Stratigraphy and Structure of the Iranian Makran*

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Abstract

Four main tectono-stratigraphic provinces were distinguished in the central Makran Accretionary Wedge, in southern Iran: North, Inner, Outer and Coastal Makran. North Makran is dominated by mafic to intermediate igneous rocks, tectonic mélanges and Cretaceous deep-water marine sediments. Upper Cretaceous shallow-water limestone unconformably covers Lower Cretaceous sediments and igneous rocks. The oldest turbiditic sequences are Late Cretaceous. Lower Eocene deep-marine sediments grade into deeper marine Eocene turbidites that show a general thickening- and coarsening-upward trend, becoming more terrigenous and proximal during Early-Late Oligocene. This suggests progradation of submarine fans, followed by more distal deposition during the Late Oligocene. Pro-delta turbidites grade up-section into Lower Miocene sandstones deposited on a shelf dominated by waves and tidal currents. The Lower Miocene sediments are mainly marls with gypsum deposited in basins with restricted circulation. These deposits grade laterally into bioclastic sandstones and marls and coral limestones bordering the basin. The passage from the Lower to Middle Miocene is not observed but the Middle Miocene starts with deep-marine turbidites and grade up-section into shallower facies. Coastal Makran exposes sediments mostly younger than the Late Miocene. These sediments represent a wedge-top basin with a shallowing-upwards sequence from slope marls to coastal and continental deposits. All provinces, Coastal Makran excepted, are covered unconformably by a large, Tortonian (11.6-9.6 Ma) olistostrome.

A series of analogue experiments tested the influence of erosion and deposition on the deformation style of the wedge. Sudden mass redistribution caused a change of thrusting pattern, with thrusting jumping to the front of the re-sedimented load. Striking differences in deformation style and intensity observed in the Iranian Makran are explained by the mass-redistribution caused by the Late-Miocene olistostrome.

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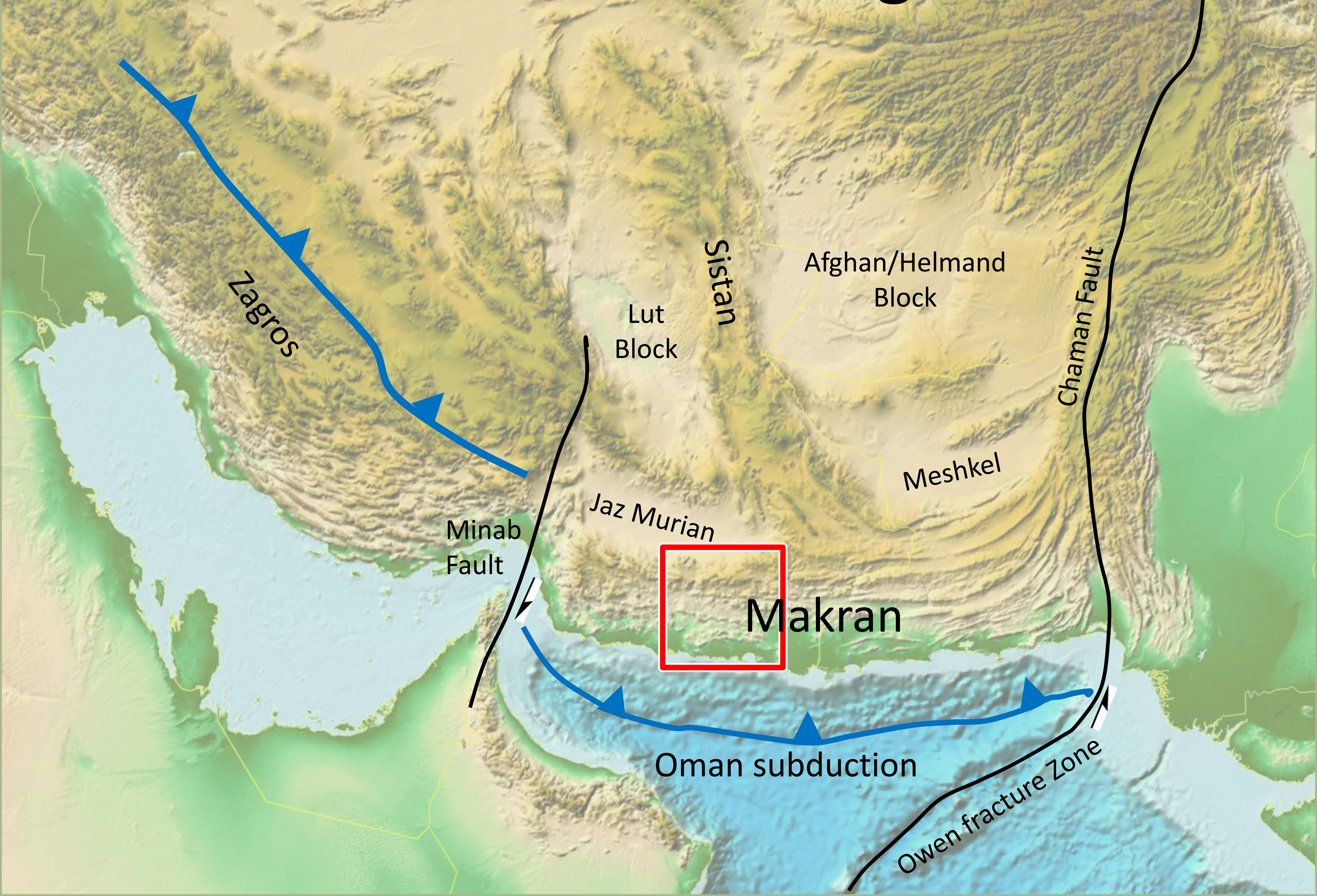
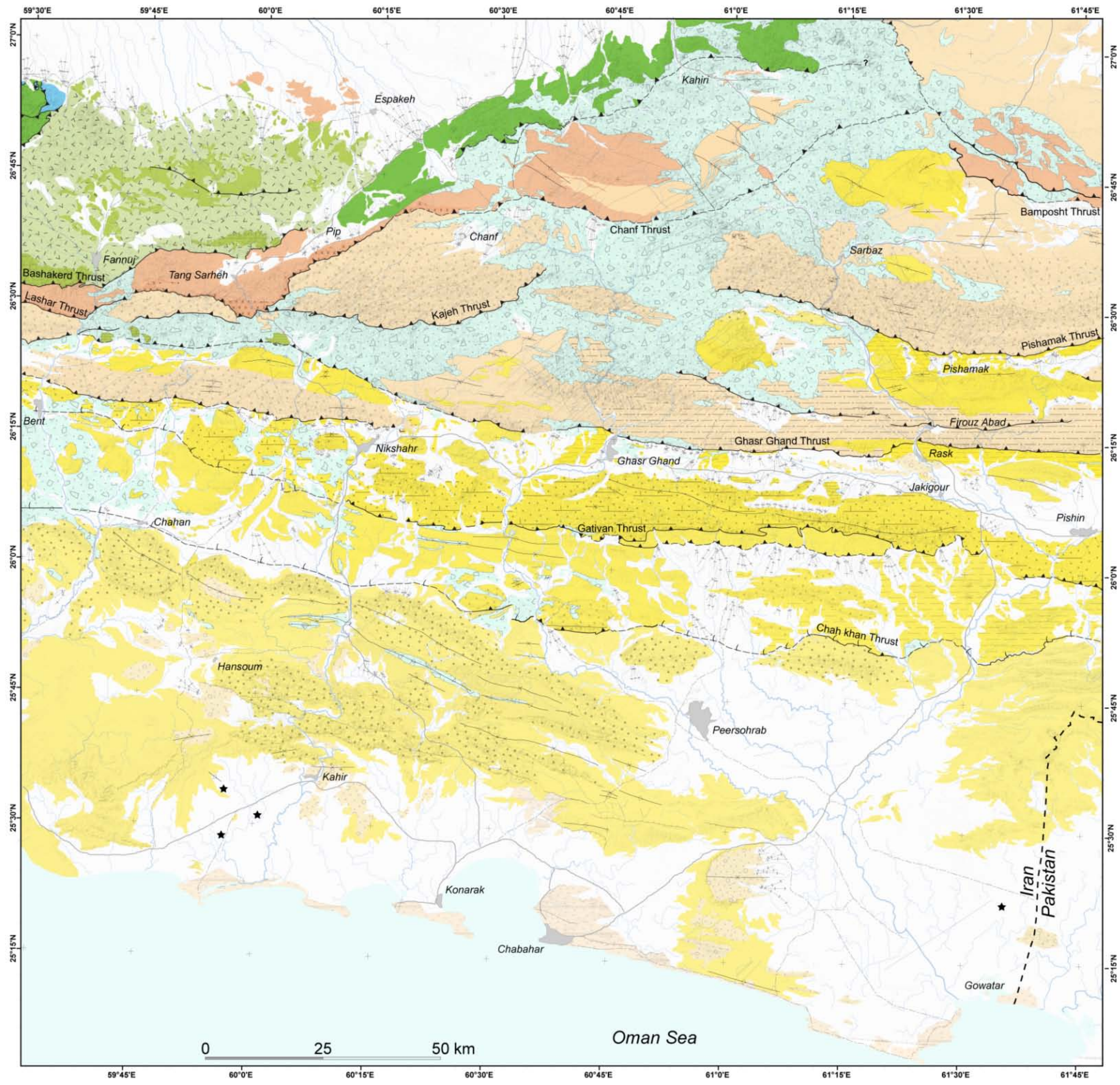
Milano, October 26, 2011

Tectonic setting

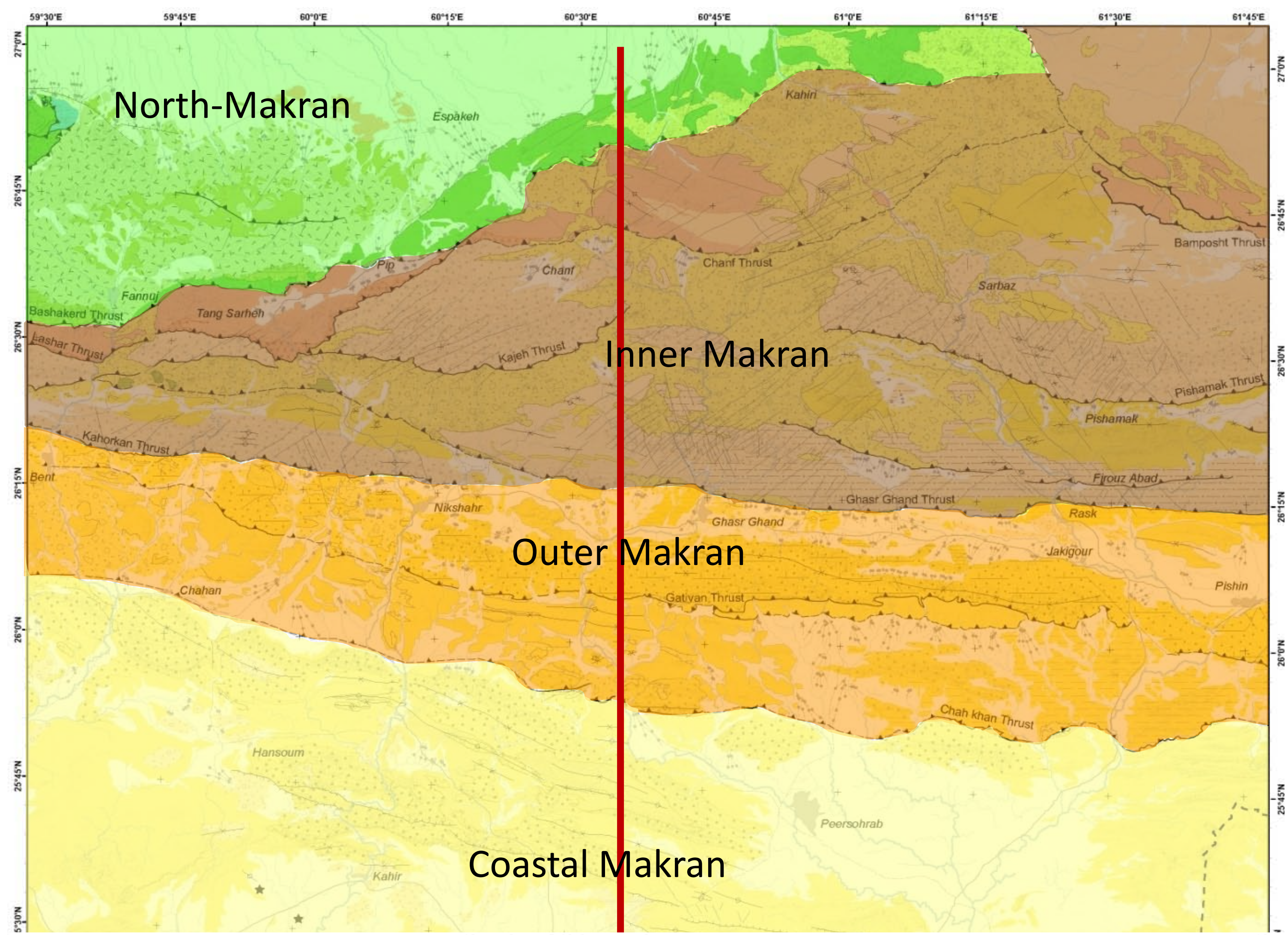




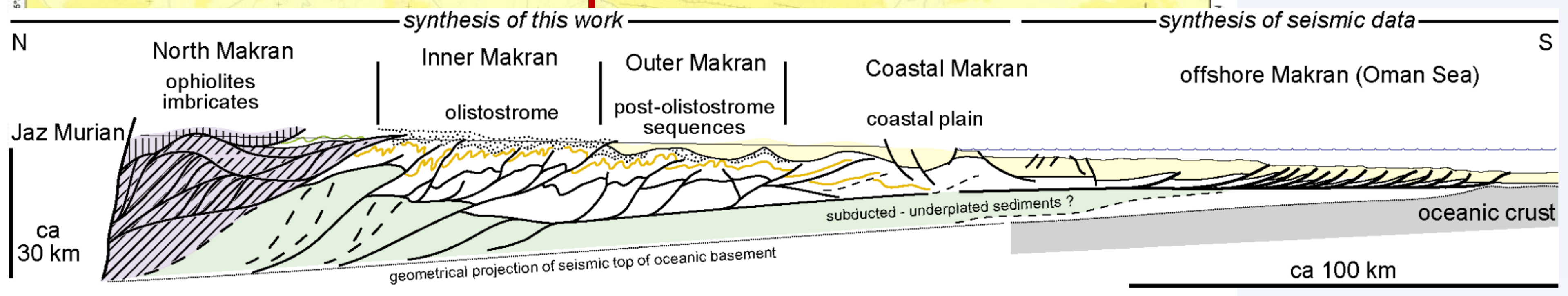
Eastern Iranian Makran

Map from
A. Dolati
PhD Thesis
ETH Zurich
(2010)
#19151

Eastern Iranian Makran



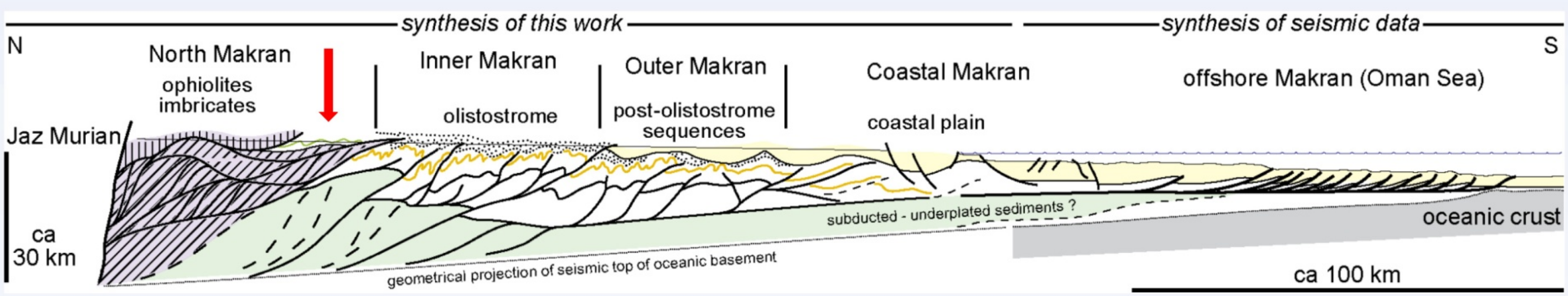
Map from A. Dolati PhD Thesis ETH Zurich (2010) #19151



North-Makran

Early-Late Cretaceous: deep marine sedimentation with submarine volcanic activity

Pillow lavas and interbedded hemipelagic limestone and marls containing *Nannoconus colomii* = not younger than Barremian (ca. 145–125 Ma).

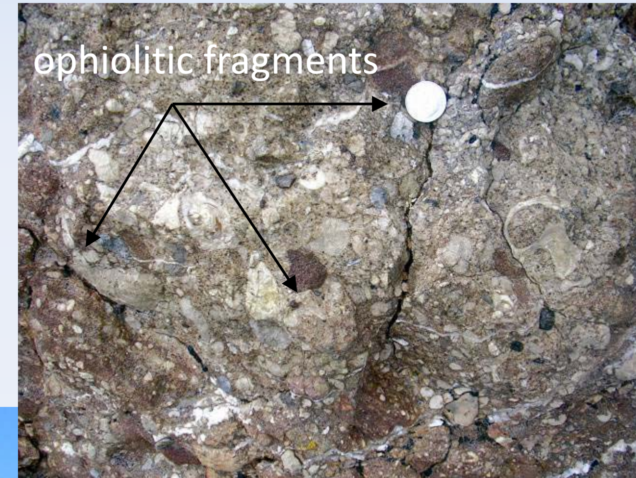


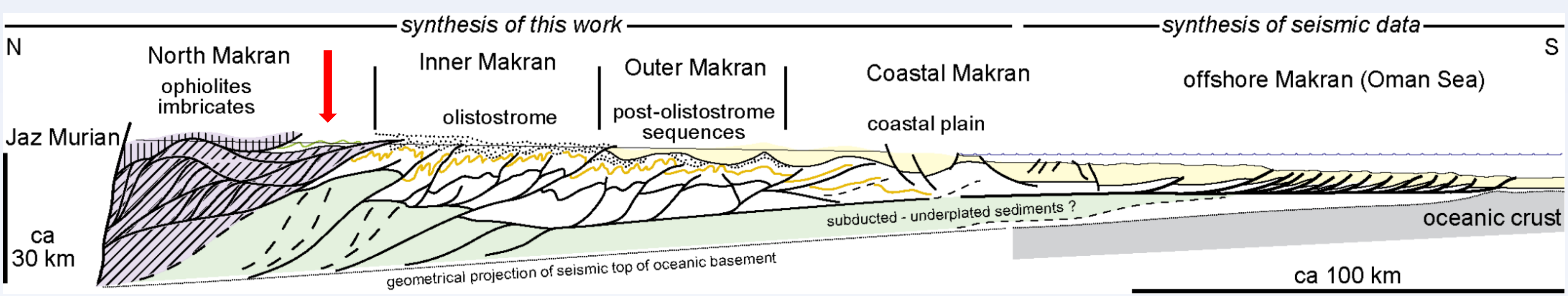
Presenter’s notes: The oldest sediments in the study area crops out in North-Makran which are usually hemipelagic limestone and marls as you see in slide 1 and 2. the numbers in map shows the location of slides. The sediments which indicate deep marine deposition are closely associated with pillow lavas. The slide 2 show how the marls and hemipelagic limestone lays conformably on the pillow lava layer.

North-Makran

Late Cretaceous-Paleocene: unconformable shallow water limestones, first turbiditic sequences, continued volcanic activity and eroded ophiolites.

Turonian to late-Campanian nanofossils (ca. 90 – 70 Ma).
Micula murus
M. Staurophora
Watznaueria barnesae

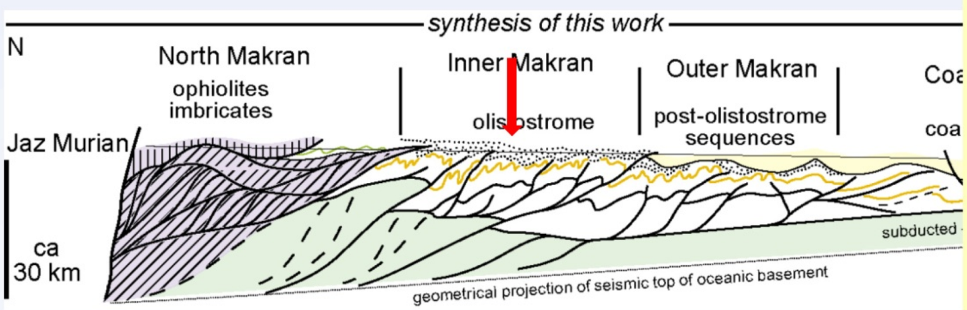




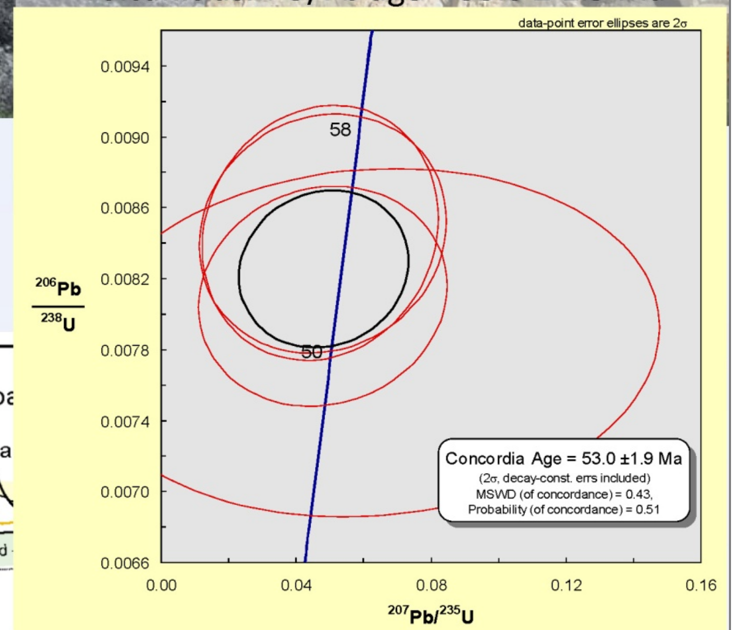
Inner Makran

Early Eocene: Deep oceanic basin, hemipelagic limestones on pillow lavas, volcanoclastic sandstones and ash layers.

Late Ypresian to Early Lutetian planktonic foraminifera Zones P8-P10 (ca. 51–45 Ma)



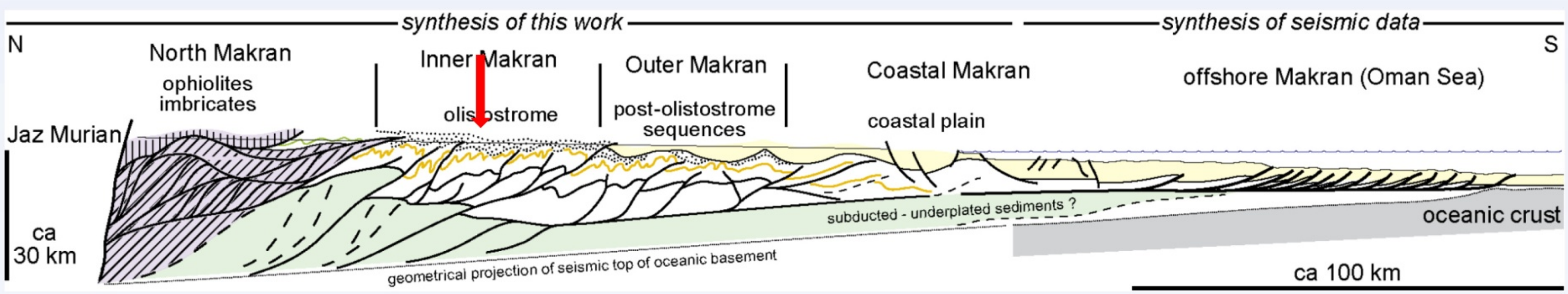
Volcanic ash: U/Pb age = 53.0 ± 1.9 Ma



Presenter's notes: The oldest sediments in Inner Makran are Lower Eocene hemipelagic limestone and volcanoclastic sandstones witch indicate a deep marine environment. The sediments are associated with volcanic rocks that it self indicate volcanic activity in the basin. We have done U-Pb dating on ash layers founded in the Lower Eocene outcrops and make precise ages for these outcrops.

Inner Makran

Late Eocene: turbidites with a thickening and coarsening-upward trend, patches of carbonate shelf to the North.



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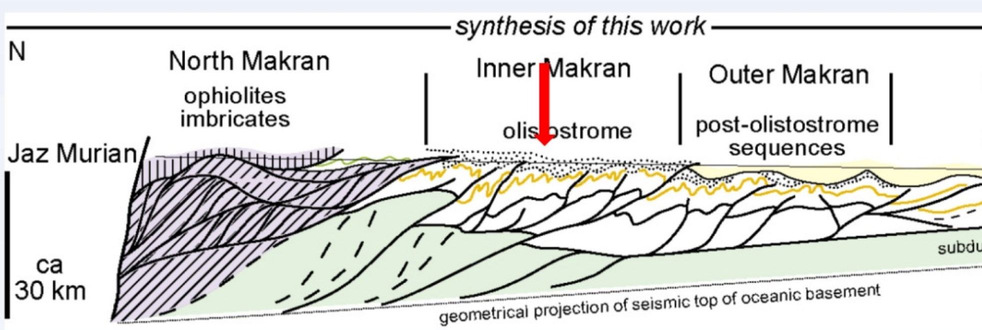
Inner Makran

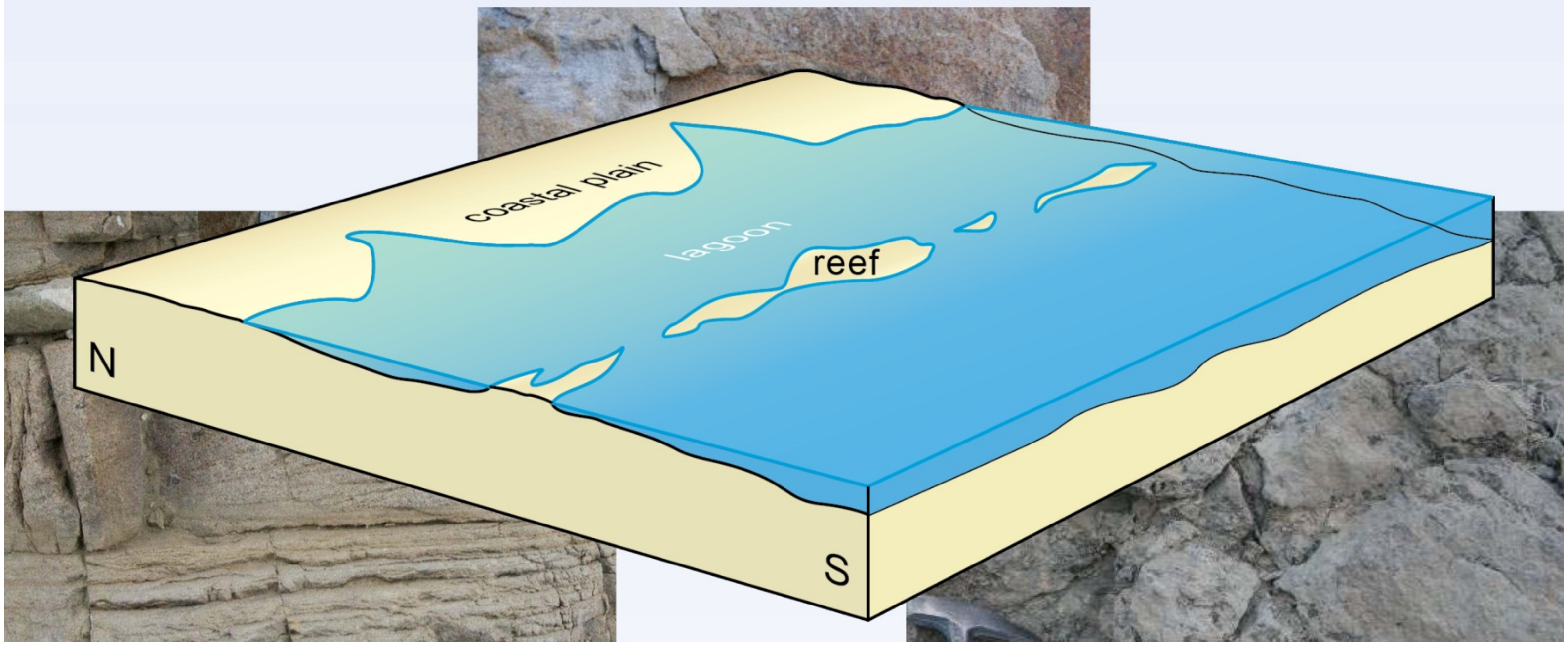
Oligocene: turbidite deposition, progradation of submarine fans followed by more distal deposition.



Presenter's notes: Prodelta turbidites

Inner and Outer Makran

Early Miocene: shallow-water and shelf deposition, tidal influence, emerging area to the north



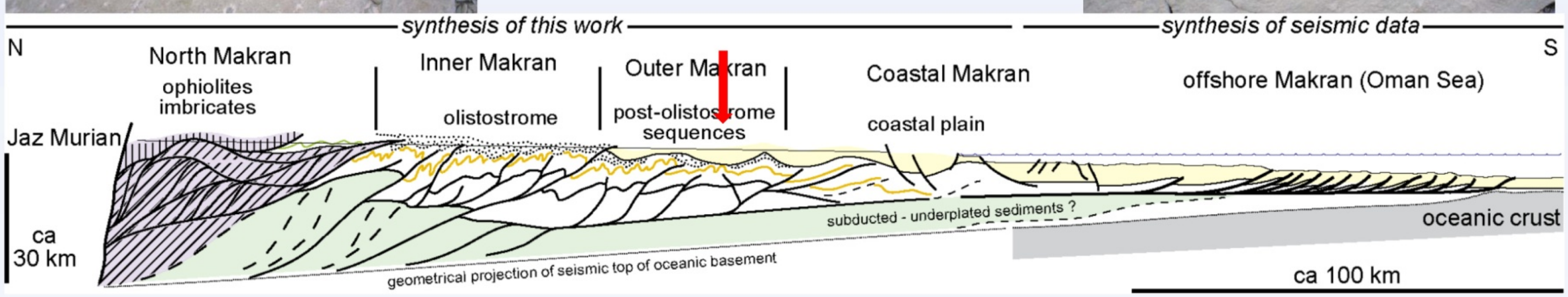
Presenter's notes: The deep marine shale dominated grade up-section into Lower Miocene shallow-water sediments. The Lower Miocene outcrops exposed in both Inner and Outer Makran. During Early Miocene marls with gypsum were deposited in a lagoon environment. These deposition grade laterally into sandstones with herring-bone structures which itself indicate deposition on shelf dominated by waves and tidal currents. Also the marls grade into limestone with coral and algae fossils which typically forms in reef carbonates. Well preserved leaves fossils suggest an emerging area to the north.

Outer Makran

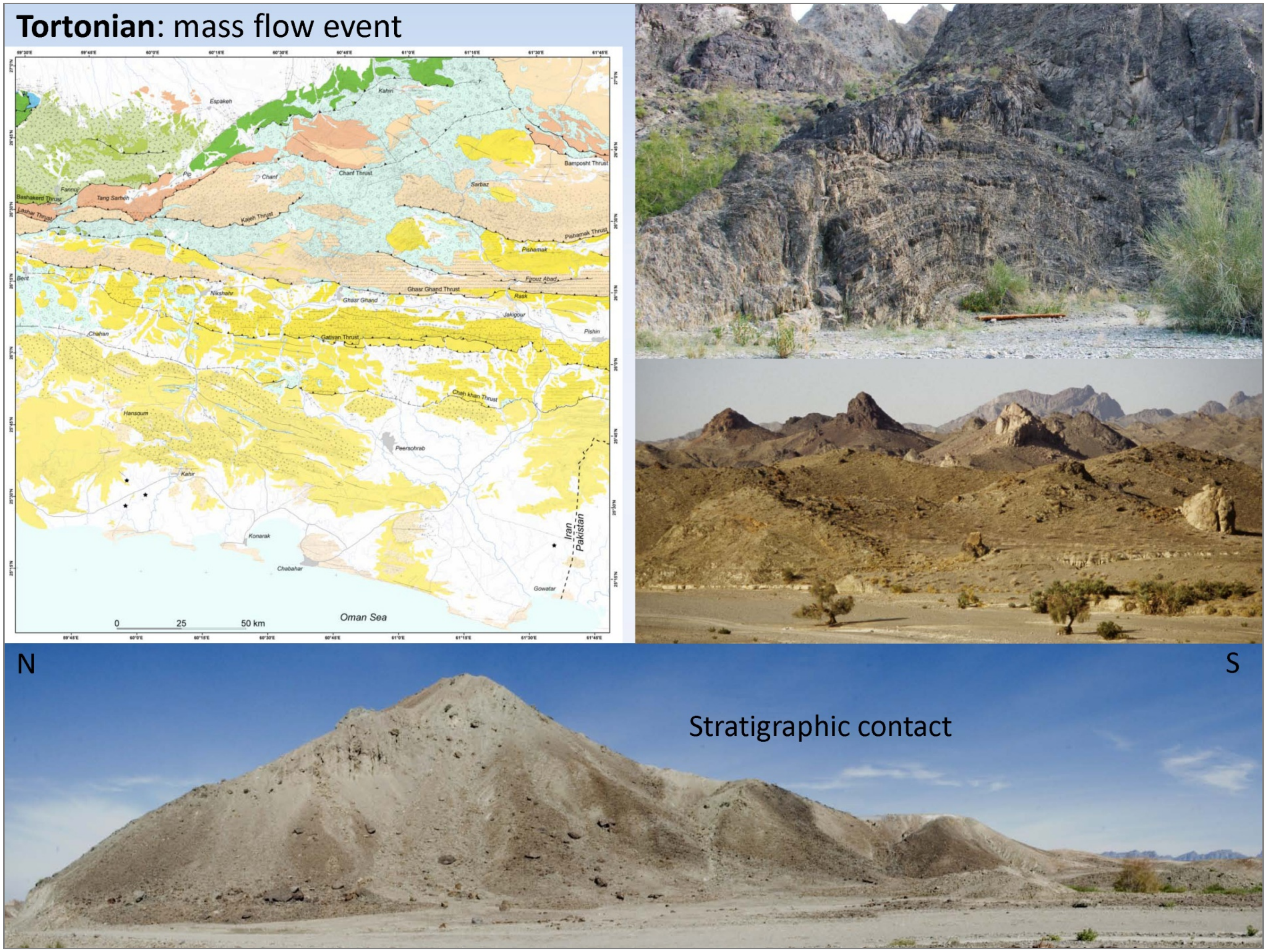
Middle Miocene: deposition in a basin with marked tectonic activity.

Paleodictyon

Spiroraphe



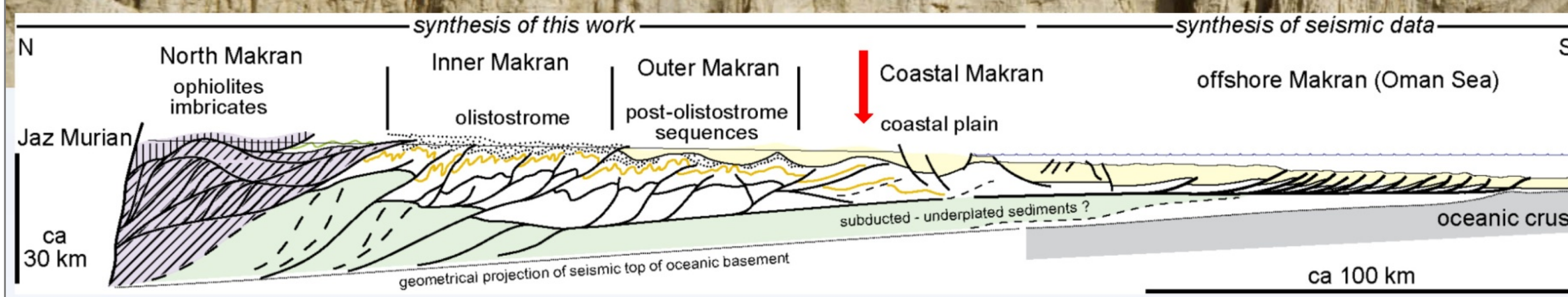
Presenter's notes: The Middle Miocene outcrops are mainly exposed in Outer Makran. For fist time we recorded growth structure in Makran region which indicate deposition in a basin with high activities. The passage from Lower to Middle Miocene has not been observed but in southern part of Outer Makran turbidites with deep-marine fossil traces like paleodyctyon and spiroraphe grade into sandstone with symmetric ripple marks which indicate shallower facies.



Presenter's notes: During Tortonian a catastrophic mass flow occurred which deposited an huge olistostrome. The olistostrome is the youngest marine deposition in North- Inner and Outer Makran that covers unconformably the older units and it is oldest outcrops in Coastal Makran which exposed in core of anticlines. The observation indicate the olistostrome has a stratigraphic contact with Upper Miocene sediments. The olistostrome incudes blocks derived from North-Makran and reworked chunks of sediments from Inner and Outer Makran.

Coastal Makran

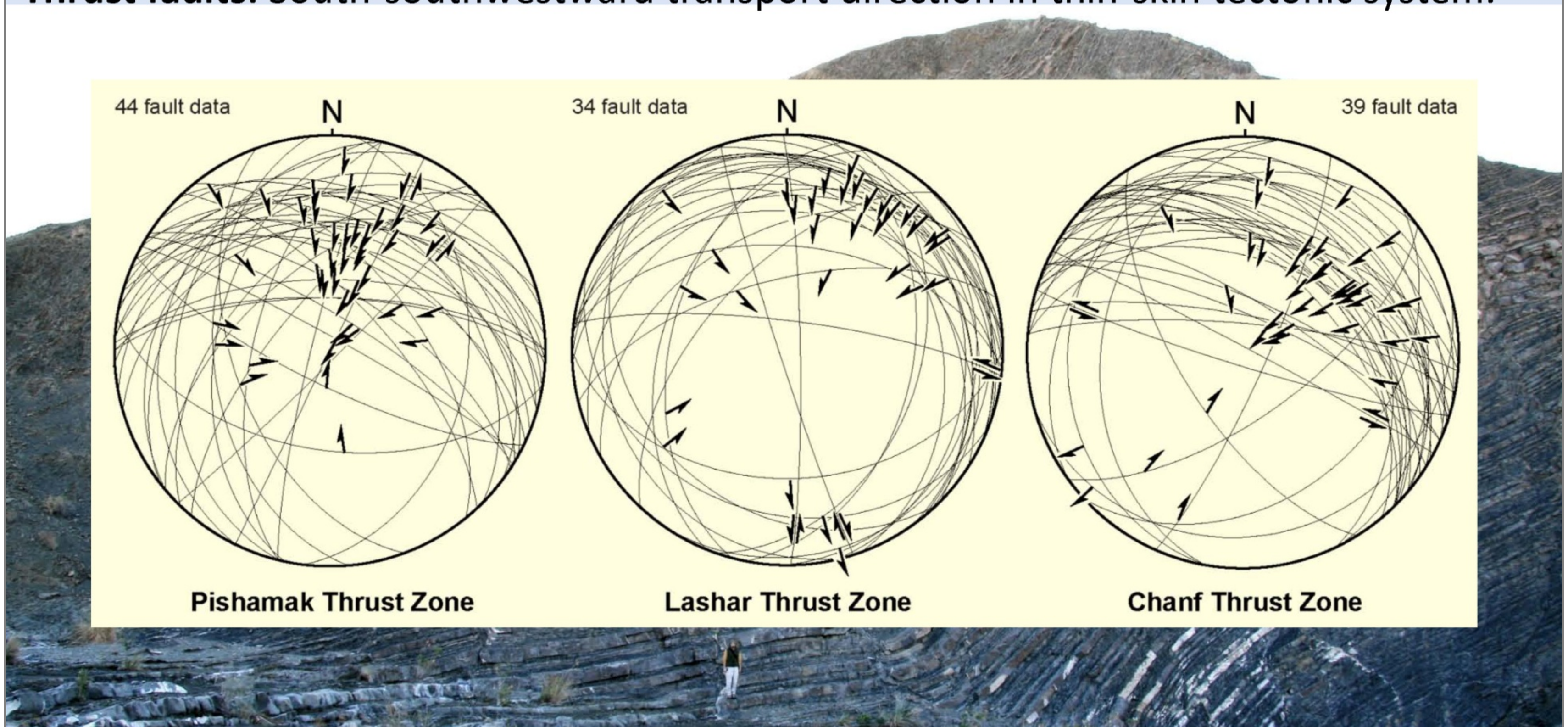
Upper Miocene and Pliocene-Pleistocene: Neritic coastal / shelf clastic sediments.

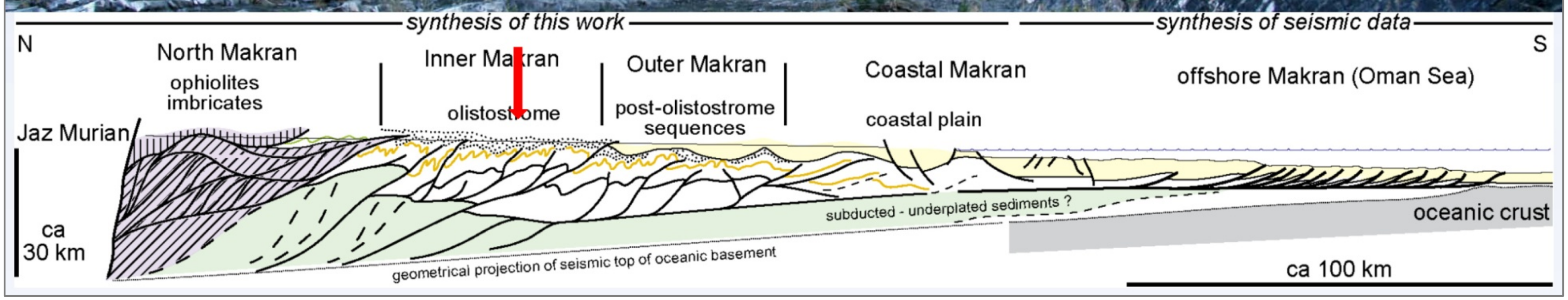


Presenter's notes: Younger than Upper Miocene marine sediments are exposed mainly in Coastal Makran. Oyster layers as well as herring-bone structures indicate neritic coastal deposition. The Pliocene-Pleistocene marine deposition in coastal line changes to continental deposition toward north which are unconformably lays on the Upper Miocene sediments.

Structures

Thrust faults: South-southwestward transport direction in thin-skin tectonic system.





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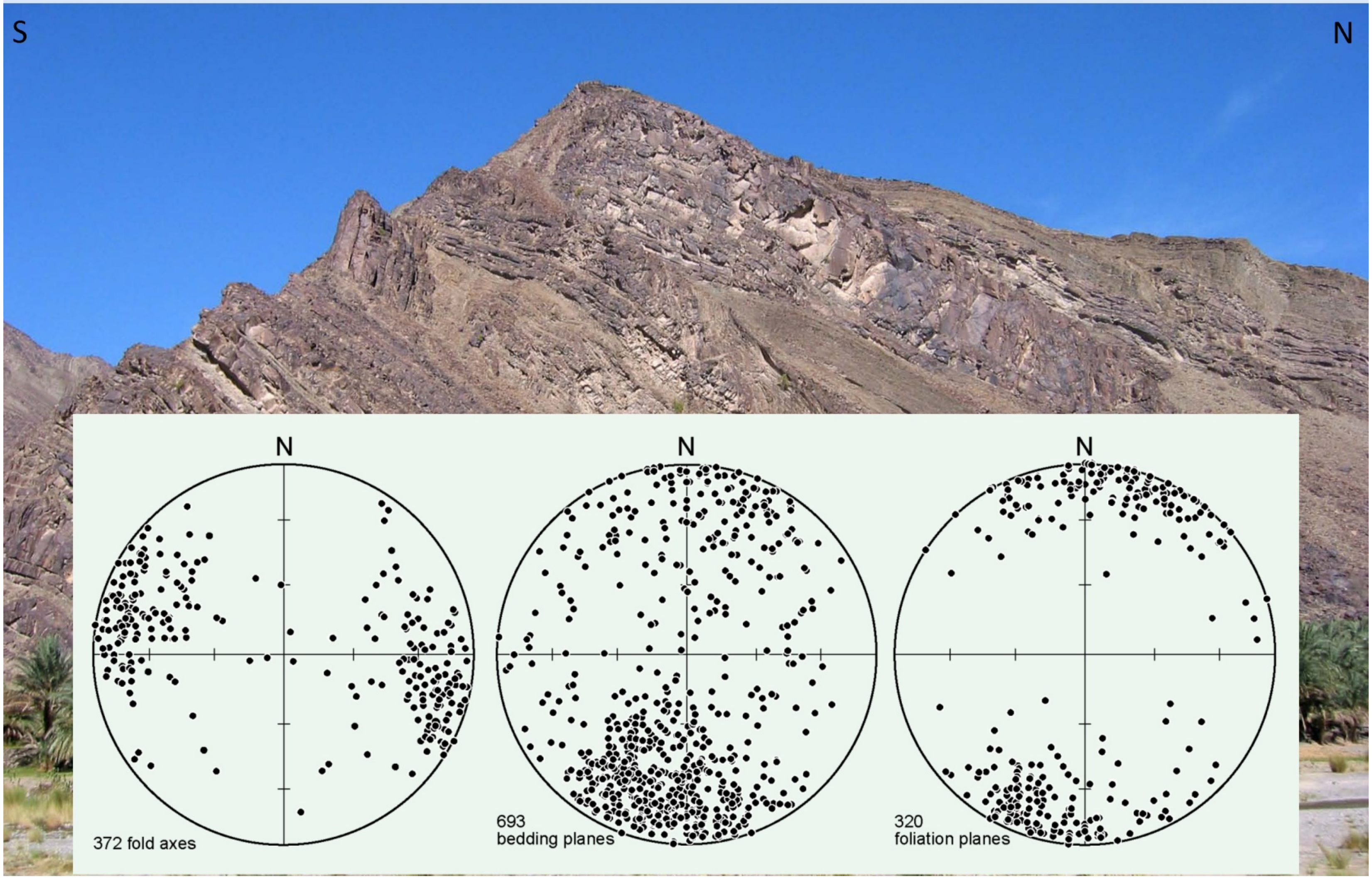
Structures

Folds: Everywhere consistent with south-southwestward thin-skin tectonics.



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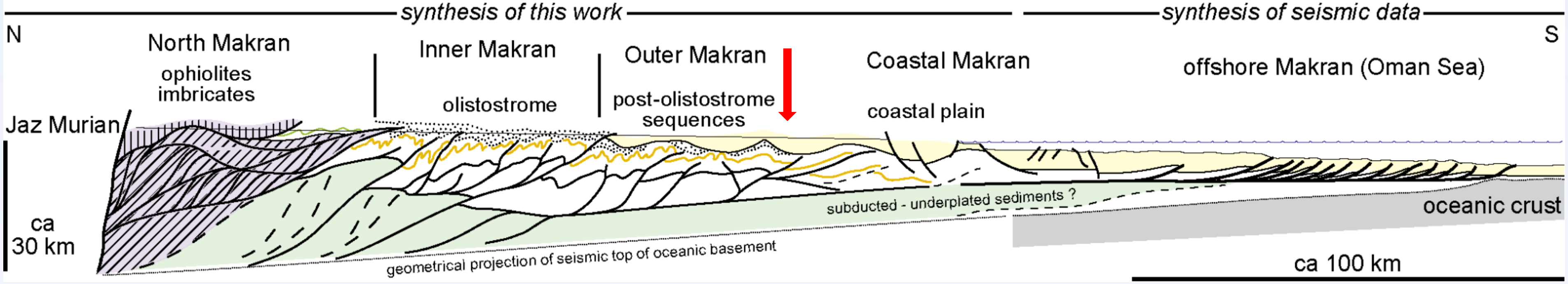
Olistostrome unconformity

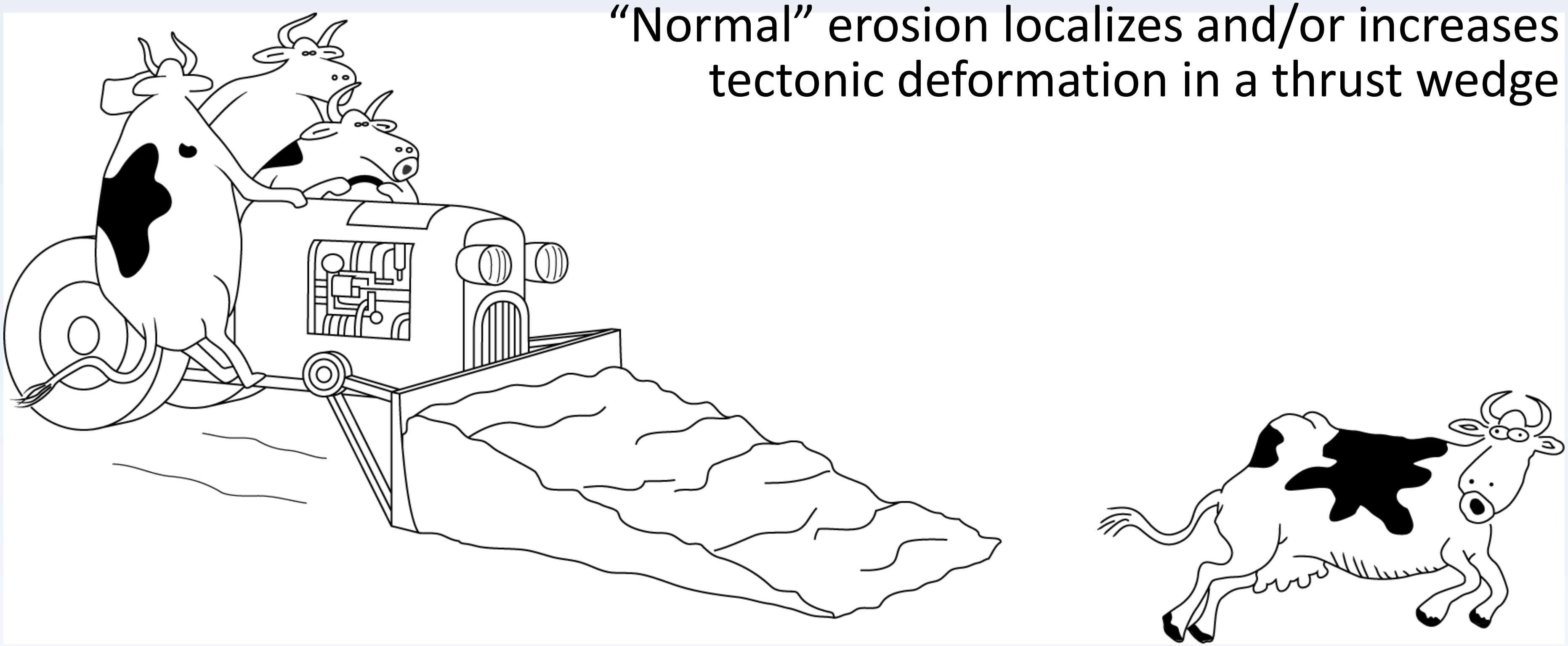
Post-olistostrome thrusting / folding

Post-olistostrome thrusting / folding

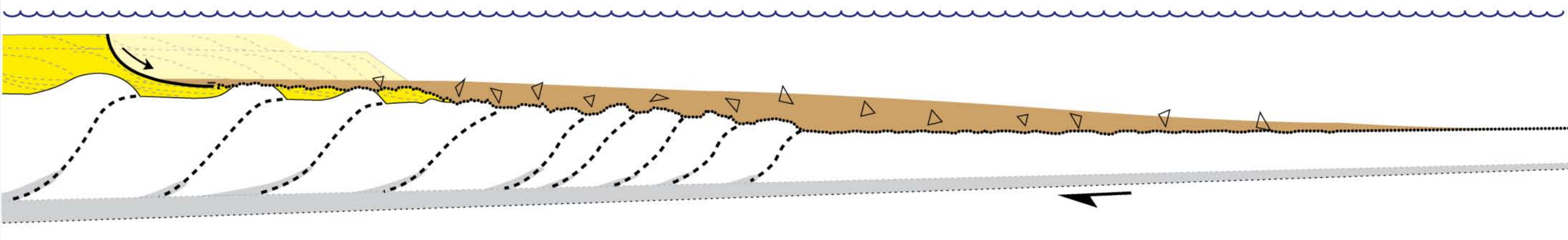


What is the influence of sudden regional burial due to a giant mass waste event?

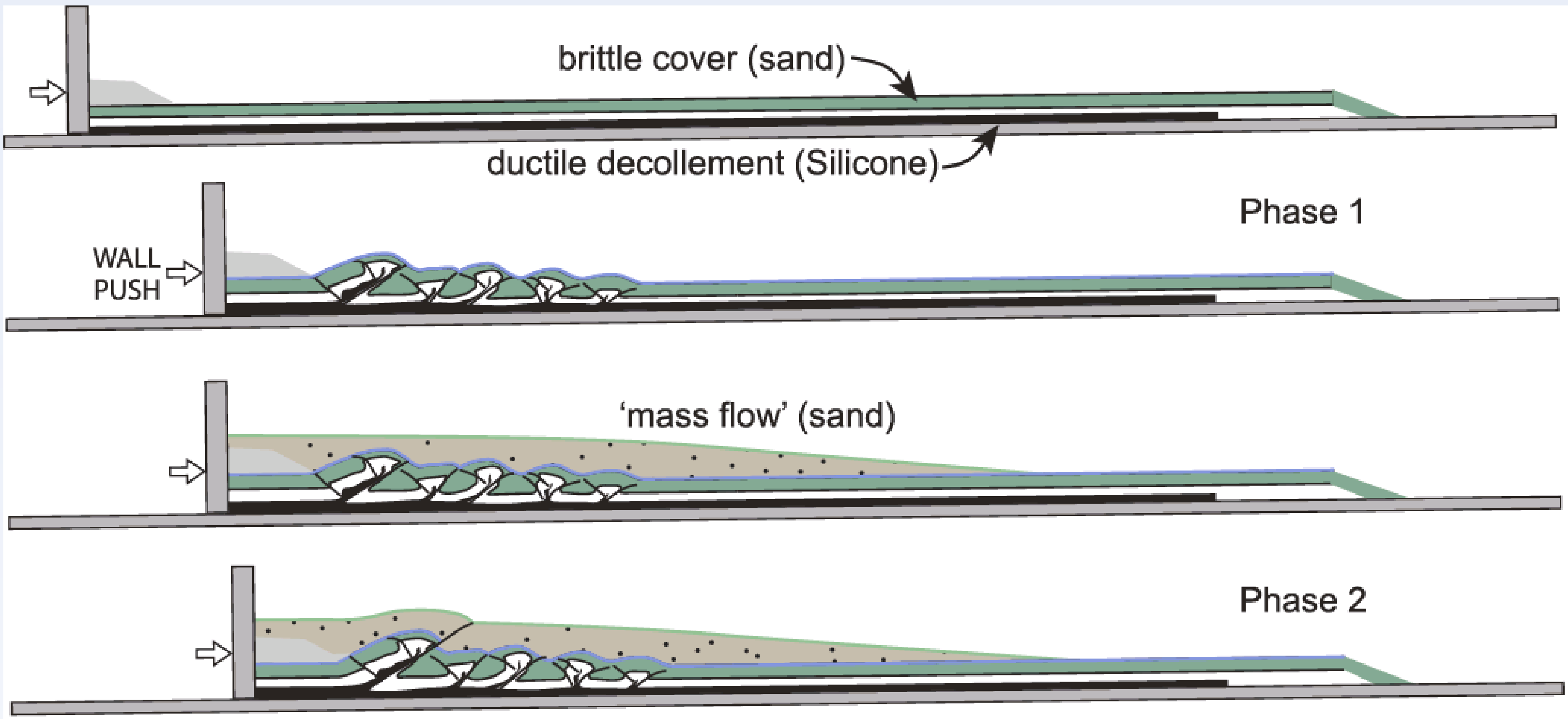
“Normal” erosion localizes and/or increases tectonic deformation in a thrust wedge



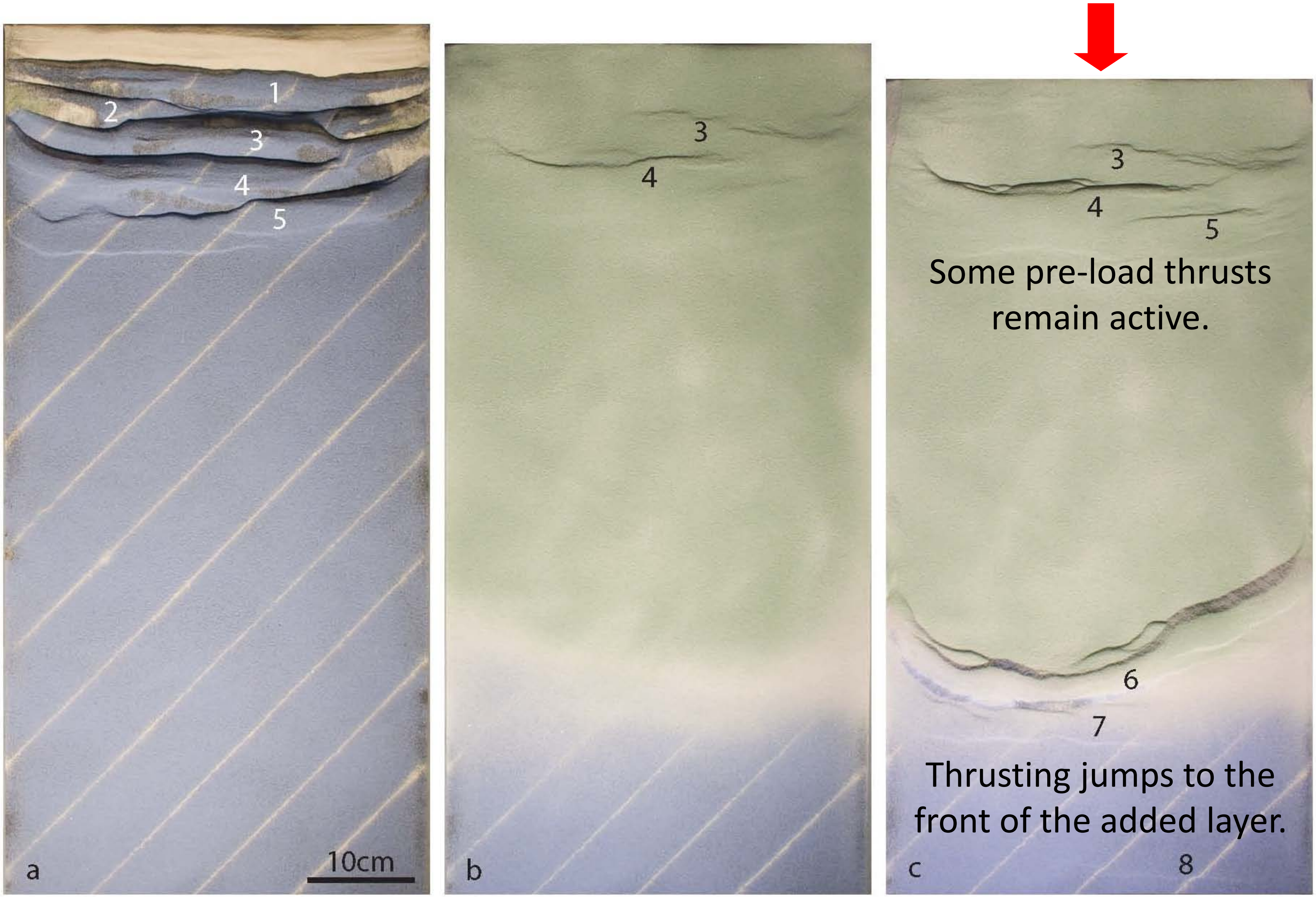
Olistostrome emplacement: Analogue



Mass-waste event: Catastrophic collapse of water-saturated sediments and rocks exposed in “backstop”, transport over >100km before downslope deposition.

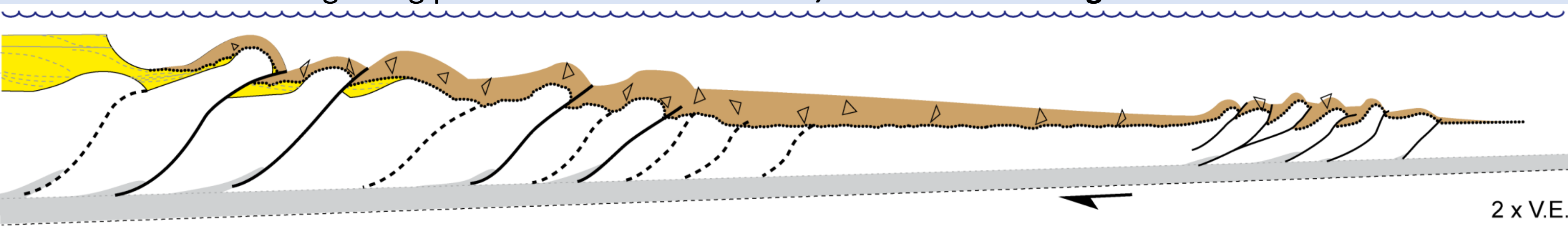


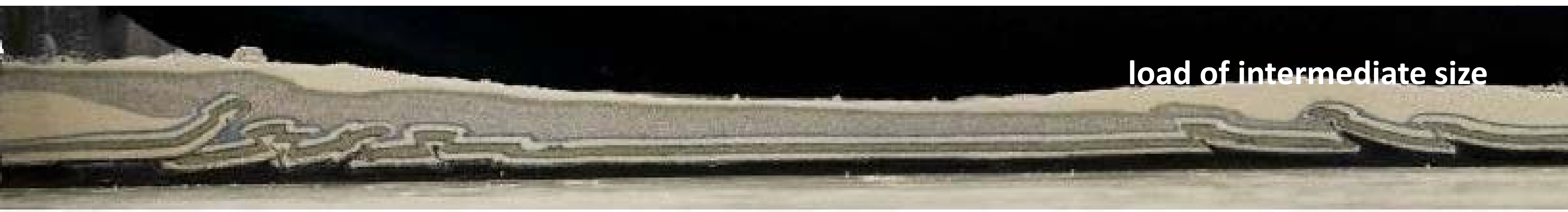
Olistostrome emplacement: Analogue



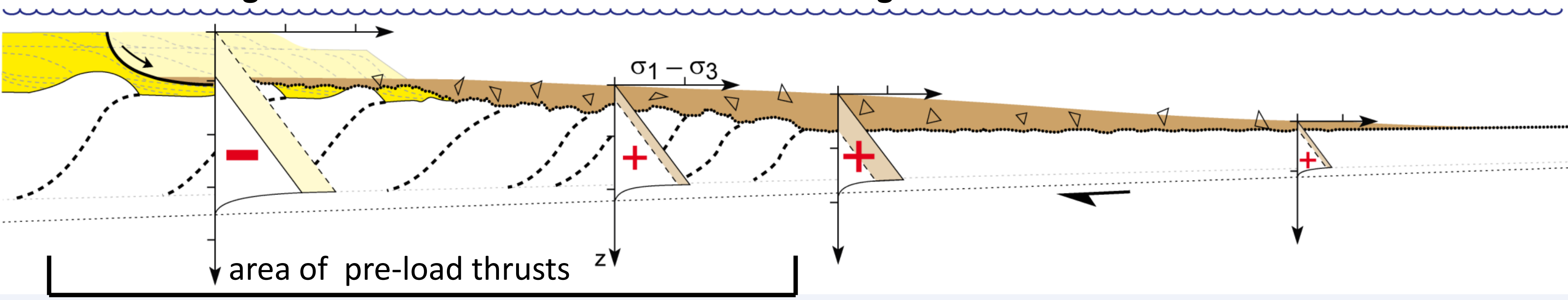
Mechanical explanation

shortening along pre-load thrusts **no, or little shortening** new thrusts





strong decrease small increase **strong increase** small increase



Conclusions

- Makran is a fill-up basin. It started with deep marine deposition and submarine volcanic activity in the Early Cretaceous and became a shelf in Pliocene-Pleistocene times.
- The ophiolites of North-Makran were exposed in the Late Cretaceous.
- The main tectonic activity took place in the wedge during the Early to Middle Miocene, with subsequent erosion, recycling and reworking of wedge sediments during the Miocene.
- E-W trending folds and N-S kinematic structures indicate consistent and still active N-S compression/shortening.
- The onshore Makran is a fold-and-thrust belt over blind décollement surfaces, with the deformation front progressing towards the south, and jumping ahead of the olistostrome after the Tortonian.
- The overall structure is a duplex system with the roof décollement at 2-4 km depth.