Understanding the Reactivation of Basement Structures in SE Nebraska Using Analog Models

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Overview

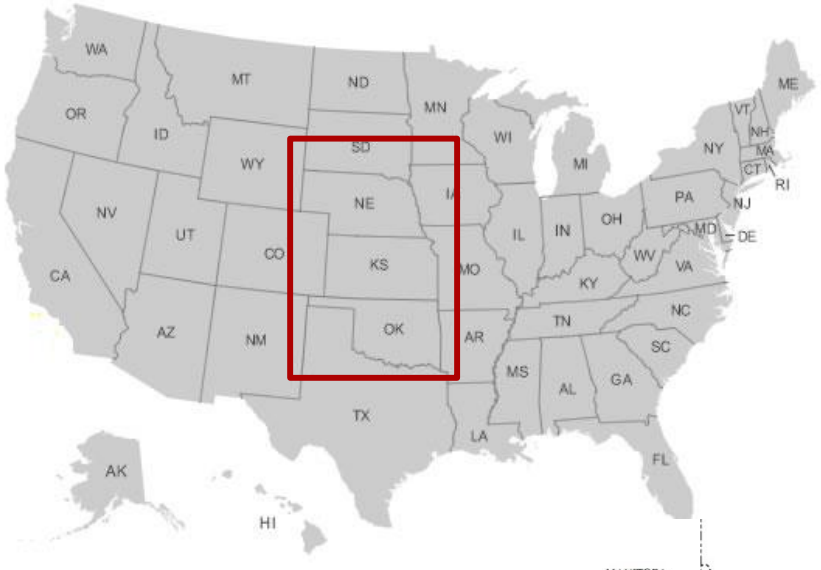
- Problem statement
- Based on a real region - SE Nebraska
- Surface data
  - Mapping of Surface Lineaments
  - Results from this mapping
- Testing research question using analog models
- Results - analog modeling
- Conclusions
- Future Work

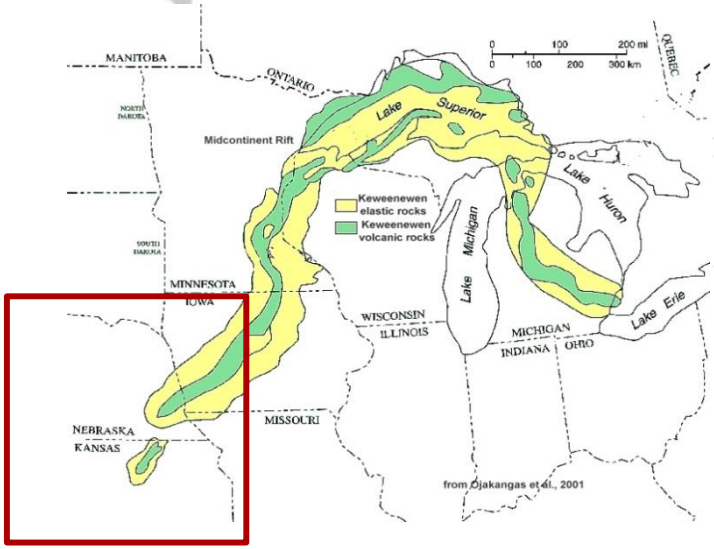
Problem Statement

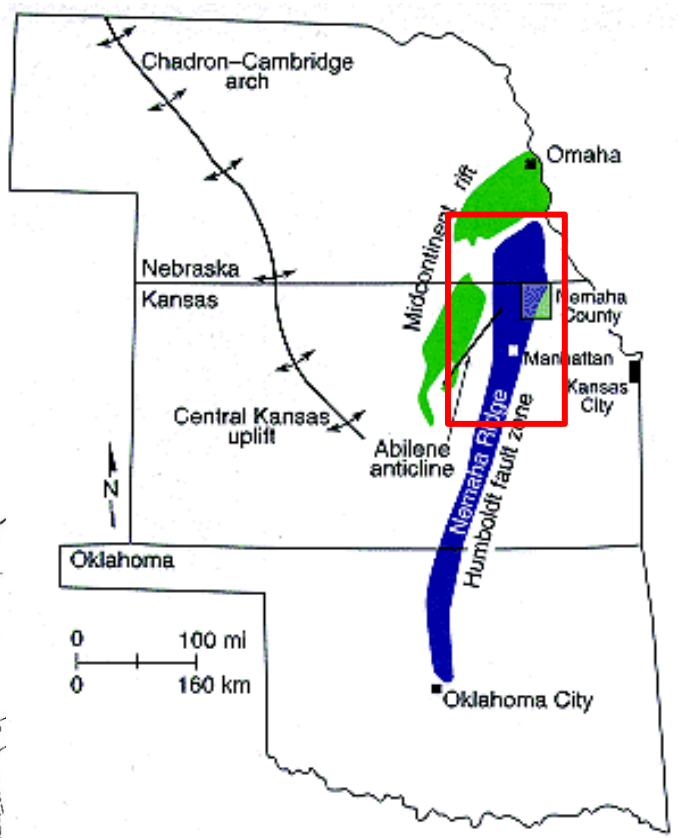
- Can reactivation of pre-existing faults affect the geometry/orientation/location of surface faults/fractures/lineaments?

- How? Do younger structures parallel older ones? What is the effect of multiple orientations of pre-existing faults?

Area of Interest



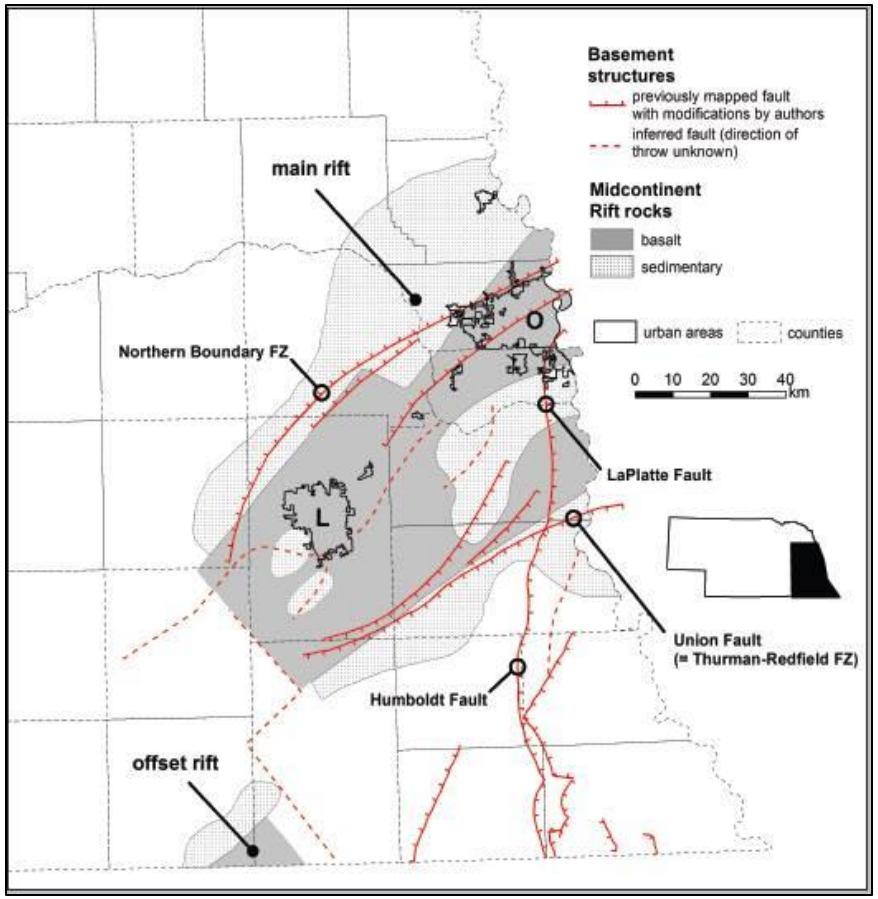




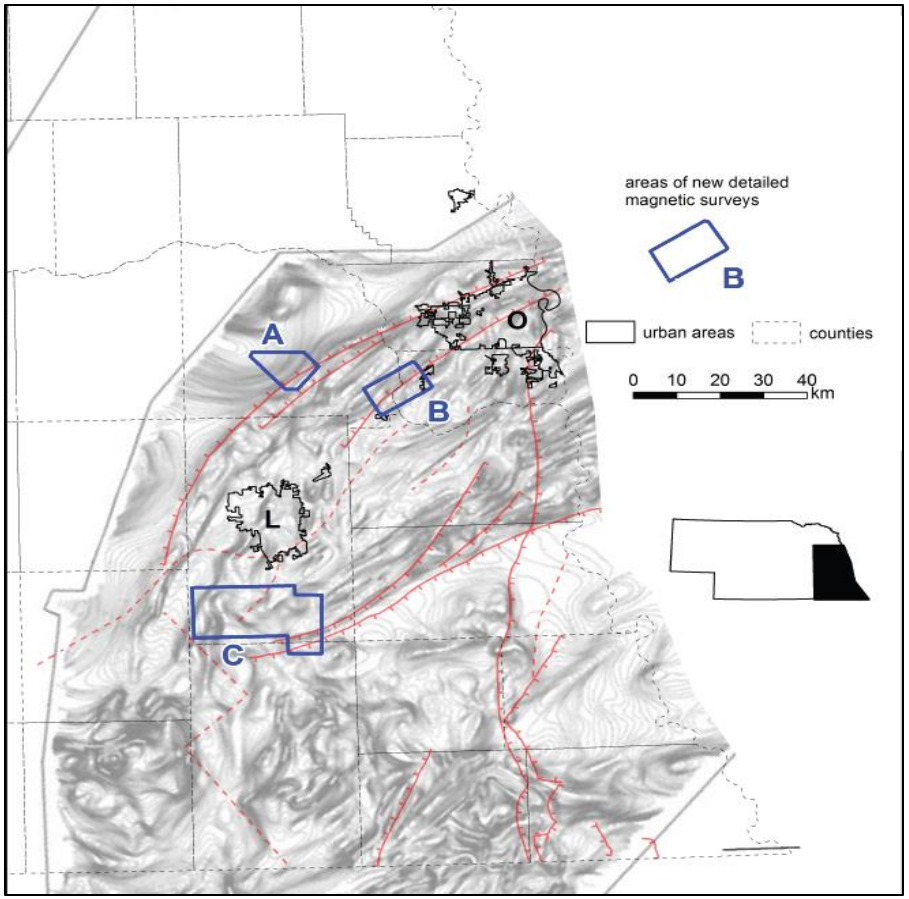
May 21, 1999, “Earthquake Images”, KGS: Geokansas, http://www.kgs.ku.edu/Extension/image/earthquake8.html, August 1, 2013.

Detailed basement structure, SE Nebraska

Fault map

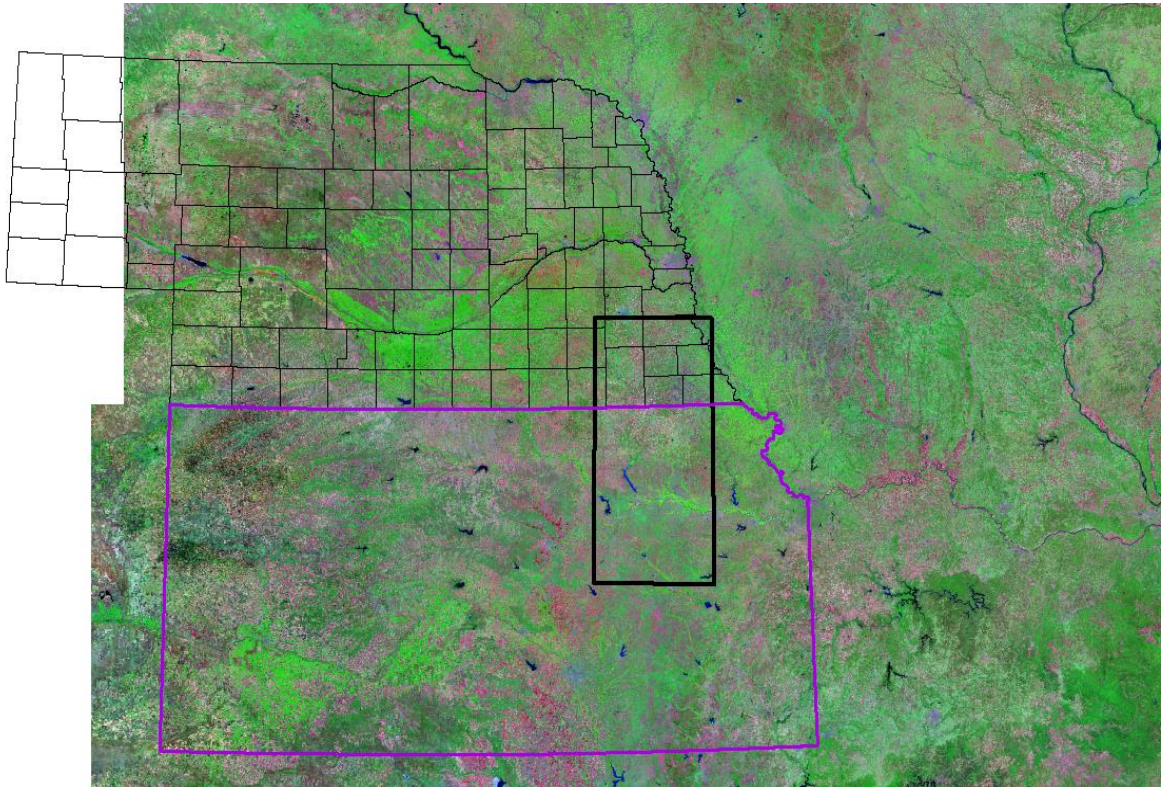


Magnetics map

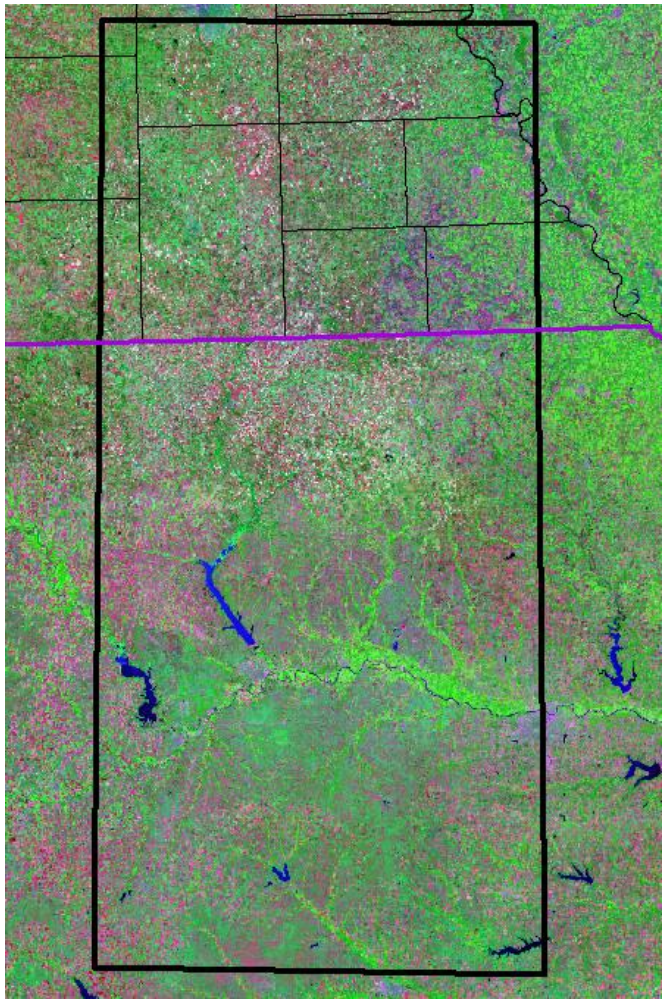


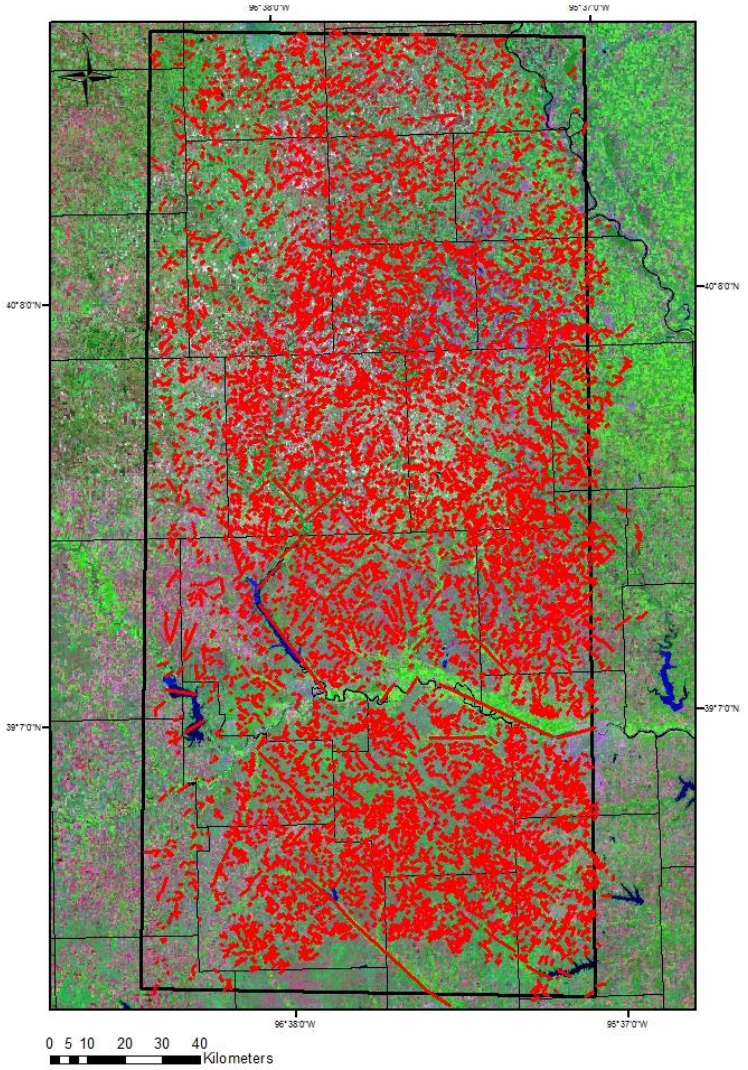
Burberry et. al. 2012

Surface Lineaments

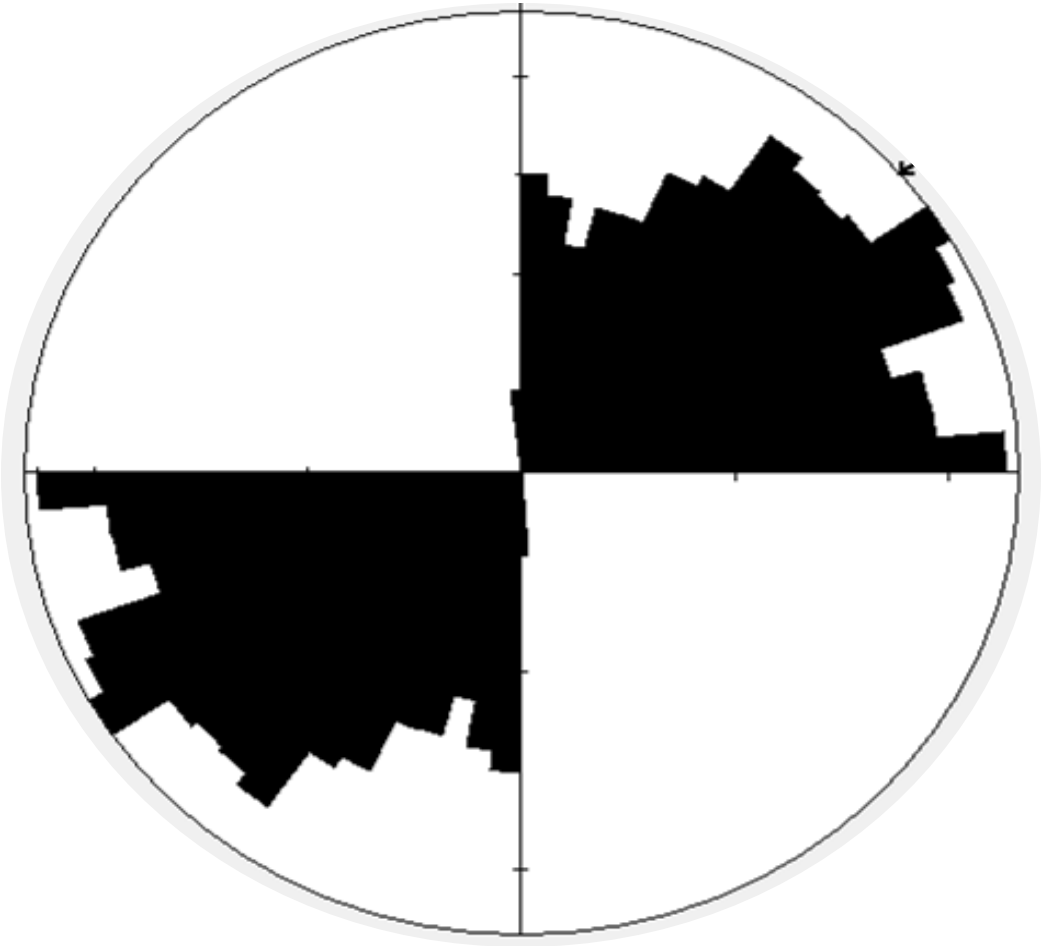


Results - Surface Lineaments mapped

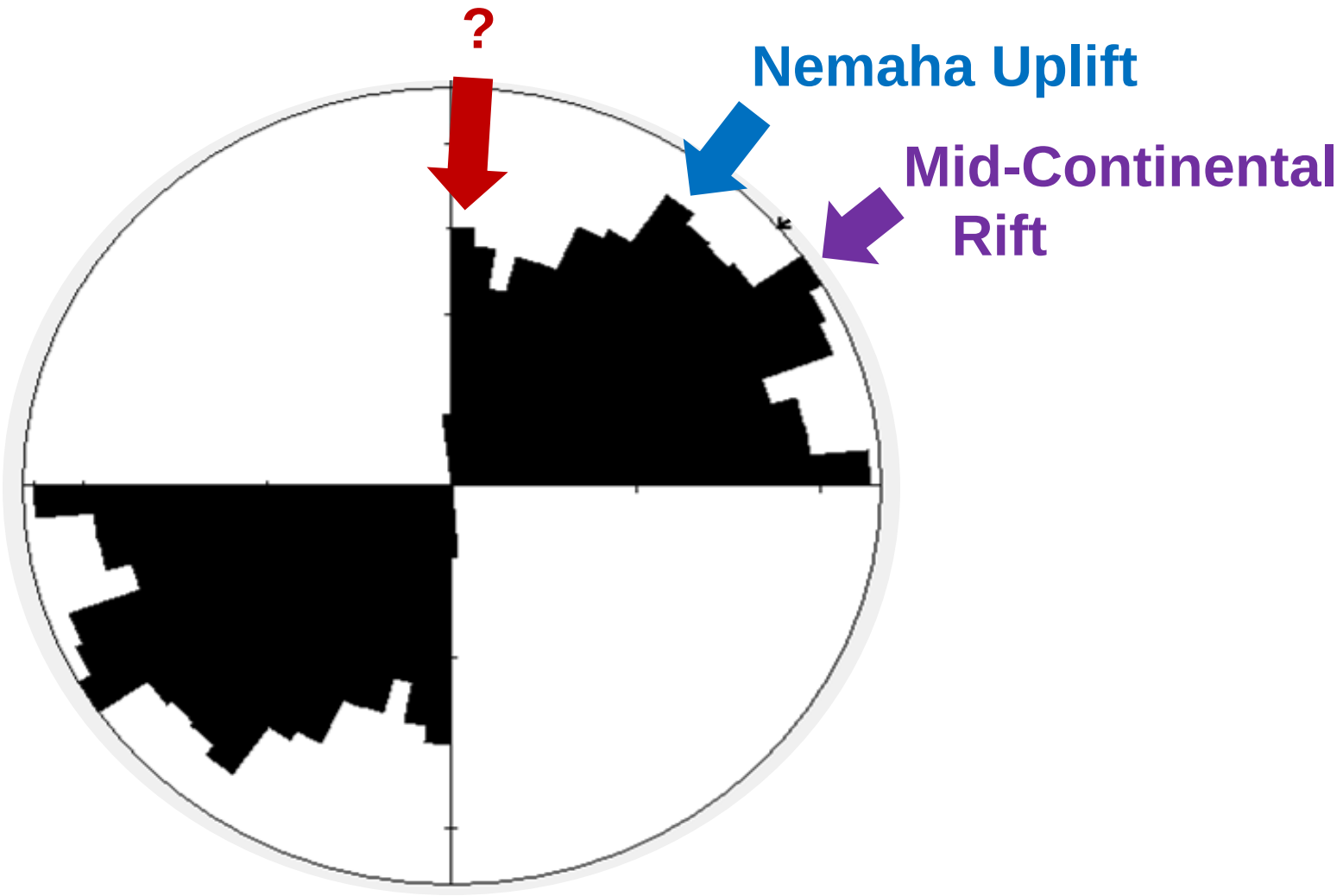




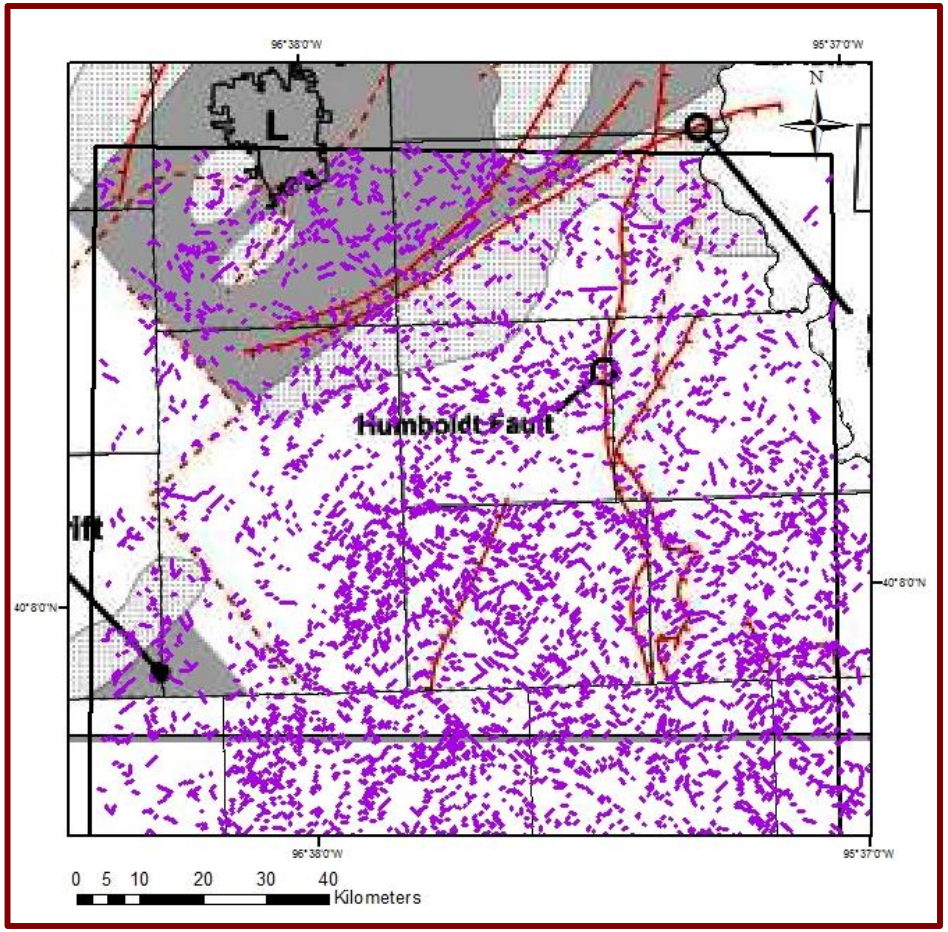
Results – Lineament orientations



Results – Lineament orientations

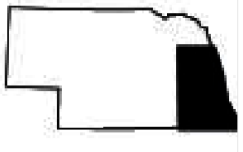


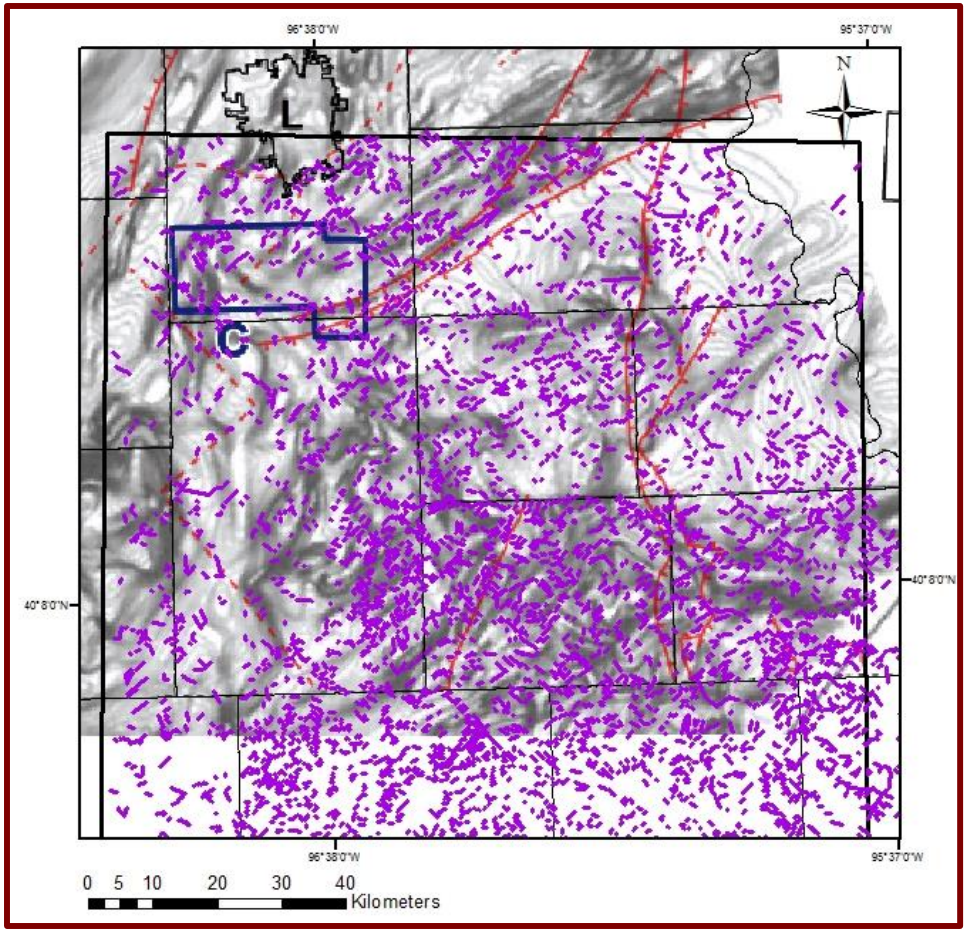
Results – Lineament orientations



Fault map

Magnetics map





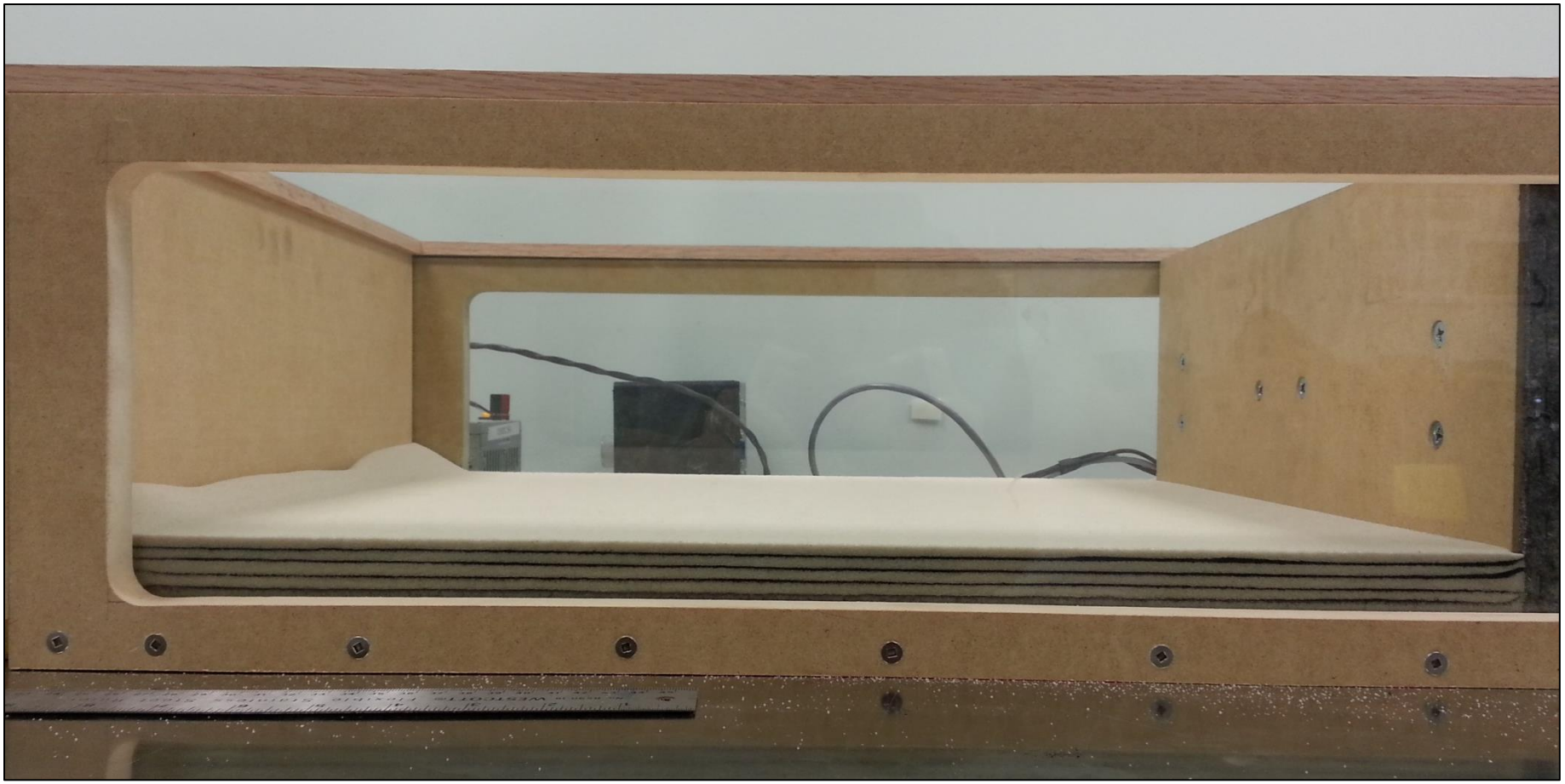
Burberry et. al. 2012

Stage 2 – Analog Modeling

- Can we use analog models to test the idea that basement faults reactivate under subsequent stress regimes?
  - In doing so, do they influence the geometry/orientation/location of surface structures?

- Constructed a series of models, progressively more complex, similar to the assumed pre-existing geometry of the study area

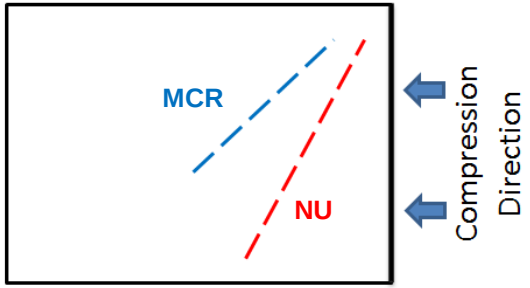
Creation of Models



Stage 2 – First set of analog models

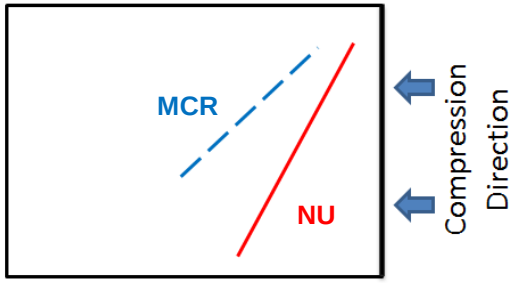
Model 1

The MCR and NU represented as basement faults.



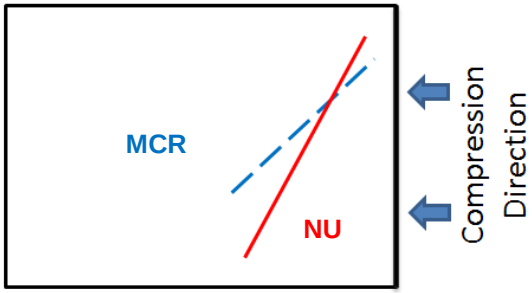
Model 2

The MCR is a basement fault whereas the NU is 3 sand layers up cutting down into the basement.



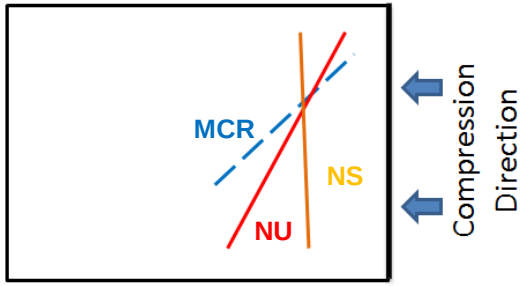
Model 3

The MCR and NU are crossing each other at the top with the MCR as a basement fault and the NU is 3 sand layers up cutting down into the basement.



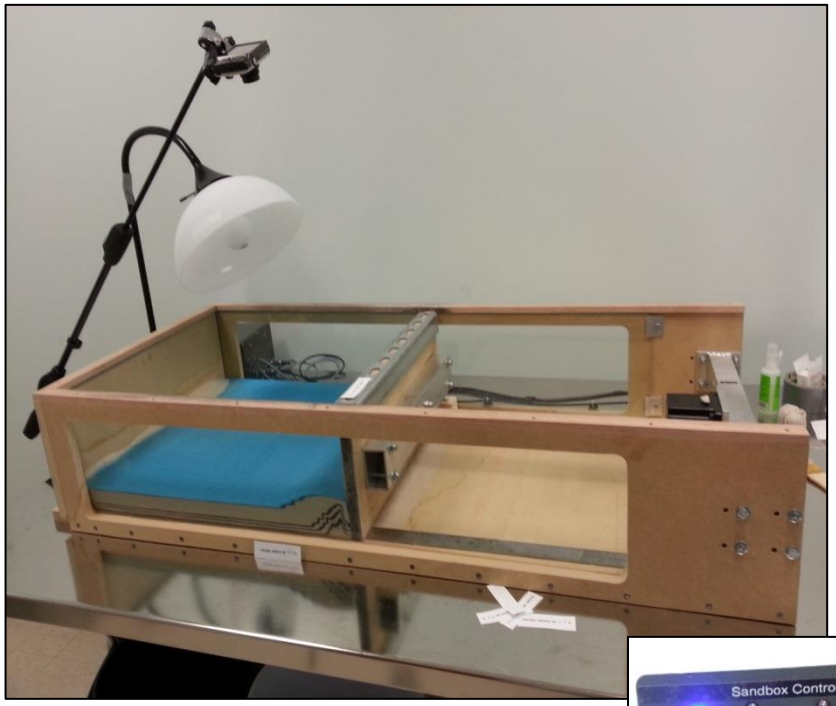
Model 4

Same as Model 3 except with another fault, from the results of the rose diagram (Fig. 14), 3 sand layers up cutting down into the basement which runs North-South (NS).



MCR: Mid-Continental Rift **NU**: Nemaha Uplift **NS**: North-South Trending

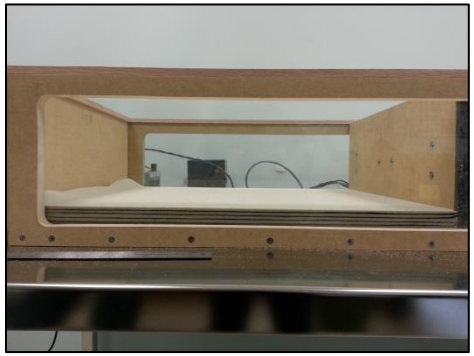
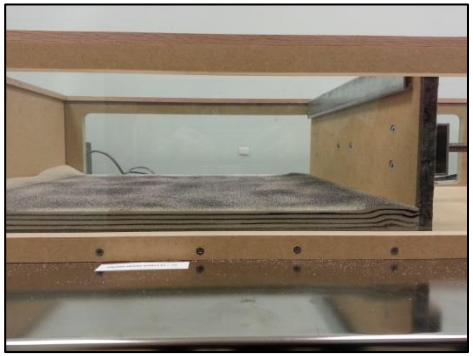
Lab Setup




Sandbox Control
Power
Out Limit
In Limit
Busy
Stop
Step Out
Fast Out
Step In
Fast In
10
5
15
Mode
Speed
mm/hour
(Step Mode)


Shinho
NATURALLY BREWED
SOY SAUCE
Bounty

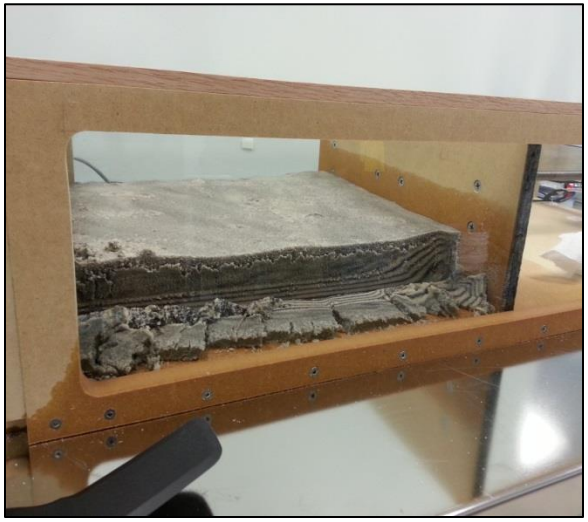
Time lapsed

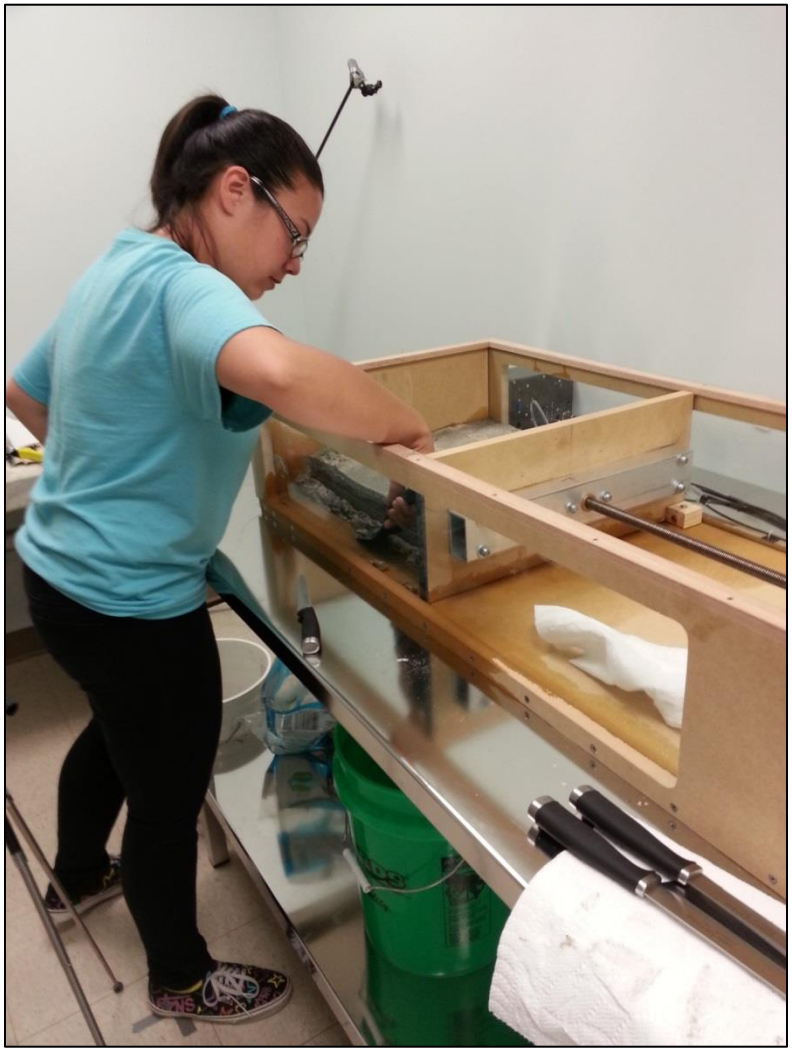





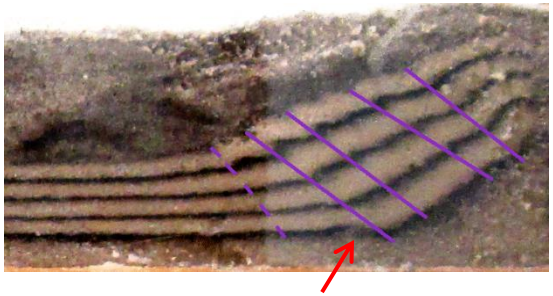


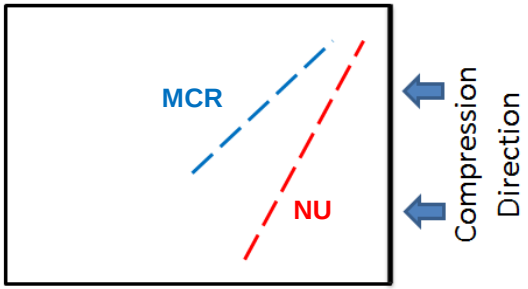
Slice into cross sections



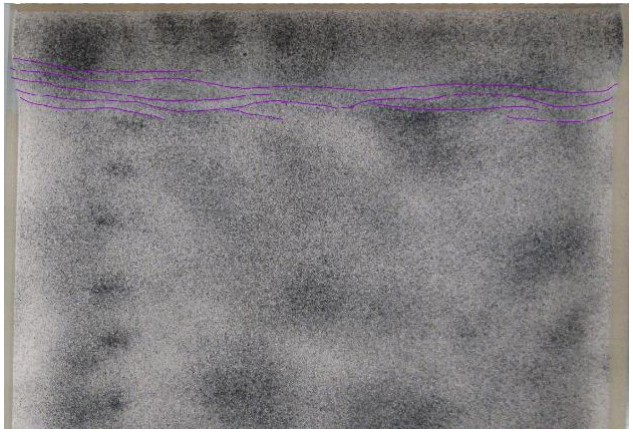


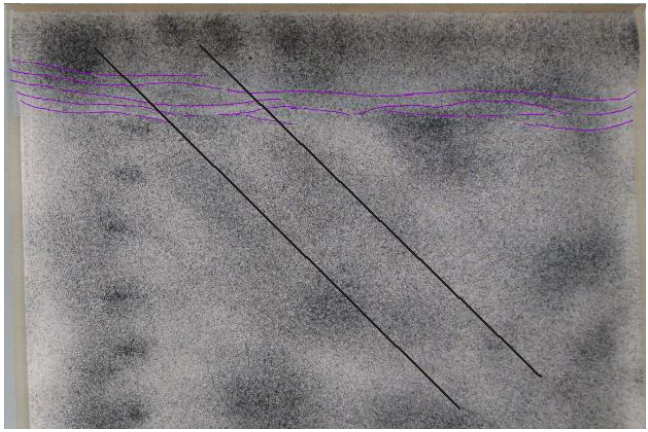
Model 1 Results





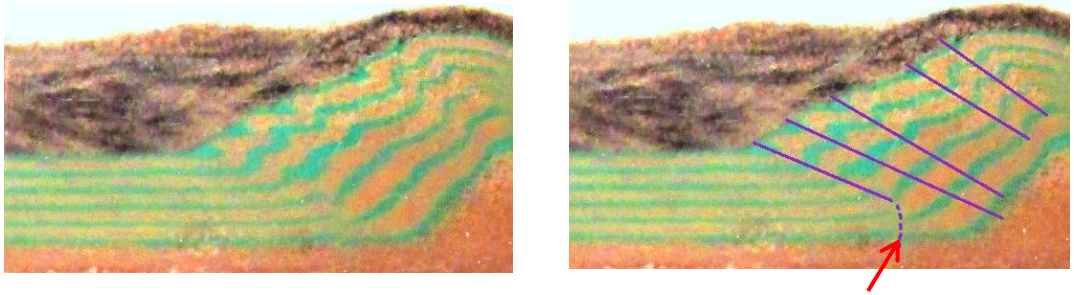
Cross section 34cm at 15.2% BS showing reactivation of the basement fault



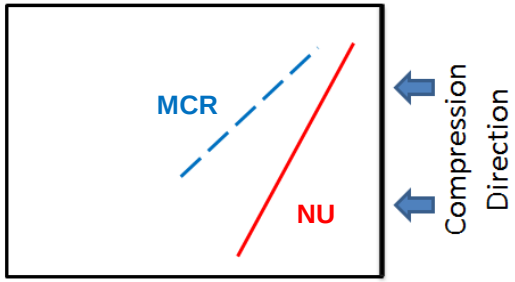


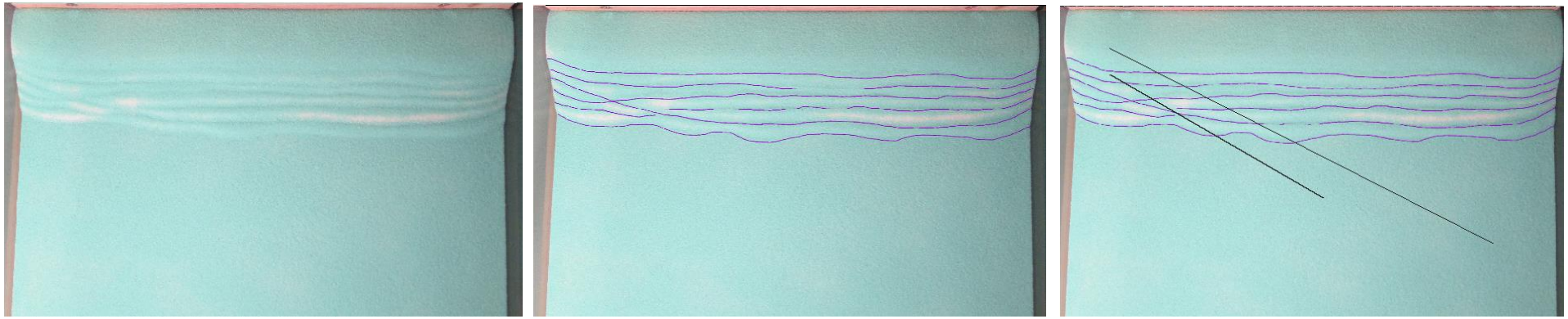
Map view at 7.7% BS of surface faults aligning with MCR and NU

Model 2 Results



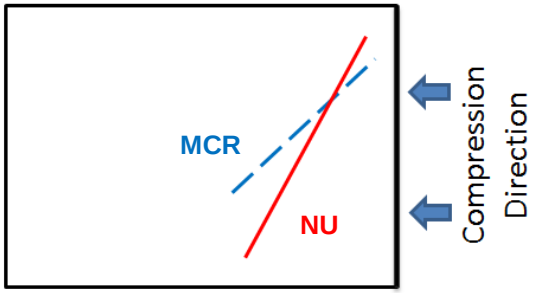
Cross section 30cm at 14.9% BS showing reactivation of NU fault

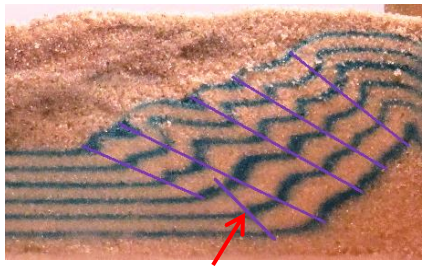




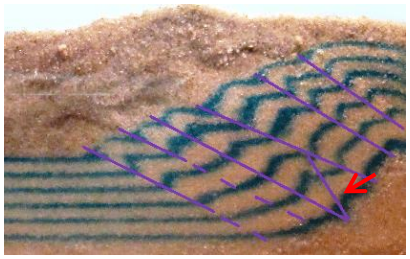
Map view at 13.7% BS of surface faults aligning with MCR and NU

Model 3 Results

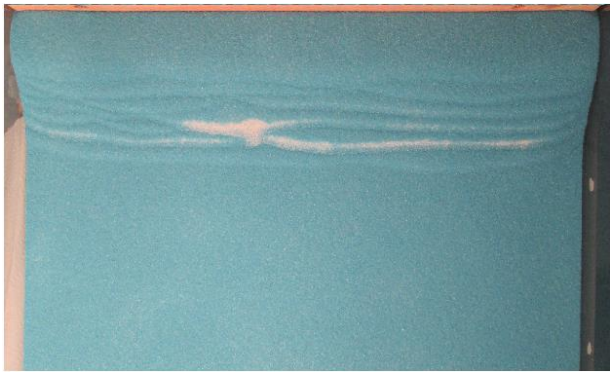


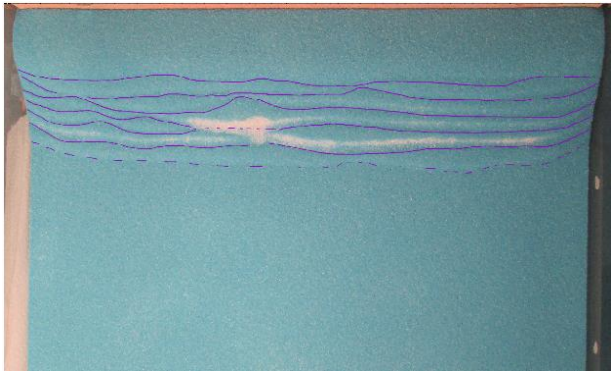


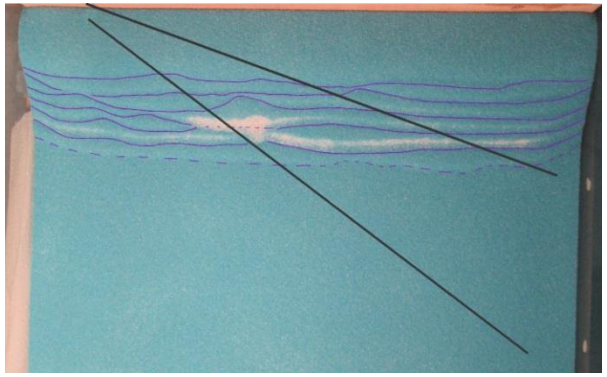
Cross section 21cm at 14.6% BS showing reactivation of NU fault



Cross section 37cm at 14.6% BS showing reactivation of NU fault cutting through previously made fault

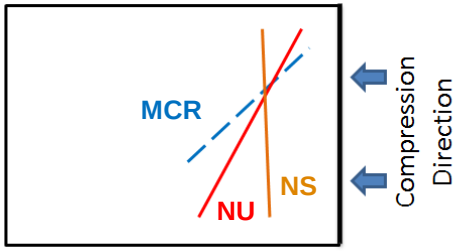


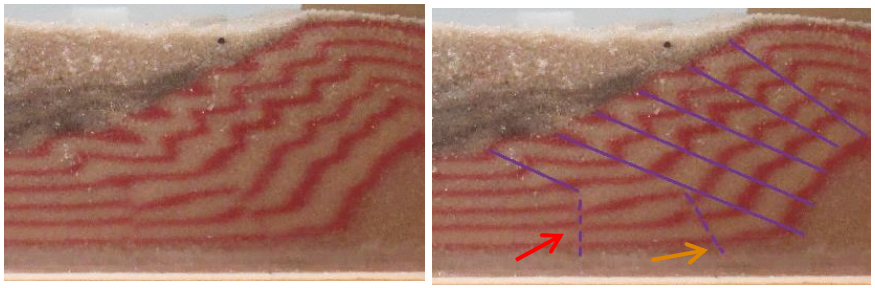




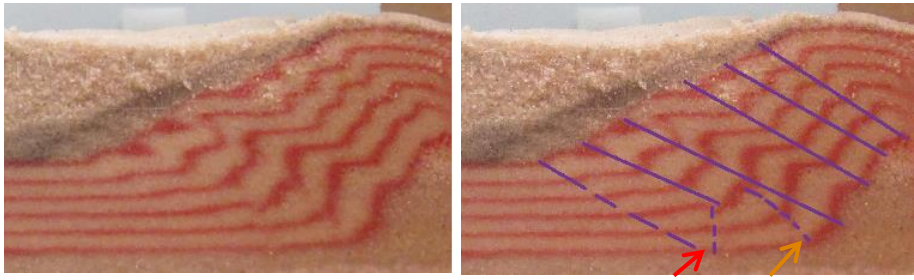
Map view at 13.7% BS of surface faults aligning with MCR and NU

Model 4 Results

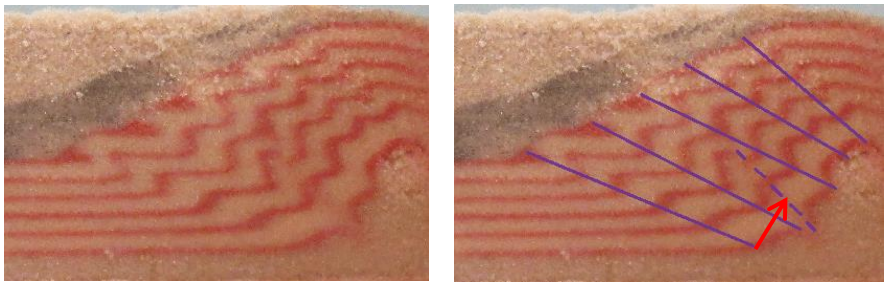




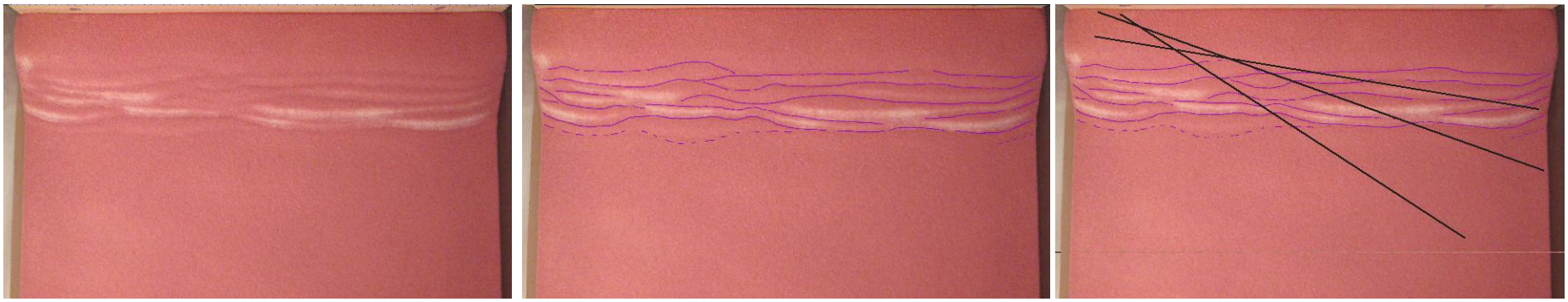
Cross section 9cm at 14.7% BS showing uplift due to the NU and NS faults



Cross section 20cm at 14.7% BS showing creation of faults due to NU and NS



Cross section 36cm at 14.7% BS showing uplift and creation of a new fault due to NU

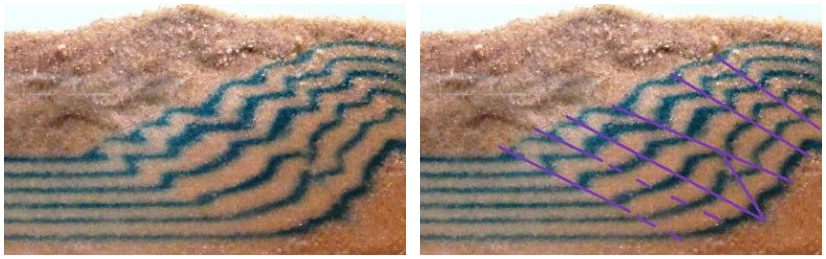


Map view at 13.5% BS of surface faults aligning with MCR, NU, and NS

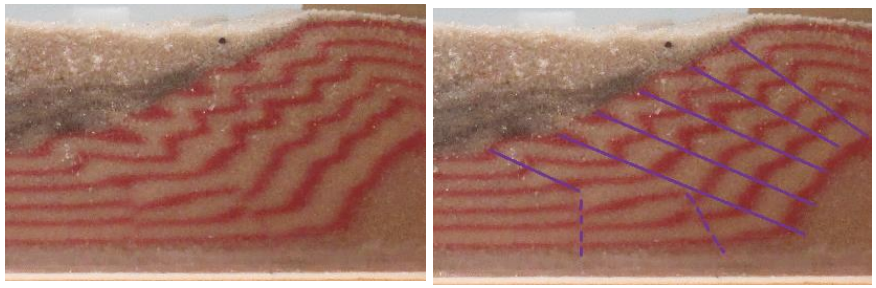
General conclusions

- Q: Can reactivation of pre-existing faults affect the geometry/orientation/location of surface faults/fractures/lineaments? **YES**
- Q: How?
  - Do younger structures parallel older ones? **Yes, average orientation of the younger structures parallels older ones**
  - What is the effect of multiple orientations of pre-existing faults? **Complex interactions and deflections of surface features**

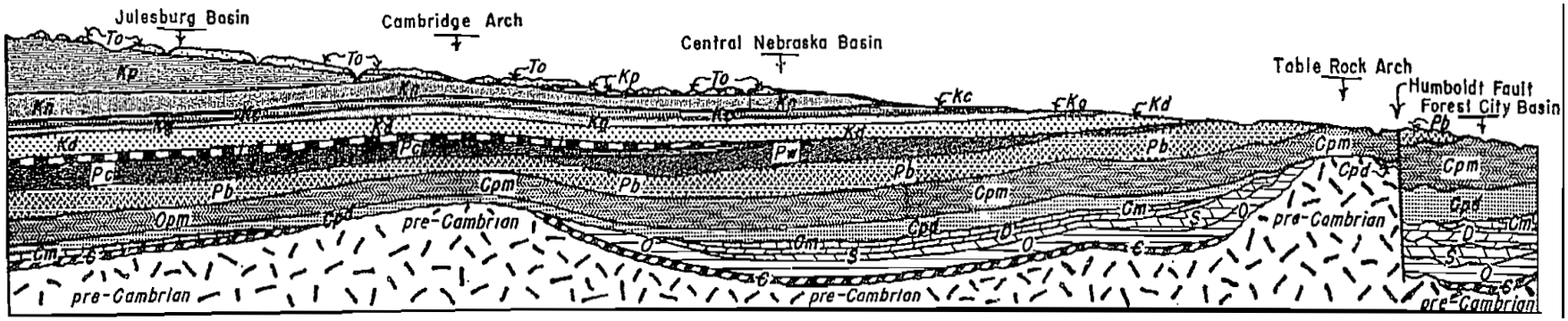
Conclusions: Comparing to SE NE



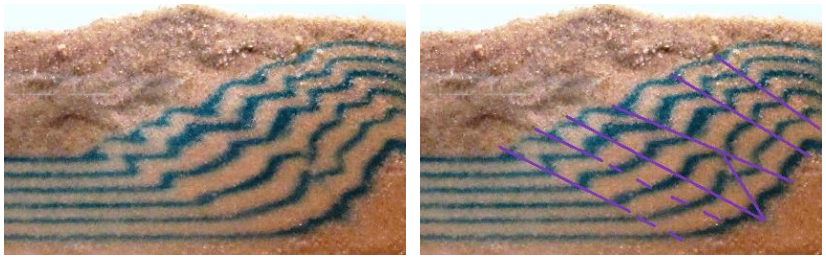
Model 3 reactivation of NU fault



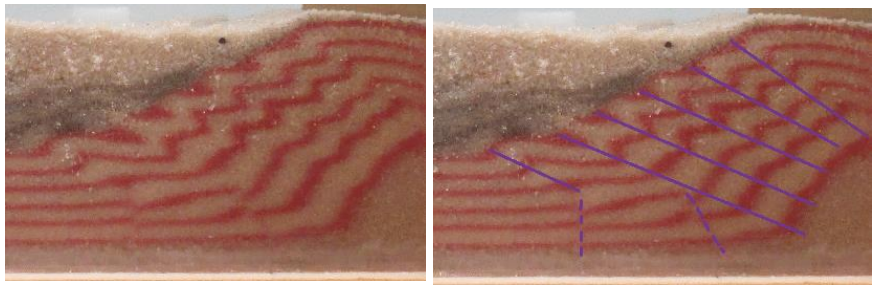
Model 4 showing uplift from NU and NS faults



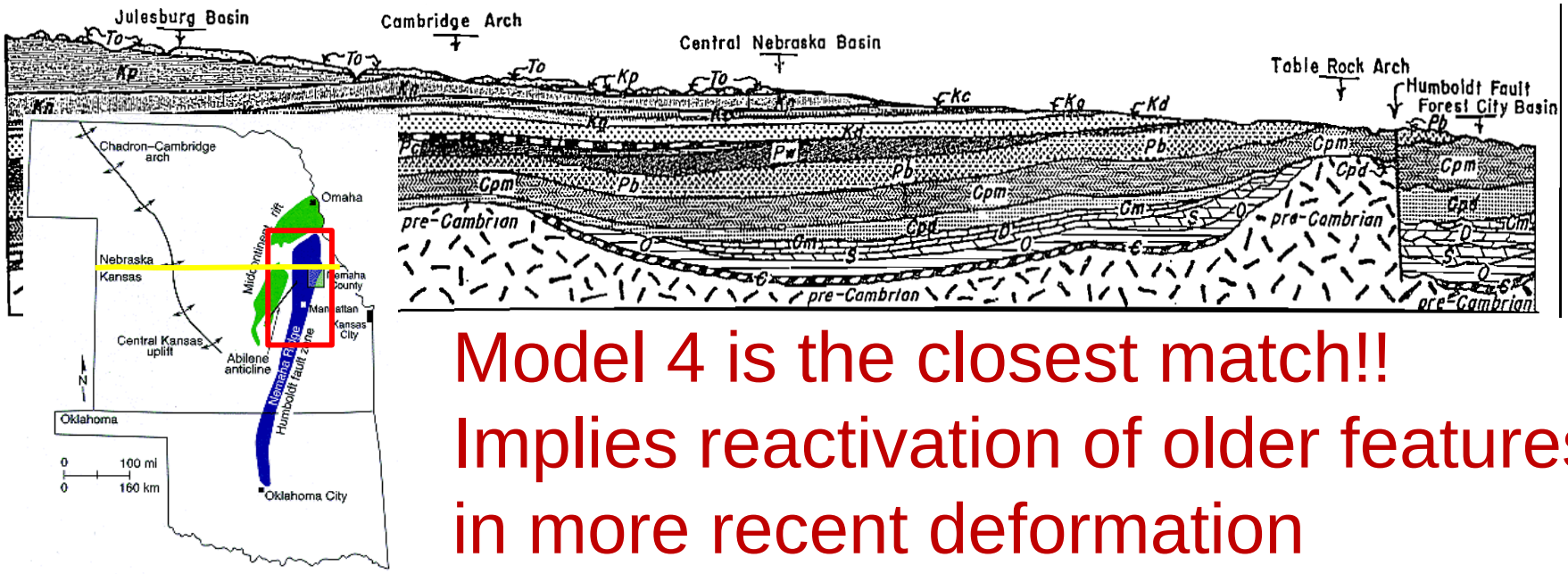
Conclusions: Comparing to SE NE



Model 3 reactivation of NU fault



Model 4 showing uplift from NU and NS faults



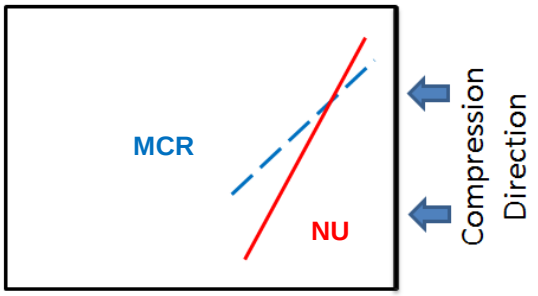
Model 4 is the closest match!!
Implies reactivation of older features in more recent deformation

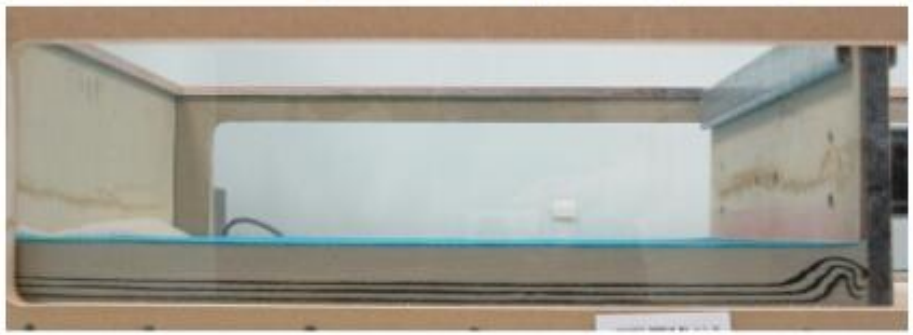
Next steps…

- So far, we have modeled deformation occurring post-Ancestral Rocky Mountains and neglected the fact that the MCR predates the NU.
- We have concentrated on three prominent basement features, the known MCR and NU, and the additional N-S trending feature.
- Next model series (e.g. Model 5, next slides) will attempt to investigate the issue of multi-phase deformation.

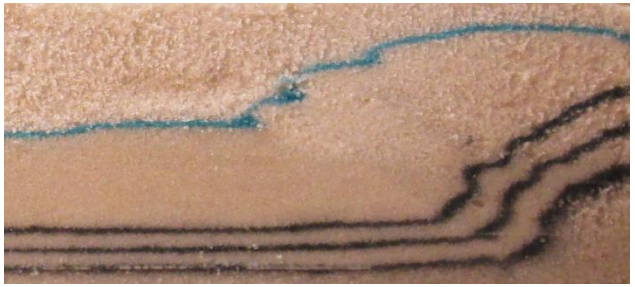
Model 5: Multi-Phase Deformation

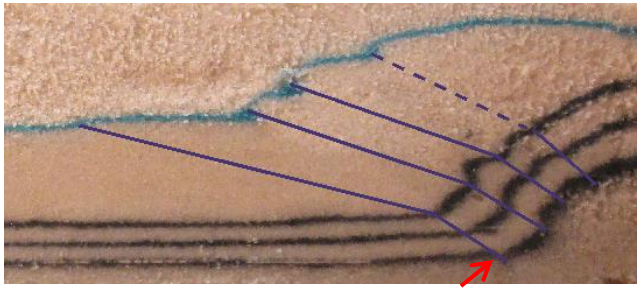
- Same setup as model 3:

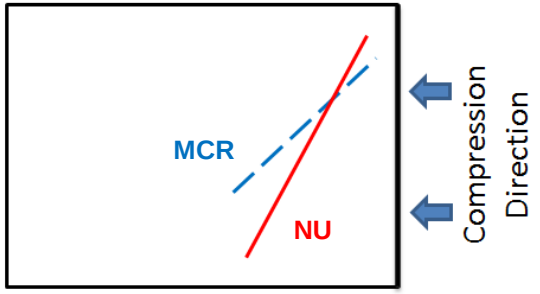




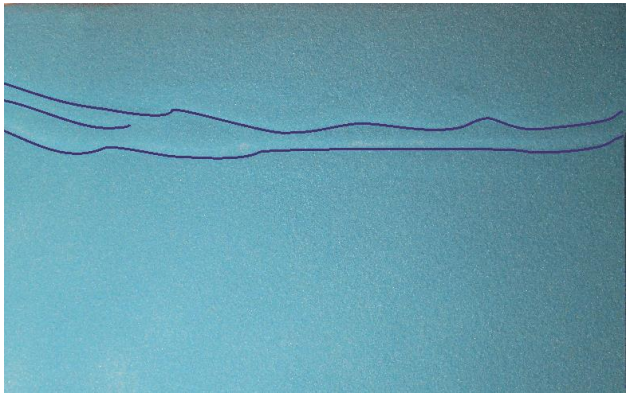
Model 5 Results

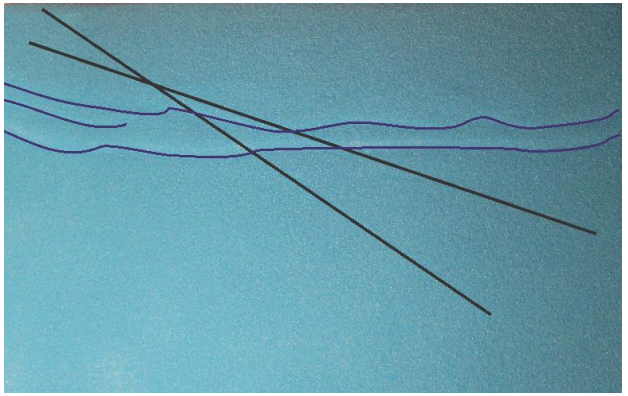






Cross section 30 cm at 14.8% BS showing reactivation of MCR fault, also the thrust angle changes through to the top layer

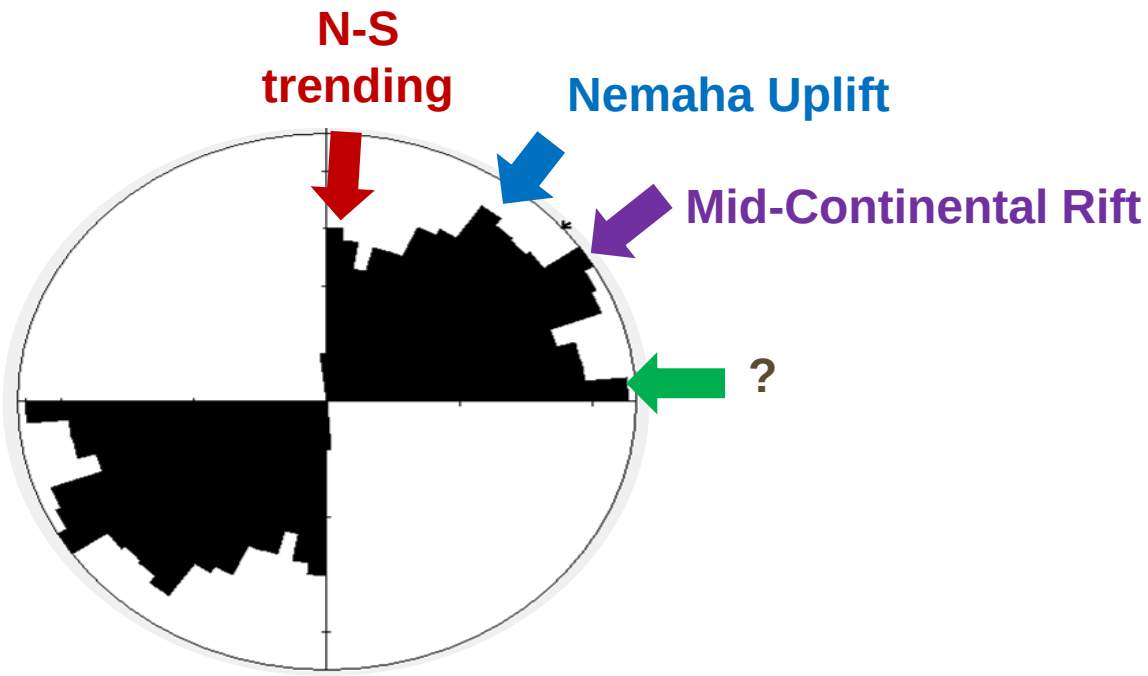




Map view at 11.4% BS of surface faults aligning with basement faults

Next steps…

- Look more into the effects of multi-phase deformation using scaled models
- Future models to test the effect of adding E-W orientation in the rose diagram from surface features



Thank you!

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