Yerbilimleri, 30 (2), 113–126
Hacettepe Üniversitesi Yerbilimleri Uygulama ve Araştırma Merkezi Dergisi
Journal of the Earth Sciences Application and Research Centre of Hacettepe University

Geodynamic evolution of Kosovo during the Triassic and Jurassic

Triyas ve Jura sırasında Kosova'nın jeodinamik evrimi

Zenun ELEZAJ
Faculty of Mining and Metallurgy, Mitrovice, University of Prishtina, KOSOVO

Geliş *(received)* : 09 Mart *(March)* 2009
Kabul *(accepted)* : 28 Mayıs *(May)* 2009

ABSTRACT

During the Triassic and Jurassic time, important geological events were recorded in the Kosovo area. The initial continental rifting occurred during the Early – Middle Triassic. It was followed by a continental break-up leading to the splitting of the Korab-Pelagonian and Peje - Drina - Ivanice micro blocks from the Euro - Asiatic plate in the East and Adria (Apulia) in the West. The Latest Anisian – Earliest Jurassic is marked by basin differentiation and oceanic spreading in the Vardar and Mirdite - Gjakove –Dinaride areas. The oceanic lithosphere is generated at slow spreading ridges. By the end of the Early Jurassic – Middle Jurassic, the intra oceanic subduction zones were installed in the respective oceanic areas. This phase corresponds to the "eastern" type ophiolite production. The ophiolite formation is interpreted in a different paleotectonic context, where compression and distension are combined. During the Middle – Late Jurassic, in close association with intraoceanic subduction, the melange formations were generated., The tectonic-olistostrome mélanges accumulated in the subsided basins. In the Late Jurassic, the Vardari and Mirdita Gjakova - Dinaride oceanic basins were closed. Continental margin subsidence and the oceanic lithosphere emplacement occurred on both sides. The bidivergent obduction of Triassic and Jurassic ophiolites produced the metamorphic soles. At that time, oceanic crust accretion wedges developed onto neighboring continental margins, as well.

Keywords: Evolution, Jurassic, Kosovo, tectonics, Triassic.

ÖZ

Triyas ve Jura dönemlerinde, Kosova'da önemli jeolojik olaylar kaydedilmiştir. İlk kıtasal riftleşme Erken-Orta Triyas döneminde gerçekleşmiştir. Bunu, Korab-Pelogoniyen ve Peje-Drina-Ivanice mikro bloklarının doğuda Avrasya ve batıda Adria (Apulia) levhalarından ayrılmasıyla sonuçlanan kıtasal kırılma izlemiştir. Geç Anisiyen-Erken Jura, Vardar ve Mirdite-Gjakove–Dinar alanlarında havza farklılaşması ve okyanusal yayılma ile temsil edilmektedir. Okyanusal litosfer yavaş yayılan sırtlarda türemiştir. Erken Jura-Orta Jura'nın sonlarına doğru okyanuslar arası dalma kuşakları oluşmaya başlamıştır. Bu dönem "doğu" tipi ofiyolit üretimine karşılık gelmektedir. Ofiyolit oluşumu, sıkışma ve yayılmanın birlikte değerlendirildiği farklı bir paleotektonik bağlamda yorumlanmıştır. Orta-Geç Jura döneminde okyanus içi dalma ile ilişkili olarak melanj oluşumları gelişmiştir. Çöken havzalarda, tektonik olistostromal melanjlar birikmiştir. Geç Jura döneminde, Vardar ve Mirdita-Gjakova-Dinar okyanusal havzaları kapanmıştır. Her iki kıyıda kıtasal kenar çökmüş ve okyanusal litosfer yerleşmiştir. Triyas ve Jura yaşlı ofiyolitlerin kıtalar üzerine çift taraflı bindirmesi sırasında ofiyolit tabanı ile metamorfik birimler oluşmuştur. Aynı dönemde, komşu kıtasal kenarlar üzerine yığılan okyanusal kabuk kamaları gelişmiştir.

Anahtar Kelimeler: *Evrim, Jura, Kosova, tektonik, Triyas.*

Z. Elezaj
E-mail: zenunelezaj@yahoo.com

INTRODUCTION

Kosovo is situated in the southeastern part of Europe and extends into the central part of the Balkan Peninsula. It is stretched between the northern latitudes of 41° 50' 58'' and 43° 15' 42'', and the eastern longitudes of 20° 01' 30'' and 21° 48' 02''. Kosovo occupies a key setting in the geological structure of the Central and Western parts of the Balkans (Aubouin and Ndojaj, 1964). In this area, major geological structures of the Alps-Carpathian-Balkan arc and the Dinaride structures (sensu largo) are developed (Figure 1). At the boundary of these major tectonic units, the Dardan Massif is exposed. It reveals a very original position and although it doesn't belong to the Dinaride-Albanide – Hellenide Belt, it displays a typical North/northwestern – South/southeastern extension, which is characteristic for this belt. At the same time, the Dardan Massif is parallel to the Vardari composite unit.

It is inferred (Elezaj and Kodra, 2008) that the boundary of the Vardari composite unit with the Dardan Massif marks the boundary between the Euro - Asiatic plate and the Adria microplate (Apulian), which is a part of the African major plate (Gondwana). The Kosovo area is the place where the Dinaride structures are closer to Balkanide structures.

Various sedimentary, magmatic and metamorphic formations are widespread. Folded and tectonic structures complicate the geological architecture. The regional syntheses carried out in the recent years in Kosovo and neighboring areas have helped scientists to understand different aspects of its geodynamic evolution. At the same time, the geological correlations of the tectonic zones have been suggested (Elezaj and Kodra, 2008; Xhomo et al., 2002). In this paper, emphasis is given to the Triassic and Jurassic period because in that period major and important tectogenetic events occurred.

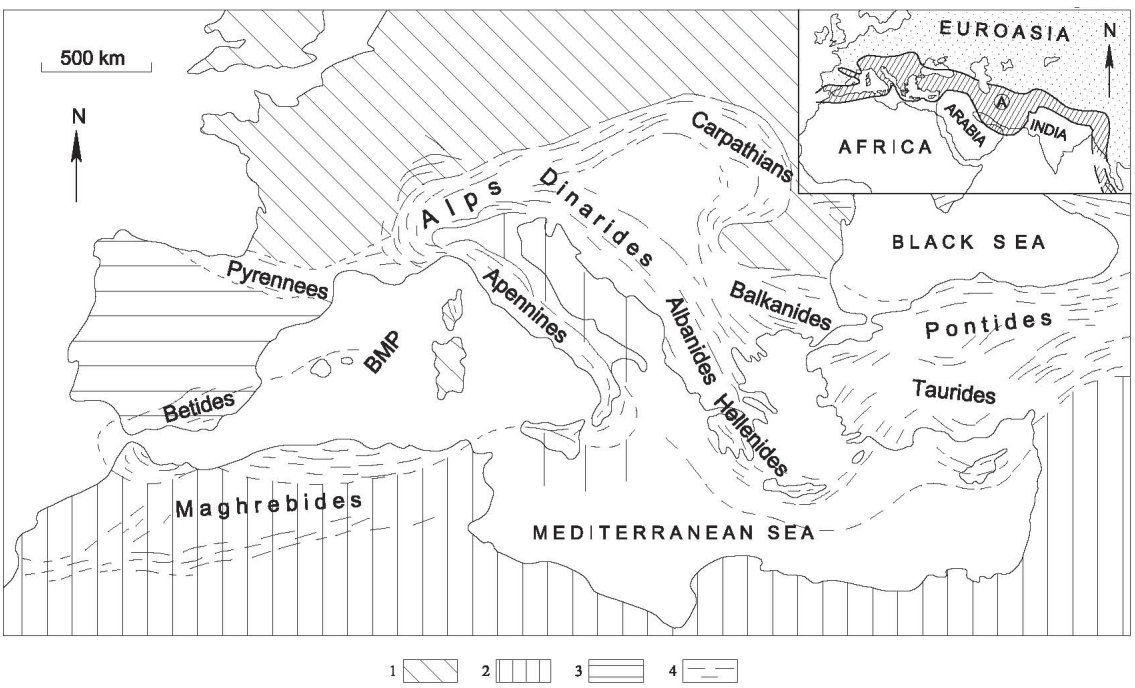

Figure 1. Structural sketch of Alpine Mediterranean Belt (between Europe and Africa) and Albanide setting (Godroli, 1992) (1. Europe and Corsica-Sardinia block, 2. Africa and Apulia - Adriatic block (or Adria), 3. Iberia block, BMP: Western Mediterranean basin, B. Pan.: Panonian basin, 4. Alpine folded chains. A: Tethysian oceanic basin).

Şekil 1. Alpin Akdeniz Kuşağı ile (Avrupa ve Afrika arasındaki) Arnavutluk bölgesinin yapısal şeması (Godroli, 1992) (1. Avrupa ve Korsika-Sardunya bloğu, 2. Afrika ve Apulya-Adriyatik bloğu (veya Adriya), 3. İberya bloğu, BMP: Batı Akdeniz havzası, B. Pan.: Panoniyen havzası, 4. Alpin kıvrımlı zincirleri. A: Tetis okyanus havzası).

GEOLOGICAL UNITS

According to stratigraphic volume, the nature of the facies, the geological setting related to ophiolite graben basins, structural features, magmatism, metamorphism, and tectogenetic events etc., several stratigraphic tectonic units are distinguished in the Kosovo area (Figure 2). In general, the stratigraphic-tectonic units are limited by major faults. From West to East the followed units crop out:

Albanian Alps composite unit (Valbona unit): This unit belongs to external stratigraphic tectonic units. It is exposed in the western part of Kosovo, just on the border with Albania. In this area, the Upper Cretaceous flysch formation crops out. The Valbona unit displays a pericline termination and plunges beneath the tectonic sheets of Kosovo's internal tectonic units.

Mirdita-Gjakove ophiolite belt: In the Kosovo area the ophiolite formation crops out along a

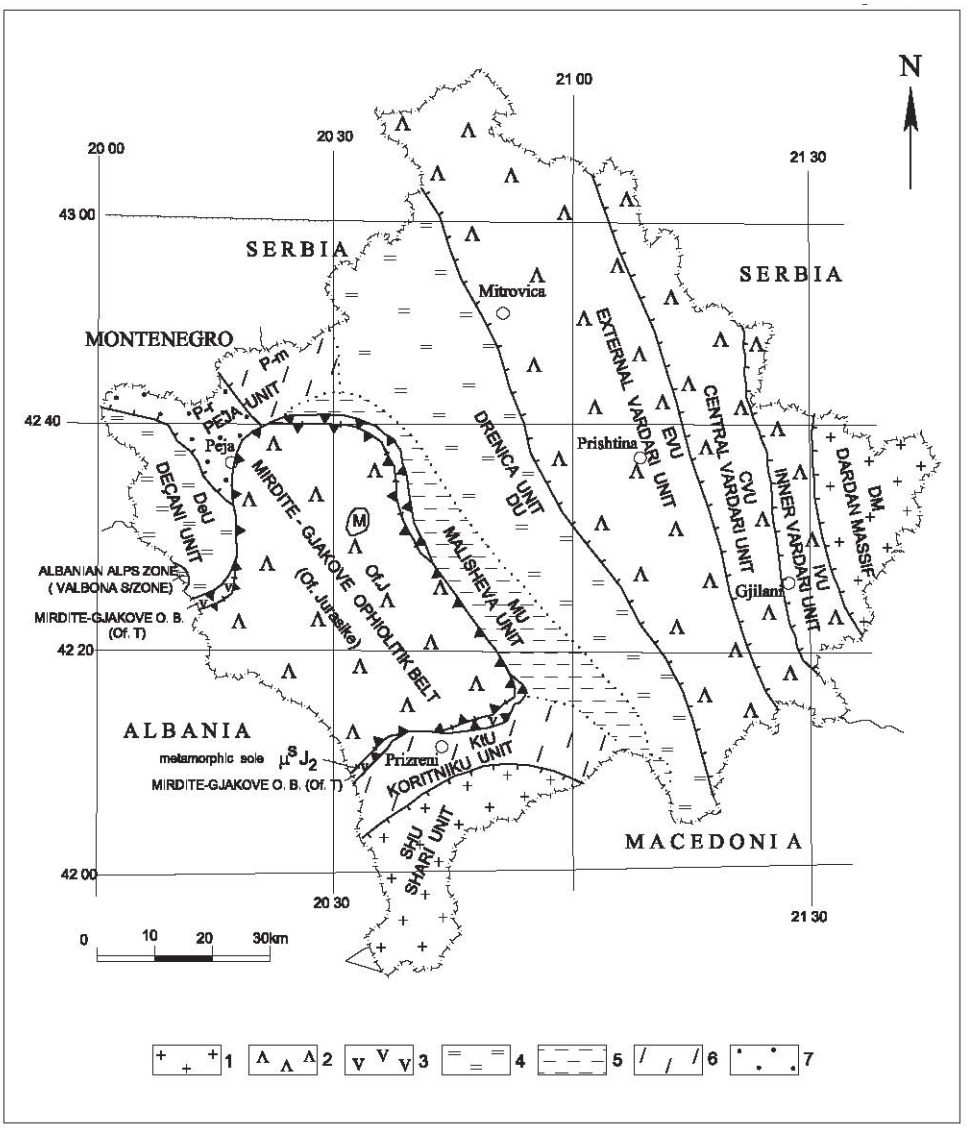

Figure 2. Stratigraphic – tectonic units of Kosova (1. Continental units, 2. Middle Jurassic ophiolites, 3. Middle Triassic- Lower Jurassic ophiolites, 4. Basin slope units (western margin of Vardar oceanic basin), 5. Basin slope units (eastern margin of Mirdite-Gjakove oceanic basin), 6. Platform units, 7. Pelagic units).

Şekil 2. Kosova'nın stratigrafik-tektonik birimleri (1. Kıtasal birimler, 2. Orat Jura ofiyolitleri, 3. Orta Triyas-Alt Jura ofiyolitleri, 4. Havza yamacı birimler (Vardar okyanus havzasının batı kenarı), 5. Havza yamacı birimler (Mirdite-Gjakove okyanus havzasının doğu kenarı), 6. Platform birimler, 7. Pelajik birimler).

belt of about 130 km^2. Two ophiolite complexes are distinguished: Middle Jurassic and Middle Triassic-Lower Jurassic ophiolites. The Middle Jurassic ophiolites are widespread and are mainly represented by mantle ultrabasic members. A minor spreading shows the oceanic crust formations (gabbro, basalts, and andesite-dacites).

Deçani unit: This unit extends over a limited area. It is composed of Lower Paleozoic schists, Permian-Triassic conglomerates and Triassic-Jurassic formations, which are in close association with serpentinite accretion wedges. It is overthrusted onto the Albanian Alps, while in the northeast it is emplaced onto the Peja unit. In the paleotectonic context, the Deçani unit represents the western basin-slope of the Dinaride oceanic basin and it is correlated with the Qerret-Miliska unit in Albania (Kodra, 1987; Kodra et al., 2000; Xhomo et al., 2002).

Peja unit: This is composed of Paleozoic schists, Triasic platform facies, and Middle Jurassic radiolarite cherts. This unit is seen as a platform area located at the East of the Dinaride oceanic basin. It is constituted of two sub-units: Rugova (Pr) and Mokna ones (Pm). (Figure 2).

Koritniku unit: This can be traced from Albania in the West to Brezovica in the East. The main geological formations are the Silurian-Devonian schists, Permian-Lower Triassic conglomerates, Olenekian-Anisian limestones and dolomites, Ladinian chert platy limestones, and Upper Triassic-Lower Liassic platform limestones. Ophiolite sheets are emplaced on the Triassic-Jurassic formations a metamorphic sole is found at their base. In the paleotectonic context, the Koritniku unit is analogous with the Gjallica unit in Albania. It represents a platform basin corresponding to the eastern flank of the Mirdita-Gjakova oceanic graben structure.

Sharri unit: This unit corresponds to the Kollovozi unit in Albania (Xhomo et. al., 2002) and to the western Macedonia zone (Pencerovski and Haxhidimitrova., 1975). It is composed of Lower Paleozoic formations (schists, quartzites, ignimbrites etc.). Triassic pelagic carbonates are found as well. The Sharri unit thrusts on to the Koritniku unit.

Malisheva unit: This is developed in the central part of Kosovo. Triassic-Jurassic pelagic carbonate chert formations, Middle – Upper Jurassic terrigenous sequences, Jurassic-Cretaceous flysch, Upper Cretaceous deposits and Neogene molasses are found. It is interpreted as the eastern basin - slope area of the Mirdite - Gjakove oceanic basin (see Figure 2).

Drenica unit: This is composed of Paleozoic, Triassic-Jurassic and Jurassic formations unconformably covered by the Jurassic-Cretaceous flysch and Upper Cretaceous limestones and flysch sequences. This unit is considered as the western basin-slope area of the Vardari oceanic basin.

Vardari composite unit: This is the major tectonic unit with a large regional extension. To the East it is in tectonic contact with the Dardan Massif, while in the West it is overthrusted onto the Drenica unit. Three tectonic sub-units are distinguished: the external Vardari unit (EVU), the Central Vardari Unit (CVU) and the Inner one (INU), (Figure 2). The ophiolitic rocks are widespread, and Upper Jurassic and Cretaceous cover deposits occur as well. Very characteristic are the Oligocene-Miocene molasses and the young dacite-andesite, rhyolite magmatism.

Dardan Massif: In literature this is known as the Serbian-Macedonian crystalline massif. The Dardan Massif separates the Alpidic arc (Alpide-Carpathians-Balkan arc) in the East from the Dinaride Belt in the West. It is composed of Proterozoic metamorphic formations (gneisses, migmatites, amphibolites, schists etc) intruded by granite intrusions. The Oligocene and Middle Miocene molasse and the andesite-dacite and rhyolite magmatism cover the old formations.

MAIN TECTOGENETIC EVENTS

Summing up the main tectogenetic events affecting the Kosovo area (Elezaj and Kodra, 2008), the most significant events are briefly evaluated in the following paragraphs.

Pre-Variscan Tectogenesis: It is supposed that this orogenic event is developed in the most eastern areas, but no stratigraphic and structural data are available. In the Dardan Massif, an early tectonic event is distinguished.

Variscan tectogenesis: This has not been studied in the Kosovo area in detail. This event developed during the Late Paleozoic and is expressed by the absence of Upper Carboniferous - Lower Permian deposits, and sometimes by Permian (?) – Lower Triassic conglomerates that are unconformable on Silurian – Devonian sediments.

Alpine tectogenesis:

A. Tectonic episodes developed in the extensional regime (preceding the Alpine tectogenesis):

The Alpine tectogenesis was preceded by opening and oceanic spreading in the Vardari and Mirdite-Gjakove-Dinaride areas (Kodra et al., 2000; Kodra and Gjata, 2002; Elezaj and Kodra, 2008). Due to extension, several successive episodes developed:

(a) Early – Middle Triassic continental rifting: At that time the continental crust was split and led to the formation of graben like structures associated with intra continental volcanism of a porphyrite-radiolarite-type (Kodra et al., 1993).

(b) A Late Anisian break-up: The Korab-Pelagonian and the Peje - Drina Ivanice blocks are detached by the Euro-Asiatic plate in the East and the Adria (Apulia) in the West. It is believed that this marks the starting of Tethyan oceanic spreading in the Vardari and Mirdita – Gjakove – Dinaride area. This event seems to correspond to the beginning of the Pangaea detachment.

(c) Latest Anisian – earliest Jurassic oceanic spreading: In Vardari and Mirdite - Gjakove –Dinaride this led to individualization of the tectonostratigraphic units. In the central parts of the graben structures, oceanic formations were generated. With reference to their limbs, well configured tectono-stratigraphic units are developed. The last ones are composed of basin-slope units with a thin continental crust representing the passive margins of oceanic basins; platform units with thick a continental crust bordering the graben structures; and pelagic basins with a thin continental crust that developed between the platform units.

B. Tectonic episodes developed in the compressional regime (Alpine tectogenesis):

(a) End of the Early Jurassic – Middle Jurassic: This period marks the Early Kimmeric phase. It firstly affected the oceanic basin areas, followed by the continental margins. In the Vardari and Mirdite - Gjakove – Dinaride areas, this phase starts with supra-subduction-zone ophiolite formation, corresponding to the “eastern” type ophiolites. The ophiolite generation is interpreted in different paleotectonic contexts, where compressional and distensional tectonic regimes are combined: the western dipping SSZ (Shallo, 1996; Robertson and Shallo, 2000), the eastern dipping SSZ (Kodra et al., 1994, 1995), and the intraoceanic thrusting (Meshi, 1996; Nicolas et al., 1999; Fejza, 2004).

(b) Middle – Late Jurassic: Melange formations and oceanic accretion wedges are produced (Middle Kimmeric phase). Intraoceanic subduction and accumulation of tectonic-olistostromic mélanges in subsiding basins are developed.

(c) Late Jurassic: the Vardari and Mirdita – Gjakove - Dinaride oceanic basins are closed (Late Kimmeric phase). Continental margin subsidence and oceanic lithosphere emplacement occurred on both sides. The bidivergent obduction of Triassic and Jurassic ophiolites produced the metamorphic soles (Kodra and Gjata, 1982; Elezaj and Kodra, 2008). At this period, oceanic crust wedges obtruded onto neighboring continental margins.

(d) Hauterivian: During this period, a strong orogenic phase developed. A vigorous uplifting of the Mirdite - Gjakove ophiolite belt and the adjacent tectonostratigraphic units is documented. After the Hauterivian, the extensional tectonic regime was installed. The intensive erosion processes and Barremian - Aptian transgression started.

(e) Early – Late and latest Cretaceous: No distinct deformational phases are recognized in the Kosovo area.

(f) Late Eocene – Early Oligocene (Illyrian events): Thrusting of the inner units to the West developed.

C. Post-Alpine episodes developed in extension: After the Illyrian tectogenesis, at the end of Eocene and the beginning of Oligocene, Kosovo terrains reveal an extensional tectonic scenario. The normal faulting activity configures the future molasse depressions.

TRIASSIC, JURASSIC PALEOGEOGRAPHIC AND GEODYNAMIC SCENARIO

Based upon recently accommodated data (Elezaj and Kodra, 2008; Xhomo et al., 2002; Kodra et al., 2000), the state of the art for the Triassic and Jurassic is more complete and may provide a clear picture for the geological evolution of this period. During Triassic and Jurassic times, geological events defined the major tectonic features of Kosovo area and its neighboring terrains (Figure 3).

Permian - Early Triassic

Reddish conglomerate-sandstone formations (Veruccano series) mark the beginning of the

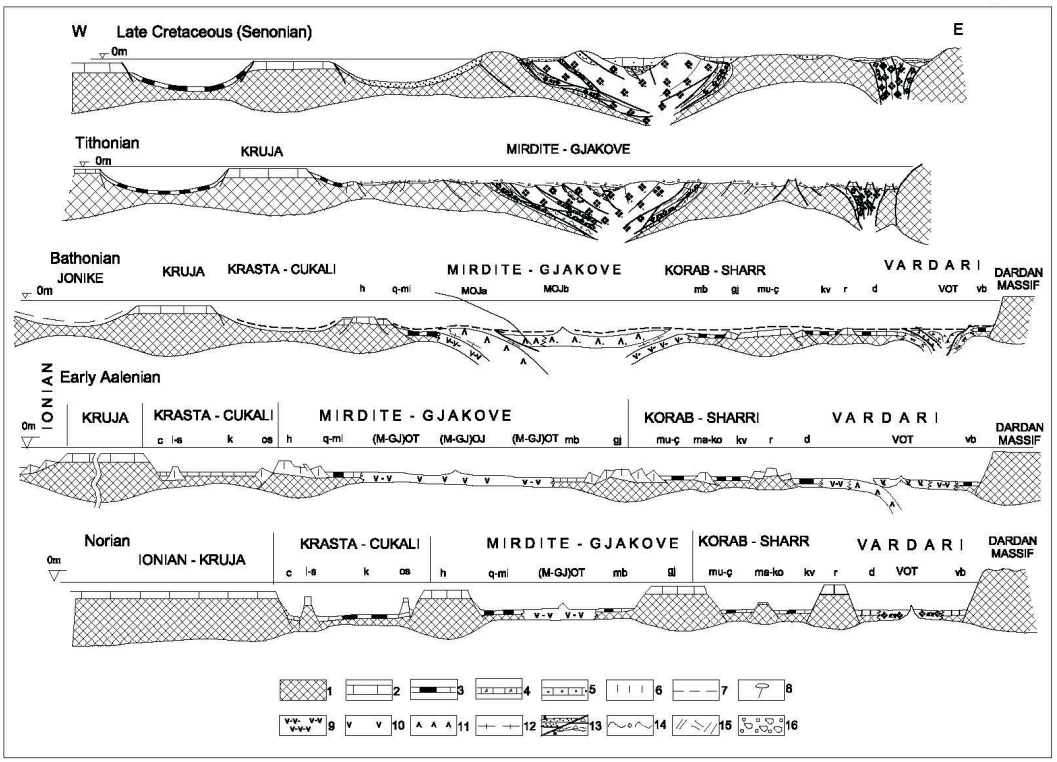

Figure 3. General sketch of the Mesozoic formations (Kosova, Albania, Macedonia) (Elezaj and Kodra, 2008) (1. Continental units, 2. Platform limestones, 3. Pelagic limestones, 4. Breccia limestones, 5. Neritic limestones, 6. Nodular limestones with manganese nodules, 7. Radiolarites, 8. Continental rift volcanics, 9. Triassic-Liassic oceanic formations (volcano-sedimentary formation etc.), 10. Middle Jurassic oceanic formations (mid - ocean ridge type ophiolites), 11. Supra subduction setting ophiolites, 12. Metamorphic sole, 13. Flysch: a. young, b. early, 14. “Block in matrix” type mélange, 15. Evaporites, 16. Molasse. M-GJ: Mirdite - Gjakove ophiolite belt, VO: Vardar ophiolites, C: Cukali, L – s: Lisne-Spiteni, k: Krasta, os: Ostreni, h: Hajmeli, q-mi: Qerret Miliska, mb: Mbasdeja, gj: Gjallica, m-cu: Muhurr-Çaja, kv: Kollovozi (Sharri), r: Radusha, d: Drenica, vb: Vardar inner unit).

Şekil 3. Mesozoyik yaşlı formasyonların genel görünümü (Kosova, Arnavutluk, Makedonya) (Elezaj ve Kodra, 2008) (1. Kıtasal birimler, 2. Platform kireçtaşları, 3. Pelajik kireçtaşları, 4. Breşik kireçtaşları, 5. Neritik kireçtaşları, 6. Manganez yumrulu kireçtaşları, 7. Radyolaritler, 8. Kıtasal Rift Volkanikleri, 9. Triyas-Liyas yaşlı okyanusal formasyonlar (volcano-sedimanter formasyon vd.), 10. Orta Jura yaşlı okyanusal formasyonlar (okyanus ortası sırtı türünde ofiyolitler), 11. Dalma-Batma zonu üstü ofiyolitleri, 12. Ofiyolit tabanı Metamorfikleri, 13. Filiş: a. genç, b. erken, 14. “Matriks içinde bloklu” türde melanj, 15. Evaporitler, 16. Molas. M-GJ: Mirdite - Gjakove ofiyolit kuşağı, VO: Vardar ofiyolitleri, C: Cukali, L – s: Lisne-Spiteni, k: Krasta, os: Ostreni, h: Hajmeli, q-mi: Qerret Miliska, mb: Mbasdeja, gj: Gjallica, m-cu: Muhurr-Çaja, kv: Kollovozi (Sharri), r: Radusha, d: Drenica, vb: Vardar iç birimleri).

Alpine cycle. They are found in the Sharri, Koritnik, Peje and Deçani units (Figure 2). The Permian – Lower Triassic conglomerates and sandstones do not occur in the Vardari unit or in the Dardan Massif. The Veruccano-type reddish conglomerate-sandstone formations were formed in the deltaic environments. Simultaneously, in the Sharri unit (Kosovo) and southward, in Albanian and Macedonian terrains, the coeval marine sandstone, conglomerate, green-spotted sequences with rose radiolarite limestone lenses containing abundant pelagic bivalves occur. The volcanic rocks lying at the top of the conglomerate – sandstone sequence are of a high Ti and calc-alkaline type, and it is inferred that they were generated at considerable depths.

In several cases, a light structural discordance of conglomerates setting on Silurian –Devonian yellowish schists is evidenced, while in other cases this formation is set in full concordance onto underlying formations. These data argue that the Hercynian folding phase was very weak.

Triassic

The Triassic deposits have close relations with Veruccano-type reddish conglomerate-sandstones (P-T_1). The stratigraphic section continues with Lower Triassic terrigenous sandstone, sandstone – siltstone - clay, clay-carbonate formations (Seiss facies) and oolithic limestones (Kampil facies). In the Koritniku, Deçani units and the Rugova sub-unit, besides the shallow water facies, nodular red limestones associated with volcanics are also, but rarely, found. They testify to the continental rifting development in limited areas.

During the early Anisian a wide platform area was installed. It is represented by yellow dolomitic limestones. This platform is intersected by narrow rift trenches where reddish limestones are deposited.

In the late Anisian, the continental rifting reached its culmination, expressed by the wide development of the Han Bulog nodular reddish limestones facies. At that same time, coinciding with rifting culmination, the continental break up in the Vardari and Mirdite - Gjakove areas occurred. In this way, two independent oceanic basins originated (Figure 3). By that time, two strands floored with oceanic lithosphere developed: the Vardari and Mirdita - Gjakova oceanic basins. At the mid ocean ridges (MOR) the basalt-radiolarite formations were produced. The oceanic extrusive sequences indicate a clear Mid Ocean Ridge Basalt (MORB) nature, whereas the volcanics produced onto adjacent continental margins show a within-plate basalt (WPB) nature. It should be noted that during the Late Anisian and Early Ladinian, in many sectors, transitional basalt types (MORB-WPB) are frequent. A typical example is described by Maliqi (2001) for the Trepçe – Mitrovice - Zveçan area.

The Vardari and Mirdite – Gjakove slow spreading MOR-type basins are gradually extended at the centers of the graben-like structures. At their topmost parts, besides MOR- type basalts, radiolarites, cherts and rare carbonate sediments are deposited. The volcano-sedimentary basalt-radiolarite formation (βT_2-J_1) originated in these conditions,.

To the West of the Vardari oceanic basin, the Drenica basin-slope unit developed. In this area, the pelagic sediments, mainly of carbonate-chert composition display much reduced thickness. In its western part, only near Gllobojçice village, a carbonate platform was installed. This platform unit is preserved in a southern direction and fragmentary outcrops are found in Macedonia and Greece (Radusha unit). On the contrary, the Sharri unit is found in the Sharri Mountains, and in the southern part, Sharr (Dragash), and Restelice represents a pelagic area, where chert limestones are deposited (see Figure 3).

The Koritnik platform displays a wide development of the shallow water sediments and in general indicates a very monotonous deposition. The organic and detritic limestones dominate. The faunal associations belong to warm and shallow water environment. In the southwest, the Koritnik platform continues in Albania and corresponds to the Gjallica platform.

The Mbasdeja unit in Albania (Xhomo et al., 2002) represents the eastern slope-basin of the

Mirdite – Gjakove oceanic basin. This unit is covered by Mirdita - Gjakova ophiolites in the major part in Albania and totally in the Kosovo area,.

During the Triassic, on the western flank of the Dardan Massif, diverse type basins are installed:

(a) The Vardari oceanic basin: It appears that an oceanic lithosphere was created at and along a slow-spreading ridge.

(b) The Drenica pelagic basin – slope representing the passive continental margin of the Vardari oceanic basin: The Triassic deposits thickness is much reduced in this area. Only in Smrekonice (Vardari external unit) is a typical Hallstat facies of the Middle – Upper Triassic (platy limestones with cherts) found. It is interpreted as part of the Drenica unit, tectonically covered by Vardari ophiolites (Elezaj and Kodra, 2008).

(c) The Peja platform with Mokna (Pm) and Rugova (Pr) subunits (see Figure 2): During the Late Triassic up to Early Jurassic, in the Mokna sub-unit shallow waters sediments of monotonous nature were deposited. The limestone muds contain abundant fauna assemblages such as foraminifers, algae, corals and lamellibranchiate. To the North-Northwest of the Peja unit (outside of Kosovo and mainly in Serbia, Montenegro etc.), the palaeogeographic panorama is much the same as that of the South – Southeast of Koritniku unit.

Along the Late Triassic and the beginning of the Jurassic, differently from the Mokna platform subunit, the Rugova sub-unit indicates a pelagic nature. The presence of pelagic bivalves argues a relatively deep basin. This emphasizes that this sector is different from other adjacent areas. For example, Southwest of Peja a shallow basin is evidenced. In this neritic basin, carbonate muds with megalodonts, corals and algae are developed. Summing up the available data, the Rugova sub-unit is interpreted as the Southwestern part of Peja Unit and represents the transitional basin – pelagic slope segment of the Dinaride oceanic basin.

(d) The Deçani basin – slope unit: The geological structure of this unit is the most complicated one in the whole of Kosovan territory. The platy limestones with cherts allow us to suppose that during the Ladinian and in particular along the Late Triassic – Early Jurassic, the Deçani unit represented a deep basin. Limestone muds and cherts with abundant pelagic bivalves were deposited. This unit is considered as the western slope-basin of the Dinaride oceanic basin. It is necessary to emphasize that, for the Kosovo terrains, the available data for such an interpretation are limited and we are relying on the analysis of the geological situation in Montenegro and other neighboring areas. It is inferred that the Deçani unit is the western basin-slope of the Dinaride oceanic basin, and the Durmitori unit has served as a platform-margin unit of the Dinaride graben structure. To the West of the Durmitori platform up to the Adriatic Sea, the Bosnian platform, Albanian Alps platform, Budva basin (= Cukali) and Dalmatian platform (= Kruja) are found.

(e) The Malisheva unit: With reference to the Ladinian and Late Triassic-Early Jurassic, the data on the palaeogeographic situation in Malisheva unit are scarce. This unit is extended along the Shkoder - Peje fault (Dercourt, 1968). In this area the Cretaceous, Neogene and Pleistocene-Holocene covers are largely developed and the Upper Triassic-Lower Jurassic platform limestones do not outcrop. In the Northeast and East, the Malisheva unit is unified with the Drenica pelagic unit, whereas in the Southwest and West, it continues to the Mbasdeja pelagic unit of Albania. In Kosovo, this last is totally covered by Mirdite - Gjakove ophiolites.

Jurassic and Jurassic-Cretaceous

During the Early Jurassic, in the Vardari and Mirdite – Gjakove basins, the slow-spreading of the ocean floor continued. In the environment of passive continental margins composed of slope - basins the sedimentation of carbonate-siliceous muds followed, while in the Peja (Mokna) and Koritniku platforms, with shallow warm waters of normal salinity, the carbonate mud sedimentation continued.

With reference to the Sharri unit, the available data are scarce, but in analogy with neighboring countries, such as Albania (Kodra, 1987; Xhomo et al., 2002) and Macedonia (Pencerovski and Haxhidimitrova, 1975), the sedimentation of carbonate- siliceous muds continued in deep sea conditions

During the Middle – Late Liassic and along the Early Dogger over all the Kosovan area, different geological events occurred. The continental rifting encompasses in particular the Peja and Koritniku platform areas. The last one is fractured and onto the tilted and subsided blocks are deposited syn-rift condensed pelagic facies with *Involutina liassica*, ammonites and other middle Liassic to lower Dogger micro facies. On the basin-slopes of the oceanic basins the deep sea sedimentation continued, but the limestones were replaced by marlstones. Meanwhile, the rifting processes continued on the continental margins. In the Vardari and Mirdite - Gjakove ocean basins, the oceanic spreading progressed and the initiation of the intraoceanic subduction started firstly in Vardari and later in Mirdite - Gjakove, (see Figure 3). The beginning of the intraoceanic subductions marks the passage of the extensional geodynamic regime to the compressional one.

No reliable age data on the starting of the intraoceanic subduction is available. In Albania, in several sectors within island arc tholeiite (IAT) type basalts, radiolarite layers of Bajocian- Bathonian age are documented (Chiari et al., 1994; Kodra et al., 1994; Kodra et al., 1995; Prela, 1994, 1996). These data indicate that the intraoceanic subduction in the Mirdite - Gjakove oceanic basin occurred during the beginning of the middle part of the Middle Jurassic. It is important to emphasize also that the age of the radiolarites covering the IAT type volcanics found at the topmost part of oceanic crust is Middle Jurassic and more exactly Bajocian - Callovian (Kelliçi et al., 1994; Marcucci et al, 1994; Kodra et al., 1994; Prela, 1994, 1996). The data provided refine termination of the subduction event.

The age of the metamorphic sole formation for the northern half of the Mirdite -Gjakove ophiolite belt ranges within the time span 160 -170 Ma, and corresponds to Middle Jurassic (Bajocian - Bathonian) (Elezaj and Kodra, 2008). In this way, a fairly simultaneous intraoceanic subduction and bidivergent intraoceanic emplacement leading to the metamorphic sole production occurred. In the Mirdite - Gjakove oceanic basin, more specifically in the Kosovo area, the intraoceanic subduction episode led to the complete consummation of the Triassic - Jurassic MOR-type oceanic lithosphere. In contrast, the Gjakova and Rahovec ophiolite massifs belonging to SSZ-type ophiolites are well preserved. The Middle Jurassic radiolarites mark the maximum homogenization of the oceanic basins and adjacent passive continental margins depths.

It is inferred that at the North of the Shkoder-Peje fault different events such as continental rifting, intraoceanic subduction and metamorphic sole formation started a little bit later, but it should be noted that all these episodes occurred during the Jurassic period.

The metamorphic ophiolite sole is formed at the boundary between the Middle Triassic - Lower Jurassic old oceanic crust and the Middle Jurassic thick and hot oceanic lithosphere (Nicolas, 1989; Kodra et al., 1994, 1995; Xhomo et al. 2002; Elezaj and Kodra, 2008).

The compressional regime gradually started up onto the oceanic crust, which is affected by the transform faults. It started with intraoceanic subduction and metamorphic sole production episodes and was rapidly associated with essential modifications of the sedimentation types. In the narrow oceanic basins an intensive tectonic activity developed. It is expressed by intraoceanic subduction and different barrier formation. In these conditions, the important oceanic bottom currents led to radiolarite accumulations or their absence on the basaltic upper levels and passive continental margins pelagic carbonates. It seems that the Middle – Upper Jurassic tectonic-olistostrome mélange in the Vardari and Mirdite - Gjakove oceanic basins is formed in such active conditions. The similar ages indicate also that the tectonic olistostrome mélanges or ophiolitic breccias are related to continental margins.

During the closure of the Vardari and Mirdite-Gjakove oceanic basins, the accretion wedges represented by serpentinite and basalt-radiolarite slices developed. In the most peripheral parts, carbonate and carbonate-chert slices are also noticed. The close mixture with adjacent tectonic olistostrome mélange is recognized as well. The deformation processes also affected the basin-slope environments and the proximal platform units; the listric paleo - faults pass to inverse type ones; the block rotations and overturned structures are largely identified. The tectonic movements affected the oceanic formations, especially the Triassic ones and the continental margin sequences, leading to a further complication of geological architecture. Intensive tectonic processes are recognized in the Vardari composite unit, where the compressional dynamics is combined with strike-slip faulting. At the same time, local extensional tectonics took place. It is believed that multiple tectonic factors facilitated the formation of linear and boudinage type structures.

In Kosovo, the Middle Triassic-Lower Jurassic ophiolites are consumed. They were stripped away during the closure episode of the Mirdite - Gjakove oceanic basin. Only near Korishe are the relationships of the Middle Jurassic ophiolites with the Middle Jurassic metamorphic sole and the Middle Triassic- Lower Jurassic basalt-radiolarites preserved.

In the Kosovo area, the reconstruction of the Mirdite - Gjakove oceanic basins closure style is difficult due to tectonic complications. Southward, in Albania, numerous data exist testifying the bidivergent ophiolite emplacement that occurred during the intraoceanic stage (see Figure 3), (Kodra and Gjata, 1982; Kodra et al., 1993; Kodra, 1987; Kodra et al., 2000; Kodra and Gjata, 2001; Godroli, 1992; Xhomo et al., 2002).

ROOT ZONES OF OPHIOLITES

The root zones of the ophiolites is an important question for any tectonic models of their origin and emplacement (Jones et al., 1991; Smith, 1993; Robertson and Karamata, 1994). The closure of the Vardari and Mirdite - Gjakove ocean basins closure is interpreted in different modes by various authors (Figure 4).

According to Bortolotti et al. (1996), Bernoulli and Laubscher (1972), and Çollaku et al. (1992), all ophiolites are generated at the Vardari oceanic basin and the Mirdite - Gjakove ophiolite belt is considered a thick tectonic nappe. Robertson and Shallo (2000) infer that the original setting of the Albanian ophiolites is the Krasta-Cukali trough (= Pindos in Greece), located between the platforms of Kruja (= Gavrovo in Greece) in the West and the Korabi - Pelagonian block in the East. They suppose the ophiolite emplacement to lie from West to East. Geological data from the Krasta-Cukali zone in Albania and its continuation in Greece (the Pindos zone) testify that from Anisian to Tertiary, in those zones, no oceanic spreading occurred (Kodra and Gjata, 2002). They suppose that simultaneously with the Krasta - Cukali trough, another oceanic crust was generated at the Vardari basin.

According to Kodra and Gjata (1982), Kodra (1987), Godroli (1992), Vergely and Kodra (1995), Vergely et al. (1997), two independent oceanic basins, the Vardari and the Mirdita – Gjakova, originated. Their closure led to the bidivergent ophiolite paleo emplacement onto continental margins.

The Vardari oceanic basin was closed before the Kimmeridgian (Robertson and Karamata, 1994). Beside the Kimmeridgian - lower Tithonian neritic formations, in the Vardari zone, the condensed slope facies represented by nodular red ammonite limestones also occur. The upper Tithonian flysch formations are the youngest ones and they are lying onto the Kimmeridgian – Tithonian limestones.

In the Mirdite – Gjakove area, the geological data provides another picture. In Volljake, cherts and red and green tuffs – siliceous rocks intercalated with siltstone layers unconformably cover the Jurassic mélange and the northern part of the Rahoveci ophiolite massif. The ophiolites are set tectonically on mélange and basalt-radiolarite fragments. The Jurassic - Cretaceous flysch is deposited on the chert levels. It is composed of marls, sandstones, and ophiolitic breccia etc. The flysch is Tithonian - Va-

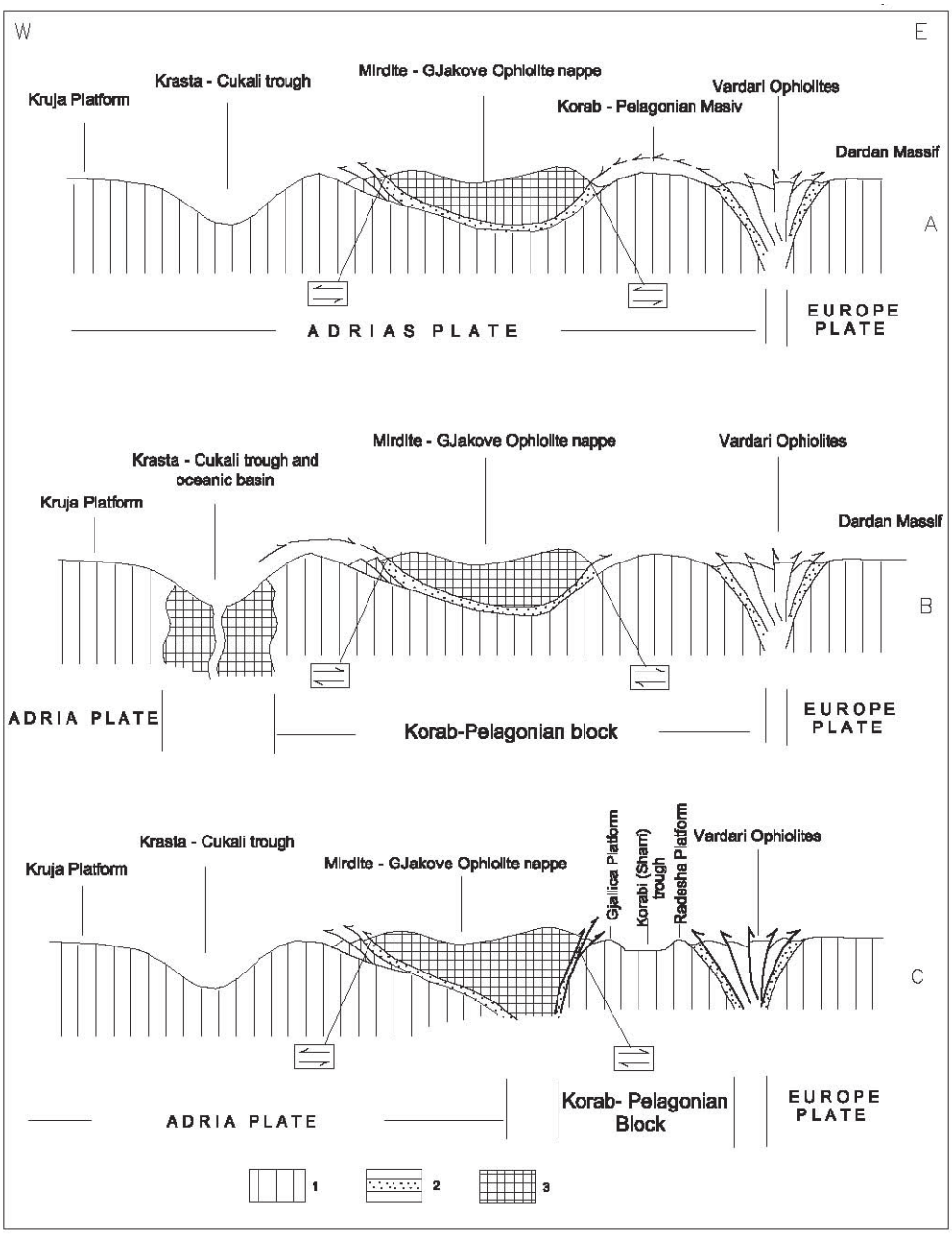

Figure 4. Interpretations on the origin setting of Mirdite – Gjakove ophiolite belt (Kodra et al., 1994) (1. Continental crust, 2. Tectonic olistostrome mélange and accretionary wedges, 3. Triassic and Jurassic ophiolites and the metamorphic sole between them. A. Vardarian origin (Bortolotti et al., 1996; Bernoulli and Laubscher, 1972; Çollaku et al., 1992). B. Krasta – Cukali origin (=Pindi) (Jones et al., 1991; Robertson and Shallo, 2000). C. Mirdita-Gjakova origin with bidivergent ophiolite paleo emplacement onto continental margins (Kodra and Gjata, 1982; Kodra, 1987; Godroli, 1992; Vergely and Kodra, 1995, 1997)).

Şekil 4. Mirdite-Gjakove ofiyolit kuşağının kökeniyle ilgili yorumlar (Kodra vd., 1994) (1. Kıtasal kabuk, 2. Tektonik olistrostrom melanjı ve yığışım kaması, 3. Triyas ve Jura ofiyolitleri ile bunlar arasındaki ofiyolitik metamorfikler A. Vardarian kökeni (Bortolotti vd., 1996; Bernoulli ve Laubscher, 1972; Çollaku vd., 1992). B. Krasta – Cukali kökeni (=Pindi) (Jones vd., 1991; Robertson ve Shallo, 2000). C. Kıta kenarina çift taraflı bindirme ile yerleşmiş Mirdita-Gjakova kökeni (Kodra ve Gjata, 1982; Kodra, 1987; Godroli, 1992; Vergely ve Kodra, 1995, 1997)).

langinian in age and it is a deep sea formation indicated by the presence of siliceous rocks, marls etc. The Volljaku flysch is an unmetamorphosed formation, testifying that the main tectono-thermal events were terminated by the Middle Jurassic-Late Jurassic.

CONCLUSIONS

Kosovo occupies a key setting in the geological structure of the Central and Western parts of Balkan Peninsula. During the Triassic and Jurassic period important geotectonic episodes occurred. In general, they defined the major tectonic features of the Kosovan area and its neighboring terrains.

The Early – Middle Triassic period is marked by continental rifting, leading to the splitting of the continental crust. This episode is associated with its respective volcanism. In the Late Anisian a major break up developed. The Korab-Pelagonian and the Peje - Drina - Ivanice micro blocks were detached from the Euroasian plate in the East and Adria (Apulia) in the West. It is believed that slow - spreading oceanic ridges were installed in the Vardari and Mirdita – Gjakove – Dinaride areas during this period.

During the latest Anisian – earliest Jurassic, the individualization of the stratigraphic units is accentuated. Oceanic basins, basin-slope units with thin continental crust, platform units with thick continental crust bordering the graben structures and pelagic basin units with thin continental crust developed.

During the Middle Jurassic – Early Dogger, intensive rifting episodes are registered on the continental crust. This process is followed by oceanic spreading. The “western” type ophiolites of the Mirdite - Gjakove Ophiolite Belt and their analogous associations in Vardari ophiolites originated in this period. By the end of the Early Jurassic – Middle Jurassic, under the compressional regime in the Vardari and Mirdite - Gjakove – Dinaride oceanic areas, a supra subduction zone was installed. As a result, “eastern” type ophiolites were produced.

During the Middle – Late Jurassic, the melange formations and oceanic accretion wedges were formed. In that time, intraoceanic plunging and subsiding basins accumulating tectonic-olistostromal mélanges developed. During the Late Jurassic, the Vardari and Mirdita Gjakova-Dinaride oceanic basins closed. In consequence, on both sides of the continental margin, subsidence and oceanic lithosphere emplacement occurred. The bidivergent obduction of Triassic and Jurassic ophiolites produced the metamorphic sole formations.

ACKNOWLEDGEMENTS

The manuscript has been considerably improved by the careful reviews of M. Cemal Göncüoğlu and Aral Okay, and the editors. We had helpful discussions with A. Kodra. I am very grateful to all.

REFERENCES

Aubouin, J., and Ndojaj I., 1964. Regard sur la géologie d’Albanie et sa place dans la géologie des Dinarides. Bulletin de la Societé Géologique de France, 7, VI, 593-624.

Bernoulli, D., and Laubscher, H., 1972. The palinspatic problem of the Hellenides. Ecclogae Geologica Helvetica, 65, 107-118.

Bortolotti, V., Kodra, A., Marroni, M., Mustafa, M., Pandolfi, C., Principi, G., and Saccani, E., 1996. Geology and petrology of ophiolitic sequences in the Mirdita region. Ofioliti, 21 (1), 3-20.

Chiari, M., Marcucci, M., and Prela, M., 1994. Mirdita ophiolite project: 2. Radiolarian assemblages in the cherts at Fushe Arrez and Shebaj (Mirdite area, Albania). Ofioliti, 21, 313-318.

Çollaku, A., Bonneau, M., Cadet, J. P., and Jolivet, L., 1992. L’édiffice structurale de l’Albanie septentrionale: des elements de réponse sur les modalités de la mise en place. Bulletin de la Societé Géologique de France, 164 (2), 150-165.

Dercourt, J., 1968. Sur l’accident Scutari - Pec, la signification palèogeographique quelques series condenseés en Albanie septentrionale. Annales de la Societé

Géologique de Nord, LXXXVIII, 3, 109-117.

Elezaj, Z., and Kodra, A., 2008. Gjeologjia e Kosoves. Monografi, Universiteti i Prishtines, Prishtine.

Fejza, I., 2004. Tiparet strukturore dhe petrologjike te masiveve ofiolitike te Goleshit dhe Rahovecit – modele te rrjedhjes mantelore. PhD Thesis, Universiteti i Prishtines (unpublished).

Godroli, M., 1992. Tectonique des ophiolites dans les Albanides internes. Modalité d'ouverture et de fermeture d'un bassin océanique étroit. Thèse pour l'obtention du titre de Docteur de l'Université d' Orsay (unpublished).

Jones G., Robertson A. H. F., and Cann, J. R., 1991. Genesis and emplacement of the supra-subduction zone Pindos ophiolite, Northwestern Greece. Tj. Peters et al. (eds.). Ophiolite Genesis and Evolution of the Oceanic Lithosphere, pp. 771-799.

Kelliçi, I., De Wever, P., and Kodra, A., 1994. Radiolaires Mésozoiques du massif ophiolitique de Mirdita, Albanie. Revue de Micropaleontologie, 3, 54-67.

Kodra, A., 1987. Paleogjeografia dhe zhvillimi gjeotektonik i Albanideve te brendeshme gjate Triasikut dhe Jurasikut. Buletini i. Shkencave Gjeologjike, 4, 24-34.

Kodra, A., and Gjata, K., 1982. Ofiolitet ne kuadrin e zhvillimit gjeotektonik te Albanideve te brendeshme. Buletini i. Shkencave Gjeologjike, 2, 49-62.

Kodra, A., and Gjata K., 2002. Comment on the paper 'Mesozoic-Tertiary tectonic evolution of Albania in its regional Eastern Meditterranean context" by Robertson and Shallo (Tectonophysics 316 (2000), 197-254). Tectonophysics, 344, 297-301.

Kodra, A., Gjata, K., and Bakalli, F., 1993. Les principales étapes de l'evolution paléogeographique et géodynamique des Albanides internes au cours du Mésozoique. Bulletin de la Societé Géologique de France, 164 (1), 69-77

Kodra, A., Vergely, P., and Meshi, A., and Haxhidimitrova. 1994. Evolucioni strukturor i ofioliteve te Shqiperise, Tirane, (unpublished report).

Kodra A., Gjata K., and Bakalli, F., 1995. The Mirdita oceanic basin from rifting to closure. Workshop on Albanian ophiolites and related mineralization. IUGS/UNESCO Modeling Programme, Documents du Bureau de Recherches Géologiques et Minières, Orléans, 244, 9-26.

Kodra A., Gjata K., and Xhomo, A., 2000. Tectonic history of the Mirdita oceanic basin (Albania). Buletini i. Shkencave Gjeologjike, 1, 5-26.

Maliqi, G., 2001. Ndertimi gjeologjik i rajonit te Trepçes. PhD Thesis, Universiteti i Prishtines (unpublished).

Marcucci, M., Kodra, A., Pirdeni, A., and Gjata, Th., 1994. Radiolarian assemblages in the Triassic and Jurassic cherts of Albania. Ofioliti, 19(10), 105-115.

Meshi, A., 1996 Struktura dhe deformacioni i masivit ultrabazik te Bulqizes. Modele te rrjedhjes astenosferike dhe litosferike. PhD Thesis, Universiteti i Tiranes (unpublished).

Nicolas, A., 1989. Structures of Ophiolites and Dynamics of Oceanic Lithosphere. Kluwer Academic Publishers, Amsterdam.

Nicolas, A., Boudier, F., and Meshi, A., 1999. Slow spreading accretion and mantle denudation in the Mirdita ophiolite (Albania). Journal of Geophysic Researches, 104 (87), 15155-15167.

Pencerovski, J., and Haxhidimitrova, S., 1975. Geoloshka karta S. R. Makedonija, Sc. 1:200.000, Skopje.

Prela, M., 1994. Radiolarian biostratigraphy of the sedimentary cover of ophiolites in Mirdita area (Albania): initial data. Ofioliti, 19, 279-286.

Prela, M., 1996. Biostratigraphia a radiolari della copertura diasprina delle ofioliti della Mirdita (Albania). Tesi di dottorato in scienze della terra, Universita di Pisa (unpublished).

Robertson, A. H. F., and Karamata, S., 1994. The role of subduction-accretion processes in the tectonic evolution of the Mesozoic Tethys in Serbia. Tectonophysics, 234, 73-94.

Robertson, A., and Shallo, M., 2000. Mesozoic-Tertiary tectonic evolution of Albania in its regional Eastern Mediterranean context. Tectonophysics, 316, 197-254.

Shallo, M., 1996. Relationships between the Albanian ophiolites and Korab-Pelagonian microplate. In: V. Knezevic and B. Krstic (eds.), Terranes of Serbia, Belgrade, pp. 231-236.

Smith, A. G., 1993 Tectonic significance of the Hellenic-Dinaric ophiolites. H. M. Prichard, Alabaster T., Harris N. B. and Neary C. R. (eds.). Magmatic Processes and Plate Tectonics, Geological Society Special Publication, 76, 213-243.

Vergely, P., and Kodra A., 1995. Palinspathic probable models of the geodynamic evolution of the Albanian ophiolites. Workshop on Albanian Ophiolites and Related Mineralization, IUGS/UNESCO Modeling Programme, Documents du Bureau de Recherches Géologiques et Minières, Orléans, Abstracts, 244, pp. 96-98.

Vergely P., Dimo A., and Monié P., 1997. Datation des semelles métamorphiques ophiolitiques de l'Albanie par la methode Ar40/Ar39: Consequences sur le mécanisme de l'obduction. Compte Rendu d'Académie des Sciences, Paris, 326, 713-723.

Xhomo, A., Kodra, A., Xhafa, Z., and Shallo, M., 2002. Gjeologjia e Shqiperise. Monografi, Sherbimi Gjeologjik Shqiptar, Tirane.