Quaternary International xxx (2016) 1–13

Contents lists available at ScienceDirect

Quaternary International

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

MIS 5–1 dinoflagellate cyst analyses and morphometric evaluation of *Galeacysta etrusca* and *Spiniferites cruciformis* in southwestern Black Sea

Shannon Ferguson [a, b], Sophie Warny [a, b, *], Gilles Escarguel [c], Petra J. Mudie [d]

[a] Department of Geology and Geophysics, E-235 Howe-Russell, Louisiana State University, Baton Rouge, LA 70803, USA
[b] Museum of Natural Science, E-235 Howe-Russell, Louisiana State University, Baton Rouge, LA 70803, USA
[c] Laboratoire d'écologie des hydrosystèmes naturels et anthropisés, UMR CNRS 5023, Université Claude Bernard Lyon 1, Boulevard du 11 novembre 1918, F69622 Villeurbanne Cedex, France
[d] Geological Survey Canada Atlantic, Dartmouth, Nova Scotia B2Y 4A2, Canada

A R T I C L E I N F O

Article history:
Available online xxx

Keywords:
Dinoflagellate cysts
DSDP Site 380
Brackish
Paleosalinity
Sea level

A B S T R A C T

Here we evaluate the changes in dinoflagellate cyst assemblages and intraspecies morphometric variability in dominant Black Sea species during MIS 5–1 in sediment recovered from DSDP Site 380. Twenty-three taxa represent the majority of the 16,000 cysts tabulated. Qualitative assessment of assemblage composition indicates that the taxa are distributed in three ecological assemblages; marine stenohaline, marine euryhaline, and brackish Ponto-Caspian endemic species; the fluctuation of these assemblages provide evidence for changes in environmental conditions from the end of MIS 5e to MIS 1. Although some fluctuations in sea-surface salinity are highlighted by changes in dinoflagellate assemblages, the continuous presence of *Pyxidinopsis psilata*, *Galeacysta etrusca* and *Spiniferites cruciformis* likely indicate brackish conditions for most of the interval sampled at this site. Statistical analysis of measured morphometric changes in *Galeacysta etrusca* endocyst:ectocyst ratios indicate that the specimens recovered mostly belong to a smaller morphotype forming group 'b' of Popescu et al. (2009), interpreted as indicative of brackish–marine conditions after migration to the Mediterranean from the Paratethys. Although not fully conclusive because of sampling constraints and limited chronological control, the lack of sudden, large abundance changes in marine salinity-tolerant species the relatively low species diversity, and the sequence of sapropelic layers relative to banded clastic muds provides evidence against the occurrence of sustained marine flooding between ca. 0.07–0.007 Ma and it is not clear that the last interglacial marine highstand during MIS 5e was fully sampled at this site.

1. Introduction

The salinity of the Black Sea is controlled by the inflow of marine water through Marmara Sea and its shallow straits (Fig. 1) during marine highstands, and by precipitation and the volume of runoff from vast rivers draining Europe and Western Russia during and immediately after glacial marine regressions (Major et al., 2006) The unusual configuration and unique oceanographic features of the semi-isolated Black Sea makes it a fascinating biome to study unusual dinoflagellate cysts (Mudie et al., 2007; Ivanova et al., 2012; Yanko-Hombach et al., 2013, 2014) that have been able to adapt to large-scale salinity fluctuations and can tell us about these past environmental changes. Some of these cysts are relics of the Pliocene Paratethyan Seas, while others are more recent Mediterranean immigrants (Marret et al., 2015). Here we provide new data on late Pleistocene to early Holocene dinoflagellate cyst assemblages recovered from DSDP Site 380 in deep water at the base of the western continental slope apron, 2107 m water depth. Morphological changes seen in two of the most abundant relic Paratethyan endemic dinoflagellate cyst species present, *Galeacysta etrusca* and *Spiniferites cruciformis*, are combined with dinoflagellate assemblage data to evaluate a possible morphological response of the cysts to changes in sea-surface salinity and to examine the impact of sea-level changes and the history of the connections.

* Corresponding author. Department of Geology and Geophysics, E-235 Howe-Russell, Louisiana State University, Baton Rouge, LA 70803, USA.
E-mail address: swarny@lsu.edu (S. Warny).

http://dx.doi.org/10.1016/j.quaint.2016.07.035

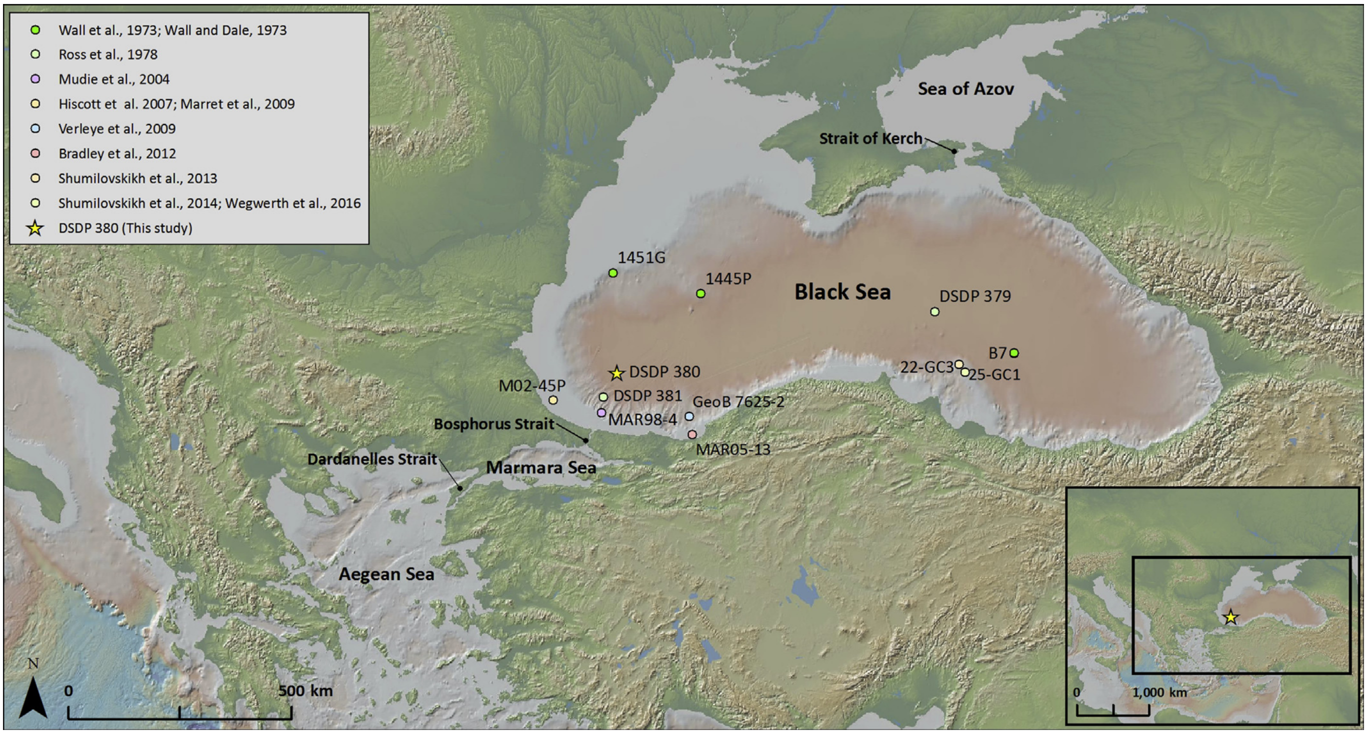

Fig. 1. Location of the study area showing DSDP Site 380 in proximity to the connections between the Eastern Mediterranean Sea and the Marmara Sea.

Furthermore, discriminant analysis is performed to verify the morphometric variations between these two different dinoflagellate species. DSDP Site 380 (Fig. 1) was selected for its proximity to the narrow Bosphorus Strait as drops in eustatic sea level during the glacials disconnected the Black Sea from Marmara and the Aegean Sea, creating a change from higher salinities to more brackish water conditions that should be evidenced at the studied site. These salinity changes were further overprinted by fluctuations in evaporation (E) relative to total freshwater input (P) derived from runoff, melt water and rainfall and will be discussed as well (Major et al., 2006; Wegwerth et al., 2016).

Debate exists on the exact timing of connections between the low salinity Black Sea and more saline Mediterranean between the last interglacial maximum (high salinity phase, MIS 5e) and the Holocene interglacial (MIS 1). Two main scenarios exist for the Late Pleistocene–Holocene marine reconnection: 1) a rapid (Catastrophic Flood model (Ryan et al., 1997, 2003; Major et al., 2006; Lericolais et al., 2007; Soulet et al., 2011) around 8.4 ka BP, and 2) the Progressive or Gradual Flood model starting around 11 ka BP (Hiscott et al., 2007; Aksu et al., 2002a). In addition to debates over the timing of the Holocene marine transgression in the Black Sea, there are significant disagreements regarding the timing and manner of marine reconnections between the Aegean, Marmara and Black Seas during MIS 3 and regarding the salinity of the Black Sea after MIS 5e (Karangatian highstand 130–115 ka BP). Benthic foraminifera (Yanko-Hombach, 2007) and some mollusk data (e.g. Aksu et al., 2002b; Panin and Popescu, 2007) indicate a marine incursion in the southwestern Black Sea during MIS 3 (Tarkankutian beds, dated 40–27 ka BP; Surozhian interstade 40–25 ka BP) and show that during the Karangatian, salinity was higher, being comparable to that of the present Mediterranean, ranging from ca. 30–37 psu (practical salinity unit). Dinoflagellate cyst assemblages in the southeastern Black Sea (Shumilovskikh et al., 2013) also indicate a higher salinity and temperature for MIS 5e. Oxygen isotope records from Sofular Cave (Badertscher et al., 2011) indicate marine connections only during MIS 5e and the Holocene, as also evident in the absence of an Aegean Sea sapropel between the end of MIS 5 (71 ka BP) and early MIS 1 (İşler et al., 2016). In contrast, there are three MIS 5 sapropel layers in the northern Aegean Sea (S3, S4 and S5), with well constrained median termination ages at 70.8, 96.2 and 121.0 ka BP (İşler et al., 2016).

2. Regional setting

The Black Sea is a large, deep semi-enclosed basin located between southeastern Europe and Asia (Fig. 1). The Black Sea is thought to have evolved from a freshwater lake to a brackish–marine basin around the Oligocene – Miocene (Muratov et al., 1978). From the Miocene onwards, the basin has been characterized by successive fluctuations between brackish to fresh water conditions (Muratov et al., 1978). The present marine connection to the Mediterranean Sea is complex as the shallow Bosphorus Strait first connects the Black Sea to the Marmara Sea, which then connects to the Aegean and Mediterranean seas through the deeper Dardanelles strait (Fig. 1). The Bosphorus strait is relatively shallow (average 40 m), with a minimum depth of about 30 m near Istanbul, Turkey. The depth of this connection limits the salinity, stratification and oxygen exchange within the Black Sea (Kerey et al., 2004). In addition to this marine connection, the Black Sea is connected to the almost freshwater (<11 psu) Sea of Azov through the narrow Strait of Kerch. At a maximum depth of 15 m, the Sea of Azov is the presently shallowest sea in the world. At present, it provides a constant freshwater outflow to the Black Sea via the Don River (Kosarev et al., 2008) and it was probably a large river valley during intervals of lower sea level. However, during the late Pleistocene, it was connected to the Caspian Sea via the Manych River valley floodway (Major et al., 2006) from which reddish-brown "chocolate" clays flooded into the northern and western Black Sea around 16–18 cal ka BP (Major et al., 2006). Although the Black Sea hydrographic configuration is largely controlled by fluvial inputs from

Please cite this article in press as: Ferguson, S., et al., MIS 5–1 dinoflagellate cyst analyses and morphometric evaluation of *Galeacysta etrusca* and *Spiniferites cruciformis* in southwestern Black Sea, Quaternary International (2016), http://dx.doi.org/10.1016/j.quaint.2016.07.035