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Invited research article

Seismic geomorphology of submarine channel-belt complexes in the Pliocene of the Levant Basin, offshore central Israel

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ABSTRACT

In this study, analyses of a high-resolution, three-dimensional seismic reflection dataset and well-log data were combined to characterise a distinct Pliocene interval in the Levant Basin offshore central Israel. This succession is characterised by moderate to high-amplitude, discontinuous to continuous seismic reflections between a mass transport deposit above and an undeformed basin series below. The studied interval contains two separate channelised subunits, which predated the salt related deformations. Morphologically, the channels trend in a north to northwest direction, are incised < 50 m, are ~50 m to 350 m wide and increase in number from base to top. A vertical variation in channel morphology style and stratigraphic organization is identified. The lower part of each subunit is dominated by coarser grained, narrow V-shaped channels (average width < 120 m and low sinuosity, < 1.06). In contrast, the upper part of each subunit is predominantly fine-grained and U-shaped with relatively wide channels (average width > 230 m and higher sinuosity, > 1.1). The mechanisms that control the interplay between sedimentary processes and channel evolution show a cyclic pattern. Due to the cyclic occurrence of different channel types and the estimated age of the studied interval, formation and evolutionary processes of the submarine channels in the study area are likely to be controlled by relative sea level fluctuations and increased Nile River sediment supply, which is associated with rapid uplift of the Ethiopian plateau and increased African Monsoon rainfall during the Pliocene.

1. Introduction

Submarine channels are pervasive geomorphic features documented on both the modern-day seafloor and in the geological record buried intervals within marine settings (Feng, 2000; Posamentier et al., 2000, 2007; Posamentier, 2001; Miall, 2002; Carter, 2003; Posamentier and Kolla, 2003; Saller et al., 2004; Samorn, 2006; Wood, 2007; Gamboa et al., 2012; Gamboa and Alves, 2015; Harishidayat et al., 2015; Qin et al., 2016). They represent major conduits for transporting sediments from the shelf and upper slope into the deep basin (Piper and Normark, 2001; Babonneau et al., 2002), and have been described in detail within the submarine fans that are associated with major river systems such as the Niger (Deptuck et al., 2003; Adeogba et al., 2005; Heiniö and Davies, 2007), Mississippi (Pickering et al., 1986; Posamentier, 2003), Amazon (Damuth et al., 1983; Flood and Damuth, 1987), and Bengal rivers (Hübscher et al., 1997; Schwenk et al., 2003).

Submarine channels have been the foci of several studies in the last decade as they can serve as prime targets for petroleum exploration (Mayall et al., 2006, 2010; Weimer et al., 2007; Di Celma et al., 2010), and may have significant implications for geohazard prediction and prevention (Bruschi et al., 2006; Thomas et al., 2010; Carter et al., 2014). Additionally, they can also hold significant sedimentological and climatic information on the controlling mechanisms behind their formation (Bouma, 2001; Brenchley et al., 2006; Zühlsdorff et al., 2007; among others). As a result, much work has focused on the depositional processes, internal architecture, and morphological evolution of submarine channels (Posamentier and Kolla, 2003; Babonneau et al., 2010; Covault et al., 2014; Li and Gong, 2016; Sylvester and Covault, 2016; Hansen et al., 2017). Past studies have mostly focused on the understanding of initiation, geomorphological characteristics, and development of submarine channels and are mostly based on outcrops, recent fan systems, and 2-D reflection seismic studies (Bouma et al., 1962; Mutti and Lucchi, 1972; Walker, 1978; Posamentier et al., 1991; Mutti and Normark, 1991). This has been due to the paucity of high-

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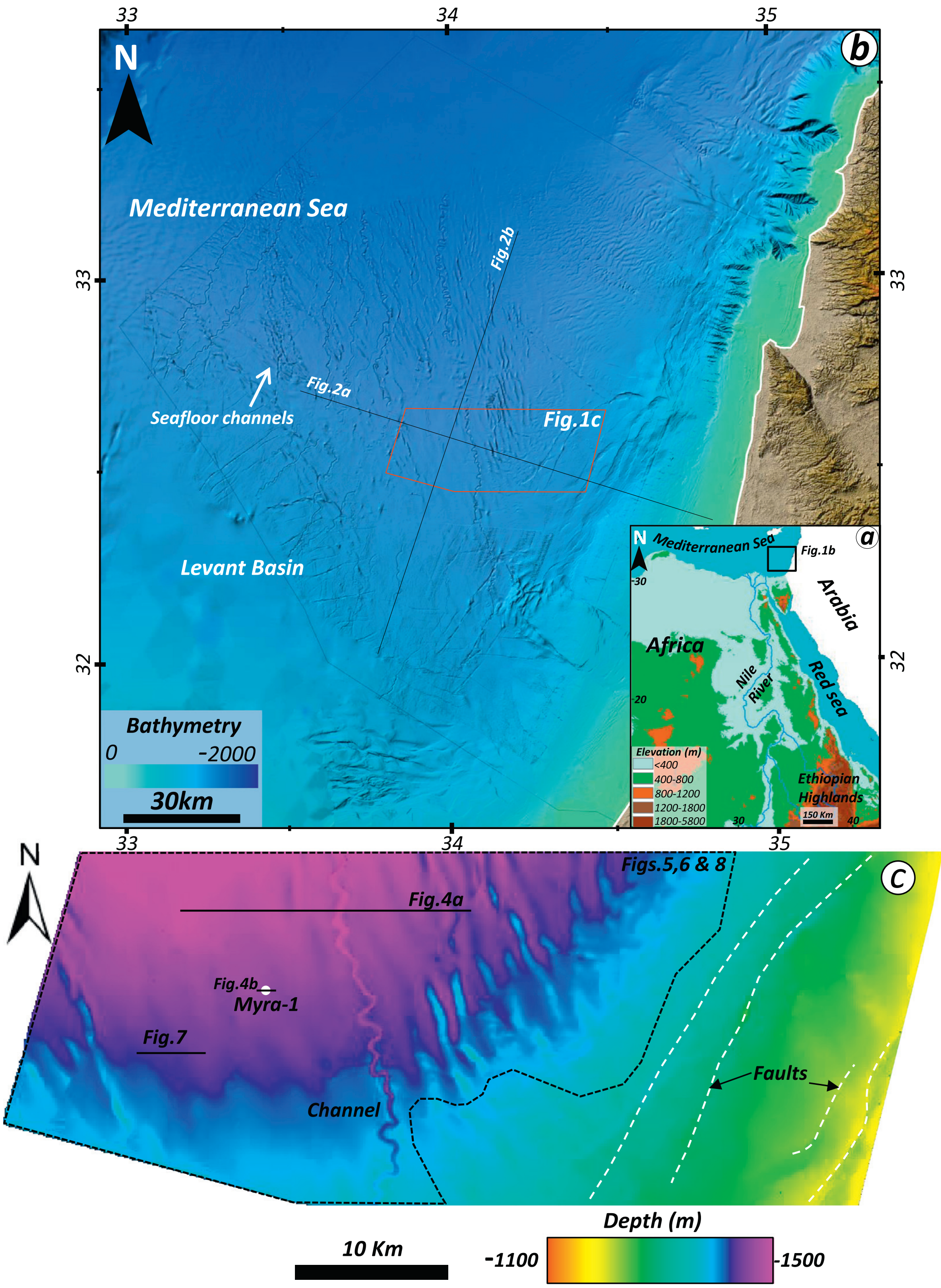

Fig. 1. (a) 30 Arc-Second Elevation (GTOPO30) digital elevation model (DEM) of Africa (NASA LP DAAC, 2013). The blue line represents the Nile River; the black rectangular represents the location of Fig. 1b. (b) Bathymetry map of the Levant Basin (modified from Hall et al., 2015). Locations of the two 2-D lines and 3-D seismic survey area are represented by black straight lines and red rectangular, respectively. (c) Seafloor map of the study area from 3-D seismic data (location in Fig. 1b), with location of seismic sections from 3-D data. Location of the Myra-1 well, normal faults and present-day seafloor channels are shown. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

resolution deep subsurface geophysical datasets, which are recently becoming available to academia as hydrocarbon exploration transits into deep and ultra-deep waters (Pirmez et al., 2000; and others).

This study presents seismic geomorphological analysis of a channelised interval developed during the Pliocene in the deep Levant Basin, offshore central Israel (Fig. 1). Previous studies in the region only focused on recent and Holocene submarine channels and their interaction with subsurface salt tectonics (e.g., Folkman and Mart, 2008; Clark and Cartwright, 2009; Gvirtzman et al., 2015; Zucker et al., 2017). The nature and evolutionary history of deeper channelised units remain poorly constrained. A high resolution, 3-D seismic reflection data was employed to: (1) characterise and classify submarine channels that were developed in the Pliocene interval of the Levant Basin, (2) investigate the influences of salt tectonics on channel evolution, (3) demonstrate their spatio-temporal distribution and stratigraphic organization, and (4) suggest possible controlling mechanisms on their