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Abstract: The Palaeozoic to recent evolution of the Tethys system gave way to the largest mountain chain of the world extending from the Atlantic to Pacific oceans – the Alpine–Himalayan Mountain chain, which is still developing as a result of collision and northwards convergence of continental blocks including Apulia in the west, the Afro-Arabian Plate in the middle and the Indian Plate in the east. This Special Publication addresses the main problems of the middle part of this system incorporating the Balkans, Black Sea and Greater Caucasus in the north and the Afro-Arabian Plate in the south. Since the Early Mesozoic a number of small to large scale oceanic basins opened and closed as the intervening continental fragments drifted northwards and diachronously collided with and accreted to the southern margin of the Eurasian Plate. Despite the remarkable consequences of this, in terms of subduction, obduction and orogenic processes, little is known about the timing and palaeogeographic evolution of the region. This includes the amounts of shortening and interplay between synconvergent extension and compression, development of magmatic arc and arc-related basins and the timing and mechanism of their deformation. The chapters presented in this Special Publication present new information that help to fill some of the gaps of the puzzle.

The tectonic history of the sedimentary basins of the Black Sea–Caucasus and surrounding areas and the geodynamic processes governing the formation and deformation of these basins, as well as the development of related mountain belts, corresponded to the goals of two thematic working groups of the Middle East Basin Evolution (MEBE) Programme (Black Sea and Caucasus working groups led by R. Stephenson and M. Sosson respectively). The scientific results of these working groups, which form the contents of this Special Publication, along with some complementary studies that took place outside MEBE (e.g. Adamia *et al.* 2010; Kuscu *et al.* 2010; Özacar *et al.* 2010; Ustaömer & Robertson 2010), are briefly summarized and collectively discussed in terms of the key objectives of the MEBE programme in the Black Sea–Caucasus area.

Regional tectonic issues in the Black Sea–Caucasus–Arabian Platform corridor

The Alpine–Himalayan belt evolved through a series of tectonic events related to the opening and closing of the Tethys Ocean, producing the largest mountain belt of the world, running from the Atlantic to the Pacific oceans. The basins associated with this belt contain invaluable information related to mountain-building processes and are also the locus of rich hydrocarbon accumulations; however, knowledge about the geological evolution of the region is limited compared to what is ultimately available. This has been mainly due to the difficulty and inaccessibility of cross-country studies. This Special Publication is dedicated in part to redressing this situation in the segment of the

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Alpine–Himalayan belt running from Bulgaria to Armenia and from Ukraine to the Arabian Platform (Figs 1 & 2).

Considering the degree of ambiguity and number of conflicting models proposed for the region, many fundamental issues pertaining to the evolution of sedimentary basins and mountain belts remain to be (re)solved. It was the aim of the MEBE programme to elucidate some of these issues using modern methods and ideas. At the outset of the MEBE programme, project teams working in the Black Sea–Caucasus region identified four main themes for attention and elucidation, involving four broad periods of distinct tectonic evolution of this area. These, from oldest to youngest, were as follows.

(1) How pre-Cimmerian tectonics may have or may not have controlled or influenced the subsequent deformational history of the Black Sea–Caucasus area. There is considerable uncertainty regarding the geometry and evolution of the southern margin of Europe generally during the Palaeozoic and Early Mesozoic. It appears as though there was no Late Palaeozoic accretionary event (i.e. 'Scythian Orogeny'), adding to the European continent, but that widespread extensional tectonics of older crustal basement prevailed throughout much of the Black Sea–Caucasus area during this time. Allied to this are issues such as the crustal affinity of the mid–Black Sea ridge and the nature of the basement of the Crimean Orogeny and the relationship of these, for example, with the crust of the Transcaucasus area.

(2) The significance of Cimmerian 'Orogeny' tectonics throughout the Black Sea–Caucasus area, as expressed by the reportedly widespread occurrence of various Late Triassic–Jurassic unconformities. The 'mid-Cimmerian' unconformity was thought to be the most profound. A key question that was asked was whether Cimmerian tectonic events were related to continental collision or rather a response to (minor?) plate geometry reorganizations and/or to subduction-accretion 'anomalies' broadly affecting the kinematics of convergence.

(3) Cretaceous extensional tectonics, being the main phase of development of the Black Sea basin, and its relationship with earlier extensional events in the Jurassic (and earlier) such as the Greater Caucasus (and, further afield, South Caspian) basin. The Black Sea is generally interpreted as a back-arc basin but, in fact, fundamental issues such as the presence or absence of a related magmatic arc and the orientation of the related subduction zone remain vague at best. There are obvious implications for the geometry of extension and rifting within the western and eastern Black Sea basins and the role of broader plate configuration and kinematics in controlling this.

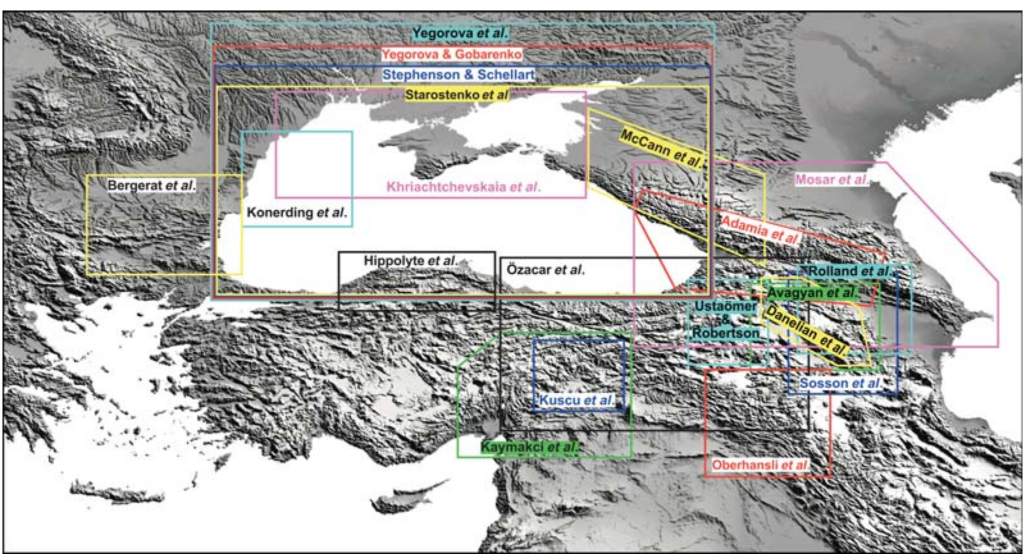

Fig. 1. Shaded relief image obtained from SRTM data (*www2.jpl.nasa.gov/srtm*) and approximate locations of the papers presented in this volume.

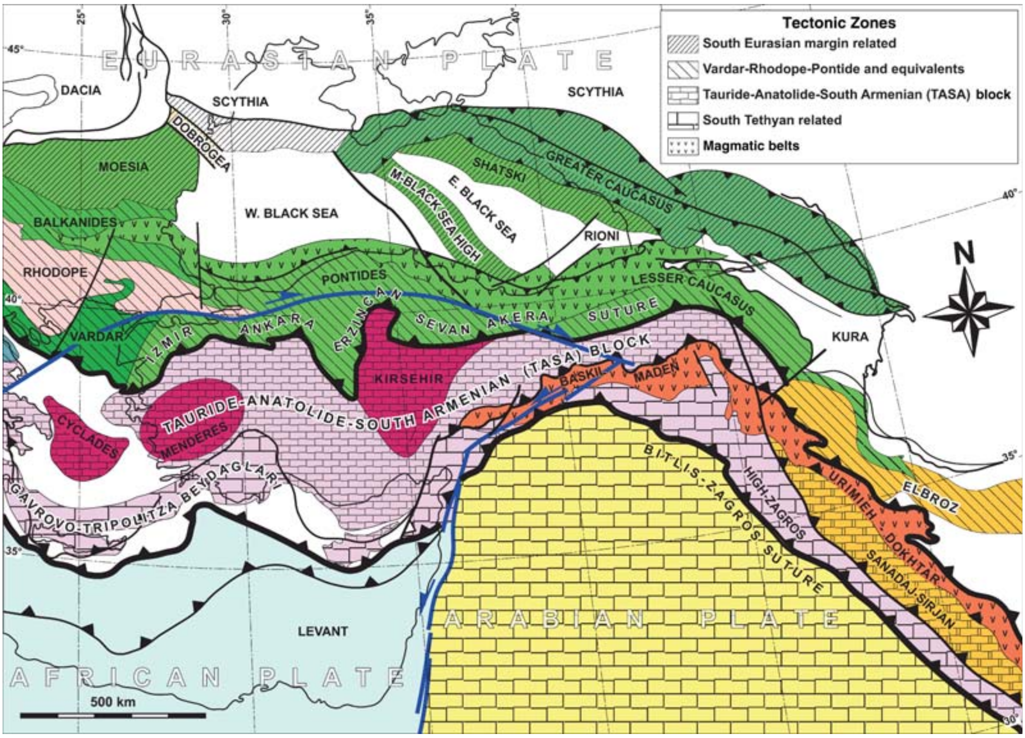

Fig. 2. Tectonic outline of eastern Mediterranean region (modified from Kaymakci *et al.* 2010).

(4) Mid-Eocene and younger shortening that is widespread, affecting almost all of the Balkanides–Black Sea–Caucasus–eastern Anatolian area. Was the onset of this deformation – and discrete pulses of compression thereafter – almost synchronous throughout the area or is there clear evidence of diachroneity? Are observations that suggest essentially coeval active extension in the eastern Black Sea basin and its margins at this time evidence for a penultimate regime of extension in what was otherwise a broad zone of convergence throughout the Mesozoic and Cenozoic. Accordingly, it may provide important inferences on the geometry of indentation of convergence during the Palaeogene.

Results

This Special Publication includes 20 multidisciplinary studies covering topics in structural geology/tectonics, geophysics, geochemistry, palaeontology, petrography, sedimentology, stratigraphy, as well as subsidence and lithospheric modelling, reporting results obtained during MEBE and related projects in the circum Black Sea and peri-Arabian regions. All are aimed at addressing the general issues highlighted above. These papers are presented in five sections.

The first two sections deal with the crustal and lithospheric structure of the Black Sea basin and its margins, using new potential field and seismic reflection and refraction data and other geophysical observations, including the reinterpretation of 'old' seismic refraction data, linked with information obtained from old and new boreholes. Onshore geological studies are also represented. Many of the papers in these sections discuss their results at the scale of the lithospheric processes responsible for back-arc basin formation and inversion and how these help to understand the observed tectonic styles and timing of key events in the Black Sea region, involved in the origin and evolution of the eastern and western Black Sea basins. The important role of 'Cimmerian' tectonics in the region prior to the formation of the Black Sea itself, from the Late Triassic until the Early Cretaceous, also receives attention. The third section of the volume focuses on documenting the geological characteristics and geodynamic evolution of the sedimentary basins related to the Greater Caucasus, located in the internal part of the Alpine–Himalayan belt within the Eurasian plate. The fourth and fifth sections comprise newly obtained data acquired from fieldwork and modern analytical studies on collected field materials, including geochronological dating, petrology and geochemistry, as well as structural mapping and palaeostress determinations. A comprehensive compilation of the information from the pre-existing literature, as related to the tectono-stratigraphic and geodynamic evolution of the external part of the Caucasus area (Eastern Pontides, Lesser Caucasus and South–East Anatolia), is also found in this section.

Black Sea: crustal and lithosphere structure

The Black Sea is generally considered to be a Cretaceous–Palaeogene back-arc basin and, in the first paper of the collection, **Stephenson & Schellart** point out that this means that its formation, behind a subduction zone, must be viewed in the context of subduction-scale geodynamic processes. They argue that observations and models of modern (recent and currently active) subduction zones formed as a result of asymmetric subduction rollback are compatible with the geometry and history of the Black Sea as a whole. Although such a model predicts a slightly earlier onset of development of extensional structures in the western compared to the eastern Black Sea sub-basin, with the youngest such activity being in the east and NE, it implies that the development of these would be essentially contemporaneous. Comparison of the regional structure of the Black Sea and its sub-basins to model predictions also implies that the proto-basement of the Black Sea probably comprised strong, cratonic, lithosphere.

Yegorova & Gobarenko, in the second paper of the volume, take a look at this very issue of basement lithosphere structure and affinity from the point of view of a comprehensive analysis of available geological and geophysical information on the Black Sea region. Their key result is that there are observable differences between the lithosphere underlying the western and eastern sub-basins of the Black Sea. This is based in part on new local seismic tomography results that suggest that the lithosphere underlying the latter has a lower average P-wave velocity (and higher temperature?) than the former. Yegorova & Gobarenko consider the implications of this for the distribution of seismicity around the Black Sea and conclude that this may partly explain why earthquakes in the east mainly occur on the northern margin of the Black Sea while those to the west mainly occur on the southern margin.

One of the key geophysical observables used in the analysis of Yegorova & Gobarenko, consisted of new crustal-upper mantle velocity models presented by **Yegorova *et al.*** based on old Soviet-era Deep Seismic Sounding (DSS) data. The old DSS data were re-analysed on two north–south running profiles, one from the northern margin (Odessa Shelf) of the western Black Sea into its deep basin and one from the Azov Sea south to the central part of the eastern Black Sea sub-basin. It is the first and only time that any of the old Black Sea DSS data have been studied using modern computer-based ray-tracing methods. The results provide more robust estimates of the thickness of sedimentary and crustal layers and, importantly, the seismic velocities that characterize the latter, than almost all of those previously available. Within the limits of the accuracy of the data and models, the crustal structure and thickness of sediments in the eastern Black Sea sub-basin is the same as that of the western Black Sea sub-basin.

Starostenko *et al.* give an overview of the observed occurrences of methane gas seeps in the northern Black Sea, particularly in shelf-slope transition zone, and how these are related to their geomorphological and geological environments, including submarine canyons, mud volcanoes, and gas hydrates. It is argued that the gas hydrate stability zone in the Black Sea lies at a depth of 600–650 m below the sea floor. The authors consider that the methane in the Black Sea is mostly of abiogenic origin and that deep-seated faults, which are also thought to control the locations of submarine canyons, play a role in transporting gas to the sea floor. It is assumed that the faults observed there are predominantly deep-seated faults, which by definition cut down to crystalline basement levels, related to important crustal-scale structures, although no data are presented to support this assertion.

Margins of the Black Sea: crustal affinity, basin formation and inversion and neotectonics; Balkanides, Romanian and Bulgarian shelves, Odessa Shelf and Azov Sea; central Pontides of Turkey

Bergerat *et al.* present new brittle tectonics analysis and stress tensor reconstructions that add considerable knowledge about the Mesozoic and Cenozoic geodynamic evolution of the superimposed basin systems of the eastern Balkanides. Evidence of Jurassic–Early Cretaceous tectonic events are presented, especially in the Strandja Zone, in which NE–SW extension followed by ENE–WSW compression is recorded, possibly corresponding to Early Alpine phases of rifting and shortening, respectively. Late-Alpine tectonic phases correspond to the Late Cretaceous–Middle Eocene period dominated by: 1) the back-arc basin/island-arc system of the East Balkan/Srednogorie zones, with the main direction of extension, Turonian–Early Campanian, being north–south to NNE–SSW; 2) the inversion of extensional structures within this zone after the Maastrichtian (Laramian phase); and, finally, 3) a major shortening phase that began in the latest Middle Eocene (Illyrian phase) with the development of large shearing and thrusting structures. Compression was directed during these two last phases NE–SW and north–south, respectively.

The paper by **Hippolyte *et al.*** deals with the Western Black Sea Basin. These authors provide new, high precision palaeontological data related to the timing of the opening of the western Black Sea and the Eocene inversion of the Central Pontides. New nanoplankton ages reveal that subsidence and rifting started in the Late Barremian and accelerated during the Aptian. Rifting in the western Black Sea Basin lasted about 40 Ma (from the Late Barremian until the Coniacian). The syn-rift sequence terminates with shallow marine sands in the inner, inverted, Black Sea margin. The authors propose that the uppermost Albian to Turonian corresponds to a period of erosion or non-deposition and that the Coniacian–Santonian succession represents the results of rapid thermal post-rift subsidence on the basin margin. They infer that the collision of the Central Pontides and the Tauride–Anatolian Block began during the Early Eocene and that this led to compressional deformation and sedimentation in piggyback basins in the Central Pontides.

Khriachtchevskaia *et al.* interpret recently acquired industry seismic reflection and newly correlated well data from the Odessa Shelf and the Azov Sea, on the northern margin of the Black Sea, to elucidate the timing and style of tectonic events shaping the architecture of the Black Sea. Structural and subsidence analyses demonstrate that active extension (rifting) began by Aptian–Albian times and ended in the Santonian in the Late Cretaceous, essentially consistent, given correlation uncertainties, with the observations of Hippolyte *et al.* derived from the opposite margin of the Black Sea. Discrete inversion events are documented to have begun in the late Middle Eocene, similar to what Bergerat *et al.* found in Bulgarian eastern Balkanides, and to have ended by the Middle Miocene.

Konerding *et al.* focus on the Miocene and younger sequence stratigraphy of the Romanian sector of the Black Sea shelf. Older (Black Sea rifting) extensional structures inverted during Middle Eocene–Oligocene times, as documented by Bergerat *et al.* to the (south)west and Khriachtchevskaia *et al.* to the (north)east in part define the architecture of the Mio-Pleistocene successions with sediment input and, to a lesser extent sea-level changes, also playing a role according to the authors. There is evidence of extensional tectonic activity from the latest Miocene (Pontian), after the cessation of inversion tectonics documented by Khriachtchevskaia *et al.*

Greater Caucasus: basin and tectonic evolution in Russia, Georgia and Azerbaijan

McCann *et al.* analyse structural, sedimentological, petrological and geochemical data from numerous field localities in the Fore-Caucasus and Central and Western Greater Caucasus mountain belt. This is a high Alpine fold-and-thrust belt on the southern margin of the East European Platform and this study is aimed at elucidating the earlier Triassic–Jurassic Cimmerian tectonic and palaeogeographic evolution of the area. The authors document that a broad asymmetric basin, with associated emergent volcanic islands, dominated the area in the Jurassic and interpret this as the result of incipient back-arc rifting. Similar rifting episodes in the Pontides and South Caspian Sea areas suggest the redevelopment of a common Tethys subduction zone at this time to the south of a Late Triassic–Early Jurassic Eo-Cimmerian accretionary belt. The associated volcanic arc subsequently widened, taken to indicate a temporary shallowing of the northward subducting slab until the Late Jurassic, when sediment accommodation space was rapidly created to form the Crimea-Greater Caucasus sedimentary basin.

An overview of the lithological and structural characteristics of basins associated with a later phase of development of the Greater Caucasus, specifically the Late Cenozoic collisional basins in front of the Greater Caucasus in Georgia, as well as the coeval magmatic events, is given by **Adamia *et al.*** on the basis of numerous studies carried out during past decades. With the help of field and well data, complemented by some interpreted seismic reflection lines, these authors present the detailed lithostratigraphy of each of the Upper Cenozoic formations of these basins, including the Rioni, Kartli, Kura and others. The fold-and-thrust belts of the Greater and Lesser Caucasus ranges, separated by the Transcaucasian intermontane depression, formed during syn-collisional (Oligocene–Middle Miocene) and post-collisional (the Late Miocene–Quaternary) phases where, previously, back-arc basins had developed. Adamia *et al.* also describe the post-collisional, Late Miocene to Pleistocene magmatic activity of the central part of the area.

The paper by **Mosar *et al.*** describes the orogenic processes that led to the present mountain belt of the Greater Caucasus, starting in early Cenozoic times, accelerating during the Plio-Pleistocene, and being still active as demonstrated by GPS and earthquake studies. The chain is a doubly verging fold-and-thrust belt, with pro- and retro-wedges actively propagating into the foreland sedimentary basins, the Kura to the south and the Terek to the north, respectively. The mountain range can be subdivided into several zones with different uplift magnitudes and rates with significantly heterogeneous strain partitioning. The authors show that clear links exist between that geomorphology, seismicity and tectonics that can be observed in the Greater Caucasus.

Lesser Caucasus and Eastern Pontides: obduction and collision stages in Armenia, Azerbaijan, Georgia and Turkey

Ustaömer & Robertson is the first of five papers that deal with the Eastern Pontides, in Turkey, and the Lesser Caucasus area, in Armenia, Azerbaijan and Georgia. They document new data from the Artvin region in the Eastern Pontides located near the SE margin of the Black Sea basin. They propose that a large continental block rifted away from the southern margin of Eurasia in a supra-subduction zone environment during the Early–Middle Jurassic and the intervening basin is filled with a thick sequence of terrigenous clastics, debris flow deposits and turbidites, and deep-sea deposits associated with radiolarites and volcanic rocks and mafic intrusions. The Middle Jurassic is dominated by subduction influenced basalts and volcaniclastics. They elegantly document that this basin was inverted during the Late–Middle Jurassic Neo-Cimmerian deformation that resulted in local uplift and erosion, this unconformity being later covered by an Upper Jurassic continental to shallow marine succession. They also provide information about the timing of onset of Eastern Pontides magmatic arc activity, resulting in a huge accumulation of magmatic and volcanogenic rocks, during the Late Cretaceous. They propose that the region was telescoped during the Middle Eocene continental collision and claim that the geological evolution of the Artvin area correlates with the Pontides further west and with the southern and northern Transcaucasus to the east. They also argue that there is no evidence of 'Palaeotethyan' ophiolites in the Eastern Pontides region.

Sosson *et al.* present new data on the structure of the Lesser Caucasus and its geodynamic evolution. From SW to NE they recognize three main domains: 1) the autochthonous South Armenian Block (SAB), a Gondwana-derived terrane, 2) the ophiolitic Sevan–Akera (Se–Ak) suture zone and 3) the Eurasian plate. According to field data and geochemical analyses, they find evidence for two Middle Jurassic to Late Cretaceous subductions zones, one related to Neotethys consumption beneath the Eurasian margin and an intra-oceanic one (in a supra-subduction zone context) responsible for the opening of a back-arc basin correlatable with the ophiolites of the Lesser Caucasus. New dating of nannofossils allow a Late Coniacian to Santonian age for obduction, responsible for the widely exposed ophiolitic nappe in front of the Se–Ak suture zone, to be specified. The collision of the SAB with Eurasia started during the Paleocene. The completion of oceanic lithosphere subduction beneath Eurasia and the onset of collision between the Arabian plate with the SAB to the south took place from the Middle Eocene to the Miocene, during which time there southward propagation of shortening featured by folding and thrusting all along the belt.

Rolland *et al.* describe new geological, petrological, geochemical data and radiometric ages on the Se–Ak, Stepanavan and Vedi ophiolitic massifs in Armenia. The authors conclude that a single large ophiolite unit has been obducted onto the SAB. Ophiolite rock assemblages suggest a slow-spreading rate in Early–Middle Jurassic times. The age of the ophiolite is constrained by $^{40}Ar/^{39}Ar$ dating that has provided a magmatic crystallization age of 178.7 ± 2.6 Ma. The top-to-the-south obduction was likely initiated along the margin of the back-arc domain and was transported as a whole onto the SAB in Coniacian–Santonian times, as reported by Sosson *et al.* Final closure of the basin is Late Cretaceous in age as dated by metamorphic rocks.

Danelian *et al.* provide new information relevant to the palaeogeographic and geodynamic evolution of the Tethyan realms preserved in the Lesser Caucasus on the basis of new and revised radiolarian biochronology for the sedimentary cover of Armenian ophiolites, including those associated with the Se–Ak suture zone discussed by Sosson *et al.* and Rolland *et al.* Danelian *et al.* also provide a review of previously existing data for these sedimentary rocks. The oldest available ages come from the Se–Ak and suggest that ocean crust formation had occurred by the Late Triassic, somewhat older than Ar dates reported by Rolland *et al.* Data from both the Se–Ak and Vedi ophiolites provide new evidence for Middle Jurassic (Bajocian) oceanic environment continuing until at least the Late Jurassic (Mid–Late Oxfordian to Late Kimmeridgian/Early Tithonian).

The paper by **Avagyan *et al.*** deals with the recent tectonic stress evolution in the area. The present stress field, derived from the kinematics of active faults, corresponds to a strike–slip regime with both transtensional and transpressional characteristics. However, both the micro fault kinematic data and the distribution of Neogene to Quaternary volcanic clusters demonstrate changes of stress field orientation through time since the beginning of the Arabia–Eurasian collision. A NW–SE orientation of compression was dominant between the Palaeogene and the late Early Miocene, a NE–SW one prevailed between the Late Miocene and the Quaternary. The stress field has accordingly changed from a general north–south compressional regime (expressed as thrusting and reverse faulting) to a transtensional-transpressional one (expressed by strike–slip faulting with various vertical components).

East and SE Anatolia: stratigraphic and tectonic evolution of the Peri-Arabian suture zone

Kaymakci *et al.* present new data and a comprehensive review of kinematic evolution of the SE Anatolian Orogen based on a palaeostress inversion study for the Late Cretaceous to Recent. They nicely illustrate that the region experienced five different phases of deformation. Among these, the first and the third deformation phases are characterized by extension while the other three phases are related to compression. They propose that the first three phase are related to subduction related processes that include slab roll-back, subduction of young oceanic crust and slab-detachment/slab tear processes. They relate the last two phases to the northwards convergence of the Arabian Plate into Eurasia since the end of the Middle Miocene.

The paper by **Kuscu *et al.*** presents new geochemical and geochronological results about the Late Cretaceous to Middle Eocene igneous rocks in the southeastern-eastern Anatolian orogenic belt. These authors have studied the major intrusive and extrusive rocks in this belt using high-precision geochronology (U–Pb and $^{40}Ar/^{39}Ar$) and provide a complete set of new geochemical data. The integration of these geochronological and geochemical data from an evolving orogen provides the basis to reconstruct the temporal and spatial transition from subduction-related to post-collision and to late-orogenic magmatism in the region. Kuscu *et al.* suggest that the subduction-related magmatism is rooted to the closure of the Neotethys ocean during Late Cretaceous to Palaeogene times, whereas post-collision and late orogenic-within plate-related magmatism is driven by the collision of a northern promontory of the SE Anatolian orogenic belt with northerly derived ophiolitic rocks during the Palaeogene.

Oberhänsli *et al.* present the alpine evolution of the eastern Bitlis complex in southeastern Anatolia according to new field studies, including the discovery of HP–LT rocks. These authors demonstrate that the Bitlis complex, now accreted to the Tauride–Anatolide–South Armenian (TASA) block, was derived from north Arabia. Metamorphic studies in its cover sequences have allowed constraints to be placed on the thermal evolution of the massif: the regionally distributed HP–LT metamorphic evolution is documented by glaucophane, relics of carpholite in chloritoid-bearing schists and pseudomorphs after aragonite in marbles. A new metamorphic age of these assemblages is determined from $^{40}Ar/^{39}Ar$ dating as 74 ± 2 Ma. This indicates that the Bitlis complex is a terrane detached from an indenter belonging to the Arabian plate that was subducted and stacked to form a nappe complex during the closure of the southern branch of Neotethys and that during its Late Cretaceous to Cenozoic evolution it never was heated to temperatures over 450 °C.

The final paper of this volume is related to crustal structure in Eastern Anatolia. **Özacar *et al.*** use teleseismic P-wave receiver functions to map out Moho depths in the region and illustrate that the crust is thinnest under the Arabian plate and gradually becomes thicker towards the TASA block in the NE. These authors also provide new data from the western part of Eastern Anatolia showing that the crust is thicker near the Bitlis suture and towards the interiors of Anatolian plate. In addition, the Moho displays pronounced topography and, apparently, multiple fragmentations with anomalously high V_p/V_s along the North Anatolian Fault and near the youngest volcanic units inferred to indicate the presence of partial melting. A prominent low velocity zone in the lower crust indicative of a decoupling zone between the crust and the upper mantle in Eastern Anatolia is also inferred.

Synthesis and summary

Pre-Cimmerian and Cimmerian history

Palaeotethys is a triangular remnant oceanic basin with its tip located around present-day Iberia and widening eastwards. The polarity of subduction of the oceanic crust of Palaeotethys is a matter of debate. Nevertheless, a number of continental blocks rifted away from the northern margin of Gondwana, on its southern boundary, and these blocks drifted northwards during the Mesozoic giving rise to the opening of the Neotethys (also known as Mesozoic Tethys) ocean behind them.

The evolution and closure of the Neotethys has dominated the subsequent tectonics of the Black Sea–Caucasus region and, as such, is the main concern of this book. However, the contentious issue of the polarity and timing of subduction of

Palaeotethys ('Cimmerian' tectonic events) during the Mesozoic and initiation of Neotethyan subduction ('Alpine' tectonic events) are closely related. The general assumption among different researchers is that early to mid-Mesozoic events on the south-eastern margin of the European continent are related to the closure of the Palaeotethys ocean although no conclusive evidence related to the age of oceanic remnants and its epiophiolitic cover have been reported from the region. This issue has also been addressed in GSL Special Publication No. 312 (Brunet *et al.* 2009), also based on results of the MEBE programme. The new results in this issue from the eastern Pontides and Greater Caucasus (McCann *et al.* 2010; Ustaömer & Roberston 2010) support models in which the subduction of Palaeotethys terminated at the end of Triassic to earliest Jurassic times. The evidence includes the presence of widespread volcanic rocks in Crimea and Caucasus that imply that the subduction of Neotethys had already commenced in the Early–Middle Jurassic.

The location of crustal accretion associated with Palaeotethys closure, determined here to be the eastern Pontides and Greater Caucasus, has implications for the pre-Black Sea position of the margin of the European continent. The geological results show that the early Mesozoic (Palaeotethys subduction) accretionary margin of Europe was indeed to the south of the Scythian Platform (Fig. 2). This is consistent with the inferences of Stephenson & Schellart, who concluded that in general the basement lithosphere of the Black Sea, in which it formed, is strong (craton-like) and also the geophysical results of Yegorova & Gobarenko who found that the crust is colder and stronger beneath the western Black Sea sub-basin than the eastern one.

Cimmerian deformations are also well imprinted in the Eastern Pontides (Ustaömer & Robertson) and the Crimean and Greater Caucasus region (McCann *et al.* 2010). Rifting in the region was initiated during the early Middle Jurassic with deformed units unconformably overlain by the Upper Jurassic deposits. These results are comparable to those of the Transcaucasus region to the SE where it seems that a similar tectonic evolution occurred during this period (Sosson *et al.* 2010). Metamorphosed rock units related to Cimmerian events are also found in the Strandja unit of Eastern Balkanides (Bergerat *et al.* 2010).

Back-arc basins: extension and magmatism

The Mid-Jurassic–Cretaceous period witnessed two subduction processes and two remnant suture zones in Anatolia (Fig. 1). The Izmir-Ankara-Erzincan-Sevan Suture Zone demarcates the former position of the northern subduction. The ophiolites associated with this suture zone are considered to be derived from the Northern Neotethys Ocean. The Bitlis–Zagros Suture Zone demarcates the former position of the Southern Neotethys Ocean. The subduction zones associated with these suture zones were characterized by slab roll-back, slab detachment and slab-tear processes that possibly gave way to development of supra-subduction zone ophiolites, subduction related magmatism mainly in the Pontides (Ustaömer & Robertson), and opening of the western and eastern Black Sea sub-basins (Hippolyte *et al.* 2010; Stephenson & Shellart 2010).

The newly obtained $^{40}Ar/^{39}Ar$ ages and geochemical data (Kuscu *et al.* 2010; Oberhänsli *et al.* 2010) indicate that similar processes were operating in the southern Neotethys ocean, which is also characterized by the Supra-Subduction Zone (SSZ) ophiolite generation and widespread magmatic activity (starting from 98.9 Ma). The SSZ ophiolites of the northern Neotethys Branch were obducted onto the Tauride–Anatolide–South Armenian (TASA, Fig. 2) microplate during Late Coniacian–Santonian as evidenced by stratigraphic and geochronological data (Rolland *et al.* 2010; Sosson *et al.* 2010) and by the ages of the plutons intruding both these ophiolitic nappes and their footwall (Kuscu *et al.* 2010).

Inversion: compression and magmatism

The extensional events, including the formation of the Black Sea basin, that took place mainly during middle-Late Cretaceous times (Bergerat *et al.* 2010; Kaymakci et *al.* 2010; Khriachtchevskaia *et al.* 2010; Konerding *et al.* 2010) were replaced as subduction terminated in the northern Neotethys and collision of the intervening continental terranes began, leading to inversion tectonics throughout the circum-Black Sea area. The onset of inversion tectonics is fairly precisely dated by structural relationships seen in seismic data on the northern margin of the Black Sea as late Middle Eocene (Khriachtchevskaia *et al.* 2010), following a period of relative quiescence. However, extension following Late Cretaceous obduction processes on the SE margin of the TASA block in SE Turkey and on the Arabian Plate continued until the Middle Eocene possibly due to roll-back of the slab related to the southern Neotethys Oceanic (Kaymakci *et al.* 2010). The collision in the north gave way to deposition of thick Palaeogene flysch to molasse on the Pontides and TASA Block (Hippolyte *et al.* 2010; Sosson *et al.* 2010; Ustaömer & Robertson 2010). Compressional deformation and inversion along the Bitlis–Zagros suture zone also started by the Late Eocene.

From the Late Oligocene onwards slab roll-back, slab-detachment and finally collision and further convergence of the Arabian Plate gave way to the present-day tectonics that affects a very large area extending from the Arabian Plate in the south to Greater Caucasus and the Black Sea Basin in the north. Inversion tectonics in the immediate Black Sea area ended by the Middle to Late Miocene (Khriachtchevskaia *et al.*; Konerding *et al.* 2010), as indicated by evidence of renewed extensional tectonic activity in the western Black Sea area (Konerding *et al.* 2010).

Present configuration and active tectonics

The collision between Arabia and Eurasia led to north–south shortening, thickening and uplift of the crust of the Taurides Anatolides and the Armenian highland as well as Lesser and Greater Caucasus regions, since the Neogene. This also gave way to the development of active thrust and strike–slip faults recently expressed by devastating earthquakes. Tomographical studies indicate that the depth to Moho beneath East Anatolia and the Bitlis region is deeper than the Arabian plate, possibly indicating the effect of convergence and the consequent shortening of Eurasia in the region (Özacar *et al.* 2010). As a result of this compression, the Greater Caucasus is uplifted and thrust over the flanking foreland basins northwards and southwards (Mosar *et al.* 2010), as a large, intraplate, crustal-scale inversion structure. The Quaternary magmatic activity in the Lesser Caucasus and adjacent regions is aligned to major fault zones (Avagyan *et al.* 2010) while it is distributed in large area in eastern Turkey (Kuscu *et al.* 2010). The main active strike–slip faults in the Lesser Caucasus correspond to inherited structures related to the collision of the TASA block with Eurasia. On the other hand, some of the active normal faults within the TASA basement are most likely related to the early Mesozoic Neotethys rifting and/or synconvergence extensional deformation related to Late Cretaceous to Eocene back-arc extension (Avagyan *et al.* 2010; Kaymakci *et al.* 2010; Kuscu *et al.* 2010).

Conclusion

The 20 papers presented in this Special Publication address various aspects of evolution of Tethys system in the area extending from the Balkans, Black Sea and Greater Caucasus to the Arabian Plate. They cover some of the main events related to closure of the Palaeotethys and opening of Neotethys oceans, Early to Late Jurassic Cimmerian events, the Cretaceous opening of Black Sea basins, formation of arcs and back arc basins along with the subduction of Neotethys, Late Cretaceous to Early Cenozoic convergence and collisional processes, as well as uplift and present day crustal and lithospheric structure in the region.

The results of these papers indicate that the Palaeotethys Ocean completely closed at the end of Triassic–Early Jurassic times, while two branches of the Neotethys ocean were opening. The northern branch lay between the Pontides and the Tauride–Anatolide–South Armenian (TASA) Block and the southern branch lay between the TASA block and the Afro-Arabian Plate. There is convincing evidence that the subduction of Neotethys commenced possibly during the Jurassic, therefore much earlier than previously thought. Formation of arcs and back-arc basins took place during the Late Jurassic and Cretaceous. The Late Cretaceous and, especially, the early Cenozoic is dominated by compressional deformation, basin inversion, and widespread subduction to collision related magmatism. Uplift and full development of the mountain chains in the region began at this time and culminated by the Oligo-Miocene in response to the collision and further northwards convergence of the Arabian Plate along the Bitlis Zagros Suture zone. This ultimately gave way to the development of active thrust and strike–slip fault systems in the region.

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