A new experimental approach to assess the influence of gravity gliding on salt tectonics in rift basins

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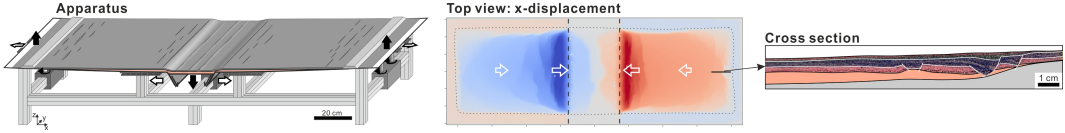
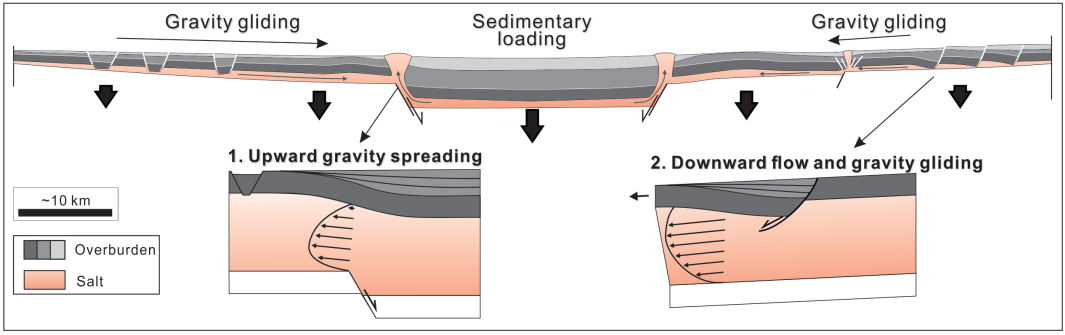


Drivers for salt tectonics in rift basins



RESEARCH QUESTIONS

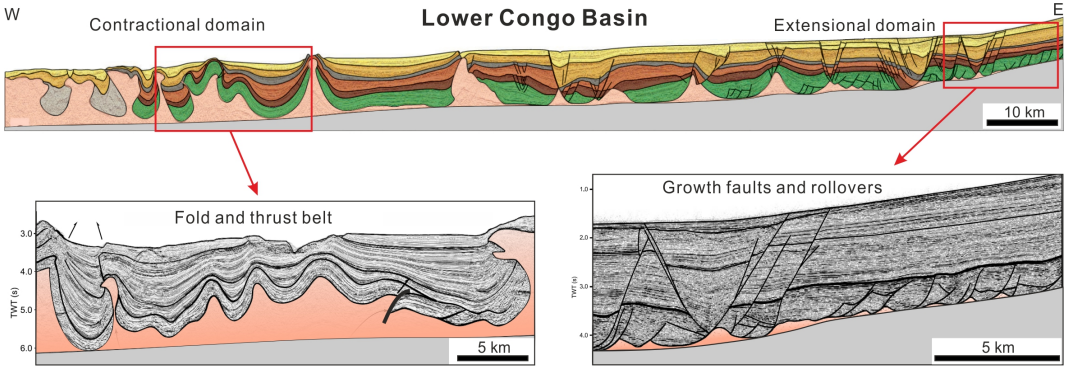
1. Under which conditions can gravity gliding occur in rift basins?
2. What are characteristic supra-salt deformation structures?

METHODS

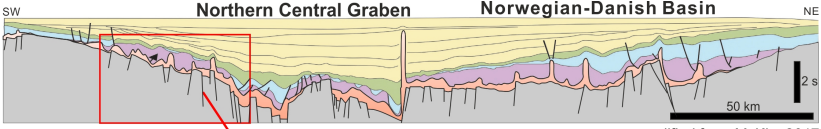
- Analog modelling
- 3D digital image correlation

GRAVITY GLIDING IN PASSIVE MARGIN SALT BASINS

- Seaward sediment progradation and tilting of the basin floor
- Unrestricted salt flow in downslope region → Space for downward salt flow and gravity gliding
- Gravity gliding and spreading leading to formation of downslope contractional and upslope extensional domain



modified from Fort et al., 2004



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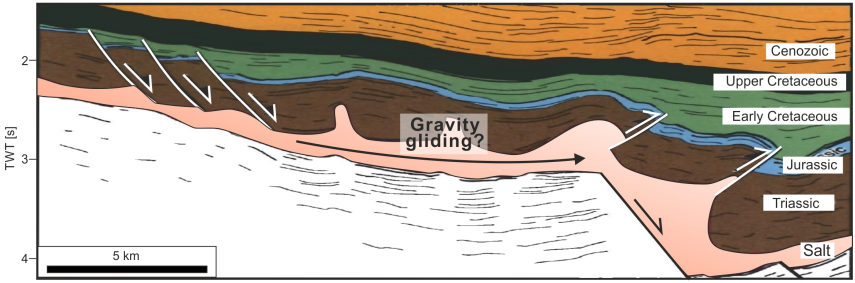
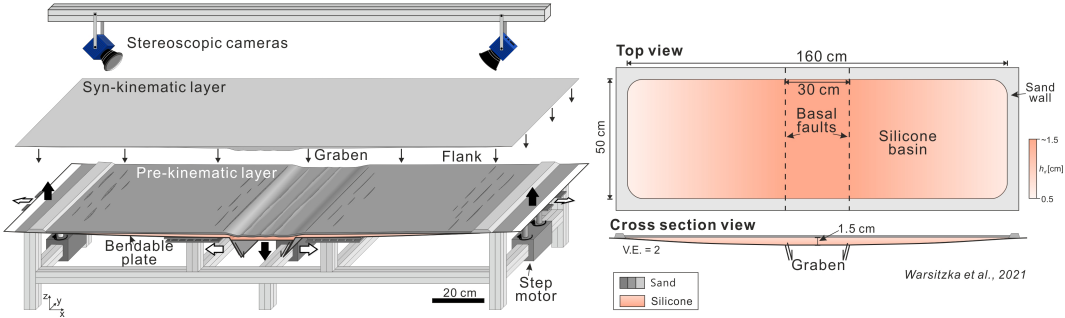


modified from Stewart & Coward, 1999

SALT TECTONICS IN RIFT BASINS

- Graben structure in basin centre
- Sometimes tilted graben flanks
- Thickest sediments in basin centre drive upward salt flow
- Basinward salt flow and gravity gliding due to tilting of the flanks?

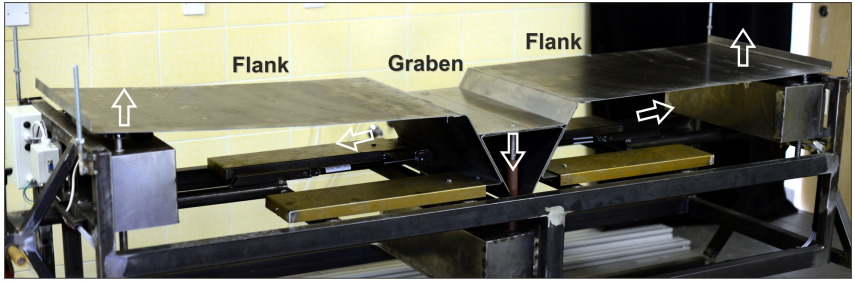


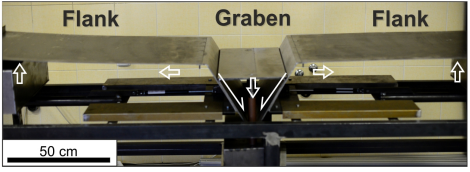
ANALOG MODELLING: NEW EXPERIMENTAL SETUP

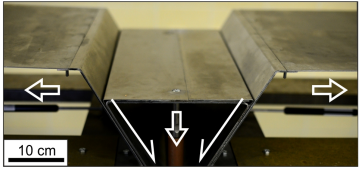
- Graben structure + bendable plates to simulate sub-salt graben formation + flank tilting
- Graben block is pulled down, while flanks can be pushed up
- Monitoring of displacement and strain patterns in top view

EXPERIMENTAL SETUP

- Photos showing main parts of the apparatus
- Glass side walls are not shown





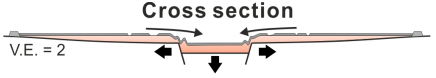


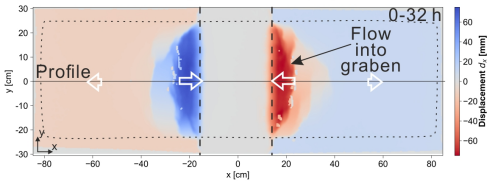
EXPERIMENT: ONLY EXTENSION

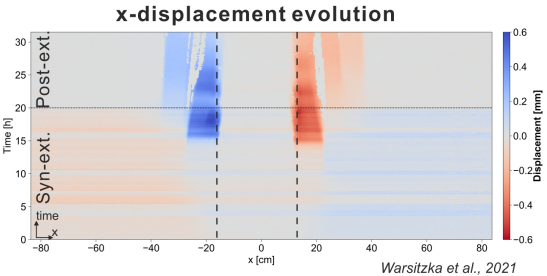
- Only extension of the basal graben (displ. rate = 1 mm/h)
- No tilting of flanks, no syn-kinematic sedimentation

RESULTS

- Inward movement of overburden into the subsiding graben
- Decoupled extension close to basal normal faults







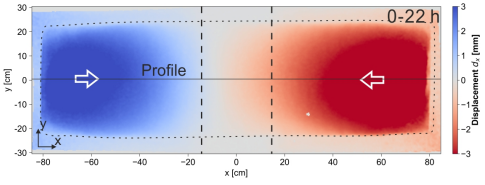
Warsitzka et al., 2021

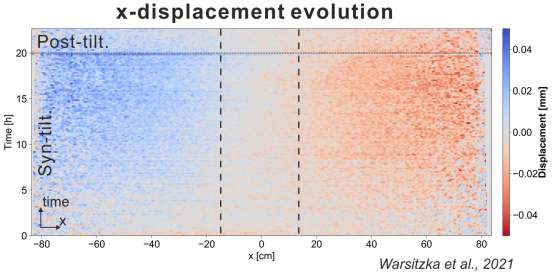
EXPERIMENT: ONLY TILTING

- Only tilting of flanks (displ. rate = 1 mm/h)
- No extension, no syn-kinematic sedimentation

RESULTS

- Widespread downward movement
- Localized fault zones at the basin margins





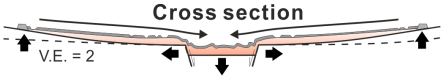
Warsitzka et al., 2021

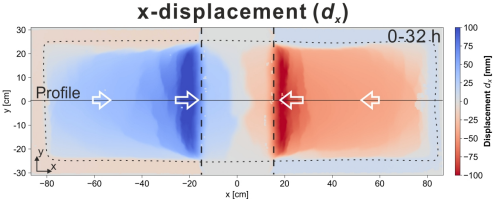
EXPERIMENT: EXTENSION + TILTING

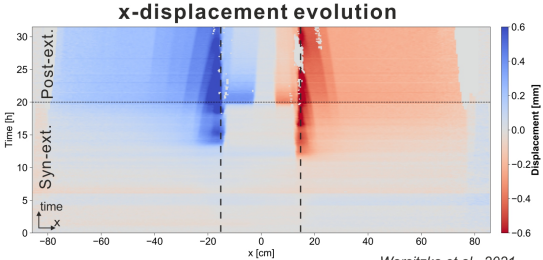
- Extension + tilting of flanks (displ. rate = 1 mm/h)
- No syn-kinematic sedimentation

RESULTS

- Widespread gravity gliding
- Folding in the graben centre
- Extension at the graben edges and the basin margins



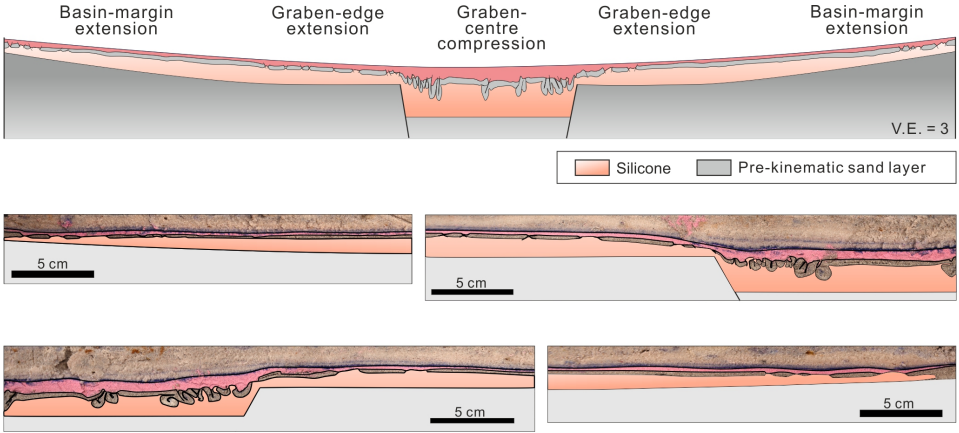


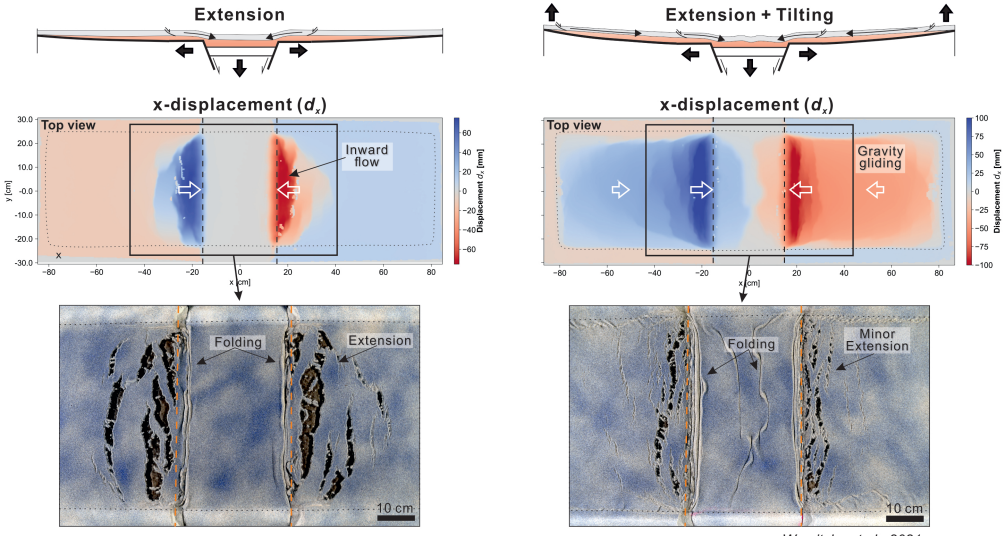


Warsitzka et al., 2021

EXPERIMENT: EXTENSION + TILTING

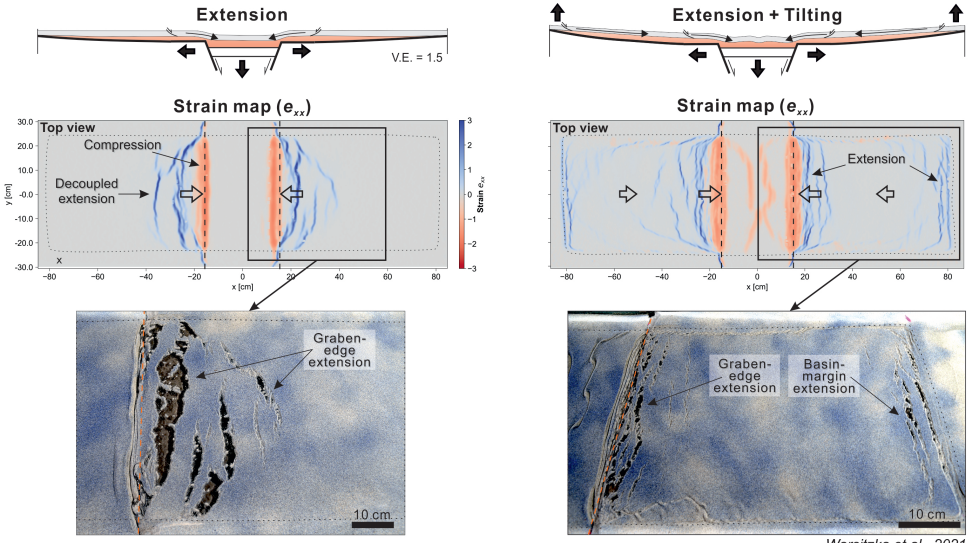
- Extensional fault zones above flanks and at basin margins
- Folds in graben centre





Warsitzka et al., 2021

COMPARISON: EXTENSION VS: EXTENSION+TILTING



Warsitzka et al., 2021

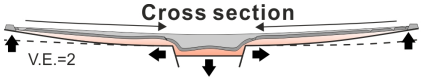
COMPARISON: EXTENSION VS: EXTENSION+TILTING

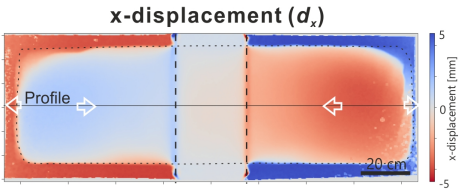
EXPERIMENT: EXTENSION + TILTING + SEDIMENTATION

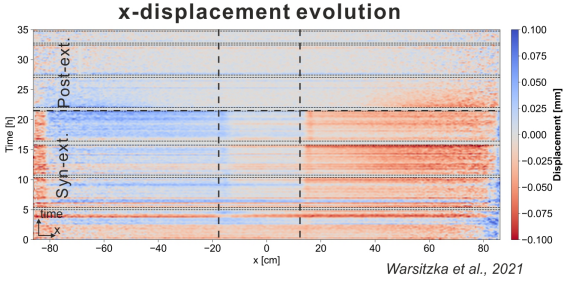
- Extension tilting of flanks (displ. rate = 1 mm/h)
- Syn-kinematic sedimentation (every 6 h)

RESULTS

- Reduced gravity gliding
- Localized fault zones at the basin margins







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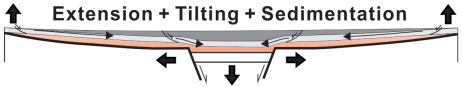
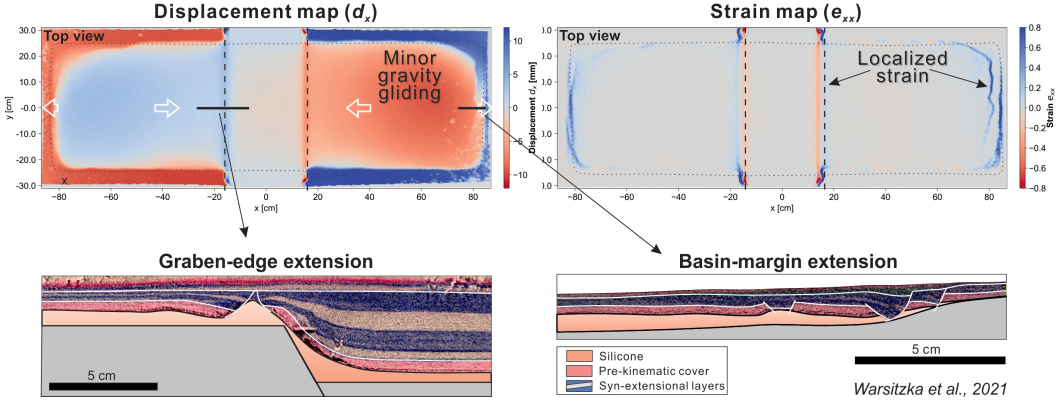
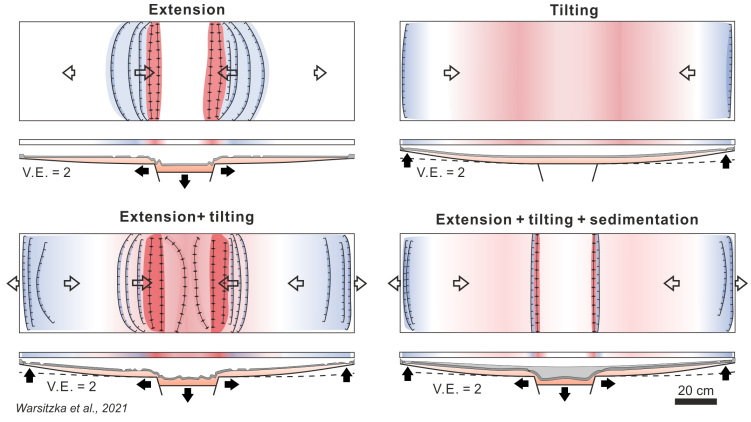




CHARACTERISTIC STRUCTURES



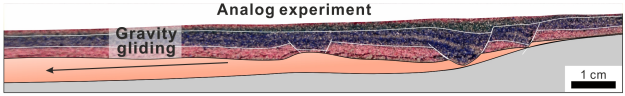
Warsitzka et al., 2021

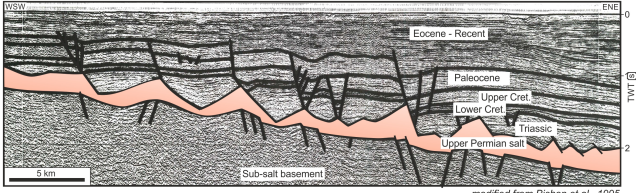
SUMMARY

- Due to tilting of the flanks, gravity gliding overprints deformation patterns close to the graben
- Gravity gliding can take place even if the basin centre is filled with syn-kinematic sediments

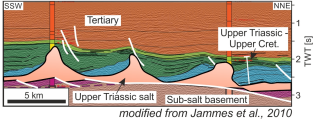
NATURAL EXAMPLES

- Extensional fault zones occur at the margins of many salt-bearing rift basins
- Listric growth faults and rafted blocks
- Minor faulting of tilted salt base
- Such fault zones are indicators for gravity gliding





modified from Bishop et al., 1995



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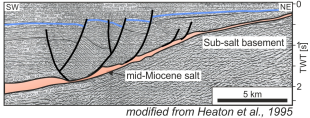

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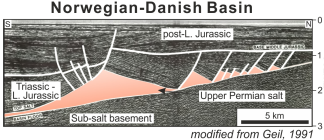
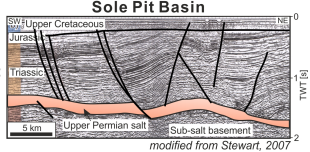


modified from Geil, 1991



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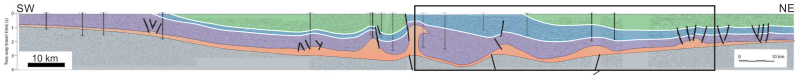

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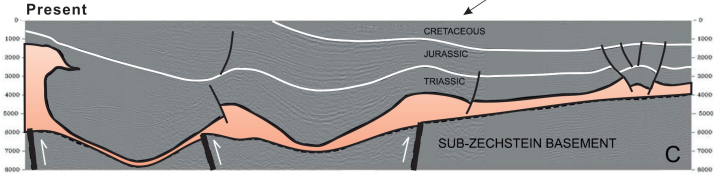
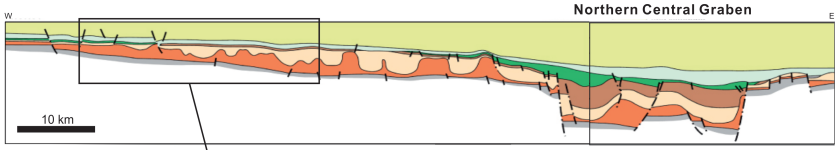


EXAMPLE: POLISH BASIN

- Thin-skinned extensional structures at basin margins
- Salt anticlines and diapirs in the basin centre

INTERPRETATION

- Gravity gliding or decoupled extension?
- Indications for upslope extension and downslope shortening during Triassic rifting
- Could be explained by moderate gravity gliding



Johnson, 2005

Buchanan et al., 1996

EXAMPLE: CENTRAL GRABEN

- Rifting during the Triassic and Jurassic
- Deeply subsided graben centre
- Widespread tilting of flanks

INTERPRETATION

- Expulsion of salt from graben centre towards flanks
- Coeval gravity gliding above graben flanks (e.g. Buchanan et al., 1996; Penge et al., 1999)