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Research paper

Recurrent mass transport deposits and their triggering mechanisms in the Kaiping Sag, Pearl River Mouth Basin

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ABSTRACT

High-quality three dimensional seismic data integrated with well data are used to identify, interpret and assess the significance of mass transport deposits (MTDs) to the evolution of the Kaiping Sag, Zhu-II depression, Pearl River Mouth Basin (northern South China Sea). Diagnostic features observed in 3D and 2D reflection seismic profiles document a multifarious mass movement history spanning from the Middle Miocene to the Quaternary period. MTDs in the Kaiping Sag were composite and multi-event units involving the entire spectra of mass transport processes. The diagnostic fingerprints of MTDs includes chaotic to transparent acoustic facies, and significant amounts of basal erosion grooves in the middle part of basal shear surfaces. We decipher for the first time that tectonic events, sea level fluctuations slope instability and/or volcanism may control the southwest decreasing distribution of MTDs in the Kaiping Sag. Knowledge regarding the seismic identification characteristics, the spatial and temporal distribution of MTDs, along with a better understanding of their underlying geological processes is valuable for providing new insights on the tectono-stratigraphic evolution of the Kaiping Sag.

1. Introduction

Mass transport deposits (MTDs) are the resulting strata of submarine mass-wasting processes, which play an important role on reservoir distribution (Alves, 2015). MTDs development in open environments caused by slope instability, and especially widely distributed, generally development on passive continental margin with large delta(s) (Alves, 2015; Bull et al., 2009; Gamboa and Alves, 2015; Gee et al., 2007). In addition, large scale submarine slumping represents an important mechanism in shaping passive margins and sea floor morphology (Alves, 2010; Gamboa and Alves, 2015; Gee et al., 2007; Strasser et al., 2011).

There are several general terminologies used to describe submarine slope failure deposits, such as slump complex (es) (Frey Martínez et al., 2005), submarine landslide(s) (Frey Martínez et al., 2006; Gee et al., 2007), mass transport complex (es) in seismic data (Gong et al., 2014; Yang et al., 2013), mass transport deposit(s) (Deckers, 2015; Zhao et al., 2015; Gamboa and Alves, 2015; Lamarche et al., 2008), and olistostrome, olistoliths, and rafts used at outcrop (Alves, 2015). More specific nomenclatures have been used to describe the failure process, e.g., slump, debris avalanche, debris flow, and debris slide, where the data allow more detailed interpretation (He and Zhong, 2015; Gee et al., 2007).

Disintegration of strata during downslope transport probably evolved into a clast-and-matrix mass flow, leading to the distinctive chaotic-to-transparent acoustic facies of the MTDs in the depositional area. The generation of MTDs is largely affected by slope gradient and tectonic activities including fault reactivation, and also volcanism (Lamarche et al., 2008). As a result, there is a growing interest in understating their causal mechanisms and morphological characteristics, which is aided by increasingly sophisticated seismic imaging (Bull et al., 2009; Frey Martínez et al., 2005).

The extent and appearance of different kinds of slope failures have been studied by means of sidescan sonar imagery, multibeam bathymetry, sub-bottom profiling and seismic reflections (Bull et al., 2009; Canals et al., 2004; Shanmugam, 2012). Although each of these techniques gives a particular insight into the failure processes, only 3D seismics allow a truly holistic study of the morphology of the feature of interest (Alves, 2010; Bull et al., 2009; Hart, 1999; Wu et al., 2011).

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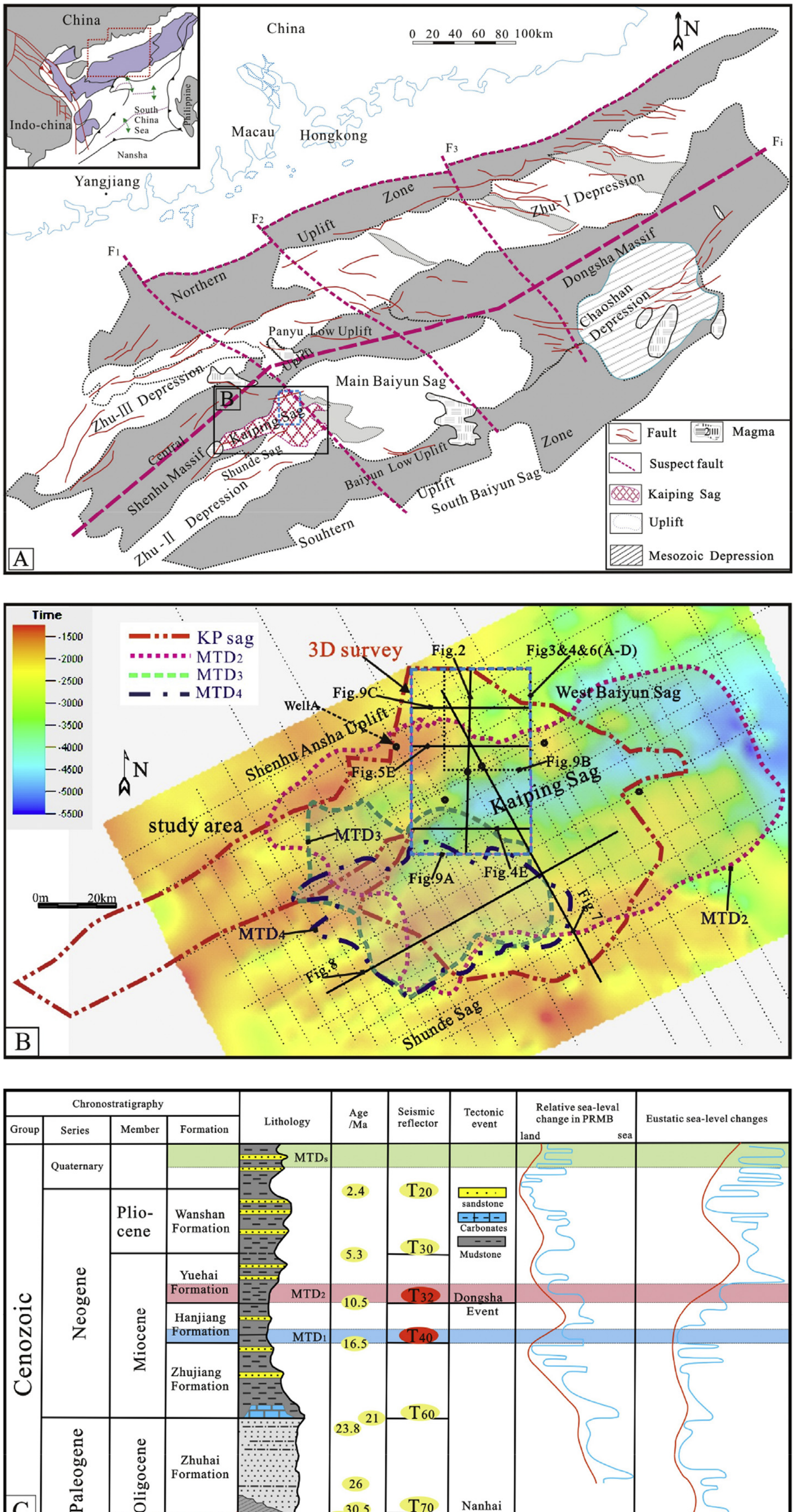
China
Indo-china
South China Sea
Philippine
Nansha
China
0 20 40 60 80 100km
N
Macau
Hongkong
Yangjiang
F1
F2
F3
Fi
Northern
Uplift
Zone
Zhu-I Depression
Dongsha Massif
Chaoshan Depression
Panyu Low Uplift
Main Baiyun Sag
Zhu-III Depression
Central
Shenhu Massif
Kaiping Sag
Shunde Sag
Zhu-II Depression
Baiyun Low Uplift
Uplift
South Baiyun Sag
Zone
Souhtern
B
A
Fault
Magma
Suspect fault
Kaiping Sag
Uplift
Mesozoic Depression
Time
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000
-5500
KP sag
MTD2
MTD3
MTD4
3D survey
Fig.2
Fig3&4&6(A-D)
Fig.9C
WellA
West Baiyun Sag
Shenhu Ansha Uplift
Fig.5E
Fig.9B
Kaiping Sag
N
study area
MTD3
Fig.9A
Fig.4E
Fig.7
0m 20km
MTD4
MTD2
Fig.8
Shunde Sag
B
Chronostratigraphy
Group
Series
Member
Formation
Lithology
Age /Ma
Seismic reflector
Tectonic event
Relative sea-leval change in PRMB
land
sea
Eustatic sea-level changes
Quaternary
MTD5
2.4
T20
sandstone
Carbonates
Mudstone
Plio-cene
Wanshan Formation
5.3
T30
Yuehai Formation
MTD2
10.5
T32
Dongsha Event
Hanjiang Formation
MTD1
16.5
T40
Cenozoic
Neogene
Miocene
Zhujiang Formation
21
23.8
T60
Paleogene
Oligocene
Zhuhai Formation
26
30.5
32
T70
Nanhai Event
C