High-resolution analysis of Vegetated Linear Dune construction The northwestern Negev dunefield, Israel

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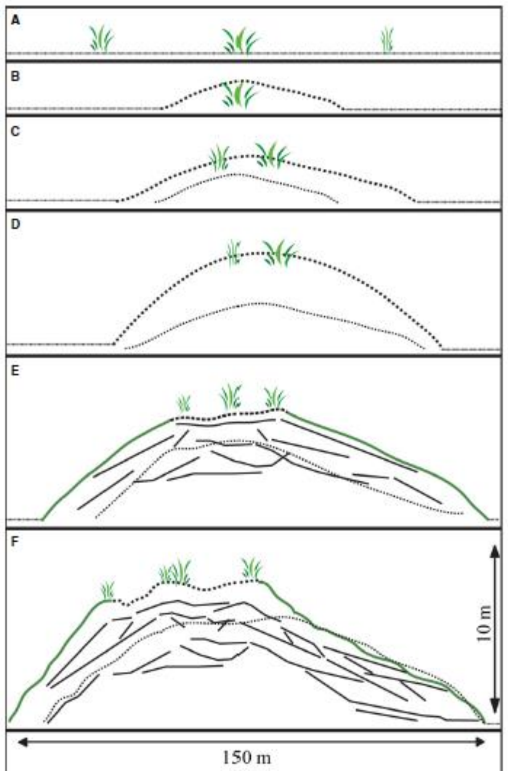
Vegetated Linear Dunes

- Linear dunes form in two distinct environmental settings:
    - winds of bimodal directions that form sinuous-shaped seifs
    - unidirectional winds on partly vegetated (15-20%) sand surfaces that form straight Vegetated Linear Dune (VLDs) morphologies.
- VLDs also vertically accumulate sand that can enable optical dating of sand deposition stages



Roskin et al., 2014

Negev desert - Israel

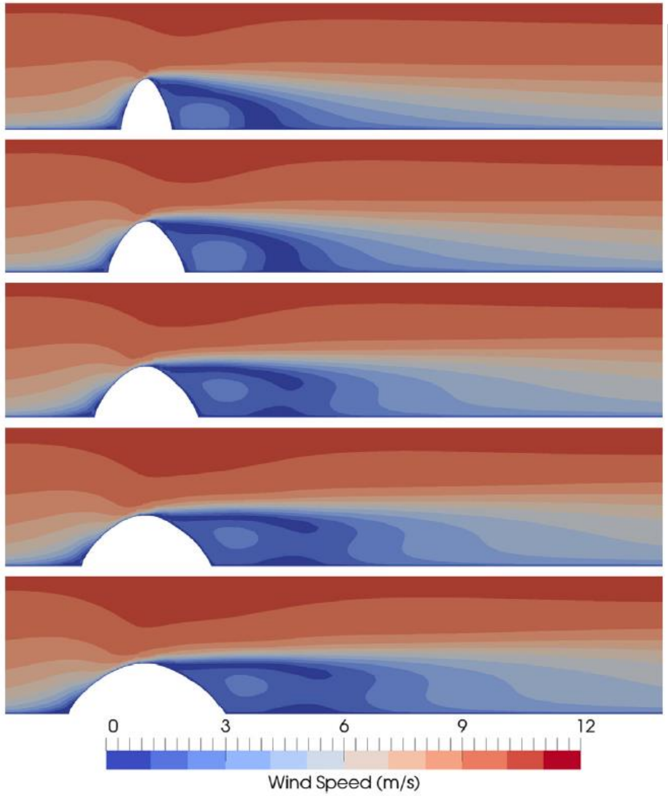
Kalahari desert – Southern Africa

Simpson desert - Australia

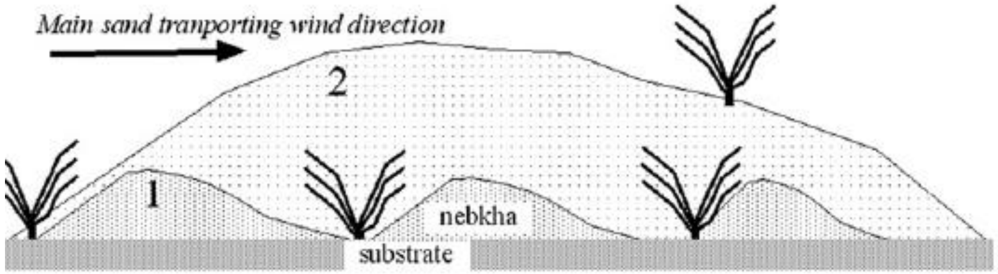
Vegetated Linear Dune construction

- The transport of sufficient amount of sand leads to the formation of large Nebkhas behind shrubs, followed by the formation of shadow dunes.

- In a unidirectional wind regime, shadow dunes may extent downwind and connect to the next shadow dune downwind of it**,** to form a VLD morphology.



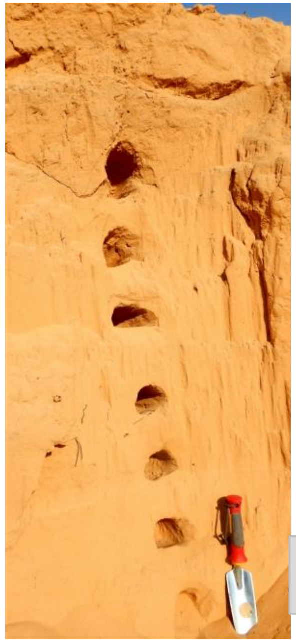
Nebkha and shadow dune construction model (Hesp et al., 2017)



Conceptual and hypothesized model of VLD elongation (Roskin et al., 2011)

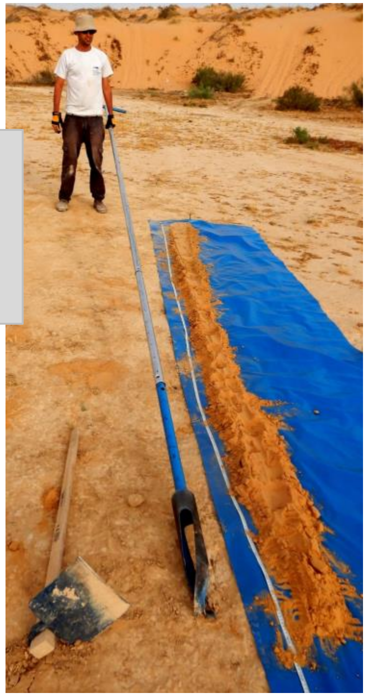
Research gaps

- Many VLDs are not cemented, enabling only augers or drills for samples collection, limiting the chronological and formation analysis.
- The lack of defined stratigraphic boundaries and the pulsed-like pattern of aeolian deposition, limits the chronological analysis.
- Elongation of VLDs have never been fully analyzed due to the uncertainty regarding the complex relation between upper wind erosion and downwind deposition.



Examples of boundaryless stratigraphic structure of aeolian sand

Auger usage for samples collection



Aims of study

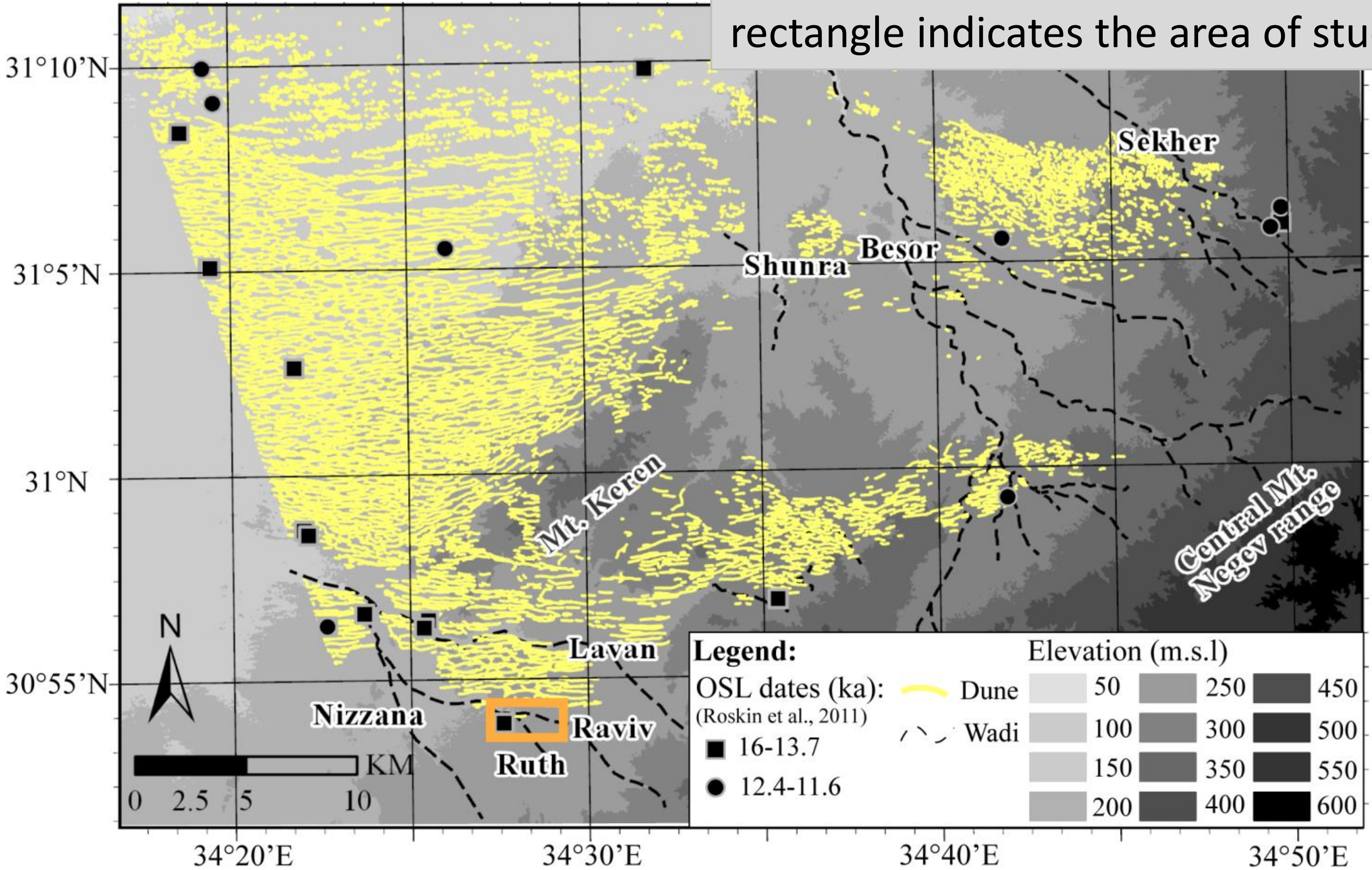
- High resolution analysis of vertical VLD construction during the late Pleistocene strong carrying sand winds periods.

- Horizontal analysis of VLD elongation, at the dunefield margins during the late Pleistocene.

- Accumulation rates estimations of each late Pleistocene VLD accumulation and elongation period.

The Northwestern Negev dunefield

- In the late Quaternary the majority of the VLDs in the Negev dunefield accumulation and elongation occurred during the Heinrich-1 (H1) and the Younger Dryas (YD) events, based on OSL studies.



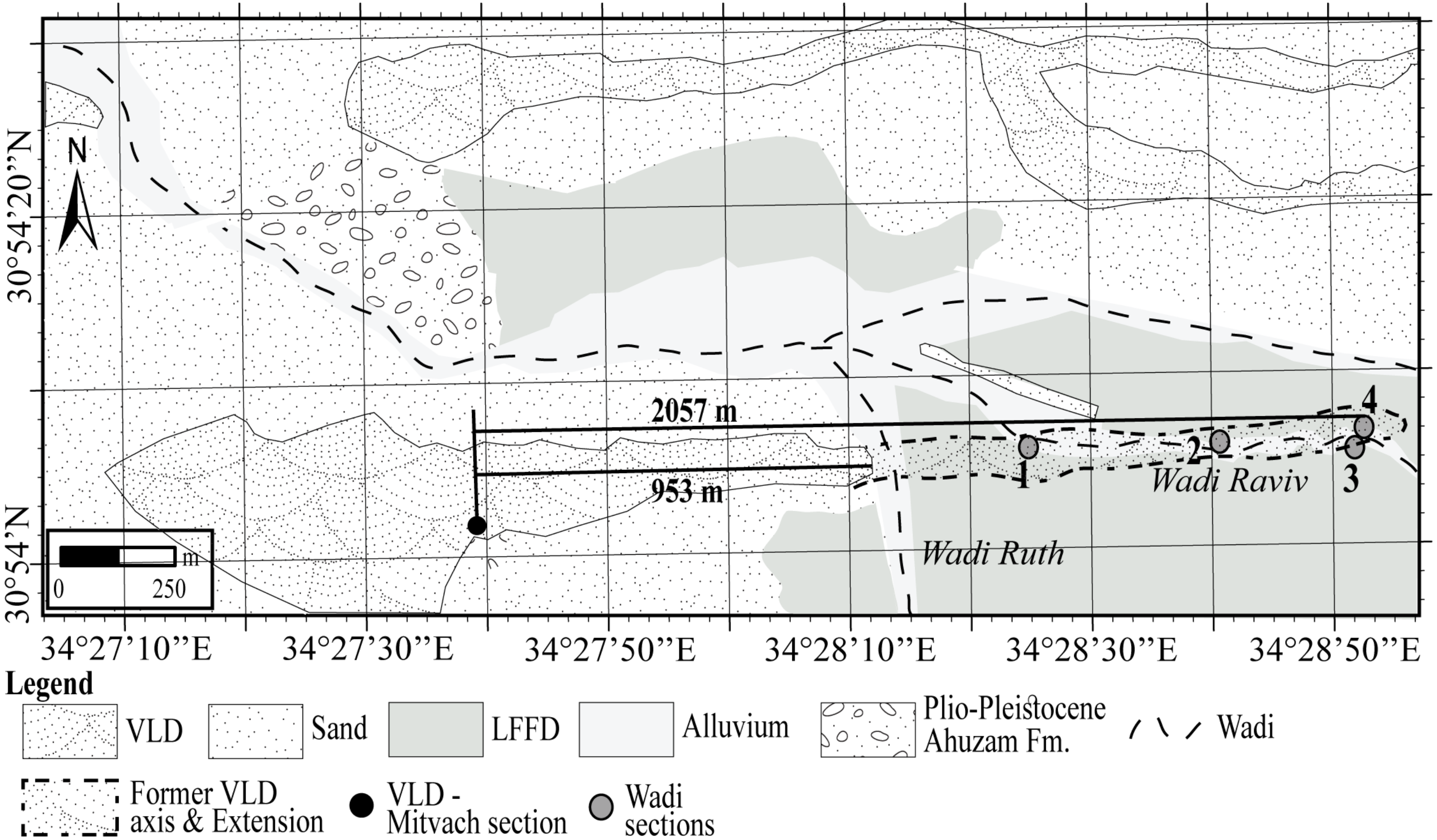
The NW Negev dunefield. The orange rectangle indicates the area of study.

Active VLD crest with Nebkhas (Tsoar et al., 2008)

- Today the NW Negev dunefield is stable, with some active VLD crests.
- The current transporting sand winds directions are similar but less powerful than those during the late Pleistocene (Roskin et al. 2011).
- The dunefield extends along an arid climatic gradient from north to south, 180-80 mm annual av. rainfall respectively

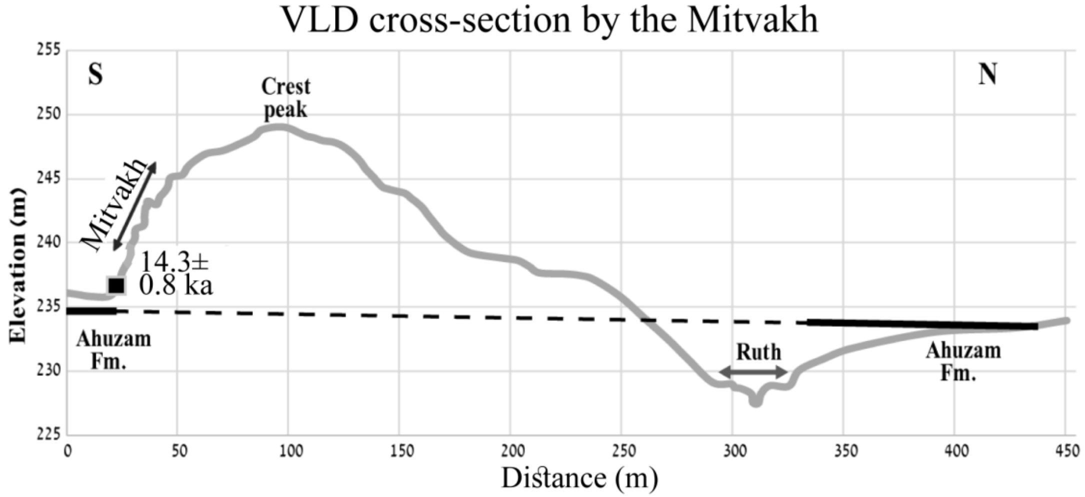
Area of study

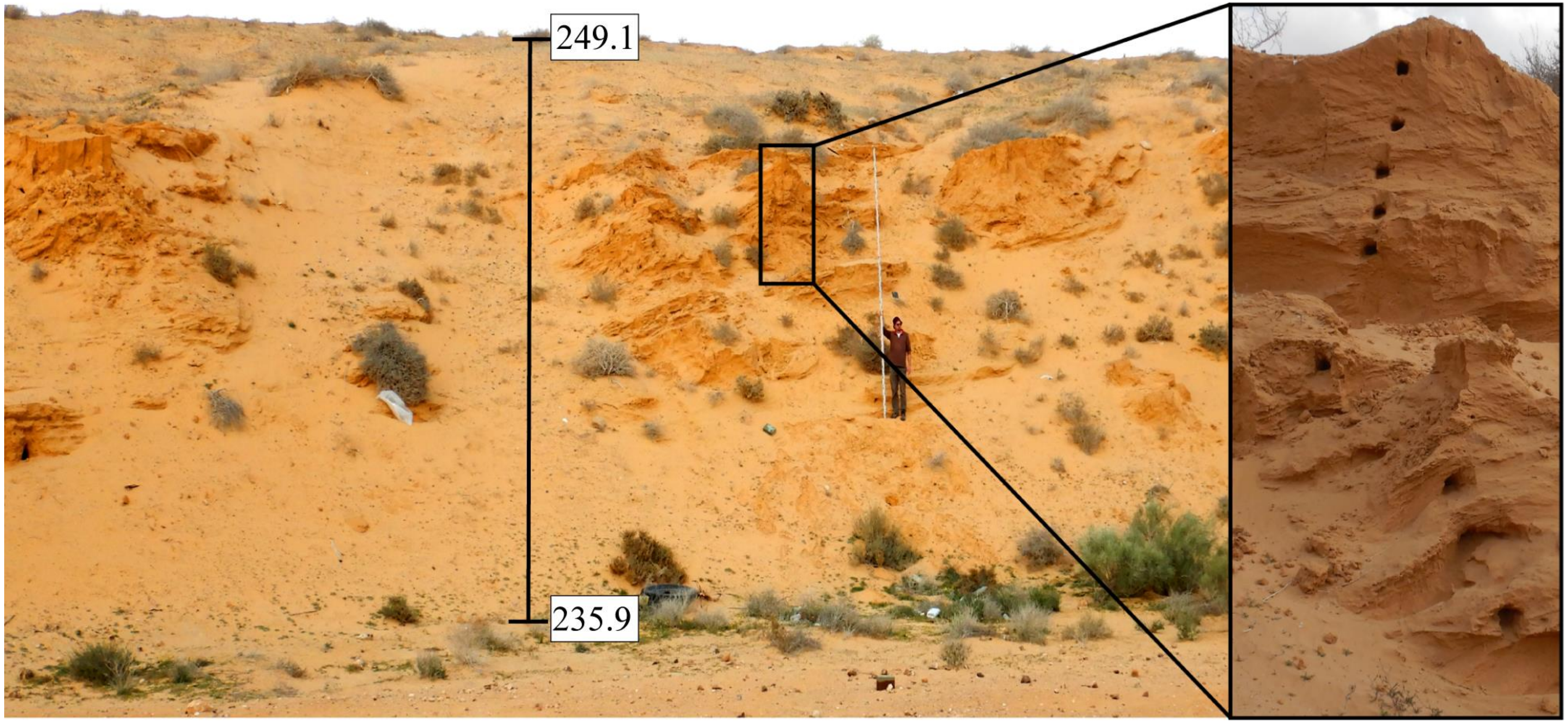
- A VLD at the southern dunefield margins was analyzed.
- This VLD is hypothesized to elongate across wadi (Ruth) in the past.
- Low energy Fluvial Fine-grains Deposits (LFFDs) are common in the dunefield margins.



Sampling sites

- A slightly cemented VLD exposure – The Mitvakh section was formerly analyzed by Muhs et al., 2013. The base of the exposure was OSL dated to 14.3±0.8 ka (Muhs et al., 2013).

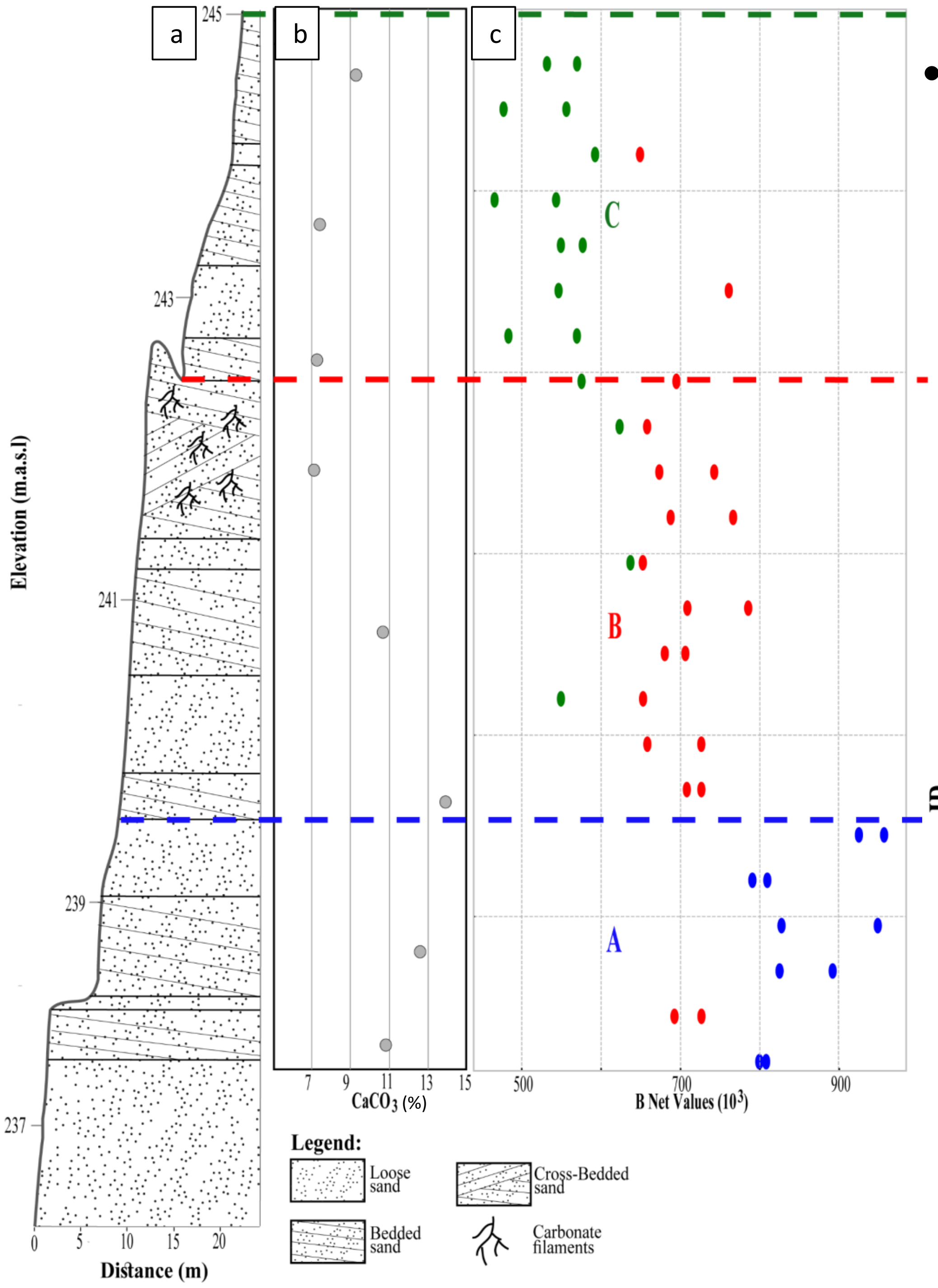




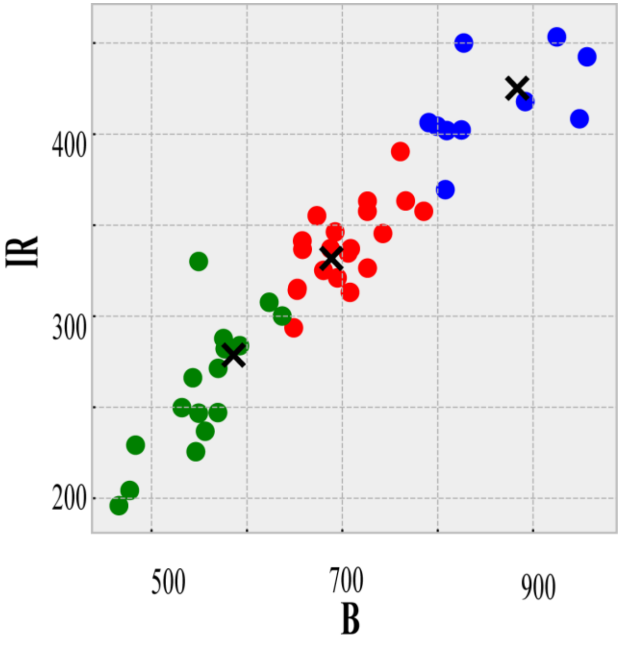
- In the present research, samples were collected every ~25 cm, from the Mitvach for high-resolution analysis using POSL, OSL, Grain-Size analysis and IC.

Results – Mitvakh section

- The Mitvakh stratigraphy illustrates mainly slightly tilted bedded exposures with one exposure which is cross-bedded and contains carbonate filaments (a).
- $CaCO_3$ values are low (b).
- 3 POSL calculated clusters, are plotted according to their elevation (Y axis) and Blue Net values (X axis), in order to identify break-points within the VLD (c).

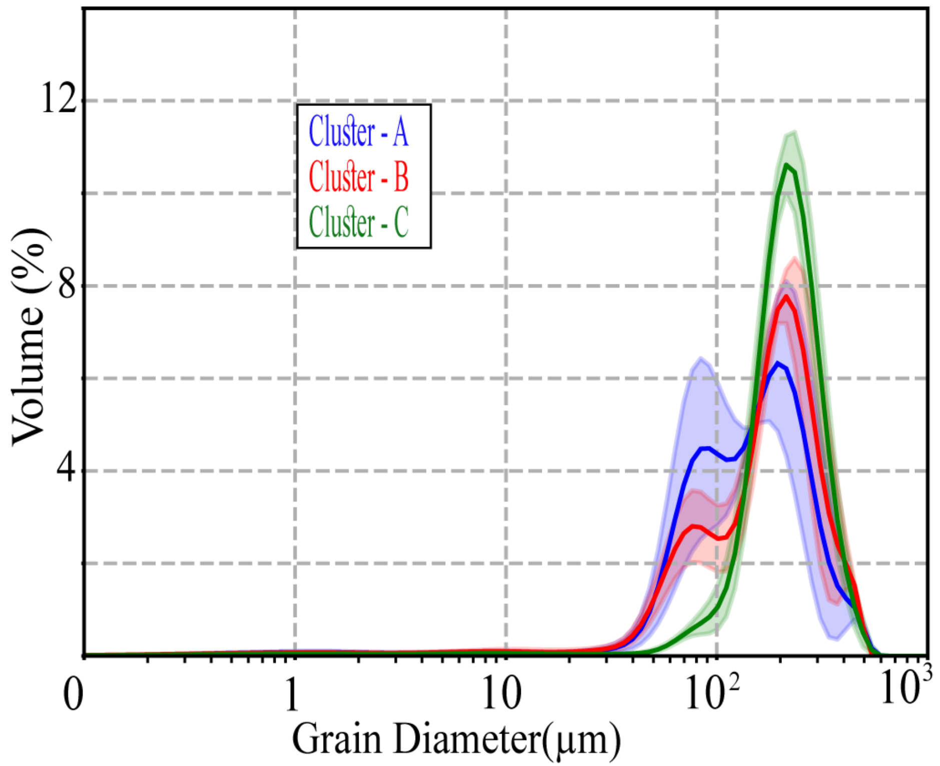


- POSL mean-shift cluster analysis based on the IR and Blue luminescence Net values indicates **3 clusters** within the Mitvakh section.

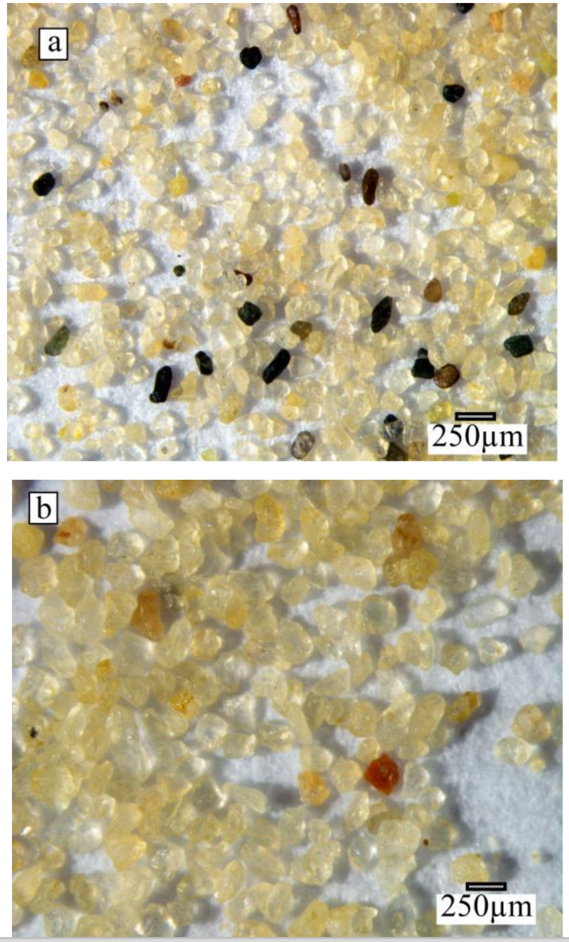


Results – Mitvakh section

- PSD analysis of the Mitvakh shows finer fraction at the bottom parts, with a tendency of coarsening upwards towards the VLD crest.
- PSD analysis according to the main stratigraphic units shows a bimodal pattern for units A and B (75-90µm and 230-250µm), while unit C has a unimodal pattern (210-250µm).



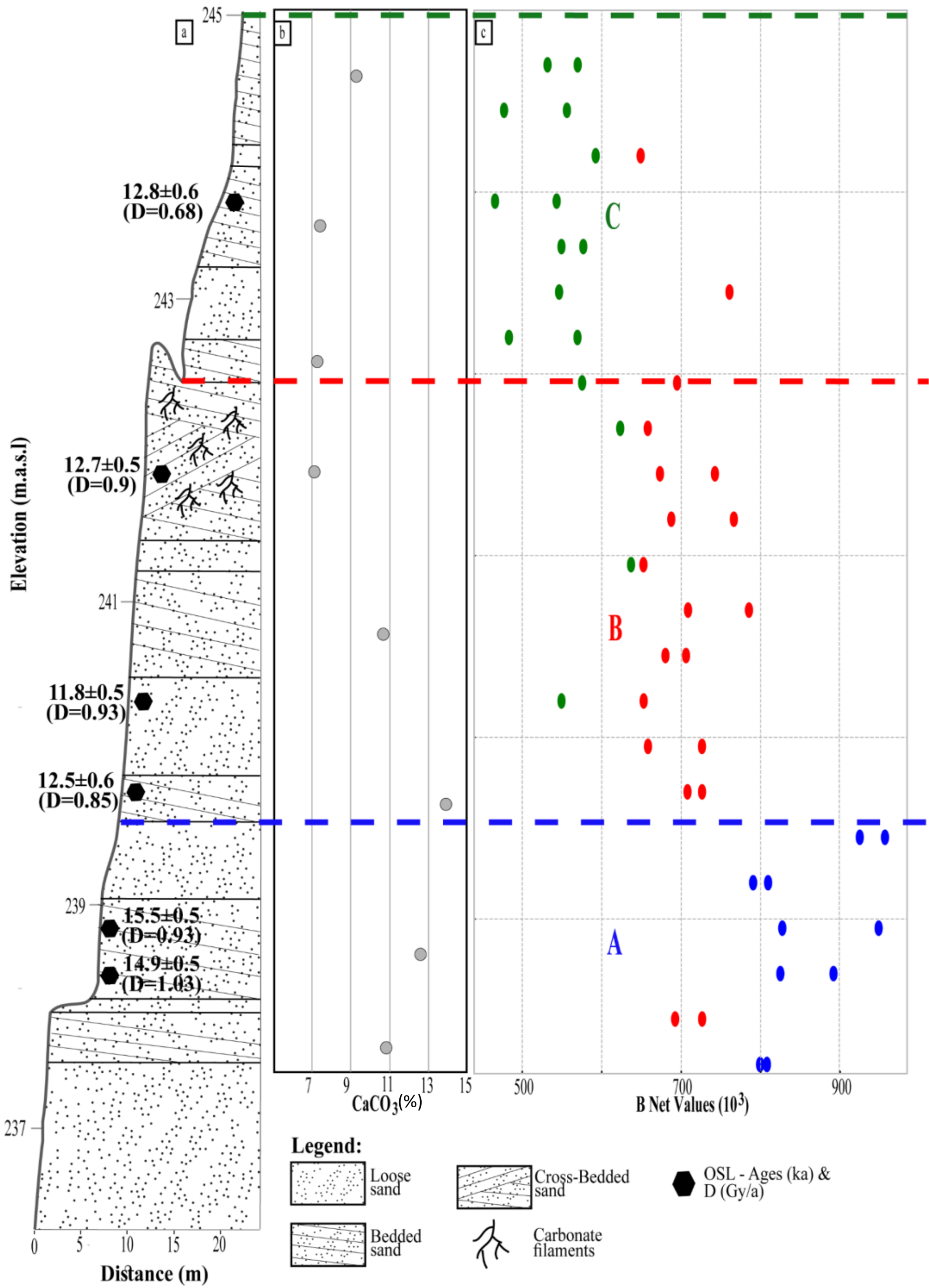
- Very Fine Sand (65-125) fraction contains more heavy minerals (a) compared to coarser sand (b).



Binocular microscope images of sieved and washed VLD sand

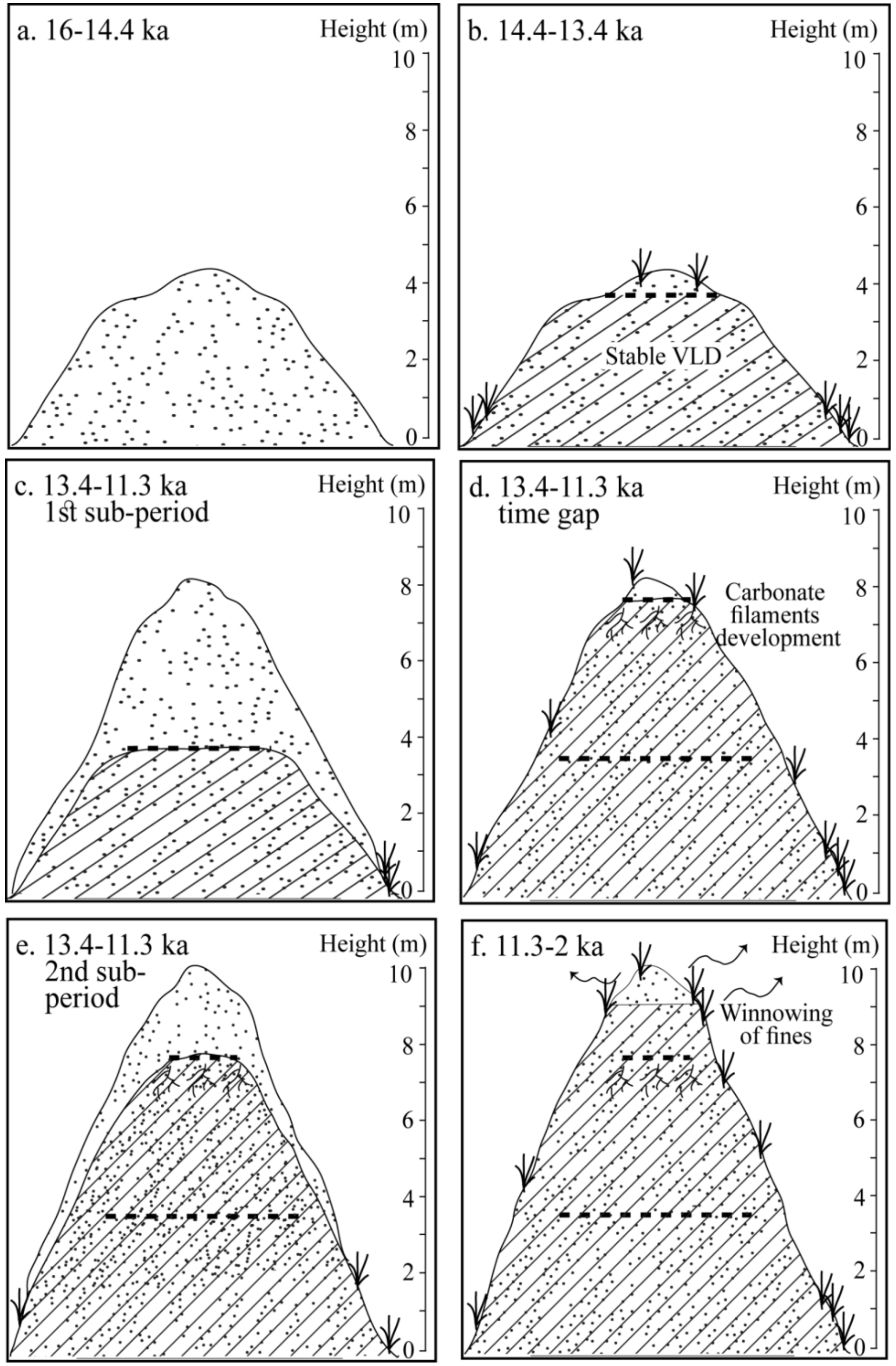
POSL and OSL differences

- OSL ages of the different units are:
  - Unit A dates to 16-14.4 ka.
  - Unit B dates to 13.2-11.3 ka.
  - Unit C dates to 13.4-12.2 ka.
- Because unit C has only one OSL date, and it falls within the time range of the overlaid unit B, it is interpreted as a single time span of deposition (13.4-11.3 ka).
- Luminescence signal can be attributed to the time of deposition, but to mineralogical differences and other luminescence properties as well.
- There are several differences between the POSL and OSL, regarding the sample's pretreatment, measurement procedure and calculations.
- The OSL ages are calculated by dividing a calibrated luminescence signal with a matching environmental dose rate value (**D**), thus normalized, while the POSL are not.
- It is therefore assumed that different environmental dose rates, caused by changes of minerology, are main cause for mismatching between POSL and OSL in a quartz rich environment.
- The carbonate filaments development and the POSL clusters indicate that units B and C could be divided into two sub-periods, regardless to the OSL dating.

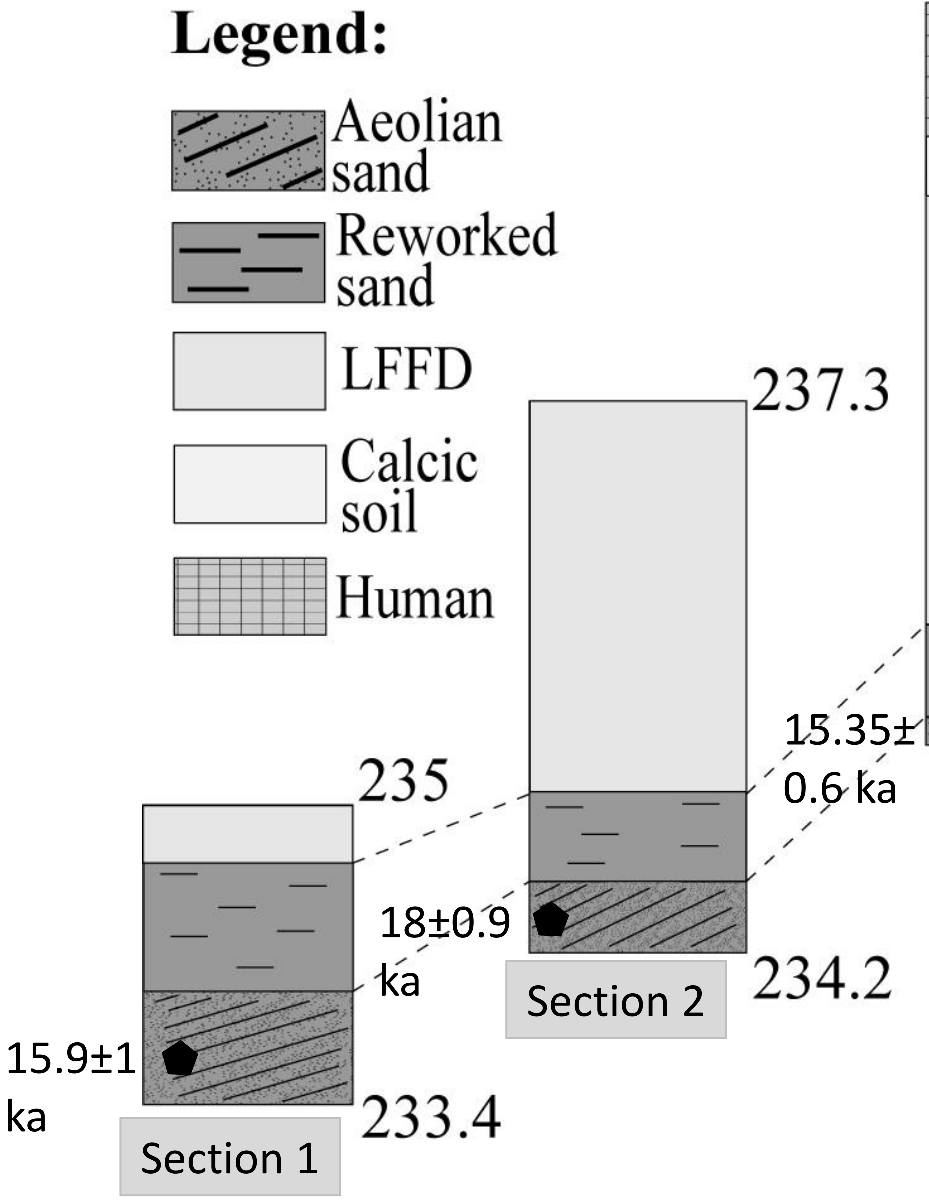


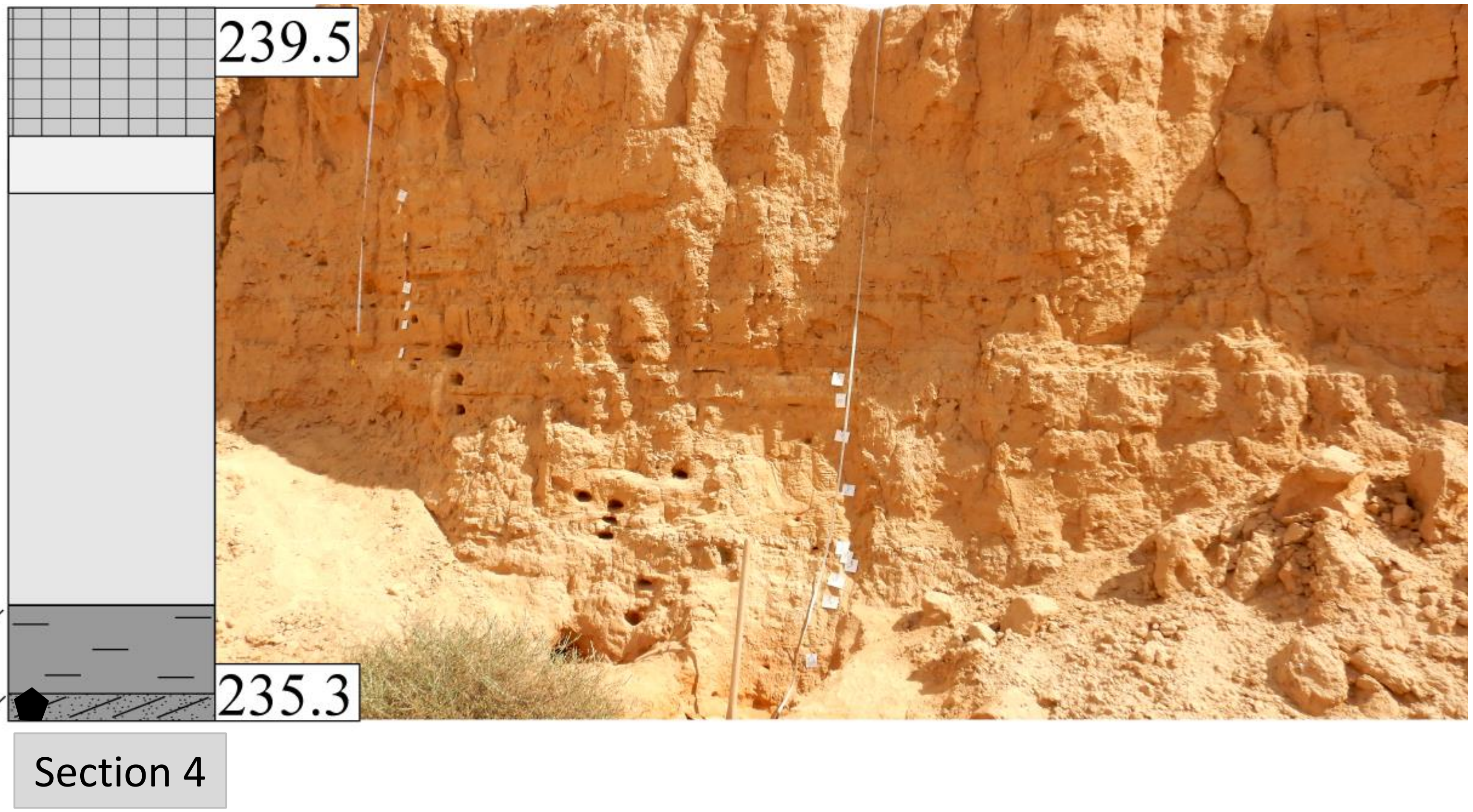
VLD vertical construction

- The first period of deposition occurred between 16-14.4 ka and during the H1 event.
- A relatively stable vegetated period occurred between 14.4-13.4 ka.
- The second period of deposition occurred between 13.4-11.3 and relate to the Younger Dryas.
- The textural and mineralogical differences between the Mitvach units, probably caused due to the duration differences of stable conditions, which enabled fine winnowing from the active parts:
- The most upper unit (unit C) was subjected for winnowing for a period of minimum 9 ka in its upper active parts, while units A and B were subjected for winnowing of 1 ka and less than 2.1 ka respectively, after stabilization.



Sampling sites – wadi sections

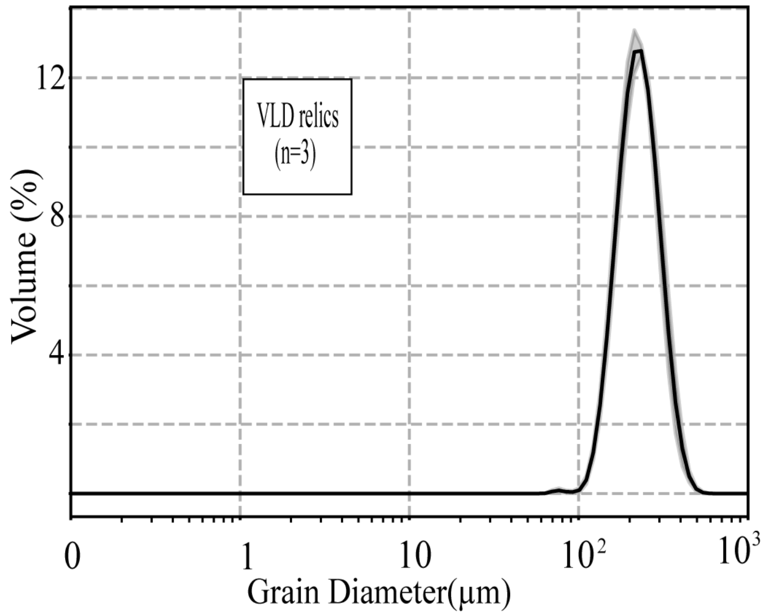


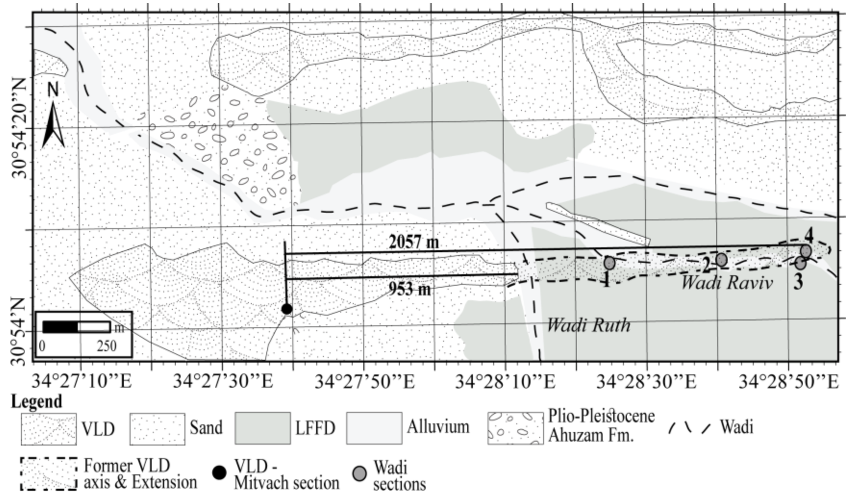


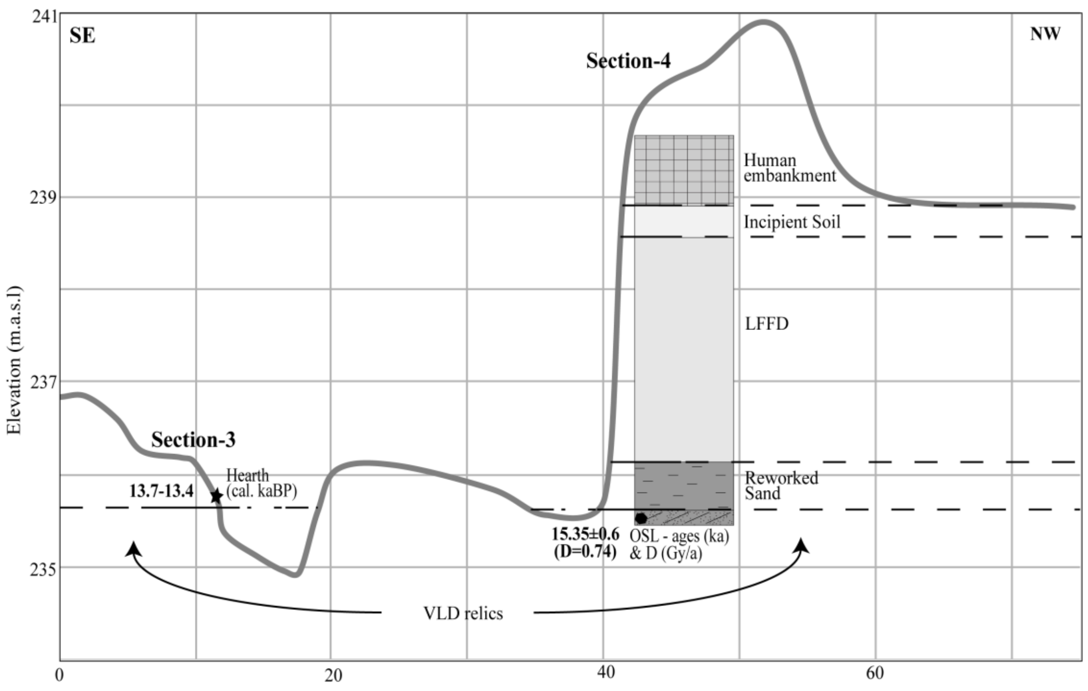
Samples from the aeolian sandy unit at the bottom of the wadi bank sections 1,2 and 4 were analyzed.

Horizontal elongation

- The aeolian sandy units PSD unimodal pattern is a common pattern for active parts of VLDs in the northwestern Negev.
- OSL ages from section 1, 2 and 4 from the aeolian sandy unit are: 15.9±1, 18±0.9, 15.35±0.6 respectively.
- Section 3 hearth remains were dated to 13.7-13.4 by C_{14} analysis. prehistoric activity in this area relates to the development of water bodies due to dune dams, indicating fluvial activity after sand deposition within the wadis.

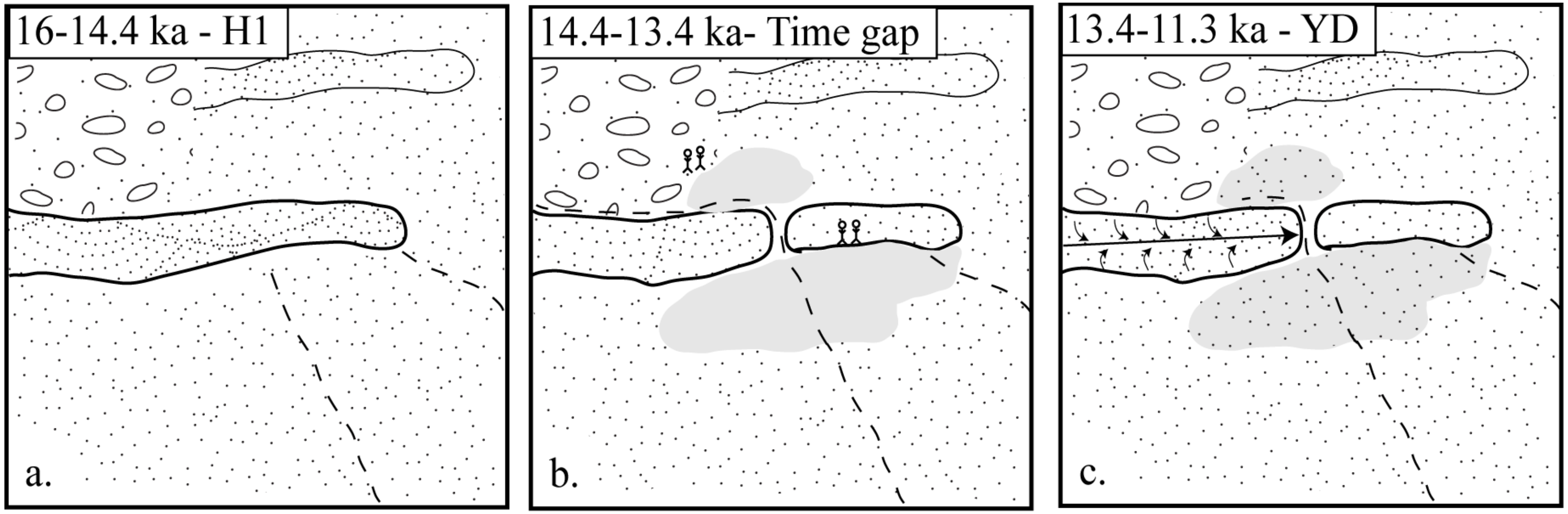






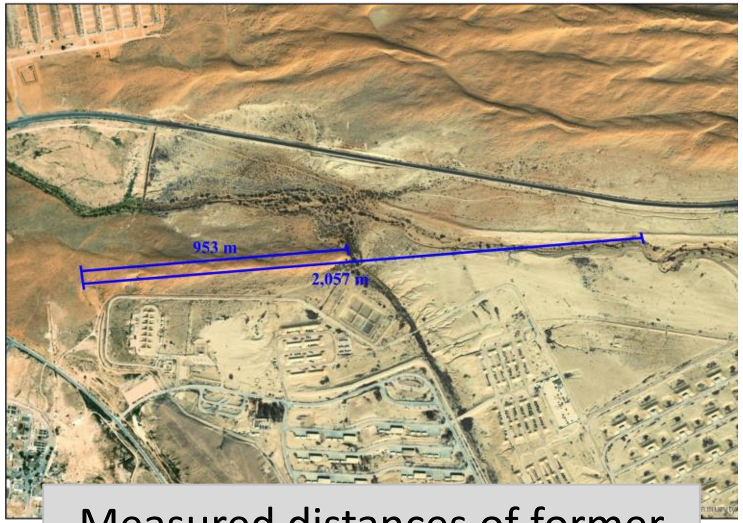
VLD horizontal elongation

- During the first period of accumulation and prior, the VLD elongated crossing wadi Ruth and reached it furthest point, more than 1.1 km than today's VLD nose.
- Between the two accumulation periods, VLD stability was recognized by the lack of OSL dates and fluvial activity recognized by the prehistoric hearth, probably resulted in the VLD truncation.
- During the second period of accumulation the VLD did not elongate across wadi Ruth, causing deposition only at the upper wind side of the wadi.

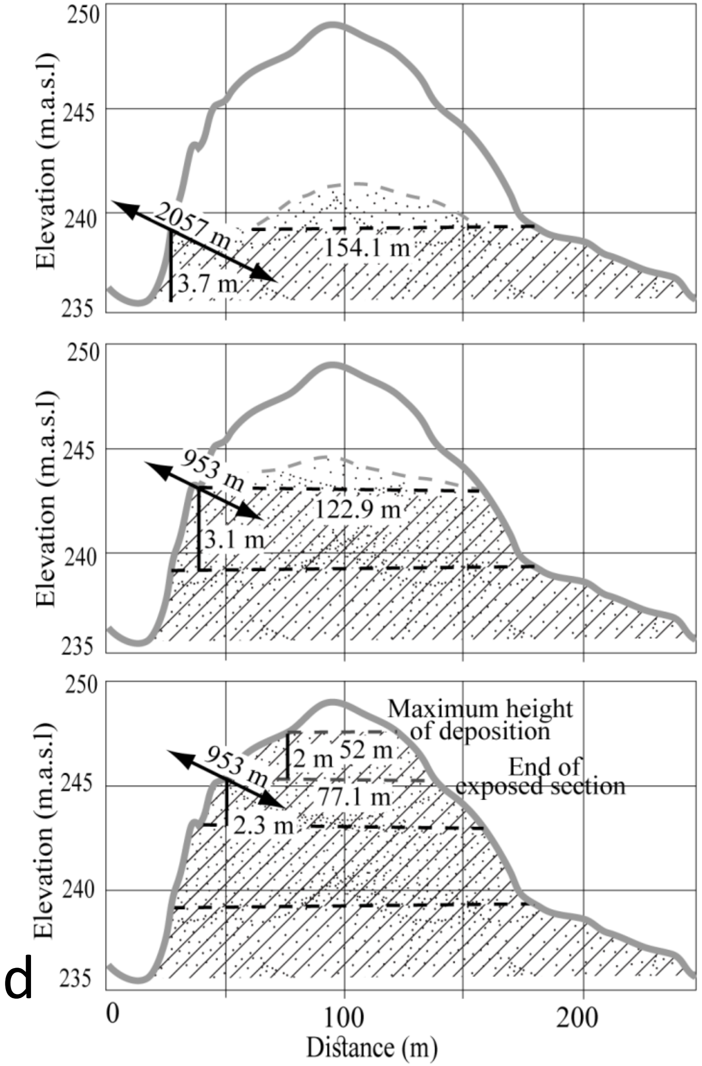


Estimated sand volumes

- Unit A estimated sand volumes: **390,000 m^3 in ~ 1.6 ka**
- Unit B estimated sand volume: **120,000 m^3**
- Unit C estimated range of sand volume: **55,000 – 90,000 m^3**



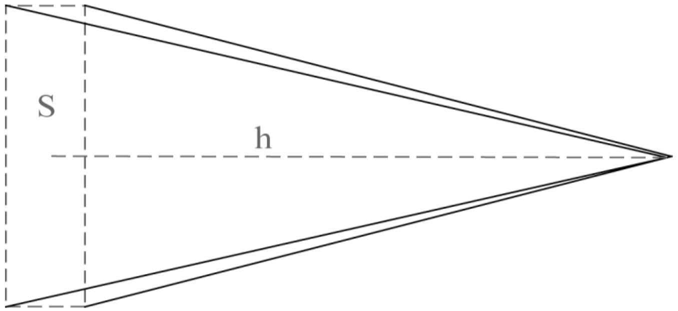
Measured distances of former and modern VLD



- This rough estimation indicates that:

➢ During the H1 event (unit A) a substantial larger volume of sand accumulated in comparison to the YD event (units B and C).

➢ During The first YD sub-period (unit B) larger volume of sand accumulated compared to the following sub-period (unit C).



Geometric shape used for volume calculation

Conclusions

- High-resolution analysis of a VLD section using POSL, OSL and texture analysis enabled stratigraphic units classification.
- During the late Pleistocene two main events of accumulation constructed the VLD, 16-14.4 ka (unit A) and 13.4-11.3 ka (units B & C). These finding are in agreement with prior research suggesting VLDs accumulation during the Heinrich-1 (H1) and the Younger Dryas (YD) events.
- The YD event could be divided into two sub-periods (units B & C), indicated by the development of carbonate filaments and POSL clusters. These sub-periods were not recognized by OSL analysis.
- Elongation analysis of exposed and buried VLD suggest sand deposition began prior to the H1 event. The VLD transaction occurred after the H1 event. During the YD the VLD did not elongate over wadi Ruth nonetheless deposition occurred at the upwind parts.
- Combination of the vertical construction and the horizontal elongation enabled volumetric calculations, which shows that the H1 event accumulation rate was substantially larger (244,000 m^3/ka) compared to the YD event (84,000-100,000 m^3/ka).
- The First YD sub-period accumulated volume (120,000 m^3) was larger than the second YD sub-period (55,000 – 90,000 m^3).

Thanks for participating