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Research paper

Submarine erosional troughs in the northern South China Sea: Evidence for Early Miocene deepwater circulation and paleoceanographic change

Qiliang Sun [a, b, *], Joe Cartwright [c], Shiguo Wu [d], Guangfa Zhong [e], Shenghao Wang [f], Hailong Zhang [g]

[a] *Key Laboratory of Tectonics and Petroleum Resources of Ministry of Education, Faculty of Resources, China University of Geosciences, Wuhan 430074, China*
[b] *Department of Marine Science and Engineering, Faculty of Resources, China University of Geosciences, Wuhan 430074, China*
[c] *Department of Earth Sciences, University of Oxford, Oxford OX1 3AN, England, UK*
[d] *Sanya Institute of Deep-sea Science and Engineering, Chinese Academy of Sciences, Sanya 572000, China*
[e] *State Key Laboratory of Marine Geology, Tongji University, Shanghai 200092, China*
[f] *Shenzhen Branch of CNOOC Ltd., Guangzhou, China*
[g] *Qinghai Oilfield Research Institute of Exploration & Development, Dunhuang 736202, China*

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ABSTRACT

The paleoceanography of the South China Sea (SCS) is poorly understood, although recent cruises and an ODP expedition (Leg 184) have provided a useful general framework. Here we report previously unrecognized multi-km scale sedimentary structures consisting of coupled ridges and troughs within the Early Miocene strata, using high-resolution 3D seismic data from the northern SCS margin. The troughs are interpreted as linear and/or arcuate erosional features which truncate the underlying strata. They range in orientation from E-W in the southern part of the study area to nearly NE-SW in the northwestern part of the study area. The spacing of erosional troughs varies from less than 0.1 km in the southern part to more than 3 km in the northern part, and they are about 50–1500 m in width, with a relief of 10–90 m. The erosional troughs are parallel to the regional strike of the Early Miocene slope of the northern SCS. From their internal geometry, context, regional distribution and most importantly their orientation relative to the paleo-slope gradient at the time of their formation, it is argued that they formed due to the action of bottom currents linked to the broader paleo-circulation regime in the basin. We infer that the paleo-bottom currents intruding from the Pacific flowed along the northern SCS slope, resulting in the occurrence of localized erosional troughs as deep water masses impinged on and interacted with the sea floor topography. This study provides new insights into the Early Miocene paleoceanography of the SCS and demonstrates the utility of 3D seismic data to enhance our understanding of paleo-bottom current circulation regimes.

1. Introduction

Contourites and associated erosional features created by bottom currents have been observed over basin-floor regions and slopes of continental margins worldwide (e.g. Faugères et al., 1999; Knutz and Cartwright, 2003; Hernández-Molina et al., 2006; Andresen et al., 2008; Kilhams et al., 2011; Rebesco et al., 2014). They are crucial repositories of sedimentary and geochemical data for the study of paleoclimatology and paleoceanography, slope-stability/geological hazard assessment and hydrocarbon exploration (e.g., Wynn and Stow, 2002; Rebesco, 2003; Hernández-Molina et al., 2006; Hohbein and Cartwright, 2006). Ancient ocean circulation and climate can be inferred from contourite depositional systems using discrete sampling analyses (e.g. geochemical, faunal and sedimentological techniques) (Rebesco et al., 2014). However, because of the large scale of contourite bodies and limited coverage of lithological sections, the gross depositional construction of large

* Corresponding author. Key Laboratory of Tectonics and Petroleum Resources of Ministry of Education, Faculty of Resources, China University of Geosciences, Wuhan 430074, China.
E-mail address: sunqiliang@cug.edu.cn (Q. Sun).

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contourite bodies is only really tractable with seismic-stratigraphic approaches (e.g. Knutz and Cartwright, 2003; Gong et al., 2012; Chen et al., 2014). The wide variety of bottom current-generated bedforms caused by erosion, moulding, sediment transportation and redistribution of bottom currents provide important insights into the local effects of bottom-current action (Fig. 1) (Stow et al., 2008; Sayago-Gil et al., 2010; Van Rooij et al., 2010; Campbell and Deptuck, 2012; Rebesco et al., 2014; Gong et al., 2015). Since these bedforms can be readily identified and mapped using both 2D and 3D seismic data, such data can provide excellent constraints on paleo-bottom current pathways and on changes in current energy and direction (Faugères et al., 1999; Knutz and Cartwright, 2003,

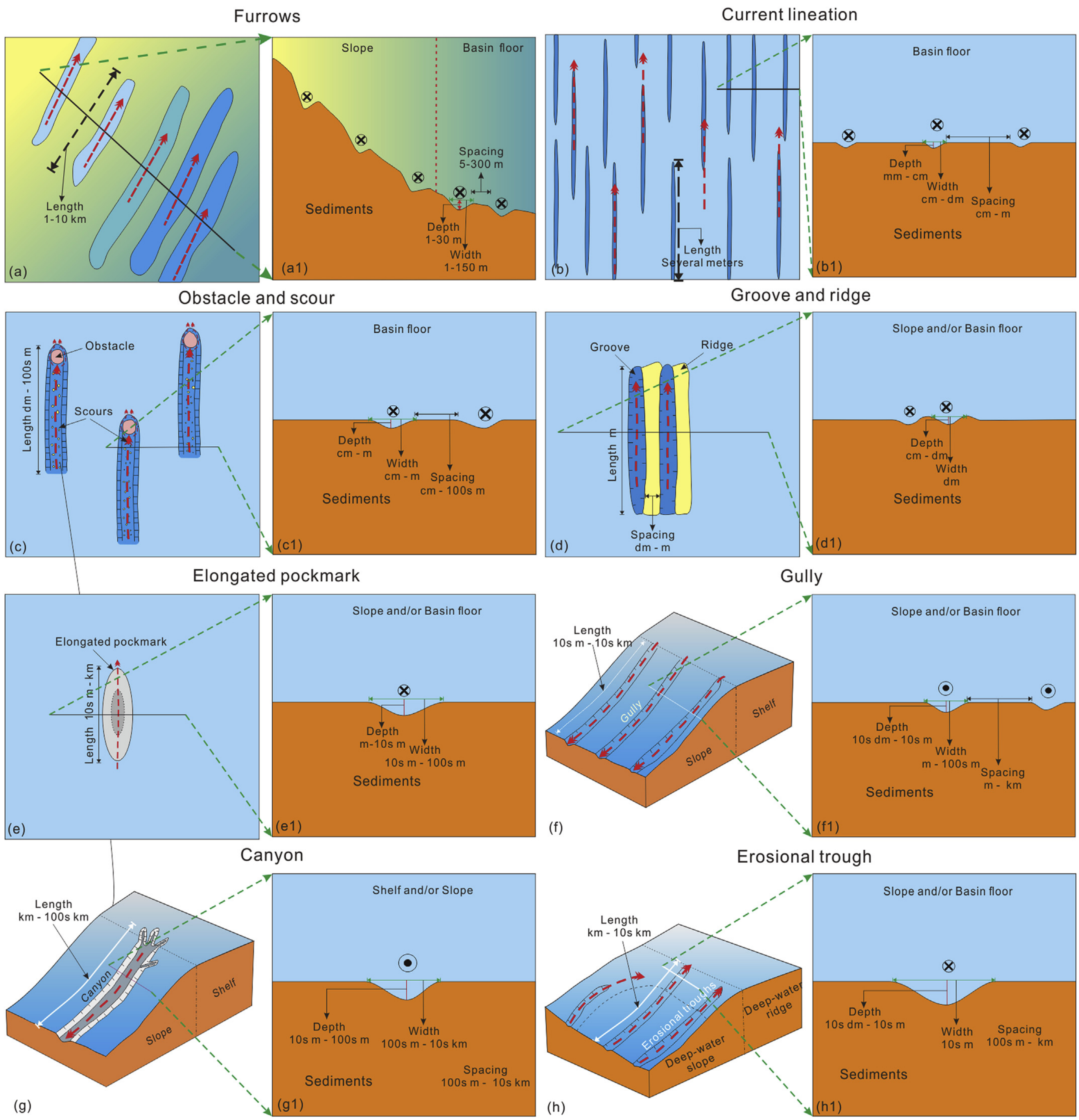

Fig. 1. Cartoons of main negative structures on the seabed caused by different currents (bottom currents, turbidity currents and/or cascading dense water currents) and their cross-cutting profiles. (a) - (d1) are mainly caused by bottom currents. Their extensions are mainly parallel to the regional slope and they mainly occur on the basin floor (some occur on the slope environment). Their sizes are adapted from Stow et al. (2009); (e) – (e1) are pockmark whose shape is reworked by the bottom current and its long axis is parallel to the flow direction of bottom current. Its sizes are adapted from Judd and Hovland (2007), Andresen et al. (2008), Kilhams et al. (2011), Sun et al. (2011); (f) – (g1) are large-scale linear negative structures. They mainly occur at the slope and their extensions are perpendicular to the regional slope. They are mainly caused by cascading dense water currents and turbidity currents, and their scales are adapted from Lonergan et al. (2013), Gales et al. (2013); (h) – (h1) are the erosional troughs in this study.