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Μεταπτυχιακή Διπλωματική Εργασία

"Synthesis from well data of the nature, characteristics and parameters of the different petroleum systems in Albania and Greece. Mapping the paleo-environment and parameters of the source rocks and evolution through time and location"

Κωνσταντίνος Βασιλείου

ΑΜ: 21329

Τριμελής Επιτροπή

Επιβλέπων: Επίκ. Καθηγητής Στυλιανός Λόζιος

Καθηγητής Βασίλειος Καρακίτσιος

Καθηγητής Ευθύμιος Λέκκας

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Περίληψη

Αντικείμενο της παρούσας διπλωματικής εργασίας είναι τα μητρικά πετρώματα πετρελαίου στην περιοχή της Δυτικής Ελλάδας και της Αλβανίας. Σκοπός της εργασίας είναι να γίνει η σύνθεση, μέσω της βιβλιογραφίας και των δεδομένων από τις γεωτρήσεις, της φύσης και των χαρακτηριστικών των διαφορετικών πιθανών μητρικών πετρωμάτων πετρελαίου. Επίσης η χαρτογράφηση του παλαιο-περιβάλλοντος και η περιγραφή του ανάλογα με την τοποθεσία και τον χρόνο.

Η μεθοδολογία που ακολουθήθηκε ώστε να επιτευχθούν οι στόχοι της διπλωματικής εργασίας είναι η εξής: Αρχικά έγινε εκτίμηση της ποιότητας των πιθανών μητρικών πετρωμάτων και στην συνέχεια ταξινομήθηκαν σε κατηγορίες σύμφωνα με την ποιότητά τους. Για την εκτίμηση αυτή, χρησιμοποιήθηκε η γεωχημική ανάλυση των δειγμάτων ώστε να προσδιοριστούν τα χαρακτηριστικά τους, όπως το TOC (total organic carbon), ο δείκτης S2 (mg TOC/gr rock), ο δείκτης HI (Hydrogen Index), ο δείκτης OI (oxygen Index) και το στάδιο ωριμότητας. Για την χαρτογράφηση του παλαιο-περιβάλλοντος, αρχικά προσδιορίστηκαν τα περιβάλλοντα απόθεσης των μητρικών πετρωμάτων και στη συνέχεια παρουσιάστηκαν σε παλαιο-γεωγραφικό χάρτη.

Τα καλύτερα μητρικά πετρώματα, όπως αναμενόταν, βρέθηκαν στην Ιόνια Ζώνη στο Τριαδικό, στο Κατώτερο και Ανώτερο Ιουρασικό και στο Μέσο Κρητιδικό. Ωστόσο καλά μητρικά πετρώματα βρέθηκαν στην ζώνη Kruja στην Αλβανία, στο Ανώτερο Κρητιδικό. Το περιβάλλον απόθεσης των καλύτερων μητρικών πετρωμάτων είναι βαθύ θαλάσσιο ενώ καλά μητρικά πετρώματα βρέθηκαν και σε υπερ-παλιρροιακά περιβάλλοντα. Επομένως είναι δύσκολο να γίνει ένας σαφής προσδιορισμός της σχέσης μεταξύ καλού μητρικού πετρώματος και περιβάλλοντος απόθεσης.

Abstract

The subject of this thesis is the source rocks in the region of Western Greece and Albania. The aim of the study is to synthesize, through literature and data from wells, the nature and characteristics of the different possible source rocks. Also the mapping of the paleo-environment and describe their evolution through location and time.

In order to meet the objectives of this study, an evaluation of the potential of the possible source rocks has to be done first as well as classification in categories according to their potential. For the evaluation of the possible source rocks we have to use the available geochemical analysis of the samples and define their characteristics and parameters as TOC (total organic carbon), S_2 (mg TOC / gr rock), HI (Hydrogen Index), OI (Oxygen Index) and stage of maturation. For the mapping of the paleo-environment, the depositional environments of the source rocks were first identified and then presented on a paleo-geographic map.

The best source rocks, as expected, were found in the Ionian Zone in the Triassic, Lower and Upper Jurassic, and Middle Cretaceous. However, very good source rocks were found in the Kruja zone in Albania, in the Upper Cretaceous. The depositional environment of the best source rocks is deep marine, while good source rocks are found in supratidal environments. Therefore, it is difficult to make a clear determination of the relationship between good source rock and depositional environment.

Ευχαριστίες

Πρώτα και πριν από όλους, θα ήθελα να ευχαριστήσω θερμά τον καθηγητή Β. Καρακίτσιο για την εμπιστοσύνη που μου έδειξε και την ευκαιρία που μου έδωσε να βρεθώ και να εργαστώ στην εταιρία TOTAL στο Παρίσι. Επίσης θα ήθελα να ευχαριστήσω τον επίκουρο καθηγητή Σ. Λόζιο, επιβλέποντα καθηγητή της διπλωματικής μου εργασίας, για την βοήθειά του και την εμπιστοσύνη που μου έδειξε. Θα ήθελα να εκφράσω τις θερμές μου ευχαριστίες στον κύριο Κ. Σούκη (Ε.ΔΙ.Π.) που χωρίς την πολύτιμη βοήθειά του δεν θα είχα καταφέρει να πετύχω πολλούς από τους στόχους μου. Όντας καθηγητής μου στα πλαίσια των προπτυχιακών μου σπουδών με παρότρυνε να συνεχίσω τις σπουδές μου, ενώ δεν αρνήθηκε πότε να με βοηθήσει όσες φορές και αν του το ζήτησα. Τον ευχαριστώ ως επιστήμονα και ως άνθρωπο για την βοήθειά του.

Όσον αφορά το τμήμα της εργασίας που εκπονήθηκε στην εταιρία TOTAL στο Παρίσι, θα ήθελα να ευχαριστήσω τον υπεύθυνο της εταιρίας για την εργασία μου, κύριο Jean-Michel Champanhet για την καθοδήγησή του και την στήριξή του. Επίσης θα ήθελα να ευχαριστήσω την κυρία Camille Raulin για τις συμβουλές της και την καθοδήγησή της σε θέματα σχετικά με τα μητρικά πετρώματα. Θα ήθελα να ευχαριστήσω επίσης τον κύριο Francois Roure(IFP) για τις συζητήσεις που είχαμε και με βοήθησαν να καταλάβω καλύτερα την σχέση μεταξύ των μητρικών πετρωμάτων και της τεκτονικής. Αναφορικά με τους χάρτες που χρησιμοποιήθηκαν στην παρούσα εργασία, θα ήθελα να ευχαριστήσω τον κύριο Raphael Bonfils για την βοήθειά του στο πρόγραμμα GIS.

Τέλος θα ήθελα να ευχαριστήσω την μητέρα μου, Μαρία Κορρέ για την ηθική και όχι μόνο στήριξή της καθ' όλη την διάρκεια των σπουδών μου.

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Introduction

In the field of petroleum exploration, one of the most important aspects is to be able to recognize the various types of source rocks in geological series which, under the effect of increasing temperature during burial, produce petroleum compounds. As a matter of fact, the quantity and quality of hydrocarbons which have been produced depend on the type and the amount of the organic matter originally deposited in these source rocks (Espitalie J. et al., 1977). The amount and type of organic matter are controlled by environmental and depositional conditions as well as by the subsequent thermal evolution. Organic content depends on biologic productivity, sediment mineralogy and oxygenation of the water column and sediment (Jacobson S.R., 1991).

Greece and Albania have had a broadly similar geological history and the hydrocarbon potentials of both areas may be comparable, although the number of discoveries in Albania is significantly greater than in Greece. A number of sizeable oilfields (mostly located in Albania) produced from Mesozoic to Paleogene carbonates assigned mainly to the Ionian Zone. In both Albania and western Greece, the Permian to Eocene succession includes organic rich shales which were deposited on the Apulian margin of the Ionian Basin. Tertiary closure of Pindos Ocean resulted in thrusting onto the Apulian margin along Triassic evaporite decollements. A thick, late Eocene to Miocene flysch sequence has been deposited synchronously in the Ionian foreland basin and was deformed by advancing thrust system(Zelilidis et al., 2003).

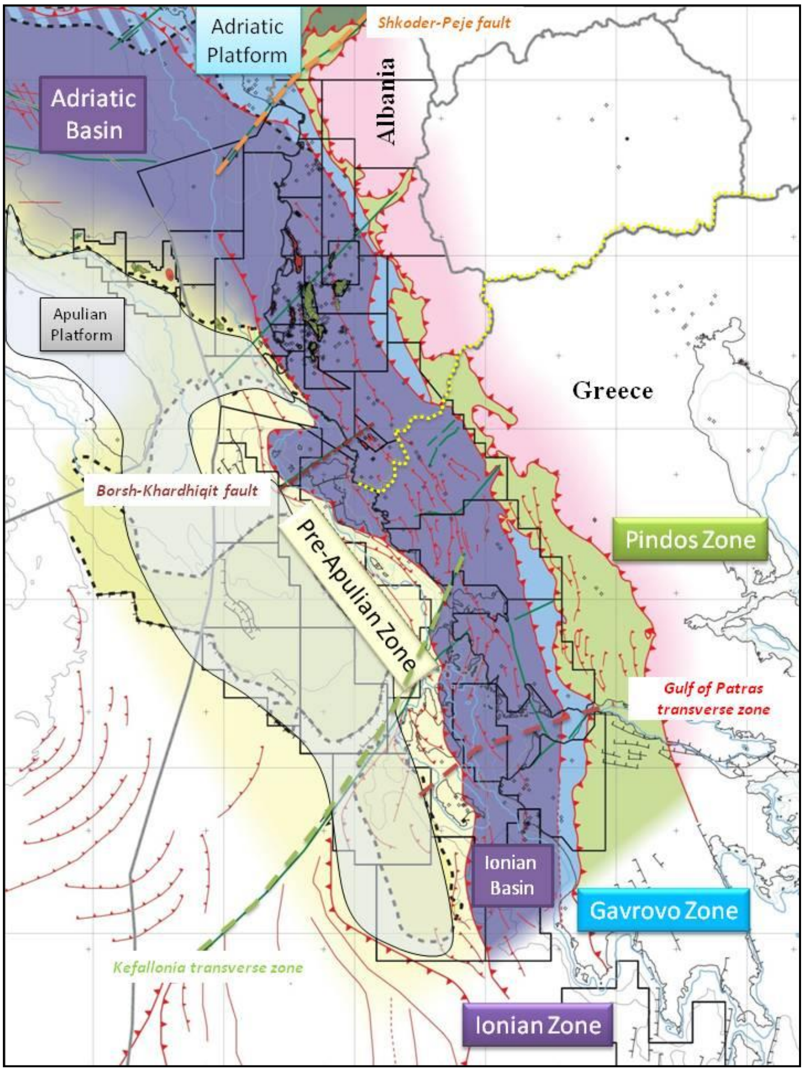

Figure 1 : External tectonic zones in Greece and Albania.

The area of interest corresponds to Greece and Albania. In this study we will focus in the external part of Hellenides and Albanides, where the source rock intervals seem to be quite similar in both countries.

The principal aim of this study is to synthesize, from literature and well data, the nature and the characteristics of the different potential source rock intervals, mainly in the external part of Albania and Greece. Mapping the paleo-environments of the possible source rock and describe their evolution through time and location. In order to do this, an evaluation of the potential of the possible source rocks has to be done first as well as classification in categories according to their potential. For the evaluation of the possible source rocks we have to use the available geochemical analysis of the samples and define their characteristics and parameters as TOC (total organic carbon), S1-S2-S3 contents, HI (Hydrocarbon Index), OI (oxygen Index) and stage of maturation. For the mapping of the paleo-environments, first we have to describe or define better, from all available data, the depositional environments of the source rocks and then to presented them on a paleo-geographic map.

Data set

Most of the data for this study were provided by internal bibliography (Total) and external bibliography (e.g. web sites, library of University of Athens) and composed of:

- Data from geochemical analysis of samples
- Scientific programs for diagrams
- Well logs and well interpretation results
- Geological and Paleogeographic maps

1. Geological context

Greece and Albania are part of the Dinaric – Albanic – Hellenic arc of the Alpine orogeny. The collision of the African and Eurasian plates caused the area to become folded and displaced from east to the west. The Apulian platform is overthrust in the east by Albanides – Dinarides – Hellenides and to the west by Appenines. The Albanides – Dinarides – Hellenides comprises four main units: the autochthonous foreland, the foredeep, the internal and the external tectonic zones. All the tectonic zones are thrusting westwards, partially covering each other and are thrusted together over the autochthonous foreland which is represented by the Sazani zone (Albania), Apulian Platform (Italy) and Paxos or Pre-Apulian zone (Greece)(Velaj 2015; Velaj et al. 1999).

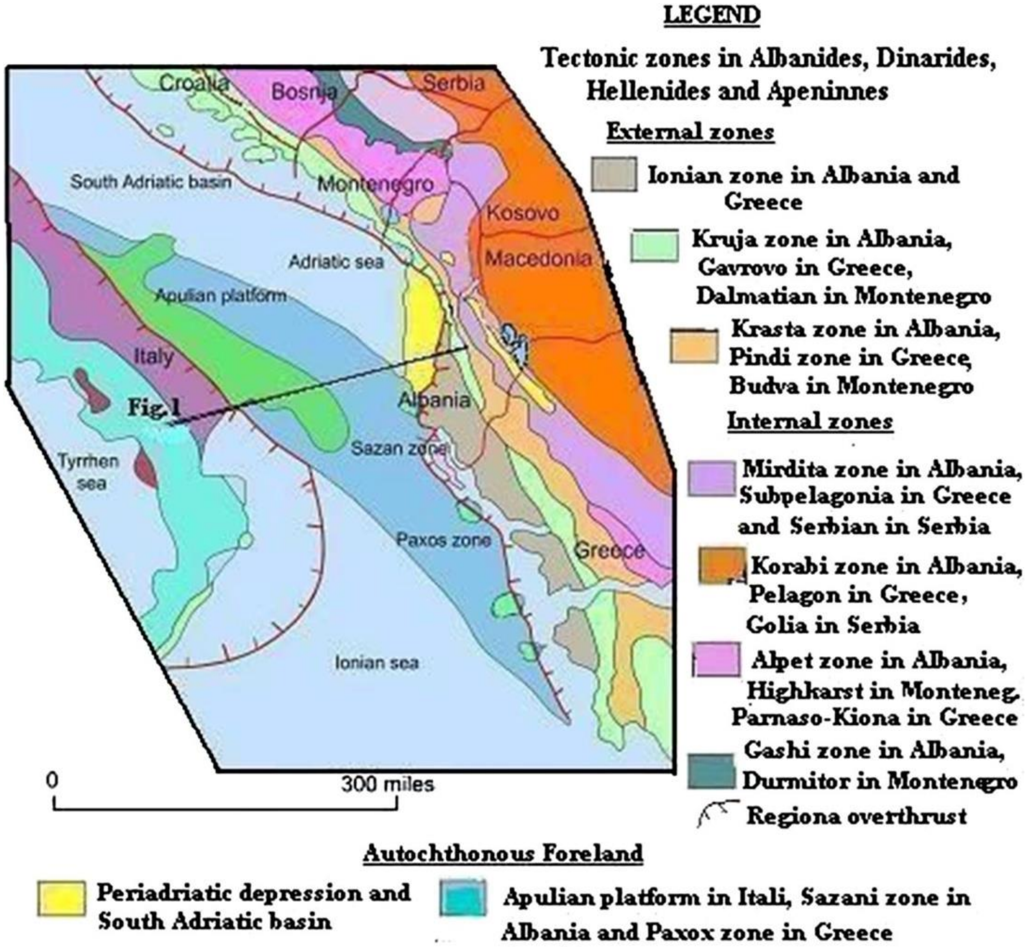

Figure 2 : Tectonic Zones in Albanides, Dinarides, Hellenides and Apennines (Velaj, 2015).

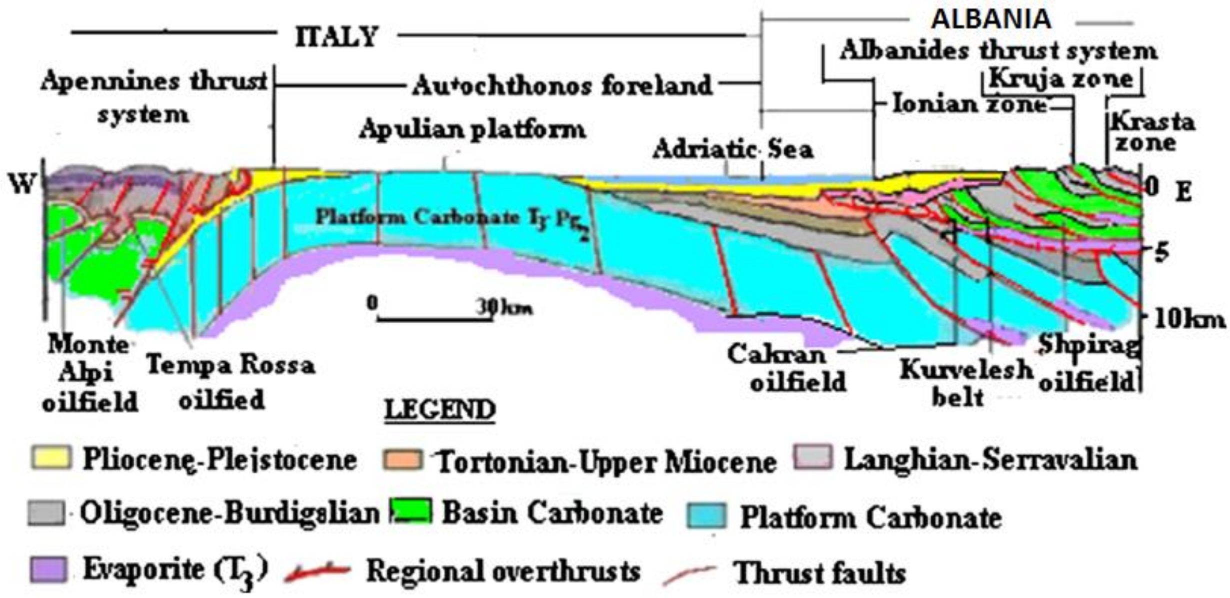

Figure 3 : Schematic geological cross-section between the Albanides and Apennines. See location in Fig 6 (Velaj, 2015).

Both Hellenides and Albanides can be divided into two major parts: internal (eastern) and external (western). These major units can be split into several tectono-stratigraphic sub-units, each of them being characterized by a former typical paleo-geographic/geodynamic environment. These sub-units are almost the same in Greece and Albania and some of them continue northwards in Montenegro and Croatia. They have been differentiated from east to west as follow (Roure et al., 1995; Swennen et al., 1998, Velaj et al., 1999; Karakitsios, 1995; Vilashi, 2009):

- The Krasta-Cukali zone in Albania, equivalent to the Pindos zone in Greece; has an intermediate location between external and internal Albanides and can be considered as part of external Albanides.
- The Kruja Zone in Albania equivalent to the Gavrovo Zone in Greece;
- The Ionian zone, which can be divided into three belts in Albania: Berati, Kurveleshi and Cika belt (Shallo, 1990; Roure et al., 2004). A similar separation in internal, middle and external belts can be made for the Greek part of the Ionian zone.
- The Sazani Zone in Albania equivalent to the Pre-Apulia or Paxos Zone in Greece.

The Peri-Adriatic Depression represents the external zones of the Albanides – Dinarides – Hellenides and the Apennines in Italy. Post-carbonate deposition is composed of terrigenous sediments, the placement and the distribution of which indicate a basin environment, which itself is included in the South Adriatic Basin (Zappaterra 1994; Picha 2002). The southern and western part of this basin (Albania, Greece and Italy) overlies the Ionian, Kruja and Apulian platform (Frasheri et al. 2009; Bega 2010; Velaj 2012), whereas in the north, it continues with the South Adriatic Basin. (Velaj, 2015)

1.1. Tectonic evolution

At plate tectonics scale, Greece and Albania have quite similar evolution. Within this chapter we will describe the tectonic evolution of both countries through the time, considering them as one area and highlight the differences when possible. The tectonic evolution of western Greece and Albania can be divided in four main events: prerift, synrift, postrift (of Jurassic rifting) and Tertiary deformation.

Pre-Mesozoic

Permian is a not well known period in the area of interest because of the fact that Permian rocks do not crop out and neither has been penetrated by boreholes, except in Hydra island and in Albanian Alps tectonic zone (Frasheri, 2007). However, this period has been studied from several authors who have made some hypotheses about the tectonic evolution. According to some authors (Robertson & Dixon, 1984; Nieuwland et al, 2001), a rifting event took place during Upper Permian which has been inverted in the Lower Triassic and left a depression, bounded by NE-SW transform faults. This depression continued to exist and is currently expressed in the topography of Albania as the Peri-Adriatic Depression.

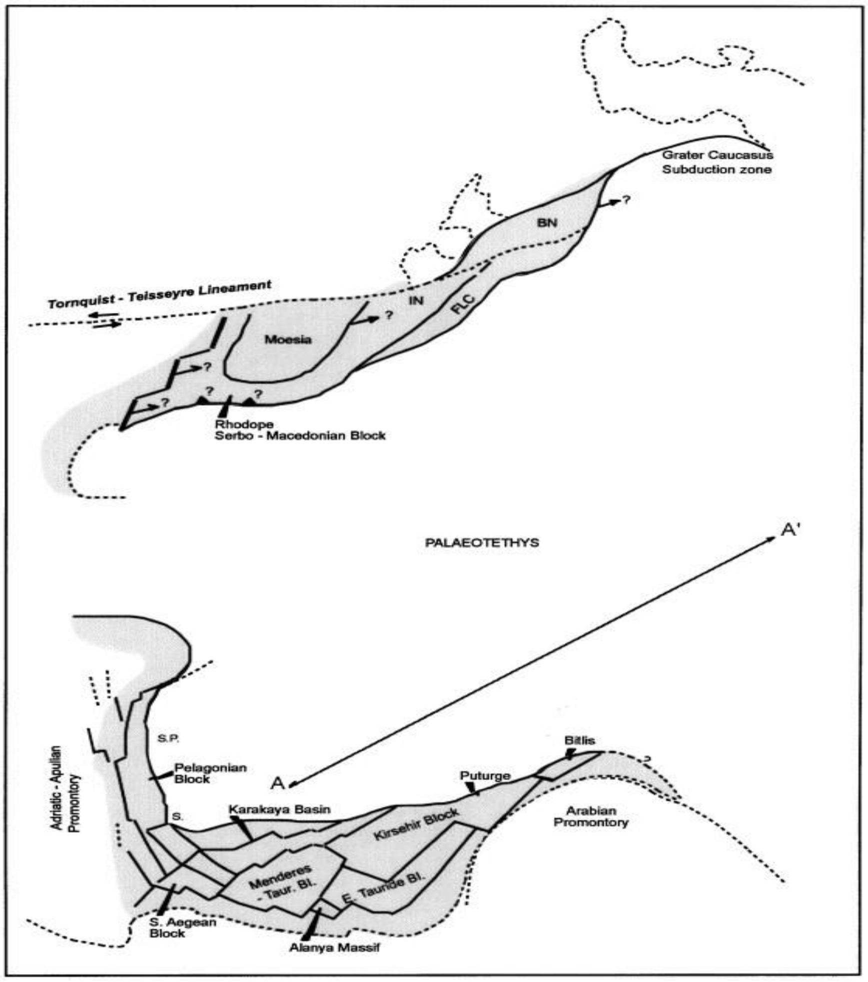

Figure 4 : Plate tectonic reconstruction at 240 Ma (Upper Permian – Lower Triassic), modified after Robertson et al (1996) (Nieuwland et al, 2001).

Upper Triassic-Lower Jurassic

The oldest known rocks in western Greece and south Albania are Triassic evaporites. This period corresponds to the "pre-rift phase" of Jurassic rifting(Karakitsios & Rigakis 2007; Karakitsios, 1995). By Late Triassic deposition conditions changed. The passive margins of Tethyan seaway were fully established in the Peri-Adriatic region and they were characterized by the development of extensive shallow marine and restricted carbonate platforms. At the same time to the east, Middle Triassic rifting of the Pindos Ocean separated the Pelagonian microcontinent from the (Godwanan) Pre-Apulian- Ionian-Gavrovo (Kruja) microcontinent. Seafloor spreading has been initiated during the late Triassic with the opening of the Pindos Ocean.

Lower – Upper Jurassic

The "syn-rift" phase started during Pliensbachian times (Karakitsios 1990, 1995), when the extensive Liassic carbonate platform began to founder and Neotethyan rifting resulted in the formation of the Ionian Basin and the adjacent western Pre-Apulian platform carbonates and eastern Gavrovo – Kruja (SE extension of Dinarides platform). The extensional phase may have provoked halokinetic movements in the Triassic substratum which influenced the synrift mechanism by increasing the amount of the fault throws. The directions of synsedimentary structures (e.g. slumps and synsedimentary faults), in Ionian zone, indicate that deposition was controlled both by structures formed during extension related to the opening of the Neotethys and during by halokinesis of evaporites at the base of Ionian zone succession(Karakitsios 1995; Karakitsios & Rigakis 2007; Karakitsios 2013).

The large scale crustal extension utilized the transform faults formed in the earlier Permian-Triassic phase. The extension resulted in crustal necking (Ziegler et al, 1995). The promontory failed eventually along the most eastern necking zone, opening the Pindos Ocean and resulting in the formation of ophiolites in the spreading centre, separating the Pelagonian micro-continent from the promontory.

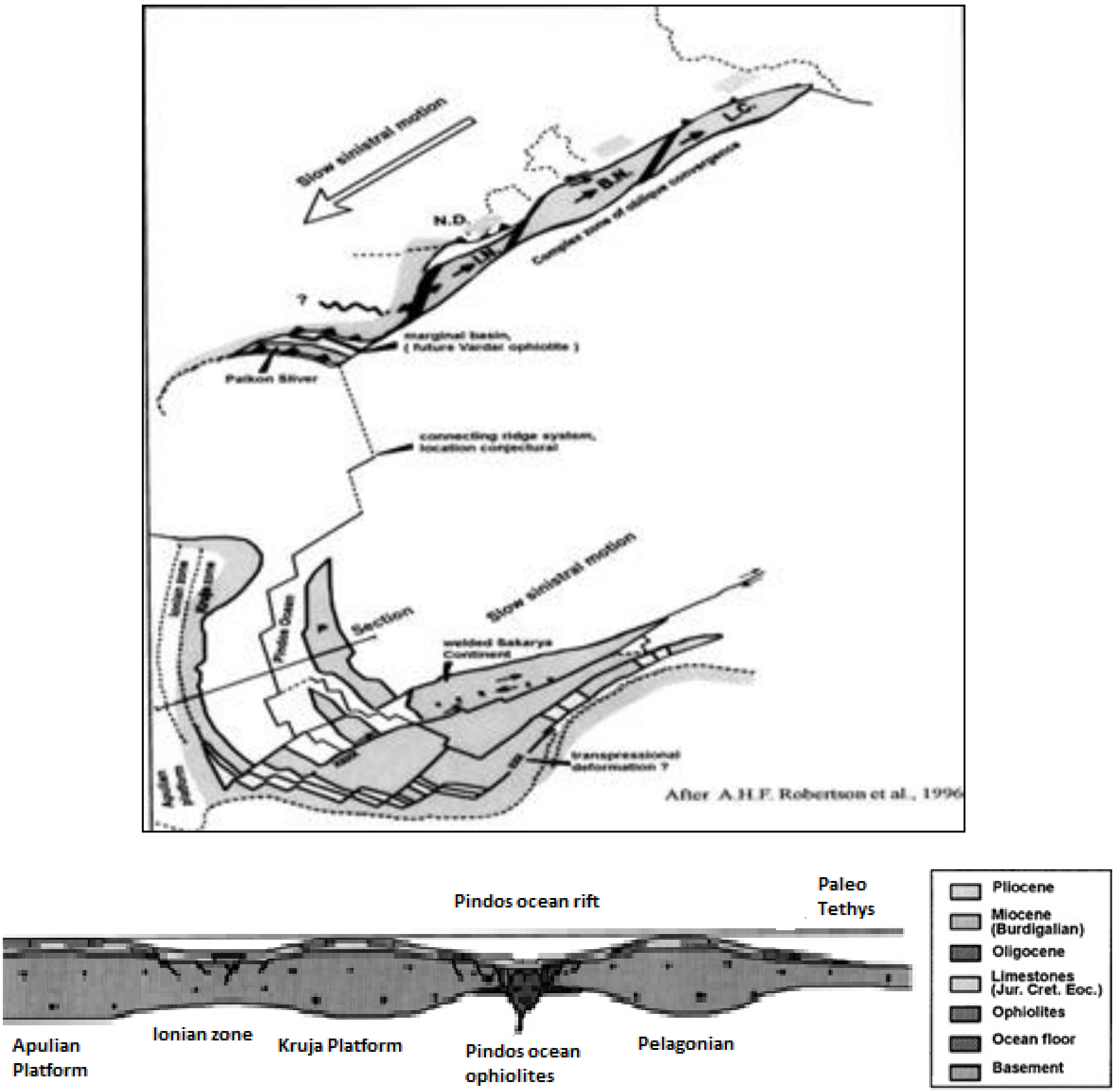

Figure 5 : Plate tectonic reconstruction at 180 Ma (upper part of Lower Jurassic), modified after Robertson et al (1996) (Nieuwland et al, 2001).

The high between the Ionian rift and the Pindos Ocean forms the Kruja platform in Albania, equivalent to the Gavrovo zone in Greece(Nieuwland et al. 2001). East of Pelagonia, the Paleo-Tethys ocean floor moved away from the Adriatic-Apulian promontory. In the upper part of Lower Jurassic, the Pindos Ocean ophiolites started to form, but had not yet been extruded. On the Apulian and Kruja platforms the environment of deposition remained shallow marine (Nieuwland et al, 2001). During the Middle Jurassic (170 Ma) extension continued, leading to the formation of pelagic carbonates in the Ionian and Krasta-Cukali zone. On Apulia, platform carbonates indicate the continued existence of these areas as crustal highs. From the Kruja zone, the oldest sediment record in Albania is of Upper Cretaceous age, whereas in Greece, in the equivalent Gavrovo-Tripolitsa Zone, Late Triassic beds are known in more southern parts (Robertson & Shallo, 2000). The Kruja platform was not affected by tectonic thinning; it probably existed as crustal high throughout its history. In response to the continued opening of the Pindos Ocean, the ophiolites penetrated the crust, intruding the pelagic carbonates and extruding onto the ocean floor.

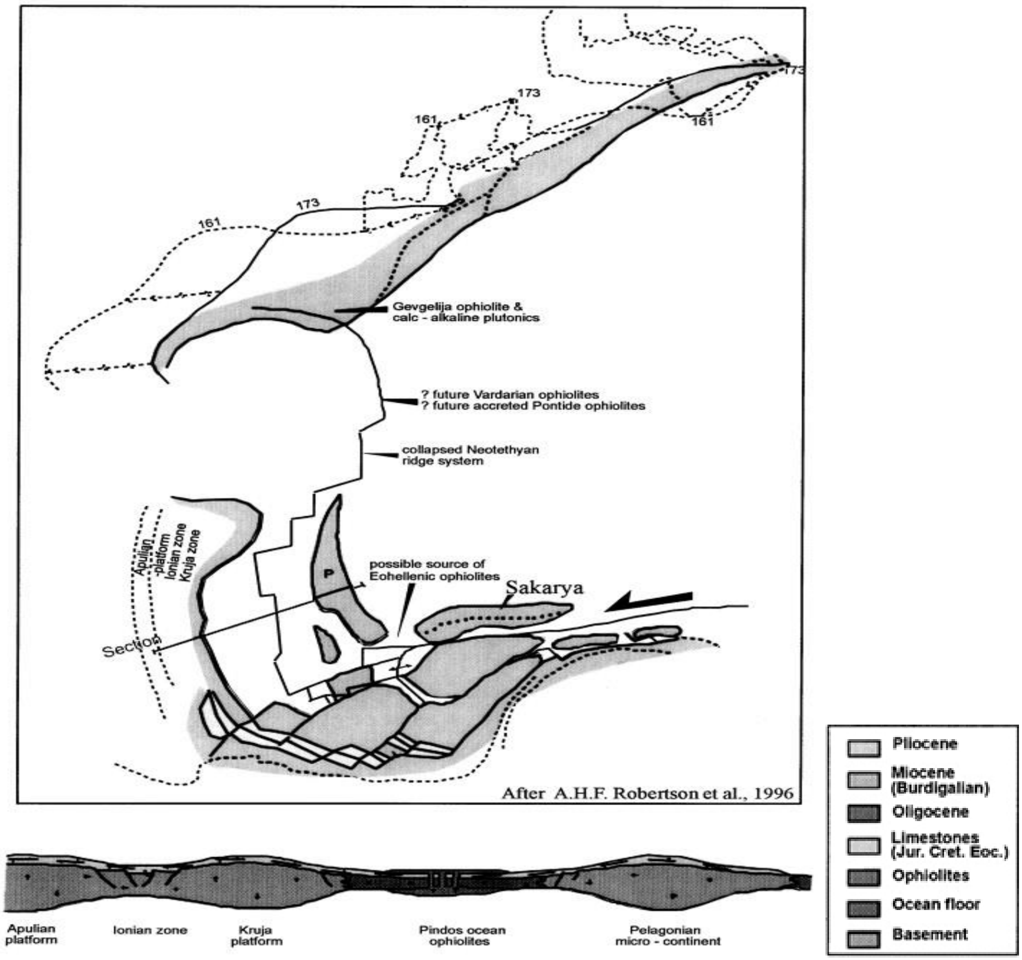

Figure 6 : Plate tectonic reconstructions at 170 Ma (Middle Jurassic), modified after Robertson et al (1996) (Nieuwland et al, 2001).

The timing of the crystallization of the ophiolites is based on a compilation of K-Ar radiometric ages from the Vardar zone, Albania and Greece, and ranges from 159 to 179 Ma (Spray et al, 1984; Nieuwland et al, 2001). Evidence of intrusive contacts can be seen in outcrop by contact metamorphic limestone turned into marble. The ophiolites in the contact zone have sheared chilled margins and sills can be seen to intrude into the carbonates. During the middle Jurassic, convergence within the Pindos ocean begun in response of changes in plate motion (apparently initiated in response to the opening of the North Atlantic ocean) and consumption of the ocean took place in an ocean-ocean subduction zone (Kaplanis et al, 2013). This event marked the onset of "Eohellenic" compression. The timing of Neohellenic compression has been constrained at 165 My (Bajocian/Bathonian) (Jones & Robertson 1991; Kaplanis et al. 2013). By the end of the Kimmeridgian, final closure of the Pindos Ocean is believed to have occurred in the Dinarides of Albania and Yugoslavia, while the Pindos ocean basin remained partly open in the Hellenides.

Cretaceous – Paleocene

The "post-rift" stage begins in the Early Cretaceous (Berriasian), with the pelagic Vigla limestones in Ionian Zone, whose deposition was synchronous throughout the Ionian Basin (Karakitsios 1992; Karakitsios et al, 2007). The transgressive nature of the Vigla Limestones is attributed to post-rift thermal subsidence as opposed to a eustatic sea level rise. The substantial thickness variations may be attributed to either the preservation of syn-rift half-graben geometry due to sediment starvation or continued halokinetic activity (Karakitsios, 1995).

In Albania area, at the Early Cretaceous, the westward movement of Paleo-Tethys has completed the emplacement of the Pindos ophiolites on the western margin of the Pelagonia micro-continent. To the east of Pelagonia, the Sakarya microcontinent started to move to the north-west, closing the gap with Pelagonia along an oblique collision zone. This resulted in the emplacement of ophiolites along the eastern margin of Pelagonia, in the southern part of the future Vardar zone (Nieuwland et al, 2001).

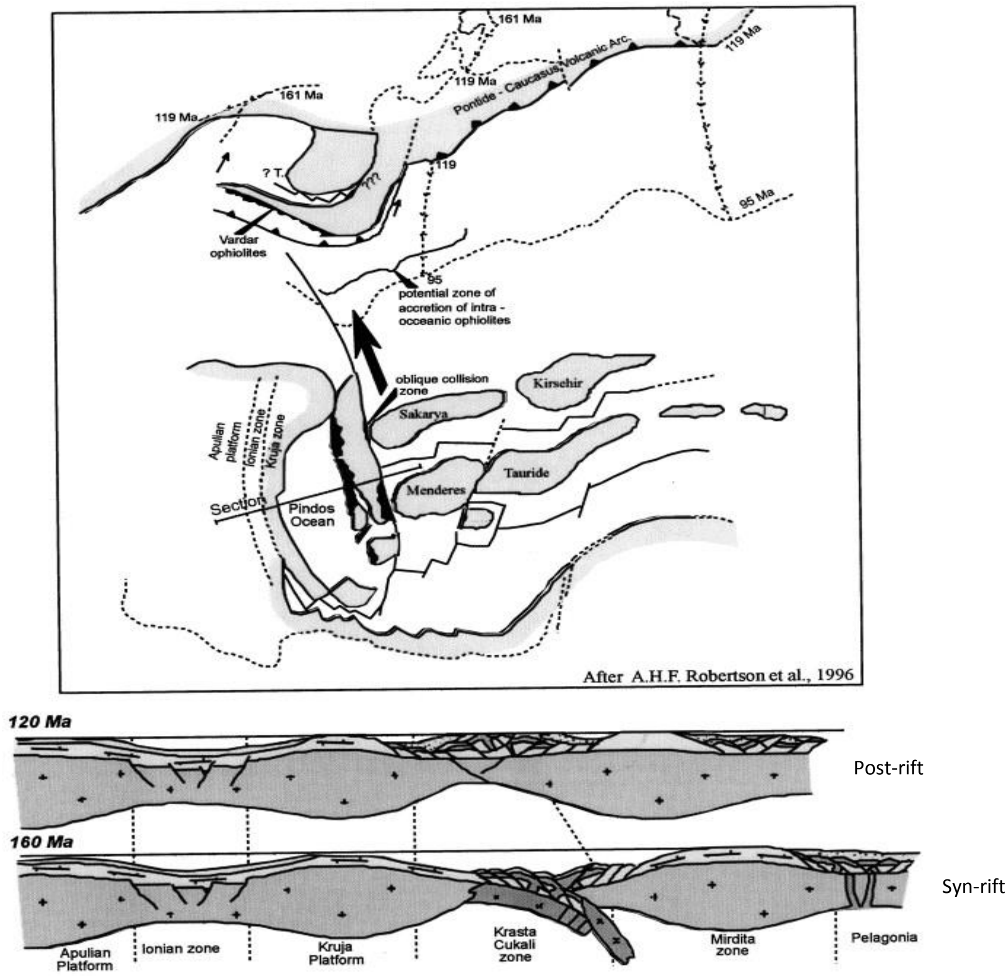

Figure 7 : Plate tectonic reconstructions at 160 – 120 Ma (Late-Middle Jurassic to Lower Cretaceous), modified after Robertson et al (1996) (Nieuwland et al, 2001).

The Pindos Ocean was now fully closed in Albania at the Upper Cretaceous and became inactive. The E-W motion locked and the remaining movement of Pelagonia was directed to the north, with Sakarya being displaced to the south-east corner of Pelagonia. The collision with Sakarya in the east and subduction of Pindos ocean floor in the west led to uplift of Pelagonia and consequently erosion of the ophiolites and deposition of clastic sediments (old flysch) in the Pindos basin, as recorded in the Krasta-Cukali zone, the most eastern zone of the External Albanides.

Paleogene

Continued northward movement of Pelagonia, resulted in the development of a connection between the SerboMacedonian-Rhodope block and the north-eastern margin of Pelagonia, along the Vardar transform zone (65 Ma). The Vardar ophiolites, which were formed along the southern margin of the SerboMacedonian-Rhodope block, were now connected with the ophiolites that formed along the oblique collision zone between Pelagonia and Sakarya. Following locking-up of the moving micro-continent in the Upper Cretaceous, continued compression in Paleocene resulted in thrusting of the Inner Albanides and initiation of flysch deposition in the Krasta-Cukali zone.

In Greece during the Early Tertiary, the Meso-alpine orogenic phase resulted in renewed compression and the eventual closure of the remnant Hellenide segment of the Pindos Ocean basin (Mesohellenic phase) (Jones & Robertson 1991). In the Ionian Zone a regional unconformity between the Mesozoic and Tertiary sequences was identified. Some Maastrichtian sequences are absent due to erosion and the basal unit of the Tertiary is a massive calcirudite of Upper Paleocene age. The Early Palaeocene was evidently a time of emergence, uplift and erosion which may have been related to the final closure of the remnant Pindos Ocean in Greece.

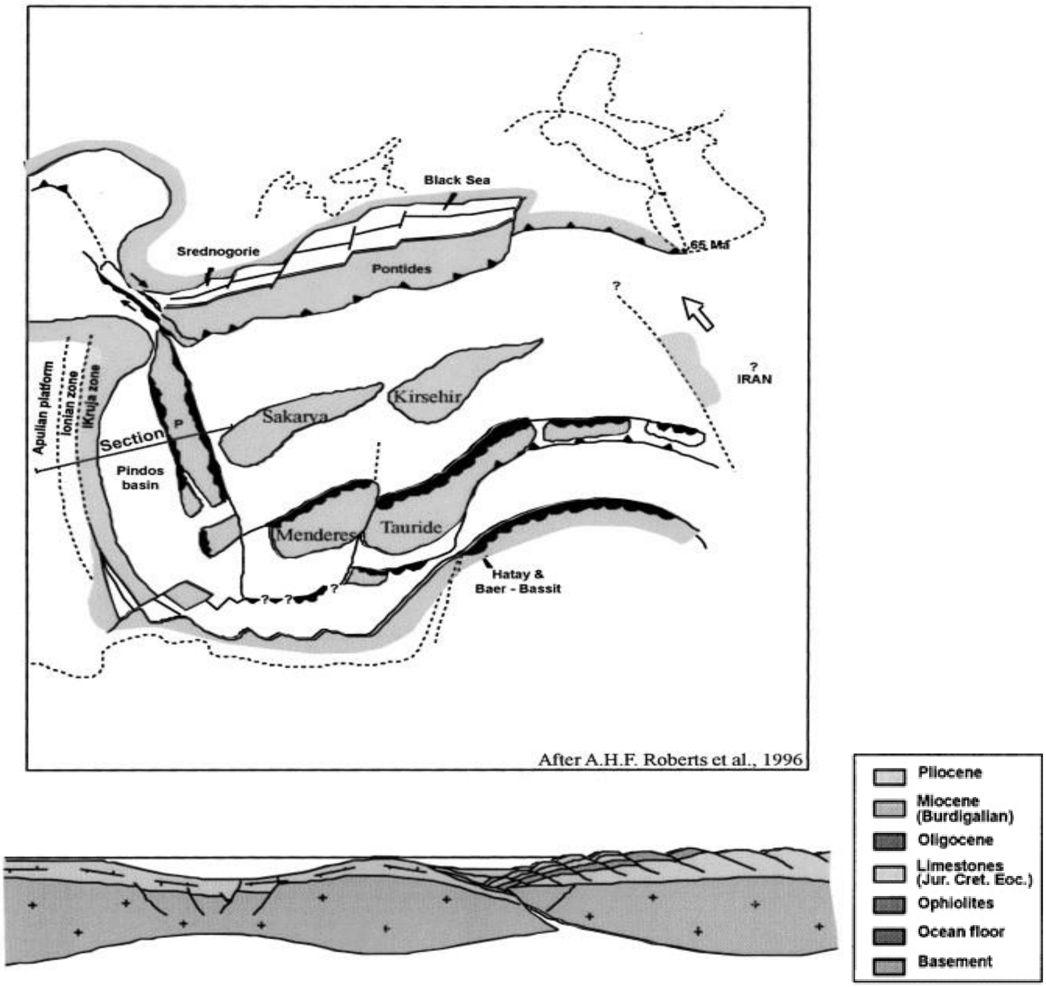

Figure 8 : Plate tectonic reconstruction at 65 Ma (Upper Cretaceous), modified after Robertson et al (1996) (Nieuwland et al, 2001).

During the Eocene (40 Ma) Pelagonian and Apulia had almost reached their current positions relative to each other. The ocean basins had closed, the subduction system was locked and further compression had to be accommodated by crustal thickening.

During the Bartonian times, westward migration of the Hellenides deformation front resulted in the initiation of activity on the Pindos Thrust. Deposition of a thick succession of Upper Eocene to Lower Miocene flysch occurred in a rapidly subsiding foredeep which developed in front of the advancing Pindos thrust sheets and stretched from the Gavrovo Zone in the east to the Pre-Apulian Zone in the west. The newly uplifted Pindos Mountains provided the predominant source area and the lithologies range from coarse clastics in the Gavrovo Zone to deep water turbidites in the Ionian Zone and marls in the Pre-Apulian Zone. Activity on the Pindos Thrust is believed to have ceased in the Late Oligocene (approximately 26 My) (Fleury 1980 in Brooks *et al* 1988) after which, the locus of Hellenide deformation migrated westwards to the Gavrovo Thrust.

In Albania in Oligocene (30 Ma) times, the deformation was expressed by uplift of the Mirdita zone and deposition of the Oligocene flysch on the Kruja Ionian zone.

Neogene

During the Burdigalian (20 Ma) the major thrusting took place in the Kruja zone and the Ionian zone. In the Early Miocene, the locus of Hellenides deformation migrated further westwards to the Kalamitsi Thrust of Lefkas (Ionian thrust). This marked the start of a major Early-Late Miocene compressional event which affected the entire Ionian Zone (Cushing 1985 in Brooks *et al* 1988). Onset of this event was dated as late Burdigalian to early Langhian and it closely coincided with the initiation of subduction along the Hellenic Arc, which has been variously dated around 13 Ma or at 16 Ma. The Pre-Aprulian Zone has traditionally been regarded as the undeformed autochthonous foreland to the Hellenide Thrust belt. However, recent studies have shown that the deformation front continued to migrate westwards into the Paxos Zone during the Late Pliocene and Quaternary. Late Pliocene to Quaternary compressional deformation can be best observed in western Kefallinia.

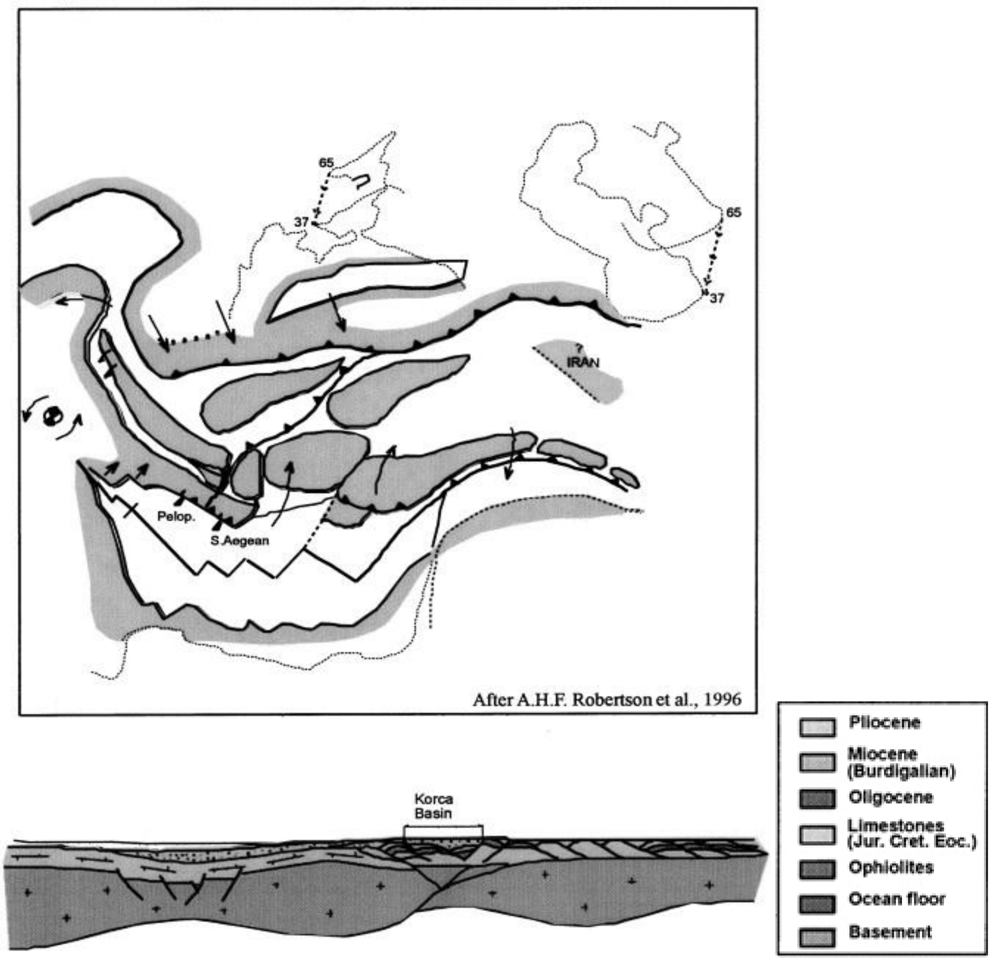

Figure 9 : Plate tectonic reconstruction at 40 Ma (Eocene), modified after Robertson et al (1996) (Nieuwland et al, 2001).

The late orogenic, orogen-parallel strike-slip tectonics in the frontal Dinarides-Hellenides represents the last stage of the mountain-building process, when the foreland thrust propagation was locked by stacking of thrust sheets and overall thickening of the continental crust (Picha 2002).

In a process of adjusting to regional compressional stresses, as well as to geometries of principal crustal units, some segments of systems were attenuated and others compressed. The late orogenic, orogen-parallel strike-slip faulting partly disrupted the depositional continuity of the foreland and the structural coherence of the thin-skinned Dinaric-Hellenic thrust belt, thus further complicating the paleogeographic reconstruction and structural balancing of the area. The dextral strike-slip faults in the Adriatic region provided a means of tectonic transport, or escape, from the collision zone of Apulia with Europe toward the oceanic realm of the Ionian Sea and the Hellenic Trench (Picha 2002). In western Greece, the southeastward-moving Dinarides-Hellenides apparently deflected the westward motion of the Anatolian plate into the southwest. Figure 15 represents schematic conceptual cross sections of the tectonic evolution of Albania and the main events. At a plate tectonics scale, the tectonic evolution of Greece and Albania can be considered as the same.

Thrusting has overprinted the Mesozoic extensional structures, but there is a close association between Hellenides thrusts and areas of evaporites, even where the thrusts are not precisely located. Evaporites are interpreted as a moderate to major decollement level throughout the external Hellenides and Albanides (Ionian zone), instead of a widespread diapirism(Karakitsios 2013; Roure et al. 2004). The whole Alpine belt can be considered as the inverted margin of the Tethys Ocean in response to African/Europe collision.

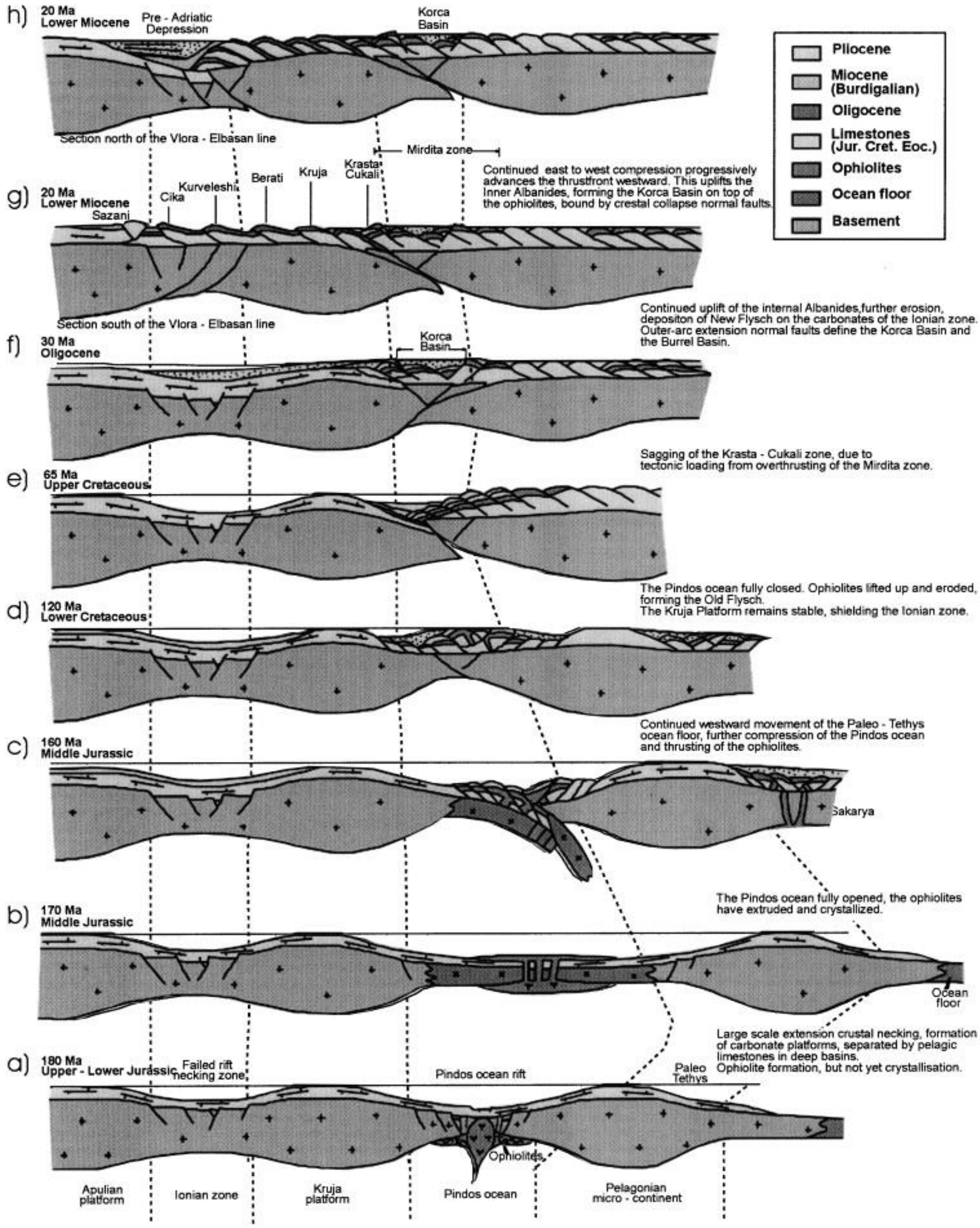

Figure 10 Conceptual cross sections of the tectonic evolution of Albania and Greece. Location in Figures 8-13 (Nieuwland et al, 2001) a) Upper Triassic – Lower Jurassic: large scale extension crustal necking, formation of carbonate platforms separated by pelagic limestones in deep basins. Ophiolites formed but not yet crystallizated. b) Middle Jurassic: the Pindos Ocean fully opened, the ophiolites have been extruded and crystallized. c) Middle Jurassic: continued westward movement of the Paleo-Tethys ocean floor, further compression of the Pindos Ocean and thrusting of the ophiolites. d) Lower Cretaceous: the Pindos Ocean is fully closed. Ophiolites lifted up and eroted forming the "Old Flysch". The Kruja platform remains stable, shielding the Ionian zone. e) Upper Cretaceous: Sagging of the Krasta-Cukali zone, due to tectonic loading from overthrusting of the Mirdita zone. f) Oligocene: continued uplift of the internal Albanides, further erosion, and deposition of the "New Flysch" on the carbonates of the Ionian zone. g) Lower Miocene: continued east to west compression progressively advances the thrust front westwards. This uplifts the internal Albanides forming the Korcan Basin.

1.2. Stratigraphy

In this chapter will be described the stratigraphic evolution of the zones that are in the study area. A stratigraphic description will be made for the Ionian zone, Pre-Apulian – Sazani Zone, the Peri-Adriatic Depression, Kruja-Gavrovo, Krasta-Cukali – Pindos zone and Albanian Alps zone. Even if, at a large scale, external part of Greece and Albania seems to have quite similar statigraphy, there are some local differences. Within this chapter we will consider the tectonic zones as tectono – statigraphic units and we will describe their stratigraphic evolution pointing out the main differences when possible.

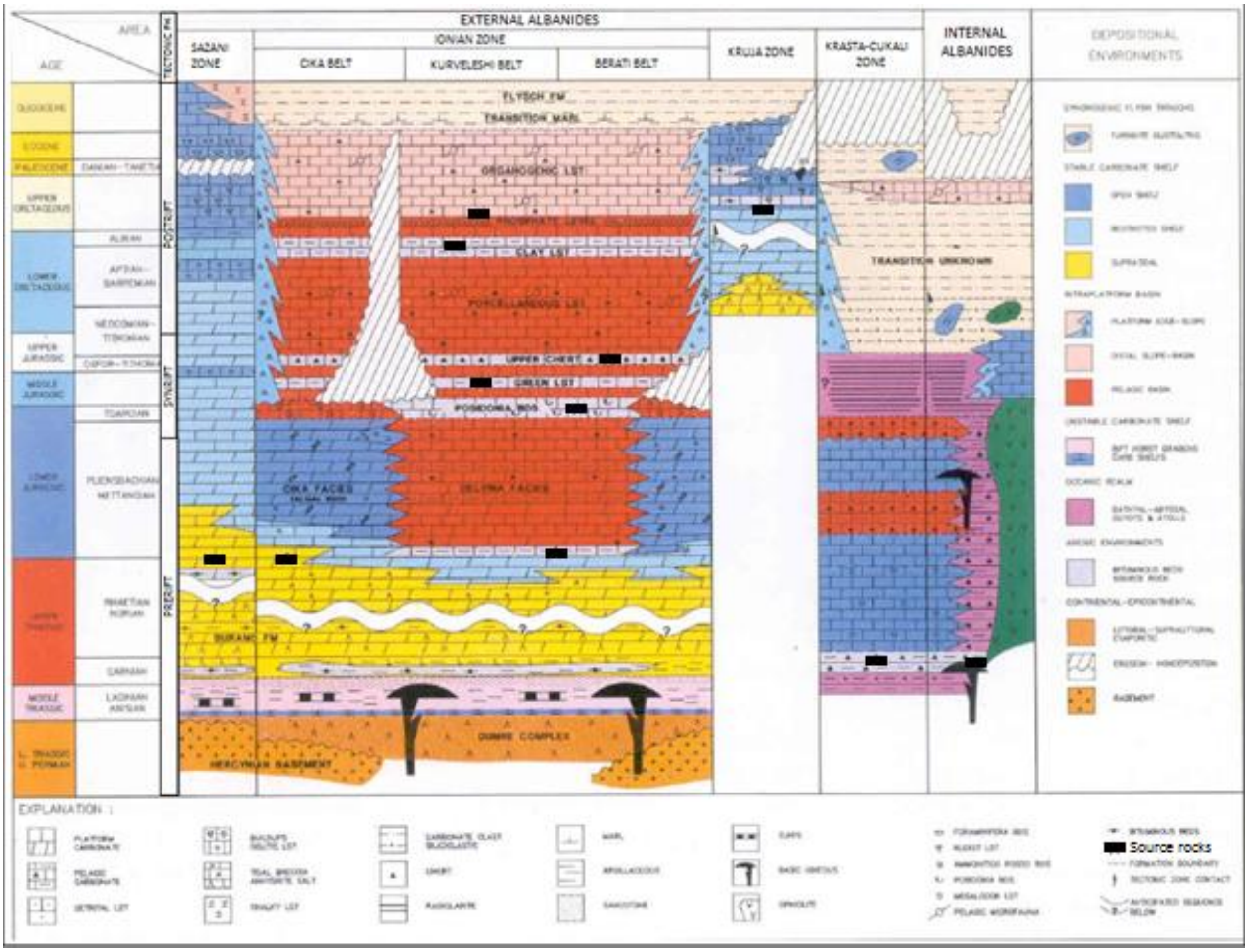

Figure: 11 Overview of the stratigraphic evolution in the External Albanides (Swennen et al, 1998; Vilasi 2009).

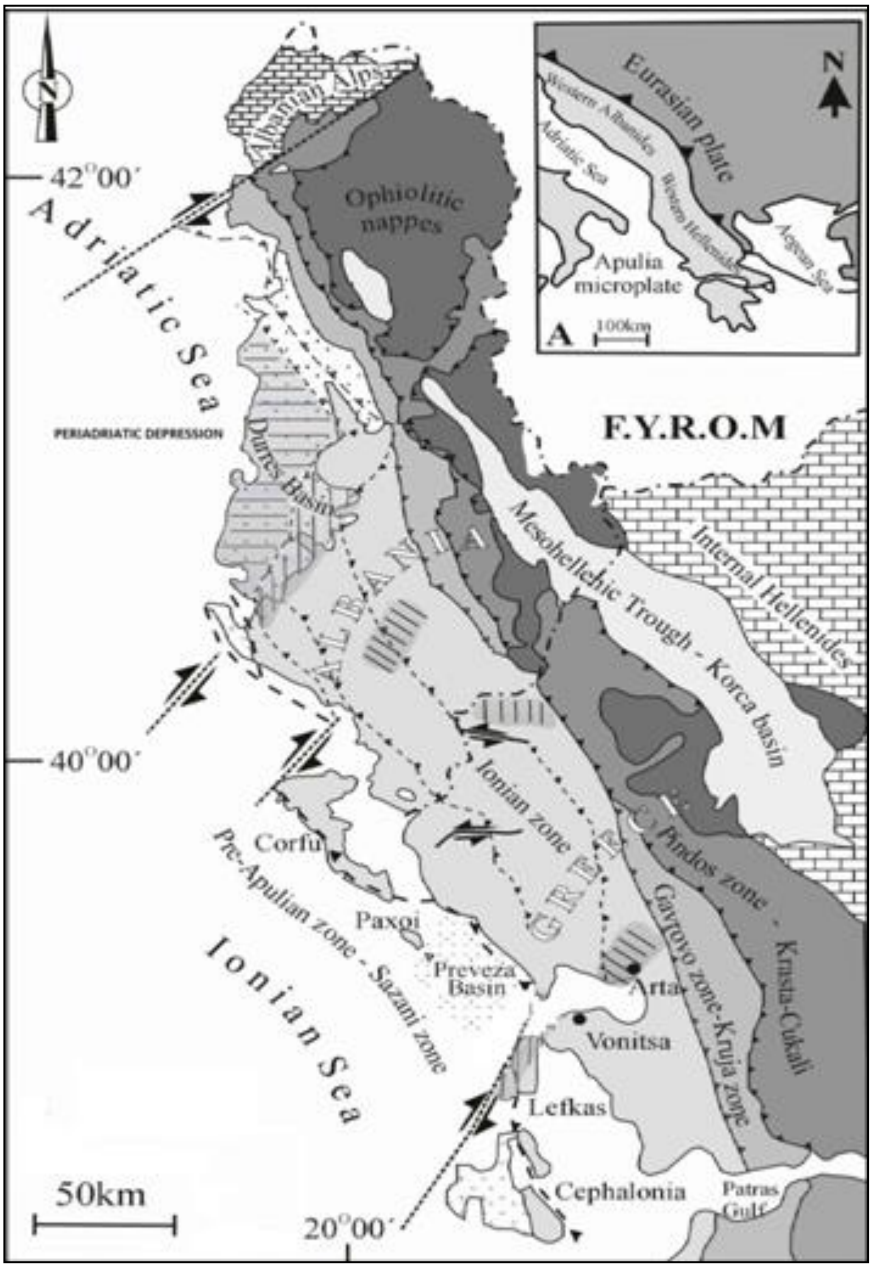

Figure: 12 Map of tectonic zones in western Greece and Albania (Zelilidis 2003).

1.2.1. Ionian Zone

The Ionian Zone is made up of three distinct stratigraphic sequences: prerift, synrift and postrift (of Jurassic rifting) (Karakitsios 1995; Karakitsios & Rigakis 2007; Karakitsios 2013).

Lower Triassic – Lower Jurassic

The oldest unit known at outcrops and wells in the prerift sequence is represented by Lower to Middle Triassic evaporites (>2000m), composed of anhydrites, gypsum and halite with usually thin interbeds of limestones or dolomites. They are assigned in Scythian – Ladinian age (Karakitsios 1995). This unit, represented by white gypsum and dark limestone, is exposed at surface in the hangingwall of thrust faults and diapirs. The prerift sequence is completed by the upper Ladinian – Rhaetian limestones and dolomites of the Foustapidima Formation and by the overlying shallow water limestones of the Pantokrator Fm (Hettangian to Sinemurian). Jurassic carbonate deposits, mainly be composed of limestones. They feature remarkable facies homogeneity and consist of calcareous algae, benthonic foraminifera and locally brachiopods.

In Albania the sedimentation begins with Upper Triassic evaporites which are made of of gypsum, anhydrites, salts, multicolored clays and breccias with interbedded dolomite and thin organic - rich shales. Salts are widespread in the Kurveleshi anticlinal belt, whereas gypsum and anhydrite facies predominate in the Berati and Cika belt (Velaj 2001).

Lower Jurassic – Upper Jurassic

The synrift sequence begins with the Pliensbachian pelagic Siniais limestones and their lateral equivalent Louros Limestones, overlain by Ammonitico Rosso and 'Limestones with filaments', laterally replaced and overlain by Posidonia Beds (Karakitsios 1995). The boundary between the Pantokrator Limestones and Siniais Limestones is gradational. These formations correspond to the general deepening of the Ionian domain with the formation of the Ionian Basin.

The structural differentiation that follows separated the initial basin into smaller paleo-geographic units with half-graben geometry. This is recorded in the abruptly changing thickness of the synrift formations that take the form of syn-sedimentary wedges. In the deeper parts of the half-grabens, these wedges include complete Toarcian – Tithonian successions comprising from base to top: Ammonitico Rosso (Toarcian – Aalenian) or Lower Posidonia Beds, Filament Limestone (Bajocian-Bathonian) and Upper Posidonia Beds (Callovian - Tithonian). In the shallower parts of the half-grabens the succession is interrupted by hiatuses and unconformities. The opening of the Tethys Ocean was accompanied by the formation of a series of northnorthwest–and east-southeast–trending conjugate faults (Karakitsios, 1995). The direction of syn-sedimentary structures (e.g. slumps and synsedimentary faults) indicate that deposition was controlled both by structures formed during extension related to the opening of the Neotethys ocean, and halokinessis of evaporites at the base of the Ionian zone succession (Karakitsios, 1995, 2007).

During Lower to Upper Jurassic the same conditions existed in Albania, with the deposition of pelagic limestone with chert, marl and shale interbedded, continuously throughout the Jurassic, Cretaceous and up to the Upper Eocene (T. Velaj 2015). At the beginning of the Lower Jurassic (Lias), a differentiation at the bottom of the Ionian zone is noticed, which is associated with the formation of two carbonate facies: pelagic facies represented by crystalline limestone with chert lenses and neritic facies represented by algal limestone and dolomite. In the central part of Ionian zone (Kurveleshi anticlinal belt), lithofacies of marl schists with "Posidonia" is formed, whereas on both sides, Berati and Cika anticlinal belts, recorded the deposition of limestone and dolomitice limestones with ammonites, known as "Amonitico Rosso". These deposits are shallower than "Posidonia" facies (Velaj 2011). During the Upper Jurassic, the deepening of the Ionian Trough continued and is associated with a marked increase in silicious material (the upper chert package), which develops in the entire Ionian Zone. At the Tithonian – Berriasian the water depth reaches its maximum covering the Liassic neritic deposits.

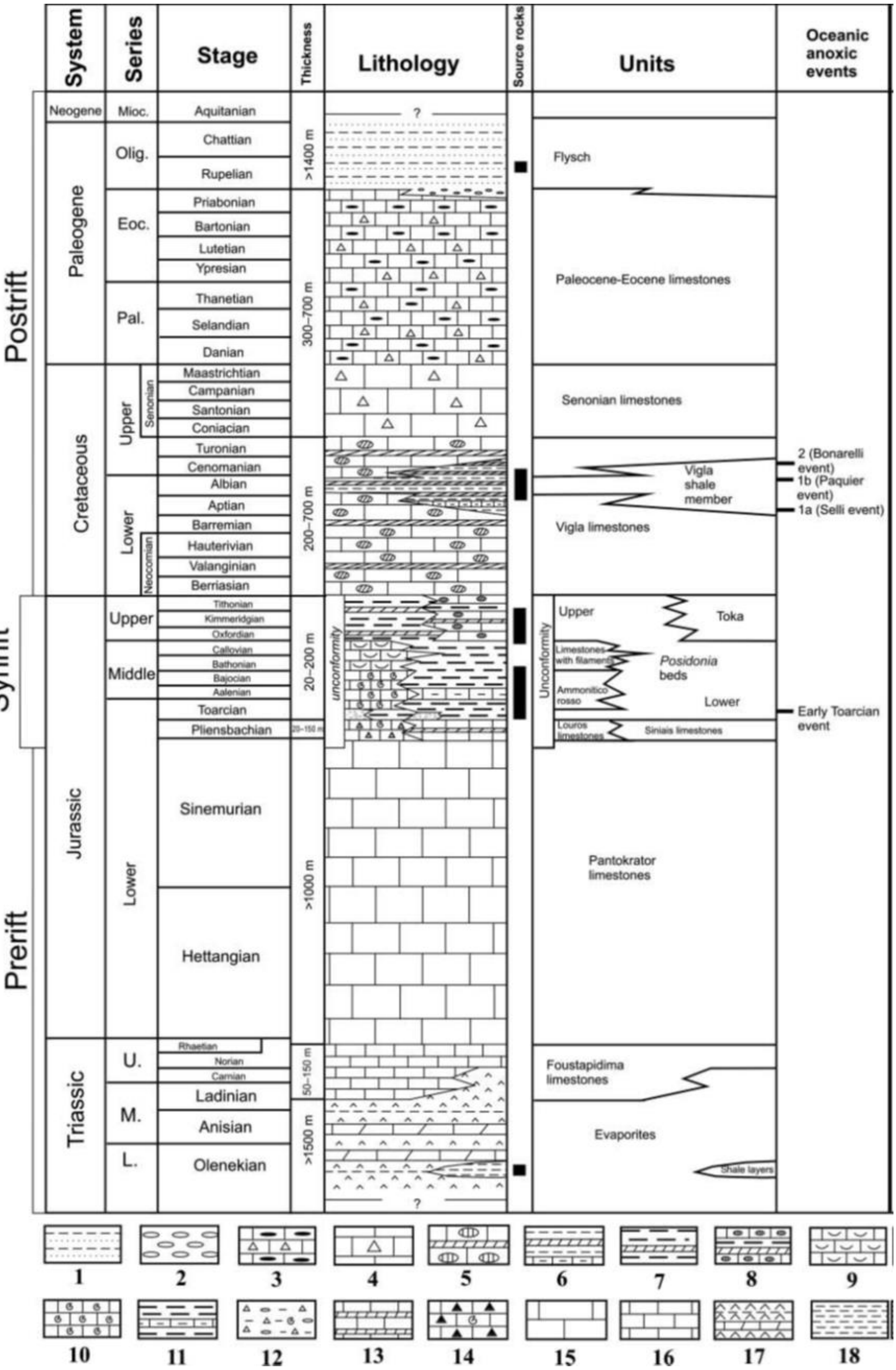

Figure 13 Synthetic lithostratigraphic column of the Ionian zone (modified from Karakitsios, 1995). (1) Pelitesand sandstones. (2) Conglomerate. (3) Limestones with rare cherty intercalations occasionally brecciated. (4) Pelagic limestones with calciturbidite intercalations. (5) Pelagic limestones with cherts. (6) Cherty beds with shale and marl intercalations. (7) Alternating cherty and shale bends. (8) Pelagic limestones with cherty nodules and marls. (9) Pelagic limestones with lamellibranches. (10) Pelagic, nodular red limestones with ammonites. (11) Marly limestones and laminated marls. (12) Conglomerates-breccias and marls with ammonites. (13) Pelagic limestones with rare cherty intercalations. (14) External platform limestones with brachiopods and small ammonites in the upper part. (15) Platform limestones. (16) Thin-bedded black limestones. (17) Evaporites. (18) Shale horizons. OAE = oceanic anoxic event; Mioc. = Miocene; Olig. =Oligocene; Eoc. = Eocene; Pal. = Paleocene; U = Upper; M = Middle; L = Lower; Malm. = Malm; Dogg. = Dogger

Cretaceous – Eocene

The postrift sequence begins with the pelagic Vigla limestones, whose deposition was synchronous throughout the Ionian Basin, beginning in the Early Berriasian (Karakitsios 1995, 2007). The Vigla limestones blanketted the synrift structures (Karakitsios 1992), and in some cases directly overlie prerift units. The base of the Vigla Limestones represents the break up unconformity of the postrift sequence in the Ionian Basin. Longstanding differential subsidence during the deposition of the Vigla limestone was probably caused by continued halokinesis of the basal Ionian Zone evaporites. In the Epiros area, this unit consists of series of fine sub-lithographic limestones occurring in small beds of 5 – 20cm, with numerous radiolarians and layers of chert also enriched with radiolarians. These layers of cherts become more abundant towards the upper part of the Vigla formation (Albian – Cenomanian), containing intercalations of green and red and locally black shales known as the 'Upper siliceous zone' of Vigla shales. They are time equivalent of the general anoxic event OAE 1b (Tsikos et al, 2004b; Karakitsios et al, 2007) and extend to Albania. The Senonian limestones, which rest on the Vigla limestones, comprise two facies: (a) limestones with fragments of Globotruncanidae and rudists, and (b) microbreccated intervals with limestones and rudists fragments within calcareous cement containing pelagic fauna. Thus, the Senonian is interpreted to correspond to a period of basinal sedimentation and its facies distribution reflects the separation of the Ionian Basin into a central topographically-higher area characterized by reduced sedimentation and two surrounding talus slopes with increased sedimentation.

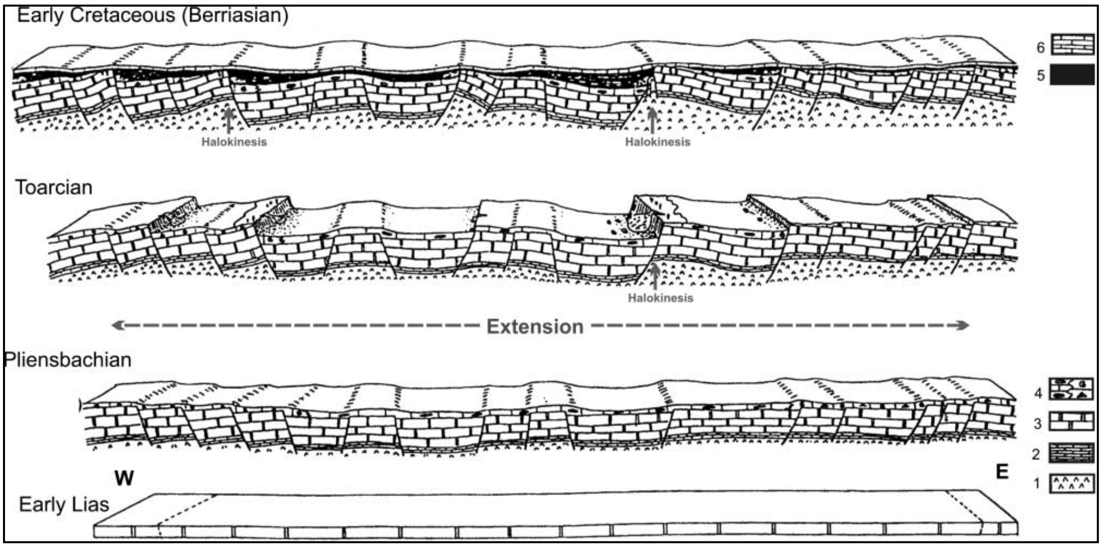

Figure 14 Paleogeographic evolution of the Ionian zone, from the Early Jurassic to the Early Cretaceous (Berriasian) (Karakitsios, 1992). (1)Evaporites. (2) Foustapidima limestones. (3) Pantokrator limestones. (4) Siniais and Louros limestones. (5) Synrift formations. (6) Vigla limestones.

During the Eocene, the supply of clastic material diminished significantly, especially in the central Ionian Basin. The main depositional facies during this period were platy wackestone and mudstone with Globigerinidae and siliceous nodules, analogous to those of the Vigla limestones, but lack continuous cherty intervals. The greatest thickness of the Eocene units can be found in the marginal parts of the Ionian Zone, where the microbreccias are more frequent.

A regional unconformity is present between the Mesozoic and Tertiary. The basal unit of the Tertiary is a massive calcirudite of Upper Paleocene age, which contains abundant redeposited Cretaceous material. The Early Paleocene was a time of uplift and erosion and the detrital limestone at the base of the Upper Paleocene overlain by foraminiferal micritic limestone indicates renewed subsidence.

In Albania, the Cretaceous deposits are pelagic and are represented by porcellaneous, clayey limestone and bituminous clays (Lower Cretaceous) on which lies phosphatic limestone with intercalations of organic clastic limestone (Upper Cretaceous). During the Paleocene – Eocene, the pelagic conditions are still preserved, reflected in the formation of micritic limestones with detrital intercalations. At this time the erosion of the carbonate platform from the Kruja Zone in the east and the Sazani Zone in the west, contributed as a distal source to the thick carbonate tourbidites deposited in the Ionian Basin during the Upper Cretaceous and Paleocene (Velaj et al. 1999; Roure et al. 2004). These turbidites, which reworked platform carbonate, are interbedded within finer-grained pelagic limestone. These carbonates maybe highly fractured and they may constitute the main hydrocarbon reservoirs in the Ionian zone in the thrust and subthrust closures (Velaj, 2015). A transitional zone with marls, 20 – 50 m thick, marks the change in sedimentation from pelagic carbonate to a flysch succession of the Oligocene age.

Oligocene – Lower Miocene

During this period flysch has been deposited in the entire Ionian Zone both in Greece and Albania. In Greece, flysch sedimentation in the main part of the Ionian Zone began at the Eocene – Oligocene boundary during the final closure of the Tethyan Ocean. The flysch consists of alternations of fine sandstones, locally with coarser elements. These elements are bedding and are calcareous, glaugonitic and micaceous, silty mudstones. Carbonaceous material occurs widely. Beds range in thickness from 0.05 – 1m. The flysch facies mainly occur in the Epirus – Akarnania syncline on the eastern flank of the Ionian Basin where it reaches 6000m thickness. In more external western areas it occurs as 'Basal Flysch' with progressively diminishing thicknesses. Sediments also become progressively finer in the westward direction. In the western external Ionian Zone the Upper Oligocene is represented by the Ayii Pantes formation dated as Upper Oligocene – Lower Aquitanian. It is overlain by the 'Upper Flysch' (Aquitanian) and by the 'Radhovizi Formation' (Aquitanian – base Bourdigalian) extending also to the middle Ionian Zone.

The flysch in Albania consists of intercalation of sandstones, siltstone and clays, as well as limestone olistoliths of the Upper Cretaceous – Eocene age. Its thickness varies from 1000 to 3000 m (Velaj, 2015), and decreases from the east (Berati anticlinal belt) to the west (Cika anticlinal belt). The eastern part of the Ionian Zone (Berati anticlinal belt) emerged from the end of Upper Oligocene, because the coastal line continues its regression westward. From the Oligocene to the Aquitanian, the sea regression intensified, and at the end of Aquitanian, the western sector of the Ionian Zone (Kurveleshi and Cika anticlinal belts) is tectonized and emerged. The tops of the anticlinal structures are eroded. The sedimentation continues without interruption in the synclines.

Lower – Middle Miocene

Younger Neogene sediments are only known in the external and middle parts of the Ionian Zone in Greece. In the latter they are represented by isolated lacustrine deposits, and in the former they are marine and continental sediments. Their accumulation after a major phase of tectonism at the end of the Burdigalian means that these formations are unconformable with the underlying sediments. This unconformity is marked by thick basal breccia.

In Albania, the premolasses formation consists of marls, clays, sandstones and organogenic limestone. It belongs to the Aquitanian – Burdigalian – Lower Serravalian period and it exists only in the Kurveleshi and Cika anticlinal belt. The thickness of this formation varies from 900 m in the east (Kurveleshi belt) and up to 2300 – 2500 m in the west (Cika belt)

Middle Miocene – Pliocene

Two other major regional unconformities are associated with the top of the Miocene sequence and with the top of the lower Pliocene; they are associated with renewed compression, observed especially in the external Ionian zone and Paxos Zone. In Aitoloakarnania region, a regional unconformity occurs between the Oligocene and Miocene. Middle to Upper Miocene sediments are found only in Lefkas. The Middle – Upper Miocene sediments represent localized deposition and indicate that the eastern part of Lefkas Island was tectonically active in the Middle Miocene, while the western (Paxos) part was stable. Later deposits in Aitoloakarnania are confined to post – orogenic lacustrine infill of Pliocene – Recent age. During the Quaternary the area underwent intensive uplift and erosion. In most of the onshore Peloponnesos, Pliocene sediments directly overlie the Carbonate unit.

At the same period the molasses formations were depositing in Albania also. These formations of the Middle Serravalian to Pliocene age are composed of a large number of sandy – clayey mega sequences. In some cases these sequences become more complete beginning with conglomerates and clastic limestones with lithothamnion and ending with coals or clayey-gypsum. They are wide spread in the Peri – Adriatic Depression and South Adriatic Basin.

The stratigraphy of this period is affected from the Messinian salinity crisis (MSC). MSC resulted from a complex combination of tectonic and eustatic processes which progressively restricted and finally isolated the Mediterranean Sea from the open ocean (W. Krijgsman et al, 1999). This isolation from the Atlantic Ocean caused a large fall in sea water level followed by erosion and deposition of non-marine sediments which correspond to the Messinian evaporites (gypsum and halite) that overlie cyclically bedded marine sediments. Marine conditions were re-established at the beginning of the Pliocene as a consequence of flooding from the Atlantic Ocean (W. Krijgsman et al, 2001).

1.2.2. Pre – Apulian (Paxoi) - Sazani Zone

The Paxoi or Pre – Apulian Zone and the Sazani Zone correspond to the most external domains of the fold and thrust belt. Outcropping successions differ from Ionian Zone in stratigraphy completeness, sedimentary development and fauna and/or floral content. The depositional sequence in the Pre – Apulian Zone begins with Triassic limestones, containing intercalations of black shales and anhydrites. The Triassic in the Pre – Apulian Zone differs from that in Ionian Zone in that anhydrites and halite play a noticeably less significant role and carbonates occur in greater proportion. Another major distinction is the extension of the evaporitic sequence into Liassic – lower Dogger. The stratigraphically lowest outcrops, located in Lefkas Island in Greece, consist of Lower Jurassic dolomites and Middle Jurassic cherts and bituminous shales.

The Upper Jurassic – Lower cretaceous succession consist of white chalky limestones with dolomite intercalations, accompanied by rare cherts and organic carbon- rich black shales, containing planktonic species together with benthic foraminifera and algal species. Lower cretaceous limestones and dolomites crop out only on the Kefallonia Island and their facies are less pelagic than their age equivalent Ionian facies (Karakitsios 2013). The pelagic depositional environment throughout the Cenomanian – Turonian interval is indicated by the presence of rudist fragments, benthic foraminifera, and algal species. The Campanian – Maastrichtian platy limestones gradually become chalky with thin argillaceous layers. They contain plangtonic foraminifera, in addition to rudist fragments. This coexistence indicates the reworking of slope and Apulian platform in the Ionian

Basin. Outcrops show frequent chaotic beds, slumps and well bedded limestones analogs to proximal turbidites of Albania. Micritic limestones with planktonic foraminifera of Paleocene age sometimes rest on Santonian or Maastrichtian limestones and neritic facies microbreccias and brecciated limestones usually occur at their base. This indicates intense tectonic activity that resulted in the differentiation of the Pre – Apulian Zone into relatively deep water and relatively shallow (sometimes emergent) areas, which provided the brecciated material (Karakitsios 2013). The Lower Eocene consists of pelagic limestones with marl intercalations. Massive limestones with algae, bryozoans, corals, echinoids and large foraminifera compose the Upper Eocene. The Oligocene Pre – Apulian sediments show the progressive passage from the Ionian typical flysch to a more calacareous (age – equivalent) facies in the Pre – Apulian Zone indicating that they correspond to an atypical distal flysch unit. This facies is replaced in the lower part of Pre – Apulian slope (Paxos and Antipaxos Islands) by calciturbidites. This unit has been partially or completely eroded in the areas corresponding to the most external part of forebulge in the Hellenide foreland basin.

Finally, in the late Early Miocene, progressive deepening occurred, flooding the former carbonate slope. In the Pre – Apulian Zone, the Burdigalian marks a transition between carbonate and clastic sendimentation. Younger sediments are represented by clastic, non – conglomeratic formations and marls with evaporitic sediments in the Messinian. These sediments correspond to the massive evaporite (gypsum and halite) deposition due to Messinian salinity crisis in the Mediterranean Sea. During this period the Mediterranean basin were isolated from the Atlantic Ocean which caused a large fall in the Mediterranean water level followed by erosion and deposition of non-marine sediments (W. Krijgsman et al, 1999).

The Pre – Apulian zone, as the Ionian zone, continues towards Albania and can be considering as the same tectono – stratigraphic unit than the Sazani Zone with similar stratigraphic evolution. The stratigraphic successions in northern Greece and Albania are similar, except that Early Miocene clastics are coarser grained in Albania than in northern Greece. These clastics relate to erosion of the orogen after Early Tertiary collisional deformation (Robertson and Shallo 2000).

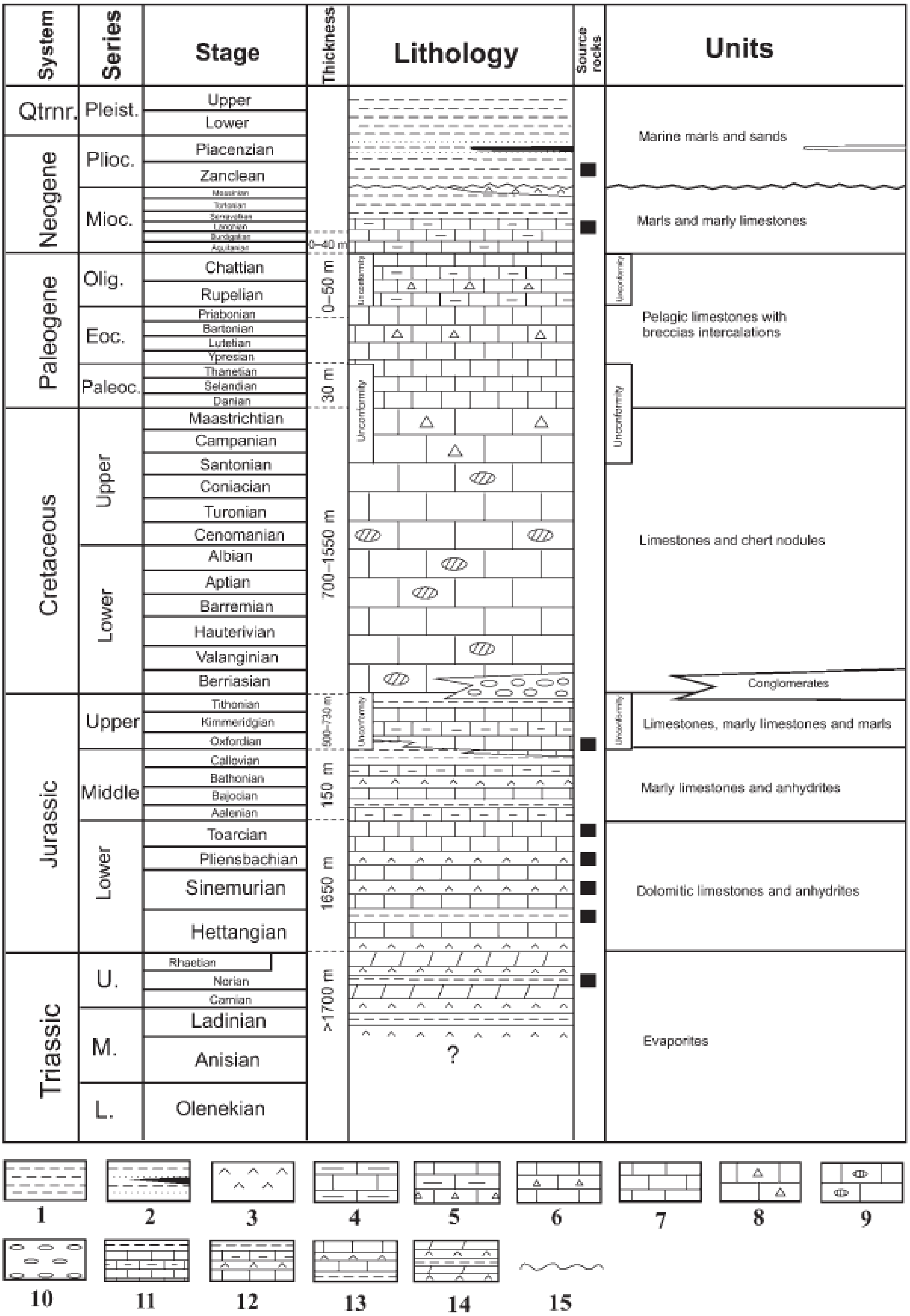

Figure 15 Synthetic lithostratigraphic column of the Paxos (pre-Apulian) zone (Karakitsios and Rigakis, 2007). (1) Marine marls. (2) Marine marls and sand (in black, lignite intercalations). (3) Evaporites. (4) Limestones commonly marly. (5) Pelagic limestones or marly limestones and brecciated intercalations. (6) Mixed pelagic-neritic limestones sometimes with breccias. (7) Pelagic limestones. (8) Mixed pelagic-neritic calcareous sediments with rudist fragments. (9) Pelagic limestones with nodules and rare cherty intercalations. (10) Conglomerates with calcareous and magmatic elements. (11) Pelagic limestones commonly marly. (12) Limestones, shales, and basal anhydrites. (13) Limestones and dolomitic limestones, anhydrites, and shale intercalations. (14) Evaporites with shale intercalations. (15) Unconformity. Qtrnr = Quaternary; Pleist = Pleistocene; Plioc =Pliocene; Mioc = Miocene; Olig = Oligocene; Eoc = Eocene; Paleoc = Paleocene; U = Upper; M=Middle; L = Lower.

1.2.3. Peri – Adriatic Depression

The Peri – Adriatic Depression covers the Ionian, Sazani and part of the Kruja tectonic zones in the northern part of the external Albanides. The Peri – Adriatic Depression consists of a foredeep filled with thick – terrigenous syn-flexural Oligocene flysch and a syn-kinematic Neogene molasses that is covered by Quaternary deposits (Vilasi 2009). From south – east to north – west, the thickness of the molasses increases. The total thickness of this siliclastic deposits can exceed 7 km, based on seismic profiles. This post – carbonate deposition of terrigenous sediments and their placement and distribution indicate a basin environment. The basin fill consist of Upper Tortonian – Pliocene sedimentary rocks. The Messinian low stand is characterized by gypsum – bearing clastics in the western and NW parts of the basin, whereas in the east, mixed marine and brackish – water facies were deposited at this time. However, unlike in the Ionian Basin, no intra-Triassic decollement has ever been evidenced beneath the Peri-Adriatic Depression, accounting for a major paleogeographic change occurring on both sides of the Vlora-Elbasan transfer zone (Roure et al, 2004; Vilasi 2009).

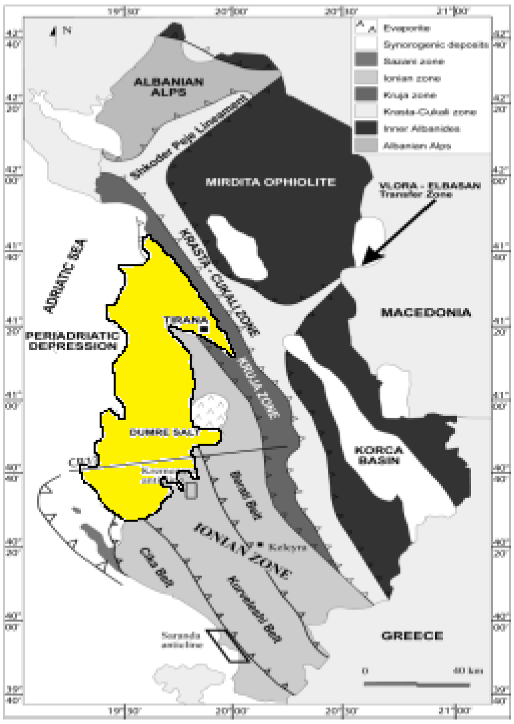

Figure 16 : Map of tectonic zones in Albania. The formation with the yellow colour corresponds to the PAD (Vilasi 2009).

1.2.4. Kruja – Gavrovo Zone

During Mesozoic-Early Tertiary time the passive margin of Apulia was bordered by regionally extensive carbonate platforms, known as the Kruja zone in Albania and the Gavrovo-Tripolitsa zone

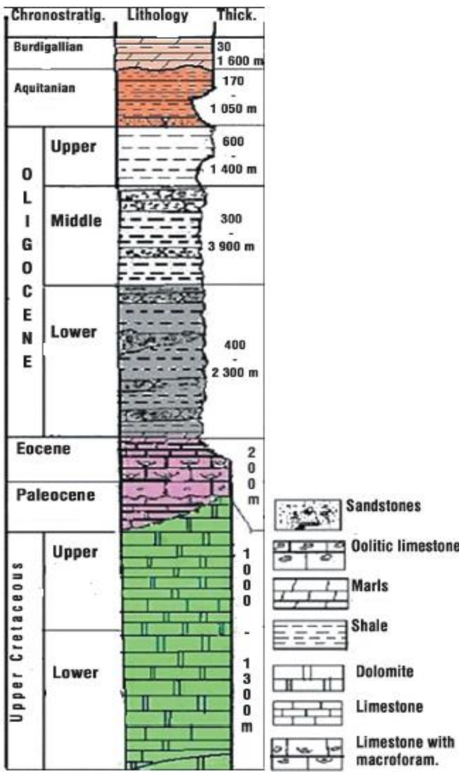

Figure 17: Lithological and steatigraphic section of Kruja zone (Velaj, 2012).

in Greece. In Albania, this unit is dominated by Mesozoic shallow-water carbonates, deformed into large scale westward-verging anticlines and synclines, cut by reverse faults and minor thrusts. The exposed succession is 1.5 km thick and begins with Late Cretaceous platform carbonates. They consist of dolomites, limestones with rudistes, limestones rich in miliolides and textularides with frequent hiatus, emersions and erosional surface and even bauxite horizons, passing into pelagic carbonates with Globotruncana sp. The Oligocene flysch sequence confirms the development of a Paleogene foredeep basin, sourced by the erosion of thrusted units in the east which inducted a coeval flexure of Kruja zone. The Kruja region in the Lower Oligocene was filled with flysch deposit reaching a thickness of 3 000 to 4 000 m. The Oligocene-Aquitanian is represented by intercalations of flysch-flyschoidal sandstone-clays-silts with underwater slumping horizons and olistoliths of organogenic-clastic limestones which became thicker and coarser eastward and upward (Velaj, 2012). These successions are locally overlain by shallow-water to terrestrial clastics of Serravalian – Tortonian age, similar to facies of both the Ionian and Sazani zones. The Kruja zone extends southwards into the Gavrovo zone of northern Greece; where a shallow-water carbonate succession of Jurassic – Middle cretaceous age is overlain by Later Cretaceous deep-water carbonates, then Upper Eocene – Lower Miocene terrigenous turbidites. Further south, in the Peloponnesos, a facies counterpart, the Tripolitsa zone, is well exposed in large tectonic window through overlying thrust sheets of the Pindos – Olonos zone. In general the succession begins with weakly metamorphosed argillaceous sediments (Tyros Beds), overlain by shallow water carbonates and culminates in Paleogene terrigenous turbidites.

The Kruja zone, and counterparts to the north and south are interpreted as a shallow-water carbonate platform and related shallow, intra-platform basins that bordered the eastern margin of Apulia platform from the Late Triassic onwards. The carbonate platform was regionally submerged in the Late Cretaceous – Early Tertiary, followed by transition to a foreland basin related to westward thrusting of allochthonous units over the Apulian margin (Robertson & Shallo, 2000).

1.2.5. Krasta-Cukali – Pindos Zone

The Krasta-Cukali zone extends the in Albania as a narrow exposure known as the Krasta sub-zone in the south and as the Cukali sub-zone in the north. The Krasta-Cukali zone is thrust westwards over the Kruja zone. The Krasta sub-zone in the south is folded and thrust repeated with vergence towards the west and south-west. No complete succession is exposed. Here the succession begins with Cretaceous terrigenous turbiditic sandstones and mudstone, overlain by Late Cretaceous pelagic carbonates, and is followed by terrigenous turbidites that extend from Maastrichtian to the Eocene. Further north, the succession begins with Triassic extrusive igneous rocks of intermediate to basic composition, shales, limestones and radiolarian cherts of Middle Triassic (Anisian – Ladinian) age, overlain by variable neritic and pelagic carbonates of Middle Triassic to Late Triassic age. The Jurassic interval comprises pelagic carbonates, siliceous limestones, radiolarian chert and thinly interbedded shales. This formation is overlain by relatively thin (5-50m) Early Cretaceous-Cenomanian red shales, hemipelagic carbonates, calcareous turbidites, radiolarian-rich limestones and mudstones, and also Albian-Cenomanian red-green marlstone. Upper Cretaceous Globotruncana)-bearing pelagic carbonates follow, overlain by Maastrichtian – Eocene terrigenous turbidites (Robertson & Shallo 2000).

The Krasta-Cukali zone passes southwards without a break into the Pindos-Olonos zone of Greece. There is a progressive southward change from an imbricate thrust belt in the Pindos-Olonos zone of Greece through a narrow thrust belt of the Krasta sub-zone in southern Albania, to mainly fold deformation in the Cukali sub-unit further north. Thus, the restored width of the Krasta–Cukali zone is much less in Albania (tens of km) than the Pindos–Olonos zone in Greece (hundreds of km).

In northern Greece, in the Koziakas Mountains (Lekkas 1988) the Pindos-Olonos zone emerges as a coherent thrust belt, forming the backbone of western Greece as far as the southern tip of the Peloponnesos. The succession begins with intermediate composition volcanics and pelagic Late Triassic Halobia-limestone, exposed just above the basal decollement (in Triassic evaporites) of the Pindos-Olonos thrust stack. The succession continues with calcareous turbidites of Late Triassic – Early Jurassic age, then passes into radiolarian facies of Middle –Late Jurassic age. The early Late Cretaceous interval is marked by turbiditic siliclastic sandstones with ophiolite-derived grains ("First Flysch") in the north, but not in the south, where calpionella-bearing pelagic limestones are found instead (Thiebault, 1982). The Late Cretaceous interval is dominated by pelagic carbonates, transitional upwards to siliclastic turbidites of Paleogene age (Pindos Flysch) (Robertson & Shallo, 2000).

1.2.6. Albanian Alps

The Albanian Alps belong to the internal part of Albanides. They constitute a rugged mountainous area of northern Albania and extend about 70 km from east to west. Several units with different paleo-geographical and paleo-tectonic histories are recognized within the Albanian Alps.

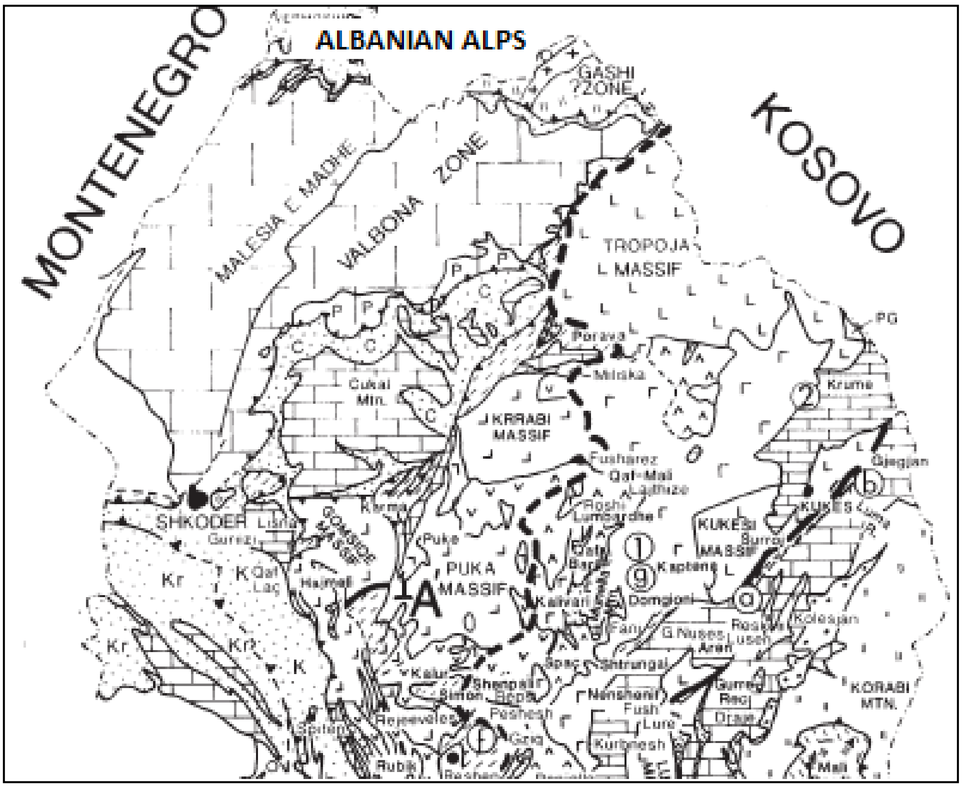

Figure 18 : Map of the northern part of Albania. In the north part exposed the Albanian Alps tectonic zone which divided to Malesia e Madhe and Valbona subzones (Robertson & Shallo 2000).

The Valbona subzone is a faulted and folded unit, overthrust by ophiolitic rocks in the south. A succession, 2.3 – 3.1 km thick, begins with Middle – Late Permian limestones and clastics, with Fusulina sp., and then passes into marine sandstones and shales of Early Triassic age, in turn overlain by Middle – Late Triassic shallow-water platform carbonates. Bauxite mineralization occurs locally at the Middle – Late Triassic boundary, indicating locally emersion events. After the Liassic subsidence, mainly pelagic limestones accumulate from Middle-Late Jurassic to Early Cretaceous age. The Late Cretaceous was marked by a return to a shallow-water platform conditions, until the Maastrichtian – Paleogene, when terrigenous turbidites 700 – 1200 m thick) accumulated in a foredeep setting related to westward thrusting. The Malesia e Madhe subunit, is located to the northern part of the Albanian Alps, the stratigraphic succession comprises Late Triassic – Middle Cretaceous shallow water platform carbonates, overlain by few meters of Late Cretaceous, Globotruncana – bearing pelagic limestones, followed by terrigenous and calcareous turbidites during the Paleocene. The Malesia e Madhe subzone is interpreted as a shallow-water carbonate platform, until subsidence occurs in the Late Cretaceous. The Valbona and Malesia e Madhe subzones are separated by a high-angle tectonic contact, and represent contrasting paleo-geographic units during Mesozoic time, with the Valbona subzone being the more basinal. The Valbona subzone is interpreted as equivalent to the Gavrovo-Tripolitza zone in Greece, whereas the Malesia e Madhe subzone shows some similarities with the Parnassus zone in central Greece.

2. Methods

Source rock evaluation consists in assessing the hydrocarbon generating potential of sediments by looking at the sediment's capacity for hydrocarbon generation, type of organic matter present and what hydrocarbons might be generated, the sediments thermal maturity and how it has influenced generation. With this data it is possible to begin answering questions about how much, what kind and when hydrocarbon generation has occurred. The analytical methods most frequently used for this purpose are total organic carbon (TOC) content analysis, Rock-Eval pyrolysis and vitrinite reflectance analysis (Dembicki H. Jr., 2009).

2.1. TOC

The TOC content of sediment is expressed as a weight percent. The TOC is an indicator of the total amount of organic matter present in the sediment (Ronov, 1958) and is composed of:

a) Organic Carbon contained in hydrocarbons already generated by the source rock

b) Organic Carbon that can be converted to petroleum (reactive carbon)

c) Organic material with insufficient hydrogen atoms to produce petroleum (dead or residual carbon)

The most important component for the oil industry is the "reactive" component. However, the organic carbon that left the source rock as petroleum has to be added, to define the original Total Organic Carbon of the source rock

2.2. Rock-Eval Method

The Rock-Eval technique provides several measurements. A flame ionization detector senses any organic compounds generated during pyrolysis. The first peak (S1) presents milligrams of hydrocarbons that can be thermally distilled from one gram of the rock. The second peak (S2) represents milligrams of hydrocarbons generated by pyrolytic degradation of the kerogen in one gram of rock. The third peak (S3) represents milligram of carbon dioxide generated from a gram of rock during temperature programming up to 390°C and is analyzed by thermal conductivity detection. The temperature at which the maximum amount of S2 hydrocarbons is generated is called Tmax (Peters, 1986).

In order to define the type and generation capacity of the source rock we calculate the Hydrogen and Oxygen indices are calcuted:

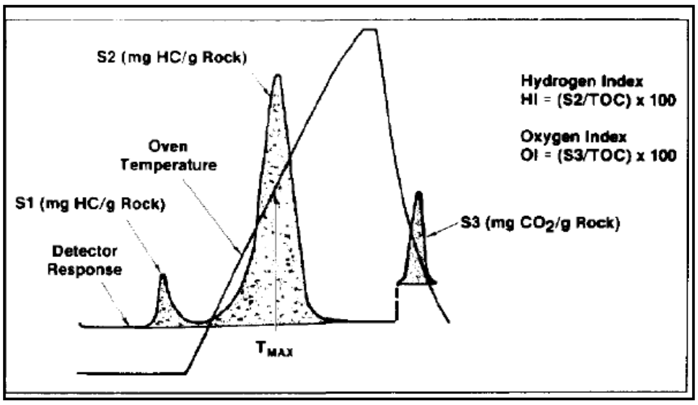

Figure 19 : Pyrogram showing evolution of organic compounds from rock sample during heating (increasing time from left to right). Important measurements include S1, S2, S3 and Tmax. Hydrogen and Oxygen indices are calculating as shown (Peters, 1986).

- The Hydrogen index (HI) corresponds to the quantity of the organic compounds or hydrocarbons (HC) from S2 relative to the total organic carbon (TOC) in the sample (mg hydrocarbon/g organic carbon). Hydrogen Index is a parameter that characterizes the origin of organic matter.
- The Oxygen index (OI) corresponds to the quantity of carbon dioxide from S3 relative to the TOC (mg dioxide carbon/g organic carbon). Oxygen Index is a parameter that represents the ratio of oxygen to carbon.

The type of hydrocarbon a source rock generates will be determined by the type of kerogen found in the sediment and its thermal maturity. There are 4 types of kerogen:

- Type I: high initial H/C and low initial O/C atomic ratios, derived primarily from algal material deposited mainly in lacustrine environments that produces mainly waxy oil.
- Type II: moderately high H/C and moderate O/C atomic ratios derived from autochthonous organic matter deposited under reducing conditions in marine environments that produce mainly naphthenic oil.
- Type III: low initial H/C and high initial O/C atomic ratios derived from terrestrial plant debris and/or aquatic organic matter deposited in an oxidizing environment that produces mainly gas.
- Type IV: very low initial H/C ratio and a variable initial O/C atomic ratio. Type IV kerogen is a product of severe alteration and/or oxidation of organic matter in the depositional environment and is essentially inert with no hydrocarbon generating potential.

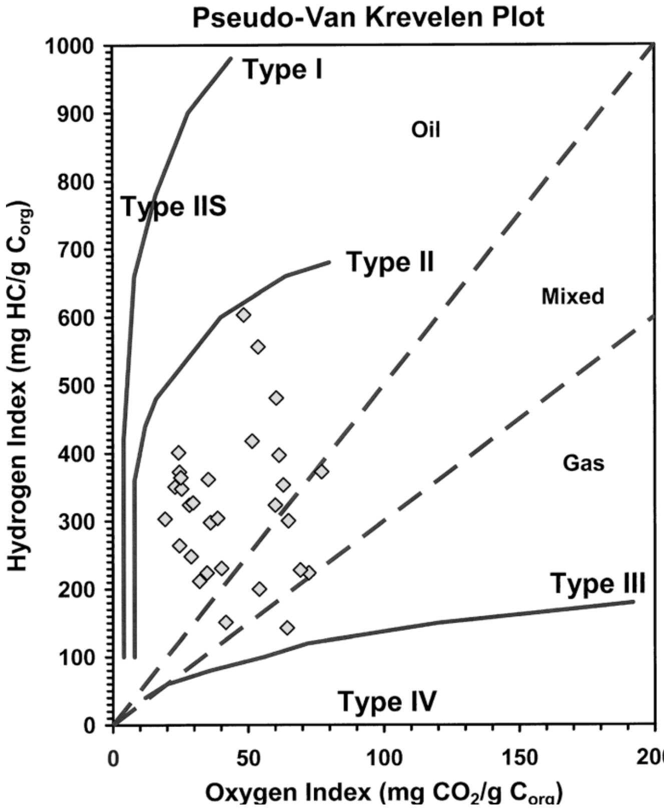

Figure 20 : Typical source rock hydrogen and oxygen index data set plotted on a pseudo – Van Krevelen diagram

The Hydrogen Index and Oxygen Index are commonly plotted on a pseudo – Van Krevelen diagram which gives types I, II, and III kerogen trends that converge near the origin and differ considerably, far from this area.

Very few source rocks contain only one type of kerogen. Mixed kerogen types are a more prevalent and difficult problem when interpreting Rock-Eval data on a pseudo – Van Krevelen. Most of the sediments contain mixtures of two or more kerogen types.

For the evaluation of potential source rocks we are using both source rock quality indicators (Peters & Casa, 1994) and diagrams.

Source rock quality indicators

1) Total organic Carbon content (TOC %)

Potential	TOC (wt %)
Poor	<0.5
Fair	0.5-2
Good	2-5
Very good	5-10
Excellent	>10

2) Hydrocarbon potential (S2)

Potential	S2
Very Poor	<0.5
Poor	0.5-2
Fair	2-5
Good	5-10
Very good	10-20
Excellent	>20

3) Kerogen type (from the Hydrogen Index, HI)

Kerogen quality	Hydrogen Index (mg hydrocarbon/g TOC)
I	>700
II	450-700
II/III	250-450
III	50-250
IV	<50

4) Hydrocarbon type (S2/S3)

Main product	S2/S3
Gas prone	0-2.5
Mixed oil-gas	2.5-5
Oil prone	>5

Another significant factor for the evaluation of the possible source rock quality is thermal maturity of organic matter. In general, Tmax less than 435°C indicates immature organic matter and

Tmax over 470°C indicates organic matter in post mature stage. When the Tmax is higher than 440 ^{0}C, the organic matter is in peak-mature stage of maturation. In this case, a recalculation of the initial values has to be made in order to see how the increased temperature affected the hydrocarbon potential of the sample.

Maturity	Tmax (°C)
Immature	<435
Early mature	435-440
Peak mature	440-450
Late mature	450-470
Postmature	>470

Diagrams are also important for the evaluation of potential source rocks as they can give important and combined information. For example, in a diagram where the values of Hydrocarbon and Oxygen Indexes are presented, we can take the information about the type of kerogen and consequently the quality of organic matter. A Tmax versus Hydrogen Index diagram presented the maturity of organic matter as well as the quality of it. TOC values can give us information about the quantity of organic matter. A S2 versus Tmax diagram shows the hydrocarbon source rock potential in combination with TOC values and also the information about the quality and maturity of organic matter (HI, Tmax values).

Type of information	Diagram
Quantity of organic matter	TOC
Kerogen type	Oxygen Index vs Hydrogen Index
Kerogen maturity and type	Tmax vs Hydrogen Index
Hydrocarbon source potential	S2 vs TOC

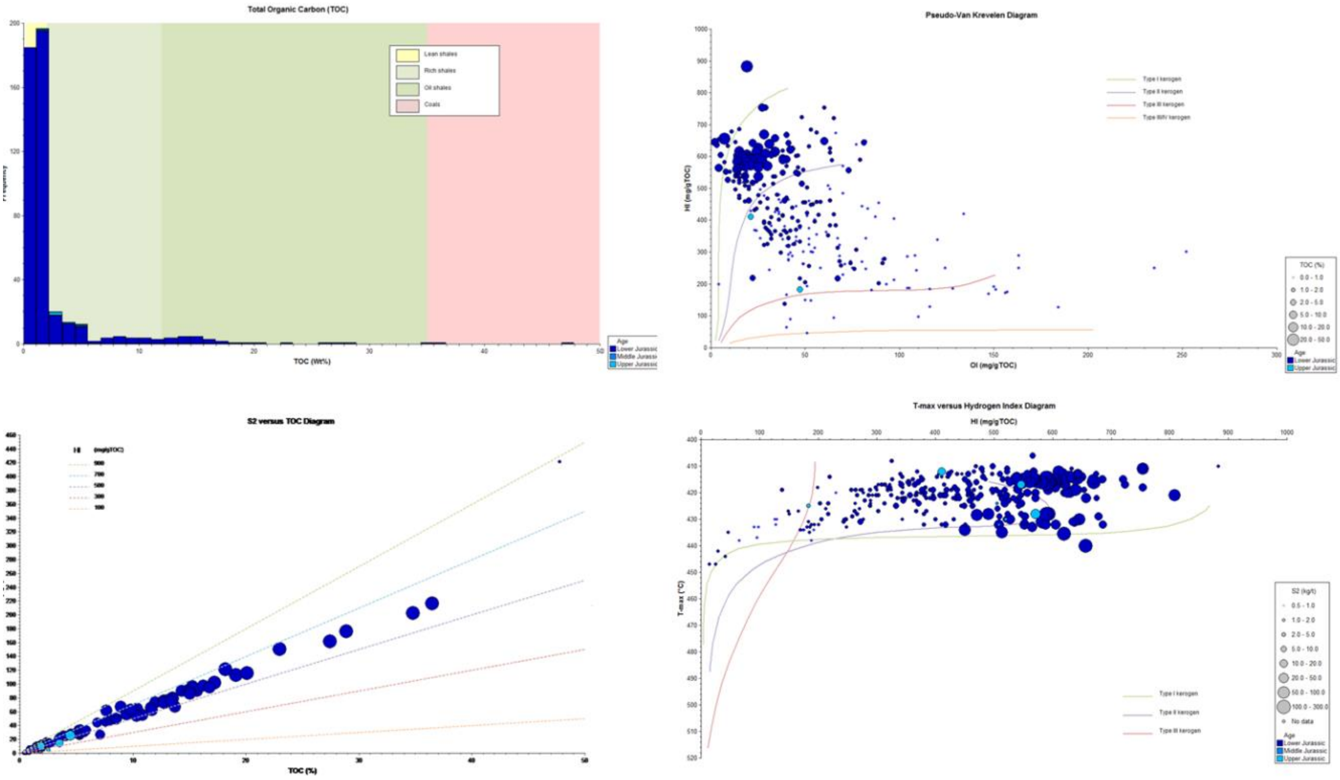

Figure 21 : Example of diagrams in source rock evaluation of Jurassic samples in Ionian Zone. From left to right present the follow diagrams: TOC, OI vs HI, S2 vs TOC and Tmax vs HI.

2.3. Vitrinite Reflectance

Vitrinite is a maceral group derived from terrestrial higher plants. Vitrinites contain more carbon-ring structures than the aliphatic oil prone kerogens. Temperature increase causes vitrinites to become more aromatized and reflective. Reflectance of vitrinite is a parameter calculated using incident light reflected from polished samples. The reflectance (Ro) of vitrinites can be used to define thermal maturity (or rank) of the kerogens.

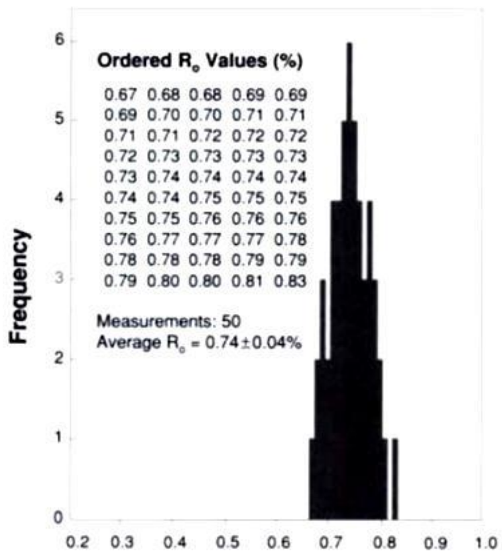

Figure 22 : example of a vitrinate reflectance histogram from measurements on a kerogen isolated from rock samples.

Maturity	Vitrinite Reflectance (Ro%)
Immature	0.20 – 0.60
Early	0.60 – 0.65
Peak	0.65 – 0.90
Late	0.90 – 1.35
Postmature	>1.35

Due to severe uncertainties in Ro determination, at least 50 measurements of different vitrinite phytoclasts per sample must be taken for the results to be accurate.

3. Source Rocks

In this chapter, will be presented the results from the Rock-Eval analysis of the possible source rocks,. According to these results the possible source rocks will be evaluated and divided into categories of poor, fair, good, very good and excellent richness in organic matter (TOC values) and hydrocarbon potential (S2 values). Also an evaluation of the quality of organic matter will be done, according to the values of hydrocarbon and oxygen indexes using as well specific diagrams (HI vs OI, TOC, Tmax vs HI, and S2 vs TOC).

Furthermore, we will try to describe as precisely as possible the depositional environment of the possible source rocks in order to make a representation in paleo-environmental maps, for every age. On these maps the Rock-Eval analysis results and the paleo-environments will be combined so as we can have a completed image of the parameters and characteristics of the possible source rocks.

It has to be noticed that, in the following chapters the samples which had very low ranking in the evaluation for their potential have been removed. Only samples which have higher than “poor” potential have been included and presented in this study.

3.1. Triassic

The oldest known potential source rock intervals in area of interest have been deposited within Middle –Upper Triassic formations. In Greece source rock materials have been identified within shale fragments of Triassic breccias, in Ionian zone (Rigakis & Karakitsios, 1998). These breccias correspond to typical evaporate dissolution collapse breccias (Karakitsios & Pomoni-Papaioannou, 1998). They were studied in Mavroudi North section and Iraklis well. In Albania, Upper Triassic source rock intervals have been found in bituminous horizons which crop out in Cika unit of Ionian zone (Roure et al, 2004). In addition, in more internal zones as in the Krasta-Cukali zone, source rock intervals have been found within green to black marly shales with cherts, rich in organic matter.

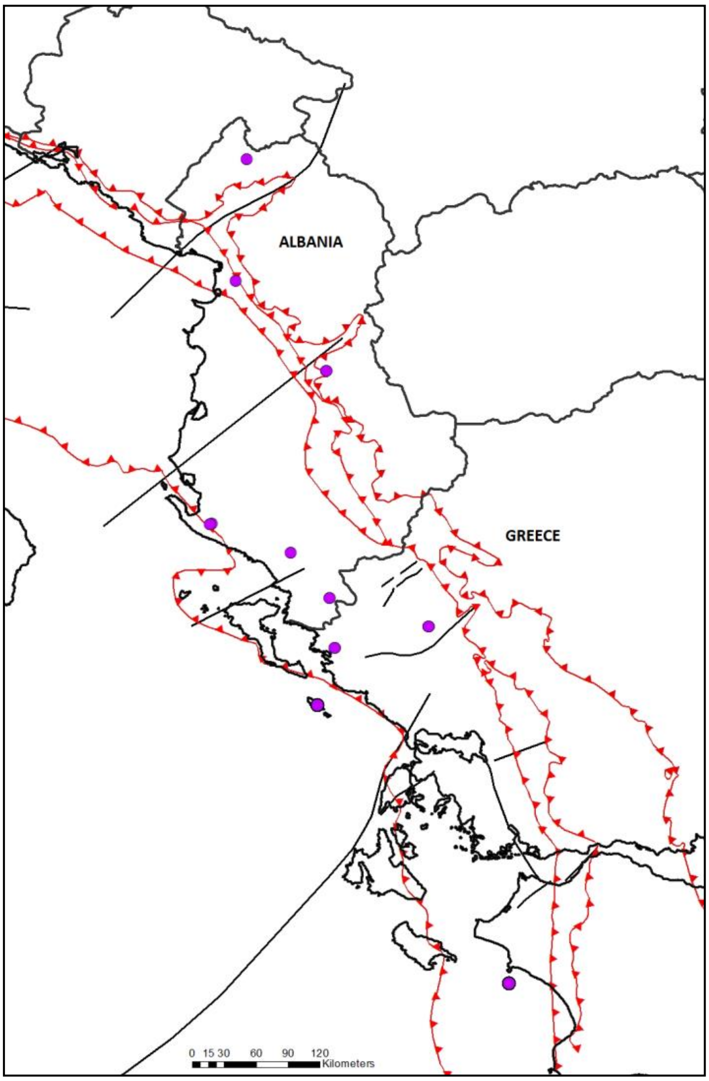

Figure 23 : Map of the Triassic samples.

3.1.1. Source rock parameters

Some Triassic source rock samples are in peak-mature stage of maturation, with Tmax values higher than 440 ^{0}C. For these samples, a calculation of the initial values has been made in order to have the initial petroleum potential of the Triassic source rock. In fact, TOC and S2 values decrease with the maturity. In order to make this recalculation of the initial values, estimation about the initial HI value has been made first. This estimation made by taking as initial values of HI, the average value of the samples from the same area and age that are not overmature. If there are no other samples then we are using any available data such as depositional environment in order to make an assumption about the initial HI value.

For example, an initial value of Hydrocarbon Index (HI) =500 has been estimated for the source rock samples of Mavroudi North area. This assumption, about the initial HI has been made because the samples of Mavroudi North are quite similar to black shales fragments as of Iraklis well (at the depth of 1250-1275 m; Riggakis & Karakitsios, 1998).

Mirake samples are from the Krasta-Cukali Zone. They are the only samples from this area and is difficult to make a good estimation about the initial HI values. The only information that we have for these samples is that they are composed of green to black marly shales and have been deposited probably in an anoxic environment (Vilasi 2009), which allowed an estimation of HI value about 500.

Location	TOC	S2	Tmax	HI	Initial TOC	Initial S2	Initial HI
Mavroudi	1.25	0,67	452	54	2,03	6	500
Mavroudi	0.64	0,21	455	33	1,06	3	500
Mavroudi	0.59	0,18	449	31	0,98	3	500
Mavroudi	1.29	0,78	452	60	2,01	7	500
Mirake	1,31	0,66	471	50	2,13	7	500
Mirake	1,36	0,32	467	23	2,26	5	500
Mirake	1,51	0,53	475	35	2,48	3	500

Table 1 : Rock-Eval data for Mavroudi North and Mirake samples and the calculated initial values.

Generally, analyzed samples of Triassic age are rich in organic matter with total organic carbon (TOC) values ranking between 0.31% - 42.9%. Also S2 values are showing fair to excellent hydrocarbon potential, between 1.44 and 255.96 (mg/g). It has to be noticed that three of the highest S2 values are from HIS and GEOL6 database, which present the results of Rock-Eval analysis without any other information for the sample and these values cannot be verified. Nevertheless, the hydrocarbon potential remains excellent even if these values are excluded, ranging between 1.44 and 98.08 (mg/g). The organic matter of Triassic samples is mainly of type I (highly oil prone) and type II (oil prone) as Pseudo-Van Krevelen (HI s OI), S2 vs TOC and Tmax vs HI diagrams showed.

Specifically, in Iraklis well, samples at the depth of 1250 – 1265 m have very high amounts of organic matter with TOC values ranking between 3,84% and 16,12% and high hydrocarbon potential with S2 values from 23,7(mg/g) to 98,08 (mg/gr). Vitrinate reflectance (Ro) measurements showed values of 0.30% (immature). According to the HI values, the quality of organic matter is very good, mostly type I and consists of algal amorphous matter in a proportion of 99% (Riggakis and Karakitsios 1998). Other samples from Iraklis well, at depths of 1270 – 1275 m and 1400 – 1520 m, have been analyzed also but the TOC and S2 values are lower ranking between 0,31% - 1,62% and 1,44 – 8,33 (mg/g) respectively, but still having fair to good potential. In the Mavroudi North section, the initial values indicate good to fair organic carbon content with TOC values ranking between 1,06% to 2,1% and S2 values from 3(mg/g) to 7(mg/g). From the Menelaos well sample, the only data that have been found are the TOC and the HI values. This sample presented excellent richness in organic matter with TOC value of 19%. According to the HI value the quality of organic matter is very good, type I. Samples from the southern part of Ionian zone have been found also. In South Achileas well samples showed generally poor hydrocarbon potential.Other samples from Ionian zone that have been analysed such as Mali-Gjere, Dukat outcrops, sample “267” (Dukat area) and samples “Terrain Albanie” seem to have a very good potential with TOC ranking between 4,96% to 42,19% and also great hydrocarbon potential with S2 values from 33,6 (mg/g) to 286,5 (mg/g).

It has to be noticed here, that the extremely high values of TOC (>30%) and S2 (>100mg/g) probably indicate the presence of coals in the sample, which reduce significantly the potential. However, there is no any petrological description available for these samples in order to make any safe assumption. The organic matter of these samples is of very good quality, type I and type II.

After the calculation of the initial values, samples of Mirake area (Krasta-Cukali tectonic zone) showed good TOC values ranking between 2,13% to 2,48% and fair to good hydrocarbon potential with S2 values from 3(mg/g) to 7(mg/g).

Only one Triassic sample has been analyzed from Albanian Alps tectonic zone (sample "1"), showing good TOC value of 4,04% and excellent hydrocarbon potential with S2 value 31,5(mg/g). The HI value is also very high (780), indicating a very good quality of organic matter of type I and probably a lacustrine depositional environment.

Samples from the southern part of Ionian zone (Katakolon) and from Pre-Apulian zone have been found, with poor hydrocarbon potential. The source document is providing only the average values of TOC and S2 contents which are not enough for a complete evaluation of the samples. However, they can be considered as evidence of the source rock existence.

Maturity

In Albania, in the Upper Triassic series of the Cika unit (Ionian Zone), vitrinite reflectance values are between 0.7 and 0.9%, thus indicating a mature source rock. Because they relate to surface samples, these values attest an early maturation of the Triassic series, which eventually reached the oil window and started to expel hydrocarbons long before the onset of thrusting (Roure et al, 2004). For the Mavroudi North samples, of northwest Greece, vitrinite reflectane (Ro) is equal to 1,01% indicating that these source rocks are close to the maximum of oil generation. These Triassic sediments were buried at significant depths for a long period, so their organic matter was affected by a high degree of maturation (Riggakis and Karakitsios 1998). Also high Ro values (1,20%) have been recorded for the Mirake samples of Krasta-Cukali tectonic zone. Generally Triassic samples are immature stage, presenting Tmax values lower than 435^{o}C except from the samples which showed Tmax values between 449 and 475 ^{o}C.

Name	Tectonic Zone	Country	type	Age	TOC	S2	Tmax	HI	OI
Mavroudhi N	Ionian	Greece	Outcrop	Triassic	2,03	6		500	
Mavroudhi N	Ionian	Greece	Outcrop	Triassic	1,06	3		500	
Mavroudhi N	Ionian	Greece	Outcrop	Triassic	0,98	3		500	
Mavroudi N	Ionian	Greece	Outcrop	Triassic	2,01	7		500	
Iraklis	Ionian	Greece	Well	Triassic	11,2	73,1	436	655	5
Iraklis	Ionian	Greece	Well	Triassic	16,1	98,1	430	608	4
Iraklis	Ionian	Greece	Well	Triassic	3,84	23,7	429	617	6
Iraklis	Ionian	Greece	Well	Triassic	7,69	44,8	429	582	4
Iraklis	Ionian	Greece	Well	Triassic	1,62	8,33	421	514	12
Iraklis	Ionian	Greece	Well	Triassic	0,31	1,44	428	464	58
Iraklis	Ionian	Greece	Well	Triassic	0,57	2,25	428	394	45
Iraklis	Ionian	Greece	Well	Triassic	0,65	3,16	428	486	33
Iraklis	Ionian	Greece	Well	Triassic	0,51	2,55	424	500	35
Mali-Gjere	Ionian	Albania	Outcrop	Triassic	31,95	189,1	428	591	
Dukat	Ionian	Albania	Outcrop	Triassic	31,03	255,9	412	757	
Terrain-Alb	Ionian	Albania	Outcrop	Triassic	4,9	36,5	422,5	663	
Terrain-Alb	Ionian	Albania	Section	Triassic	42,2	286,5	410	679	
Mirake	Krasta	Albania	Field	Up Triassic	2,13	7		500	
Mirake	Krasta	Albania	Field	Up Triassic	2,26	5		500	
Mirake	Krasta	Albania	Field	Up Triassic	2,48	3		500	
267	Ionian	Albania	Field	Up Triassic	4,96	33,6	416	617	
Menelaos	Ionian	Albania	Well	Up Triassic	19			700	
1	Alb Alps	Albania	Field	Up Triassic	4,04	31,5	435	780	10

Table 2 : Results from Rock-Eval analysis for Triassic samples.

3.1.2 Paleo-environment

Despite the fact that the information for the paleo-environment of Triassic source rock is few, we have tried to define the depositional environment using all the available data.

Samples of Iraklis well and Mavroudi North section, are part of the Triassic breccias of the Ionian Zone. The predominance of shallow intertidal to supratidal carbonate fragments, indicates that the strata that gave birth to the breccia, formed in a very shallow, restricted, hypersaline, lagoonal setting, evolved into sabkha sequences in the frame of a lowstand episode (Karakitsios and Pomoni – Papaioannou 1998).

For samples "Terrain Albanie", "Mali – Gjere" and "Dukat outcrop" no information has been found about the depositional environment, not even a petrological description. It was thus, impossible to make any assumption for the depositional environment. For sample "267", the only information found from literature is a general petrological description which is not giving us enough data for the depositional environment. The only assumption that can be made for these samples is that as part of Triassic age formation of the Ionian zone the depositional environment may be in general, shallow marine.

In Pre-Apulian zone the paleo-environment is shallow-marine and in some cases has been described as subtidal that is overlying the evaporitic basin.

Samples of Mirake area belong to Krasta-Cukali tectonic zone. There is not any information about the paleo-environment of these samples. However, it is known that Krasta-Cukali zone was a deep water margin during Triassic (Robertson & Shallo, 2000; Vilasi 2009). These samples are part of one formation that seems to have been deposited in anoxic conditions during Upper Triassic times (Swennen et al, 1998; Vilasi, 2009). Consequently, only an assumption of deep-water deposition could be made for these samples.

Only one sample has been found in the Albanian Alps tectonic zone (sample "1"). The northern part of Albanian Alps Zone (Malesia e Madhe subunit) comprises Late Triassic – Middle Cretaceous shallow-water carbonates (Robertson & Shallo, 2000). As there is not any other information for the paleo-environment of this sample, an assumption can be made from this description, for a shallow-water depositional environment.

3.1.3 Conclusions

Triassic source rock samples, present fair to very good hydrocarbon potential, according to the previous analyzes of the TOC and S2 values. In many cases the HI value is bigger than 700, indicating type I (highly oil prone) and type II (oil prone), organic matter.

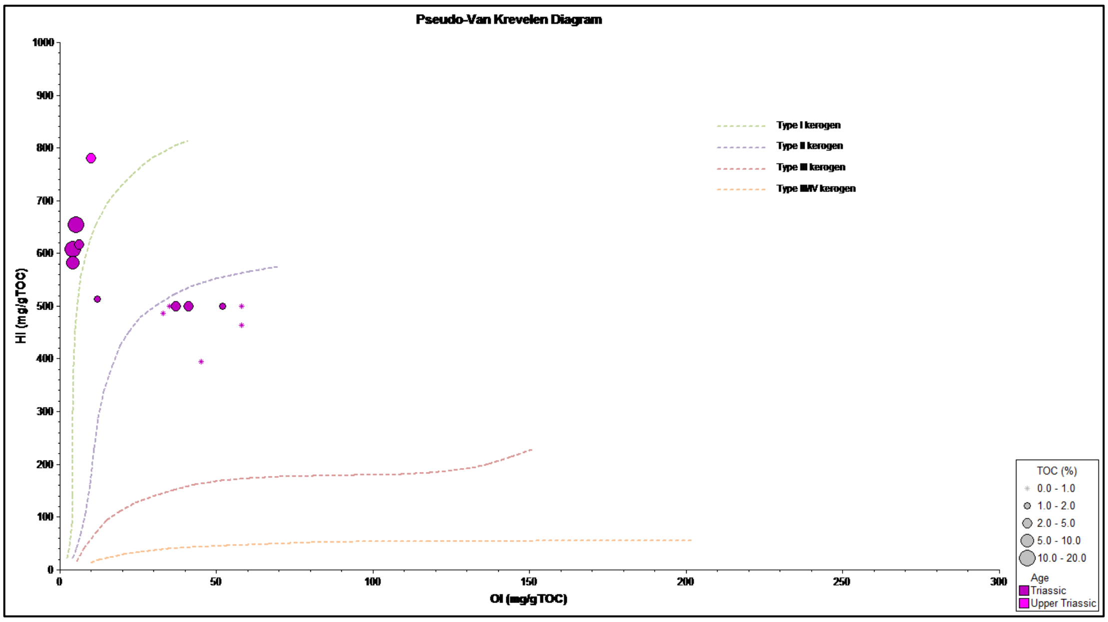

Figure 24 : Pseudo-Van Krevelen Diagram (HI vs OI) for samples of Triassic age.

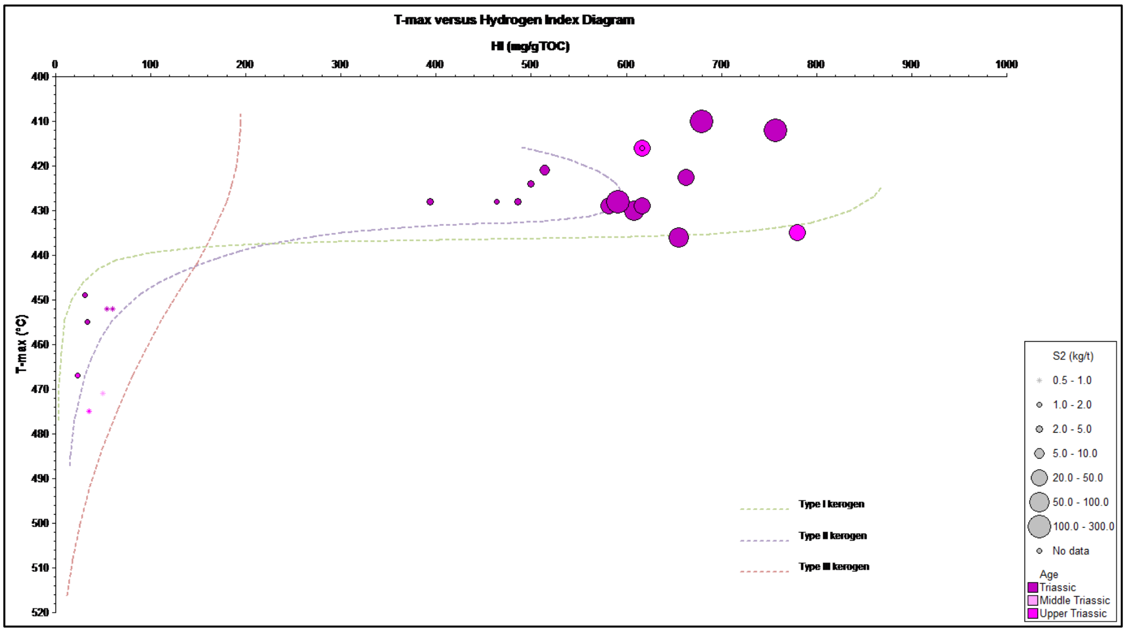

Figure 23 : Tmax vs HI diagram. Original values are presented.

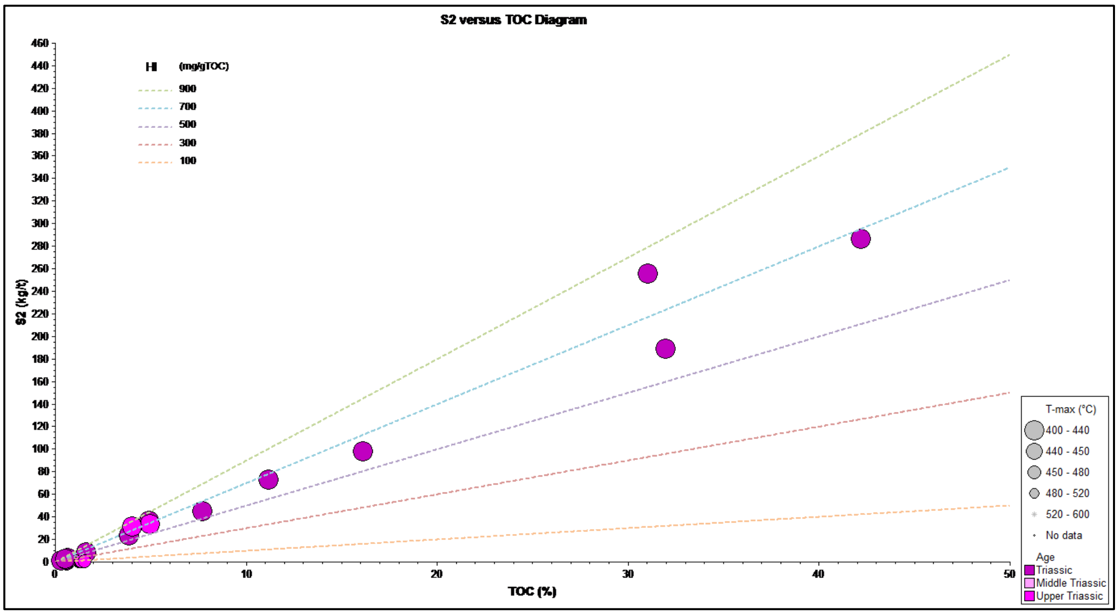

Figure 25 : S2 vs TOC diagram. Original values are presented.

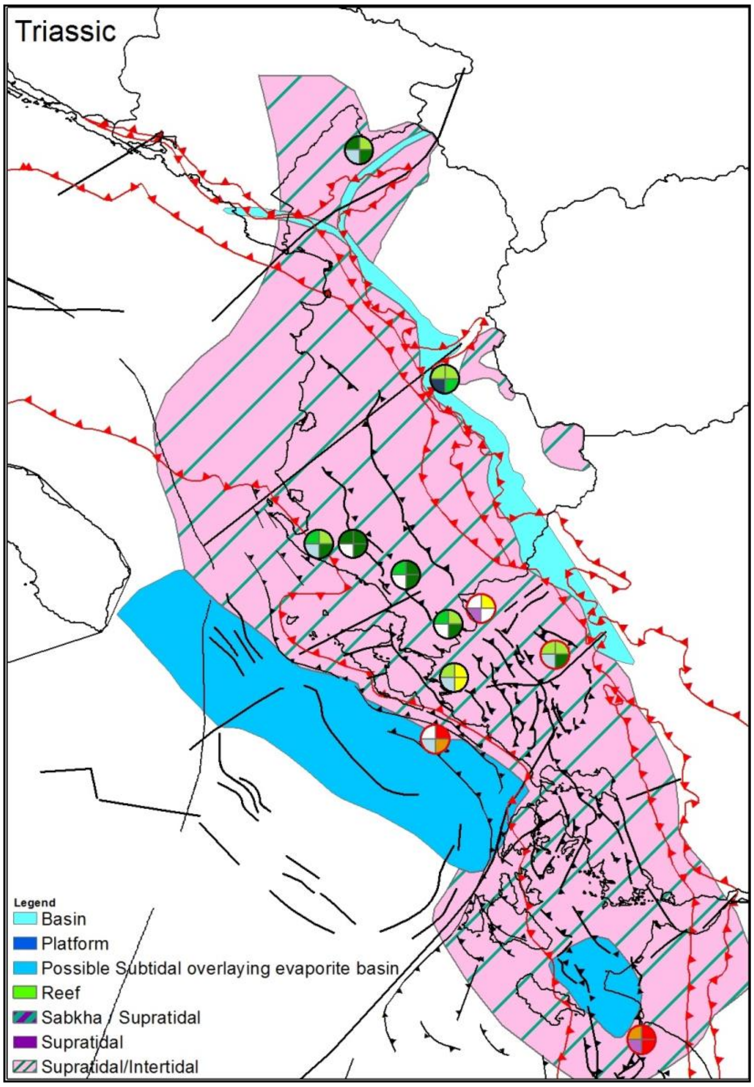

Figure 26 : Representation of Triassic samples on GIS after the Rock-Eval analysis, in combination with the depositional environment. In the circles presented (clockwise) TOC, S2, environment and HI values.

The depositional environment of Triassic formations is sabkha to supratidal in Ionian Zone. Also the anoxic depositional conditions that were predominating in the more internal zones (Krasta-Cukali zone) during the Upper Triassic (Swennen et al, 1998; Vilasi 2009) increased the possibility for the generation of good source rocks. In addition, the thickness of the formation which includes the possible source rocks is an important factor for the evaluation of one possible source rock horizon.

We can identify some horizons of possible source rocks in Triassic age:

- In Ionian Zone, at Iraklis well at depths of 1250 to 1275 m and 1400 to 1520 m in the shale fragments within the Triassic breccias which are in immature stage. In Mavroudi North area, outcrops within the same formation have been analyzed. Mavroudi North samples, according to the Ro values are close to their maximum of oil generation. Also there are possible source rock horizons in Dukat and Mali-Gjere areas in Cika anticlinal belt, within 15m thick bituminous horizons which are also mature (Roure et al, 2004). However, the information is not enough (based on outcrops and only one well) in order to make an assumption of the continuity of these source rock intervals.
- In Krasta-Cukali Zone, at Mirake area in the dark-green to black marly shales with cherts with total thickness of 25 – 30 m. Vitrinite reflectance value is 1.20% indicating overmature samples.

The only sample from Albanian Alps tectonic zone (sample “1”) that has been analysed shows great hydrocarbon potential but there are not enough data in order to better characterize this source rock horizon.

<u>Possible extension of Triassic source rock horizons</u>

An assumption has been made of how the source rock horizons can be extended. This assumption is based on similar characteristics and parameters of the different source rocks observed for a given age. For example source rocks which have been deposited in the same formation at the same time and are presenting similar hydrocarbon potential, depositional environment, maturity and type of organic matter, are considered to belong to the same source rock horizon. In the following figure are presented the main Triassic source rock horizons (SRH) and their possible extension.

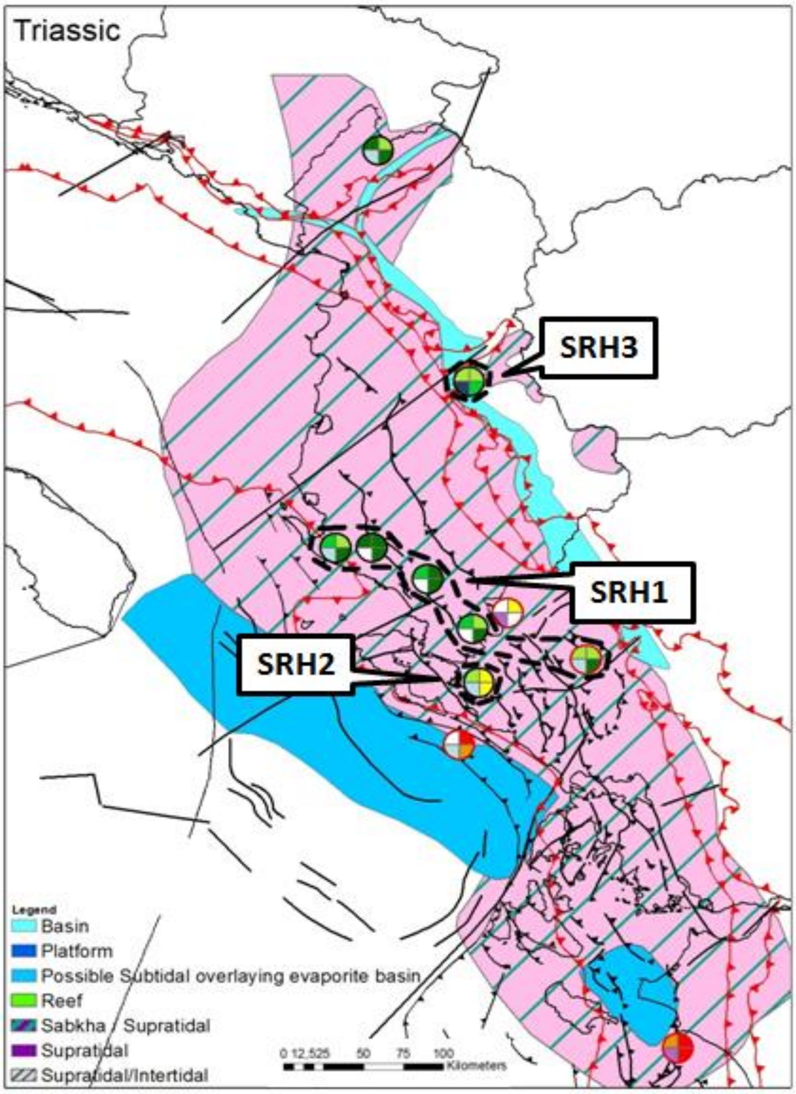

Figure 27 : Possible extensions of Triassic source rock horizons (SRH). There are 3 different source rock horizons. SRH1: from Iraklis well to Dukat area (Cika belt) in Albania. SRH2: at Mavroudi North area and SRH3 at Mirake area.

The first source rock horizon (SRH-1) includes samples from Ioannina, Mali Gjere and Dukat areas. These samples showed fair to excellent hydrocarbon potential and type II or type I organic matter. Source rock horizon 2 (SRH-2) is located in Mavroudi North area, where samples showed fair hydrocarbon potential and peak to late maturity. There is no information in order to extend further this SRH-2 or to link it with the SRH-1. The SRH-3 is located in Mirake area, where samples have fair hydrocarbon potential and are overmature.

3.2. Jurassic

In the Jurassic important number of samples has been found and analysed. In order to make an adequate evaluation of the samples and to define their parameters, a classification has been made. Samples have been separated according to their age in Lower Jurassic and Middle-Upper Jurassic.

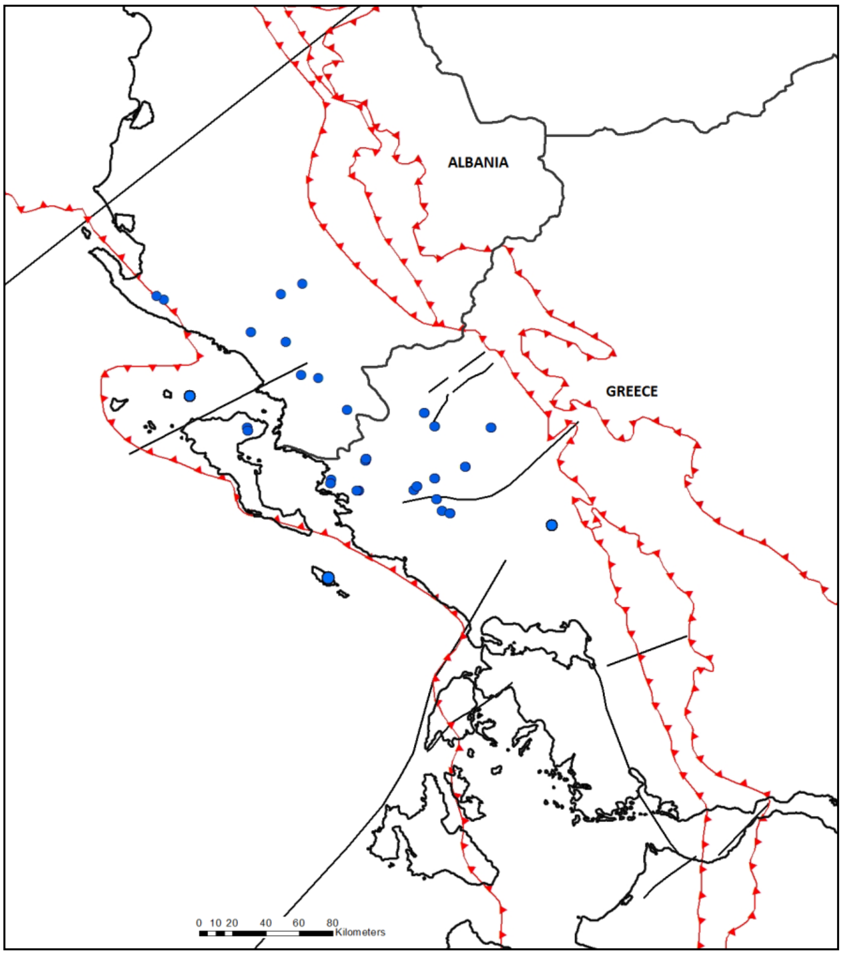

Figure: 28 Map of Jurassic samples.

3.2.1 Lower Jurassic

All samples of Lower Jurassic, from the area of interest have been deposited in Ionian zone. In the Liassic age we have samples within dolomitic bituminous shales, at Tragjasi anticline (sample 268), Cika anticline (sample 269), Ftera anticline (sample 282) and at Mali Gjere anticline (samples 286 and 314)

Most of the samples have been found in lower “Posidonia beds” and have a Toarcian age. The Lower Posidonia Beds are composed of well-bedded pelagic limestones, marles and siliceous argilites and show variations in facies and thickness depending on their position in each half-graben (Karakitsios 1990, 1992; Rigakis & Karakitsios 1998). This formation constitutes the main source rock horizon of the Ionian Zone (Jenkyns, 1988; Baudin & Lachkar, 1990; Karakitsios & Rigakis, 1996; Rigakis & Karakitsios 1998). It is found in many places and contains high amounts of organic matter. Samples from Posidonia Beds have been analysed in Mali Gjere area in south Albania, and also in Chionistra, Elataria, Geromerion, Khionistra, and Koukoulioi areas in Greece.

In many places of the Ionian Zone, the Lower Posidonia Beds are not clearly differentiated from the Upper Posidonia Beds, so the whole formation is named as “undifferentiated Posidonia Beds” spreading from Toarcian to Tithonian (Rigakis & Karakitsios 1998). Samples of undifferentiated Posidonia Beds have been analysed in Petousi, Paliogrimpiani, Mali Gjere areas and in Iraklis and Ivi wells.

In Lower Jurassic samples of Toka shales have been analysed also. These samples are within the marls that are underlying the Ammonitico Rosso Limestones. This formation consists of dark gray to blue-green foliated marls and marly, slightly siliceous lime wackestones (Rigakis & Karakitsios 1998). This lithological member is observed only in the areas where the Ammonitico Rosso of Toarcian – Aalenian age is well developed. These areas correspond to the depocenters of the half-grabens created by the Ionian Basin internal syn-rift differentiation (Karakitsios, 1995).

3.2.1.1 Source rock parameters

Some Lower Jurassic samples from Mavroudi South area, are in peak-mature stage with Tmax values higher than 440 ^{0}C. For these samples initial values have been calculated in order to have the initial petroleum potential of these source rocks. In order to make this recalculation of the initial values, estimation about the initial HI value has been made first. This estimation made by taking as initial values of HI, the average value of the samples from the same area and age that are not mature. The average HI value of these samples is 250 and will be made the assumption that this is the initial HI value for the peak-mature samples. As been expected after the recalculation the initial values are higher than the original (table 3). As it has been expected after the initial values, the hydrocarbon potential is higher for these samples.

Location	TOC	S2	Tmax	HI	Initial TOC	Initial S2	Initial HI
Mavroudhi S	0,34	0,1	442	29	0,42	1	250
Mavroudhi S	0,59	0,1	447	14	0,74	2	250
Mavroudhi S	0,79	0,1	447	14	0,98	2	250
Mavroudhi S	0,44	0,2	444	41	0,53	1	250
Mavroudhi S	0,57	0,1	447	25	0,7	1	250

Table 3: Rock-Eval data of Mavroudi South samples and the calculated initial values.

Generally, samples of Lower Jurassic age are presenting fair to very good TOC values rating from 0.34% to 36.48% and a fair to excellent hydrocarbon potential with S2 values from 0.5 (mg/g) to 216 (mg/g). It has to be noticed that this geochemical analysis has included samples with extremely high TOC and S2 values (e.g. sample '268' with TOC = 47.77% and S2 = 421.71 mg/g, sample 'Fterra outcrop' with TOC = 28.86% and S2 = 176.58 mg/g) from IHS and GEOL6 database, which present the results of Rock-Eval analysis without any other information for the samples and cannot be verified. However, the richness in organic matter and the hydrocarbon potential of Lower Jurassic samples are not biased even if these values are excluded. The organic matter is type II (oil prone) in most of the cases, type I (highly oil prone) in some cases and in few cases is mixed type II/III and type III, as Pseudo-Van Krevelen (HI s OI), S2 vs TOC and Tmax vs HI diagrams showed.

Specifically, outcrops from Chionistra area within marls and marly limestones of Lower Posidonia Beds are rich in organic carbon with fair to good TOC values ranging between 0.5% and 1.62%. The TOC value is the only information that has been found for these samples.

In Elataria section, samples shows relatively high quantity of organic matter with TOC values from 0.87% to 2.32% with an average of 1.37%, while S2 values range between 4.36 (mg/g) and 17.49 (mg/g) (Appendix 1), indicating good to excellent hydrocarbon potential. The organic matter is mainly of type II and in some cases type I such as for the sample '247'.

Samples of Frossini, Geromerion, Paliogrimpiani and Ieromnimi areas which are found in limestones within Lower Posidonia Beds, present fair to good TOC values from 0.55% to 1.11% and fair hydrocarbon potential with S2 values between 1.2 and 4.1 (mg/g). The quality of organic matter according to the HI values is type II and type III and relatively high OI values that indicate oxidization of the samples.

In Khionistra area samples within limestones, siliceous limestones and thin limestones and blue-grey marls have been analyzed and showed fair to good organic matter content with TOC values from 0.4% to 1.89% and fair to very good hydrocarbon potential with S2 values ranging between 0.9 (mg/g) and 10.9 (mg/g). Hydrogen Index values are comprised between 219 and 654 (Appendix 1) indicating organic matter of mixed type III/II, type II and in few cases type II or type I.

In Koukoulioi area, samples within Lower Posidonia schists were analyzed and present fair to good content of organic carbon with TOC values from 0.49% to 1.54% and fair to good hydrocarbon potential with S2 values between 0.9 (mg/g) and 5.5 (mg/g). The quality of organic matter is according to HI values, type III and mixed type II/III as a result of oxidization and high OI values.

Samples in Mavroudi North outcrops are relatively reach in organic matter with TOC values between 0.35% and 1.61%, and they present fair to very good hydrocarbon potential with S2 values ranging from 1 (mg/g) to 7.2 (mg/g). HI values are indicating mainly type II and mixed type II/III organic matter.

In Mavroudi South area, five samples in limestones of Pantocrator facies were in the peak-mature stage of maturation with Tmax values between 440 and 450^{0}C. After the calculation of the initial values, we can have a quite good evaluation of the samples in this area. They have fair to good content of organic matter with TOC values between 0.42% and 1.22% and S2 values from 0.5 (mg/g) to 4.7 (mg/g) (Appendix 1)that are indicating poor to good hydrocarbon potential. The organic matter is mainly of type II and mixed type III/II according to HI values comprised between 98 and 421.

In Perithia area samples within limestones and blue-grey marls were analyzed and showed good to very good organic content with TOC values ranging from 0.98% to 2.06% and fair to good hydrocarbon potential with S2 values from 3 (mg/g) to 5.9 (mg/g). Hydrocarbon Index indicates organic matter of type II or mixed type III/II. In Perivleptos area we can observe higher OI values which indicate oxidization of the samples while the TOC and S2 values are showing fair hydrocarbon potential.

In Petousi area, despite the fact that a big number of samples have been taken within the Undifferentiated Posidonia Beds, the only information that we have from the geochemical analysis are the TOC values. According to these values, samples seem to be rich in organic matter, with TOC ranging between 0.53% and 4.86% .

In Siniais area, samples within grey marly limestones and black-grey marls, have fair to very good TOC values between 0.35% and 5.19% and presenting fair to excellent hydrocarbon potential with S2 values from 1 (mg/g) to 34.1 (mg/g). HI values are comprised between 244 – 657 indicating organic matter mainly of type II, mixed type III/II and in one case type II or type I.

Samples of Skoupitsa area, that have been taken within the Lower Posidonia shales, have fair to good content of organic matter with TOC values ranging from 0.49% to 1.41% and fair to good hydrocarbon potential with S2 values between 0.6 (mg/g) to 6 (mg/g) (Appendix 1). HI values between 413 and 432 indicate type II organic matter.

Samples of Toka area, within the Toka shales are rich in organic matter with TOC values between 0.64% and 5.15%. However, the TOC value is the only information, we have and we cannot make a valuable evaluation of these samples.

Samples 268,269, 282, 286, 314 and 322, are within black bituminous shales in Tragjasi and Cika anticlines, and in Ftera and Mali-Gjere areas (south Albania) respectively. They are very rich in organic matter presenting TOC values between 1.51% and 47.7%. They also have extremely high hydrocarbon potential with S2 values from 5.22(mg/g) to 421.7(mg/g) (Appendix 1). The organic matter quality, according to HI values, is mainly of type II and in case of sample '268', type I.

The samples 'Terraine Albanie', 'Mali Gjere outcrop' and 'Ftera outcrop' present also high TOC values from 2.14% to 28.86% and have very high hydrocarbon potential with S2 values between 11.1 (mg/g) and 176.58 (mg/g). HI values indicate organic matter quality of type II and type I. However, the source documents of these samples (HIS, GEOL6) are not giving us any further information such as petrological description or the formation inside which they have been sampled and the evaluation cannot be completed.

Samples of possible source rocks have been found in Gjere Mountain, Ftere, Kurveleshi Kremenare, Ballish and Patos/Verbas areas with no specific coordinates. These Lower Jurassic age samples are in Ionian zone within dolomitic, argillaceous and marly bituminous shales and present fair to excellent values of TOC ranging from 0.49% to 15.66% and very high hydrocarbon potential with S2 values between 0.62 (mg/g) and 55.71 (mg/g) (Appendix 1). Hydrocarbon Index values indicate organic matter quality of type II in most of the cases. In some cases the organic matter is type II, mixed type III/II and type III.

Samples from wells have been analyzed also in Lower Jurassic. In Ivi well which penetrated the Undifferentiated Posidonia Beds at depths intervals of 1477.5 – 1601m. The lithology of the formation is made of siliceous marly limestones in alternations with very thin-bedded marls and thin layers of chert (Rigakis & Karakitsios, 1998). These samples are very rich in organic matter with TOC values comprised between 0.96% and 20.06%, and they have high hydrocarbon potential with S2 values between 3.65 (mg/g) and 121.85 (mg/g) (Appendix 1). Their organic matter is of type II and type I according to the high HI values.

In Iraklis well, Posidonia Beds cover the interval from 615 to 1010m. Samples within marly limestones, black shales and cherts have been analyzed. They presented fair to excellent TOC values from 0.62% to 9.82% and they have fair to excellent hydrocarbon potential with S2 values ranking between 3.62 (mg/g) and 63.41 (mg/g) (Appendix 1). The quality of organic matter, according to high HI values in addition to very low OI values, is of type II, and type I. Highest HI values are present at depth intervals of 715 m and 900 – 1005 m.

Form Dafni and Ifikratis wells the only known values from the geochemical analysis are the average values of TOC and S2 contents. According to these values, samples of Paxoi area showed poor to fair hydrocarbon potential and samples from Erikousa area showed good hydrocarbon potential. However, average TOC and S2 values are not enough for a completed evaluation.

Maturity

In Albania, Liassic carbonates and Toarcian Posidonia shales which were sampled in surface outcrops of the Ionian Basin, display vitrinite reflectance (Ro) values lower than 0.55% and thus the rocks are immature (Roure et al., 1995; 2004). For Greece the Tmax of samples is generally lower than 435 ^{0}C (Rigakis & Karakitsios, 1998) except from samples in Mavroudi South area which showed

Tmax values between 442-447 °C. Also the vitrinite reflectance (Ro) values of most of the outcrop samples are lower than 0,60%, showing that the present day surface organic matter has not entered the main oil generation phase (Rigakis & Karakitsios, 1998).

3.2.1.2. Paleo-environment

Although the information that describes the paleo-environment of the possible source rocks is poor, we used any available data in order to define the depositional environment.

In Elataria, Paliogrimpiani, Chionistra, Petousi areas and in Ionnina-1 and Ivi wells the samples are within Lower Posidonia Beds. According to Rigakis and Karakitsios 1998, the Lower Posidonia Beds (Elataria area) include some slightly siliceous lumachelles rich in radiolarian and large pelagic bivalves (Bositra). This description gives us the information for the depositional environment, which is deep-marine.

For samples 268, 269, 282, 286, 314 and 322 the only information we have is that these samples are within dolomitic or black bituminous shales in some cases with posidonia, which indicate a deep-marine depositional environment.

In Perithia, Siniais, Mavroudi North, Mavroudi South and Khionistra areas the depositional environment seems to be different. There are clues in these areas that indicate Supratidal to shallow-marine environment such as algae, terrestrial elements (spores, wood debris etc) and other fossils (Baudin, 1989).

In Skoupitsa and Koukoulioi areas the Ammonitico Rosso facies and radiolaria have been found, which indicate a deep marine depositional environment.

For samples from Gjere Mountain, Ftere, Kurveleshi, Kremenare, Ballish and Patos/Verbas areas the source document (Sedjini et al, 1994) is not giving us enough information for the depositional environment, only some general descriptions and it is rather difficult to make any assumption.

Concerning the paleo-environment, In Elataria, Paliogrimpiani, Iraklis well, Ivi well, Chionistra, Koukoulioi, Skoupitsa and Petousi areas (Lower Posidonia Beds), the depositional environment is deep-marine. The same depositional environment characterises also the samples 268, 269, 282, 286, 314 and 322 in Albania. From the other hand, in Perithia, Siniais, Mavroudi North, Mavroudi South and Khionistra areas the depositional environment is Supratidal to shallow-marine.

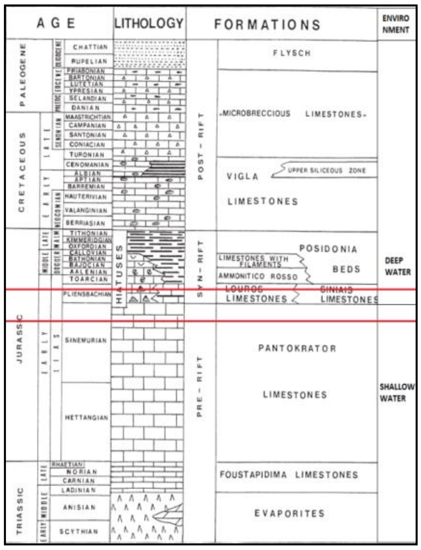

Figure 29 : Stratigraphic column of the Ionian Zone and the observed change of the environment from shallow to deep water in the Pliensbachian (Karakitsios 1995).

A differentiation in the depositional environment can be observed, during the Pliensbachian times, due to the general deepening of the Ionian area (formation of Ionian basin), which was followed by the internal synrift differentiation of the Ionian basin marked by smaller paleo-geographic units (Karakitsios, 1995; 2013).

In Pre-Apulian zone the paleo-environment is supratidal to intertidal.

3.2.2. Middle to Upper Jurassic

In Middle to Upper Jurassic there are a few possible source rocks samples. They have been found in Ionian zone and localized in Mavronoros, Kurveleshi and Kocul areas.

3.2.2.1. Source rock parameters

In Mavronoros area, two samples of Upper Posidonia Beds have been analyzed. They are rich in organic carbon with TOC values from 2.51% to 3.47% and they have good to very good hydrocarbon potential according to S2 values, which are between 4.6 (mg/g) and 14.28 (mg/g). HI values (183-411) indicate mainly type III and type II organic matter.

Sample 273, is in Kurveleshi belt, in black bituminous shales within limestone and chert. It has very good organic content with TOC value of 4.47% and excellent hydrocarbon potential with S2 value of 25.55 (mg/g). HI value of 571 indicates type II organic matter.

One sample in Kocul area has been found and analyzed. It showed good values of organic matter with TOC value of 1.86% and very good hydrocarbon potential with S2 value of 10.17 (mg/g).

Name	Zone	Country	Type	Age	TOC	S2	Tmax	HI	OI
273	Ionian	Albania	Field	Malm	4,47	25,55	428	571	
Mavronoros 2407	Ionian	Greece	Outcrop	Late Callovian-Tithonian	2,51	4,6	425	183	47
Mavronoros 2408	Ionian	Greece	Outcrop	Late Callovian-Tithonian	3,47	14,28	412	411	21
Kocul	Ionian	Albania	Field	Upper Jurassic	1,86	10,17	417	546	

Table 4 : Results fromRock-Eval analysis of Middle to Upper Jurassic samples.

3.2.2.2. Paleo-environment

In Mavronoros area, the Upper Posidonia Beds formation consists of thin-bedded siliceous argillites and cherts containing abundant pelagic bivalves and radiolarian. In the lower part, thin intercalations of lumachelles with large planktonic bivalves, are present (Bositra) (Rigakis & Karakitsios 1998). These fauna indicate a deep-marine environment.

The only information that we have for sample "273", is that it has been found in black bituminous shales within micritic limestones and cherty beds. Although this is not an environmental description we can say that the depositional environment is probably deep-marine.

For the sample of Kocul area, no information for the depositional environment has been found and we cannot make any assumption.

Samples from Pre-Apulian zone have been deposited in inner platform environment.

3.2.3. Conclusions

A large amount of samples of Jurassic age have been analyzed. The results show that Jurassic samples have fair to excellent richness in organic carbon and also have fair to excellent hydrocarbon potential according to the TOC and S2 values. As it can be observed in the diagrams (HI vs OI, S2 vs TOC, Tmax vs HI; Figures 29, 30, 31) the quality of organic matter covers all types. Few samples are characterized by organic matter of type I (highly oil prone). Furthermore, a significant percentage of samples have type II (oil prone) organic matter. There are also samples with organic matter of mixed type III/II and few samples with organic matter of type III.

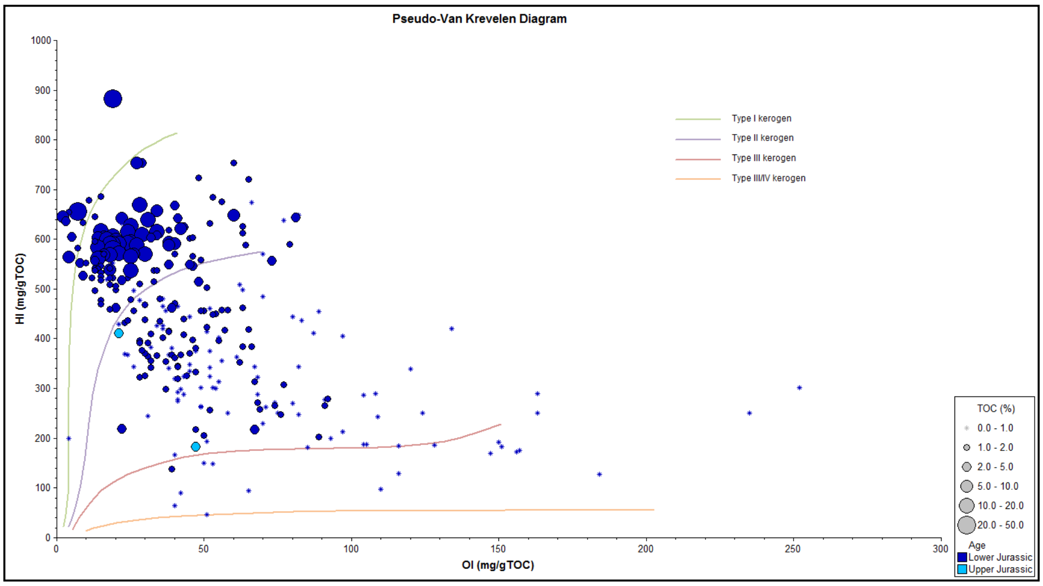

Figure 30 : Pseudo-Van Krevelen diagram. Dark blue colour corresponds to the Lower Jurassic samples.

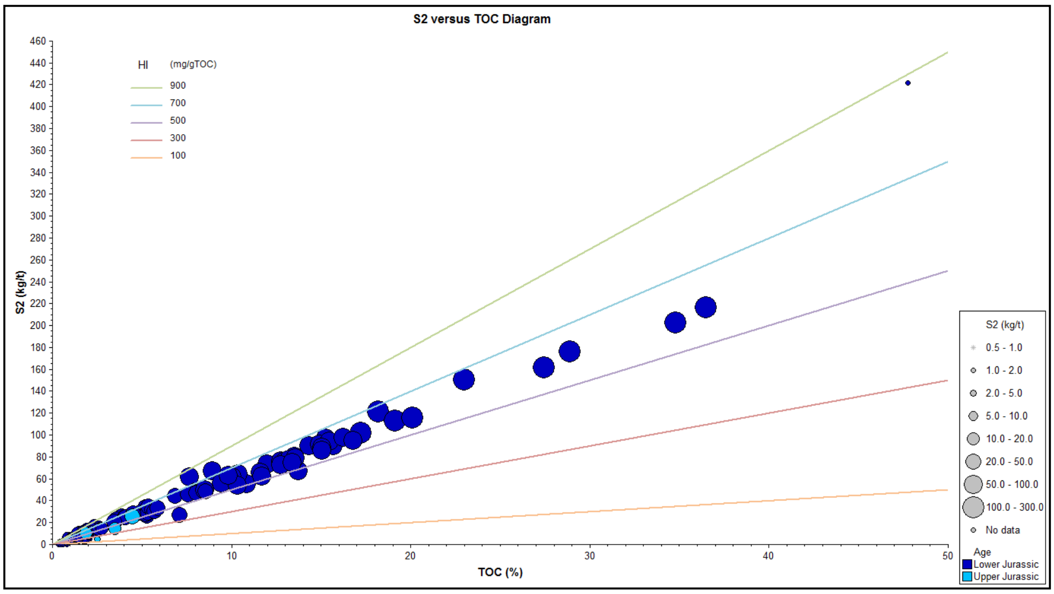

Figure 31 : S2 vs Tmax diagram. Dark blue colour corresponds to the Lower Jurassic samples.

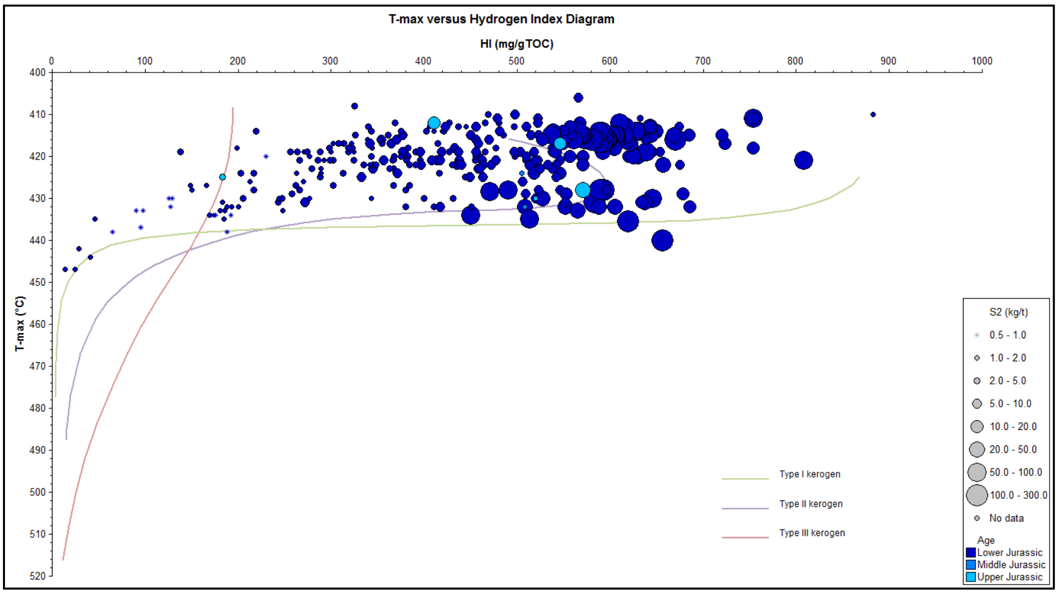

Figure 32 : Tmax vs HI digram. Dark blue colour corresponds to the Lower Jurassic samples.

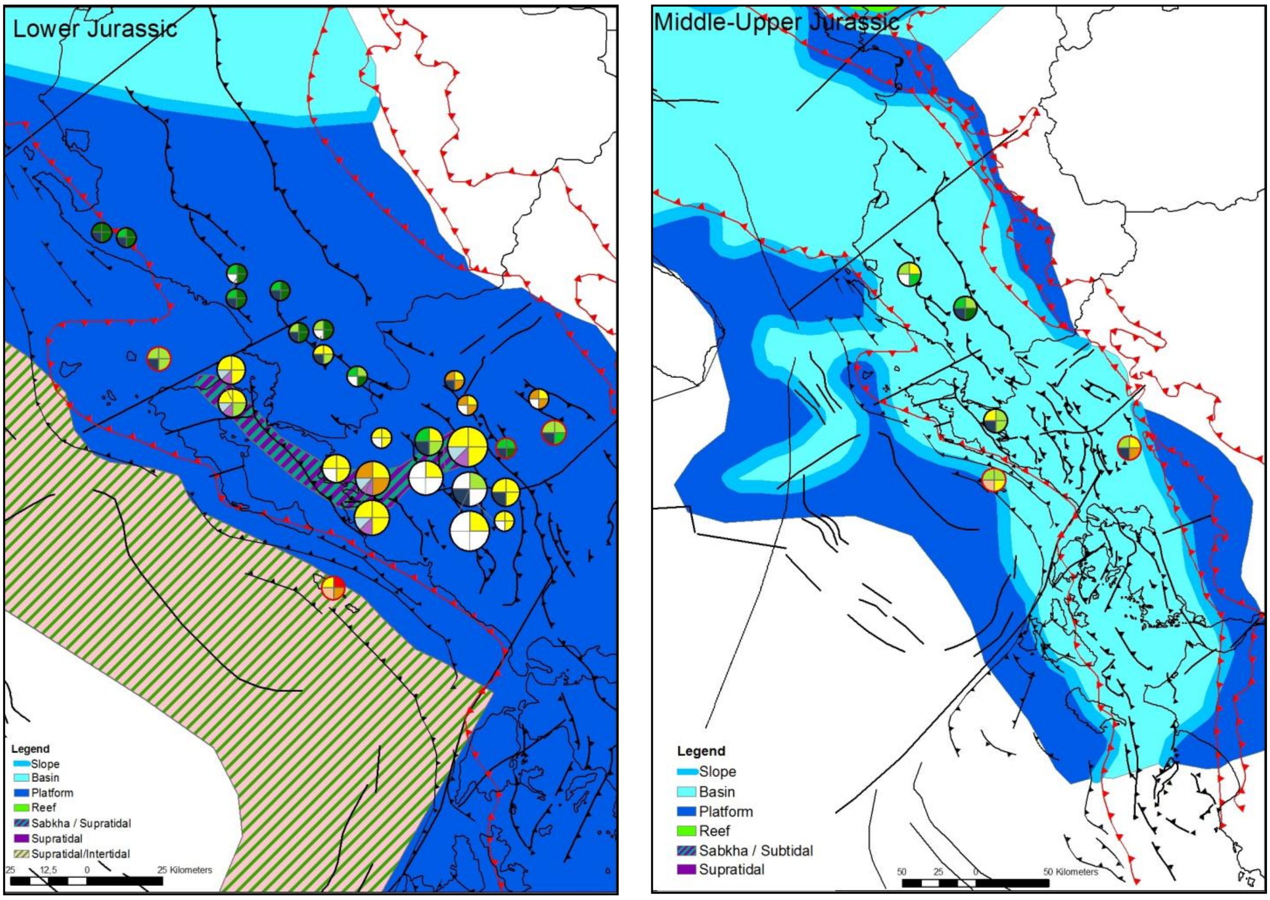

Figure 33 : Representation of Jurassic samples on GIS after Rock-Eval analysis, in combination with the depositional environment. In the circles are presented (clockwise) the TOC, S2, environment and HI values.

In Jurassic we can identify several source rock horizons and some of them are very important.

- In Elataria section, in the Lower Posidonia Beds, where the thickness is 41m. Samples in this area shown good TOC values and good to excellent hydrocarbon potential. HI values indicate type I (highly oil prone) and type II (oil prone) organic matter.
- In Ivi well, the thickness of the formation is about of 80m. The samples from this well have good to excellent organic matter richness and hydrocarbon potential. The paleo-environment is deep-marine and the quality of organic matter, according to the HI values, is of type I and type II. We can say that this is an important source rock horizon.
- In Iraklis well, the Undifferentiated Posidonia Beds cover the interval from 615-1010m but the true thickness of the formation is lower because of the dip. Organic matter richness and hydrocarbon potential are good to excellent. Especially at the depth of 715m and between 920-1005 m, these high values combined with the higher HI values in this formation, indicate type II organic matter.
- In Khionistra area, the thickness is 70m (Baudin, 1989). HI values are not high, and only in few cases indicate type II or type I, organic matter. However, the TOC and S2 values are good and this formation can be considered as a possible source rock horizon.
- In Mavroudi North and Mavroudi South area, samples have relatively high TOC and S2 values but the quality of organic matter is poor with low to very low HI values, indicating an

oxidization of the samples. With 38m and 59m thickness respectively (Baudin, 1989), we can consider them as possible source horizons but not as good as the previous. The same types of source rocks were observed in Skoupitsa, Perithia (20m thickness), Perivleptos (10m thickness), Koukoulioi (16m thickness), Frossini (12,5m thickness), Geromerion (78m thickness), Paliogrimpiani and Ieromnimi areas. Despite the fact that the TOC and S2 values are good the HI values are low indicating mainly organic matter of type III (gas prone). In this case we can say that these possible source rock horizons are probably gas prone.

- In Siniais area, samples have good to very good TOC values and good to excellent hydrocarbon potential. HI values indicate mixed type II/III and in few cases type II or type I organic matter. The thickness here is 20m (Baudin, 1989).

- In Mavronoros area, samples of Upper Jurassic in Upper Posidonia Beds with total thickness of about 9 m, showed very good richness and hydrocarbon potential and type II and III organic matter. The depositional environment is deep-marine and they probably constitute a possible source rock horizon for gas.

- In Kurveleshi area, Upper Jurassic sample 273, presents excellent hydrocarbon potential, very good richness in organic carbon and organic matter type II. The depositional environment is probably deep-marine.

Sample 269 is from Cika anticlinal belt of Ionian Zone within dolomitic bituminous shales with thickness of 0-30m. The geochemical analysis showed great richness and hydrocarbon potential and type II organic matter. However, we do not have enough information in order to make a valuable assumption on paleo-environment.

Samples 286, 314, and 322 from Mali-Gjere area have very good to high richness in organic carbon and hydrocarbon potential (type II organic matter). Thickness is unknown except from sample 314 which is deposited in dolomitic shales with 15m. Other samples from Mali-Gjere area (Gjere Mountain samples) have been analysed also, presenting almost the same results but their coordinates cannot be verified and it is not clear if they are from the same outcrop.

In Ballish and Patos-Verbas areas, samples within dolomites are presenting good to very good richness in organic matter and hydrocarbon potential (type I organic matter). For the same source document there are samples “Kurveleshi”, “Kremenare”, “Ftere” which presented fair to good TOC and S2 values, organic matter type III/II but the available information does not allow a detailed characterization of the source rocks (unknown thicknesses and depositional environment, no coordinates of the samples).

Although samples “Terrain-Albanie” and “Ftera Outcrop” may be excellent source rocks we cannot be sure due to the lack of information from source documents (GEOL6 and HIS, databases provide only the results of geochemical analysis without any further information for the samples).

For samples of Petousi and Chinistra areas the only information that we have from the geochemical analysis are the TOC values. According to these values, samples present good richness in organic matter.

Possible extension of Jurassic source rock horizons

As in the previous chapter (3.1.3) an assumption has been made also for the possible extension of Jurassic source rock horizons. Lower Jurassic source rocks from Dukat, Ftera, and Mali

Gjere areas have quite similar characteristics with samples from Iraklis and Ivi wells. In addition these samples have been deposited during the same period and probably are parts of the same source rock horizon (SRH-1). These source rocks showed fair to excellent hydrocarbon potential and organic matter type II or type I.

Source rocks from Khionistra, Mavroudi S, Mavroudi North, Siniais and Perithia areas constitute a different source rock horizon (SRH-2). Source rocks of this horizon have been generated in supratidal to shallow marine depositional environment and showed fair to excellent hydrocarbon potential. The organic matter is type III and mixed type II/III.

Source rock horizon 3 (SRH-3) is located in Mavronoros area. Middle-Upper Jurassic age source rocks of this horizon showed good to very good hydrocarbon potential and type III or mixed type II/III organic matter. Samples from Kocul and Kurveleshi areas cannot be included to this horizon because of their different type of organic matter (type II) and they may be parts of a different source rock horizon.

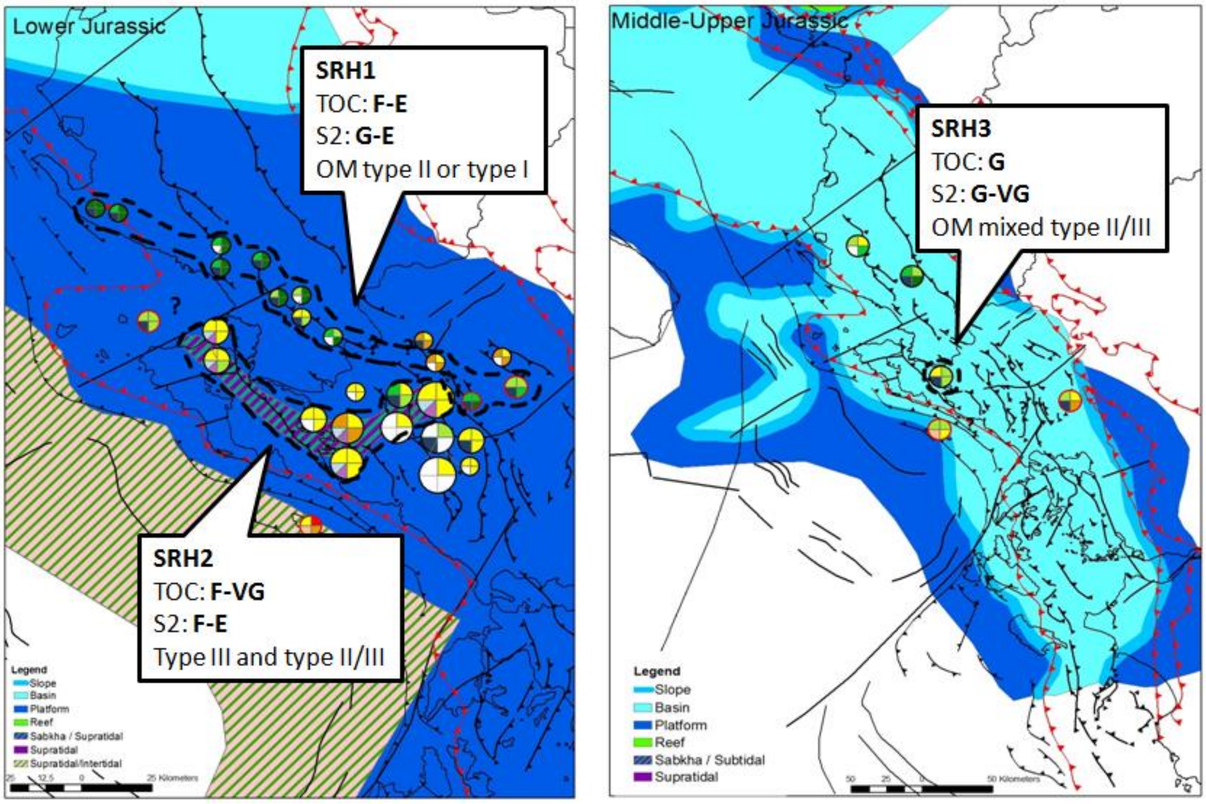

Figure 34 : Possible extensions of Jurassic source rock horizons (SRH). SRH-1 extends from Ioannina and Dragopsa areas to Mali Gjere, Ftere, Kurveleshi and Dukat areas. SRH-2 includes Perithia, Siniais, Mavroudi and Khionistra areas. SRH-3 is located in Mavronoros area.

3.3. Cretaceous

A large number of Cretaceous samples are available. In order to have a clearer picture of the parameters and characteristics of the possible source rocks, samples of the Cretaceous age have been divided into Lower and Upper Cretaceous.

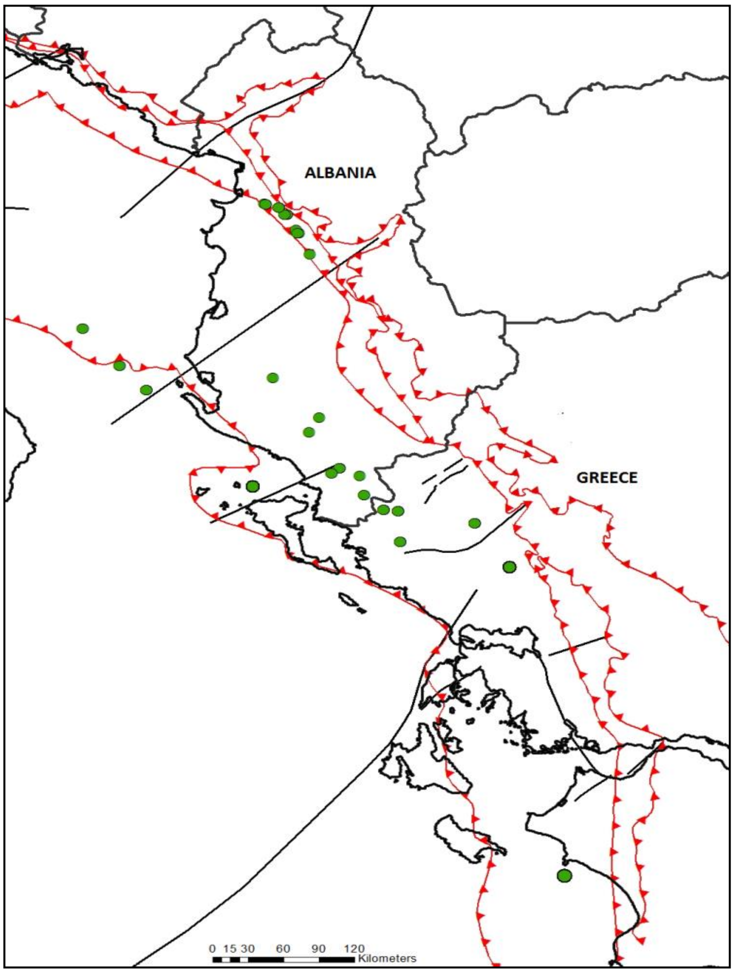

Figure 35 : Map of Cretaceous samples.

3.3.1. Lower Cretaceous

Lower Cretaceous samples have been deposited in Ionian Zone. In Kurveleshi area they correspond to black bituminous shales and marly shales. Samples “274” and “Kurveleshi” have been analyzed.

In Gotzikas section and Iraklis well “Vigla shales” formation has been sampled and analyzed. Vigla shales consist of limestone and cherty beds with dark grey to green or red shale interbedding. The Vigla shales were dated as Albian-Cenomanian (Karakitsios 1995). In Paliampela area and Sopoti section, analyzed samples correspond to radiolarian cherts, limestones and black shales.

In Gjere Mountain, Ftere, Kurveleshi, Kremenare, Ballish, Patos-Verbas and Cakran areas of Ionian Zone analyzed samples are argillaceous, bituminous and marly shales.

“Terrain-Albanie” Lower Cretaceous source rock samples, deposited in dolomites, limestones and shales, have been analyzed.

3.3.1.2. Source rock parameters

In Gotzikas, Sopoti and Paliampela section, the only information that has been found from the geochemical analysis is the TOC value. According to this value, samples of Gotzikas area, showed good to excellent richness in organic matter. TOC values are comprised between between 1.08% and

28.87%. In Sopoti area, samples have fair to very good richness in organic matter with TOC values from 0.64% to 8.5%. In Paliampela area TOC values were between 0.55% and 6.71%, indicating fair to very good richness.

In Iraklis well, samples showed good richness in organic matter with TOC values from 1.44% to 2.24% and good to very good hydrocarbon potential with S2 values comprised between 7.16 (mg/g) and 13.38 (mg/g). The quality of organic matter is mainly type II, according to the HI values, which are ranging between 476 and 597 (Appendix 2).

Samples from Dafni and Hermione-1 wells, showed good to very good hydrocarbon potential according to TOC and S2 values. It has to be noticed that these values are the average values and the evaluation cannot be considered as completed.

“Terrain-Albanie” samples present a very high hydrocarbon potential with TOC values between 6.74% and 32.6% while S2 values are comprised between 50.1 (mg/g) to 245.6 (mg/g). Hydrocarbon Index values are also very high indicating type I organic matter. It has to be noticed that such a high TOC and S2 values, higher than 30% and 100 (mg/g) respectively, probably indicating the presence of coal in the sample. Thus, the hydrocarbon potential is totally different.

In Gjere Mountain area, samples have been taken in argillaceous and bituminous shales. The sample within the argillaceous shales has fair TOC value of 0.8% and good S2 value of 5.2 (mg/g), whereas the sample in bituminous shales showed extremely high potential, with TOC value of 26.01% and S2 value 181.5 (mg/g) (Appendix 2). However, both the samples have type I or type II organic matter, according to the HI values (652 and 700, respectively).

Samples in Kurveleshi area (“Kurveleshi and “273”) are presenting very high richness in organic matter with TOC values from 1.63% to 25.95% and also very high hydrocarbon potential with S2 values between 6.23(mg/g) and 185.01(mg/g). HI values are between 354 and 704 (Appendix 2), indicating an organic matter between type II and type I.

In Ftere, Kremenare, Ballish, Patos-Verbas and Cakran areas, samples have fair to very good organic matter richness, with TOC values from 0.8% to 6.33% and good to excellent hydrocarbon potential with S2 values between 1.74 (mg/g) and 33.17 (mg/g) (Appendix 2). The quality of organic matter is good and Hydrocarbon Index values are high, from 443 to 652, indicating type II or type I organic matter.

Maturity

In the Kurveleshi unit of Ionian zone, vitrinite reflectance (Ro) values are between 0,48 and 0,53% (Roure et al, 2004). Samples from Vigla Shales in Gotzikas section showed Ro values lower than 0,50%, whereas in the same formation in Iraklis well (at the depth of 480m) vitrinite reflectance is equal to 0,62% (Rigakis & Karakitsios 1998). Tmax values of Lower Cretaceous samples are lower than 435 ^{0}C, indicating that these source rocks are in the immature stage of maturation.

3.3.1.2. Paleo-environment

The only information for sample “274”, is that it is deposited within black bituminous shales, this may indicates that the depositional environment is deep-marine.

Samples in Gotzikas section and Iraklis well, are within the “Vigla shales” formation. This formation consists of thin bedded gray packstones in rhythmical alterations with chert layers and intercalation of shale (Rigakis & Karakitsios, 1998), which indicate a deep-marine environment. Additionally according to Tsikos et al, 2004, in Gotzikas area the depositional environment is marine and quite distant from source of fresh continental organic matter.

In Paliambela area, the organic matter derived mainly from plankton or bacteria and is usually related to marine reducing environments (Danelian et al, 2002). Generally, the sedimentation consists of pelagic limestones with chert nodules, Radiolarites and black shale. The depositional environment is deep-marine. Also in Sopoti section, the black shale levels rich in organic matter of marine origin and the presence of large Assiptra nannoliths and Radiolaria (Danelian et al, 2007) indicate a deep-marine environment.

For samples of Gjere Mountain, Ftere, Lumi Zeze, Kurveleshi, Kremenare, Ballish, Patos-Verbas and Cakran areas, the source document (Sedjini et al., 1994) does not give a lot of information for the depositional environment, only that generally the sedimentation is pelagic.

3.3.2 Upper Cretaceous

Samples of Upper Cretaceous are from Sazani, Ionian and Kruja tectonic zones.

Samples of Sazani zone are from Newton well. Although their age is “undifferentiated Mesozoic”, their position under Olicocene age limestone, indicates Upper Cretaceous to Eocene. This part of Newton well, consists of dolomitic limestone and limestone with occasional stringers of gray, dark grey and light grey-green calcareous claystone.

In Ionian Zone samples from Gotzikas area have been analyzed. They are within the “Vigla shales” formation as the samples of Lower Cretaceous from the same area but they belong to its upper part which is Cenomanian – Turonian (Upper Cretaceous). Samples “315”, “318”, “206” and “256” are from Ionian Zone. Samples 315 and 318 are located in Mali–Gjere anticline within interbedding of cherts, bituminous cherty and limestones. Sample 206, is in Kremenare anticline in interbeddings of bituminous shales and marly limestones. Sample 256 is in Kurveleshi belt, within dark to black bituminous shales.

In Kruja tectonic zone, samples have been taken in several areas and analyzed. In Djora area we have samples in schists and black bituminous shales of Upper Cretaceous age. In Erzeni area Upper cretaceous samples are corresponding to dolomites and limestones. In Lumi-Zeze area, field samples have been taken within carbonate dolomites and schists and have been analyzed. In Tuzani and Vaja areas Upper Cretaceous samples are located within bituminous schists and dolomites and carbonates. In Zeza river and Milot areas there are samples in bituminous dolomitic black shales and carbonates.

3.3.2.1. Source rock parameters

In Gotzikas area, samples showed high richness in organic matter with TOC values ranging from 0.94% to 21.61% and good to excellent hydrocarbon potential with S2 values between 4.67 (mg/g) and 167.11 (mg/g) (Appendix 3). The quality of organic matter type II and type I (high HI values, from 377 to 912). Also in the southern part of Ionian zone (Afroditi-1 well) samples showed good richness in organic matter with an average TOC value of 2.45%.

In Djora area, samples are rich in organic matter with good TOC values from 0.92% to 3.93% and have high hydrocarbon potential with S2 values between 5.25 (mg/g) and 31.83 (mg/g). Hydrocarbon Index has high values from 570 to 914, indicating type I and type II organic matter. In Erzeni area, one sample has been analyzed. The results showed very good richness in organic matter and also very good hydrocarbon potential with TOC value of 7.22% and S2 value 14.99 (mg/g). HI value is relatively low (208) indicating type III organic matter. Samples of Lumi-Zeze area have poor to good richness in organic matter with TOC values between 0.31% and 1.72% (Appendix 3); they also have good to very good hydrocarbon potential with S2 values from 1.25 (mg/g) to 9.71 (mg/g). The quality of organic matter is mainly type II or type I, according to the HI values which rating between 390 and 635. One sample from Milot area has been analyzed and showed very good richness in organic matter and very good hydrocarbon potential with TOC value of 4.21% and S2 value of 17.58 (mg/g). The HI value of 417 indicates type II organic matter. In Tujani area, samples showed poor to excellent richness in organic matter with TOC values from 0.3% to 12.05% and good to excellent hydrocarbon potential with S2 values between 1.86 (mg/g) and 36.87 (mg/g) (Appendix 3). Hydrocarbon Index values rate range is between 184 and 661, indicating a good quality type II or type I organic matter. In few cases the organic matter is mixed type II/III. Samples of Vaja area presented poor to good richness in organic matter with TOC values from 0.33% to 1.91% and fair to very good hydrocarbon potential with S2 values between 1.6 (mg/g) and 19.46 (mg/g). HI values, which are comprised between 484 and 687, showed good quality type II or type I organic matter. For samples of Zeza River area, the only information that is available is the TOC values, which is ranging from 1.24% to 3.37% and show a good richness in organic matter.

Samples 206, 256, 315 and 318 have good to excellent richness in organic matter with TOC values from 2.12% to 38.46% and also good to excellent hydrocarbon potential with S2 values comprised between 12.1 (mg/g) and 290.31 (mg/g). Hydrocarbon Index values are very high, from 570 to 898 (Appendix 3), which is indicating a very good quality mainly type I organic matter.

In Sazani zone, Upper Cretaceous samples from wells have been analyzed also. In Newton well, samples showed fair to good hydrocarbon potential with TOC values ranging between 0.53 and 1.29% and S2 values from 0,79 to 1,82 (mg/g) (Appendix 3). In Kepler well one sample has been analyzed and is presenting poor hydrocarbon potential with TOC value of 0,5% and S2 value of 0,60 (mg/g).

Maturity

Samples of Kruja zone present Tmax values lower than 435 ^{0}C. Vitrinite reflectance (Ro) values comprised between 0.34 to 0.40% showing that the organic matter is not mature (Velaj, 2012). For Upper Cretaceous samples of Ionian zone vitrinite reflectance values remained lower than 0.55% (as in the Lower Cretaceous). Also Tmax values are lower than 435 ^{0}C, indicating an immature organic matter.

3.3.2.2. Paleo-environment

The only information that we have for samples 206, 256, 315, 318, Zeza-River and Tujan is that these samples are within dolomitic and black bituminous shales. From this description we can assume that the depositional environment is deep-marine.

Samples of PSG well are deposited in a slope environment. For samples of Newton well we have only the petrologic description. The formation consists of dolomitic limestone, limestone and calcareous claystone. The depositional environment may be deep-marine.

In Droja, Vaja, Lumi-Zeze, Tujani and Erzeni areas of Kruja Zone, samples were taken in formations which contain macerals of amorphinite, bituminite and liptodedrinite. This nature of organic matter is characteristic of a shallow-water environment.

In Gotzikas area, samples are within "Vigla shales" which consist of thin bedded gray packstones in rhythmical alternations with chert layers and shale horizons. The depositional environment is deep-marine.

3.3.3. Conclusions

Samples of Cretaceous age are rich in organic matter with TOC ranging from fair to excellent values and also have high hydrocarbon potential with high S2 values. The quality of organic matter, as it can be observed from the diagrams (HI vs OI, S2 vs TOC and Tmax vs HI) is mainly good to very good type II (oil prone) and type I (high oil prone) with HI values in some cases above 900 (Tmax vs HI, diagram). Samples of Kruja zone seem to have very good potential considering the high TOC and S2 values in combination with the shallow marine environment.

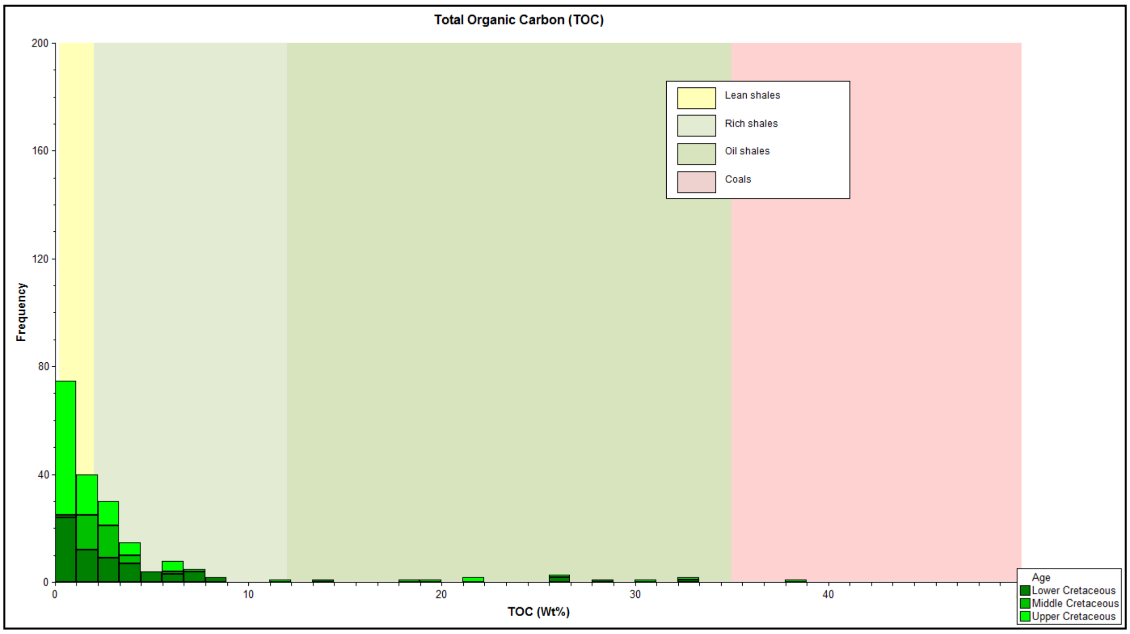

Figure 36 : TOC histogram of Cretaceous samples. Dark green color corresponds to the Lower Cretaceous samples, light green to the Upper Cretaceous samples and the middle green to the Middle cretaceous samples (Albian – Cenomanian).

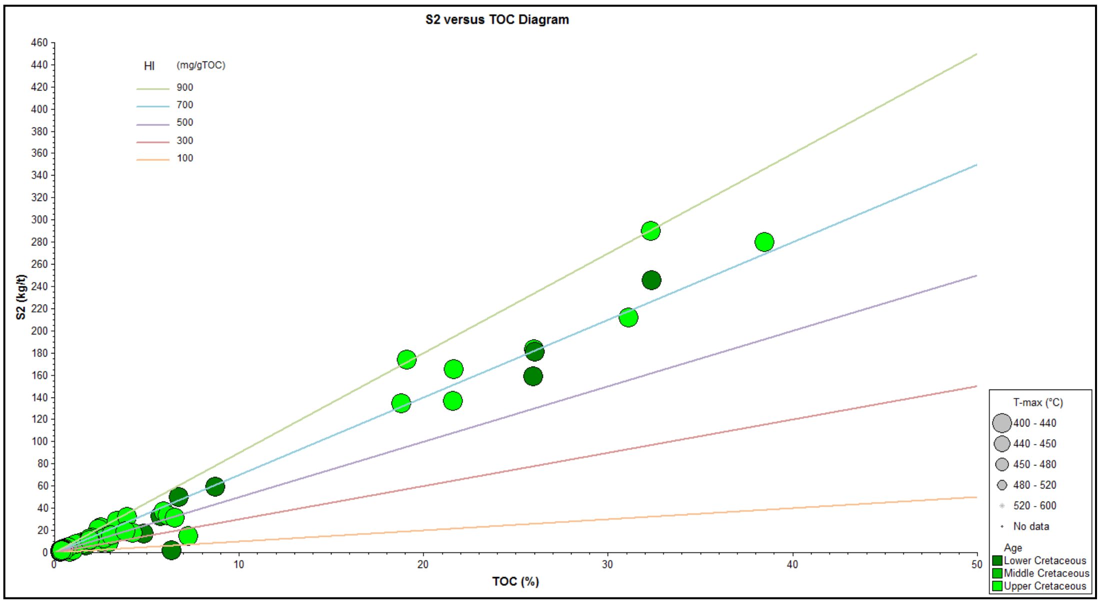

Figure 37 : S2 versus TOC diagram of Cretaceous samples. Dark green color corresponds to the Lower Cretaceous samples, light green to the Upper Cretaceous samples and the middle green to the Middle cretaceous samples (Albian – Cenomanian).

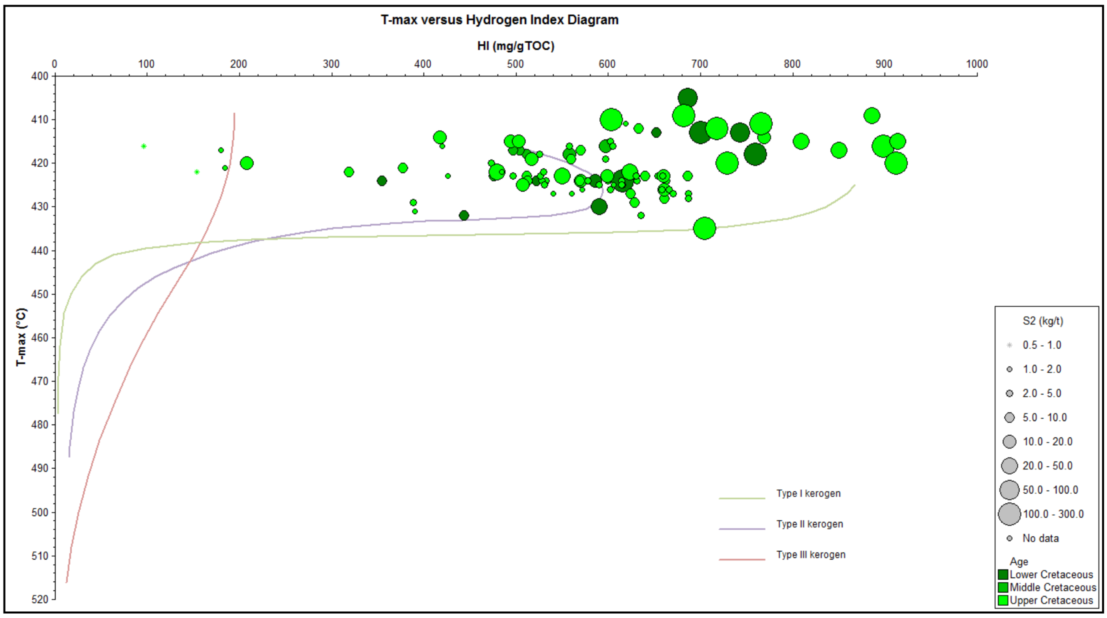

Figure 38 : Tmax versus HI TOC diagram of Cretaceous samples. Dark green color corresponds to the Lower Cretaceous samples, light green to the Upper Cretaceous samples and the middle green to the Middle cretaceous samples (Albian – Cenomanian).

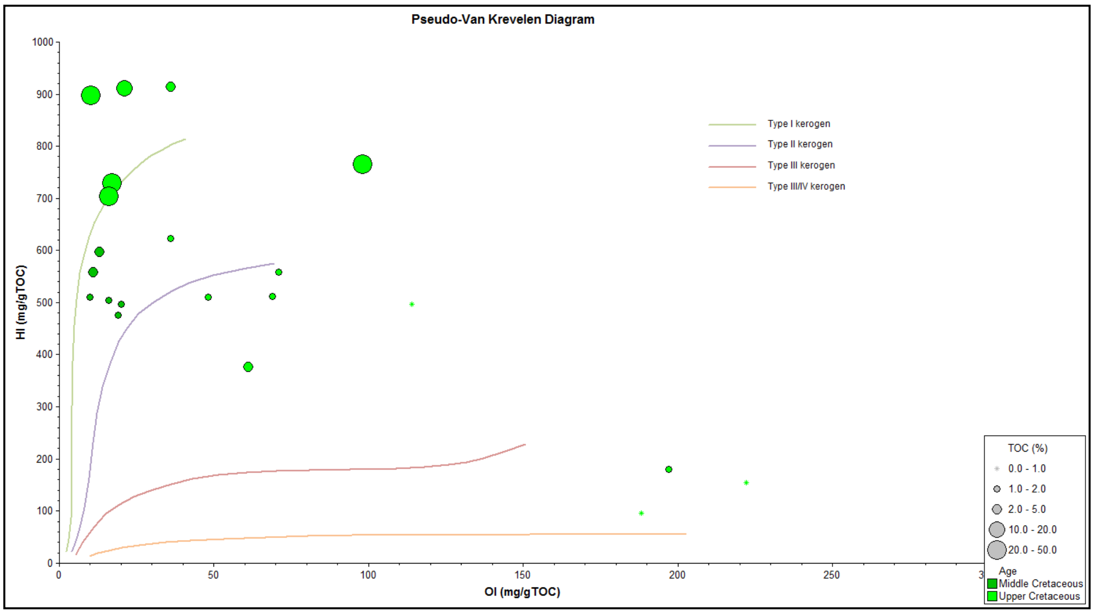

Figure 39 : HI versus OI diagram of Cretaceous samples. Dark green color corresponds to the Lower Cretaceous samples, light green to the Upper Cretaceous samples and the middle green to the Middle cretaceous samples (Albian – Cenomanian).

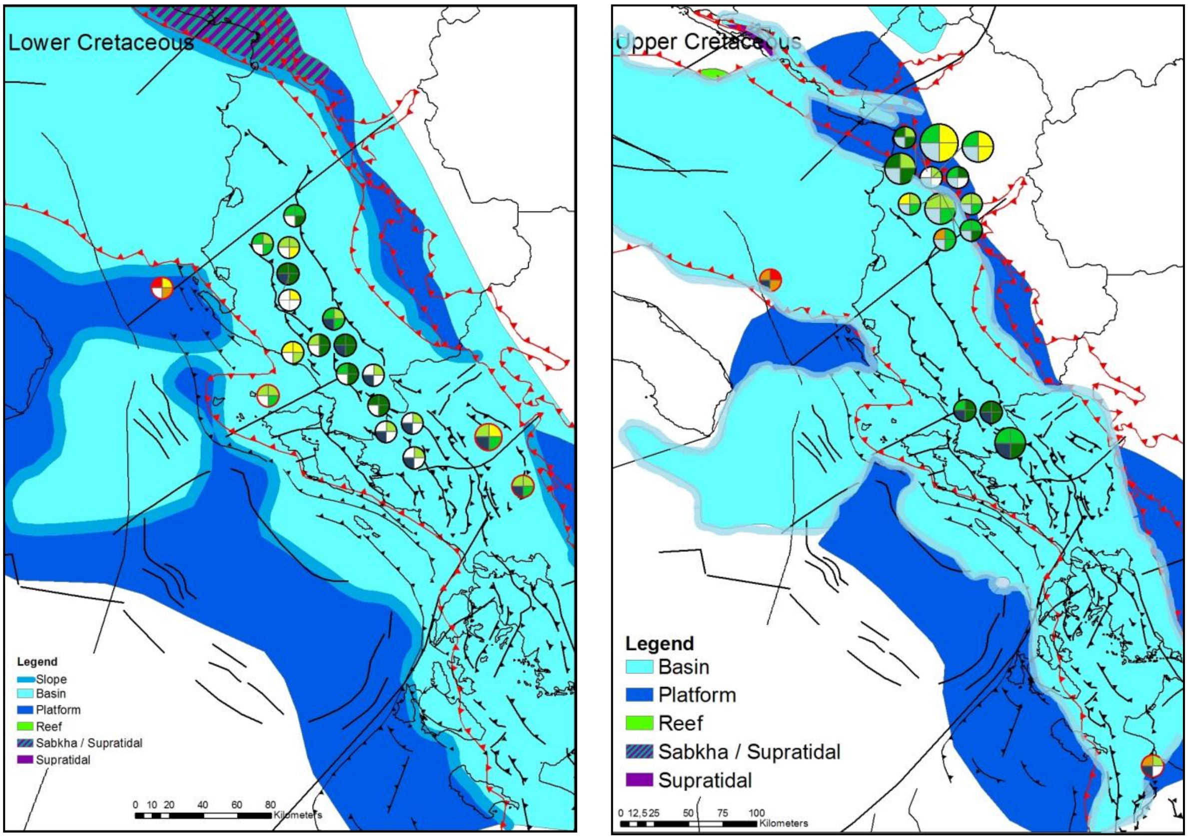

Figure 40 : Representation of Cretaceous samples on GIS after Rock-Eval analysis, in combination with the depositional environment. In the circles presented (clockwise) the TOC, S2, environment and HI values.

We can identify some source rock horizons in Cretaceous age:

– In Ionian zone, in Iraklis well at depths between 460-485m, within the Vigla shales of Lower Cretaceous age (Albian-Cenomanian) and in Gotzikas section where their evaluation showed high hydrocarbon potential. These samples are part of Vigla Limestone formation and dated as Cenomanian-Turonian. The outcropping thickness of this formation is about 180m but only in the last 90 m of the formation include the organic rich horizons (Rigakis & Karakitsios

1998). According to the vitrinite reflectance values (lower than 0.5%) and the Tmax values (lower than 435 ^{0}C), these source rocks are immature.

- Samples from Kurveleshi and Cika belts of Ionian zone in Albania showed very high hydrocarbon potential. However no information for thickness has been found.
- In Kruja zone, Upper Cretaceous samples from several areas have been analyzed. Although they presented good hydrocarbon potential, no information has been found about thicknesses. Furthermore where the thickness is known (e.g. samples of Tujan, Zeza River, Djora and Erzeni areas) the formations are some centimeters thick and cannot be considered as an important source rock horizon.

Possible extension of Cretaceous source rock horizons

Source rocks from Ftere, Kremenare, Ballish, Patos Verbas Kurveleshi and Iraklis well seem to have quite similar characteristics and have been deposited in the same formation at the same period (Lower Cretaceous). Probably they are parts of the same source rock horizon (SRH-1), which is characterized by fair to excellent hydrocarbon potential and organic matter of type II. For samples of Gotzikas, Paliampela and Sopoti areas there is not enough information in order to include them in this source rock horizon.

The second source rock horizon (SRH-2) is located in Godzikas area and probably extends up to Kurveleshi belt. Source rocks of this horizon showed fair to excellent hydrocarbon potential and type II organic matter.

Samples of Kruja zone constitute the third source rock horizon (SRH-3). These source rocks have fair to excellent hydrocarbon potential and type I organic matter.

It has to be noticed here that the possible extension of the source rock horizons depends on the location of the samples that have been analyzed within this study.

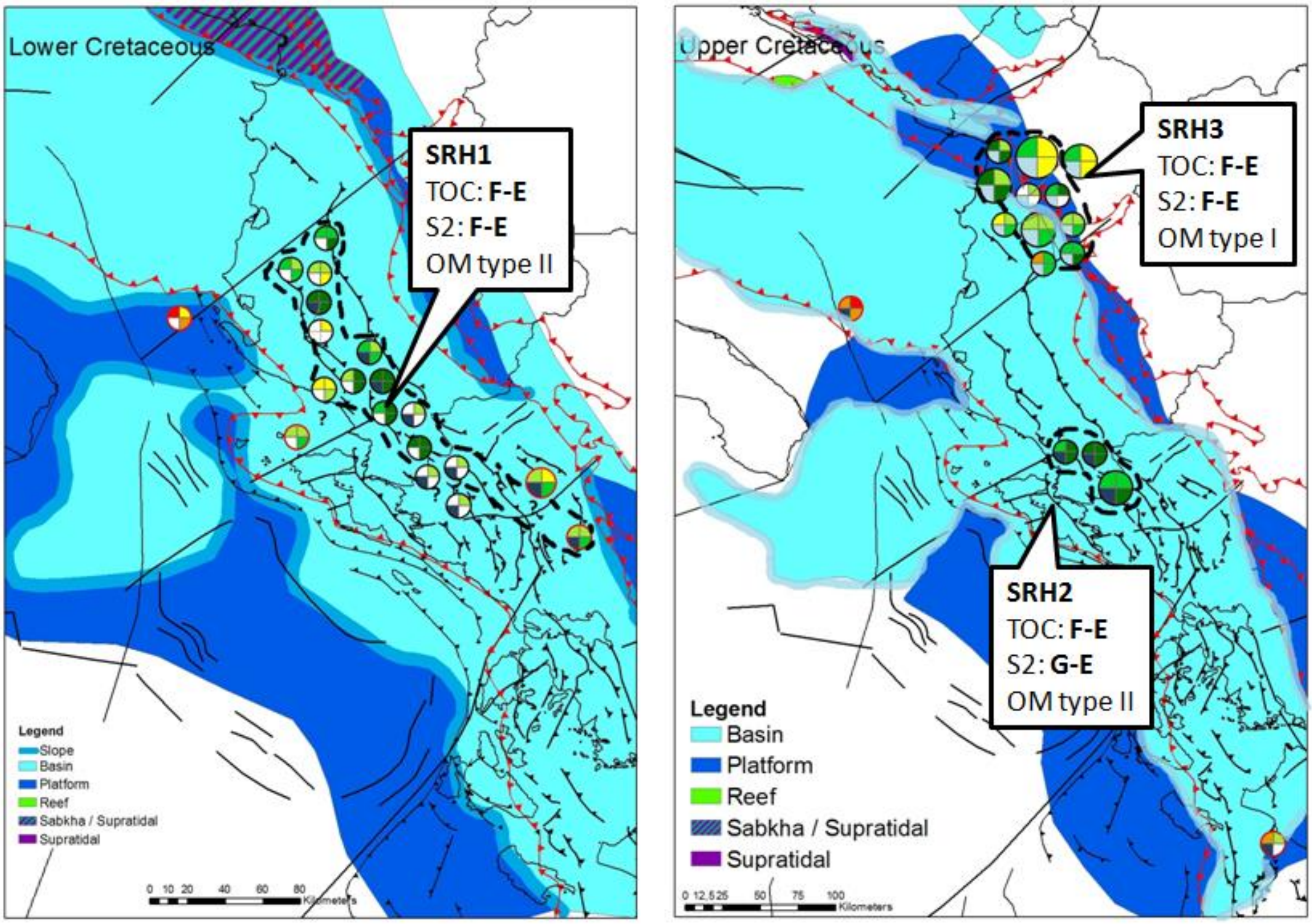

Figure 41 : Possible extensions of Cretaceous source rock horizons (SRH). SRH-1 extends from Ioannina to Ftere areas. SRH-2 includes Gotzikas and probably Kurveleshi belt source rocks. SRH-3 consist of Kruja zone source rocks.

3.4. Paleogene-Neogene

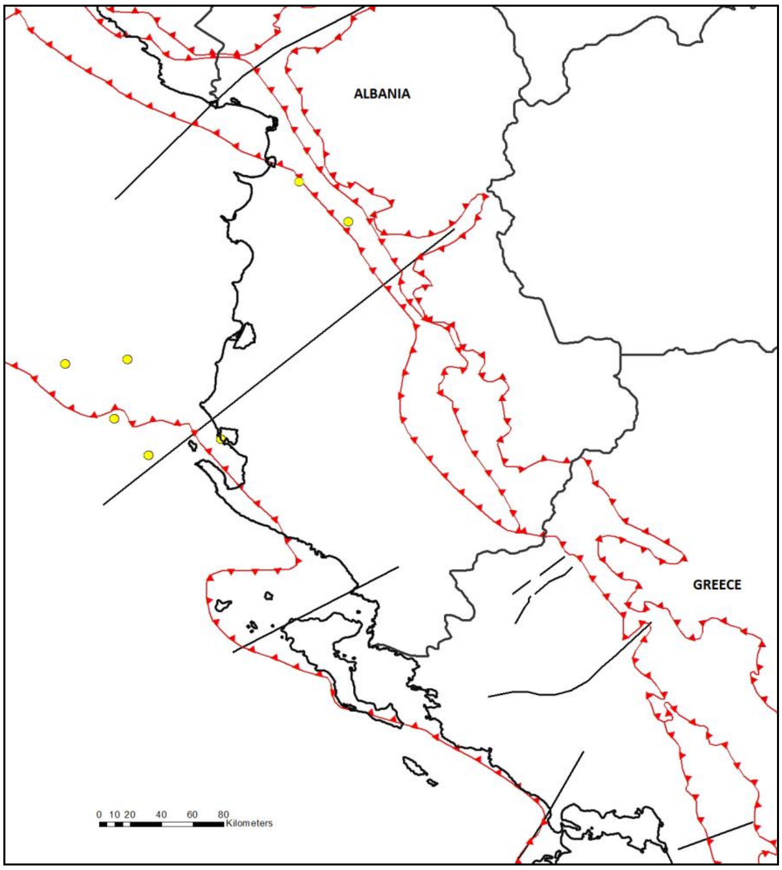

Figure 42 : Map of Paleogene-Neogene samples

In Paleocene only two samples have been analyzed. They have been deposited within limestones of Sazani tectonic zone.

In Miocene most of the samples that have been analyzed are from wells (Paul, Newton, Kepler, PSG, Safira, and Iokasti) and only few samples are from the field (Milot area). Samples in Iokasti and Milot have been deposited within sandstones in the Kruja zone. All the other samples have been deposited mainly in silty shales with limy sandstones and/or limestone, in Sazani tectonic zone.

Pliocene samples that are analyzed have been deposited in calcareous claystones and quartz-lithic sands in Sazani zone.

3.4.1. Source rock parameters

Generally samples of Paleogene-Neogene age presented fair to very good hydrocarbon potential with TOC values from 0,5% to 5,38% and S2 values ranging between 0,5 (mg/g) and 18,85 (mg/g). Hydrocarbon Index values are low (lower than 300 in most of the cases), indicating type III and mixed type III/II organic matter. In addition to low HI values, OI values are indicating the oxidization of the samples.

Two Oligocene samples have been analyzed from Newton well. The only known value parameter from geochemical analysis is the TOC. According to these values (0,52-0,96%) samples presented fair richness in organic matter.

Lower Miocene (Burdigalian) samples were analyzed in Kepler and Paul wells. In Kepler well, samples presented fair to good hydrocarbon potential with TOC values from 0,52 to 2,91% and S2 values between 1,37 and 12,2 (mg/g) (Appendix 4). Hydrocarbon Index values (263-419) indicate type II and mixed type III/II organic matter. In Paul the analysis of the samples showed fair to good hydrocarbon potential; TOC values are comprised between 0,5 and 1,29%, and S2 values between 0,68 and 2,86 (mg/g). Hydrocarbon Index values are between 113 and 419, indicating mainly type III and type III/II organic matter. Additionally, high OI values have been observed (51-423) in these samples, often higher than HI values, indicating a high grade of oxidization.

Middle Miocene samples (Langhian-Serravallian) from Paul and PSG well presented fair hydrocarbon potential with TOC values from 0,5 to 0,76% and S2 values between 0,75 and 1,68 (mg/g) (Appendix 4). HI values are ranging between 144 and 246, indicating organic matter of type III; oxidization of the samples is high, according to OI values (112-336)

Upper Miocene samples (Tortonian-Messinian) have been taken from Newton, Kepler, PSG, Safira, Iokasti wells and in Milot area (field samples from Kruja tectonic zone). Analysis from well samples showed fair to good hydrocarbon potential with TOC values from 0,55 to 2,06% and S2 values from 0,5 to 3,86 (mg/g). HI values are low, ranging between 52 and 244 (Appendix 4), which indicate a poor quality of organic matter (mainly type III). In Iokasti well one sample have been analyzed and is presenting good hydrocarbon potential with TOC value of 1.98%, S2 value of 6,64 (mg/g) and HI value of 335 (organic matter of mixed type III/II). In Milot area, field samples have been analyzed, showed higher hydrocarbon potential than the well samples. They presented very good hydrocarbon potential with TOC values from 3,06 to 4,99% and S2 values between 10,05 and 18,85 (mg/g). HI values are ranging between 328 and 391 indicating a type III organic matter.

Pliocene samples from Safira, PSG and Newton after the analysis, presented fair to good hydrocarbon potential with TOC values from 0,52 to 5,28% and S2 values between 0,54 and 3,63 (mg/g) (Appendix 4). HI values are very low between 32 and 75, indicating poor quality of organic matter.

Maturity

Samples of Paleogene-Neogene age, presented T max values lower than 435 ^{0}C. Additionally vitrinite reflectance values are lower than 0.5% (Roure et al. 2004). According to these values, Cenozoic samples are immature.

3.4.2. Paleo-environment

Most of the paleo-environmental information is provided by the composite logs. Paleogene samples of Newton have been deposited in deep-marine environment. Early Miocene samples from Kepler well have been deposited in reef environment, while in the Paul area the environment was basinal.

Middle Miocene samples of Kepler well, were deposited in an Epibathyal environment (in general deep-marine), and in Paul area the paleo-environment was slope to basin.

Upper Miocene samples from Kruja zone (Iokasti and Milot areas) have been deposited in a shallow marine environment. Samples of Safira well, are deposited in a bathyal, outer to inner neritic environment. For samples of Kepler well, the depositional environment was neritic to evaporitic (generally shallow-marine). PSG well samples depositional environment was epibathyal-neritic to evaporitic.

3.4.3. Conclusions

Samples of Paleogene-Neogene age presented in general good hydrocarbon potential. Most of the samples that have been analyzed have a Miocene age. As it can be observed from the diagrams (Figures 36, 37, 38) the quality of organic matter is poor, mainly type III (gas prone) which indicates a terrestrial origin. Analyzed samples showed also high OI values (Pseudo-Van Kreleven diagram, Fig. 36), indicating an oxidization. Generally except for samples of Kruja zone, samples of Paleogene-Neogene age are considered to be gas prone.

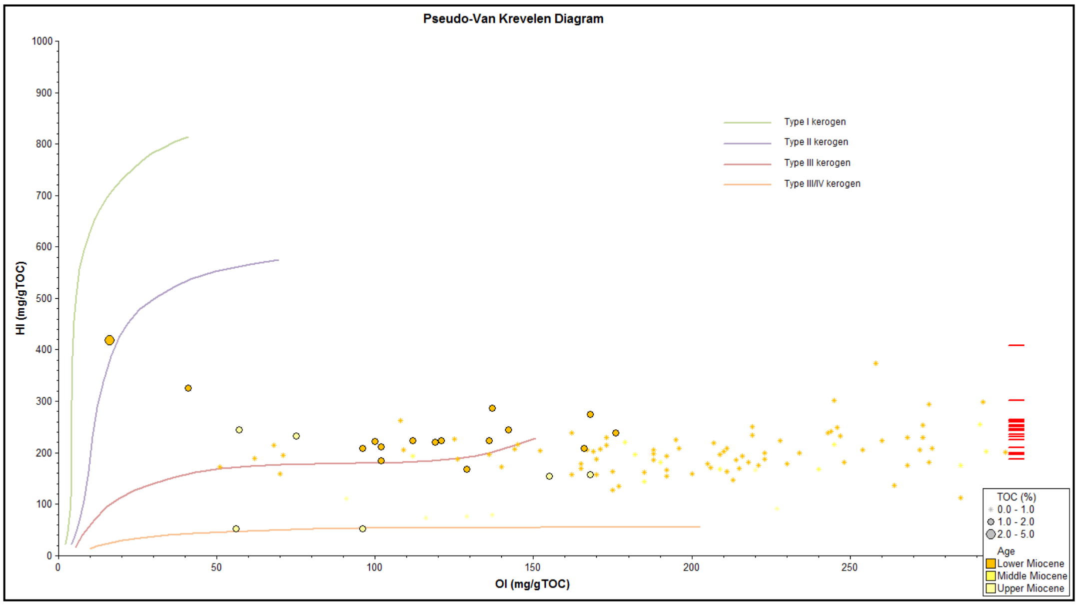

Figure 43: Pseudo Van Kreleven diagram (HI vs OI), of Miocene samples. Light yellow color corresponds to the Upper Miocene samples, middle yellow color to the middle Miocene samples and orange color to the Lower Miocene samples.

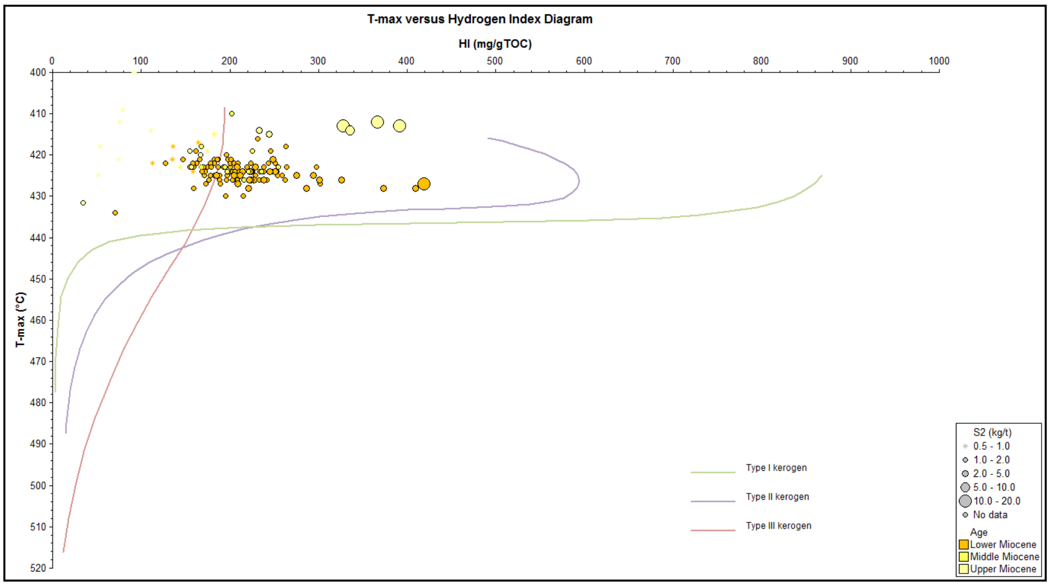

Figure 44: Tmax versus HI diagram, of Miocene samples. Light yellow color corresponds to the Upper Miocene samples, middle yellow color to the middle Miocene samples and orange color to the Lower Miocene samples.

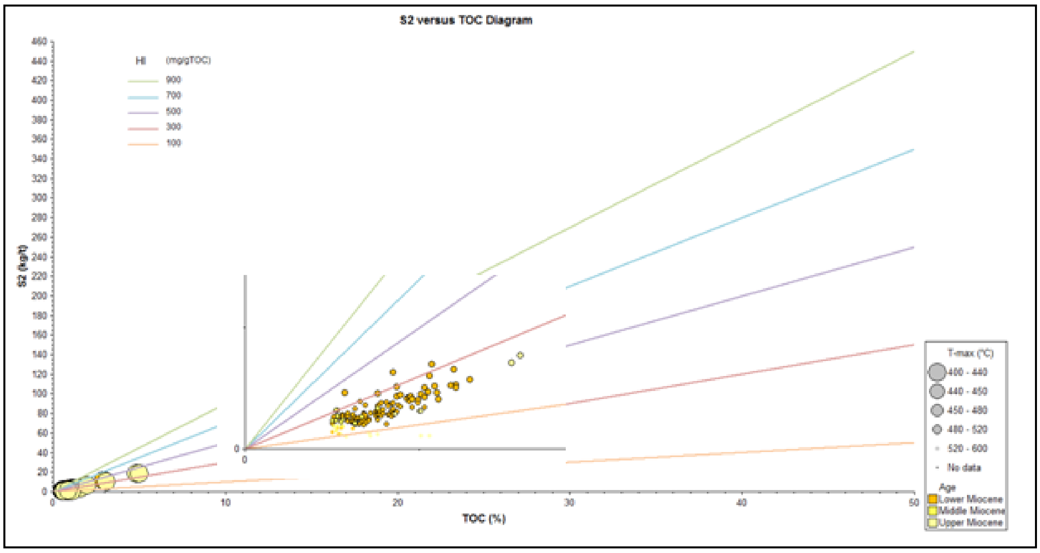

Figure 45: S2 versus TOC diagram, of Miocene samples. Light yellow color corresponds to the Upper Miocene samples, middle yellow color to the middle Miocene samples and orange color to the Lower Miocene samples.

In Paleogene - Neogene times, some possible source rocks can be identified such as in Milot and Iokasti areas (Kruja zone) in Upper Miocene. Samples in these areas showed very good hydrocarbon potential and type II organic matter. However, no information concerning their thickness has been found in order to make a better evaluation of these source rocks.

In Paul area in Lower and Middle Miocene, analyzed samples presented good hydrocarbon potential and organic matter of mixed type II/III and type III (gas prone). In Kepler well in Lower and Upper Miocene, samples presented good potential and type III (gas prone) organic matter.

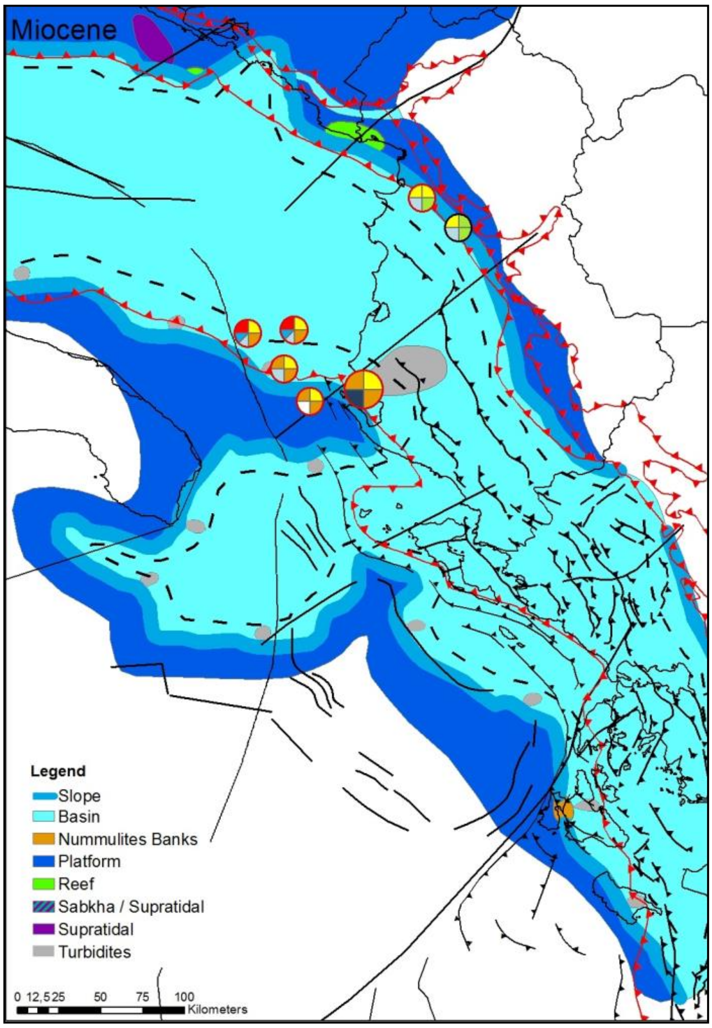

Figure 46 : Representation of Miocene samples on GIS after Rock-Eval analysis, in combination with the depositional environment. In the circles are presented (clockwise) the TOC, S2, environment and HI values.

Possible extension of Miocene source rock horizons

The first source rock horizon (SRH-1) is located in Paul area and consists of Lower Miocene source rocks with fair to good hydrocarbon potential and organic matter type III and mixed type II/III.

Upper Miocene samples from Newton, PSG and Safira wells present quite similar characteristics and probably are parts of the same source rock horizon (SRH-2). These source rocks showed fair to good richness in organic matter and fair to very good hydrocarbon potential, according to TOC and S2 values and type III organic matter.

The third source rock horizon (SRH-3) is located in Kruja zone, in Iokasti and Milot areas, where the source rocks showed good to very good hydrocarbon potential and mixed type II/III organic matter.

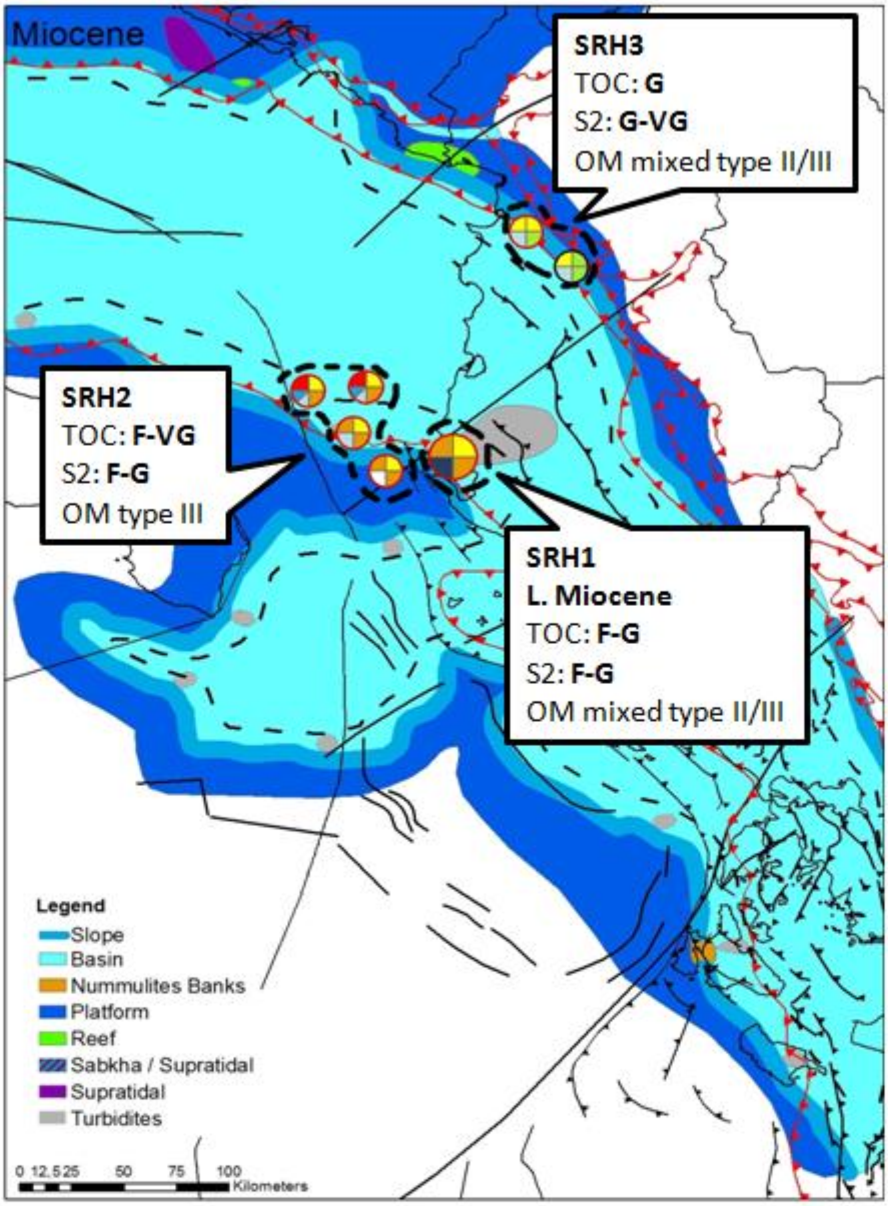

Figure 47 : Possible extensions of Miocene source rock horizons (SRH). SRH-1 is located in Paul area. SRH-2 includes Newton, PSG, PSV and Safira wells source rocks. SRH-3 consists of Kruja zone source rocks.

4. General conclusions

As a conclusion this study tried to describe the evolution of the source rocks in combination with their depositional environment, in Albania and Greece, through the time.

The main source rock intervals that have been identified within this study are:

In Triassic times, in Ionian zone, source rocks have been found in shale fragments, in Triassic breccias located on top of Triassic salt Dyapir (Cap Rock) and between bituminous shales (Cika belt). These source rocks have been deposited in a sabkha to supratidal environment, within the general shallow-water conditions that predominated during this period in the Ionian zone, as evidenced from the evaporitic sedimentation. Triassic source rocks seem to be mature for oil generation and in some cases (e.g. Mavroudi North samples) are in a late-mature stage. The maturation of organic matter probably resulted from the burial to significant depths for a long period, considering that the geothermal gradient is low in Ionian zone (about 20°C/km). Also in more internal units, as in the

Krasta-Cukali zone, another Triassic source rock interval has been identified, the depositional environment of which being completely different (deep-marine conditions). These source rocks are over mature.

Jurassic is an important period in terms deposition of the source rock. There were some significant regional events which increased the concentration of the organic matter during this period. This fact explains why most of the samples analyzed in this study are from this time period. Possible source rock horizons that have been identified are: in Lower Posidonia Beds (Toarcian-Aalenian) in Upper Posidonia Beds (Callovian-Tithonian), in so called Undifferentiated Posidonia Beds (Posidonia Schists, as described in Albania region; Toarcian-Tithonian) and in the base of Ammonitico Rosso formation (lower Toarcian). Concerning the paleo-environment, there was a big change in the Pliensbachian, when the shallow-water conditions turned to deep-marine during this period, due to the evolution from the pre-rift to the syn-rift phase of Jurassic rifting that generates a major drowning of the Liassic platforms. It was the result of the extensional stresses associated with the opening of the Tethys Ocean. There was a general subsidence of the area and the formation of the Ionian basin. Also the Toarcian Oceanic Anoxic Event (T-OAE) which is exposed in Pindos zone (Karakitsios 2010; Kafousia et al, 2013), affected the sedimentation of the Ionian zone, at this period, with the deposition of organic-rich deposits.

During Cretaceous, source rock horizons were identified in Ionian and Kruja tectonic zones. They are located in the Upper part of Vigla shales (Cenomanian-Turonian), in Upper Cretaceous bituminous shales of Cika belt and at the boundary between Upper and Lower Cretaceous in Kurveleshi belt of the Ionian basin. In Kruja zone source rocks have been deposited in organic-rich dolomites and schists. Although these source rock intervals presented very good hydrocarbon potential, thicknesses remain unknown. The paleo-environment remained deep-marine during this period in Ionian zone. On the other hand, in Kruja zone the paleo-environment was different during this period, with shallow marine depositional conditions. Additionally, several Oceanic Anoxic Events (OAE) during the Cretaceous, have been recorded in Ionian zone, which increased the concentration of organic matter within the Ionian basin and probably affected the Kruja zone as well. These are: the OAE-2 at the Cenomanian-Turonian boundary, the OAE-1b of Lower Albian age and the OAE-1a in the Aptian-Albian formations of the Pindos zone (Karakitsios et al, 2005).

Cenozoic source rock intervals are located mainly within shales associated to flysch deposits in Peri-Adriatic Depression (PAD) and they are presenting a terrestrial signature with type III kerogen and are considered to be good only for generating gas. Another Cenozoic source rock interval has been identified within shales of Kruja zone, but according to some authors it is not taken into consideration as a separate source rock level. However, from the analysis of this study, this interval presented good hydrocarbon potential and type II organic matter. The depositional environment during Cenozoic was general deep-marine (bathyal, slope and basin) in Peri-Adriatic Depression and shallow marine in Kruja zone.

<u>Further study and improvements</u>

In terms of petroleum exploration in Albania and Greece, a domain that needs to be better studied is the paleo-environment of the source rocks. A detailed paleo-environmental map is needed. For a better understanding of the paleo-environment, it is important to gain a deeper knowledge of the tectonic movements that took place in the area and to realize balanced cross sections. The interpretation of seismic profiles can be used to gain more information, especially in places which structural conditions are not helping for drillings. For example the exploration of Kruja zone considered as high risk due to structural conditions (eroded anticline structures of very small strike direction closure; Velaj, 2012). Most of the outcropping samples that have been analyzed in this study were immature for oil generation. Samples from the same formation can be mature when they are buried by tectonic processes. Information on the level of maturity of the source rocks in the more internal parts of the thrust belt can be obtained only by wells (Drilling pending to the identification of potentially economic structures).

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<u>APPENDIX 1</u>

Table of results from Rock-Eval analysis of Lower Jurassic samples:

Name	Zone	Country	Type	Age	TOC	S2	Tm	HI	OI
268	Ionian	Albania	Field	Liassic	47,77	421,71	410	883	19
269	Ionian	Albania	Field	Liassic	14,29	90,22	414	631	
282	Ionian	Albania	Field	Liassic	22,96	150,56	440	656	7
282	Ionian	Albania	Field	Liassic	34,76	202,6	431	583	21
286	Ionian	Albania	Field	Liassic	36,48	216,56	428	593	
286	Ionian	Albania	Field	Liassic	27,43	161,63	428	589	
314	Ionian	Albania	Field	Liassic	13,73	67,32	428	490	
314	Ionian	Albania	Field	Liassic	15,66	90	434	450	
322\1	Ionian	Albania	Field	Toarcian	1,51	5,22	423	345	
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,61				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,48				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,42				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,40				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,40				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,38				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,30				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,13				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,08				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,08				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,06				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,05				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,05				
Chionistra	Ionian	Greece	Outcrop	Toarcian	1,00				

Chionistra	Ionian	Greece	Outcrop	Toarcian	0,96				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,85				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,82				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,80				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,67				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,67				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,66				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,66				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,60				
Chionistra	Ionian	Greece	Outcrop	Toarcian	0,50				
Elataria 927	Ionian	Greece	Outcrop	Toarcian	1,62	6,17	420	381	47
Elataria 928	Ionian	Greece	Outcrop	Toarcian	1,32	5,53	419	419	65
Elataria 929	Ionian	Greece	Outcrop	Toarcian	1,1	4,36	421	396	55
Elataria 930	Ionian	Greece	Outcrop	Toarcian	1,15	6,51	406	566	46
Elataria 933	Ionian	Greece	Outcrop	Toarcian	1,1	5,04	423	458	58
Elataria 934	Ionian	Greece	Outcrop	Toarcian	1,38	6,94	419	503	51
Elataria 935	Ionian	Greece	Outcrop	Toarcian	0,98	4,52	420	461	52
Elataria 936	Ionian	Greece	Outcrop	Toarcian	2,02	10,40	422	515	48
Elataria 937	Ionian	Greece	Outcrop	Toarcian	1,2	5,54	421	462	63
Elataria 938	Ionian	Greece	Outcrop	Toarcian	1,8	10,84	415	602	45
Elataria 939	Ionian	Greece	Outcrop	Toarcian	1,07	6,31	416	590	79
Elataria 940	Ionian	Greece	Outcrop	Toarcian	1,52	6,84	415	450	54
Elataria 941	Ionian	Greece	Outcrop	Toarcian	1,57	8,45	419	538	33
Elataria 943	Ionian	Greece	Outcrop	Toarcian	1,37	9,25	422	675	56
Elataria 945	Ionian	Greece	Outcrop	Toarcian	1,22	7,64	418	626	63
Elataria 946	Ionian	Greece	Outcrop	Toarcian	1,47	10,07	415	685	53
Elataria 947	Ionian	Greece	Outcrop	Toarcian	2,32	17,49	418	754	29
Elataria 948	Ionian	Greece	Outcrop	Toarcian	1,35	8,34	420	618	38
Elataria 949	Ionian	Greece	Outcrop	Toarcian	0,97	6,29	414	648	82
Elataria 950	Ionian	Greece	Outcrop	Toarcian	0,87	5,86	413	674	66
Frossini	Ionian	Greece	Outcrop	Toarcian	1,11	4,1	420	368	42
Geromerion 55,4	Ionian	Greece	Outcrop	Toarcian	0,55	2	423	367	38
Geromerion 55,45	Ionian	Greece	Outcrop	Toarcian	0,57	2,2	421	381	39
Geromerion 56,55	Ionian	Greece	Outcrop	Toarcian	0,93	1,8	432	188	105
Ieromnimi 8,15	Ionian	Greece	Outcrop	Toarcian	0,61	1,2	432	200	93
Khionistra BA 12	Ionian	Greece	Outcrop	Toarcian	0,96	4,8	420	498	63
Khionistra BA 13	Ionian	Greece	Outcrop	Toarcian	0,44	2	421	455	89
Khionistra BA 14	Ionian	Greece	Outcrop	Toarcian	0,58	3	421	509	62
Khionistra BA 15	Ionian	Greece	Outcrop	Toarcian	0,37	1,2	417	322	68
Khionistra BA 16	Ionian	Greece	Outcrop	Toarcian	0,93	4,2	420	456	37
Khionistra BA 17	Ionian	Greece	Outcrop	Toarcian	0,54	1,9	418	344	67
Khionistra BA 19	Ionian	Greece	Outcrop	Toarcian	0,46	2,2	415	485	70
Khionistra BA 20	Ionian	Greece	Outcrop	Toarcian	0,71	4,1	414	570	70
Khionistra BA 21	Ionian	Greece	Outcrop	Toarcian	0,45	1,9	414	411	87
Khionistra BA 22	Ionian	Greece	Outcrop	Toarcian	0,34	1,4	413	406	97
Khionistra BA 23	Ionian	Greece	Outcrop	Toarcian	0,54	2,4	413	437	83
Khionistra BA 4	Ionian	Greece	Outcrop	Toarcian	0,41	1,7	414	420	134
Khionistra BA 5	Ionian	Greece	Outcrop	Toarcian	0,46	1,4	417	302	252
Khionistra BA 9	Ionian	Greece	Outcrop	Toarcian	0,49	1,17	416	339	120
Khionistra BAA(2) 1	Ionian	Greece	Outcrop	Toarcian	0,58	2,7	412	466	36
Khionistra BAA(2) 2	Ionian	Greece	Outcrop	Toarcian	0,4	1,8	413	445	45
Khionistra BAA(3) 3	Ionian	Greece	Outcrop	Toarcian	1,33	5,8	418	433	23

Khionistra BAA(4) 4	Ionian	Greece	Outcrop	Toarcian	0,48	0,9	434	192	150
Khionistra BAA(4) 5	Ionian	Greece	Outcrop	Toarcian	0,44	2	419	466	41
Khionistra BAA(4) 7	Ionian	Greece	Outcrop	Toarcian	0,82	3,1	418	383	32
Khionistra BAA(4) 8	Ionian	Greece	Outcrop	Toarcian	0,82	3,9	418	477	28
Khionistra BAA(4) 9	Ionian	Greece	Outcrop	Toarcian	1,08	4,2	419	391	31
Khionistra BAA(6) 1	Ionian	Greece	Outcrop	Toarcian	1,3	5,9	416	456	50
Khionistra BAA(6) 14	Ionian	Greece	Outcrop	Toarcian	1,51	7,9	411	522	19
Khionistra BAA(6) 17	Ionian	Greece	Outcrop	Toarcian	0,47	1,9	414	402	55
Khionistra BAA(6) 3	Ionian	Greece	Outcrop	Toarcian	1,89	10,9	417	577	13
Khionistra BAA(6) 35	Ionian	Greece	Outcrop	Toarcian	0,64	2,7	412	427	34
Khionistra BAA(6) 6	Ionian	Greece	Outcrop	Toarcian	0,94	4,7	413	497	26
Khionistra BAA(6) 8	Ionian	Greece	Outcrop	Toarcian	1,61	7,4	417	458	56
Khionistra BAA(6) 8	Ionian	Greece	Outcrop	Toarcian	1,52	6,9	419	456	49
Khionistra BAA(6)40	Ionian	Greece	Outcrop	Toarcian	1,09	6,3	415	583	7
Khionistra BAA(6)40	Ionian	Greece	Outcrop	Toarcian	1,23	6,4	412	522	24
Khionistra BAA(6)44	Ionian	Greece	Outcrop	Toarcian	1,46	7,4	413	510	28
Khionistra BAA(6)47	Ionian	Greece	Outcrop	Toarcian	1,25	7,1	415	570	40
Khionistra BAA(6)50	Ionian	Greece	Outcrop	Toarcian	1,45	7	414	481	35
Khionistra BAA(7) 1	Ionian	Greece	Outcrop	Toarcian	1,18	5,2	419	437	24
Khionistra BAA(7) 2	Ionian	Greece	Outcrop	Toarcian	1,14	4,7	421	410	32
Khionistra BAA(7) 2	Ionian	Greece	Outcrop	Toarcian	1,43	5,2	417	365	31
Khionistra BAA(7) 3	Ionian	Greece	Outcrop	Toarcian	1,18	5,2	421	438	30
Khionistra BAA(7) 4	Ionian	Greece	Outcrop	Toarcian	1,05	3,6	422	345	41
Khionistra BAA(7) 5	Ionian	Greece	Outcrop	Toarcian	1,28	3,8	418	298	37
Khionistra BAA(7) 6	Ionian	Greece	Outcrop	Toarcian	0,58	1,9	419	324	52
Khionistra BAA(7) 8	Ionian	Greece	Outcrop	Toarcian	0,42	1,1	419	271	74
Khionistra BAB(1) 1	Ionian	Greece	Outcrop	Toarcian	0,68	2,3	414	343	26
Khionistra BAB(1) 11	Ionian	Greece	Outcrop	Toarcian	1,9	9,8	415	515	33
Khionistra BAB(1) 13	Ionian	Greece	Outcrop	Toarcian	1,5	8,1	418	538	34
Khionistra BAB(1) 14	Ionian	Greece	Outcrop	Toarcian	0,34	1,3	421	368	24
Khionistra BAB(1) 15	Ionian	Greece	Outcrop	Toarcian	1,09	7,1	419	654	4
Khionistra BAB(1) 15	Ionian	Greece	Outcrop	Toarcian	1,02	6,6	419	646	13
Khionistra BAB(1) 3	Ionian	Greece	Outcrop	Toarcian	0,75	2,8	412	369	23
Khionistra BAB(1) 7	Ionian	Greece	Outcrop	Toarcian	0,72	2,6	423	363	61
Khionistra BAB(2) 1	Ionian	Greece	Outcrop	Toarcian	0,37	0,9	420	230	70
Khionistra BAB(2) 10- 0,05	Ionian	Greece	Outcrop	Toarcian	1,89	7	416	370	30
Khionistra BAB(2) 10- 0,05	Ionian	Greece	Outcrop	Toarcian	2	4,4	414	219	22
Khionistra BAB(2) 10- 0,6	Ionian	Greece	Outcrop	Toarcian	1,23	4	418	323	28
Khionistra BAB(2) 10- 1	Ionian	Greece	Outcrop	Toarcian	1,39	5,2	419	377	29
Khionistra BAB(2) 10- 2,5	Ionian	Greece	Outcrop	Toarcian	1,51	4,8	419	319	41
Khionistra BAB(2) 11	Ionian	Greece	Outcrop	Toarcian	0,61	1,8	419	300	54
Khionistra BAB(2) 12- 0,4	Ionian	Greece	Outcrop	Toarcian	0,88	2,4	419	274	41
Khionistra BAB(2) 12- 1,2	Ionian	Greece	Outcrop	Toarcian	0,76	2,2	419	288	43
Khionistra BAB(2) 12- 3	Ionian	Greece	Outcrop	Toarcian	1,36	5,4	419	396	28
Khionistra BAB(2) 2	Ionian	Greece	Outcrop	Toarcian	0,96	2,5	419	264	49
Khionistra BAB(2) 4- 0,07	Ionian	Greece	Outcrop	Toarcian	1,81	6,2	417	342	32
Khionistra BAB(2) 4- 0,40	Ionian	Greece	Outcrop	Toarcian	1,16	2,5	424	217	47
Khionistra BAB(2) 4- 0,40	Ionian	Greece	Outcrop	Toarcian	1,78	2,5	419	138	39
Khionistra BAB(2) 6- 0,10	Ionian	Greece	Outcrop	Toarcian	1,02	3,3	408	325	44
Khionistra BAB(2) 6- 0,60	Ionian	Greece	Outcrop	Toarcian	1,14	3,9	414	343	41
Khionistra BAB(2) 6- 0,95	Ionian	Greece	Outcrop	Toarcian	1,38	4,5	415	326	30
Khionistra BAB(2) 7	Ionian	Greece	Outcrop	Toarcian	0,59	2,5	417	415	51

Khionistra BAB(2) 7	Ionian	Greece	Outcrop	Toarcian	0,64	2	417	314	55
Khionistra BAB(2) 8- 0,05	Ionian	Greece	Outcrop	Toarcian	1,75	6,2	416	354	37
Khionistra BAB(2) 8- 0,60	Ionian	Greece	Outcrop	Toarcian	1,4	5,3	415	377	29
Koukoulioi MB 10	Ionian	Greece	Outcrop	Toarcian	0,56	1,4	433	248	82
Koukoulioi MB 20	Ionian	Greece	Outcrop	Toarcian	0,49	0,9	434	176	157
Koukoulioi MB 21	Ionian	Greece	Outcrop	Toarcian	0,71	1,3	433	186	128
Koukoulioi MB 22	Ionian	Greece	Outcrop	Toarcian	0,52	0,9	434	173	156
Koukoulioi MB 27	Ionian	Greece	Outcrop	Toarcian	0,76	1,6	426	213	97
Koukoulioi MB 28	Ionian	Greece	Outcrop	Toarcian	0,58	1	434	169	147
Koukoulioi MB 29	Ionian	Greece	Outcrop	Toarcian	0,86	2,6	421	302	49
Koukoulioi MB 30	Ionian	Greece	Outcrop	Toarcian	0,82	2,8	422	335	45
Koukoulioi MB 31	Ionian	Greece	Outcrop	Toarcian	0,87	1,6	435	185	116
Koukoulioi MB 32	Ionian	Greece	Outcrop	Toarcian	0,86	2,3	427	262	71
Koukoulioi MB 33	Ionian	Greece	Outcrop	Toarcian	1,54	5,5	421	356	32
Koukoulioi MB 34	Ionian	Greece	Outcrop	Toarcian	0,94	2,7	425	288	68
Koukoulioi MB 4a	Ionian	Greece	Outcrop	Toarcian	0,77	3,3	419	427	36
Koukoulioi MB 4b	Ionian	Greece	Outcrop	Toarcian	0,5	1,7	422	342	52
Koukoulioi MB 8	Ionian	Greece	Outcrop	Toarcian	0,97	2,4	431	243	109
Mavroudhi N DBA 13 1,6	Ionian	Greece	Outcrop	Toarcian	0,67	1,8	424	263	49
Mavroudhi N DBA 14 a	Ionian	Greece	Outcrop	Toarcian	0,63	2	421	324	43
Mavroudhi N DBA 14 b	Ionian	Greece	Outcrop	Toarcian	0,69	2,1	421	299	42
Mavroudhi N DBA 17	Ionian	Greece	Outcrop	Toarcian	0,51	1,5	421	292	41
Mavroudhi N DBA 18	Ionian	Greece	Outcrop	Toarcian	1,09	4,5	424	416	38
Mavroudhi N DBA 19	Ionian	Greece	Outcrop	Toarcian	0,85	3	422	348	45
Mavroudhi N DBA 22	Ionian	Greece	Outcrop	Toarcian	1,21	5	421	414	38
Mavroudhi N DBA 24	Ionian	Greece	Outcrop	Toarcian	1,41	6,1	422	435	35
Mavroudhi N DBA 25	Ionian	Greece	Outcrop	Toarcian	1,25	5	422	397	46
Mavroudhi N DBA 29 0,7	Ionian	Greece	Outcrop	Toarcian	1,23	4,7	422	384	63
Mavroudhi N DBA 29 s	Ionian	Greece	Outcrop	Toarcian	1,02	3,2	424	313	67
Mavroudhi N DBA 33 b	Ionian	Greece	Outcrop	Toarcian	1,41	5,8	421	408	43
Mavroudhi N DBA 36 1m	Ionian	Greece	Outcrop	Toarcian	1,46	6,9	422	472	40
Mavroudhi N DBA 36 s	Ionian	Greece	Outcrop	Toarcian	0,65	2,2	420	343	82
Mavroudhi N DBA 37	Ionian	Greece	Outcrop	Toarcian	1,61	7,1	422	440	43
Mavroudhi N DBA 38	Ionian	Greece	Outcrop	Toarcian	0,77	2,2	421	286	104
Mavroudhi N DBA 39	Ionian	Greece	Outcrop	Toarcian	1,73	7,2	421	417	57
Mavroudhi N DBA 41	Ionian	Greece	Outcrop	Toarcian	0,37	1,1	423	289	108
Mavroudhi N DBA 46 b	Ionian	Greece	Outcrop	Toarcian	0,93	3,5	420	375	52
Mavroudhi N DBA 48	Ionian	Greece	Outcrop	Toarcian	1,34	4,9	421	366	34
Mavroudhi N DBA 49	Ionian	Greece	Outcrop	Toarcian	0,35	1	424	289	163
Mavroudhi S 1 DBC 12	Ionian	Greece	Outcrop	Toarcian	0,34	0,1	442	29	235
Mavroudhi South 1 DBC 5 c	Ionian	Greece	Outcrop	Toarcian	0,59	0,1	447	14	58
Mavroudhi S 2 DBB 3	Ionian	Greece	Outcrop	Toarcian	0,79	0,1	447	14	124
Mavroudhi S 2 DBB 47 1,5	Ionian	Greece	Outcrop	Toarcian	0,44	0,2	444	41	75
Mavroudhi S 2 DBB 49 1,0	Ionian	Greece	Outcrop	Toarcian	0,57	0,1	447	25	163
Mavroudhi S_Initial	Ionian	Greece	Outcrop	Toarcian	0,42	1			250
Mavroudhi S Initial	Ionian	Greece	Outcrop	Toarcian	0,74	2			250
Mavroudhi S Initial	Ionian	Greece	Outcrop	Toarcian	0,98	2			250
Mavroudhi S Initial	Ionian	Greece	Outcrop	Toarcian	0,53	1			250
Mavroudhi S Initial	Ionian	Greece	Outcrop	Toarcian	0,7	1			250
Mavroudhi S 1 DBC 11	Ionian	Greece	Outcrop	Toarcian	0,81	1,2	427	149	53
Mavroudhi S 1 DBC 13	Ionian	Greece	Outcrop	Toarcian	0,78	1,5	418	199	4

Mavroudhi S 1 DBC 15	Ionian	Greece	Outcrop	Toarcian	0,61	0,3	435	46	51
Mavroudhi S 1 DBC 17	Ionian	Greece	Outcrop	Toarcian	0,82	1,2	428	150	50
Mavroudhi S 1 DBC 3	Ionian	Greece	Outcrop	Toarcian	0,81	0,5	438	65	40
Mavroudhi S 1 DBC 4	Ionian	Greece	Outcrop	Toarcian	0,62	0,6	433	90	42
Mavroudhi S 1 DBC 6	Ionian	Greece	Outcrop	Toarcian	0,83	1,4	427	166	40
Mavroudhi S 2 DBB 37	Ionian	Greece	Outcrop	Toarcian	0,69	1,9	420	277	41
Mavroudhi S 2 DBB 40	Ionian	Greece	Outcrop	Toarcian	1,22	3,1	419	256	52
Mavroudhi S 2 DBB 41	Ionian	Greece	Outcrop	Toarcian	1,23	2,5	424	203	89
Mavroudhi S 2 DBB 44(1)	Ionian	Greece	Outcrop	Toarcian	0,85	2,9	413	340	38
Mavroudhi S 2 DBB 44(2)	Ionian	Greece	Outcrop	Toarcian	0,92	3,9	414	421	36
Mavroudhi S 2 DBB 44a	Ionian	Greece	Outcrop	Toarcian	1,17	4,7	414	402	36
Mavroudhi S 2 DBB 44b	Ionian	Greece	Outcrop	Toarcian	0,94	3,3	417	355	56
Mavroudhi S 2 DBB 46	Ionian	Greece	Outcrop	Toarcian	0,87	3,3	414	375	47
Mavroudhi S 2 DBB 47	Ionian	Greece	Outcrop	Toarcian	0,95	3	418	319	40
Mavroudhi S 2 DBB 5a	Ionian	Greece	Outcrop	Toarcian	0,6	0,6	437	95	65
Mavroudhi S 2 DBB 5c	Ionian	Greece	Outcrop	Toarcian	0,61	0,6	433	98	110
Mavroudhi S 2 DBB 7a	Ionian	Greece	Outcrop	Toarcian	0,62	0,8	430	129	116
Perithia EB(3)10	Ionian	Greece	Outcrop	Toarcian	2,06	4,50	428	217	67
Perithia EB(3)10	Ionian	Greece	Outcrop	Toarcian	1,95	4,00	430	205	50
Perithia EB(3)12	Ionian	Greece	Outcrop	Toarcian	1,83	5,00	431	272	68
Perithia EB(3)4S	Ionian	Greece	Outcrop	Toarcian	1,36	3,60	428	266	74
Perithia EB(3)4S	Ionian	Greece	Outcrop	Toarcian	1,44	3,70	429	258	69
Perithia EB(3)6	Ionian	Greece	Outcrop	Toarcian	1,54	5,70	424	371	45
Perithia EB(3)6	Ionian	Greece	Outcrop	Toarcian	1,77	5,90	425	333	47
Perithia EB(3)7S	Ionian	Greece	Outcrop	Toarcian	0,98	3,00	427	302	53
Perithia EB(3)8	Ionian	Greece	Outcrop	Toarcian	1,49	3,70	430	247	76
Perivleptos 2,95	Ionian	Greece	Outcrop	Toarcian	0,48	0,9	438	188	104
Perivleptos 3,7	Ionian	Greece	Outcrop	Toarcian	0,99	1,8	433	181	85
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	4,86				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	4,78				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	4,32				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	3,91				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	3,87				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	3,06				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,52				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,48				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,44				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,39				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,31				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,27				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,27				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,22				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,16				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,16				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,09				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,07				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,03				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,01				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	2,01				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,93				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,91				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,91				

Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,87
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,85
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,82
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,80
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,78
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,78
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,77
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,76
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,74
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,73
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,64
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,63
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,62
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,62
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,58
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,58
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,57
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,55
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,53
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,53
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,52
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,52
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,48
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,47
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,44
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,44
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,44
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,42
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,40
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,37
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,35
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,35
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,32
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,31
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,26
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,24
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,22
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,22
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,21
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,21
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,20
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,20
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,17
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,17
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,17
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,16
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,14
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,14
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,14
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,13
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,13
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,08

Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,06				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	1,04				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,99				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,99				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,97				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,90				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,88				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,88				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,87				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,83				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,78				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,77				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,74				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,69				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,69				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,64				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,63				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,61				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,61				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,60				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,60				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,57				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,56				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,56				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,54				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,54				
Petousi	Ionian	Greece	Outcrop	Lower Toarcian	0,53				
Siniais EA (1) 11	Ionian	Greece	Outcrop	Toarcian	1,08	4,20	427	384	66
Siniais EA (1) 13	Ionian	Greece	Outcrop	Toarcian	0,54	2,40	425	444	80
Siniais EA (1) 3	Ionian	Greece	Outcrop	Toarcian	0,72	1,80	430	244	31
Siniais EA (1) 6	Ionian	Greece	Outcrop	Toarcian	1,14	4,20	427	367	39
Siniais EA (1) 8 0.3	Ionian	Greece	Outcrop	Toarcian	1,16	5,20	425	449	53
Siniais EA (1) 8 0.6	Ionian	Greece	Outcrop	Toarcian	2,20	12,00	424	546	46
Siniais EA (1) 8base	Ionian	Greece	Outcrop	Toarcian	2,04	9,40	425	463	39
Siniais EA (1) 8som	Ionian	Greece	Outcrop	Toarcian	5,19	34,10	422	657	34
Siniais EA (2) 3	Ionian	Greece	Outcrop	Toarcian	0,35	1,00	430	277	91
Skoupitsa 14,2	Ionian	Greece	Outcrop	Toarcian	0,71	1,3	431	183	151
Skoupitsa 14,3	Ionian	Greece	Outcrop	Toarcian	1,13	3	421	266	91
Skoupitsa 14,4	Ionian	Greece	Outcrop	Toarcian	1,41	6	413	423	51
Skoupitsa 14,55	Ionian	Greece	Outcrop	Toarcian	1,26	4,4	416	352	62
Skoupitsa 14,65	Ionian	Greece	Outcrop	Toarcian	1,11	3,4	417	308	77
Skoupitsa 19,35	Ionian	Greece	Outcrop	Toarcian	0,64	1,7	426	270	80
Skoupitsa 19,4	Ionian	Greece	Outcrop	Toarcian	1,06	3	423	279	92
Skoupitsa 7,35	Ionian	Greece	Outcrop	Toarcian	0,49	0,6	432	127	184
TERRAIN-ALBANIE	Ionian	Albania	SECTION	TOARCIAN	7,65	61,812	421	808	
TERRAIN-ALBANIE	Ionian	Albania	SECTION	TOARCIAN	2,14	11,08	424	517, 76	21,9 6
Toka	Ionian	Greece	Outcrop	Lower Toarcian	5,15				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	4,05				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	3,59				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	3,53				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	3,39				

Toka	Ionian	Greece	Outcrop	Lower Toarcian	3,27				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	2,48				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	2,41				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	2,03				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	2,03				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,92				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,80				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,71				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,70				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,67				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,64				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,62				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,46				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,19				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,06				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	1,02				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	0,91				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	0,80				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	0,74				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	0,66				
Toka	Ionian	Greece	Outcrop	Lower Toarcian	0,64				
Gjere Mountain	Ionian	Albania		Lower Jurassic	1,5	7,81	430	520	
Gjere Mountain	Ionian	Albania		Lower Jurassic	0,57	2,1	430	400	
Gjere Mountain	Ionian	Albania		Lower Jurassic	5,25	26,5	432	508	
Gjere Mountain	Ionian	Albania		Lower Jurassic	1,07	4,4	432	411	
Gjere Mountain	Ionian	Albania		Lower Jurassic	4,9	28,8	432	588	
Gjere Mountain	Ionian	Albania		Lower Jurassic	1,1	4,2	432	380	
Gjere Mountain	Ionian	Albania		Lower Jurassic	1,3	5,51	432	417	
Gjere Mountain	Ionian	Albania		Lower Jurassic	15,66	90	434	450	
Ftere	Ionian	Albania		Lower Jurassic	0,49	0,62	430	126	
Ftere	Ionian	Albania		Lower Jurassic	0,49	1,51	430	343	
Ftere	Ionian	Albania		Lower Jurassic	1,3	4,52	428	380	
Ftere	Ionian	Albania		Lower Jurassic	0,8	7,14	428	546	
Ftere	Ionian	Albania		Lower Jurassic	10,84	55,71	435	513	
Kurvelesh	Ionian	Albania		Lower Jurassic	5,22	27,6	430	527	
Kurvelesh	Ionian	Albania		Lower Jurassic	0,82	3,51	430	431	
Kurvelesh	Ionian	Albania		Lower Jurassic	5,32	29,35	432	552	
Kurvelesh	Ionian	Albania		Lower Jurassic	1,1	4,97	432	451	
Kremenare	Ionian	Albania		Lower Jurassic	1,39	7,27	415	523	
Ballsh	Ionian	Albania		Lower Jurassic	7,08	26,8	420	630	
Ballsh	Ionian	Albania		Lower Jurassic	1,96	11,21	420	571	
Patos/Verbas	Ionian	Albania		Lower Jurassic	1,01	5,21	420	510	
Patos/Verbas	Ionian	Albania		Lower Jurassic	2,6	16,1	420	620	
Ivi	Ionian	Greece	Well	Toarc-Tithon	8,93	67,29	411	754	27
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,49	11,24	411	754	60
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,92	13,88	417	723	48
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,42	10,23	415	720	65
Ivi	Ionian	Greece	Well	Toarc-Tithon	18,18	121,85	416	670	28
Ivi	Ionian	Greece	Well	Toarc-Tithon	3,87	25,85	415	668	40
Ivi	Ionian	Greece	Well	Toarc-Tithon	6,85	44,49	414	649	60
Ivi	Ionian	Greece	Well	Toarc-Tithon	3,59	23,13	415	644	81
Ivi	Ionian	Greece	Well	Toarc-Tithon	5,37	34,55	413	643	22

Ivi	Ionian	Greece	Well	Toarc-Tithon	2,22	14,27	413	643	41
Ivi	Ionian	Greece	Well	Toarc-Tithon	15,24	97,32	419	639	31
Ivi	Ionian	Greece	Well	Toarc-Tithon	0,98	6,25	416	638	77
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,49	9,41	415	632	52
Ivi	Ionian	Greece	Well	Toarc-Tithon	10,34	64,8	414	627	25
Ivi	Ionian	Greece	Well	Toarc-Tithon	4,03	25,18	420	625	43
Ivi	Ionian	Greece	Well	Toarc-Tithon	7,96	49,5	417	622	42
Ivi	Ionian	Greece	Well	Toarc-Tithon	14,9	91,88	416	617	15
Ivi	Ionian	Greece	Well	Toarc-Tithon	11,99	73,86	413	616	24
Ivi	Ionian	Greece	Well	Toarc-Tithon	10	61,49	415	615	34
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,07	6,55	416	612	63
Ivi	Ionian	Greece	Well	Toarc-Tithon	15,45	94,3	412	610	29
Ivi	Ionian	Greece	Well	Toarc-Tithon	3,44	20,91	416	608	34
Ivi	Ionian	Greece	Well	Toarc-Tithon	16,21	98,2	415	606	19
Ivi	Ionian	Greece	Well	Toarc-Tithon	9,5	57,45	415	605	16
Ivi	Ionian	Greece	Well	Toarc-Tithon	7,56	45,7	418	604	14
Ivi	Ionian	Greece	Well	Toarc-Tithon	4,09	24,71	418	604	32
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,85	11,16	415	603	46
Ivi	Ionian	Greece	Well	Toarc-Tithon	12,73	76,51	415	601	17
Ivi	Ionian	Greece	Well	Toarc-Tithon	9,44	56,49	416	598	25
Ivi	Ionian	Greece	Well		13,49	80,57	416	597	20
Ivi	Ionian	Greece	Well	Toarc-Tithon	8,05	47,88	417	595	38
Ivi	Ionian	Greece	Well	Toarc-Tithon	17,2	102,08	416	593	24
Ivi	Ionian	Greece	Well	Toarc-Tithon	8,02	47,49	419	592	40
Ivi	Ionian	Greece	Well	Toarc-Tithon	15,01	88,9	417	592	21
Ivi	Ionian	Greece	Well	Toarc-Tithon	19,12	112,96	415	591	19
Ivi	Ionian	Greece	Well	Toarc-Tithon	12,98	76,7	414	591	18
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,74	10,25	415	589	64
Ivi	Ionian	Greece	Well	Toarc-Tithon	13,22	77,78	417	588	27
Ivi	Ionian	Greece	Well	Toarc-Tithon	8,5	50	414	588	38
Ivi	Ionian	Greece	Well	Toarc-Tithon	13,55	79,18	416	584	14
Ivi	Ionian	Greece	Well	Toarc-Tithon	20,06	116,29	416	580	19
Ivi	Ionian	Greece	Well	Toarc-Tithon	15,04	85,96	416	572	21
Ivi	Ionian	Greece	Well	Toarc-Tithon	12,72	72,65	415	571	30
Ivi	Ionian	Greece	Well	Toarc-Tithon	5,55	31,64	415	570	26
Ivi	Ionian	Greece	Well	Toarc-Tithon	16,77	95,39	415	569	18
Ivi	Ionian	Greece	Well	Toarc-Tithon	8,52	48,47	415	569	16
Ivi	Ionian	Greece	Well	Toarc-Tithon	2,11	11,97	412	567	15
Ivi	Ionian	Greece	Well	Toarc-Tithon	11,59	65,62	414	566	25
Ivi	Ionian	Greece	Well	Toarc-Tithon	13,36	75	416	561	14
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,75	9,79	415	559	49
Ivi	Ionian	Greece	Well	Toarc-Tithon	2	11,14	413	557	73
Ivi	Ionian	Greece	Well	Toarc-Tithon	2,65	14,54	417	549	45
Ivi	Ionian	Greece	Well	Toarc-Tithon	2,67	14,66	414	549	38
Ivi	Ionian	Greece	Well	Toarc-Tithon	5,68	30,63	414	539	18
Ivi	Ionian	Greece	Well	Toarc-Tithon	11,68	62,68	415	537	25
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,43	7,13	410	498	20
Ivi	Ionian	Greece	Well	Toarc-Tithon	0,96	4,61	412	480	36
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,14	5,47	411	479	25
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,06	4,98	410	469	30
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,23	5,62	413	456	26
Ivi	Ionian	Greece	Well	Toarc-Tithon	1,01	3,65	415	361	40

Paliogrimpiani 2078	Ionian	Greece	Outcrop	Toarc-Tithon	0,88	1,7	432	193	51
Mali-Gjere outcrop	Ionian	Albania	Outcrop	Lower Jurassic	10,3	54,18	428	470, 2	
Fterra outcrop	Ionian	Albania	Outcrop	Lower Jurassic	28,86	176,58	435	619, 3	
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,69	11,6	432	686	15
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,88	12,75	429	678	11
Iraklis	Ionian	Greece	Well	Toarc-Tithon	9,82	63,41	430	645	2
Iraklis	Ionian	Greece	Well	Toarc-Tithon	4,5	28,67	431	637	3
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,74	11,04	431	634	9
Iraklis	Ionian	Greece	Well	Toarc-Tithon	0,62	3,62	411	632	22
Iraklis	Ionian	Greece	Well	Toarc-Tithon	3,46	20,96	432	605	5
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,12	6,68	428	596	13
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,79	10,23	422	571	16
Iraklis	Ionian	Greece	Well	Toarc-Tithon	5,87	33,19	433	565	4
Iraklis	Ionian	Greece	Well	Toarc-Tithon	2,54	14,17	420	557	13
Iraklis	Ionian	Greece	Well	Toarc-Tithon	2,56	14,16	429	553	8
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,64	9,06	431	552	10
Iraklis	Ionian	Greece	Well	Toarc-Tithon	0,91	5,02	416	552	19
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,64	8,96	421	546	15
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,59	8,62	425	542	13
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,05	5,7	422	542	18
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,94	10,51	419	541	14
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,55	8,35	423	538	13
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,6	8,53	422	533	15
Iraklis	Ionian	Greece	Well	Toarc-Tithon	2,75	14,51	416	527	9
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,55	8,14	423	525	15
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,38	7,22	428	523	12
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,5	7,83	421	522	18
Iraklis	Ionian	Greece	Well	Toarc-Tithon	0,96	5	421	520	17
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,48	7,67	419	518	15
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,21	6,16	429	509	18
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,3	6,59	426	506	20
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,66	8,26	419	497	13
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,6	7,64	421	477	15
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,4	6,58	416	470	15
Iraklis	Ionian	Greece	Well	Toarc-Tithon	2	9,27	422	463	20
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,39	6,4	423	460	18
Iraklis	Ionian	Greece	Well	Toarc-Tithon	0,91	3,92	422	430	21
Iraklis	Ionian	Greece	Well	Toarc-Tithon	1,08	4,23	422	391	28

APPENDIX 2

Table of results from Rock-Eval analysis of Lower Cretaceous samples.

Name	**Zone**	**Country**	**Type**	**Age**	**TOC**	**S2**	**Tmax**	**HI**	**OI**
274	Ionian	Albania	Field	Cretaceous	25,98	183,01	435	704	16
Gotzikas C35	Ionian	Greece	Outcrop	Berriasian-Turonian	28,87				
Gotzikas C41	Ionian	Greece	Outcrop	Albian-Cenom	2,33				
Gotzikas V12a	Ionian	Greece	Outcrop	Albian-Cenom	1,58				
Gotzikas V12c	Ionian	Greece	Outcrop	Albian-Cenom	2,08				
Gotzikas V13	Ionian	Greece	Outcrop	Albian-Cenom	2,5				
Gotzikas V23a	Ionian	Greece	Outcrop	Albian-Cenom	1,41				

Gotzikas V23b	Ionian	Greece	Outcrop	Albian-Cenom	2,34				
Gotzikas V26	Ionian	Greece	Outcrop	Albian-Cenom	3,35				
Gotzikas V29a	Ionian	Greece	Outcrop	Albian-Cenom	2,77				
Gotzikas V29b	Ionian	Greece	Outcrop	Albian-Cenom	2,15				
Gotzikas V29c	Ionian	Greece	Outcrop	Albian-Cenom	2,64				
Gotzikas V38	Ionian	Greece	Outcrop	Albian-Cenom	1,88				
Gotzikas V39	Ionian	Greece	Outcrop	Albian-Cenom	1,08				
Gotzikas V41a	Ionian	Greece	Outcrop	Albian-Cenom	2,15				
Gotzikas V41b	Ionian	Greece	Outcrop	Albian-Cenom	3,19				
Gotzikas V45	Ionian	Greece	Outcrop	Albian-Cenom	2,57				
Gotzikas V47	Ionian	Greece	Outcrop	Albian-Cenom	4,42				
Gotzikas V48	Ionian	Greece	Outcrop	Albian-Cenom	1,54				
Gotzikas V49	Ionian	Greece	Outcrop	Albian-Cenom	2,39				
Gotzikas V50	Ionian	Greece	Outcrop	Albian-Cenom	3,61				
Gotzikas V54	Ionian	Greece	Outcrop	Albian-Cenom	2,43				
Gotzikas V56	Ionian	Greece	Outcrop	Albian-Cenom	1,77				
Gotzikas V60	Ionian	Greece	Outcrop	Albian-Cenom	2,29				
Gotzikas V62	Ionian	Greece	Outcrop	Albian-Cenom	6,33				
Gotzikas V64	Ionian	Greece	Outcrop	Albian-Cenom	2,77				
Iraklis	Ionian	Greece	Well	Albian-Cenom	1,62	8,28	418	511	10
Iraklis	Ionian	Greece	Well	Albian-Cenom	2,07	11,56	418	558	11
Iraklis	Ionian	Greece	Well	Albian-Cenom	1,51	7,62	417	504	16
Iraklis	Ionian	Greece	Well	Albian-Cenom	2,24	13,38	416	597	13
Iraklis	Ionian	Greece	Well	Albian-Cenom	1,51	7,2	423	476	19
Iraklis	Ionian	Greece	Well	Albian-Cenom	1,44	7,16	417	497	20
Paliam 10,82	Ionian	Greece	Outcrop	Early Aptian	4,8				
Paliam 11,125	Ionian	Greece	Outcrop	Early Aptian	5,5				
Paliam 12,192	Ionian	Greece	Outcrop	Early Aptian	0,85				
Paliam 12,344	Ionian	Greece	Outcrop	Early Aptian	1,87				
Paliam 12,497	Ionian	Greece	Outcrop	Early Aptian	3,6				
Paliam 13,106	Ionian	Greece	Outcrop	Early Aptian	6,7				
Paliam 13,716	Ionian	Greece	Outcrop	Early Aptian	4,2				
Paliam 13,716	Ionian	Greece	Outcrop	Early Aptian	0,66				
Paliam 13,868	Ionian	Greece	Outcrop	Early Aptian	1,26				
Paliam 13,868	Ionian	Greece	Outcrop	Early Aptian	0,96				
Paliam 10,058	Ionian	Greece	Outcrop	Early Aptian	1				
Paliam 10,211	Ionian	Greece	Outcrop	Early Aptian	0,68				
Paliam 10,516	Ionian	Greece	Outcrop	Early Aptian	1,21				
Paliam 10,516	Ionian	Greece	Outcrop	Early Aptian	0,89				
Paliam 10,668	Ionian	Greece	Outcrop	Early Aptian	3,1				
Paliam 10,668	Ionian	Greece	Outcrop	Early Aptian	1,42				
Paliam 10,82	Ionian	Greece	Outcrop	Early Aptian	3,52				
Paliam 10,82	Ionian	Greece	Outcrop	Early Aptian	3				
Paliam 10,973	Ionian	Greece	Outcrop	Early Aptian	1,11				
Paliam 11,125	Ionian	Greece	Outcrop	Early Aptian	2,68				
Paliam 11,125	Ionian	Greece	Outcrop	Early Aptian	0,79				
Paliam 11,43	Ionian	Greece	Outcrop	Early Aptian	2,79				
Paliam 12,04	Ionian	Greece	Outcrop	Early Aptian	4,89				
Paliam 12,344	Ionian	Greece	Outcrop	Early Aptian	5,63				
Paliam 13,106	Ionian	Greece	Outcrop	Early Aptian	0,79				
Paliam 13,259	Ionian	Greece	Outcrop	Early Aptian	1,74				
Paliam 13,564	Ionian	Greece	Outcrop	Early Aptian	3,53				

Paliam 14,021	Ionian	Greece	Outcrop	Early Aptian	6,68			
Paliam 14,783	Ionian	Greece	Outcrop	Early Aptian	4,16			
Paliamb 14,9	Ionian	Greece	Outcrop	Early Aptian	1,11			
Paliambela 15	Ionian	Greece	Outcrop	Early Aptian	0,89			
Paliambela 8,3	Ionian	Greece	Outcrop	Early Aptian	0,76			
Paliambela 8,5	Ionian	Greece	Outcrop	Early Aptian	0,66			
Paliambela 8,8	Ionian	Greece	Outcrop	Early Aptian	0,76			
Paliambela 8,9	Ionian	Greece	Outcrop	Early Aptian	1,06			
Paliambela 8,9	Ionian	Greece	Outcrop	Early Aptian	0,56			
Paliambela 9,1	Ionian	Greece	Outcrop	Early Aptian	2,88			
Paliambela 9,1	Ionian	Greece	Outcrop	Early Aptian	1,16			
Paliambela 9,2	Ionian	Greece	Outcrop	Early Aptian	3,38			
Paliambela 9,2	Ionian	Greece	Outcrop	Early Aptian	2,78			
Paliambela 9,2	Ionian	Greece	Outcrop	Early Aptian	0,96			
Paliambela 9,4	Ionian	Greece	Outcrop	Early Aptian	2,47			
Paliambela 9,6	Ionian	Greece	Outcrop	Early Aptian	0,66			
Paliambela 9,9	Ionian	Greece	Outcrop	Early Aptian	2,68			
Sopoti 13,259	Ionian	Albania	Outcrop	Early Aptian	1,15			
Sopoti 14,021	Ionian	Albania	Outcrop	Early Aptian	4,16			
Sopoti 14,021	Ionian	Albania	Outcrop	Early Aptian	3,33			
Sopoti 14,63	Ionian	Albania	Outcrop	Early Aptian	1,34			
Sopoti 15,088	Ionian	Albania	Outcrop	Early Aptian	0,64			
Sopoti 16,154	Ionian	Albania	Outcrop	Early Aptian	1,99			
Sopoti 16,154	Ionian	Albania	Outcrop	Early Aptian	0,97			
Sopoti 16,307	Ionian	Albania	Outcrop	Early Aptian	8,5			
Sopoti 16,764	Ionian	Albania	Outcrop	Early Aptian	1,24			
Sopoti 17,221	Ionian	Albania	Outcrop	Early Aptian	1,09			
Sopoti 18,898	Ionian	Albania	Outcrop	Early Aptian	7,7			
TERR-ALBANIE	Ionian	Albania	Section	L. Cretaceous	32,36	245,6	418	759
TERR-ALBANIE	Ionian	Albania	Section	L. Cretaceous	6,74	50,1	413	743
TERR-ALBANIE	Ionian	Albania	Section	L. Cretaceous	8,7	59,7	405	686
Gjere Mount	Ionian	Albania	Field	L. Cretaceous	26,01	181,5	413	700
Gjere Mount	Ionian	Albania	Field	L. Cretaceous	0,8	5,2	413	652
Ftere	Ionian	Albania	Field	L. Cretaceous	1,14	5,03	432	443
Kurvelesh	Ionian	Albania	Field	L. Cretaceous	25,95	159,2	424	615
Kurvelesh	Ionian	Albania	Field	L. Cretaceous	1,67	6,23	424	354
Kremenare	Ionian	Albania	Field	L. Cretaceous	0,83			
Ballsh	Ionian	Albania	Field	L. Cretaceous	1,01	5,24	424	522
Ballsh	Ionian	Albania	Field	L. Cretaceous	6,33	1,74	424	
Patos-Verbas	Ionian	Albania	Field	L. Cretaceous	4,84	16,82	424	586
Cakran	Ionian	Albania	Field	L. Cretaceous	5,72	33,17	430	590

APPENDIX 3

Results from Rock-Eval analysis of Upper Cretaceous samples.

Name	Zone	Country	Type	Age	TOC	S2	Tmax	HI	OI
206	Ionian	Albania	Field	Up. Cretaceous	38,46	280,32	420	729	17
256	Ionian	Albania	Field	Up. Cretaceous	2,12	5,8	424	570	
NEWTON	Sazani	Albania	Well	Un Mesozoic	1,01	1,82	417	180	197
NEWTON	Sazani	Albania	Well	Un Mesozoic	0,82	0,79	416	96	188

NEWTON	Sazani	Albania	Well	Un Mesozoic	1,29				
NEWTON	Sazani	Albania	Well	Un Mesozoic	0,56				
NEWTON	Sazani	Albania	Well	Un Mesozoic	0,55				
NEWTON	Sazani	Albania	Well	Un Mesozoic	0,53				
315	Ionian	Albania	Field	Up. Cretaceous	18,78	134,84	412	717	
315	Ionian	Albania	Field	Up. Cretaceous	31,08	212,16	409	682	
315	Ionian	Albania	Field	Up. Cretaceous	21,6	136,5	410	603	
318	Ionian	Albania	Field	Up. Cretaceous	32,32	290,31	416	898	10,18
PSG	Sazani	Albania	WELL	Up. Cretaceous	0,32	0,59	422	154	222
Droja- 384	Kruja	Albania	Field	Up. Cretaceous	2,49	22,76	415	914	36
Droja_105	Kruja	Albania	Field	Up. Cretaceous	2,49	19,15	414	769	
Droja_106	Kruja	Albania	Field	Up. Cretaceous	3,37	28,66	417	850	
Droja_106	Kruja	Albania	Field	Up. Cretaceous	3,93	31,83	415	809	
Droja_108	Kruja	Albania	Field	Up. Cretaceous	2,39	21,18	409	886	
Droja_109	Kruja	Albania	Field	Up. Cretaceous	0,92	5,25	417	570	
Erzeni	Kruja	Albania	Field	Up. Cretaceous	7,22	14,99	420	208	
Gotzikas 1402	Ionian	Greece	Outcrop	Up. Cretaceous	21,61	165,32	411	765	98
Gotzikas 1403	Ionian	Greece	Outcrop	Up. Cretaceous	19,1	174,11	420	912	21
Gotzikas 1410	Ionian	Greece	Outcrop	Up. Cretaceous	0,94	4,67	423	497	114
Gotzikas 1412	Ionian	Greece	Outcrop	Up. Cretaceous	1,82	9,3	423	511	48
Gotzikas 1413	Ionian	Greece	Outcrop	Up. Cretaceous	1,83	11,41	422	623	36
Gotzikas 1414	Ionian	Greece	Outcrop	Up. Cretaceous	1,5	8,39	419	559	71
Gotzikas 1415	Ionian	Greece	Outcrop	Up. Cretaceous	1,56	7,99	424	512	69
Gotzikas 1416	Ionian	Greece	Outcrop	Up. Cretaceous	2,54	9,58	421	377	61
Kruja	Kruja	Albania	Field	Up. Cretaceous	0,1 - 4,2		427	540	
Lumi Zeze_402/a	Kruja	Albania	Field	Up. Cretaceous	0,89	5,59	429	628	
Lumi Zeze_405	Kruja	Albania	Field	Up. Cretaceous	0,52	3,01	415	602	
Lumi Zeze_415/a	Kruja	Albania	Field	Up. Cretaceous	0,58	3,24	416	558	
Lumi Zeze_417/b	Kruja	Albania	Field	Up. Cretaceous	1,06	6,71	412	633	
Lumi Zeze_418	Kruja	Albania	Field	Up. Cretaceous	0,51	3,09	416	605	
Lumi Zeze_421	Kruja	Albania	Field	Up. Cretaceous	0,31	1,91	411	619	
Lumi Zeze_429/1	Kruja	Albania	Field	Up. Cretaceous	0,4	2,54	432	635	
Lumi Zeze_434/4	Kruja	Albania	Field	Up. Cretaceous	1,45	9,06	427	624	
Lumi Zeze_728	Kruja	Albania	Field	Up. Cretaceous	0,32	1,25	431	390	
Lumi Zeze_732	Kruja	Albania	Field	Up. Cretaceous	0,86	5,69	428	661	
Lumi Zeze_770/3	Kruja	Albania	Field	Up. Cretaceous	1,72	9,71	424	569	
Milot-26/b	Kruja	Albania	Field	Up. Cretaceous	4,21	17,58	414	417	
Tujan	Kruja	Albania	Field	Up. Cretaceous	2,73	14,13	419	517	
Tujan	Kruja	Albania	Field	Up. Cretaceous	12,05		425	606	
Tujani_13	Kruja	Albania	Field	Up. Cretaceous	0,62	3,27	418	525	
Tujani_14	Kruja	Albania	Field	Up. Cretaceous	0,55	3,41	422	620	
Tujani_19	Kruja	Albania	Field	Up. Cretaceous	0,75	4,48	419	597	
Tujani_20	Kruja	Albania	Field	Up. Cretaceous	0,56	2,65	420	473	
Tujani_21	Kruja	Albania	Field	Up. Cretaceous	2,04	13,49	426	661	
Tujani_21	Kruja	Albania	Field	Up. Cretaceous	5,91	36,87	422	623	
Tujani_30	Kruja	Albania	Field	Up. Cretaceous	2,93	9,37	422	319	
Tujani_32/1	Kruja	Albania	Field	Up. Cretaceous	2,73	14,13	419	517	
Tujani_32/2	Kruja	Albania	Field	Up. Cretaceous	2,66	13,16	415	494	
Tujani_34	Kruja	Albania	Field	Up. Cretaceous	0,39	1,64	416	420	
Tujani_35	Kruja	Albania	Field	Up. Cretaceous	0,3	1,28	423	426	
Tujani_4	Kruja	Albania	Field	Up. Cretaceous	3,05	15,36	415	503	
Tujani_4	Kruja	Albania	Field	Up. Cretaceous	1,01	1,86	421	184	

Tujani_72	Kruja	Albania	Field	Up. Cretaceous	6,1	33,55	423	550	
Tujani_73	Kruja	Albania	Field	Up. Cretaceous	6,52	31,24	422	479	
Vaja_184/1	Kruja	Albania	Field	Up. Cretaceous	0,55	2,93	424	532	
Vaja_185/3	Kruja	Albania	Field	Up. Cretaceous	0,49	2,59	424	528	
Vaja_185/4	Kruja	Albania	Field	Up. Cretaceous	0,54	3,19	425	590	
Vaja_186/1	Kruja	Albania	Field	Up. Cretaceous	0,44	2,34	425	531	
Vaja_186/3	Kruja	Albania	Field	Up. Cretaceous	0,33	2,03	425	615	
Vaja_187/1	Kruja	Albania	Field	Up. Cretaceous	0,33	1,89	426	572	
Vaja_187/2	Kruja	Albania	Field	Up. Cretaceous	0,5	3,33	426	666	
Vaja_187/3	Kruja	Albania	Field	Up. Cretaceous	0,43	2,59	426	602	
Vaja_187/4	Kruja	Albania	Field	Up. Cretaceous	0,35	2,21	424	631	
Vaja_187/5	Kruja	Albania	Field	Up. Cretaceous	0,55	3,6	423	654	
Vaja_187/6b	Kruja	Albania	Field	Up. Cretaceous	1,17	7,49	423	640	
Vaja_188/1	Kruja	Albania	Field	Up. Cretaceous	0,56	3,85	427	687	
Vaja_188/2	Kruja	Albania	Field	Up. Cretaceous	0,49	3,37	428	687	
Vaja_188/3	Kruja	Albania	Field	Up. Cretaceous	0,34	2,28	427	670	
Vaja_205/1	Kruja	Albania	Field	Up. Cretaceous	0,52	3,45	424	663	
Vaja_207/1	Kruja	Albania	Field	Up. Cretaceous	0,74	5,08	423	686	
Vaja_209/1a	Kruja	Albania	Field	Up. Cretaceous	0,47	2,72	424	578	
Vaja_209/1b	Kruja	Albania	Field	Up. Cretaceous	0,41	2,52	424	614	
Vaja_210/1	Kruja	Albania	Field	Up. Cretaceous	0,34	2,09	425	614	
Vaja_211/1	Kruja	Albania	Field	Up. Cretaceous	0,38	2	423	526	
Vaja_212/1	Kruja	Albania	Field	Up. Cretaceous	1,9	12,54	423	660	
Vaja_218/1	Kruja	Albania	Field	Up. Cretaceous	0,36	2,16	424	600	
Vaja_219/1a	Kruja	Albania	Field	Up. Cretaceous	0,54	3,56	423	659	
Vaja_219/1b	Kruja	Albania	Field	Up. Cretaceous	0,49	3,09	423	630	
Vaja_227	Kruja	Albania	Field	Up. Cretaceous	0,54	2,1	429	388	
Vaja_227/1b	Kruja	Albania	Field	Up. Cretaceous	0,39	2,57	426	658	
Vaja_227/1b	Kruja	Albania	Field	Up. Cretaceous	0,33	1,6	422	484	
Vaja_228/1	Kruja	Albania	Field	Up. Cretaceous	0,4	2,12	422	530	
Vaja_232/1a	Kruja	Albania	Field	Up. Cretaceous	1,91	11,45	423	599	
Vaja_232/1b	Kruja	Albania	Field	Up. Cretaceous	3,83	19,45	425	507	
Zeza River	Kruja	Albania	Field	Up. Cretaceous	3,37				
Zeza River	Kruja	Albania	Field	Up. Cretaceous	1,89				
Zeza River	Kruja	Albania	Field	Up. Cretaceous	1,24				

APPENDIX 4

Table of results from Rock-Eval analysis of Cenozoic samples

Name	Zone	Country	Type	Age	TOC	S2	Tmax	HI	OI
Newton		Albania	Well	Oligocene	0,96				
Newton		Albania	Well	Oligocene	0,52				
Kepler		Albania	Well	Burdigalian	0,52	1,37	418	263	108
Kepler		Albania	Well	Burdigalian	1,07	3,49	426	326	41
Kepler		Albania	Well	Burdigalian	2,91	12,2	427	419	16
Paul		Albania	Well	Burdigalian	0,5	0,68	418	136	264
Paul		Albania	Well	Burdigalian	0,5	1,05	424	210	396
Paul		Albania	Well	Burdigalian	0,51	1,32	425	259	337
Paul		Albania	Well	Burdigalian	0,52	1,2	416	231	423
Paul		Albania	Well	Burdigalian	0,53	0,87	417	164	211

Paul	Albania	Well	Burdigalian	0,53	1,6	427	302	415
Paul	Albania	Well	Burdigalian	0,54	0,61	422	113	285
Paul	Albania	Well	Burdigalian	0,54	1,33	419	246	424
Paul	Albania	Well	Burdigalian	0,55	0,87	424	158	162
Paul	Albania	Well	Burdigalian	0,55	1,39	424	253	396
Paul	Albania	Well	Burdigalian	0,56	1,42	425	254	273
Paul	Albania	Well	Burdigalian	0,56	1,36	422	243	316
Paul	Albania	Well	Burdigalian	0,57	2,33	428	409	374
Paul	Albania	Well	Burdigalian	0,58	1,36	424	234	219
Paul	Albania	Well	Burdigalian	0,59	1,35	423	229	268
Paul	Albania	Well	Burdigalian	0,59	1,18	423	200	310
Paul	Albania	Well	Burdigalian	0,59	1,48	422	251	456
Paul	Albania	Well	Burdigalian	0,59	1,15	430	195	71
Paul	Albania	Well	Burdigalian	0,61	1,11	421	182	275
Paul	Albania	Well	Burdigalian	0,61	1,14	423	187	310
Paul	Albania	Well	Burdigalian	0,62	1,13	425	182	218
Paul	Albania	Well	Burdigalian	0,62	1,29	426	208	211
Paul	Albania	Well	Burdigalian	0,62	0,84	421	135	177
Paul	Albania	Well	Burdigalian	0,62	1,42	425	229	273
Paul	Albania	Well	Burdigalian	0,63	1,03	422	163	175
Paul	Albania	Well	Burdigalian	0,63	1,3	424	206	254
Paul	Albania	Well	Burdigalian	0,63	1,65	426	262	314
Paul	Albania	Well	Burdigalian	0,63	1,11	426	176	268
Paul	Albania	Well	Burdigalian	0,64	1,28	424	200	234
Paul	Albania	Well	Burdigalian	0,65	1,28	425	197	209
Paul	Albania	Well	Burdigalian	0,65	1,01	423	155	192
Paul	Albania	Well	Burdigalian	0,65	1,29	421	198	188
Paul	Albania	Well	Burdigalian	0,66	1,05	423	159	200
Paul	Albania	Well	Burdigalian	0,66	1,97	423	298	292
Paul	Albania	Well	Burdigalian	0,67	1,29	423	193	216
Paul	Albania	Well	Burdigalian	0,67	1,16	427	173	51
Paul	Albania	Well	Burdigalian	0,68	1,49	423	219	207
Paul	Albania	Well	Burdigalian	0,68	1,16	425	171	206
Paul	Albania	Well	Burdigalian	0,68	1	421	147	213
Paul	Albania	Well	Burdigalian	0,68	1,46	430	215	68
Paul	Albania	Well	Burdigalian	0,69	1,3	425	188	126
Paul	Albania	Well	Burdigalian	0,69	1,4	424	203	210
Paul	Albania	Well	Burdigalian	0,69	1,82	423	264	336
Paul	Albania	Well	Burdigalian	0,69	1,38	422	200	223
Paul	Albania	Well	Burdigalian	0,69	1,39	421	201	299
Paul	Albania	Well	Burdigalian	0,7	1,11	428	159	70
Paul	Albania	Well	Burdigalian	0,71	1,24	423	175	221
Paul	Albania	Well	Burdigalian	0,71	1,18	421	166	192
Paul	Albania	Well	Burdigalian	0,72	1,49	425	207	171
Paul	Albania	Well	Burdigalian	0,75	1,53	426	204	152
Paul	Albania	Well	Burdigalian	0,75	1,4	421	187	223
Paul	Albania	Well	Burdigalian	0,76	1,2	422	158	170
Paul	Albania	Well	Burdigalian	0,76	1,43	426	188	170
Paul	Albania	Well	Burdigalian	0,76	1,56	422	205	188
Paul	Albania	Well	Burdigalian	0,76	1,59	422	209	276
Paul	Albania	Well	Burdigalian	0,76	1,77	426	233	247
Paul	Albania	Well	Burdigalian	0,76	2,29	426	301	245

Paul	Albania	Well	Burdigalian	0,77	1,6	425	208	196
Paul	Albania	Well	Burdigalian	0,77	1,56	426	203	169
Paul	Albania	Well	Burdigalian	0,77	1,43	421	186	188
Paul	Albania	Well	Burdigalian	0,77	1,83	423	238	243
Paul	Albania	Well	Burdigalian	0,78	1,39	425	178	165
Paul	Albania	Well	Burdigalian	0,78	1,89	426	242	244
Paul	Albania	Well	Burdigalian	0,79	1,47	421	186	214
Paul	Albania	Well	Burdigalian	0,79	1,63	424	206	272
Paul	Albania	Well	Burdigalian	0,81	1,93	424	238	162
Paul	Albania	Well	Burdigalian	0,81	1,03	422	127	175
Paul	Albania	Well	Burdigalian	0,82	1,77	426	216	145
Paul	Albania	Well	Burdigalian	0,82	1,41	424	172	140
Paul	Albania	Well	Burdigalian	0,83	1,41	423	170	165
Paul	Albania	Well	Burdigalian	0,84	1,36	419	162	185
Paul	Albania	Well	Burdigalian	0,84	1,53	422	182	248
Paul	Albania	Well	Burdigalian	0,84	1,88	422	224	260
Paul	Albania	Well	Burdigalian	0,84	1,59	427	189	62
Paul	Albania	Well	Burdigalian	0,85	1,91	424	225	195
Paul	Albania	Well	Burdigalian	0,85	1,67	420	196	304
Paul	Albania	Well	Burdigalian	0,85	3,17	428	373	258
Paul	Albania	Well	Burdigalian	0,85	1,44	424	169	215
Paul	Albania	Well	Burdigalian	0,87	2,17	421	249	246
Paul	Albania	Well	Burdigalian	0,87	1,55	422	178	230
Paul	Albania	Well	Burdigalian	0,87	2,56	425	294	275
Paul	Albania	Well	Burdigalian	0,88	1,81	424	206	167
Paul	Albania	Well	Burdigalian	0,89	1,74	426	196	136
Paul	Albania	Well	Burdigalian	0,89	2,23	424	251	219
Paul	Albania	Well	Burdigalian	0,93	2,08	424	224	228
Paul	Albania	Well	Burdigalian	0,94	2,15	423	229	173
Paul	Albania	Well	Burdigalian	0,94	1,95	423	207	144
Paul	Albania	Well	Burdigalian	0,95	2,16	426	227	125
Paul	Albania	Well	Burdigalian	0,96	2,05	424	214	173
Paul	Albania	Well	Burdigalian	0,96	1,72	423	179	205
Paul	Albania	Well	Burdigalian	0,99	2,03	425	205	109
Paul	Albania	Well	Burdigalian	0,99	1,91	423	193	192
Paul	Albania	Well	Burdigalian	1,01	2,25	424	223	136
Paul	Albania	Well	Burdigalian	1,03	1,73	423	168	129
Paul	Albania	Well	Burdigalian	1,03	2,52	424	245	142
Paul	Albania	Well	Burdigalian	1,03	2,14	423	208	166
Paul	Albania	Well	Burdigalian	1,05	2,35	426	224	121
Paul	Albania	Well	Burdigalian	1,06	3,03	428	286	137
Paul	Albania	Well	Burdigalian	1,09	2,59	426	238	176
Paul	Albania	Well	Burdigalian	1,1	2,33	425	212	102
Paul	Albania	Well	Burdigalian	1,11	2,05	425	185	102
Paul	Albania	Well	Burdigalian	1,18	2,64	426	224	112
Paul	Albania	Well	Burdigalian	1,2	3,3	425	275	168
Paul	Albania	Well	Burdigalian	1,21	2,67	428	221	119
Paul	Albania	Well	Burdigalian	1,21	2,53	427	209	96
Paul	Albania	Well	Burdigalian	1,29	2,86	426	222	100
PSG	Albania	Well	Serravalian	0,52	1,59	423	194	112
Paul	Albania	Well	Langhian	0,5	1,18	424	236	336
Paul	Albania	Well	Langhian	0,51	0,93	415	182	190

Paul	Albania	Well	Langhian	0,52	1,17	419	225	312
Paul	Albania	Well	Langhian	0,52	0,75	423	144	185
Paul	Albania	Well	Langhian	0,53	0,93	419	175	285
Paul	Albania	Well	Langhian	0,53	1,35	423	255	291
Paul	Albania	Well	Langhian	0,56	1,21	426	216	245
Paul	Albania	Well	Langhian	0,56	0,94	423	168	209
Paul	Albania	Well	Langhian	0,63	1,06	418	168	240
Paul	Albania	Well	Langhian	0,67	1,32	424	197	182
Paul	Albania	Well	Langhian	0,76	1,68	424	221	179
Paul	Albania	Well	Langhian	0,55	1,11	410	202	293
Milot-28	Albania	Field sample	Tortonian	4,81	18,85	413	391	
Milot-28	Albania	Field sample	Tortonian	3,06	10,05	413	328	
Milot-26/b	Albania	Field sample	Tortonian	4,99	18,29	412	366	
SAFIRA	Albania	Well	Messinian	0,71	0,65	400	92	227
SAFIRA	Albania	Well	Messinian	0,72	0,55	412	76	129
SAFIRA	Albania	Well	Messinian	0,76	0,6	409	79	137
SAFIRA	Albania	Well	Messinian	1,01	0,54	418	53	96
KEPLER	Albania	Well	Messinian	1	1,57	423	157	168
KEPLER	Albania	Well	Messinian	1,01	1,57	419	155	155
KEPLER	Albania	Well	Messinian	1,53	3,57	414	233	75
KEPLER	Albania	Well	Messinian	1,58	3,86	415	244	57
PSG	Albania	Well	Messinian	0,55	0,61	414	111	91
PSG	Albania	Well	Messinian	1,06	0,55	425	52	56
PSG	Albania	Well	Tortonian	0,58	0,5	421	74	116
NEWTON	Albania	Well	Messinian	0,52				
NEWTON	Albania	Well	Messinian	0,86	1,44	420	167	220
NEWTON	Albania	Well	Messinian	2,06				
Iokasti	Albania	Well	Tortonian	1,98	6,64	414	335	
SAFIRA	Albania	Well	Lower Pliocene	0,92	0,54	428	59	142
PSG	Albania	Well	Early Pliocene	0,58	0,26	415	45	64
PSG	Albania	Well	Early Pliocene	0,84	0,27	417	32	75
PSG	Albania	Well	Middle Pliocene	2,96	1,64	420	56	83
PSG	Albania	Well	Middle Pliocene	3,27	2,25	411	69	78
PSG	Albania	Well	Middle Pliocene	5,38	3,63	403	67	77
PSG	Albania	Well	Early Pliocene	1,27	0,97	422	75	74
NEWTON	Albania	Well	Early Pliocene	0,52				