Integrated Fault Mapping in Gulf of Suez Rift Zone*

Andreas Laake[1] and Mohamed Sheneshen[1]

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[1]WesternGeco, Cairo Heliopolis, Egypt (MSheneshen@slb.com; laake1@slb)

Abstract

Structural mapping on the western gravel plains of the Gulf of Suez is challenging because of complex rift tectonics. Two main fault systems are observed: the NW-SE trending rift-parallel faults and SW-NE trending cross-rift faults. Rift-parallel faults show a clear impedance signature in seismic data and can be mapped through processing the seismic cube for heterogeneities. The outcrops of these faults are also mapped and satellite imagery interpreted for lithology.

Cross-rift faults, however, are not associated with a seismic impedance contrast and require a different approach. We noticed that present wadi courses are affected by the cross-rift faults and assumed that this observation would also hold for palaeo-wadis. We used satellite imagery to map a recent wadi and to generate the template for a geobody. The seismic data cube is then processed for instantaneous frequency to detect local resonances associated with palaeo-wadis and to associate geobodies with the palaeo-wadi courses. We could distinguish between the braided stream sections of the wadi courses, the spatial boundaries of which allowed us to infer the delimiting cross-rift fault and we found palaeo-deltas, which allowed the delineation of the palaeo-coastline.

In the final step, we merged the fault plains from the rift-parallel system and the cross-rift system and correlated it with the fault outcrops delineated from interpreted satellite imagery. The integration of satellite imagery interpretation with seismic data processing allowed the delineation of structural trends with very different geophysical properties and resulted in a complete structural description of this complex rift environment.

Reference

Alsharhan, A.S., and M.G. Salah, 1995, Geology and hydrocarbon habitat in rift setting: northern and central Gulf of Suez, Egypt: Bulletin Canadian Petroleum Geology, v. 43/2, p. 156-176.

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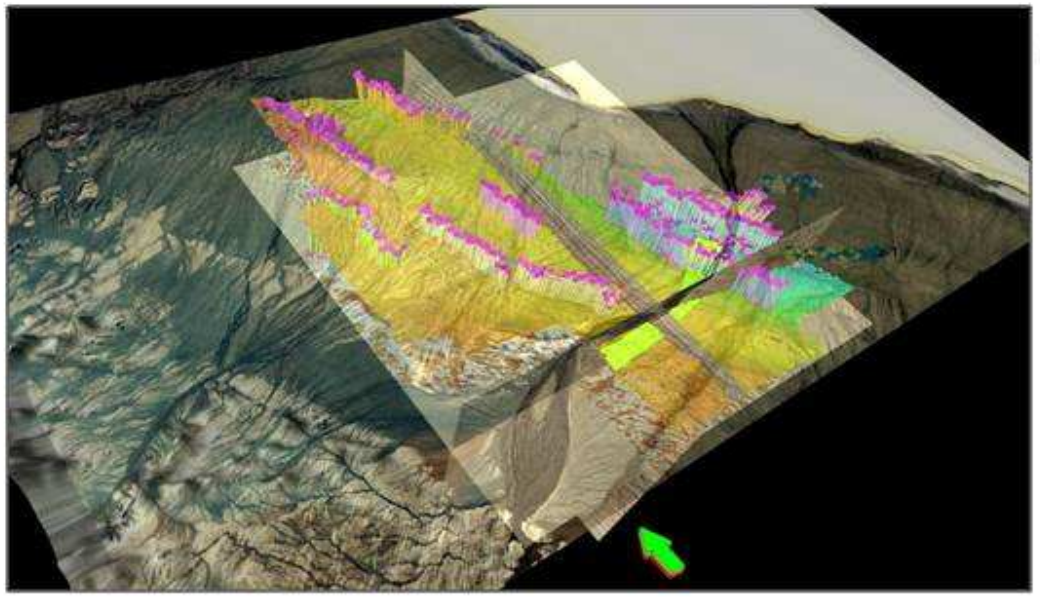
Mohamed Sheneshen and
Andreas Laake
WesternGeco Cairo
7 March 2012

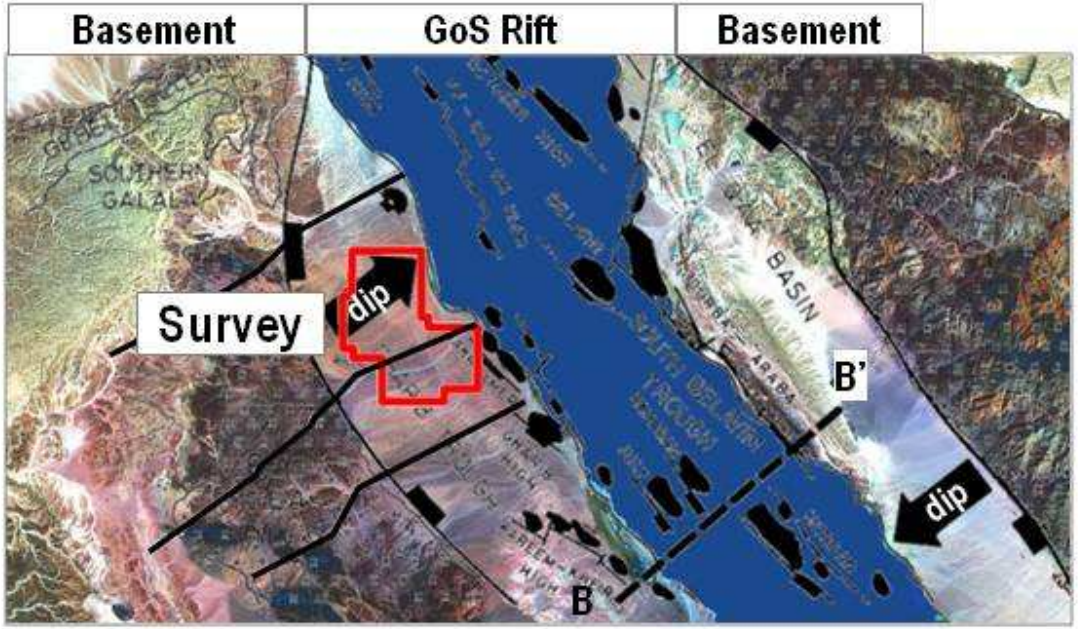


Summary

Goal	Fault mapping for reservoir delineation
Technology	Remote sensing imagery Broadband point receiver seismic data Shallow seismic technology from "noise"
Results	Mapping of two major fault plane trends Surface and near-surface 3D structural geology 3D model for drilling risk from shallow faults
Conclusions	Subsurface geology imprint at surface observed

Integration of surface mapping, near-surface geology and subsurface structure provides fault model

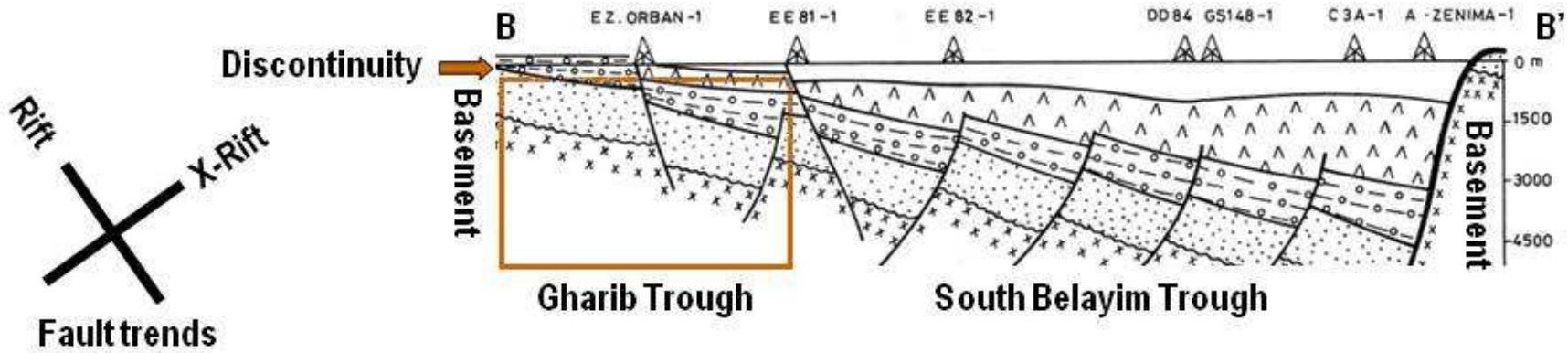
Reservoir challenges in Gulf of Suez Rift



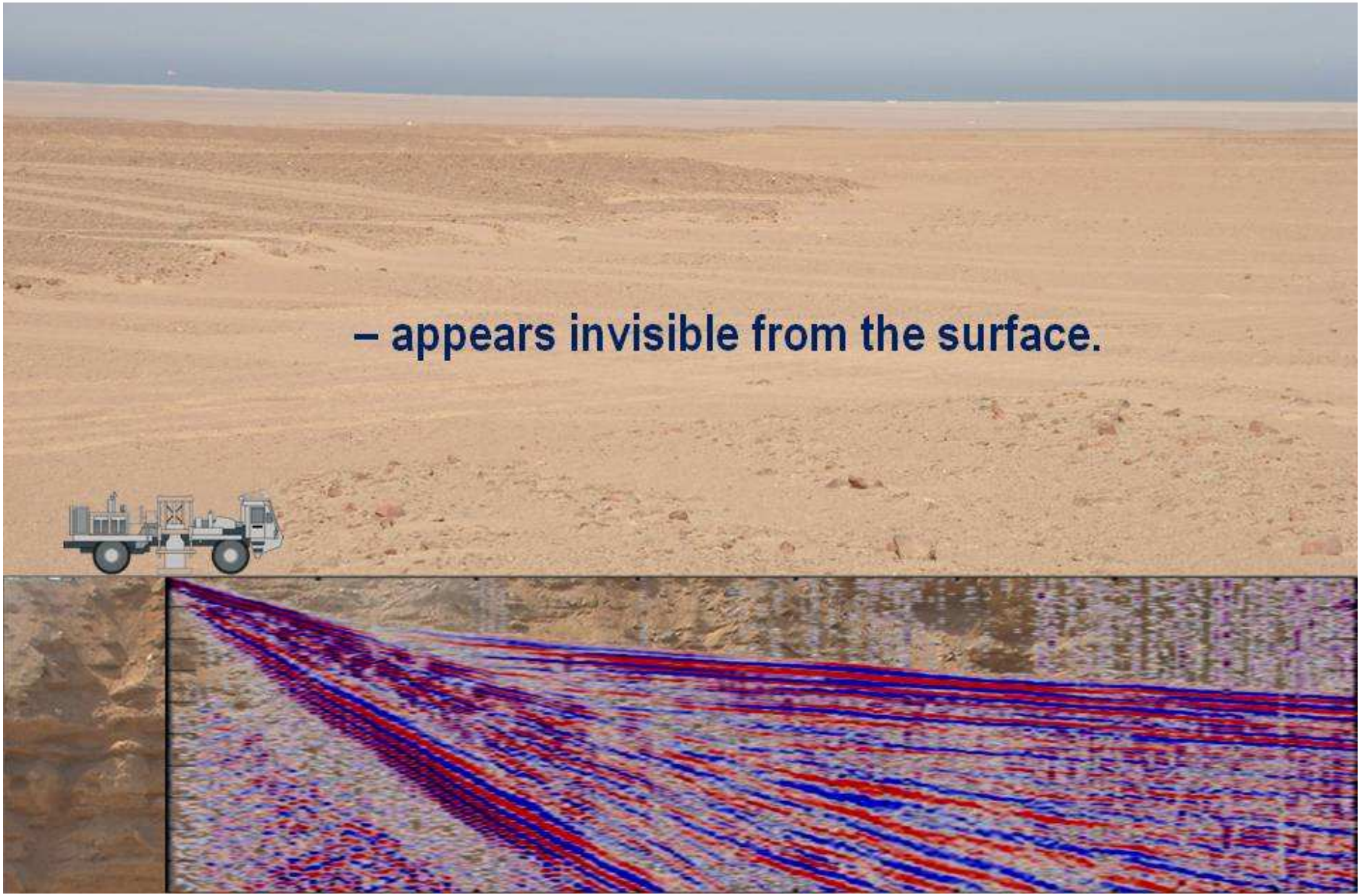
Tectonic map and section after Alsharhan and Salah (1995)

Reservoir challenges :

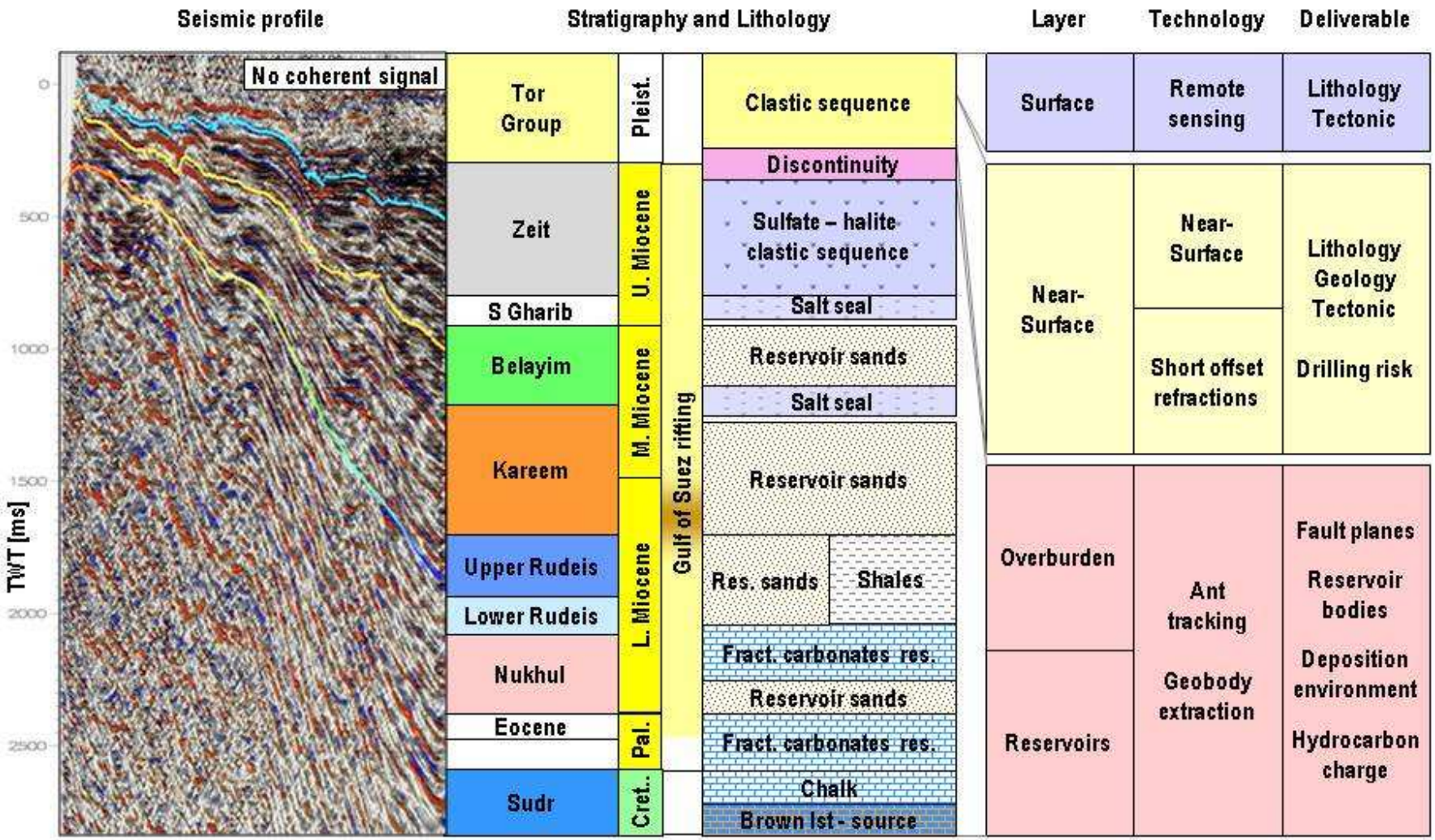
- Extensional / compressional tectonics
- Pre- + syn-rift reservoirs
- NNW-SSE and ENE-WSW fault trends
- Shallow discontinuity



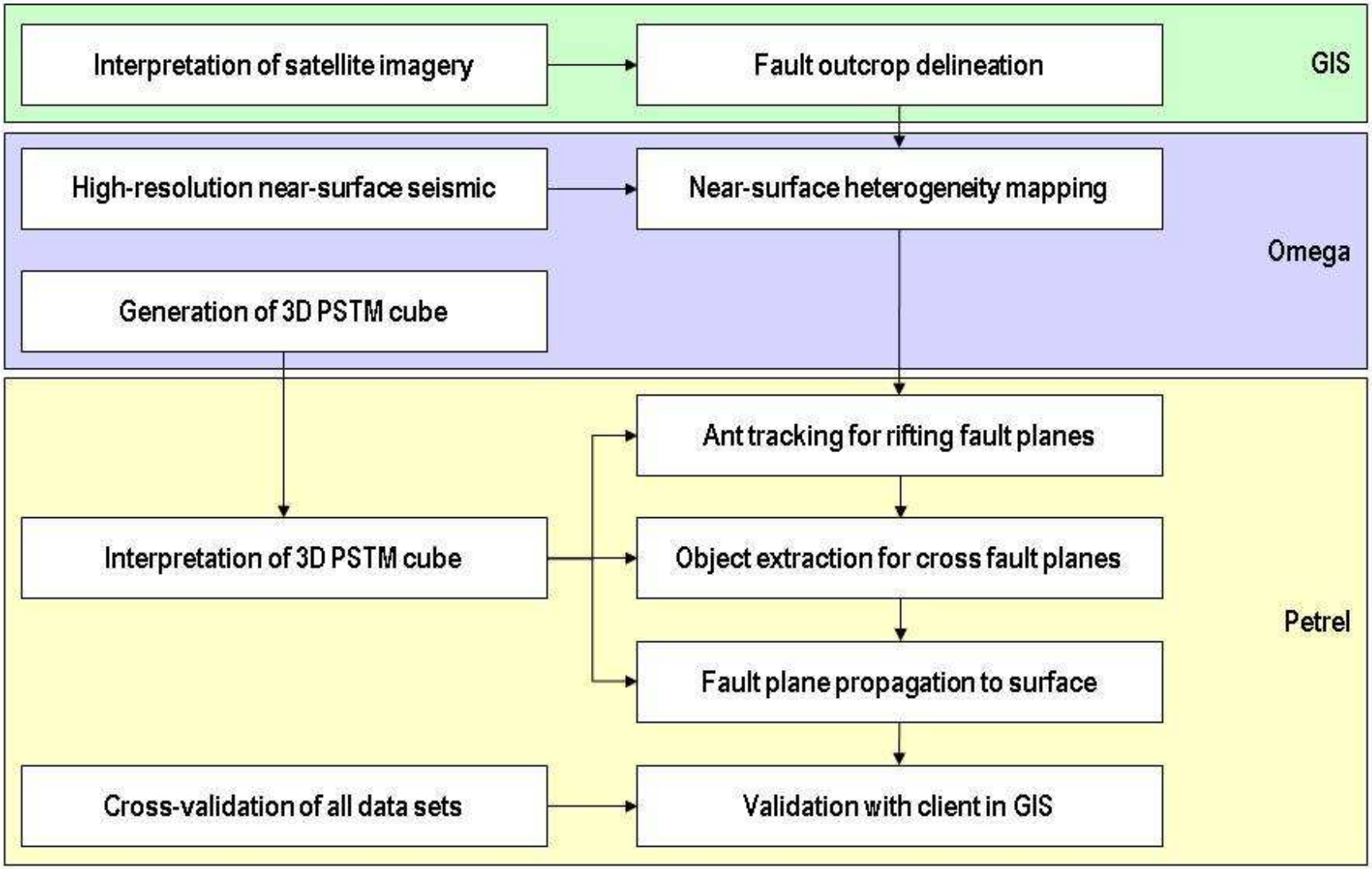
The challenge



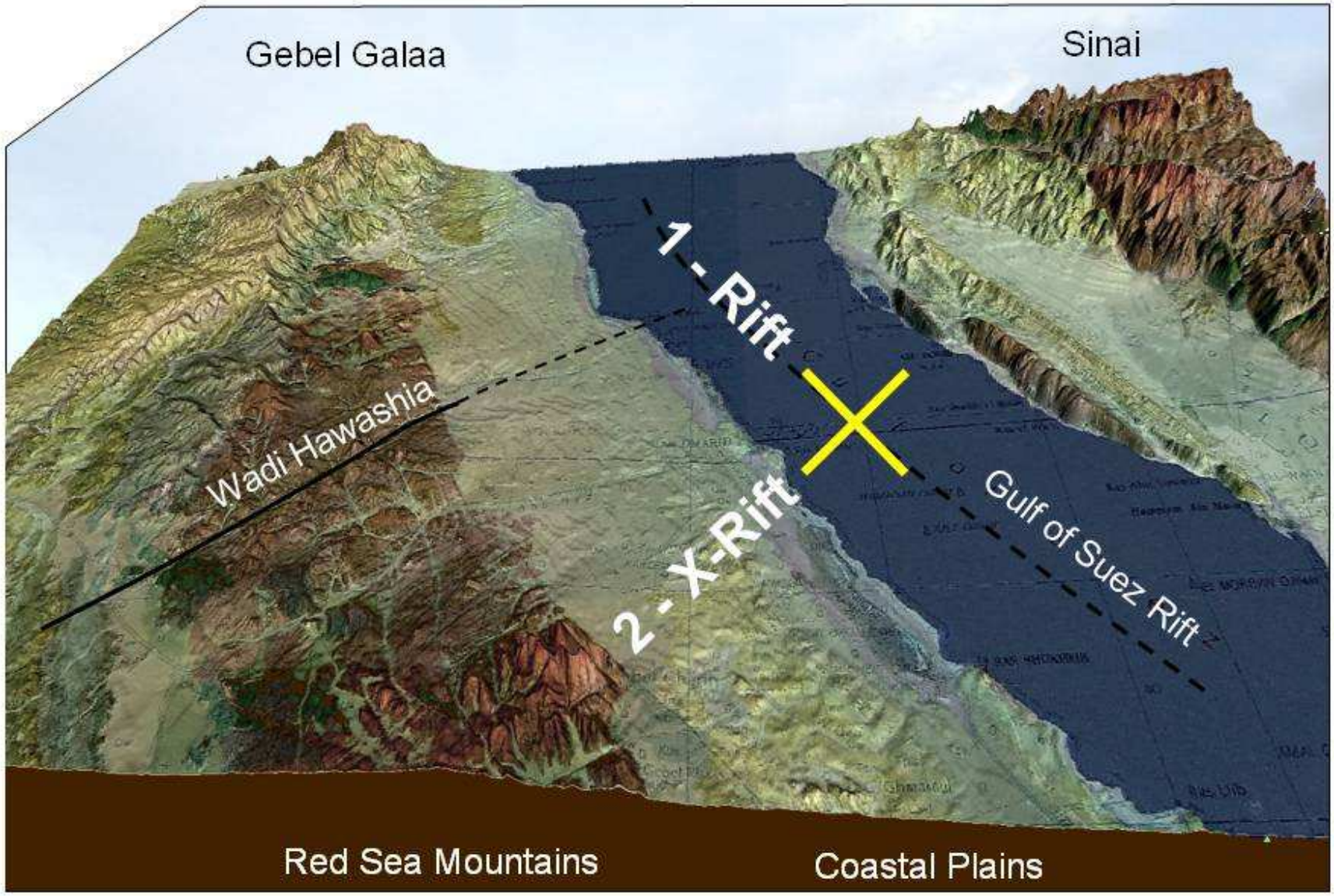
Stratigraphy and technological challenges



Mapping and integration technology



Tectonic framework



1. Rift fault mapping

Challenge

- Mapping of rifting faults from fault system parallel to main Gulf of Suez Rift

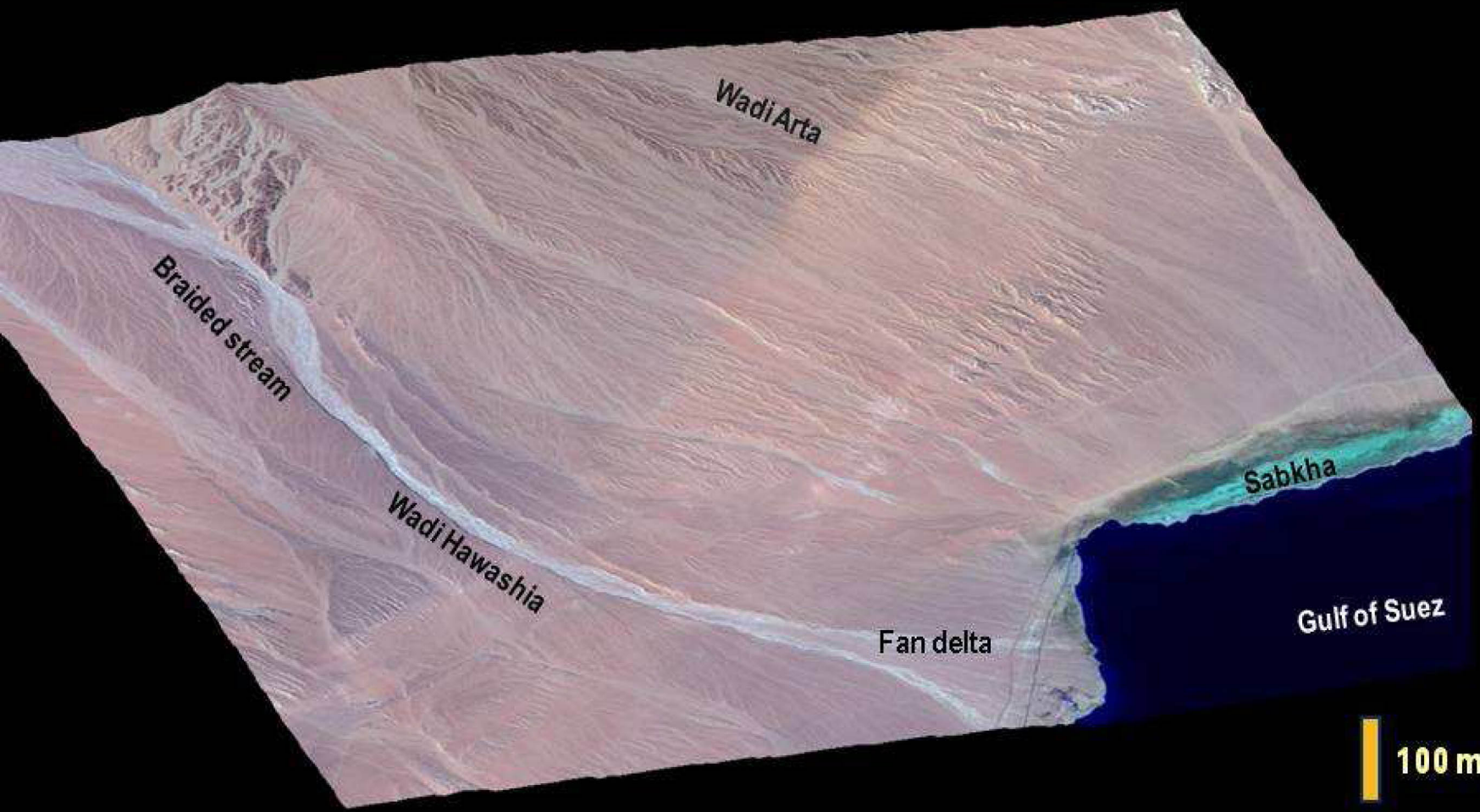
Method

- Direct mapping via guided ant tracking

Technology

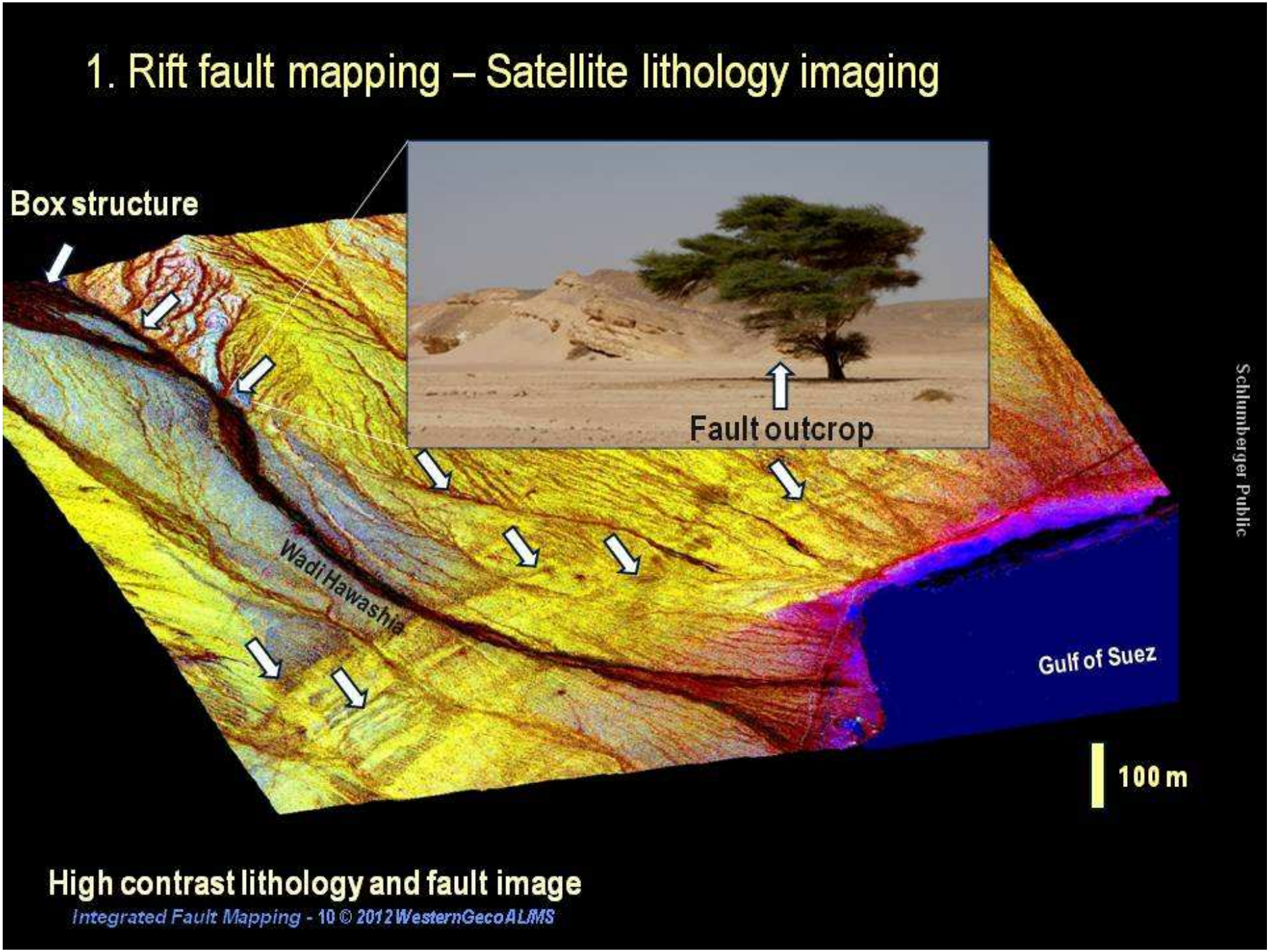
- Fault outcrop detection on satellite imagery
- Propagation through weathering using short refractions and Rayleigh waves from point receiver data
- Ant tracking in edge sharpened PSTM cube

1. Rift fault mapping – Surface satellite image



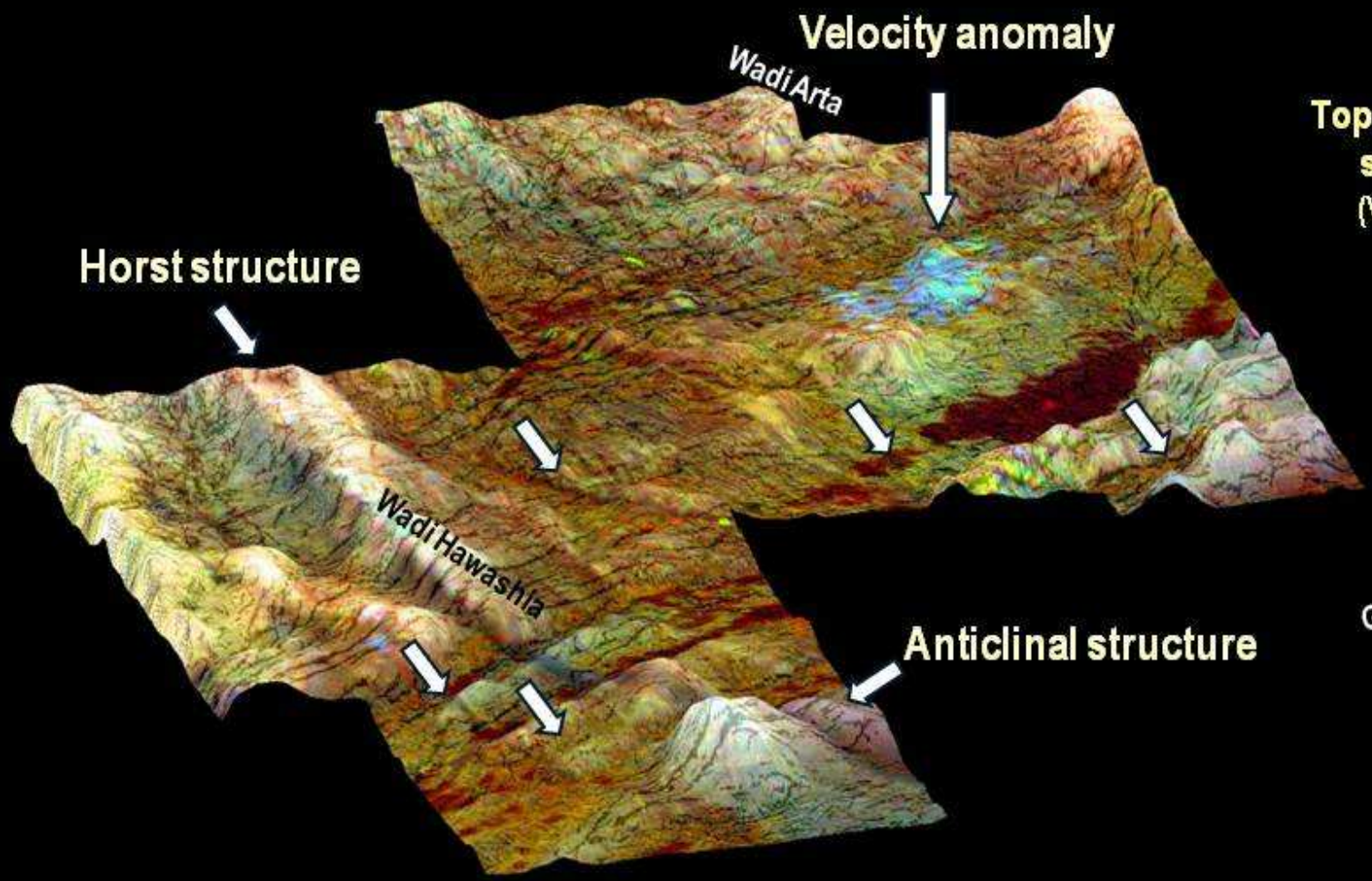
Low contrast, featureless gravel plane with wadies

1. Rift fault mapping – Satellite lithology imaging



High contrast lithology and fault image

1. Rift fault mapping – Shallow sandstone from seismic surface waves



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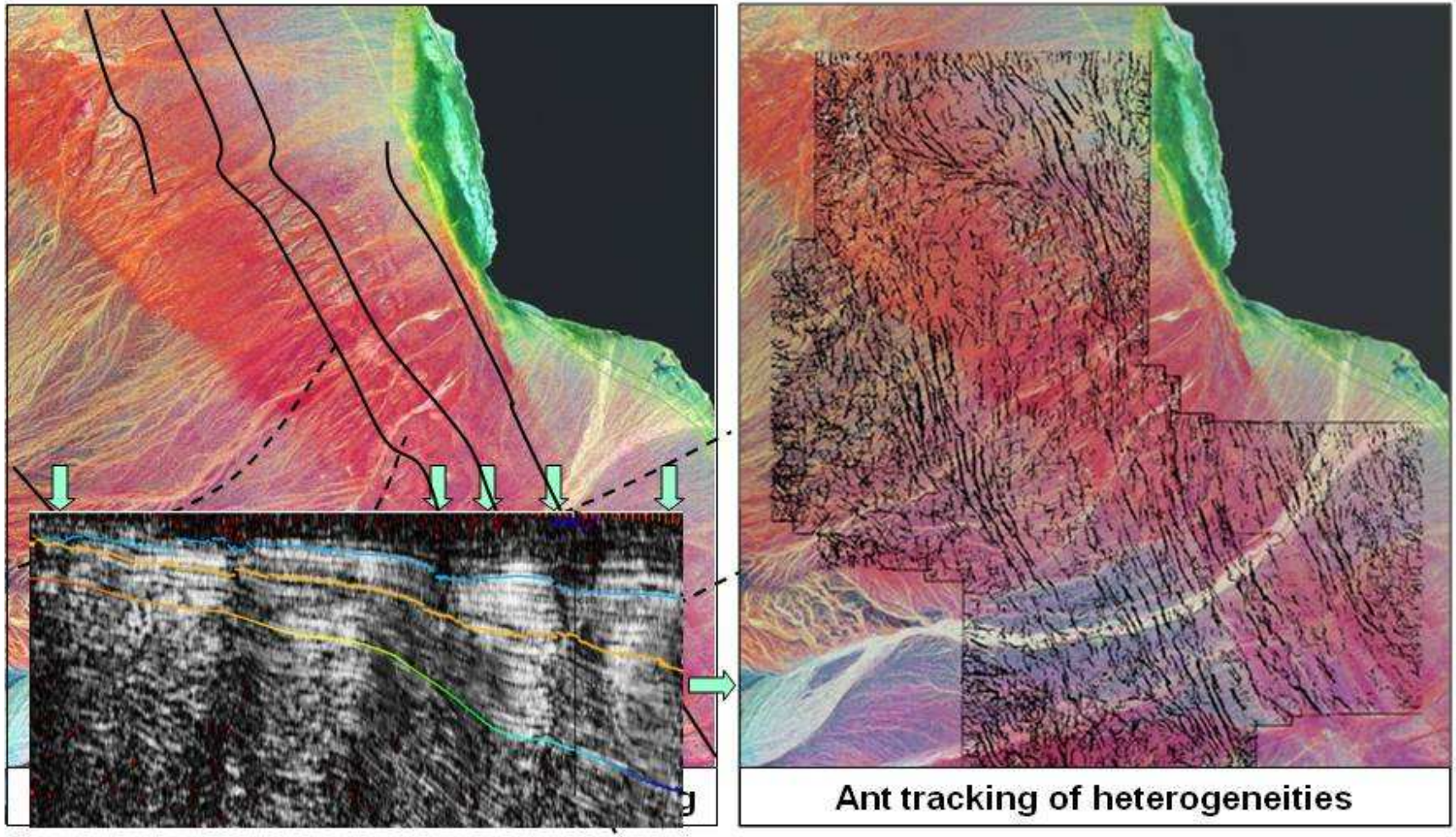
Rayleigh wave velocity structure reveals top sandstone, rift and cross-faults

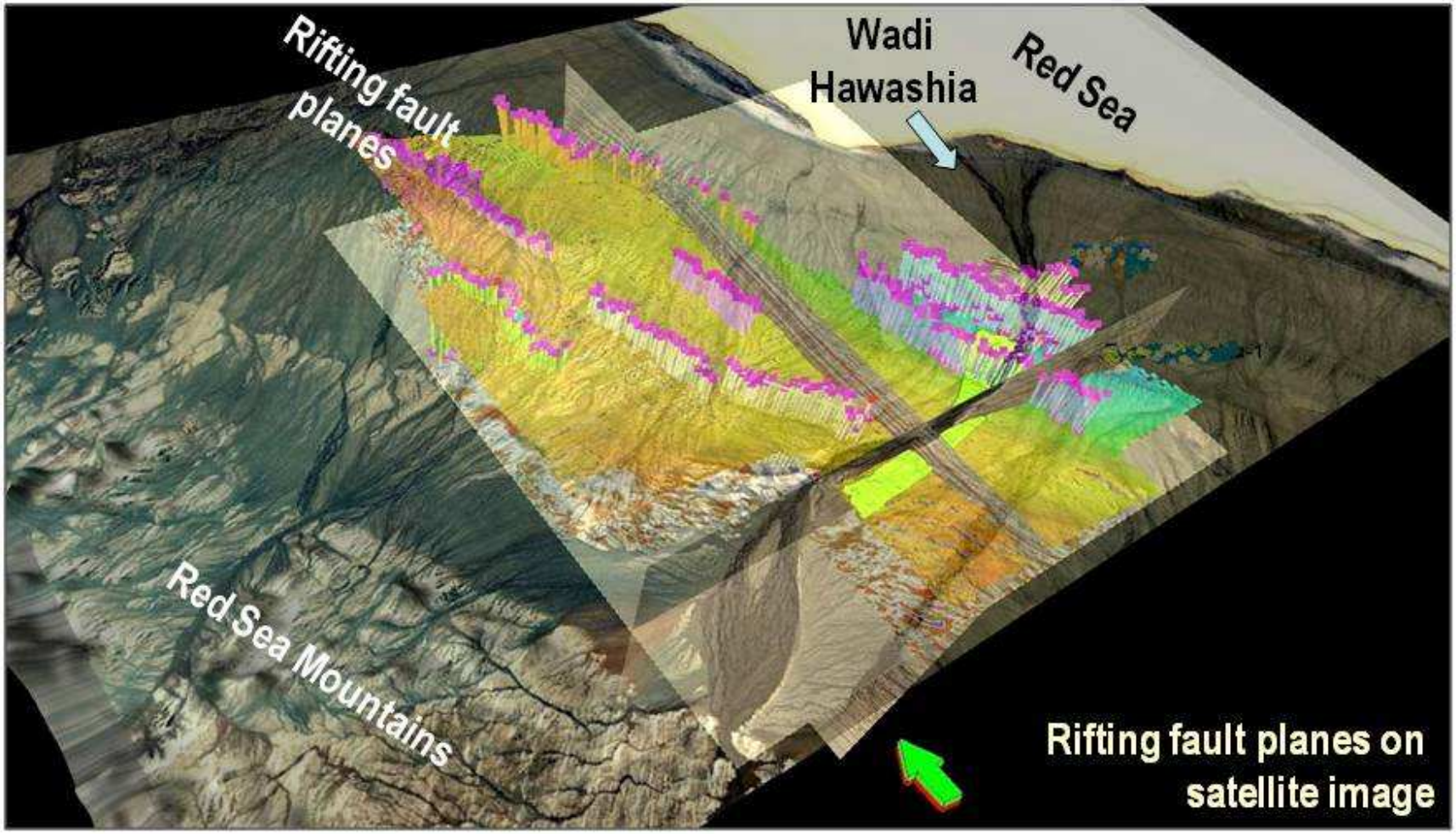
1. Rift fault mapping – Ant tracking in PSTM seismic cube



Horizon picking on cross-sections

Ant tracking picks (500 ms TWT)

1. Rift fault mapping – Extrapolation to surface



2. Cross-fault mapping

Challenge

- Mapping of faults perpendicular to main Gulf of Suez fault
- Fault trends mostly masked by paleo-wadis

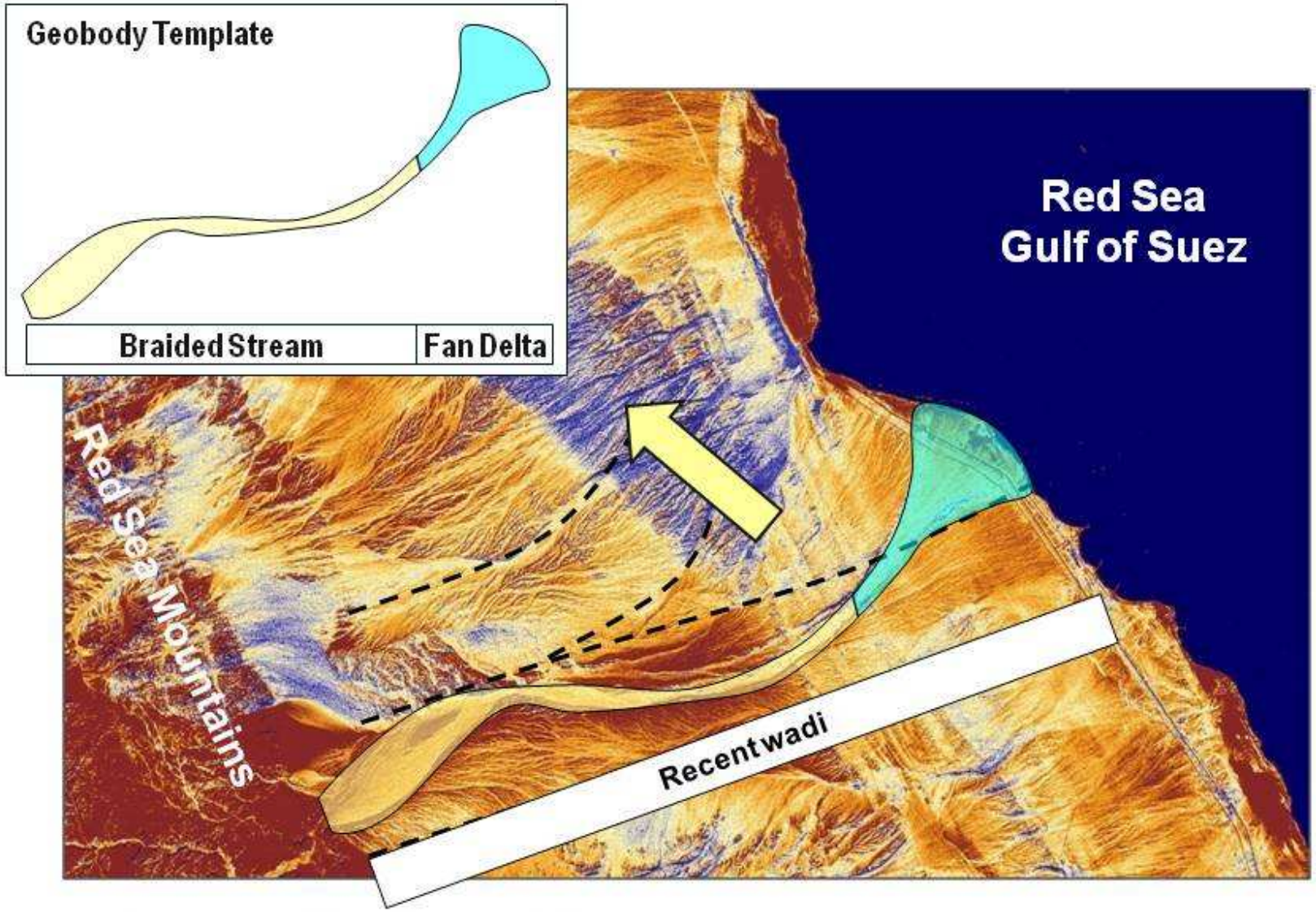
Method

- Assumption : present analogon of paleo-wadis
- Mapping of present wadi Hawashia on satellite imagery
- Recognition of similar patterns in PSTM cube

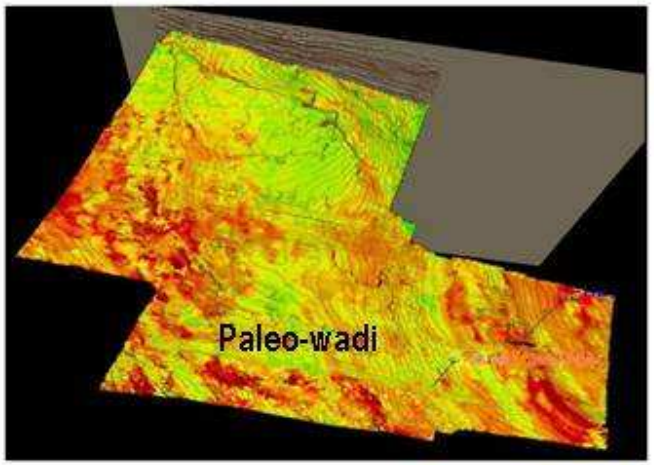
Technology

- Processing of satellite imagery for wadi characterization
- Processing of PSTM cube for instantaneous frequency
- Detection of braided stream and fan delta features
- Delineation of asymptotes of braided stream patterns

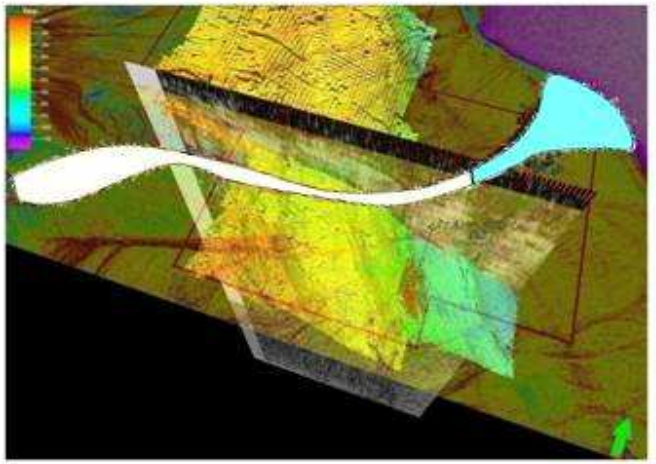
2. Cross-fault mapping – Geobody delineation on satellite map



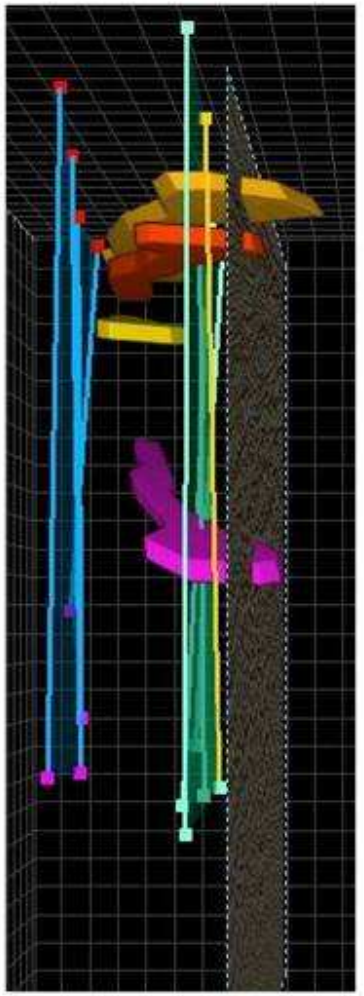
2. Cross-fault mapping – Detection of sand bodies in instantaneous frequency cube



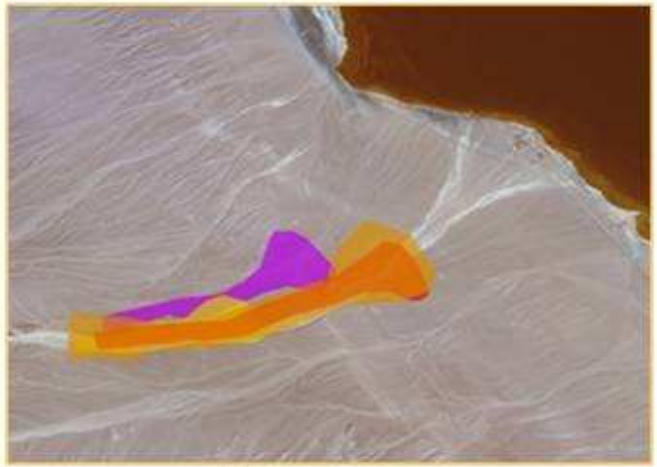
Shallow inst. frequency horizon



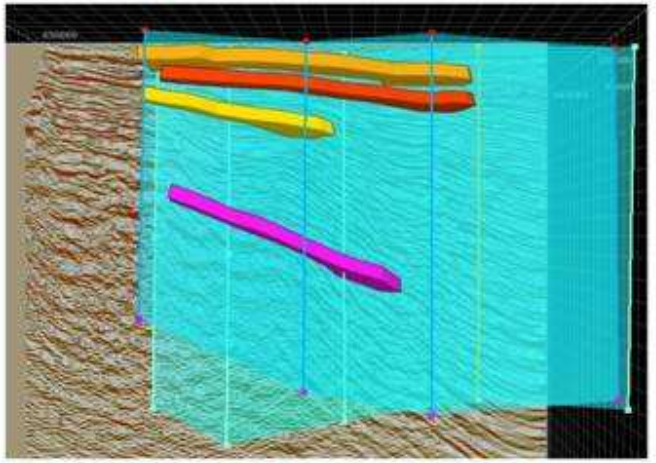
Horizon for paleo-wadi picking



Extrapolation

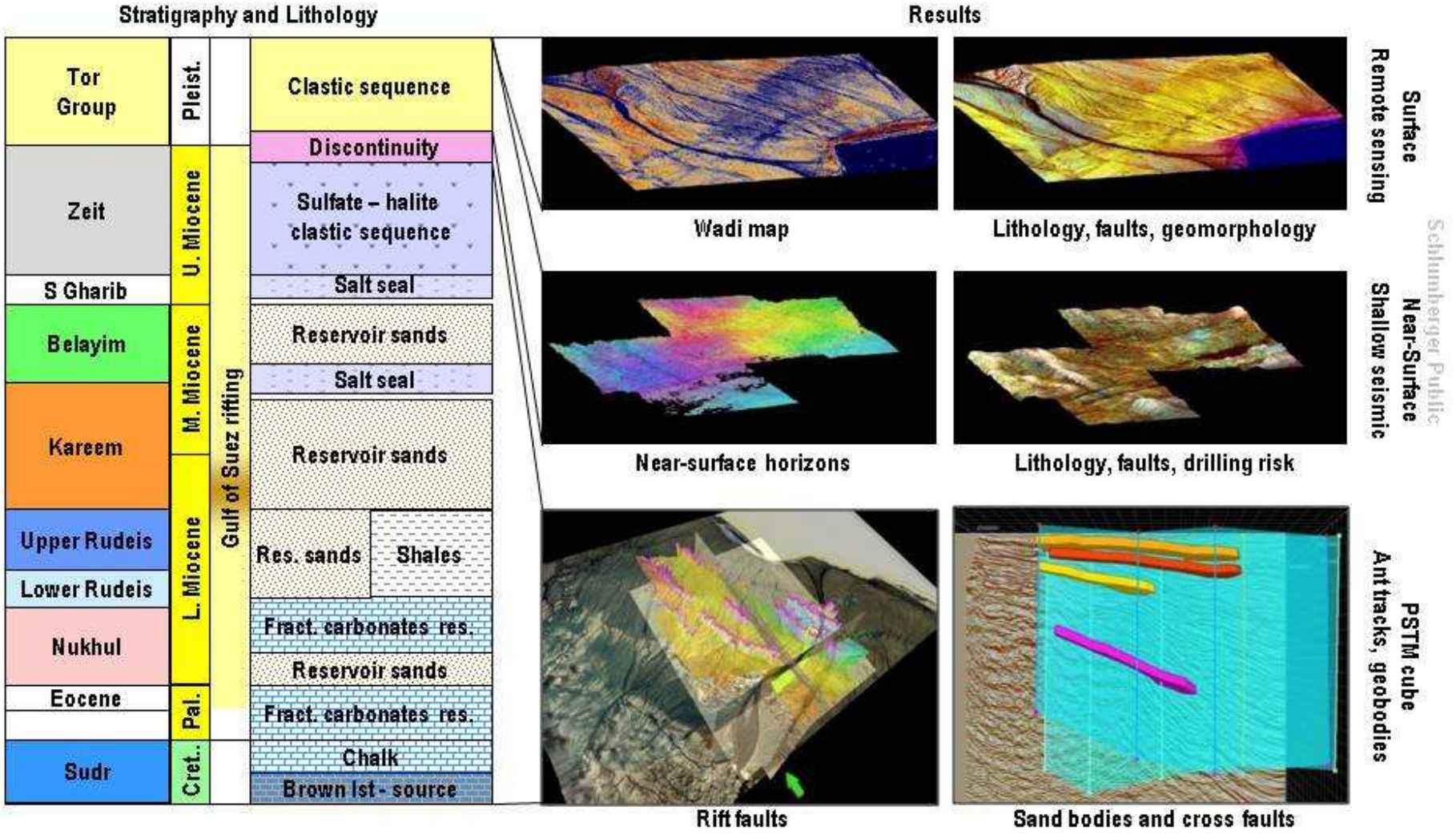


Paleo-wadis projected to surface



Location of paleo-wadi bodies

Results – Fractures traces from surface to reservoir



Conclusions

Technology and results

Satellite images	⇒	Surface litho-structural map
Surface seismic	⇒	High resolution 3D geologic model
Ant tracking	⇒	Rift fault planes, surface model seeds
Sand bodies	⇒	Cross-fault plains using geologic analogon

⇒ Broadband point receiver seismic data provide shallow and deep geologic models.

⇒ Integration of complementary surface and sub-surface data delivers geologic and tectonic model from surface to basement.

Value extracted from surface – subsurface integration

Joint interpretation with client yielded understanding of structural geology and identification of drilling risks.

Acknowledgements

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