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Development of concepts concerning the Troodos ophiolite in Cyprus

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Abstract

The foundations for study of the Troodos ophiolite and adjacent units in Cyprus were laid down by systematic mapping by the Cyprus Geological Survey Department (1952–1970). Prior to the late 1950s, Cyprus geology was interpreted in classic geosynclinal terms.

The first, integrated description of the Troodos was given by Gass & Masson Smith in 1963. Publication of the Vine & Matthew's (1963) sea-floor spreading hypothesis was followed by Ian Gass's key interpretation in 1968 of the Troodos as oceanic lithosphere formed by sea-floor spreading. During the early 1970s, the dominant view of the Troodos was of a mid-ocean ridge, formed by spreading at a narrow, linear spreading zone, fed by a single, axial magma chamber. However, early geochemical studies suggested that genesis could have taken place above a subduction zone.

During the 1980s, drilling related to the International Cyprus Crustal Study Project stimulated much new field work. By 1990 a popular view of the Troodos was that it had formed above a northward-dipping subduction zone during the earlier stages of convergence within an oceanic basin, similar in some respects to the origin of SW Pacific forearcs. Others favoured an origin as a marginal basin formed by spreading above a southward-dipping subduction zone, either in the vicinity of Cyprus, or located in central Turkey. In whatever scenario, it is generally accepted that the spreading fabric was unstable and was fed by small, multiple magma chambers. The extension outpaced magma supply and this favoured extensional detachment faulting, mainly near the base of the sheeted dykes. The Troodos lithosphere was also bounded by an oceanic fracture zone to the present south.

Studies of the Late Cretaceous-Recent sediment cover have documented deep-sea sedimentation and later uplift, related to Africa-Eurasia convergence. In W Cyprus, the adjacent Mamonia Complex was pieced together as a Mesozoic passive margin bordering a small ocean basin, although whether this was a Red Sea-type basin, or a backarc marginal basin is still debated. The Mamonia lavas and sediments were juxtaposed with the Troodos ophiolite by processes, variously interpreted as subduction/accretion, oceanic transform faulting, strike-slip, collision and/or palaeorotation of a Troodos microplate.

The Kyrenia Range in N Cyprus also includes remnants of Mesozoic passive margin; it was emplaced in stages apparently by a combination of strike-slip and thrusting. On a regional scale, the Troodos ophiolite preserves part of one of a number of inferred small oceanic basins within the Mesozoic Tethyan area of the Eastern Mediterranean.

Contrasting modes of ophiolite emplacement in the Eastern Mediterranean

The Eastern Mediterranean region is characterized by one of the largest concentrations of ophiolites anywhere in the world. Many of these ophiolites are fragmentary or highly deformed, such that their initial mode of tectonic emplacement cannot easily be inferred from the local field relations. The emplacement of many of these ophiolites can usefully be compared with the intact Oman ophiolite, one of the largest and best-studied ophiolites in the world.

The Oman ophiolite is commonly believed to have been created in Late Cretaceous time (c. 95 Ma) above an oceanward-dipping, intra-oceanic subduction zone. This was followed by collision of the subduction zone with the downflexed Arabian passive margin, facilitating the emplacement of the ophiolite onto the continental margin. A less likely alternative is that the Oman ophiolite formed at a mid-ocean ridge that then collapsed, initiating the emplacement of the ophiolite.

This Oman-type model is applicable to many of the Mid-Jurassic and the Late Cretaceous ophiolites of the Eastern Mediterranean region that were thrust over former passive continental margins. These ophiolites are again mainly of suprasubduction-zone type. Such ophiolites include many of the Jurassic ophiolites of Greece, Albania and former Yugoslavia, and also the Late Cretaceous ophiolites of Turkey and northern Syria. These ophiolites were emplaced from both more northerly and southerly Neotethyan ocean basins.

In contrast, the opposing (northerly) margins of these oceanic basins experienced a history of subduction-accretion, marginal arc volcanism and back-arc basin formation ('Cordilleran-type' ophiolites). Ophiolites that were emplaced associated with active margin settings range from large accreted thrust sheets to small slices within accretionary prisms and back-arc basins. Examples include the Late Cretaceous ophiolites that are related both to the northern margin of the southern Neotethys and to the northern margin of the northern Neotethys in Turkey.

Not all ophiolites were emplaced in response to large-scale horizontal tectonic transport (e.g. Jurassic Guevgueli ophiolite, northern Greece), and several ophiolites experienced dominantly strike-slip or transpression (e.g. the Late Cretaceous Antalya ophiolites, SW Turkey). In general, the mode of ophiolite emplacement, especially the direction of emplacement relative to the orientation of the adjacent continental margin was influenced by the regional palaeogeographical setting.

fluid-rock interactions in ocean ridge hydrothermal systems

Rb-Sr isotopic compositions of rocks and minerals from the Troodos ophiolite have been analysed to constrain the rate limiting mechanisms that control fluid-solid exchange, the extent to which recharge fluids were channelled and the thermal evolution of oceanic hydrothermal systems. Systematic regional sampling has confirmed the Sr-isotopic alteration profile suggested by Bickle & Teagle (1992). This has been previously interpreted as a consequence of recharge fluids percolating down through the extrusive series with kinetically limited fluid-rock interaction but altering the underlying ≈1 km section of sheeted dykes with near equilibrium fluid-rock Sr-isotopic exchange.

Detailed Sr-isotopic profiles reported across structural heterogeneities such as pillows, dyke margins and faults have failed to show isotopic gradients related to channelling of fluid. Rather the fluid flow in the recharge was pervasive and the degree of alteration is largely controlled by the extent of mineral recrystallization, primarily by albitization of plagioclase, and to a lesser extent by recrystallization of pyroxene. Hydrothermal recharge should cool the sheeted dykes much faster than the progression of the Sr-isotope alteration through the crust and rocks at greenschist facies (~250°C) or higher temperatures are predicted only to be found within a few hundred metres of the basal boundary layer of the system. The alteration pattern on Troodos with a zone a kilometre or more in thickness altered at greenschist facies temperatures and with significant Sr-isotope exchange is thus not easily explained.

Alternative tectonic models for the development of Tethys

A summary and discussion is given of alternative models of the Late Palaeozoic - Early Tertiary tectonic evolution of the Tethyan orogenic belt in the Eastern Mediterranean region, based on recent information (1996).

Model 1 (Robertson & Dixon 1984). A single Tethyan ocean continuously existed in the Eastern Mediterranean region, at least from Late Palaeozoic onwards. The dominant influences were episodic northward subduction of Tethyan oceanic crust beneath Eurasia, and the northward drift of continental fragments, from Gondwana towards Eurasia. During the Mesozoic, the south Tethyan area was interspersed with Gondwana-derived microcontinents and small ocean basins. Ophiolites formed mainly by spreading above subduction zones in both northerly (internal) and southerly (external) oceanic basins during times of regional plate convergence, and were mainly emplaced as a result of trench-passive margin collisions. In a related model, Stampfli et al. (1991) argued for spreading along the North African margin in the Late Permian.

Model 2A (Dercourt et al. 1986). Only one evolving Tethys existed. Triassic-Jurassic oceanic crust (Neotethys) formed in a single Tethyan ocean basin located north of Gondwana-related units. Spreading later formed a small ocean basin in the present Eastern Mediterranean Sea area during the Cretaceous. Jurassic and Cretaceous ophiolites formed at spreading ridges and record times of regional plate divergence. In an update version, Model 2B (Dercourt et al. 1993), spreading extended along the northern margin of Gondwana, with an arm extending through the south Aegean, splitting off a large microcontinent. Further spreading in the Cretaceous then opened the Eastern Mediterranean basin and fragmented pre-existing carbonate platforms. The Mesozoic ophiolites were seen as being mainly far-travelled from northerly (i.e. internal) orogenic areas.

Model 3 (Şengör et al. 1984). Subduction in the Late Palaeozoic was dominantly southwards, beneath the northern margin of Gondwana in the Eastern Mediterranean. This subduction led to opening of Triassic backarc basins; and a rifted Gondwana fragment (Cimmeria) drifted across a pre-existing Tethys (Palaeo-Tethys) to collide with a passive Eurasian margin. In this model, a backarc basin (Karakaya Basin) rifted and then closed prior to collision of a Cimmerian microcontinent in the Mid Jurassic, and this was followed by renewed rifting of a small ocean basin in the Early Jurassic. Mesozoic ophiolites mainly formed above subduction zones; they were variously seen as far-travelled (in the 'Greek area'), or more locally rooted (in the 'Turkish area').

Recent evidence shows that difficulties exist in detail with all three models. However, four key elements are met in Model 1: dominantly northward subduction in the north; multiple ocean basins from Triassic onwards in the south; supra-subduction spreading of the major ophiolites; and emplacement from both northerly and southerly Mesozoic oceanic basins. Palaeomagnetism has played an important role, in setting the large-scale Africa-Eurasia relative motion framework and in providing tests for the tectonic affinities of smaller units, but such smaller-scale studies have often been compromised by the geological complexity and by the remagnetisation of tectonically thickened units.

The Mediterranean region has been one of the most intensely studied segments of the Alpine-Himalayan chain. Geological and geophysical studies have shown that the region represents a mosaic of microcontinental and ophiolitic terranes, resulting from a sequence of strike-slip and closure movements between the African and Eurasian margins of the Tethyan Ocean. Numerous early palaeomagnetic investigations suggested that many of these terranes underwent important tectonic rotations with respect to the major continents, e.g. the Iberian peninsula (Van der Voo 1969), Sardinia and Corsica (Westphal 1977), the Ionian Islands (Laj et al. 1982), and the Troodos ophiolite (Moores & Vine 1971). These rotations occur in a variety of geological settings, ranging from those active during oceanic crustal genesis to those associated with the late stages of continental deformation. More recent palaeo-magnetic studies have provided an increasingly detailed picture of rotational deformation from the Atlantic margin to eastern Turkey. Tectonic rotations are now recognized on all scales from that of microplates down to individual thrust sheets. The papers contained in this volume, cover the full range of tectonic, magnetostratigraphic and archaeomagnetic problems currently being addressed in the region. Together they form a comprehensive review of an exciting and challenging field of research. To increase the usefulness of the volume to non-palaeomagnetists, a full glossary of palaeomagnetic and rock magnetic terms is provided.

Subduction and incipient continental collision in southern Cyprus

Evidence mainly from Neogene–Recent sedimentary units and penetrative structures (faults and folds) is used to constrain stress regimes in Cyprus. Following c. south-vergent folding/thrusting, a regional change to extension activated several depocentres during the Late Miocene–Early Pliocene. Fault analysis establishes that kinematic linkages existed between the four Late Miocene basins in southern and western Cyprus. During Late Pliocene(?)–Early Pleistocene time there was a switch to c. east–west left-lateral strike-slip/transpression and fault reactivation.

Late Pleistocene growth folding in western coastal Cyprus is explained by reactivation of extensional faults in a left-lateral stress regime. The timing of neotectonic faulting/folding in several areas is constrained by optically stimulated luminescence dating. Existing tectonic models involving north–south collision, left-lateral strike-slip and post-collisional suture tightening are problematic in certain respects. A new model is proposed in which Late Miocene extensional basin formation relates to northward subduction coupled with rollback of the African plate. Subduction culminated in collision of the Eratosthenes Seamount, the leading edge of the African plate, with the Cyprus active margin (c. 3 Ma). This initiated regional uplift focused on the Troodos Massif. Cyprus was by then coupled with Anatolia as it escaped westwards towards the Aegean subduction zone, giving rise to dominantly strike-slip-related structures in southern Cyprus during the Late Pliocene–Recent.

The Upper Cretaceous volcaniclastic Kannaviou Formation

The Kannaviou Formation (up to 750 m thick) accumulated in a deep-sea setting in west Cyprus during Campanian–Early(?) Maastrichtian time and provides evidence of a southerly Neotethyan volcanic arc. The formation depositionally overlies Upper Cretaceous ophiolitic lavas, including those associated with serpentinite-hosted arcuate lineaments. The Kannaviou Formation locally overlies ophiolitic serpentinite, indicating that mantle rocks were exposed on the seafloor prior to sediment deposition. Geochemical analyses of basalts that depositionally underlie the Kannaviou Formation, within the arcuate lineaments, indicate close similarities with the boninitic lavas of the South Troodos Transform Fault Zone in south Cyprus. Abundant volcanogenic and minor terrigenous and pelagic sedimentary rock material is present within the Kannaviou Formation, while kaolinite is common within interbedded red clays. Suitable terrigenous source lithologies are present in the deformed continental margin/deep-sea sedimentary rocks of the Mamonia Complex in west Cyprus. Whole-rock chemical analysis of sandstones of predominantly volcaniclastic origin indicates an intermediate arc-like composition. Electron microprobe analysis shows that glass is silicic, with a tholeiitic fractionation trend. Similar arc-like volcanic rocks of Late Cretaceous age are exposed in the western Kyrenia (Girne) Range, in north Cyprus. The provenance of the Kannaviou Formation provides evidence of Late Cretaceous northwards subduction of the South Neotethys beneath a continental margin to the north.

Constraints in Timing of Uplift of the Troodos Massif

Plio-Pleistocene sediments exposed around the ophiolitic Troodos Massif document spectacular uplift from below sea level to a maximum height of c. 2000 m. Sedimentation reflects a dominant control of focused tectonic uplift, modified by the effects of glacio-eustatic sea-level change and climatic change. Understanding the uplift and controls on deposition has been hindered by an inadequate age model. This 2010 paper presents a preliminary investigation of the polarity of remanent magnetizations recorded within the upper part of the Pliocene succession in the Pissouri and Mesaoria basins and from the Pleistocene marine terrace deposits that border the Troodos Massif. When integrated with available lithostatigraphic and biostratigraphic data, the main results are as follows.

Focused uplift of the Troodos Massif began during the Late Pliocene, either between 2.14 and 1.95 Ma or immediately prior to 1.77 Ma. Shallow-marine, ophiolite-derived clastic and bioclastic sediments accumulated in both the Mesaoria and Pissouri basins, implying that the Troodos Massif was uplifted as a single tectonic entity. Non-marine, deltaic and fluvial facies prograded into both of the basins during the Pleistocene (1.77 Ma–recent). Marine terraces in SW and south Cyprus were cut and covered by littoral sediments from <0.78 Ma, suggesting that high rates of uplift of the Troodos Massif persisted into mid- and late Pleistocene time.

Late Pleistocene and Holocene uplift history of Cyprus

The nature of the southern margin of the Anatolian microplate during the Neogene is complex, controversial and fundamental in understanding active plate-margin tectonics and natural hazards in the Eastern Mediterranean region. Our (2013) investigation provides new insights into the Late Pleistocene uplift history of Cyprus and the Troodos Ophiolite. We provide isotopic (14C) and radiogenic (luminescence) dates of outcropping marine sediments in eastern Cyprus that identify periods of deposition during marine isotope stages (MIS) 3, 4, 5 and 6. Past sea-levels indicated by these deposits are c. 95±25 m higher in elevation than estimates of worldwide eustatic sea-level. An uplift rate of c. 1.8 mm/year and possibly as much as c. 4.1 mm/year in the past c. 26–40 ka is indicated.

Holocene marine deposits also occur at elevations higher than those expected for past SL and suggest uplift rates of c. 1.2–2.1 mm/year. MIS-3 marine deposits that crop out in southern and western Cyprus indicate uniform island-wide uplift. We propose a model of tectonic wedging at a plate-bounding restraining bend as a mechanism for Late Pleistocene to Holocene uplift of Cyprus; uplift is accommodated by deformation and seismicity along the margins of the Troodos Ophiolite and re-activation of its low-angle, basal shear zone.

Deformation of the Kyrenia and Ovgos Lineaments in northern Cyprus

During Late Cretaceous–Mid-Eocene the Girne (Kyrenia) Range formed part of the northerly active continental margin of the southern Neotethys. Following Late Eocene–Late Miocene mainly deep-marine clastic deposition, the range was thrust southwards in a convergent (transpressional) stress regime during Late Miocene (Messinian)–earliest Pliocene time. Sinistral transpression is most evident near the front of the range in the east and in several segments, implying strain compartmentalization. The range was relatively quiescent during Early–Mid Pliocene, followed by strong c. east–west-trending uplift during Late Pliocene–Pleistocene.

Further south, the east–west Dar Dere (Ovgos) lineament was active as a north-down extensional (or transtensional) fault zone during Oligocene–Mid-Miocene. Sinistral strike-slip/transpression followed during Late Miocene, followed by strike-slip at least during Late Pliocene–Pleistocene. The latest Miocene–earliest Pliocene thrusting/oblique convergence reflects closure of the southern Neotethys and tightening of the suture between the Arabian (North African) and Turkish (Eurasian) continents. Collision-related uplift of the Girne (Kyrenia) Range and the Troodos Massif further south took place from Late Pliocene time onwards. The Dar Dere (Ovgos) lineament is interpreted as a terrane boundary that was reactivated related to westward tectonic escape of Anatolia during Neogene–Recent time. The structure as a whole reflects regional diachronous continental collision.

Cretaceous to Lower Pliocene sediments in North Cyprus

New age data from Sr isotope analysis and both planktonic foraminifera and nannofossils are presented and discussed here for the Upper Eocene–Upper Miocene sedimentary rocks of the Değirmenlik (Kythrea) Group. New dating based on 87Sr/86Sr isotopic comparison is also given of some Cretaceous and Pliocene sediments. In a revised stratigraphy the Değirmenlik (Kythrea) Group is divided into ten formations. Different Upper Miocene formations are developed to the north and south of a regionally important, E–W-trending syn-sedimentary fault.

The samples were dated wherever possible by three independent methods, namely utilizing Sr isotopes, calcareous nannofossils and planktonic foraminifera. Some of the Sr isotopic dates are incompatible with the nannofossil and/or the planktonic foraminiferal dates. This is mainly due to reworking within gravity-deposited or current-affected sediments. When combined, the reliable age data allow an overall biostratigraphy and chronology to be erected. Several of the boundaries of previously defined formations are revised.

Sr data that are incompatible with well-constrained biostratigraphical ages are commonly of Early Miocene age. This is attributed to a regional uplift event located to the east of Cyprus, specifically the collision of the Anatolian (Eurasian) and Arabian (African) plates during Early Miocene time. This study, therefore, demonstrates that analytically sound Sr isotopic ages can yield geologically misleading ages, particularly where extensive sediment reworking has occurred. Convincing ages are obtained when isotopic dating is combined with as many forms of biostratigraphical dating as possible, and this may also reveal previously unsuspected geological events (e.g. tectonic uplift or current activity).

Eocene development of the northerly active continental margin

This paper focuses on an active continental margin related to northwards subduction during the Eocene in which sedimentary melange (‘olistostromes’) forms a key component. Maastrichtian – Early Eocene deep-marine carbonates and volcanic rocks pass gradationally upwards into a thick succession (<800 m) of gravity deposits, exposed in several thrust sheets. The lowest levels are mainly siliciclastic turbidites and debris-flow deposits. Interbedded marls contain Middle Eocene planktonic/benthic foraminifera and calcareous nannofossils. Sandstones include abundant ophiolite-derived grains. The higher levels are chaotic debris-flow deposits that include exotic blocks of Late Palaeozoic – Mesozoic neritic limestone and dismembered ophiolite-related rocks. A thinner sequence (<200 m) in one area contains abundant redeposited Paleogene pelagic limestone and basalt. Chemical analysis of basaltic clasts shows that some are subduction influenced. Basaltic clasts from unconformably overlying alluvial conglomerates (Late Eocene – Oligocene) indicate derivation from a supra-subduction zone ophiolite, including boninites.

Taking account of regional comparisons, the sedimentary melange is interpreted to have formed within a flexurally controlled foredeep, floored by continental crust. Gravity flows including large limestone blocks, multiple debris flows and turbidites were emplaced, followed by southwards thrust imbrication. The emplacement was possibly triggered by the final closure of an oceanic basin to the north (Alanya Ocean). Further convergence between the African and Eurasian plates was accommodated by northwards subduction beneath the Kyrenia active continental margin. Subduction zone rollback may have triggered collapse of the active continental margin. Non-marine to shallow-marine alluvial fans prograded southwards during Late Eocene – Oligocene time, marking the base of a renewed depositional cycle that lasted until latest Miocene time.

Evolution of Neotethys in the Eastern Mediterranean region

Valid palaeotectonic and palaeogeographical reconstructions of the easternmost Mediterranean and adjacent region involve a long-lived Tethys (Rheic, Palaeotethyan and Neotethyan oceans), northward subduction beneath Eurasia and rifting of continental fragments from Gondwana. Rifted microcontinents bordering Gondwana were separated (from south to north) by the Southern Neotethyan ocean, the Berit ocean (new name), the Inner Tauride ocean and the İzmir–Arkara–Erzincan ocean. Mid-Permian to Mid-Triassic pulsed rifting culminated in Late Triassic–Early Jurassic spreading of the Southern Neotethyan oceans (the main focus of this paper).

After Early–Mid-Jurassic passive subsidence, the Late Jurassic–Early Cretaceous was characterized by localized alkaline, within-plate magmatism related to plume activity or renewed rifting. Late Cretaceous ophiolites formed above subduction zones in several oceanic basins. Ophiolites were emplaced southwards onto the Tauride and Arabian platforms during the latest Cretaceous. The Southern Neotethys sutured with the Arabian margin during the Early–Middle Miocene, while oceanic crust remained in the Eastern Mediterranean further west. The leading edge of the North African continental margin, the Eratosthenes Seamount, collided with a subduction trench south of Cyprus during the Late Pliocene–Pleistocene, triggering rapid uplift. Coeval Plio-Quaternary uplift of the Taurides may relate to break-off or delamination of a remnant oceanic slab.

Eocene high-temperature/high-pressure Metamorphism of Ophiolitic rocks

Evidence is given of Eocene high-temperature/high-pressure metamorphism of ophiolitic rocks and granitoid intrusion related to Neotethyan subduction processes in theDoğanşehir area of SE Anatolia. New data for regionally important granulite facies metaophiolitic rocks and cross-cutting granitoids rocks are presented and discussed in this 2013 paper. The high-temperature/high-pressure Berit metaophiolite is cut by unmetamorphosed Eocene (51–45 Ma) granitoid rocks. The highest metamorphic grade occurs in blocks of mafic granulites. Enveloping amphibolite facies rocks reflect retrograde metamorphism related to exhumation. Sm–Nd (pyroxene–garnet–amphibole–whole rock) isochron ages of 52–50 Ma for the granulite facies rocks are interpreted to represent the time of cooling of the granulite facies rocks.

The over-riding Malatya metamorphic unit to the north is also intruded by Eocene granitoid rocks. The granulite facies metamorphism of the meta-ophiolitic rocks is inferred to have formed in the roots of an Eocene magmatic arc, with accentuated heat flow being provided by subduction of a spreading ridge, or rupture of the subducting slab. The high-temperature/high-pressure metamorphism was followed by exhumation, as indicated by field structural relations and the evidence of retrograde metamorphism. The Eocene arc magmatism can best be explained by northward subduction of the Southern Neotethys, which persisted after the time of latest Cretaceous regional ophiolite emplacement until the collision of the Eurasian (Anatolian) and Arabian continents during the Early–Mid Miocene. Subsequent Plio-Quaternary left-lateral strike-slip strongly affected the area.

Petrology of the İspendere ophiolite from Southeast Anatolia

The İspendere (Malatya) ophiolite forms part of the Tauride active continental margin assemblage in SE Anatolia. The ophiolite exhibits an intact oceanic lithosphere section and is intruded by Late Cretaceous calc-alkaline granites. The ophiolite comprises mantle tectonites, ultramafic to mafic cumulates, isotropic gabbros, isolated diabase dykes, a sheeted dyke complex, plagiogranite and volcanic rocks.

The volcanics and the sheeted dyke complex exhibit (1) similar rare earth element patterns, with flat to light rare earth element depletion $(La–Yb)_N$=0.71–1.14 and 0.65–1.22; (2) negative Nb anomalies and (3) flat-lying high field strength element trends. These features differ from a typical Normal--Mid Ocean Ridge Basalt fractionation trend and could have resulted from c. 15% partial melting of a previously depleted mantle source.

The whole-rock chemistry and the mineral chemistry of the ultramafic to mafic cumulates [high Ca plagioclases (An89–81), magnesian olivines (Fo88–81) and clinopyroxenes (Mg#90–83)] show that the primary magma of the plutonic suite is compositionally similar to modern island arc tholeiites. The available evidence suggests that the İspendere ophiolite formed at a northerly supra-subduction zone spreading centre of the Southern Neotethys, between the Taurides and the Bitlis–Pütürge metamorphic units, during the Late Cretaceous. Comparison with the adjacent Göksun, Kömürhan and Guleman ophiolites suggests that the İspendere ophiolite represents part of a single regional-scale sheet of oceanic lithosphere that was accreted to the base of Tauride active continental margin where it was cut by arc-type magmatic rocks.

Late Palaeozoic–Early Cenozoic tectonic development of Southern Turkey

Reconstructions of the Anatolian continent and adjacent areas assume the existence of one or more continental fragments during Mesozoic–Early Cenozoic time. These rifted from North Africa (Gondwana) during the Triassic, drifted across the Mesozoic Tethys and collided with Eurasia during latest Cretaceous–Paleocene time. Current (~2010) reconstructions range from a regional-scale Tauride–Anatolide continent with oceanic basins to the north and south, to numerous rifted continental fragments separated by small oceanic basins.

Field-based evidence for the inter-relations of the continental blocks and associated carbonate platforms is discussed and evaluated in this paper, especially to distinguish between sutured oceans and intra-continental convergence zones. Several crustal units are restored as different parts of one large Tauride–Anatolide continent, whereas several smaller crustal units (e.g. Kırşehir massif; Bitlis/Pütürge and Alanya/Kyrenia units) are interpreted as continental fragments bordered by oceanic crust.

We infer a relatively wide İzmir–Ankara–Erzincan ocean in the north and also a wide South Neotethyan ocean in the south. Several smaller oceanic strands (e.g. Inner Tauride ocean, Berit ocean and Alanya ocean) were separated by continental fragments. Our proposed reconstructions are shown on palaeotectonic maps for Late Permian to Mid-Miocene. The reconstructions have interesting implications for crustal processes, including ophiolite genesis and emplacement.

Plate tectonics of the Alpine realm

New (2009) field data on the East Mediterranean domain suggest that this oceanic basin belonged to the larger Neotethyan oceanic system that opened in Permian times. A Greater Apulia domain existed in Mesozoic times, including the autochthonous units of Greece and SW Turkey. It also included a united Adria and Apulia microplate since Early Jurassic times. This key information implies that a new post-Variscan continental fit for the western Tethyan area is necessary, where the relationships between the Adriatic, Apulian and Iberian plates are defined with greater confidence.

To construct a reliable palinspastic model of the Alpine realm, plate tectonic constraints must be taken into consideration in order to assess the magnitude of lateral displacements. For most of the plates and their different terranes, differential transport on the scale of thousands of kilometres can be demonstrated. This plate tectonic framework allows a better geodynamic scenario for the formation of the Alpine chain to be proposed, where the western and eastern transects have experienced contrasting geological evolutions. The eastern Alps–Carpathians domain evolved from the north-directed roll-back of the Maliac–Meliata slab and translation of the Meliata suture and Austroalpine domain into the Alpine domain. In the western Alps, the changing African plate boundary in space and time defined the interaction between the Iberian–Briançonnais plate and the Austroalpine accretionary wedge.