Review of Palaeobotany and Palynology 217 (2015) 9–38

Contents lists available at ScienceDirect

Review of Palaeobotany and Palynology

journal homepage: www.elsevier.com/locate/revpalbo

Dinoflagellate cyst biostratigraphy of the upper Eocene and lower Oligocene of the Kirmizitepe Section, Azerbaijan, South Caspian Basin

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ARTICLE INFO

Article history:
Received 27 August 2013
Received in revised form 30 January 2015
Accepted 1 March 2015
Available online 10 March 2015

Keywords:
Dinoflagellate cyst
Upper Eocene
Lower Oligocene transition
Biostratigraphy
South Caspian Basin
Azerbaijan

ABSTRACT

The South Caspian Basin is a deep Cenozoic basin located in eastern Paratethys along the northern margin of the Arabia–Eurasia collision zone. The basin, with its proven oil and gas reserves, has been the subject of numerous biostratigraphic studies, but most of these studies have concentrated on the Pliocene reservoir rocks. Precise chronological correlations between Paratethyan sedimentary successions and Mediterranean stages have not yet been achieved, although detailed local foraminiferal and non-foraminiferal biostratigraphic studies allow chronostratigraphic division and accurate regional correlations. As a pioneering work, this paper provides a detailed dinoflagellate cyst biostratigraphy of the upper Eocene and lower Oligocene deposits in the South Caspian Basin. A total of 127 dinoflagellate cyst taxa have been studied for the first time from the Eocene Koun Formation and the Oligocene part of the Maykop Formation exposed in the Kirmizitepe Section, Azerbaijan. Three dinoflagellate cyst biozones known from classic areas in central Italy are recognizable in the South Caspian Basin. One (Aal zone) is uppermost Eocene and two (Gse and Adi zones) are lower Oligocene. Thus, although some dinoflagellate cyst species from the studied section have stratigraphic ranges different from those of mid and higher latitudes, others provide correlations with previously defined biozones and dinoflagellate cyst events in the Tethyan realm and northwestern Europe. Dinoflagellate cyst assemblages indicate shallow marine depositional conditions for the latest Eocene. Deeper conditions prevailed during the earliest part of the early Oligocene, succeeded by a pronounced shallowing later in the early Oligocene.

1. Introduction

The South Caspian Basin (SCB) is highly petroliferous; proven liquid and gas reserves in the Azeri sector have estimated capacities between 6.6–8.1 Bbbl oil and 21–34 Tcf gas (Vincent et al., 2005). Petroleum exploration in the SCB has been ongoing for over 175 years with the first oil exploration well drilled in 1848 (Narimanov and Palaz, 1995; Abrams and Narimanov, 1997; Smith-Rouch, 2006).

The basin is located in the center of the Alpine–Himalayan orogen (Katz et al., 2000; Brunet et al., 2003; Smith-Rouch, 2006; Artyushkov, 2007) (Fig. 1). Its northern boundary is along the Apsheron–Balkhan sill that links the orogenic structures of the Greater Caucasus and Kopet Dagh (Artyushkov, 2007), bordering the Middle Caspian Basin to the north and the deep Kura Basin to the west. In the east it grades into the West Turkmenistan Basin and is bounded by the Kopet Dagh range further in the east (Artyushkov, 2007). The southern and southwestern borders of the SCB are formed by the Alborz and Talysh mountains (Hinds et al., 2004; Smith-Rouch, 2006; Artyushkov, 2007) (Fig. 1).

Well-calibrated age assessments for marine Paleogene deposits in the SCB are largely unknown, even though the Maykop Formation is a world class source rock and Paleogene sequences are widely distributed and have been subjected to numerous geological studies.

Therefore, this study aims to 1) document dinoflagellate cyst assemblages of the upper Eocene and lower Oligocene from the SCB, 2) present detailed palynostratigraphical implications for the upper Eocene and lower Oligocene, 3) compare the stratigraphically important dinoflagellate cyst events observed with those documented from adjacent regions in the Tethyan realm and northwestern European basins.

2. Geological setting

The breakup of the Pangean continent and the northward drift of India and Australia characterize the Mesozoic Tethyan Ocean (Rögl, 1998, 1999). The India–Asia collision and the convergence between the Arabian and Eurasian plates resulted in uplift of the Caucasus region during the late Eocene and Oligocene. Following this uplift, the Tethyan Ocean began to close and the Black Sea and Caspian Sea became a separated structural depression (Jones and Simmons, 1996, 1997; Rögl, 1998, 1999; Ershov et al., 1999; Smith-Rouch, 2006; Brunet et al., 2003; Golonka, 2004). As an initial response to these plate collisions, a series of east–west trending sedimentary basins extending from the

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http://dx.doi.org/10.1016/j.revpalbo.2015.03.002
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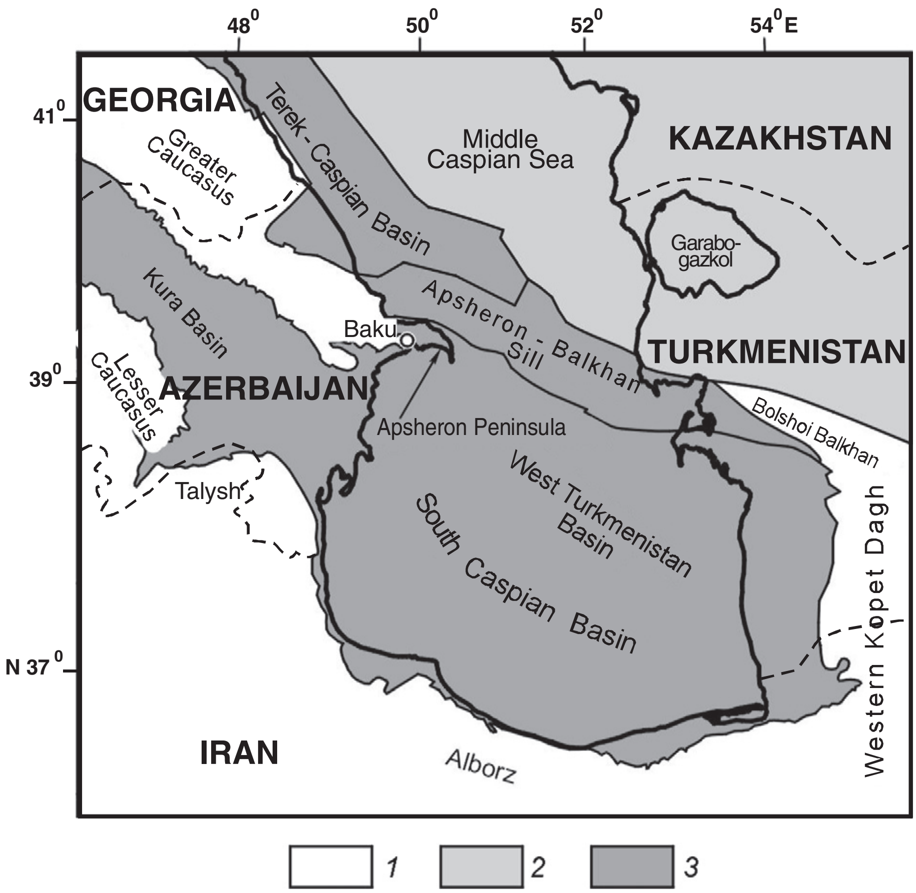

Fig. 1. Main tectonic units of the South Caspian Basin and its surroundings (modified from Artyushkov, 2007). 1—Alpine orogens, 2—Sedimentary basins of Middle Caspian and adjacent part of Turan Platform, 3—Deep sedimentary basins of the South Caspian and its surroundings (dashed lines indicate country borders).

western Molasse Basin in Switzerland and Rhône Basin in the west to the Aral Sea in Central Asia in the east formed, collectively constituting the intracontinental Paratethyan Basin (Jones and Simmons, 1996, 1997; Rögl, 1998, 1999; Meulenkamp and Sissingh, 2003; Islamoğlu et al., 2008) (Fig. 2). The concept of an isolated Paratethyan marginal sea was first introduced by Laskarev (1924), restricted to the Neogene, deduced from specific faunal and floral aspects. Following investigations of Oligocene sequences that demonstrated that the formation of an isolated Paratethys Sea had started around the Eocene–Oligocene (E–O) boundary, the "Paratethys" concept was extended to the Paleogene (Rögl, 1999; Steininger and Wessely, 2000; Schulz et al., 2005). The birth of Paratethys as a marginal sea at the E–O boundary is reflected by the basin-wide occurrences of organic rich sediments in stagnant and anoxic bottom water conditions (Popov et al., 1993; Popov and Stolyarov, 1996; Rögl, 1998, 1999; Schulz et al., 2005; Smith-Rouch, 2006; Artyushkov, 2007; Harzhauser and Piller, 2007; Shillington et al., 2008), which act as hydrocarbon source rocks in many parts of Paratethys (Schmidt and Erdoğan, 1996; Ziegler and Roure, 1999; Gürgey, 2003; Schulz et al., 2005; Smith-Rouch, 2006; Artyushkov, 2007; Sachsenhofer et al., 2009). These anoxic conditions persisted throughout the early Miocene in the deep basin representing the most extensive, longest anoxic event of the 'North-Peritethys' history, whereas regressive conditions developed on the platform after a short-term transgression at the beginning of the Miocene (Popov and Stolyarov, 1996).

Uplift of the major tectonic compression zones through the Miocene–Pliocene created the Greater Caucasus and Kopet Dagh mountain ranges and became the main control on widespread marginal to non-marine sedimentation when eustatic sea level was falling (Jones and Simmons, 1996, 1997; Smith-Rouch, 2006). The recurrent severing of the connection between the Paratethys and the world's oceans through its history, led to the evolution of largely endemic faunas and floras (particularly in eastern Paratethys) and this makes stratigraphic correlation between established Mediterranean and Paratethyan stages extremely difficult (Harzhauser et al., 2004; Jones and Simmons, 1996, 1997). Within this isolated Paratethys Sea, the SCB is a deep, Cenozoic midland and situated along the northern margin of the Arabia–Eurasia collision zone in eastern Paratethys. It comprises a deep and thick central basin in the southern part of the Caspian Sea and thinner prolongations to the east and west onshore (Brunet et al., 2003). The basin probably formed by back arc spreading related to the subduction of Neotethyan oceanic crust under southern Eurasia (Brunet et al., 2003; Hinds et al., 2004). It has geophysical properties similar to either unusually thick oceanic crust or thinned high-velocity continental crust (Berberian, 1983; Hinds et al., 2004; Vincent et al., 2010).

The SCB has one of the thickest sedimentary covers (more than 20 km) known for any basin within a regional compressional tectonic setting (Berberian, 1983; Brunet et al., 2003; Hinds et al., 2004; Artyushkov, 2007; Vincent et al., 2010). The sedimentary cover comprises two main lithologic units. The lower succession (10 km thick) consists mainly of marine mudrocks deposited from the Paleocene to the latest Miocene. Maykopian source rocks make up a part of this lower unit with thicknesses varying from hundreds of meters to 2–3 km (Jones and Simmons, 1996, 1997; Artyushkov, 2007). The upper Cretaceous–lower Paleocene Ilkhidag Formation is composed of whitish colored marls and the upper Paleocene Sumgait Formation is composed of reddish to greenish shales and marls. Eocene sediments overlying the Sumgait Formation are represented by the Koun Formation which comprises two sub-units; Bartonian-aged Kumian and Priabonian-aged Beloglinian. The Oligocene–lower Miocene Maykop