



Sediment transportation systems to the Levant Basin and the role of the Nile River since the Pliocene

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Highlights

- *The evolution of paleo-channel patterns, from shelf to deep basin, at the Levant Basin is documented using 2D, 3D seismic and borehole data.*
- *Results reveal spatial and temporal variation of sediment sources building the Pliocene-to-Recent succession.*
- *Channel complexity increases with time and is discordant to sea-level fluctuation.*
- *High peak flood discharge from the Nile River has a first order control on sediment supply to the deep basin.*
- *The balance between the northward prograding Nile Cone and the longshore currents building the Sinai-Israeli shelf dictate siliciclastic accumulation in the southeastern Mediterranean basin and the paleogeography of its margin.*

How to read this display?

Blue text for quick overview

Black text for in-depth reading

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4. The Department of Geosciences, Tel-Aviv University, Israel

Possible patterns of sediments provenance building the Pliocene-Recent succession in the deep Levant Basin

Where did the sediments come from?
 Where are they going?
 When and where accumulation occur?



a) Inset of tectonic map of the Eastern Mediterranean, plate boundaries modified from Garfunkel (1998) background topography made with GeoMapApp (www.geomapapp.org), A-Atbara River, D-Delta, L-Levant, S-Sinai, DST – Dead Sea Transform. b) Landsat Image and the various possible sediment sources. Blue polygon – 3D seismic used for this study, the detailed seismic 2D and 3D (two way time) used for this study as well as two wells are displayed in (c)

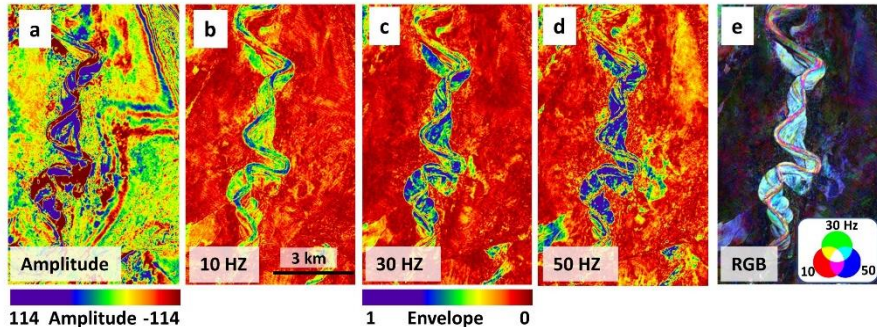
Methods

1. We map channel from 3D seismic

2. Analyze Submarine channels

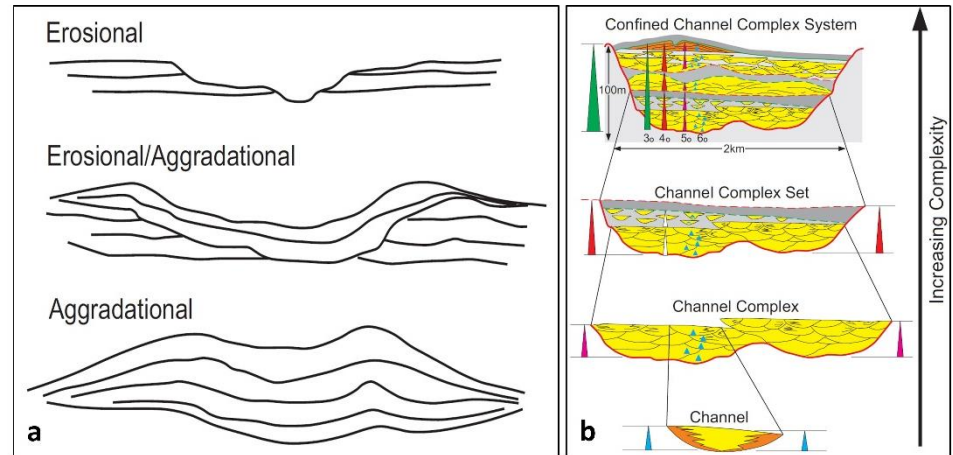
In order to better image the channels in the seismic

Seismic Attribute Analysis



Amplitude extraction (200 msec. time slice) of Gal-C survey (a) versus spectral decomposition at 10 Hz (b), 30 Hz (c), 50 Hz (d) and RGB blend of these frequencies (e).

Submarine channel morphology



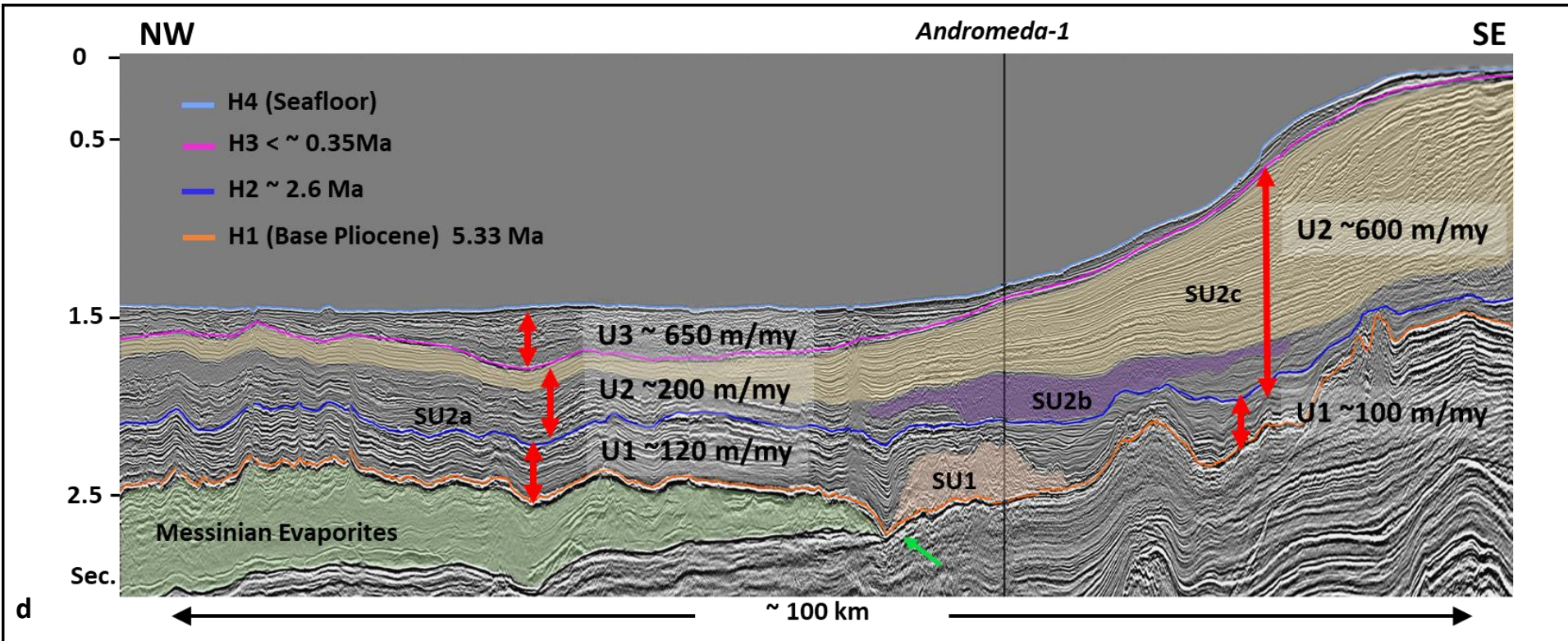
Schematic cross sections illustrating submarine channel morphology (after Weimer and Slatt, 2004). a) General classes of deep-water channels that are the products of: erosion, mixture of erosion and depositional processes, and levee deposition. b) Channel interactions within a confine setting displaying different hierarchies from a single channel element, through a complex of elements, followed by a complex set of elements, and finally to a complex system.

3. Well to seismic correlation and time to depth conversion

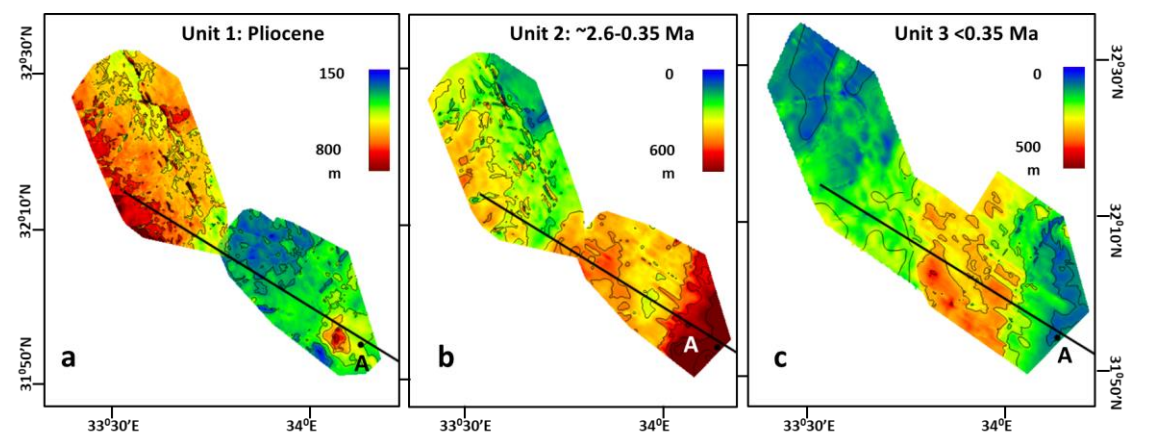
We identified continuous reflectors bounding seismic packages and having distinct characteristics that are mappable across the study area. Seismic time markers were correlated to lithostratigraphic units in the Andromeda and Hannah wells using vertical seismic profiles (VSP).

Results:

Four horizons were interpreted, three units defined



Isopach maps of Unit 1, 2 and 3 building the Pliocene-to-Recent succession. a) Unit 1 displays a thicker section in the deep basin rather than on its slope and margin. b) Unit 2 thickens towards the eastern margin and exhibits the Israeli shelf build-up. c) Unit 3 mostly accumulated along the base of the slope. It thins towards the deep basin and also eastward as it onlap the shelf. d) NW-SE oriented seismic line crossing the shelf to the deep basin displaying the interpreted horizons, units, sub-units and the approximated sedimentation rates of each unit. Green arrow marks the pinch-out of the Messinian evaporites (green drape) and the location of the thickness anomaly observed in (a). SU1 – Sand mound (orange drape), SU2a – lower part of Unit 2, SU2b – Israel slump Complex (purple drape), SU2c – sedimentary prism building the shelf and its correlative section in the deep basin (yellow drape), A – Andromeda well.

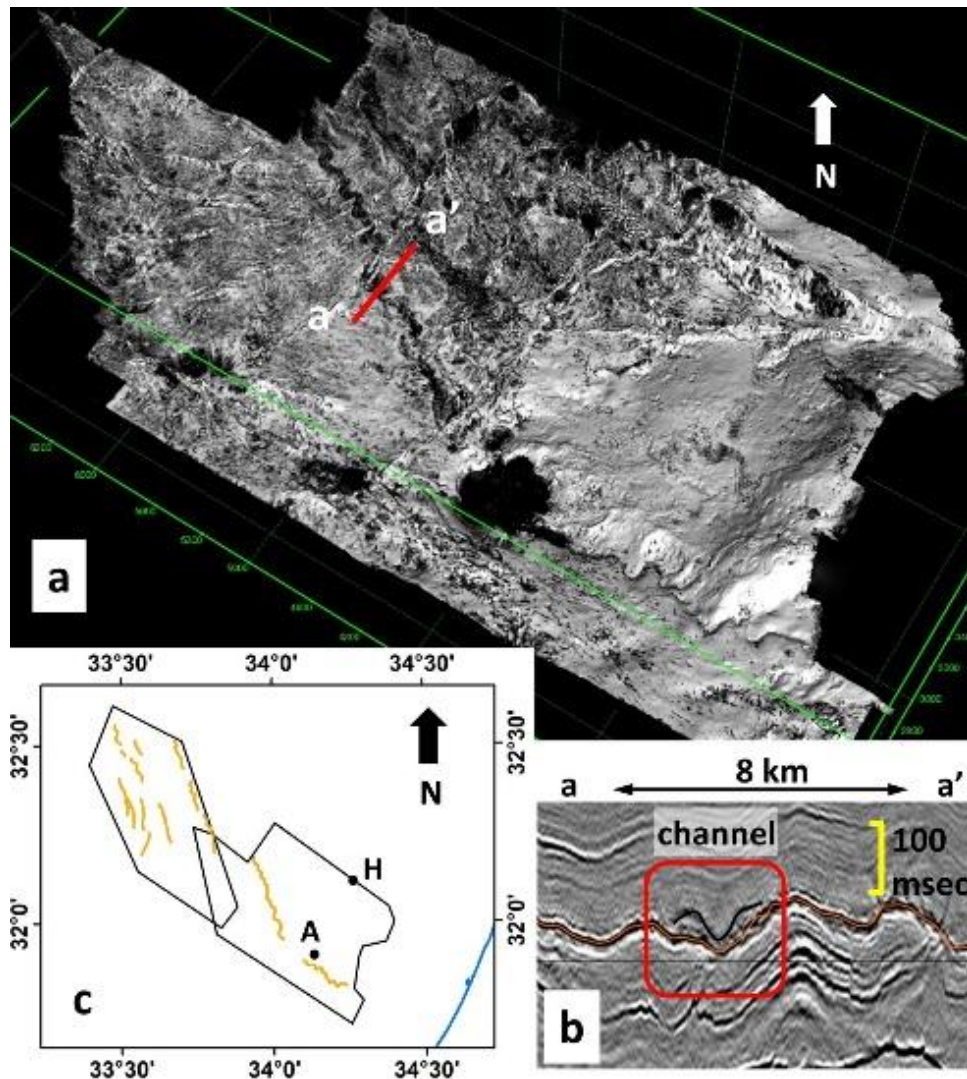


Channel sets – spatial distribution and internal structure

Four channel sets were mapped according to: **set 1** – channels at the vicinity of H1 horizon, **set 2** – Unit 1 channel group (excluding the channels of H1 horizon), **set 3** – Unit 2 channel group, **set 4** – Unit 3 channel group.

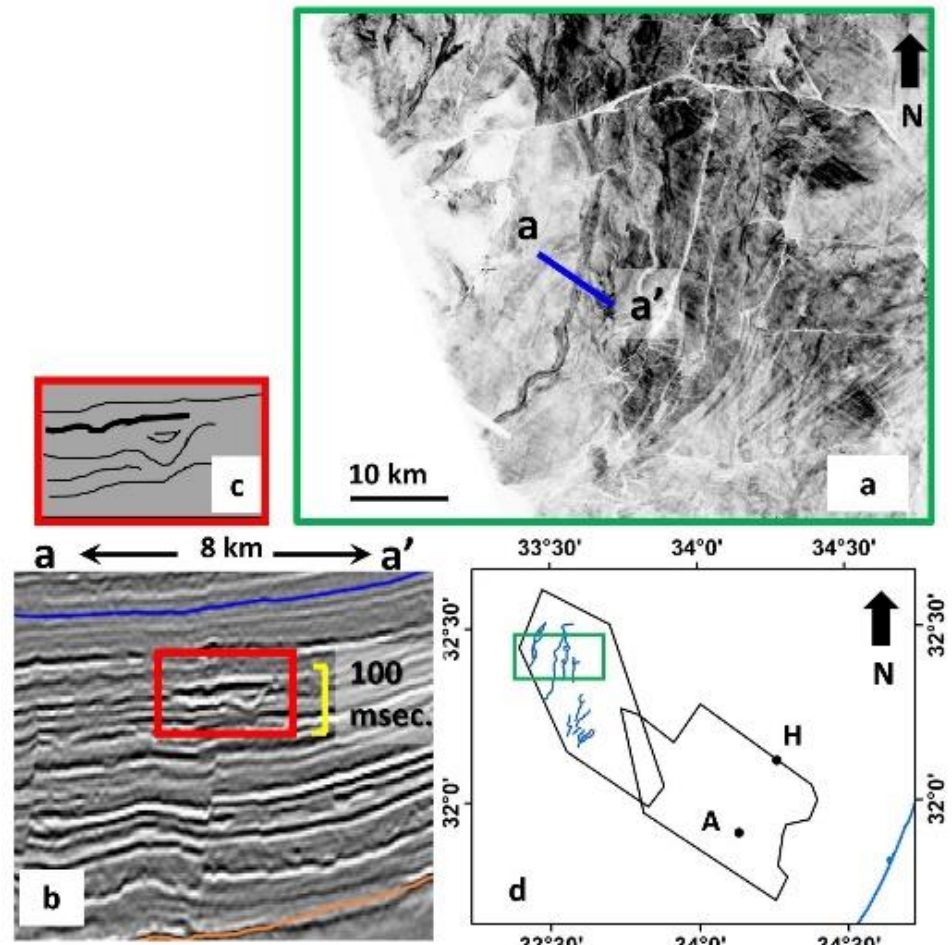
H1 channel group (set1) – onset of the Pliocene

a) Spectral decomposition (15 Hz) map along the H1 horizon (window of 16 msec. above and 4 msec. below) display the Andromeda channel flowing from south-east to north-west. b) Cross-section normal to the channel reveals a confined single channel element without channel-fill features. c) Location map of the H1 channel group (orange) for the two seismic volumes flowing from east and south east to north-west. A – Andromeda well, H – Hannah well.

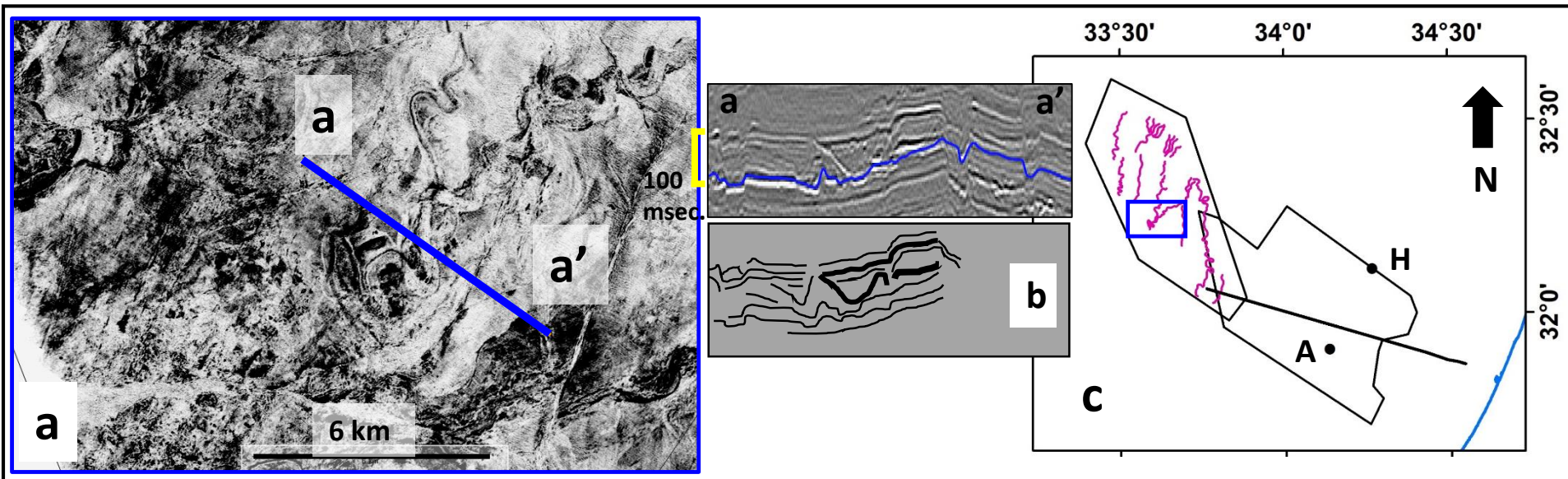


Unit 1 channel group (set 2) – Pliocene (excluding H1 channels):

Unit 1 channel group (set 2). a) Amplitude extraction map of a spectral decomposition volume along an intermediate reflector (time window of +/- 20 msec.) within Unit 1 displaying channels flowing northward. b) Cross-section of the channel reveal a confined single channel element with minor depositional features. c) Enlargement of the channel cross-section – red box in (b). d) Location map of the Unit 1 channel group (blue) for the two seismic volumes flowing from south east to north-west. A – Andromeda well, H- Hannah – well.



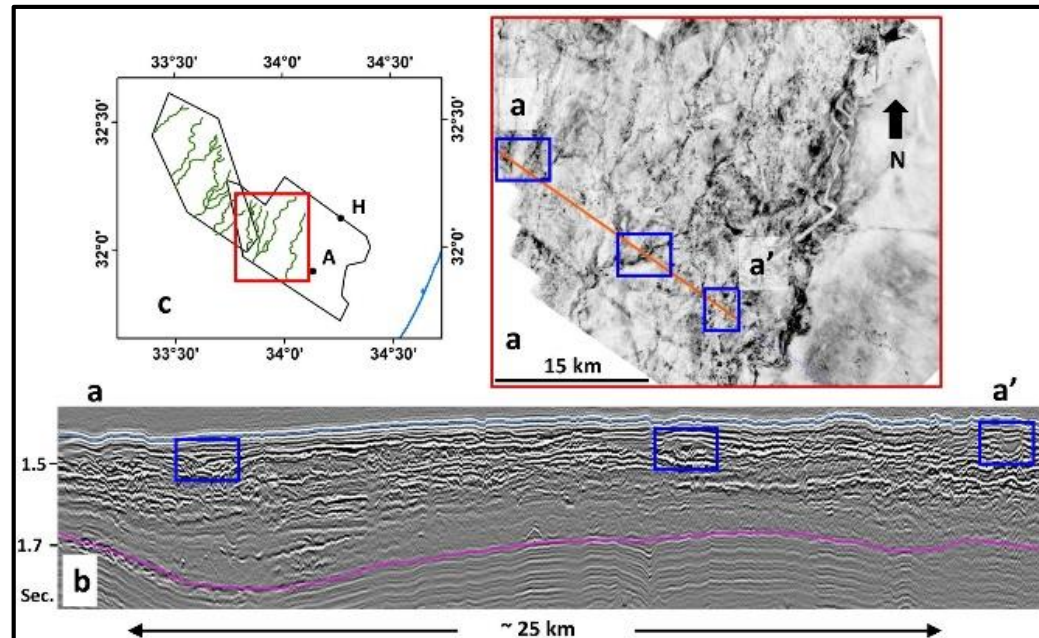
Unit 2 channel group (set 3) – ~2.6 – ~0.35 Ma:



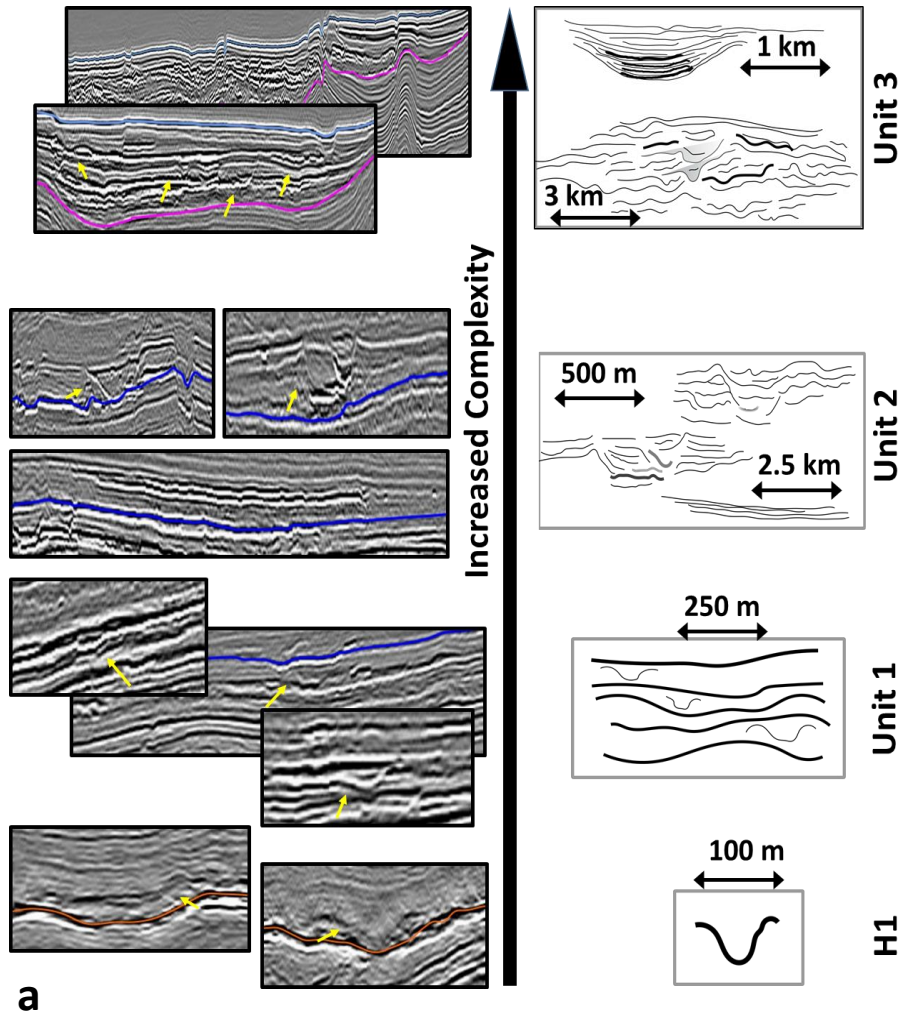
a) Amplitude extraction map of a spectral decomposition volume along an intermediate reflector (time window of +100 msec.) within Unit 2 displaying channels flowing from south-west to north-east. b) Cross-section reveals a channel complex set with lateral accretion and levee overbank. c) Location map of Unit 2 channel group (pink).

Unit 3 channel group (set 4) < 0.35 Ma:

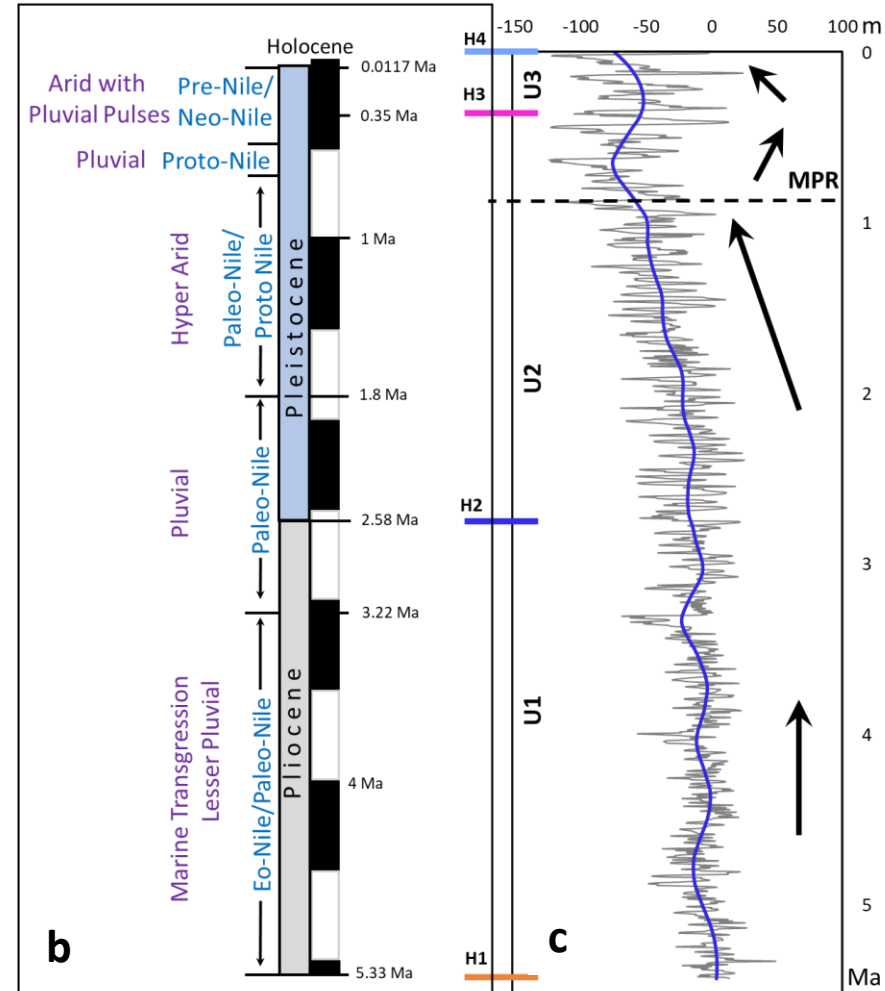
a) Amplitude extraction map of a spectral decomposition volume between H3 and H4 horizons displaying channels flowing north-eastward. b) Cross-section of Unit 3 displaying complex channel sets, locations of various channel are represented in blue squares in (a). c) Location map of Unit 3 channel group (green), red square represent location of (a). A – Andromeda well, H – Hannah well.



The complexity of the channels increases with time from Pliocene to Recent



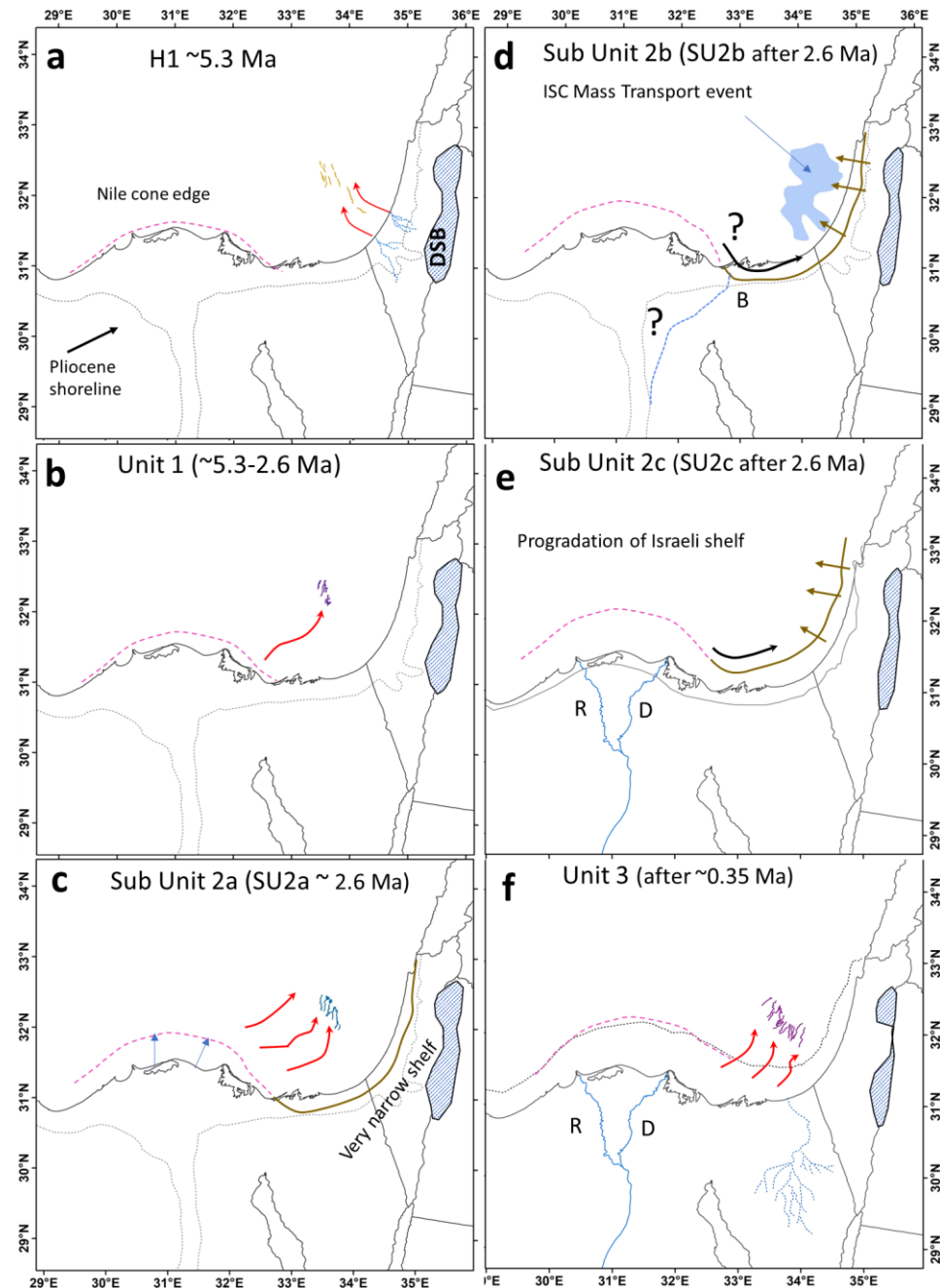
General sea-level trends are discordant to channel evolution



a) Characteristics of the unit's channel groups with schematic illustrations of specific channels (marked by yellow arrows). b) Nile evolution and major climate changes since the Pliocene to Recent (following Said, 2013 and Abdelsalam, 2018). Our interpreted horizons are superimposed. c) Sea-level curve (gray line) according to Miller et al. (2005). In order to discern the general trend of sea-level from the high frequencies fluctuations we run a moving average resulting in a smoothed sea-level curve (blue line). The average sea-level remained relatively constant (~ 0 m) since the Pliocene till ~ 2 Ma where the average sea-level declined to ~ -75 m, slightly rise to ~ -50 m at ~ 0.6 Ma and dropped back to ~ -75 m at ~ 0.35 Ma as marked by the black arrows. Black dashed line marks the Mid-Pleistocene Climate Revolution (MPR).

Synthesis - paleogeography evolution of the south eastern Mediterranean since the Pliocene

a) Remnant eastern drainage system were active at the onset of the Pliocene transporting sediments from east to west (red arrows) via single erosional channel system. b) Early Pliocene sediments transportation from the evolving Nile Cone (dashed pink) north eastward to the deep basin. c) Early Pleistocene (SU2a) northward progradation of the Nile cone, which shortened sediments transportation distance to the deep basin and boosted the evolution of more complex channel system. d) Israeli Slump Complex (ISC – SU2b) developed at the base of the Israel shelf (blue drape modified from Frey-Martinez et al., 2005), marking the westward migration of the shoreline (denoted by brown line and arrows) and initiation of the shelf buildup. Finger-like embayment of the slope edge formed by the northward prograding Nile Cone (dashed pink) and its eastward (northern Sinai) correlative shelf edge. This embayment geometry might have promoted longshore currents (black arrow) transporting sediment from the Nile Cone eastward. Alternatively, an eastern predecessor of the Damietta (dashed blue) might have delivered sediments to build the Sinai-Israeli shelf. e) Aggradation and progradation of the Israeli shelf (SU2c), concurrently channel activity ceased in the deep basin. f) A complex channel system flowing from Sinai's shelf to the north east resumed its activity during the Late Pleistocene Unit 3 (after 0.35 Ma). The Israeli shoreline has migrated westward to its current location as well as the Nile Cone edge (Pliocene shoreline modified from Gvirtzman et al., 2011 and Abdelsalam, 2018). B – Bardawil, DSB – Dead Sea Basin, D- Damietta, R- Rosetta.



Quiescence in channel activity

Conclusions

- Spatial and temporal evolution of channel pattern reveal a complex source-to-sink system for the Levant basin since the Pliocene.
- Channel complexity increases with time and is discordant to sea-level fluctuation.
- High peak flood discharge from the Nile River has a first order control on sediment supply to the deep basin.
- The balance between the northward prograding Nile Cone and the longshore currents building the Sinai-Israeli shelf dictate siliciclastic accumulation in the southeastern Mediterranean basin and the paleogeography of its margin.

Thank you for your attention

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The contents of this display were submitted to Marine Petroleum Geology as an article and are currently under review.