Academic studies focused on the Tethys oceans have been carried out through four consortium-type programmes for 25 years now. We are glad to present the next one, the DARIUS Programme, in this first issue of the DARIUS News.

At the end of 2007, with a successful close to the Middle East Basins Evolution Programme (MEBE), the MEBE team prepared a new consortium with the same partners to begin in 2009. The DARIUS Programme is the MEBE descendant. It maintains parts of the MEBE management and scientific teams, but also involves new participants and areas of investigation in Central Asia.

The frame of the new Programme was determined during 2008 from two basic considerations: (1) the tectonic and stratigraphic evolution of several regions in the Arabia-Eurasia collision zone remains highly questionable, generally due to a lack of original and reliable data, and (2) the platforms, basins and folded domains of southern Eurasia in Central Asia are poorly documented in terms of their geological evolution, besides being of great interest for hydrocarbon exploration. The idea of a new Programme, focused on the Middle East-Central Asia fold belt, its foreland and basins, appeared and the DARIUS Programme was born. Its major objective is understanding the tectonic and stratigraphic evolution of the orogenic domains and their associated basins resulting from the collision of Gondwanan blocks with southern Eurasia from the Mesozoic (Cimmerian blocks) until the Cenozoic (India, then Arabia).

Thus, DARIUS will investigate the 6000km-long continuous orogenic belt extending from Crimea-Anatolia in the west to Tien-Shan in the east, through the Caucasus, northern Iran and Zagros. To realize this objective the first year of the Programme is devoted to data acquisition through scientific projects submitted by invited senior geologists and geophysicists. Most of principal investigators have already successfully carried out projects in Middle Eastern and Central Asian countries over the last decade.

The budget of the first year of DARIUS also reflects the main orientation of the Programme, with about 90% of the total budget devoted to funding scientific projects.

For 2009-2010, 36 projects were selected out of 42 proposals submitted, covering most of DARIUS’ area of interest. These projects involve 40 research institutions and universities from 15 different countries. They involve scientists from about 150 scientific organizations from European, Middle Eastern and Western Central Asian countries.

One major aspect of DARIUS consists of developing scientific activities through cooperation programmes in many of the countries of interest, even where no, or little, recent scientific academic cooperation existed, such as in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. In 2010, about one-third of the DARIUS projects target Central Asian objectives because several regions of this vast area are of importance in terms of academic and oil interests. This area is our priority for the next years.

The phase of intensive data acquisition will last 2-3 years after which syntheses will be developed via regional or thematic DARIUS Working Groups. These will comprise DARIUS participants as well as other regional and thematic specialists. Each Working Group will produce a synthesis, integrating the newly acquired DARIUS project datasets, as well as other published data by the end of the Programme.

When the Programme ends in 2012-2013, the DARIUS participants will publish their results in several special issues of international journals. The final objective of DARIUS will also be realized through a set of 17 palaeotectonic maps of the Middle East – Central Asia domain (at a scale of 1/18 000 000). These palinspastic maps, ranging in age from Late Palaeozoic to Pliocene, will take the MEBE palaeotectonic maps as their basis. Last, and certainly not least, the GeolIS Database, built during the MEBE Programme,
The DARIUS Programme is the latest of four successive consortia that have been active during the past 25 years; namely the Tethys (1986-1991), Peri-Tethys (1993-1999), Middle East Basins Evolution (2002-2007), and DARIUS programmes. All of these programmes have two common major characteristics: (1) they are international consortium-type programmes, and (2) their thematic objectives focus on the evolution of the Tethys domain. These consortium-type programmes are funded by major oil companies and by French research organizations. An important aspect of these types of programmes is the close relationships that develop between the industrial and academic worlds. These programmes work through scientific projects funded on a year by year basis, selected by the programme committee. The projects are executed by members of the international scientific community in close cooperation with local research organizations. For 25 years, thousands of weeks of fieldwork have been performed in the Eurasian, African and Arabian platforms and mountain ranges by programme participants. Each of the programmes led to regional syntheses published in the form of atlases of palinspastic maps. In turn, the Tethys (1993), Peri-Tethys (2000), and MEBE (2008) atlases, provided reconstructions of the geodynamic, tectonic and stratigraphic evolution of the respectively studied domains (see references). Paradoxically, the Tethys domain, which has constituted the main scientific theme of all of these programmes, has essentially vanished. The remnants of this nearly mythical oceanic domain are restricted to scarce slices of ophiolites, obducted mainly during the Mesozoic, onto surrounding continental margins. Since the Late Palaeozoic, the geodynamics of the Tethyan oceanic domain has been the dominant control on the geological evolution of the southern and northern margins of Eurasia and Africa-Arabia, respectively. During the last 300 My, subduction and collision alternated along the northern Tethyan margin. In contrast, the southern margin remained a passive margin during most of this time, only affected by rifting phases and Tethyan ophiolite obduction events. The major tectonic elements that developed on the surrounding platforms and margins, behind subduction zones, are marginal basins, often reaching the point of oceanic crust accretion, and volcanic arcs, associated with strong magmatic activity, that lasted for millions of years. When Gondwanan blocks collided with the southern Eurasian margin, long-lasting orogenic belts developed along their margins and previously formed intracratonic basins are commonly inverted. Since the mid-1980s, the three previous consortia delivered a huge quantity of new data concerning the areas surrounding the Tethys domain, on the Eurasian, African and Arabian plates and these were synthesized into several sets of maps. The DARIUS programme aims at making its own new contribution to the knowledge of this fascinating domain.
In the Black Sea-Caucasus region, a number of small to large scale oceanic basins opened and closed as intervening continental fragments drifted northwards and diachronously collided with the southern margin of the Eurasian Plate from early Mesozoic times. The consequences of the associated processes, including subduction, obduction and orogenesis, can be expected to be fairly remarkable and, indeed, a considerable number of new insights were gained during the preceding MEBE Programme (see, for example, the Geological Society of London Special Publication, in press, mentioned elsewhere in this newsletter). Nevertheless, there remain unresolved questions, particularly concerning: 1) the origin and evolution of sedimentary basins and the tectonic controls on their development (surface and sub-surface structures, subsidence histories); 2) features related to various basin inversion events (such as indicated by the Mid-Cimmerian unconformity in the Greater Caucasus region) and 3) the onset of the Cenozoic orogenic stage, its acceleration and its correlation between the eastern Pontides, the Transcaucasus and the Lesser Caucasus and south-eastern Greater Caucasus.

There are four DARIUS projects being started this year in the Black Sea-Caucasus region.

The general scope of the project by Nielsen (Aarhus University, Denmark, and others) is to evaluate the structural evolution of the Crimean Mountains and the Eastern Black Sea area, with a focus on the role of inheritance on recent lithospheric shortening and on surface processes (topography modification and sediment redistribution). Sedimentological and geophysical (including seismics) data as well as thermochronology, vitrinite reflectance profiles and borehole temperatures are to be used to constrain a quantitative model of lithospheric deformation and topographic evolution. The coupled dynamic processes involved in the modelling, including lithospheric extension and compression, sedimentation and erosion, redistribution of crustal radiogenic heat production, as well as shear heating will allow heat flow evolution and hence maturity evolution of sedimentary units to be predicted.

The Ershov (Moscow University, Russia) project concerns the region of the eastern Black Sea, western Greater Caucasus and western Fore-Caucasus. Using well and seismic data from sedimentary basins as well as geological data from onshore regions, this project aims at constructing regional transects through the western part of the Greater Caucasus orogen and both adjacent foreland basins. The subsidence history in the basins, together with the folding/faulting/uplift history revealed in the mountainous areas, are to be investigated in order to establish relationships (temporal and causal) between tectonic events occurring in different parts of the study area. Observed burial/deformation histories will form the basis for thermal and fluid flow modelling, which can help elucidate the composition and distribution of hydrocarbons in the area.

Mosar and colleagues (Fribourg University, Switzerland) are investigating the timing and style of Mesozoic to Recent tectonic processes (including syn-depositional tectonics) along a broad transect in the central Greater Caucasus in Georgia and Russia. They expect to be able to characterise the major tectonic events in terms of age, paleostress regimes (based on observations of faults and kinematic indicators such as striations on fault planes in the field) and, hence, their interactions and consequences for sedimentary basins and orogenic evolution. The results of this project are expected to provide key constraints on the regional tectonic and geodynamic evolution since Triassic and, on a broader scale, the general kinematics of the history of Arabia–Eurasia collision. The Lesser Caucasus mountain belt and associated Eurasian plate basins (such as the Adjara-Trialet basin) comprise a key area for reconstructing the evolution of the Tethyan belt. Based on previous MEBE results in the three countries of this region (Armenia, Azerbaijan, Georgia), Sosson and colleagues (Université Nice-Sophia Antipolis) are focusing their new research on the evolution of the Lesser Caucasus Cenozoic foreland basin and the relationships between the Adjara-Trialet basin and syn collisional basins superposing the Sevan Akera suture zone. Among other targets, the structural relationships between the Sevan-Akera ophiolites and the allochthonous Mesozoic Eurasian active margin are to be mapped out in the south-eastern Lesser Caucasus, where rock exposure is good.

Following up on MEBE results documenting extensional faults related to Black Sea opening in the central Pontides (Turkey), Hippolyte (Université Aix-Marseille III) and Kaymakci (Middle East Technical University, Ankara, Turkey) plan to do new field work along the coast of the eastern part Black Sea, combined with seismic data, to construct a large cross-section through the piggy-back basins of the Central Pontides. The aim is to quantify the Eocene and post-Eocene shortening in this area and compare it with the Neogene tectonics of the Eastern Pontides and, in so doing, to provide new constraints (from Jurassic to Recent) for the paleotectonic maps of the southern Black Sea area.
In the DARIUS Programme, Anatolia is, contrary to its name, the westernmost part of the investigated area. In the realm of the MEBE programme, this eastern Taurides region had indeed been revisited but correlations and, consequently, paleogeographical reconstructions in eastern Turkey remained problematic. In the present day context of the alpine collisional belt running from Greece to Iran through Turkey, Anatolia represents a giant geological puzzle comprising a number of amalgamated continental microplates separated by ophiolite-bearing suture zones with ages ranging from Late Palaeozoic to Cretaceous.

The Taurides are composed of a collage of micro-continents and continental fragments with Laurasian and Gondwanan affinity, which were formed as a result of rifting and drifting of continental blocks away from the northern margin of Gondwana. This gave way to complex oceanic spreading-subduction-obduction-collision cycles starting in the Triassic and ending with the final collision of these continental blocks in Late Cretaceous to Early Miocene times. The number of oceanic domains, their relative positions and timing of closure is still under debate. Among a number of different scenarios, the most widely accepted scenario is one in which there are two branches of the Neotethys Ocean, with the northern branch separating the Pontides from the Taurides along the (future) Izmir-Ankara-Erzinçan Suture Zone (IAESZ). The Pontides have Eurasian affinity while the Taurides are of Gondwanan affinity. The southern branch of Neotethys, in this scenario, separated the Taurides from the African-Arabian Plate during the Mesozoic and the present day eastern Mediterranean Sea is a remnant of this branch. Another scenario considers the presence of a third oceanic domain, now represented by the Intra-Tauride Suture (ITS), which separated the Kirsehir Block from the main bulk of the Taurides.

Overlying these tectonised units, a linear belt of Late Cretaceous to Cenozoic basin complexes straddles the IAESZ and ITS, formed during both syn- and post-collisional periods. These basins, from west to east, include the Haymana, Tuzgölü, Ulukisla, Sivas, and Çankiri basins, surrounding the Kirsehir Block. In addition to these basins, there are basins limited to the Pontide domain (Mudurnu Basin) and to the Kirsehir Block (Çiçekdag-Avanos basins).

The DARIUS teams’ objectives in Anatolia are 1) the characterization of the suture zones in terms of age, paleostress regime, deformation rates, and sedimentary consequences; 2) the study of the relationships among the various metasedimentary basins; 3) the sedimentary and tectonic evolution of Late Cretaceous-Recent basins; 4) the paleontological study of the basins, focusing on those formed in front of the collision zones in order to constrain better the chronology of key geological events. These goals involve nine DARIUS projects led by:

M. Marroni (University of Pisa, Italy) will study the IAESZ. Currently published data and a lack of detailed study have led to controversial suggestions on paleogeographic setting, opening and closure ages of the relevant oceanic basins from which the Intrapontide ophiolites have been derived and of the tectonic evolution of the complexes involved in the Sakarya terrane.

S. Cirilli (University of Perugia, Italy) will revisit the stratigraphy of Antalya nappes, which are considered as having been derived from the southern branch of Neotethys. This multidisciplinary research will include magnetostratigraphic, biostratigraphic, sedimentological and paleogeographic studies of the Late Triassic to Triassic-Jurassic series to provide a high-resolution stratigraphic framework and to constrain paleolatitudinal position with paleomagnetic data.

A.H.F. Robertson (University of Edinburgh, United Kingdom) will focus on the evolution of the Arabian margin of SE Turkey. This project aims to determine the sedimentary, structural and magmatic processes related to the transition of the rifted passive margin of Arabia in SE Turkey into a collisional setting, involving several stages of foredeep sedimentation, ophiolite/olistostrome emplacement, collision related deformation and post-collisional neotectonics.

R. Oberhansli (University of Potsdam, Germany) is studying the metasedimentary basins that exhibit subduction related H-P blue-
The Zagros fold belt is a NW-SE trending orogen formed by five parallel structural domains, which record the entire geodynamic evolution of the mountain range from the Late Cretaceous to Present. These domains are, from internal to frontal: the Mesopotamian-Persian Gulf foreland basin, the Fold Belt, the Imbricated Zone (also called High Zagros or Crush Zone), the metamorphic and magmatic Sanandaj-Sirjan Zone and the Urumieh-Doktar magmatic arc.

It is worth noting that the large anticlines buried beneath the foreland basin and the Fold Belt in both Dezful and Kirkuk embayments in Iran and Iraq, respectively, hold the largest fold and thrust belt oil and gas province in the World.

The E-W trending Makran accretionary prism constitutes the SE tectonic continuation of the Zagros Fold Belt actually developed on top of the active oceanic subduction of the Arabian Sea lithosphere. Its evolution also started during Late Cretaceous times. From N to S the Makran prism comprises the volcanic arc and fore-arc basin together with the older accretionary prism onshore separated from the offshore frontal Makran front. The offshore Makran fold and thrust belt deforms thick Miocene to Pliocene deposits.

The Zagros fold belt and Makran accretionary prism were important objectives of the completed MEBE Programme encompassing a large number of projects that gave important results on both tectonic domains. Much of these can be found in the Geological Society of London Special Publication mentioned elsewhere in this newsletter. Six papers on the Zagros and two papers on the Makran prism were also published in an edited book on “Thrust Belts and Foreland Basins” from Springer by scientists that participated in the MEBE Programme.

Given the previous MEBE results most of the DARIUS scientific objectives are located away from main Zagros Fold Belt. Two DARIUS projects are being carried out in the Zagros-Makran tectonic domain: one by Vergés and Beamud (Barcelona) aimed at documenting the timing of Neogene deformation and its partitioning in Zagros (in Iran and Iraq) and one by Burg (Zürich) and Tajik and Iranian colleagues mapping out the structural and stratigraphic relationships across the South Sistan Suture Zone.

This is a north-south trending belt in eastern Iran (see the figure) between the Lut and Afghan continental blocks, resulting from the closure of a small branch of the Tethys Ocean. The Makran project emphasizes the importance of early (pre-Oligocene) tectonics in understanding the history and regional geodynamics of the Makran. Field mapping is combined with a variety of techniques including satellite image interpretation and new geochronology on ash layers to correlate units across the basin, which has not previously been done.
The definition of the different domains that formed Iran in Late Palaeozoic-Middle Triassic times is one of the major problems concerning the understanding of the pre-Cimmerian and Cimmerian evolution of Central Iran. The reconstruction of the complex post-Cimmerian history of the area is, in fact, strictly related to its Palaeozoic and early Mesozoic ancestry. The idea that Iran consists of more than one block is directly related to its complex setting, due to the occurrence of several ophiolitic belts, which record the repeated opening and closure of oceanic basins through Mesozoic and Tertiary times, and to the activity of large active intracontinental faults, dividing the area in several partially independent blocks.

Central Iran refers to the internal part of Iran and is a very complex and still poorly known area. Its most peculiar feature is the occurrence of a late Mesozoic ophiolitic “ring”, which delimits its most internal part. Central Iran is also affected by large active strike-slip faults. The enigmatic left-lateral Great Kavir - Doruneh fault system to the north, crossing the northern part of Central Iran bounds at present the deformational system to the north. Active deformation is accommodated within Central Iran by N-S trending dextral faults, which separate the major blocks of Central Iran, the Yazd, Tabas and Lut blocks.

According to recent stratigraphic studies, southern Alborz as well as the Yazd, Tabas and Lut blocks, were part of the stable northern margin of Gondwana during most of the Late Palaeozoic. On the other hand, the occurrence of a Late Palaeozoic to Triassic active margin has been recently documented south of the Great Kavir Fault between Anarak and Jandaq, implying a sharp separation between the regions of Central Iran located north and south of this structure. The occurrence of this Carboniferous to Eo-Cimmerian accretionary wedge within Central Iran has been explained by the displacement of a large fragment of the Palaeotethys suture once located between Mashhad and Afghanistan along the southern margin of the Turan domain. According to this interpretation, the Late Cretaceous opening of the Nain-Sabzevar ocean in a back-arc position, as a consequence of the Neotethys subduction below the Sanandaj-Sirjan zone, separated the accretionary complex from the Turan domain and was successively transported within Central Iran during the closure of the basin in Late Cretaceous – Palaeocene times. This interpretation follows the idea, already proposed in the past, that a large counter-clockwise rotation (135°) of the internal part of Central Iran accompanied these processes.

Nevertheless, several inconsistencies arise when considering the mechanisms of emplacement of the Jandak-Anarak terranes. In particular, new paleomagnetic results on the area of Nakhlak, located north of the Anarak accretionary wedge, as well as other geological data collected during the MEBE Programme, strongly question the amount of rotation postulated by most authors. In fact, primary magnetic components, when compared with reference European directions, suggest an Eurasian affinity of Nakhlak, and no significant vertical axis rotations of the area can be recognized since the late Early Triassic. A further geological argument against a large counter-clockwise vertical axis block rotation of Central Iran is given by the areal distribution of the Upper Silurian/Lower Carboniferous successions, which is consistent with their present-day distribution contradicting a large rotation of the whole region.

In addition, several authors have noted a strong affinity between the arc-related successions of the Aghdarband Triassic basin located east of Mashhad on the southern margin of Eurasia and those of Nakhlak in Central Iran, being part of the Cimmerian active margin. This supposed correlation has been used to state that these localities were part of the same Palaeotethyan convergent margin, and that the Nakhlak succession was originally close to Aghdarband being both part of the same trench-slope interval. Based on new paleontological studies on ammonoid faunas, the possible proximity of the two localities has been questioned, as they show markedly different paleogeographic affinities.

Most critical for the reconstruction of the post-Cimmerian evolution of Iran is the understanding of the evolution of the ophiolitic ring surrounding the internal part of Central Iran. The more than 700 km long N-S trending Sistan Suture, located between the Lut block of Central Iran and the Helmand block in Afghanistan, represents one of the most intriguing and less known areas in Iran. It may represent a Cretaceous branch of the Neotethys, opening in a back-arc position, which later closed due to subduction below the Helmand block between Late Cretaceous and Eocene times. The reconstruction of its extension and evolution bears severe consequences for palinspastic reconstructions. The E-W trending Sabzevar suture zone bounding Central Iran to the North is also considered to be part of the Neotethys, linked to the Sistan Ocean, later turned to a collisional orogenic belt. HP metamorphic rocks and arc-related magmatic products here suggest the occurrence of a Late Cretaceous to Early Tertiary subduction zone. Numerous
questions remain open on the evolution of the two suture zones, including the exact age and nature of the oceanic domains, relationships among subduction processes, ophiolite obduction, magmatic activity, HP metamorphic rocks exhumation, and evolution of related basins. In the frame of this complex tectonic puzzle, several projects within the DARIUS Programme will be devoted to specific aspects of the evolution of Central Iran and related regions. Two projects will focus respectively on the pre-Cimmerian to Cimmerian stratigraphic evolution of the area (M. Balini) and to its relations with the Palaeotethys suture zone recorded in NE-Iran (A. Zanchi). Three projects will be devoted to the analysis of

Central Asia represents an unusually complicated collage of different aged tectonic blocks and zones both of accretion and collision character, with associated suture zones. The evolution of the area can be divided into three main stages. The first one, from Proterozoic to Late Palaeozoic-Early Triassic, corresponds to the assembly of stable Central Asia as a collage of blocks juxtaposed during the closure of Asian oceanic basins (Turkestan, Junggar, Uralian...). The second stage, from mid-Triassic to Late Jurassic, corresponds mainly to the closure of Palaeotethys and collision of Cimmerian blocks (detached earlier from Gondwana) with the southern Eurasian margin. During the third stage, in the Cenozoic, the tectonics of the Central Asia domain is dominated by Alpine deformation associated with the collision of India and Arabia, distributed in the 3000 km-long large orogenic belts running from the Caspian Sea to the west to the Pamir and Tien Shan range to the east.

North of this belt, several basins settled in the little deformed Turan and South Kazakh platforms. For example, the Chu-Sarysu basin mainly evolved since the mid-Palaeozoic, Amu-Darya since the Late Permian-Early Triassic and Syr Darya basin since Jurassic?-Cretaceous times on folded Palaeozoic basement. The large area lying north of the Kopeh-Dagh/Tien Shan/Pamir orogenic belt is mainly covered by Upper Permian to Quaternary sedimentary successions. But there is a lack of tectonic and stratigraphic correlation at a regional scale. This is the case, for example, in the thick Late Triassic to middle Jurassic clastic series, rich in organic matter, that resulted from the erosion of relief created during terrane assembly. New dating and correlation will help in understanding the regional geological evolution of the area. The most recent deformation of this area evidently occurred in an intraplate setting.

The present day Tien Shan mountains now lie more than 3000 km or more north of the India-Eurasia plate boundary; they were within the Asian land mass when India-Asia collision began some 50 My ago. A similar situation holds for the Pamir. Thus, the present-day geology, including its numerous sedimentary basins and intervening uplifted areas including basement rocks, represents an intricate “convolution” of a series of crustal forming and deforming events from the Late Palaeozoic onwards.

A significant amount of new work was undertaken and new ideas on the tectonic and stratigraphic evolution of western Central Asia developed during the last twenty years but these data typically deal either with particular basins or mountain belts, or specific disciplines of investigation. A general understanding of the regional tectonic and stratigraphic evolution of the area is not yet clearly established.

The Late Palaeozoic is the point of departure of Darius study. Early to middle Palaeozoic orogenesis culminated with a Late Palaeozoic or Early Mesozoic final collision of microcontinents with Eurasia in the western Central Asia area, including, for example, the Karakum microcontinent in the case of Turan Plate and an unspecified continental entity in the case of the Seythian Plate. The Tien Shan orogeny was initiated at this time by collision of the Karakum-Tarim continent with the Palaeo-Kazakhstan continent, such that the western part of the Tien Shan in Kyrgyzstan and Uzbekistan is composed of a northern segment
being the deformed margin of the Palaeo-Kazakhstan continent and a southern segment being the intensely deformed accretion collision complex. Iranian blocks collided with Eurasia around the mid to Late Triassic inducing the Eo-Cimmerian orogeny. Then, towards the east, the central Afghan block, South Pamir and Tibet collided with the Eurasian margin before the end of Jurassic. Timing of these collisions is not well established, a more precise tectonic calendar and the impact of tectonic events on basin evolution is one aim of the Darius Programme. Further north in Eurasia, basins underwent inversion or a simple change in type of sedimentation after these collisional times.

In summary, the tectonic evolution of the western Central Asia area since Late Palaeozoic is complex. It includes several phases of basin opening and inversion, and of collisions of “blocks” with the Eurasian margin. In large areas of this domain, in folded belts, basins and platforms, data are very scarce or simply lacking. No integrated model of regional tectonic evolution integrating various types of data from the Late Palaeozoic to the Cenozoic has been proposed. Such a model would be a key contribution to the overall goals of the DARIUS Programme.

Ten projects have been funded by the DARIUS Programme in its first year on the western Central Asia domain: some deal mainly with the evolution of sedimentary basins as the others focus on inversion of basins and evolution of mountain belts. Among the last, two projects are related to Pamir, three to Tien Shan and one proposes a transect between the two belts.

C. G. Langereis (University of Utrecht, The Netherlands) is studying the geodynamic and paleoclimatic evolution of the Caspian Sea during the deposition of the Maikop (Oligo-Miocene source rocks) and Productive Series (Mio-Pliocene deltaic deposits). Due to continental collision, Paratethys evolved from open oceanic into restricted marine and, ultimately, into lacustrine environments. M.-F. Brunet (Université P. & M. Curie, France) aims at proposing a geodynamic scenario for the Mesozoic sedimentary basins formation in the South Caspian-Amu Darya area and their subsequent evolution. This area is of particular interest as it is located at the junction of Scythian-Turan platforms in the north and some Cimmerian blocks (Iranian and Afghan) in the south. Two companion projects deal with the sedimentary basins in southern and central Uzbekistan with two different approaches. T. McCann (University of Bonn, Germany) is mainly interested in paleogeography and the tectonics of sedimentation while R. Stephenson (University of Aberdeen, United Kingdom) and I.P. Sidorova (Institute of Geology and Geophysics, Uzbekistan Academy of Sciences, Tashkent) take a more geophysical and modelling approach of the post-Permo-Triassic basin development and orogenic belt evolution.

L. Angiullini (Università degli Studi di Milano, Italy) and V. Davydov (Boise State University, USA) are investigating the Permain sedimentary succession of SE Pamir (Tajikistan), its evolution and the biotic change of this part of the Cimmerian terranes and will compare it with the evolution of Iran, and specific Cimmerian blocks studied there during the MEBE Programme. L. Ratschbacher (Technische Universität Bergakademie Freiberg, Germany) and V. Minaev (Geology Institute of the Tajikistan Academy of Science, Tajikistan) are deciphering the burial, deformation, and exhumation history of the northwestern part of the Tajik basin and will relate its evolution to the tectonic evolution of its hinterland, the Pamir orogen.

H. Echtler (GFZ German Research Centre for Geosciences, Germany) and A. Mikolaichuk (Bishkek, Kyrgyz Republic) study the structure and the Meso- to Cenozoic evolution of the Chu Basin (Kyrgyzstan and Kazakhstan) within the northern foreland of the Tien Shan collision. E. R. Sobel (Universität Potsdam, Germany) and A. Mikolaichuk (Bishkek, Kyrgyz Republic) investigate the timing of Cenozoic deformation within the Tien Shan collision zone in western Kyrgyzstan. They will use low temperature thermochronology (apatite fission track and U-Th/He methods) to constrain the onset of exhumation in the Chatkal Range.

C. Robin (Université de Rennes 1, France) aims at examining recurrent meso-Cenozoic reactivation of inherited structures in the Tien Shan Range and their effects on sedimentation into associated basins with a multi-disciplinary study, with tectonic thermochronological, sedimentological and sequence stratigraphy.

Y. Rolland (Université de Nice-Sophia Antipolis, France) aims at deciphering the structure and geodynamic evolution along a Tien Shan – Pamir transect, on the orogen-scale, and some detailed investigations in key structural areas in order to establish a calendar of tectonic events along the transect, with the goal of inferring its bearing on basin evolution (Kyrgyzstan and Tajikistan).

The scope of the study area is the Alpine orogenic belt affected by Arabia-Eurasia collision at the scale of the lithosphere. This includes the westward escape of Anatolia, the Zagros fold and thrust belt and its south-eastern continuation along the Makran, as well as the northern orogenic belts such as the Caucasus, the Alborz, the Kopet Dagh, and the Absheron. The project also necessarily concerns the associated neighbouring sedimentary basins (the Mesopotamian foreland, the Caspian Sea basin and the Turan platform).

The long-lived convergence of Arabia and Eurasia has resulted in complicated lithospheric structures that until now have only been studied in certain areas. A first impression of the important lateral variations that exist can be obtained by looking at the geoid of the region (in the figure). Variations of up to 30 m over relatively short distances occur between eastern Anatolia and the Caucasus and between the South-Caspian Basin and the Mesopotamian
foreland. The most prominent horizontal gradients of the geoid are found in the Zagros, the eastern Caspian Sea and north of the Kopeh Dagh. Global seismic tomography models of the area show similar patterns, with strong lateral velocity variations, low velocities being related to geoid highs.

Detailed crustal structure is available in certain parts of the DARIUS study area from seismic surveys, mostly 1D receiver function analyses, in particular in eastern Anatolia but also in the Alborz region and on the Arabian peninsula. For the northern basins, some large-scale refraction seismic data exist and reflection seismic data in the Caspian Sea have been published. Potential field models exist for Anatolia and Iran and a model integrating geoid and topography data has also been published for the south-eastern Zagros. Geodynamic modelling in the region has generally been limited to studies of strain partitioning in the Zagros and the escape of Anatolia. However, no combined regional study exists so far.

The history of the subduction of Tethys oceanic lithosphere towards the NNE and the subsequent collision of the Arabian and Eurasian plates is well studied, including, for example, the wide-ranging activities of the earlier Peri-Tethys project. However, the models of the combined evolution of the Turkish segment of the suture, the Zagros and its continuation towards Makran in the SE are rather controversial.

The DARIUS lithospheric modelling project, over three years, aims to clarify the actual lithosphere structure and, subsequently, at delimiting possible dynamic scenarios that led to these structures. The scientific objectives can be summarized in four main topics: 1) crustal and lithospheric mantle structure and temperature distribution; 2) lateral variations of mechanical properties of the lithosphere in terms of rigidity and elastic thickness; 3) large-scale deformation related to the Arabian-Eurasian plate collision and strain partitioning between the Anatolian, Caspian and Iranian blocks; and 4) vertical movements in the Neogene.

To accomplish the proposed objectives a complete lithospheric model across the Arabia-Eurasia collision zone will be constructed. Once this model is ready, during the first year of the project, its predicted rheological structure will be used to calculate a fully dynamic model based on a thin-sheet approach, in which the dynamics of lithospheric deformation and surface processes are fully coupled. Deformation is calculated as that of a thin viscous layer with a vertically averaged rheology and subject to plate stresses. Surface processes are incorporated by quantitatively considering erosion, transport and sedimentation related to the model’s evolving topography.

Localizing potential lithospheric anomalies in this way can give an indication of probable vertical movements. The timing and amplitude of these provide important information for understanding geodynamic processes. The numerical modelling predictions have, however, to be verified by independent observations, such as thermochronology based mainly on fission track data. Three main areas are to be targeted during the second year of the DARIUS Programme: the northern and central inner part of the Zagros in order to test models of possible slab break-off; the Alborz Mountains and the Kopeh Dagh to gain insights into the behaviour of and role played by the South-Caspian block.

As in the Peri-Tethys and MEBE Programmes, a Geographic Information System (GIS) will be used to manage the data gathered during geological fieldwork and laboratory analyses by the participants of Darius. As before, the resulting geodatabase will be an effective tool in preparing the final Darius paleotectonic maps, which synthesize the geological results of the programme. In such a system the G of GIS can be replaced by Geology and that is why we say GeoIS. In the Darius Programme, GeoIS will continue to be developed. New data domains will be included and new specific tools will be implemented in the user interface. The goal is to provide an interactive interface between Darius team observations, analyses and syntheses and the users.

The fundamental differences between GIS and GeoIS relate to time and to georeferencing. In a GIS, such as one dealing with the infrastructures or the cadastral parcels of a town, the localization remains essentially the same through time. This is not the case in a GeoIS, which concerns the evolution of geological objects. Depending on the block to which the object belongs and the considered time-slice, its position on the Earth will change. The paleoposition of any data depends on its present position and the kinematic parameters associated with the block on which the observed object has formed. Eulerian geometrical rules allow the paleoposition to be computed, taking into account the finite rotation pole parameters. Therefore, to plot a simple observed outcrop on a paleotectonic map, the system needs a database with (i) the present day latitude and longitude of the observation; (ii) the object age so that, for example, an Aptian phenomenon is not drawn on a Callovian map and because the location of any object on the Earth depends on the relevant time period; and (iii) the block to which the object belongs. This is linked to another database having the finite rotation parameters for each block and, for each oceanic anomaly, the latitude, the longitude and the rotation angle and, in turn, a database of oceanic anomalies and their respective ages. Thus, a GeoIS links a number of different databases and also the rules related to the behaviour of the incorporated data. Thanks to Euler, the same famous mathematician of
eulerian geometry, we have graph theory and thanks to Cantor we possess set theory. Mathematics gives us the rules to implement the functions to classify, to link and to manage such a large amount of data.

The DARIUS GeolIS will not only manage the paleogeographical positioning of observations but also the descriptions of observed objects and relevant analytical results. It will also manage the present day geographic and geological maps. The topographic background will be available as two distinct DEMs (Data Elevation Model), generated from the Shuttle Radar Topographic Mission (SRTM) dataset with spatial resolutions of 30’’ (900m) and 3’’ (90m) respectively. Bathymetry will be derived from the GEBCO (General Bathymetric Chart of the Oceans) dataset. Other maps, in particular geological maps, which can be considered to be interpreted data syntheses, are overlain on the base maps. Published geological maps at scales ranging from 1:200 000 to 1:1 000 000 will be georeferenced for the DARIUS realm. Some maps will be included in digital format. Actually any kind of georeferenced map (remote sensing data, geophysical maps, etc…) can be added to the map set found in GeolIS.

Besides these geographical and geological cartographic databases, various types of geological information concerning the Late Palaeozoic to Present geological evolution of the DARIUS realm will be managed with the DARIUS GeolIS. Two main sets of information are included: currently published data and new, original data gathered by the Darius project teams. For each set, two information levels are defined: interpreted data and raw data. The first comprises two orders: the 1st order data are regional synthetic geological data including various types of regional logs (stratigraphic, sedimentological, tectonic...), across-the-board cross sections and synthetic regional maps; the 2nd order data are mainly illustrations of local data such as local logs, local sections, landscape pictures and any other kind of diagram. These illustrations, like the 1st order ones, are linked to other detailed illustrations. The raw data are the 3rd and 4th order data. They concern the objects observed at the outcrop and sample scale. The 3rd order data are stored in tables where, besides geographical location, attributes describing the geological context of the object outcrop (formation name, lithology, environmental facies, age, structural unit...) are also incorporated. Finally, the 4th order data are detailed in tables in which the attributes code the description of the object. For each object domain (tectonics, paleostress, biostratigraphy, sedimentary petrology, metamorphism...) a specific descriptive table or set of tables is to be designed.

The different datasets and object classes taken into account to conceive the database structure of the DARIUS GeolIS have been briefly described above. The data models required to develop the DARIUS GeolIS, however, cannot be explained in few lines given the extraordinary heterogeneity of the various data and the complexity of the relations between them. For example, formation entity appears in the 3rd order data tables, is detailed in the 4th order tables, could be illustrated in a 2nd order dataset and correlated in a 1st order synthesis. The development of such a geological Rubik’s cube needs strong coordination between the geological discipline specialists and the GIS specialists, particularly for the 4th order data and the specific rules used in each specialty. This is the objective of the DARIUS GeolIS team: Bruno Vrielynck - CNRS, Database Manager; Eric Barrier - CNRS; Jean-François Brouillet - CNRS; Marie-Françoise Brunet - CNRS; Isabelle Morgant – Université P. & M. Curie; Danièle Pasquier - Université P. & M. Curie.


Paleonteconic map of the eastern Tethys realm between Turkey and Iran in the early Campanian. This Atlas, published in 2008, is one of the most important final products of scientific researches carried out in the MEBE Programme. Data collected by the several contributors were managed in the MEBE database and then represented in a set of 14 maps of significant steps in the evolution of Middle East.

The DARIUS Programme will produce a set of 17 palinspastic maps depicting the tectonic evolution of the DARIUS domain since the Late Palaeozoic. These maps will include as well the tectonics, geodynamics and lithologies for the chosen periods.
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