Evolution Of Normal Faults Based On Displacement Patterns: A Case Study From The Eastern Levant Basin, Israel

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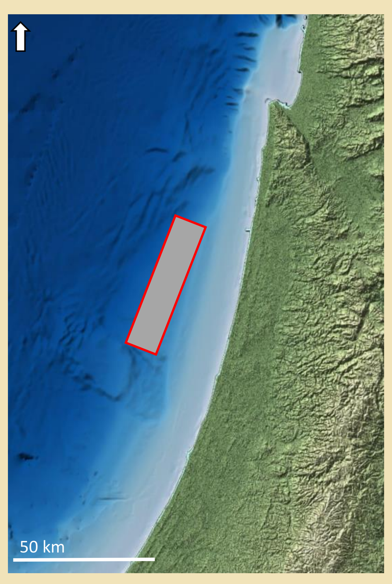
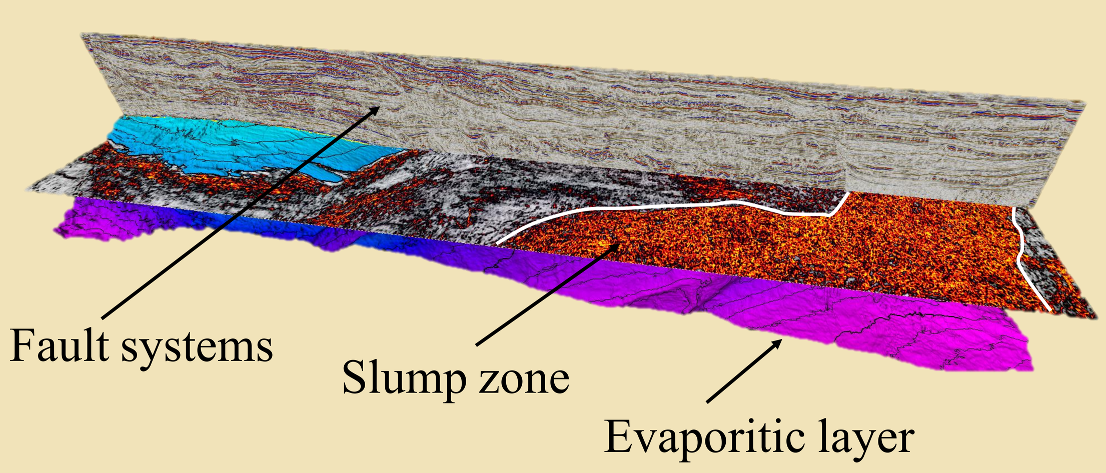
1. Introduction

The Plio-Pleistocene section of "Gabriella" 3D seismic survey, located at the eastern Levant Basin, is incised by numerous fault systems. These consist of growth faults accompanied by synthetic and antithetic faults, some of which overlay the Israel Slump Complex[1] (ISC). Displacement patterns allow to distinguish between post- and syn-depositional faults. We present a workflow to investigate the evolution of these faults by analyzing their displacement patterns.





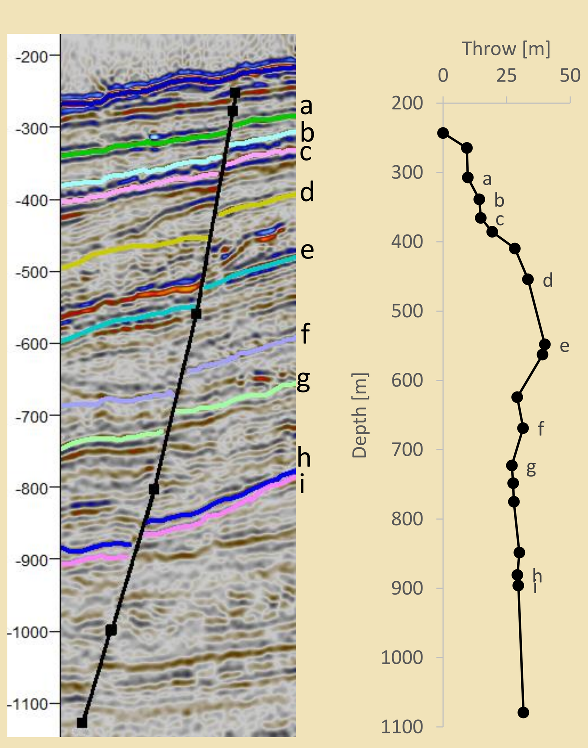
Gabriella 3D seismic survey.

2. Research Goals

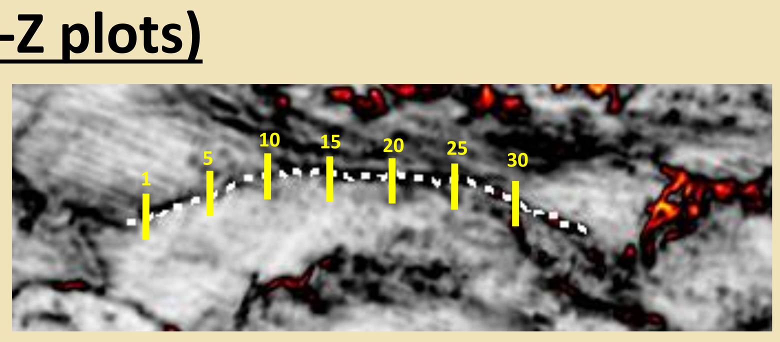
- Recapture the evolution and the propagation history of normal faults based on quantitative displacement analysis.
- Explore the interactions between fault displacement patterns and the chaotic structures incised by them.

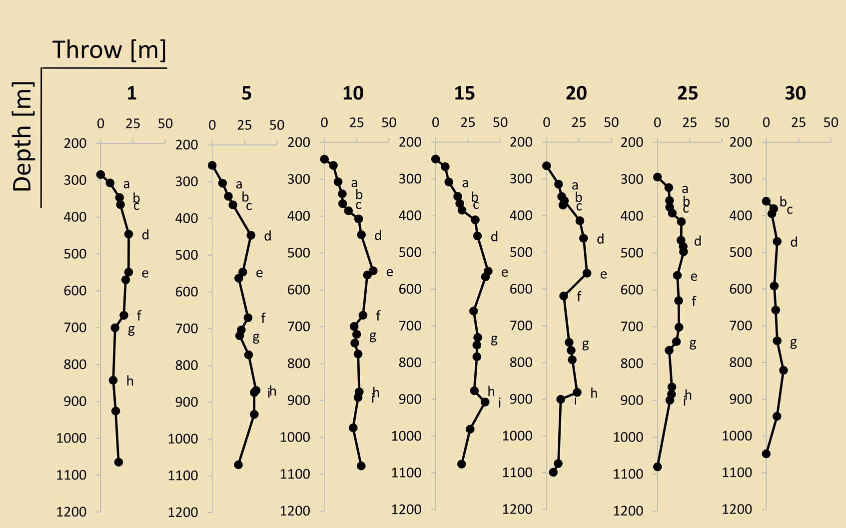
3. Methods

1. Throw vs. Depth plots (T-Z plots)



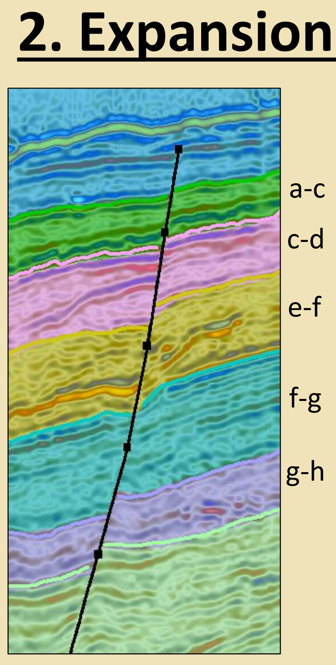
Key horizons *a-i* followed by displacement measurements.



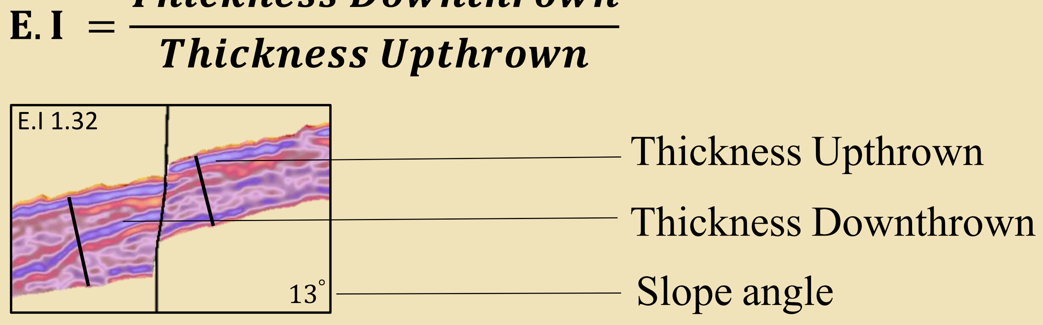


T-Z plots along a fault surface.

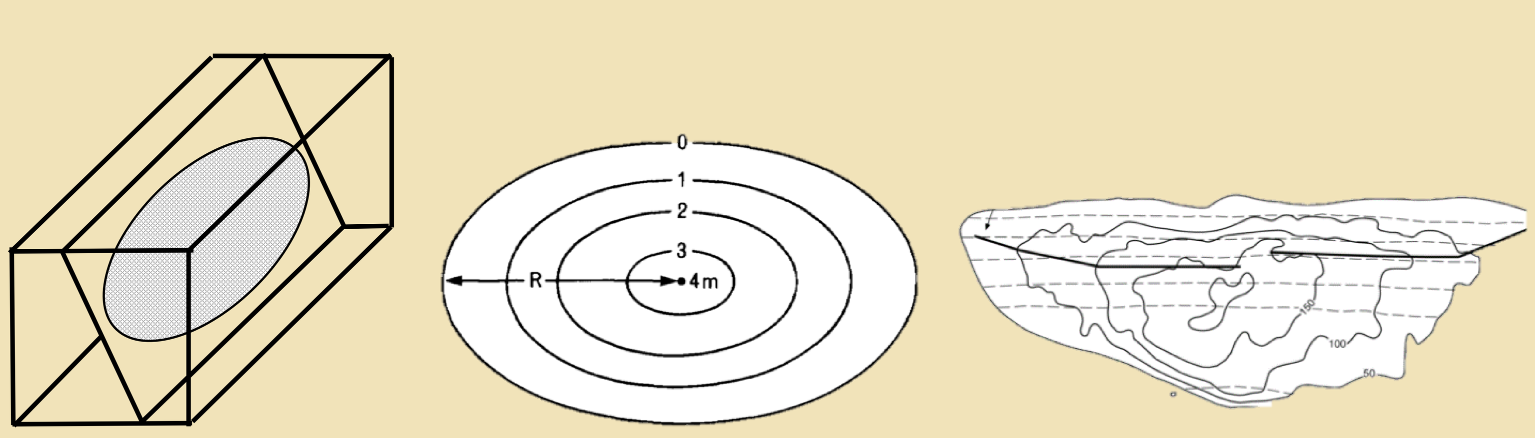
2. Expansion Index (E.I)



$$E.I = \frac{Thickness\ Downthrown}{Thickness\ Upthrown}$$



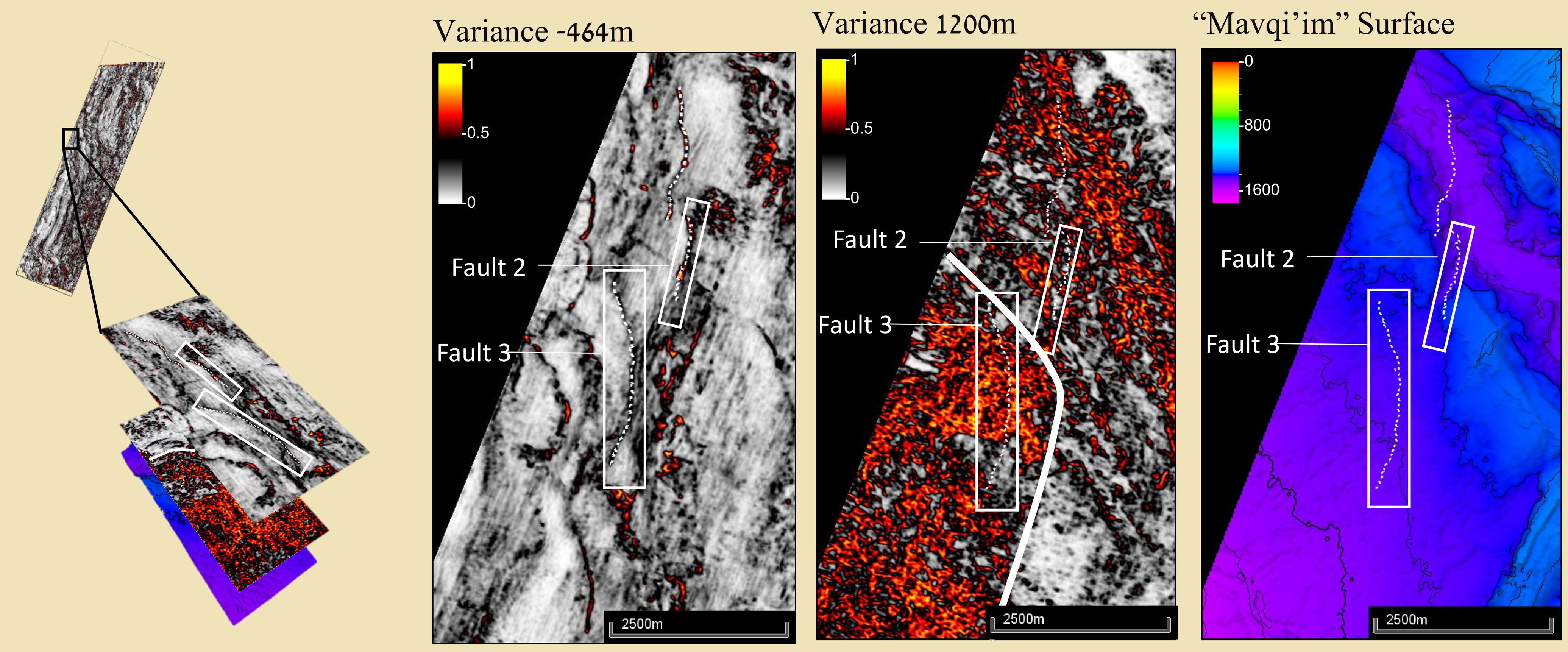
3. Displacement Contour Diagram (DCD)



DCD patterns for post[2]- and syn-depositional[3] faults. Modified after Walsh & Watterson (1990) and Childs et al., (2002).

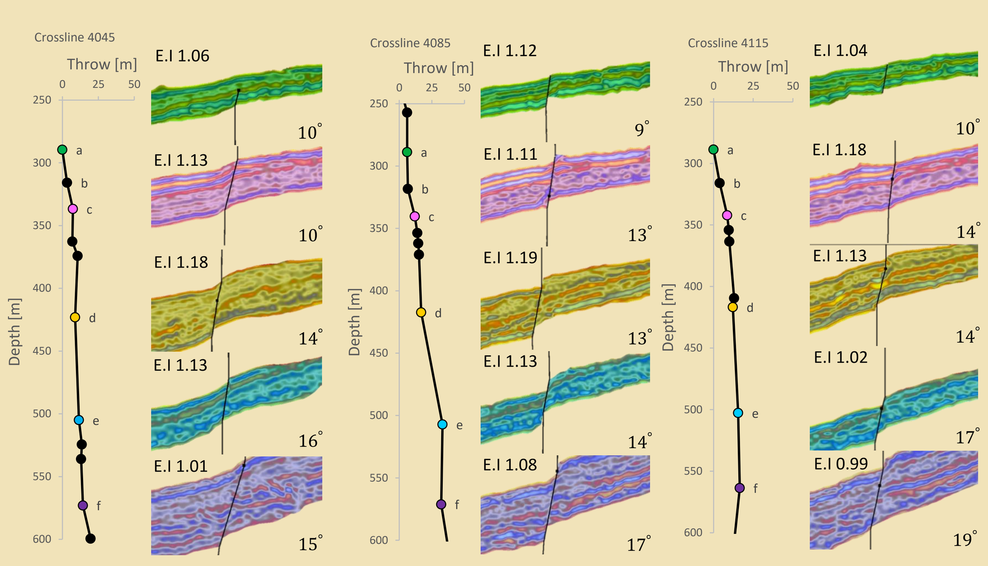
4. Results

Seismic Interpretation



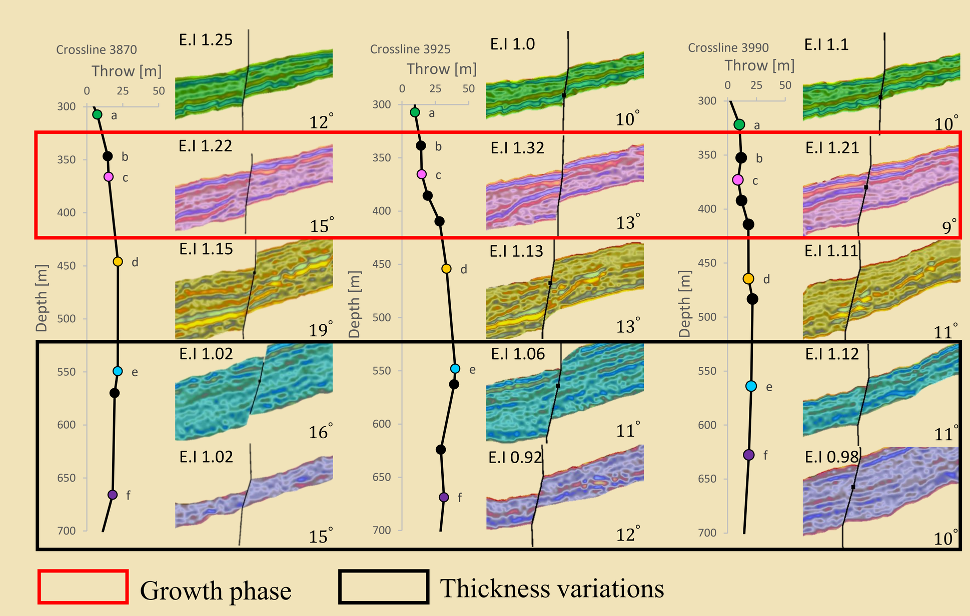
Fault traces from -464m and projected down to -1200m depth and to "Mavqi'im" structural map. Only Fault 3 incises both the ISC head scarp and the evaporitic layer.

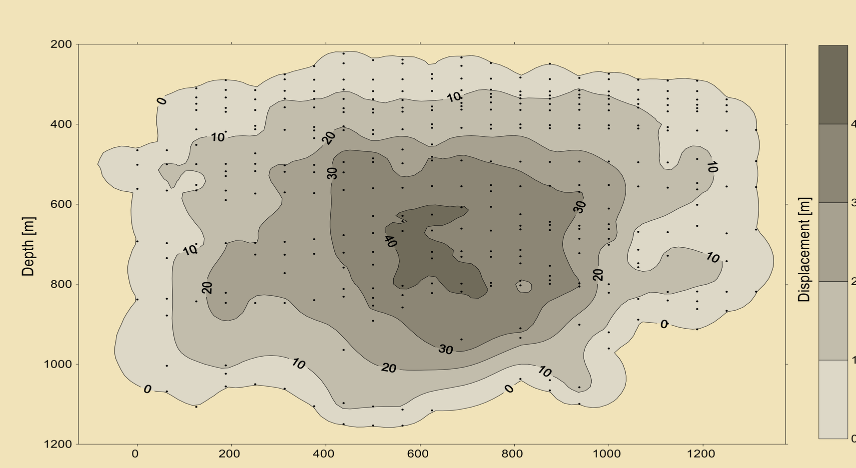
Fault 2- Blind pattern



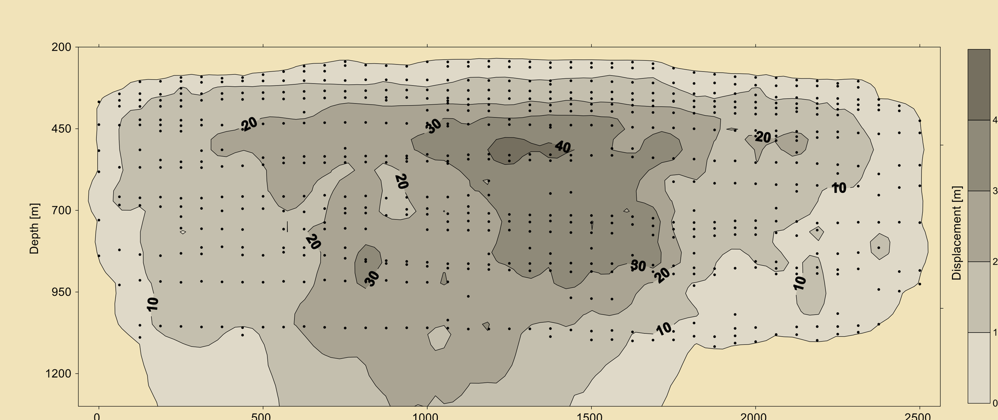
Each panel shows T-Z plot (left) and E.I with relevant seismic section (right).

Fault 3- Growth pattern

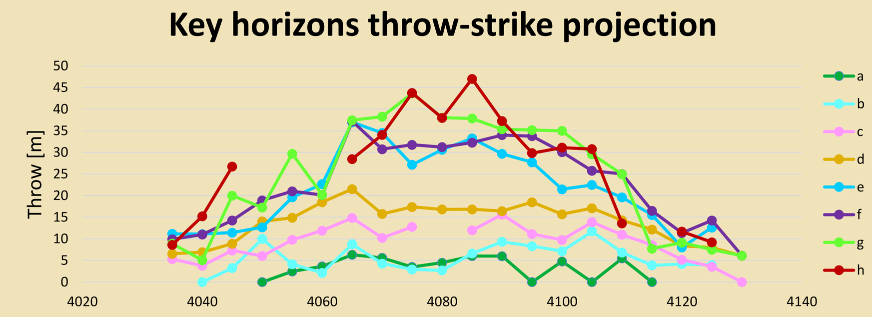




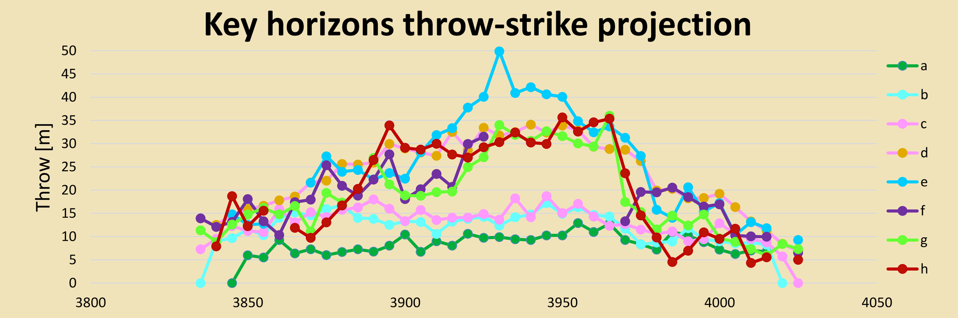
DCD pattern: blind propagation.



DCD pattern: transition from blind to growth.



Throw values increase with depth from horizon *a* to horizon *h*.



Maximum throw values measured at horizon *e*.

5. Highlights

- A sample of four faults yields four different displacement patterns.
- Chaotic structures control fault evolution, recorded as abrupt changes in displacement values resulting in irregular displacement patterns.
- Combining data from neighboring wells and fault DCDs allows to estimate the ages of onset and growth phases: 0.5-0.71 Ma.

6. References

1. Martinez, J. F., Cartwright, J., & Hall, B. (2005). 3D seismic interpretation of slump complexes: Examples from the continental margin of Israel. Basin Research, 17(1), 83–108. http://doi.org/10.1111/j.1365-2117.2005.00255.x k
2. Walsh, J. J., & Watterson, J. (1990). Displacement gradients on fault surfaces. *Journal of Structural Geology*, *11*(3), 307–316. http://doi.org/10.1016/0191-8141(89)90070-9
3. Childs, C., Nicol, A., Walsh, J. J., & Watterson, J. (2002). The growth and propagation of synsedimentary faults. *Journal of Structural Geology*, *25*(4), 633–648. http://doi.org/10.1016/S0191-8141(02)00054-8

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