R., 2002. The Paleogene evolution and sedimentary fill of the South Caspian Basin: insights from the Talysh of southern Azerbaijan (Abs.). Petroleum Geology of the Caspian Basins. 2 Day International Conference, 10–11 April 2002. The Geologica Society, Burlington House, London.

Vinogradov, A.P., (Ed.), 1968a. Atlas of the Lithological–Paleogeographical Maps of the USSR: Vol. III. Triassic, Jurassic and Cretaceouz. Ministry of Geology of the USSR and Academy of Sciences of the USSR, Moscow.

Vinogradov, A.P., (Ed.), 1968b. Atlas of the Lithological–Paleogeographical Maps of the USSR: Vol. IV. Paleogene, Neogene, and Quaternary. Ministry of Geology of the USSR and Academy of Sciences of the USSR, Moscow.

Vissers, R.L.M., Platt, J.P., van der Wal, D., 1995. Late orogenic extension of the Betic Cordillera and the Alboran domain; a lithospheric view. Tectonics 4, 786–803.

Vogt, P.R., 1981. On the applicability of thermal conduction models to mid-plate volcanism: comments on a paper by Gass et al. Journal of Geophysical Research 84, 5331–5354.

Vozárová, A., Vozár, J., 1992. Variscan Terranes and evolution of the Late Paleozoic sedimentary basins (western Carpathians). IGCP, vol. 276. GUDŠ, Bratislava, pp. 147–154. Special Volume.

Vrielynck, B., Odin, G.S., Dercourt, J., 1997. Miocene palaeogeography of the Tethys ocean; potential global correlations in the Mediterranean. In: Montanari, A., Odin, G.S., Coccioni, R. (Eds.), Miocene stratigraphy; an integrated approach. Developments in Palaeontology and Stratigraphy, vol. 15, pp. 157–165.

Watts, A.B., Platt, J.P., Buhl, P., 1993. Tectonic evolution of the Alboran Sea. Basin Research 5, 153–177.

Westphal, M., Bazhenov, M.L., Laurer, J.P., Bijou-Duval, B., 1984. Presentation of 9 paleogeographic maps at 20.000.000 scale from the Atlantic to the Pamir between Lias and Present. Bulletin de la Societe Geologique de France 8, 637–652.

Winkler, W., Ślączka, A., 1994. A Late Cretaceous to Paleogene geodynamic model for the western Carpathians in Poland. Geologica Carpathica 45, 71–82.

Withjack, M.O., Schlische, R.W., Olsen, P.O., 1998. Diachronous rifting, drifting, and inversion on the passive margin of central eastern North America: an analog for other passive margins. American Association of Petroleum Geologists Bulletin 82, 817–835.

Wortmann, U.G., Weissert, H., Funk, H., Hauck, J., 2001. Alpine plate kinematics revisited: the Adria problem. Tectonics 20, 134–147.

Yanev, S.N., 1992. Contribution to the elucidation of pre-Alpine evolution in Bulgaria (based on sedimentological data from the marine Paleozoic. Geologica Balcanica 22, 3–31.

Yilmaz, Y., Tüysüz, O., Yiğitbaş, E., Genç, Ş.C., Şengör, A.M.C., 1997. Geology and tectonic evolution of the Pontides. In: Robinson, A.G. (Ed.), Regional and Petroleum Geology of the Black Sea and Surrounding Regions. AAPG Memoir, vol. 68, pp. 183–226.

Yin, A., Nie, S., 1996. A Phanerozoic palinspastic reconstruction of China and its neighboring regions. In: Harrison, T.M. (Ed.), The Tectonic Evolution of Asia. Cambridge Univ. Press, Cambridge, pp. 442–485.

Ziegler, P.A., 1988. Evolution of the Arctic–North Atlantic and the western Tethys. Memoir-American Association of Petroleum Geologists 43, 1–198.

Ziegler, P.A., 1989. Evolution of Laurussia. Kluwer Academic Publishing, Dordrecht, Netherlands. 102 pp.

Zonenshain, L.P., Le Pichon, X., 1986. Deep Basins of the Black Sea and Caspian Sea as remnants of Mesozoic Back-Arc Basins. Tectonophysics 123, 181–211.

Zonenshain, L.P., Kuzmin, M.L., Natapov, L.N., 1990. Geology of the USSR: a Plate-Tectonic synthesis. In: Page, B.M. (Ed.), Geodynamics Series, vol. 21. American Geophysical Union, Washington, DC. 242 pp.

Zonenshain, L.P., Kuzmin, M.I., Bocharova, N.Yu., 1991. Hot field tectonics. Tectonophysics 199, 165–192.

Żytko, K., 1984. The Atlantic, the Indian Ocean and main linear fracture zones of the post-Variscan Europe. Annales Societatis Geologorum Poloniae 52, 3–38.

Żytko, K., 1985. Some problems of a geodynamic model of the northern Carpathians. Kwartalnik Geologiczny 29, 85–108.