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Structural Reservoir Heterogeneity Induced by Forced Folding in Sandstone Reservoirs

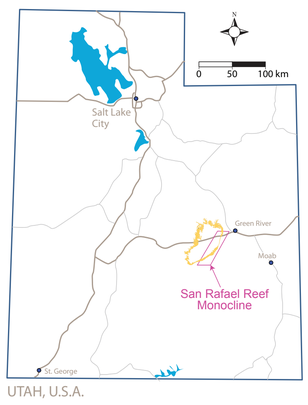
Purpose and Aim of Study

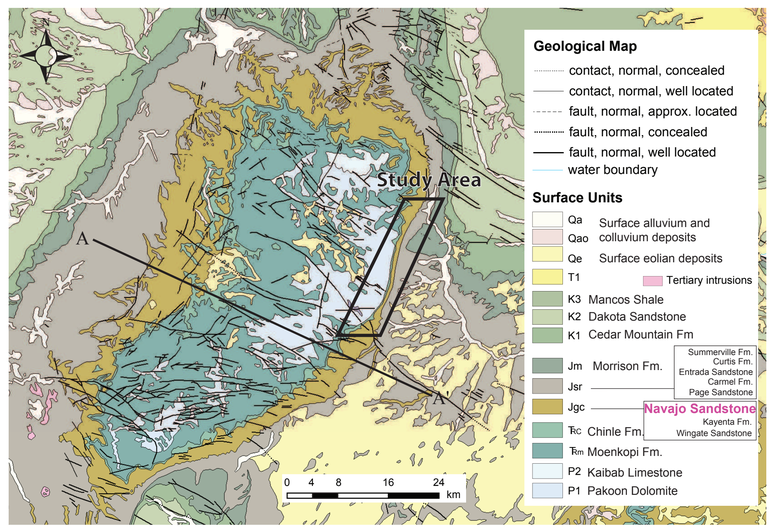
- Investigate controls on deformation band geometries and distribution in contractional forced folds and fault propagation folds
- Study the relationship between fold geometry/bed dip and strain for predictive purposes in subsurface reservoirs
- Evaluate the effects of deformation band arrays on effective reservoir permeability and assess implications for fluid flow (work in progress)

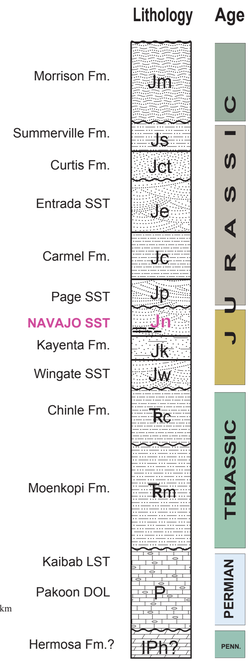
Methodology

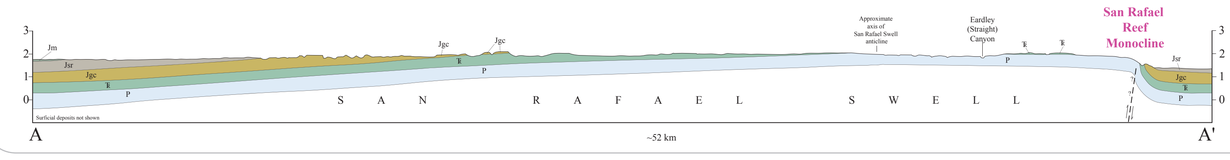
- Field observations and structural mapping
- Probe permeameter measurements of deformation band and host rock permeabilities
- Scan lines of deformation band frequency

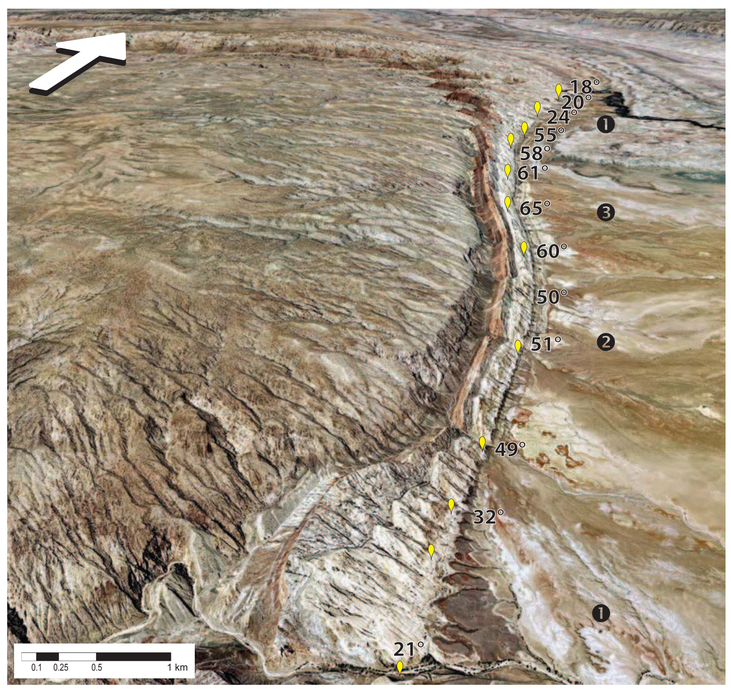
San Rafael Reef Monocline - SRR





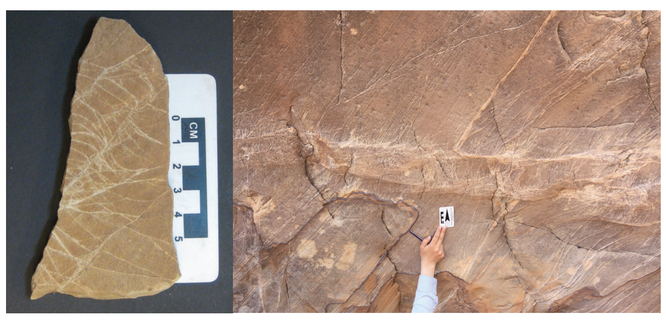






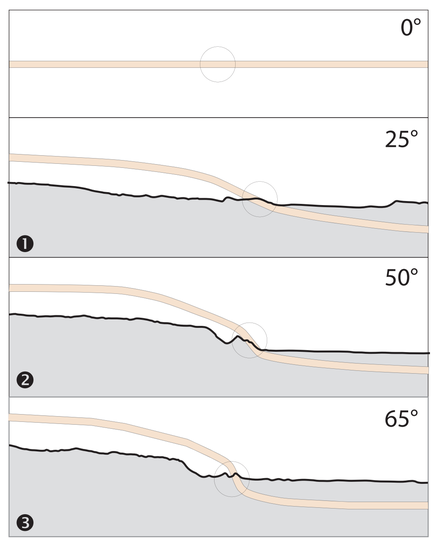
Aerial photograph of the SRR monocline
Field localities are shown in yellow, with corresponding forelimb dip

Ladder Structures

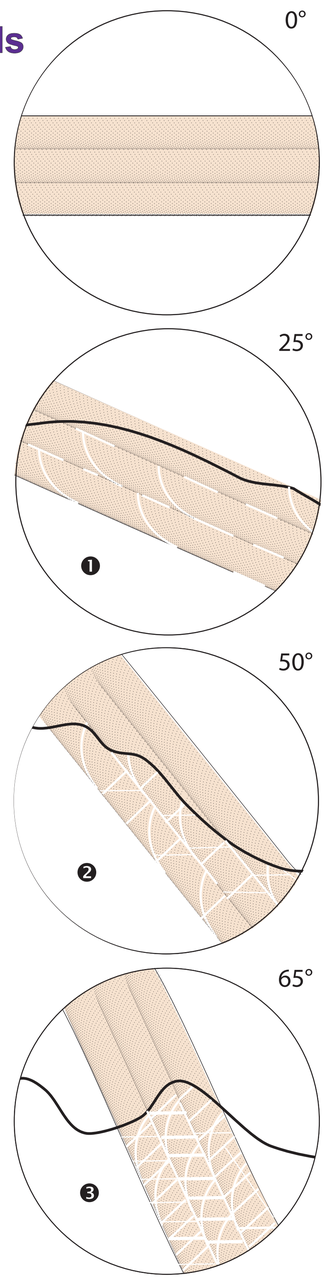


Cataclastic Deformation Bands arranged in ladder structures
Notice record of paleo fluid front being hampered by the ladder boundary as well as the self similarity of ladders at different scales of observation

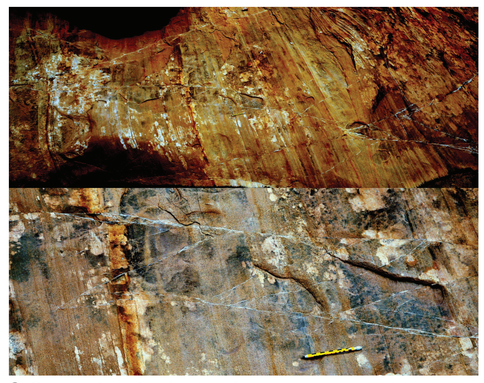
Fold Evolution and Deformation Bands



Schematic cross sections along canyons of the San Rafael Reef monocline. Navajo Sandstone interval constructed above and below present day topography



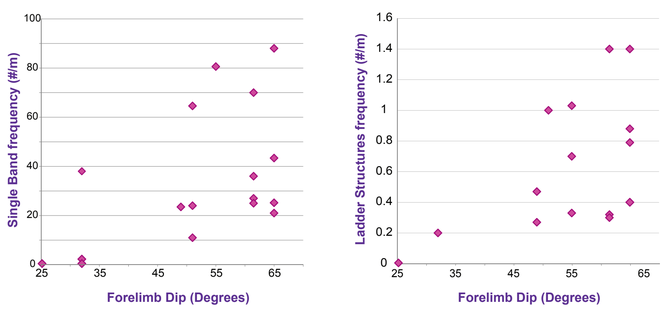
❶ Lithology contrasts in the sandstone such as crossbeds and duneset boundaries create nucleation points for deformation bands that gradually join to form thick clusters



❷ Conjugate sets of bands form perpendicular to bedding, **ladder structures** are formed in step overs

❸ Ladder Structures develop in size and lenght. The new formed structures offset those from previous stages that have been passivelly rotated

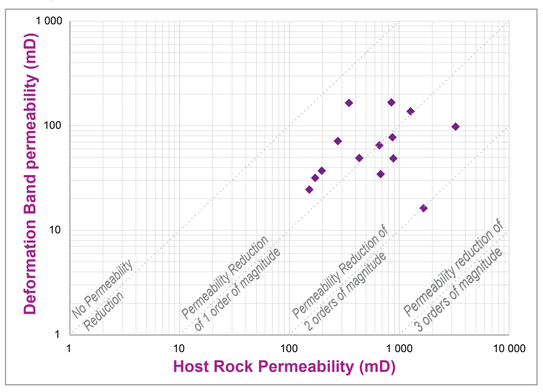
Deformation Band Frequency



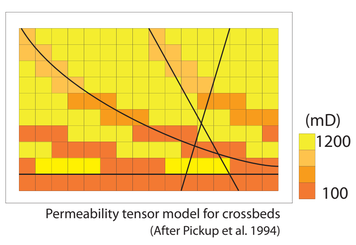
Frequencies of single deformation bands (left) and ladder structure sets (right) vs. forelimb dip

Ongoing Work: Reservoir Modelling

Grid design and upscaling strategies are being evaluated in order to build a representative reservoir model and evaluate fluid flow in this case study

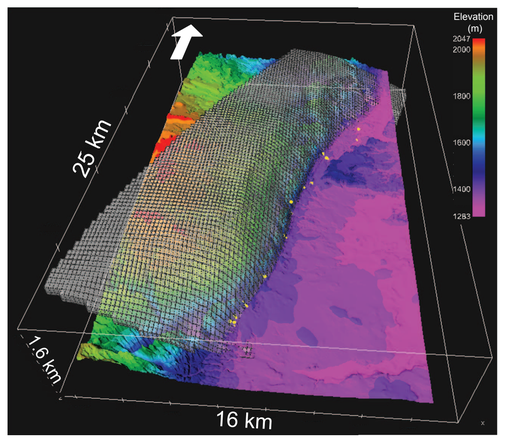


Permeability in deformation bands are 0-2 orders of magnitude lower than the corresponding host rock permeability



Permeability tensor model for crossbeds
(After Pickup et al. 1994)

Challenges in the grid design include incorporation of heterogeneities from deformation band arrays and sedimentary structures combined



Current status of the reservoir model of the San Rafael Reef:
Colored horizon is present day topography
Navajo SST interval was reconstructed from available data to create a preliminary coarse grid

Conclusions

- The identified phases for deformation band formation can be used as a proxy for different stages of fold growth:
  - i) Planar deformation Bands along bedding laminae and between dune set boundaries formed at initial stages (flexural slip mechanism)
  - ii) Progressive folding created and rotated conjugate sets of deformation band ladders across dune sets
- The self similarity of ladders at different scales of observation and the comparable trend of frequencies of single deformation bands and sets of ladders suggest a scale independent behaviour worth to explore in more detail
- Deformation bands reduce host rock permeability by up to 2 orders of magnitude, lithological contrasts account for 1 order. The combination of both heterogeneities needs to be taken into account to design a representative modelling grid

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Acknowledgements

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http://folk.uib.no/nglhe/COPS.html

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