Global and Planetary Change 141 (2016) 63–81

Contents lists available at ScienceDirect

Global and Planetary Change

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

Mediterranean-Paratethys connectivity during the Messinian salinity crisis: The Pontian of Azerbaijan

Christiaan G.C. van Baak [a,*], Marius Stoica [b], Arjen Grothe [c], Elmira Aliyeva [d], Wout Krijgsman [a]

[a] Paleomagnetic Laboratory "Fort Hoofddijk", Utrecht University, Budapestlaan 17, 3584 CD Utrecht, The Netherlands
[b] Department of Geology, Faculty of Geology and Geophysics, University of Bucharest, Balcescu Bd. 1, 010041 Bucharest, Romania
[c] Marine Palynology and Paleobotany, Utrecht University, Heidelberglaan 2, 3584 CD Utrecht, The Netherlands
[d] Geological Institute of Azerbaijan (GIA), H. Javid Av. 29A, AZ1143 Baku, Azerbaijan

ARTICLE INFO

Article history:
Received 24 July 2015
Received in revised form 29 February 2016
Accepted 18 April 2016
Available online 21 April 2016

Keywords:
Caspian Sea
Late Miocene
Paratethys-Mediterranean connectivity
Messinian Salinity Crisis
Pontian
Paratethys Outflow Water

ABSTRACT

Prior to the onset of the Messinian Salinity Crisis, a connection was established between the Mediterranean Sea and the Paratethys region to the north. Rivers currently draining into the Caspian Sea thereby became important for the Mediterranean hydrological budget. The role of this connection and the influence of the Paratethys on the hydrological budget of the Mediterranean Sea during the Messinian Salinity Crisis is however poorly understood because of a lack of records in the Paratethys with a high-resolution (cyclostratigraphic) age model. Here, we present a high-resolution integrated stratigraphic study of a key section in the Caspian Sea region (Azerbaijan), to assess the connectivity of the Caspian Sea during the salinity crisis. The studied section spans the time interval between ~6.16 Ma and <5.38 Ma, and records continuous deposition under brackish-marine conditions. We show the connection between the Mediterranean Sea and the Caspian Sea formed at 6.12 ± 0.02 Ma. Across the onset of the Messinian Salinity Crisis, the studied section changes from anoxic to oxic conditions and an abundant ostracod fauna develops. A sea-level drop in the order of 100–200 m is evident from changes in the ostracod faunal assemblage and is dated at 5.6 Ma. The top of the section marks a second sea-level drop and the complete freshening of the record. The Pontian phase of Mediterranean-Paratethys connectivity represents a maximum size of Paratethys at a time of minimum Atlantic-Mediterranean connectivity. Enhanced Paratethys outflow water at this time likely led to increased stratification and affected the Mediterranean throughout the Messinian Salinity Crisis.

1. Introduction

The Mediterranean Sea is a semi-isolated oceanic basin locked between the Eurasian and African continents with a limited exchange with the Atlantic Ocean across the Strait of Gibraltar. The hydrological budget of the Mediterranean Sea is as a result affected by both low and high latitude freshwater influxes. Rivers draining into the Black Sea (e.g. Danube, Dniester, Dnieper and Don) contribute a large part of this northern component freshwater to the Mediterranean hydrological budget (Gladstone et al., 2007). The Late Miocene Mediterranean Sea was bounded in the north by a much larger sea compared to present, the Paratethys (Popov et al., 2006). In addition, the marine Atlantic influx into the Mediterranean Sea was significantly reduced, causing the basin to become even more susceptible to changes in the hydrological budget (Flecker et al., 2015). The primary consequence was the deposition of massive salt and gypsum units between 5.97 Ma and 5.33 Ma during the Messinian Salinity Crisis (MSC) (Roveri et al., 2014). The final stage of the MSC, the Lago Mare, saw the introduction of a diverse brackish Paratethyan fauna into the Mediterranean Sea (Stoica et al., 2015), indicating the importance of the northern Paratethys region to the hydrological budget of the Late Miocene Mediterranean Sea. The connection between Paratethys in the north and Mediterranean Sea in the south was also present throughout the first phase of the MSC (Primary Lower Gypsum (PLG), 5.97–5.6 Ma) (Vasiliev et al., 2013), indicating that the northern component fresh water to the Mediterranean Sea contributed to the hydrological budget during the MSC. The hydrological budget for the Late Miocene Mediterranean and Paratethys regions is an intertwined story, and especially relevant since recently gypsum formation in the Mediterranean Sea was linked to a potential freshwater origin (Natalicchio et al., 2014).

The Paratethys can be subdivided in sub-basins which are separated by shallow sills. Because of this, significant connectivity changes can occur as the result of only minor sea-level variations (Popov et al., 2010). A major change in basin connectivity occurred immediately prior to the MSC, where Mediterranean water flooded the Paratethys region (Krijgsman et al., 2010). The event can be recognized by a short-lived influx of higher salinity indicative benthic and planktonic foraminifera species (Stoica et al., 2013). The flooding opened previously

* Corresponding author.
E-mail address: C.G.C.vanBaak@uu.nl (C.G.C. van Baak).
URL: http://www.geo.uu.nl/~forth (C.G.C. van Baak).

http://dx.doi.org/10.1016/j.gloplacha.2016.04.005
0921-8181/

closed gateways, allowing mollusk and ostracod species to migrate between previously isolated basins (Nevesskaya et al., 2003). This event occurred in the Paratethys time scale of biostratigraphically defined regional stages around the boundary between the Maeotian and Pontian stages (Stevanovic et al., 1989). Recently, the Maeotian-Pontian (MP) flooding in the Dacian Basin of Romania and the Taman Peninsula in the Black Sea region has been shown to be an synchronous event (Krijgsman et al., 2010). This flooding event has been dated at ~6.1 Ma (Chang et al., 2014). The establishment of this connection immediately precedes the onset of the MSC which is dated at 5.96 ± 0.02 Ma (Krijgsman et al., 1999) and recently refined to 5.97 Ma (Manzi et al., 2013). Creating a marine connection between this sea draining large parts of central Europe and Central Asia, stretching up to 60° north and ~75° east, and a highly restricted Mediterranean Sea, would have affected the hydrological budget and potentially disturbed the circulation pattern in the Mediterranean Sea. Therefore, it is important to know the extent of the Paratethys Sea through time to assess at which stage of the MSC rivers currently draining into the Caspian Sea (e.g. Volga, Ural and Amu Darya) contributed to the Mediterranean hydrological budget.

Here we study a time-equivalent section of the MSC in the Caspian Sea area from a long and continuous land-based section in Azerbaijan. We will use an integrated stratigraphic approach, combining magnetostratigraphic dating with cyclostratigraphy to propose an age model and biostratigraphy (on ostracods, foraminifera and radiolarians) to constrain paleoenvironmental changes. We will focus in particular on the Pontian regional stage to more accurately date, and better describe the paleoenvironmental changes occurring during the MSC in the Caspian Sea. We will discuss the connectivity between Paratethys and Mediterranean Sea during the Messinian Salinity Crisis and the influence of the Paratethyan Outflow Water (POW).

2. Section description

The Adzhiveli section (40°18.440′N, 49°4.211′E) lies 60 km southwest of Baku in the middle of the Gobustan region in a synclinal structure exposing a long and continuous section of Pontian sediments (Fig. 1). Previously, this locality was studied paleomagnetically by Trubikhin (1989). In this area, Pontian deposits are unconformably overlain by Pliocene and/or Pleistocene deposits (Azizbekov, 1972). Further west, the overlying deposits are typical highstand deposits (e.g. Akchagyl)ian, showing the region was flooded during highstands and deposition was concentrated in deeper basinal areas during lowstands.

Overlapping trenches are dug up the hillslope through up to a meter of weathered sediment to enable a continuous logging and sampling of the section. A section of in total 170 m has been logged, stretching over three hills (Fig. 2a, b). The dominant lithologies are (silty) clays and marls which alternate in color between brownish grey and dark grey (Fig. 2c). Additionally, finely laminated sediments alternate on mm-

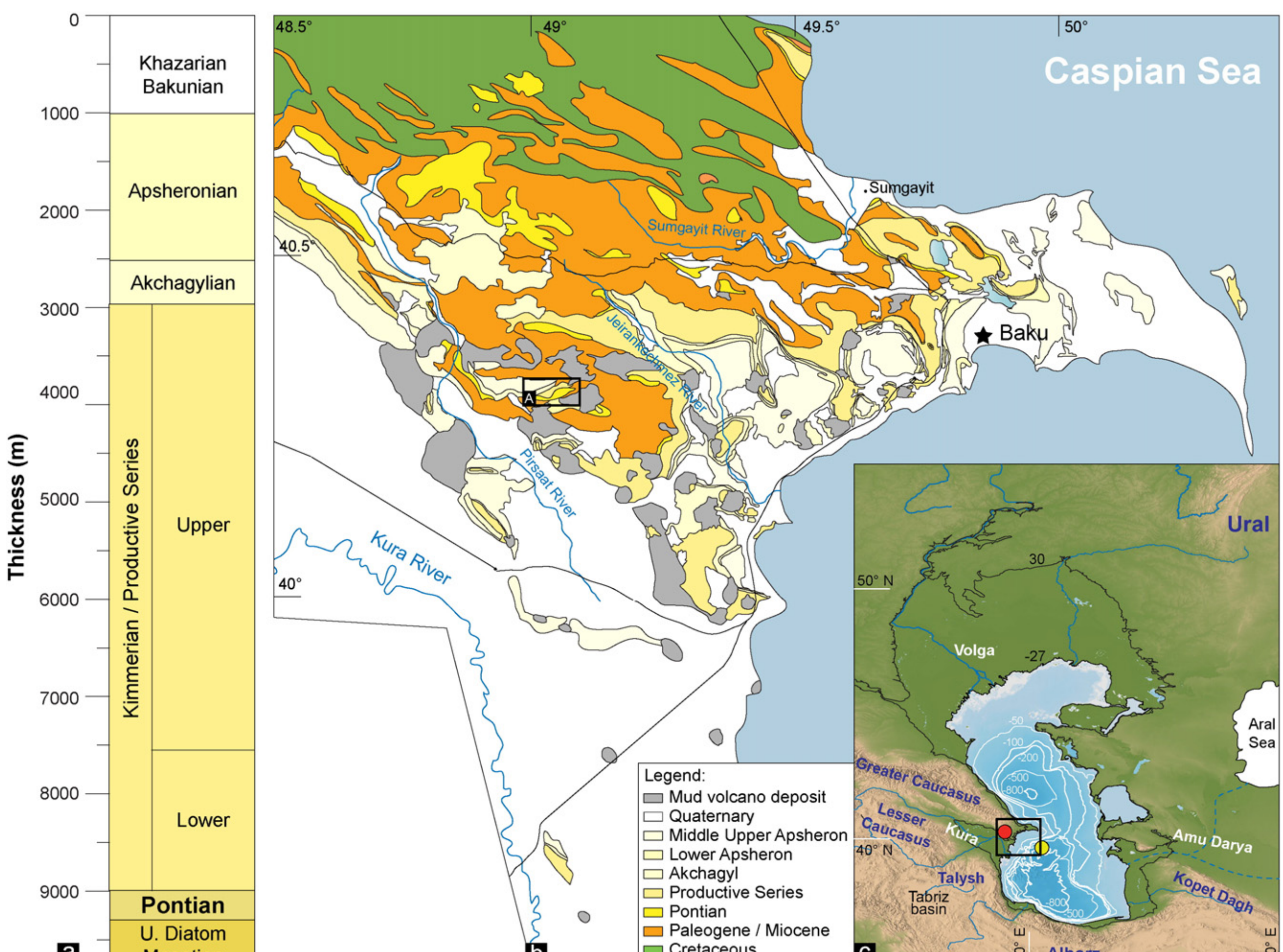

Fig. 1. a) South Caspian Basin stratigraphic nomenclature, stages plotted vs. stratigraphic thickness in an offshore location in the South Caspian Basin (after Allen et al. (2002)). b) Geological map of eastern Azerbaijan (simplified after Ministry of Geology and Mineral Resources (1960a; 1960d; 1960c; 1960b), box labelled A indicates the location of the Adzhiveli section. c) Geographical map of the Caspian Sea with major rivers and orogens. Bathymetry contours (in white) and the +30 m contour (black line) at which the Caspian Sea would overflow to the Black Sea. The red circle indicates the study area, the yellow circle the location of the Allen et al. (2002) record used in a).