Palaeogeography, Palaeoclimatology, Palaeoecology 419 (2015) 60–74

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

Ostracoda (Crustacea) as indicators of subaqueous mass movements: An example from the large brackish lake Tangra Yumco on the southern Tibetan Plateau, China

Lailah Gifty Akita [a], Peter Frenzel [a,*], Torsten Haberzettl [b], Thomas Kasper [b], Junbo Wang [c], Klaus Reicherter [d]

[a] Friedrich Schiller University Jena, Institute of Geosciences, Burgweg 11, 07749 Jena, Germany
[b] Friedrich Schiller University Jena, Institute of Geography, Department of Physical Geography, Löbdergraben 32, 07743 Jena, Germany
[c] Institute of Tibetan Plateau Research, Chinese Academy of Sciences, No. 16 Lincui Road, Chaoyang District, Beijing 100101, China
[d] RWTH Aachen University, Neotectonics and Georisks, Lochnerstr. 4-20, 52056 Aachen, Germany

ARTICLE INFO

Article history:
Received 6 February 2014
Received in revised form 29 July 2014
Accepted 3 August 2014
Available online 12 August 2014

Keywords:
Ostracods
Microfossils
Lacustrine turbidites and debrites
Dang Reyongcuo
Tibetan Autonomous Region
Holocene

ABSTRACT

A conceptual model of subaquaeous mass movements and ostracod distribution in lacustrine sediment event layers was tested. Integrated methods (geophysical, sedimentological and microfossil analyses) were performed on a short sediment core retrieved from 220 m water depth in the large brackish lake Tangra Yumco on the southern Tibetan Plateau, central Asia. The event layers of the core and their underlying and overlying sediments were investigated. Four major event layers composed of sandy silt with graded bedding are interpreted as turbidites. The fifth layer consisting of fine sand and silt and without graded bedding is characterized as a debrite.

The ostracods, small bivalved aquatic crustaceans, identified are *Leucocytherella sinensis* Huang, 1982, *Leucocythere*? *dorsotuberosa* Huang, 1982, *Limnocythere inopinata* (Baird, 1843) and *Fabaeformiscandona gyirongensis* (Huang, 1982).

Ostracod evidence is a good proxy for the evaluation of massive sediment event layers formed by subaqueous mass movements. Four assumptions of a conceptual model were confirmed: (i) fine grained sediments of event layers (turbidite deposits) contain very low numbers of ostracods compared to the underlying and overlying sediments; (ii) ostracods are sorted according to size and display high abundance and high proportion of adult valves of *Leucocytherella sinensis* at the base of event layers; (iii) a relatively low number of carapaces is present within the event layers; and (iv) the recolonization of newly event-generated habitats by pioneer assemblages transforming into pre-event association gradually.

1. Introduction

Mass movements (e.g, slumps, mass failures, landslides) can transport large amounts of sediment within a very short time (minutes to hours) in lacustrine and marine environments (Martinsen, 1994; Owen et al., 2011; Sauerbrey et al., 2013). Subaqueous mass movements (e.g., bottom current, turbidity current, debris flows) play a significant role in the transport (Covault, 2011; Talling et al., 2013) and redistribution of sediments from shallow to deep water environment of lakes and oceans (Shanmugam, 1996; Stow et al., 2002; Smith, 2004; Bernhardt et al., 2012; Talling et al., 2012). Turbidity currents and debris flows evolve due to mass failure processes along submerged sediment-covered slopes that may originate from various processes including flooding, lake level fluctuation, rapid sedimentation, earthquake, gravity-flow, density-flow, and glacial and tidal loading (Locat and Lee, 2002; Monecke et al., 2004; Hilbe et al., 2011; Smith et al., 2013). Some of these geological processes act on the submerged slopes over longer periods while others are of instantaneous nature. The local instability of submerged sediment-covered slopes is a common feature in the lacustrine and marine environment and these events can impact offshore and coastal infrastructure (Lee, 2005; Schnellmann et al., 2006; Fanetti et al., 2008). Assessment of event layers caused by subaqueous mass movement may provide a better understanding of the distribution of palaeoseismic events on spatial and temporal scales (Mutti et al., 1984). In some settings, identification of phases of enhanced rapid mass movement due to climatic variation may also provide palaeoclimatic evidence (Mattews et al., 1997). Turbidity currents, suspension of sediment that are sustained by fluid turbulence, are widespread in many deep-water settings and form successions up to kilometers in thickness. Individual turbidite beds range in thickness from a few millimeters to several meters in thickness with gradded bedding (coarse, medium and fine-grained beds). The origin of turbidity currents was first postulated in lakes (Forel, 1892; Girardclos et al., 2012), however the

* Corresponding author. Tel.: +49 3641 948619; fax: +49 3641 948622.
E-mail address: peter.frenzel@uni-jena.de (P. Frenzel).

http://dx.doi.org/10.1016/j.palaeo.2014.08.003

lacustrine turbidites (Harrison, 1975; Shiki et al., 2000; Twichell et al., 2005) are less frequently investigated than their marine equivalent (Stow and Bowen, 1980; Middleton, 1993; Dade and Huppert, 1994; Mulder et al., 2003; Satur et al., 2004). The tails of incoming tubidity currents provide high accumulation of sediments and the flow transforms into non-turbulence muddy debris flow (Weaver, 1994). Debris flow deposits (debrites) are classified as a mixture of sediments and water forming a slurry that moves downslope under the action of gravity. Debrites formed are without internal bedding and lamination (Locat and Lee, 2001, 2005). Investigation of massive sediment transported into deep water from an orginal shallow water setting is the most effective and indispensable strategy for identification of past mass movement and the threshold of different types of event sedimentation in the geological record (Einsele et al., 1996; Shiki, 1996). Benthic organisms are sensitive proxies of subaqueous mass movement (Bangs et al., 2000; Oloson and Thompson, 2005).

Ostracods (Crustacea, Arthropoda) are small bivalved crustaceans enclosed by a low-magnesium calcite carapace made up of two valves which are easy to fossilize. They are found in most aquatic habitats and even some terrestrial ecosystems (Forester, 1991; Danielopol et al., 1994; Meisch, 2000; Horne et al., 2002). Lacustrine ostracods are mostly benthonic. They can be found living on aquatic plants, crawling on sediment (epifauna) and within the sediment (infauna). Ostracods have the ability to reflect the environment in fresh, brackish and marine waters (Yang, 1988; Frenzel and Boomer, 2005; Mischke, 2012) due to their specific ecological preference and tolerance (Mezquita et al., 2001; Holmes and Chivas, 2002; Kulkoyluoglu and Sari, 2012). Ostracods are important biological indicators and their microfossils are useful for the description of stratigraphical sequence and palaeoenvironmental change (Mischke et al., 2003; Zhu et al., 2010), habitat type (Mezquita et al., 2000; Kulkoyluoglu, 2004; Kiss, 2007; Dugel et al., 2008), water quality (Padmanabha and Belagali, 2008; Pieri et al., 2012), water depth (Wrozyna et al., 2009a; Frenzel et al., 2010), dissolved oxygen concentration (Boomer and Whatley, 1992; Whatley et al., 2003; Corbari et al., 2004), hydrochemical change (Carbonel and Peypouquet, 1983; Smith, 1993; Curry, 1999; Mischke et al., 2007) and other environmental variables.

Ostracods are commonly found in lake sediments when other important proxy organisms (e.g., diatoms) are not present (Holmes, 2001; Holmes and Chivas, 2002). Fossil ostracod associations are indicators of past environmental and climatic conditions on the Tibetan Plateau (Peng, 1997; Mischke et al., 2005). The use of ostracods as indicators of mass movements is well established in the marine realm (Dingle et al., 1989; Ikeya and Cronin, 1993; Cronin et al., 1994; Arias, 2007). Nonetheless, the application in lacustrine environments is still unknown (De Deckker et al., 1979).

Ostracods are good indicators for the assessment of short-lived sediment events due to (i) their ability to reflect specific depositional environments with depth and time, (ii) their rapid response to environmental disturbances, (iii) potential discrimination of allochthonous from autochthonous valves and shallow water species from deep-water species, which could reflect different types of sediment transport processes, (iv) the ability to quantify fossil remains (expressed in abundance) and (v) by any failure of sedimentary evidence, ostracods could be used to identify subaqueous mass movement.

In this paper, we use ostracods to identify lacustrine subaqueous mass movements in the large brakish lake Tangra Yumco, central Asia. Integrated geophysical, sedimentological and micropalaeontologicial analyses of a short sediment core from this lake are discussed. The objectives are; (i) to characterize sediment event layers formed by subaqueous mass movements and (ii) to examine the potential of lacustrine ostracods as indicators of subaqueous mass movements.

The four criteria defined for our conceptual model of sediment features and ostracod distribution caused by subaqueous mass movement in large lakes, based on theoretical considerations, are:

(i) The thickness of an event-layer varies with the distance from the source. This involves the transport of sediment from a submerged slope (proximal areas) to the depositional environment (distal areas), which is the deeper bottom of the lake basin (Fig. 1A–C). The two characteristics of an event are: (a) coarser grained sediment is eroded from the steep slope at proximal areas. There is successive deposition of suspended subaqueous sediment forming a graded bedding at distal areas. The pre-event to event transition is characterized by an autochthonous ostracod association which is replaced by allochthonous ostracods during the transport of sediment from shallower water to the deeper environment (Fig. 1B–C top). Abundance of ostracods is distinctively lower within the event layer than the underlying and overlying sediments. (b) Sediment is transported as bed load and then accumulated as fine grained sediment at distal areas. The event layer contains fewer ostracods due to sorting out of the heavier valves during transport (Fig. 1B–C bottom).

(ii) A fining-upward gradation of sediment within the event layer (Fig. 1B top). The base of proximal event layer is composed of coarse-grained sediment. Redepostion of sediment involves the settling of smaller grains, which are held in suspension by currents during transport, forming a newly finer-grained muddy sediment with a coarse-grained layer on top of the event layer. The par-autochthonous pre-event ostracod association consist of articulated valves whereas carapaces are lacking from transported ostracod associations within the event layer. This is caused by the separation of articulated valves in the turbidity current. Carapaces may be cemented by sediment casts and encrustation. The sediment infill and encrustation cause the ostracod carapaces to be more stable and heavier creating enrichment of double-valved specimens within the sand-size fraction. The event layer at distal areas does not contain coarse-grained sediment due to the sorting by transport (Fig. 1B bottom). A shift from higher to lower adult/juvenile valve ratios occurs from proximal to distal sedimentation areas due to sorting. Furthermore, juvenile valves are smaller and lighter in weight than adult valves, facilitating transportation.

(iii) Biocoenoses (life assemblages) are buried by a subaqueous mass movement. In this case, the underlying distal event layer is characterized by a higher proportion of carapaces than the sediments underlying and overlying the event layer.

(iv) Recolonization of the post-event sediments (Fig. 1C) by opportunistic species with a high dispersal ability and adapted to newly muddy substrate of the event layer.

2. Study area

Tangra Yumco (30°45′–31°22′N and 86°23′–86°49′E) is located about 450 km northwest of Lhasa, the capital city of the Tibetan Autonomous Region (Fig. 2). Tangra Yumco is also known as Dang Reyongcuo, Dangre Yumtso and Tanghlha Yumco. The large brackish lake is situated at the northern flank of the central section of the Gangdise mountain within a 300 km long and 40 km wide north–south trending graben (Fig. 3), which consists of three sub-basins: Tangqung Co (also called Tangra Qonco) is situated to the north, Monco Bunyi in the middle and Xuru Co to the south (Xu et al., 2006; Cao et al., 2009). The normal faults cut through the western part of the Lhasa block (Gao et al., 2007; Kong et al., 2011). The Tibetan region is prone to frequent earthquakes (Taylor and Yin, 2009; Wu et al., 2013). The Tangra Yumco rift basin is characterized by moderate seismicity based on data from the USGS database (http://earthquake.usgs.gov/earthquakes/eqarchives). A N20-striking trend of epicenters around Tangra Yumco is observed. In the adjacent areas earthquake foci are rather scattered. The earthquakes recorded instrumentally are on the order of around 6 Mmax and have shallow foci. Rare focal mechanisms (http://www.globalcmt.org/CMTsearch.html) of larger earthquakes demonstrate dominant strike-