SPECIAL ISSUE
VOLUME 29 | ISSUE 1 | YEAR 2020
ISSN 1300-0985 • E-ISSN 1303-619X

# TURKISH JOURNAL OF EARTH SCIENCES

http://journals.tubitak.gov.tr/earth/

## SI: Eocene-Oligocene Evolution of the Black Sea Region

Guest Editors
Aral I. OKAY, Michael D. SIMMONS, and Gabor C. TARI

Published by the Scientific and Technological Research Council of Turkey
TÜBİTAK

# TURKISH JOURNAL OF EARTH SCIENCES

**Editor-in-Chief** Orhan TATAR
Sivas Cumhuriyet University, Turkey

**VOLUME 29 • ISSUE 1 • 2020**
ISSN 1300-0985 • E-ISSN 1303-619X


## SCOPE OF JOURNAL

- The Turkish Journal of Earth Sciences is published electronically 6 times a year by the Scientific and Technological Research Council of Turkey (TÜBİTAK).
- It is an international English-language journal for the publication of significant original recent research in a wide spectrum of topics in the earth sciences, such as geology, structural geology, tectonics, sedimentology, geochemistry, geochronology, palaeontology, igneous and metamorphic petrology, mineralogy, biostratigraphy, geophysics, geomorphology, palaeoecology and oceanography, and mineral-deposits.
- The journal publishes the highest quality papers and comprehensive review papers on hot topics of current interest, with high quality illustrations.
- Submitted papers should have regional implications and attract international interest as the journal aims to provide a medium for interdisciplinary papers that would be of interest to many different specialists.
- Specialized papers can be submitted if they illustrate significant progress in that specific area of the earth sciences. In addition to original and review articles, we are also interested in publishing discussions of papers that have already appeared in recent issues of the journal.
- The journal also publishes thematic sets of papers on topical aspects of geology or special issues of selected papers from conferences.
- Short articles (6 printed pages maximum) for rapid publication reporting a significant advance in the earth sciences with regional impact are welcome. Contribution is open to researchers of all nationalities.

## EDITORIAL BOARD



## ABSTRACTED AND INDEXED


- Science Citation Index Expanded
- Scopus
- Academic Search Complete
- Inspec

# CONTENTS

**Preface**

The Turkish Journal of Earth Sciences (TJES) is a publication of the Scientific and Technological Research Council of Turkey (TÜBİTAK). It was established in 1976 and has been published continually since that time. The TJES is a peer-reviewed international English-language journal for the publication of significant original research and comprehensive reviews in all fields of the earth sciences, providing a medium for interdisciplinary papers that would be of interest to many specialists. The journal has been included in SCI-E since 2004 and it is the only journal indexed in SCI-E in the field of earth sciences from Turkey. Moreover, the journal has an internationally recognized and periodically updated editorial board of geoscientists from all over the world.

The TJES publishes and will continue to publish papers of the highest quality, with regional implications and with excellent illustrations, on different aspects of the earth sciences. The journal published 12 special issues between 2009 and 2013, and we continue to publish special issues of selected papers from conferences and welcome thematic sets of papers on topical aspects of geology.

The current special issue focuses on the Eocene-Oligocene evolution of the Black Sea region. The Black Sea has recently become a target for petroleum exploration and has attracted the attention of many earth scientists in the region. To understand the stratigraphy, age, lithology, and facies of the Eocene-Oligocene sequences in the western Black Sea region, there is a need for precise geological studies in the western Black Sea region and interaction among the geologists studying the Black Sea. This special issue on the Eocene-Oligocene evolution of the Black Sea region serves to fill this gap and includes nine papers, which mostly concentrate on the geology of the west-southwestern margin of the Black Sea.

I would like to personally thank guest editors Aral I. Okay, Michael D. Simmons, and Gabor C. Tari for their outstanding efforts and contributions in publishing this special issue of the TJES.

Orhan Tatar

Editor in Chief

**Eocene-Oligocene Evolution of the Black Sea Region**

Guest Editors: Aral I. OKAY, Micheal D. SIMMONS, and Gabor C. TARI

**Preface**

This special issue of the *Turkish Journal of Earth Sciences* is devoted to papers on the stratigraphy, paleontology, geochemistry, and geological history of the Eocene-Oligocene sequences in the western Black Sea region. The Black Sea, since its inception in the Late Cretaceous as a back-arc basin, continued as a major sedimentary sink accumulating more than 10 km of Cenozoic sediments (e.g., Görür, 1988; Nikishin et al., 2015). It has been a site for deep-water hydrocarbon exploration in the last 20 years (Tari and Simmons, 2018). In contrast to the stability of the Black Sea in the last 80 million years, its southern and western margins, the Pontides and the Balkanides, underwent major changes in this period. The Tethyan İzmir-Ankara Ocean south of the Pontides closed in the Late Paleocene-Early Eocene; the collision with the Anatolide-Tauride Block resulted in uplift and shortening in the Pontides and in the Balkanides, and created Anatolia as a single land mass. This orogenic episode was followed by a major transgression in the Middle Eocene. Clastic-dominated sedimentary sequences of Middle Eocene age, frequently accompanied by volcanic rocks, were deposited over large areas in Anatolia lying unconformably over various older geological units. The sea retreated after the Middle Eocene, and the Pontides became and remained land area until present with local regions of continental sedimentation. One exception to this general picture is the Thrace Basin, which opened in the Middle Eocene, and the marine conditions in the Thrace Basin persisted until the end of the Early Oligocene. During the Late Eocene and Early Oligocene, the Thrace Basin formed a marine corridor between the Black Sea and the Eastern Mediterranean. The emergence of Anatolia and the Balkans as a land area after the Middle Eocene separated the Black Sea realm from the southern Tethyan oceans and eventually led to the formation of the Paratethys at the end of the Eocene (e.g., Rögl, 1999; Popov et al., 2004).

The papers in the present volume are concentrated on key areas of the Eocene-Oligocene deposition in the western Black Sea region. **Özcan et al. (2020)** review the Lower-Middle Eocene sequences around the Sea of Marmara using new and published measured stratigraphic sections with ages controlled by large benthic foraminifera. The paper illustrates the different Eocene history of the Thrace Basin from that of the rest of the Pontides.

Open marine Lower Oligocene marls of the İhsaniye Formation are well exposed on the sea-cliffs close to the village of Karaburun on the Black Sea coast west of İstanbul. The Oligocene marls constitute the only known open marine Oligocene occurrence in the Pontides, and the outcrop extends south towards the Sea of Marmara (Okay et al., 2019). The rich and well-preserved faunas of foraminifera, calcareous nannoplankton, and palynomorphs in the İhsaniye Formation are described and illustrated by **Simmons et al. (2020)**, along with precise information on the biozones and depositional environment. Interestingly, the diverse and abundant fossil assemblages in the Lower Oligocene marls of Karaburun, although located within the classical Paratethyan realm, indicate fully marine conditions. The İhsaniye Formation is age-equivalent to the clay- and sand-dominated Maykop Suite, a source of and reservoir for hydrocarbons on the margins of the Black Sea, and hence is of commercial as well as academic interest. **Tulan et al. (2020a)** provide detailed data on the organic matter content and type in the İhsaniye Formation at Karaburun and show that the total organic carbon (TOC) contents are relatively high, especially in its lower part. Although the depositional environment is fully marine and the low-salinity "Solenovian Event" (in standard nannofossil zone NP23) is not observed, the Sr isotope ratios in Karaburun consistently plot below the "ocean water Sr isotope curve."

In Karaburun, the Oligocene marls lie unconformably over the Upper Eocene reefal limestones of the Soğucak Formation (Sakınç, 1994; Less et al., 2011). **Yücel et al. (2020)** provide detailed and precise paleontological data on large benthic foraminifera from the uppermost parts of these reefal limestones, showing them to be of latest Eocene in age (Late Priabonian, shallow benthic zone (SBZ) 20). The fauna in these limestones is compared with other shallow marine limestones of similar age, which are exposed on the southwestern margin of the Thrace Basin on the northern shores of the Bay of Saros (Figure).

The dense vegetation around the Black Sea restricts good outcrops to coastal exposures. Another coastal area where Eocene-Oligocene sediments are well exposed is found in Kıyıköy, formerly Midye, 60 km northwest of Karaburun (Figure). The Eocene-Oligocene succession on the Serves Bay north of Kıyıköy is described by **Okay et al. (2020)**. In Kıyıköy, the shallow marine Upper Eocene bioclastic limestones and carbonate-rich sandstones lie unconformably over the metamorphic rocks of the Strandja Massif and pass up into Lower Oligocene limestone, siltstone, marl, and tuff, ascribed to the newly defined Servez Formation. Compared to the İhsaniye Formation at Karaburun, the fauna of Kıyıköy is poor, but large benthic foraminifera and nannofossils nevertheless indicate the presence of both the Upper Eocene and Lower Oligocene, although the boundary is difficult to determine precisely. The presence of the Lower Oligocene at Kıyıköy is also shown through palynology by **Sancay and Batı (2020)**. An acidic tuff bed close to the base of the Servez Formation produced an age of 33.9 ± 0.4 Ma, which coincides with the Eocene-Oligocene boundary (**Okay et al., 2020**). The Lower Oligocene beds at Kıyıköy are thinner and were deposited in a much shallower marine environment compared to those of


**Figure.** Map of the western Black Sea and northern Aegean showing the main Eocene and Oligocene outcrops, and some of the major Eocene and younger structures. The areas described in this special issue are also indicated.

the İhsaniye Formation, suggesting that the marine connection between the Paratethys and the Eastern Mediterranean was through the Çatalca gap. Interestingly, the pronounced unconformity between the Upper Eocene and Lower Oligocene beds, which is marked by a hard ground in Karaburun, is not observed in Kıyıköy, where the contact between the Soğucak and Servez formations is transitional.

The Kamchia Basin in Bulgaria is a foreland basin with Eocene and Oligocene sediments, developed north of the Balkan fold and thrust belt (Figure; Georgiev, 2011). In the Kamchia Basin the Middle and Upper Eocene are represented by marls, which are unconformably overlain by Oligocene mudstone, marl, and sandstone. **Tulan et al. (2020b)** describe Lower Oligocene sediments of the Kamchia Basin from a coastal exposure at Karadere, 145 km north of Kıyıköy (Figure). The section described by **Tulan et al. (2020b)** corresponds to the middle part of the Lower Oligocene (NP23) and consists of diatom-rich mudstones with thin sandstone beds. The section contains a diverse and well-preserved diatom assemblage, which together with calcareous nannoplankton and silicoflagellates indicates a fully marine neritic environment. Geochemistry of the mudstones at Karadere indicates fair to good hydrocarbon potential.

Oligocene and Lower Miocene deposits (the Maykop Suite) in southern Ukraine, Crimea, and the Kerch Peninsula are reviewed by **Vernyhorova and Ryabokon (2020)** based mainly on well sections. The Maykop Suite in this large area consists of marine mudstones with lesser amounts of sandstones, which lie above Eocene shallow marine strata. They were deposited in a shallow shelf on mainland Ukraine and in deeper water conditions on the Crimean and Kerch peninsulas. The thickness of Oligocene-Miocene deposits also increases towards the south.

A belt of Eocene-Oligocene magmatic rocks extend from NW Turkey to the Rhodope Massif (Figure). The magmatic rocks are represented by intermediate volcanic and volcanoclastic rocks and by granites. Eocene sequences in Thrace and along the margins of the Black Sea are, on the other hand, free of volcanic rocks. Şen (2019) describes rhyolites from the Princes' Islands south of İstanbul, which are dated as Middle Eocene. The Princes' Islands are made up mainly of Lower Paleozoic sedimentary rocks, and this is the first report of Eocene volcanism south of İstanbul.

## References


Georgiev G (2011). Geology and hydrocarbon systems in the Western Black Sea. Turkish Journal of Earth Sciences 21: 723-754.

Görür N (1988). Timing of opening of the Black Sea basin. Tectonophysics 147: 247-262.

Less G, Özcan E, Okay AI (2011). Stratigraphy and larger foraminifera of the Middle Eocene to Lower Oligocene shallow marine units in the northern and eastern parts of the Thrace Basin, NW Turkey. Turkish Journal of Earth Sciences 20: 793-845.

Nikishin AM, Okay AI, Tüysüz O, Demirer A, Amelin N et al. (2015). The Black Sea basins structure and history: new model based on new deep penetration regional seismic data. Part 1: Basins structure and fill. Marine and Petroleum Geology 59: 638-655.

Okay AI, Özcan E, Hakyemez A, Siyako M, Sunal G et al. (2019). The Thrace Basin and the Black Sea: the Eocene-Oligocene marine connection. Geological Magazine 156: 39-61.

Okay AI, Simmons M, Özcan E, Starkie S, Bidgood M et al. (2020). Eocene-Oligocene succession at Kıyıköy (Midye) on the Black Sea coast in Thrace. Turkish Journal of Earth Sciences: 29: 139-153.

Özcan E, Less G, Okay AI, Báldi-Beke M, Kollányi K et al. (2010). Stratigraphy and larger foraminifera of the Eocene shallow-marine and olistostromal units of the southern part of the Thrace Basin, NW Turkey. Turkish Journal of Earth Sciences 21: 933-960.

Özcan E, Özcan Z, Okay AI, Akbayram K, Hakyemez A (2020). Ypresian-to Lutetian marine record in NW Turkey: a revised biostratigraphy and chronostratigraphy and implications for the Eocene paleogeography. Turkish Journal of Earth Sciences: 29: 1-27.

Popov SV, Rögl F, Rozanov AY, Steininger FF, Shcherba IG et al. (2004). Lithological-paleogeographic maps of Paratethys, 10 maps Late Eocene to Pliocene. Courier Forschungsinstitut Senckenberg 250: 1-46.

Rögl F (1999). Mediterranean and Paratethys. Facts and hypotheses of an Oligocene to Miocene Paleogeography (Short Overview). Geologica Carpathica 50: 339-349.

Sakınç M (1994). Stratigraphy and paleontology of the marine Oligocene in Karaburun (west of Istanbul). Maden Tetkik ve Arama Dergisi 116: 9-14 (in Turkish).

Sancay RH, Batı Z (2020). Late Eocene to Early Oligocene palynostratigraphy of the Western Black Sea, Eastern Paratethys. Turkish Journal of Earth Sciences: 29: 115-138.

Şen F (2020). Middle Eocene high-K acidic volcanism in the Princes' Islands (İstanbul) and its geodynamic implications. Turkish Journal of Earth Sciences: 29: 208-219.

Simmons MD, Bidgood MD, Connell PG, Ćorić, S, Okay AI et al. (2020). Biostratigraphy and palaeoenvironments of the Oligocene succession (Ihsaniye Formation) at Karaburun (NW Turkey). Turkish Journal of Earth Sciences: 29: 28-63.

Tari GC, Simmons MD (2018). History of deep-water exploration in the Black Sea and an overview of deep-water petroleum play types. In: Simmons MD, Tari, GC, Okay AI (editors). Petroleum Geology of the Black Sea. London, UK: Geological Society of London Special Publications, pp. 439-475.

Tulan E, Sachsenhofer RF, Tari G, Flecker R et al. (2020a). Source rock potential and depositional environment of the Lower Oligocene İhsaniye Formation in NW Turkey (Thrace, Karaburun). Turkish Journal of Earth Sciences: 29: 64-84.

Tulan E, Sachsenhofer RF, Witkowski J, Tari G, Ćorić S et al. (2020b). Microfossil assemblages (diatoms, calcareous nannofossils, and silicoflagellates), paleoenvironment, and hydrocarbon source rock potential of the Oligocene Ruslar Formation at Karadere, Bulgaria. Turkish Journal of Earth Sciences: 29: 154-169.

Vernyhorova YV, Ryabokon TS (2020). The stratigraphy of the Oligocene-lower Miocene deposits of the southern Ukraine. Turkish Journal of Earth Sciences: 29: 170-207.

Yücel AO, Özcan E, Erbil Ü (2020). Latest Priabonian larger benthic foraminiferal assemblages at the demise of the Soğucak Carbonate Platform (Thrace Basin and Black Sea shelf, NW Turkey): implications for the shallow marine biostratigraphy. Turkish Journal of Earth Sciences: 29: 85-114.