Fracture Patterns in Laramide Thrust Structures, Wyoming*

John C. Lorenz[1] and Scott P. Cooper[2]

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[1]FractureStudies LLC, Edgewood, NM (john@fracturestudies.com)
[2]Enhanced Oil Recovery Institute at The University of Wyoming, Laramie, WY

Abstract

Analysis of outcrop and core fracture data over a spectrum of Laramide thrust structures (broad low-angle arches to tight high-angle folds) in Wyoming shows the Tensleep Formation is cut by numerous intersecting fractures, including 1) inherited F0 fracture patterns unrelated to folding are present in some structures, and 2) fold-related extension fractures trend approximately normal (F1) and parallel (F2) to the axis of folding. Hingenormal F1 extension fractures typically formed in response to horizontal stress prior to uplift and prior to the hinge-parallel F2 fractures that formed during folding. Areas on broad anticlines that were not significantly folded, i.e., relatively planar backlimbs, contain only the early, F1 fractures. Shear fractures (FS) in tightly folded structures can have strike-slip, thrust, and/or bed-parallel motions of slip. Fractures of all sets (F0, F1, F2, and FS) were locally reactivated in both shear and extension as folding intensified.

Lithology also influences fracturing with limestones accommodating much of the larger-scale bed-parallel shear through brecciation, although it is not always obvious due to weathering and secondary re-cementation. From a distance, many of the limestone beds in fact appear to be unfractured. The eolian sandstone facies accommodated strain by extension fractures, and by shear both parallel and oblique to the large-scale crossbed foresets and bedding. Fracture intensity is dependent upon fold-style and degree of folding. Idealized fracture models can be constructed but significant variations in structural style and lithology must be taken into consideration.

References

Cooper, S.C., 2000, Deformation within a Basement-Cored anticline: Teapot Dome, Wyoming: Master's Thesis, Department of Earth and Environmental Science, New Mexico Tech, Socorro, New Mexico, 274 p.

Lorenz, J.C., and S.P. Cooper, 2011, Natural fracture patterns in folded Tensleep sandstone reservoirs, Wyoming: AAPG Search and Discovery Article #90126. Web accessed 27 September 2011. http://www.searchanddiscovery.com/abstracts/pdf/2011/rocky/abstracts/ndx_lorenz.pdf

Stearns, D.W., and M. Friedman, 1972, Reservoirs in fractured rock, *in* R.E. King, (ed.), Stratigraphic oil and gas fields: Classification, Exploration Methods, and Case Studies: AAPG Memoir, v. 16/10, p. 82-106.

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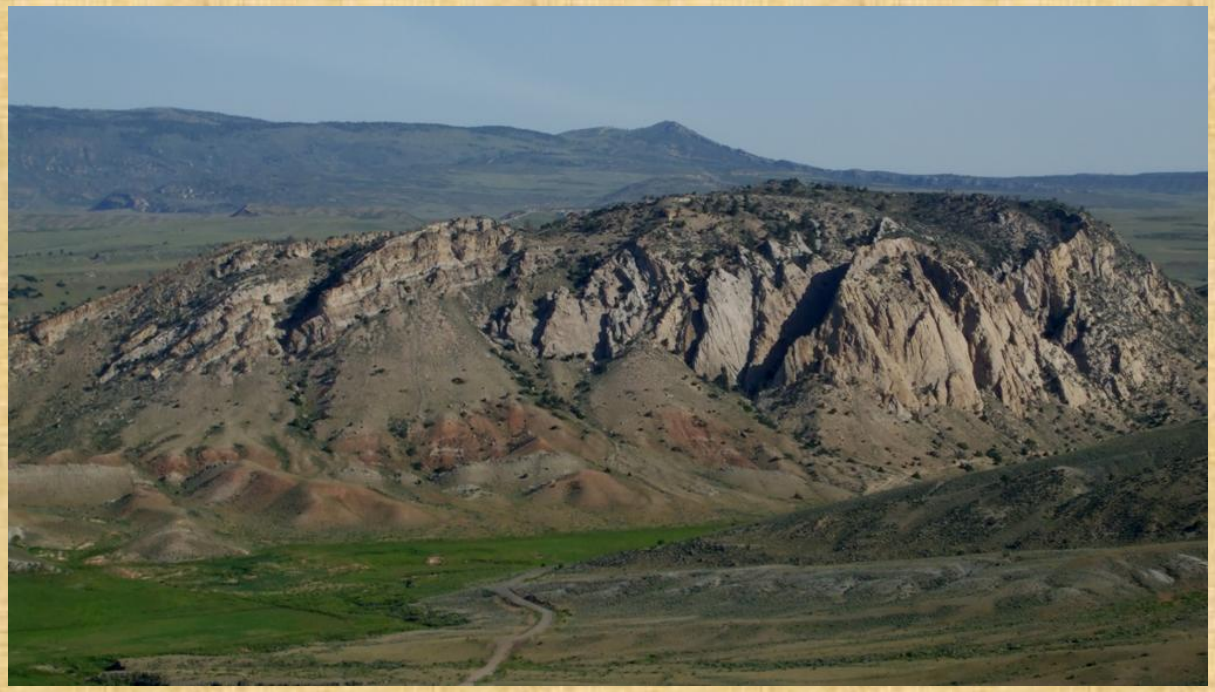
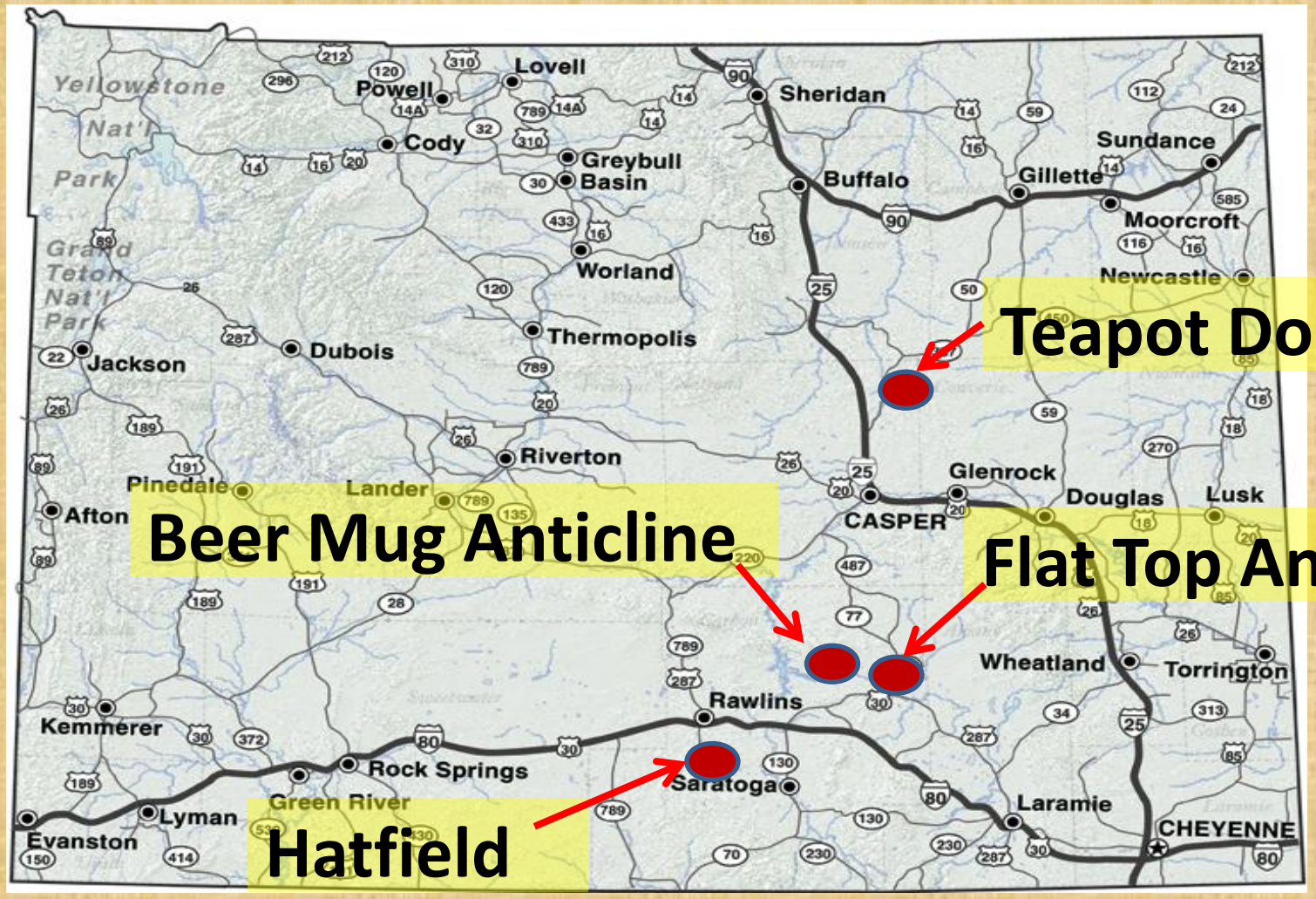
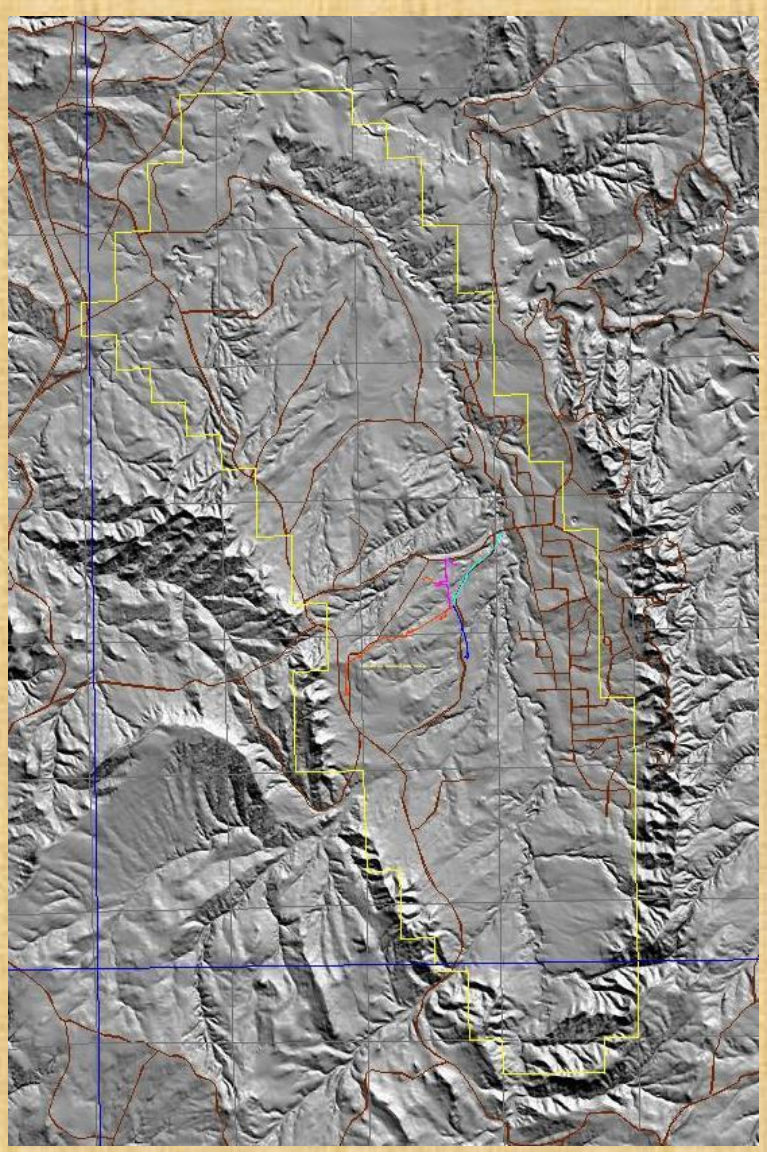
Fracture Studies/Enhanced Oil Recovery Institute



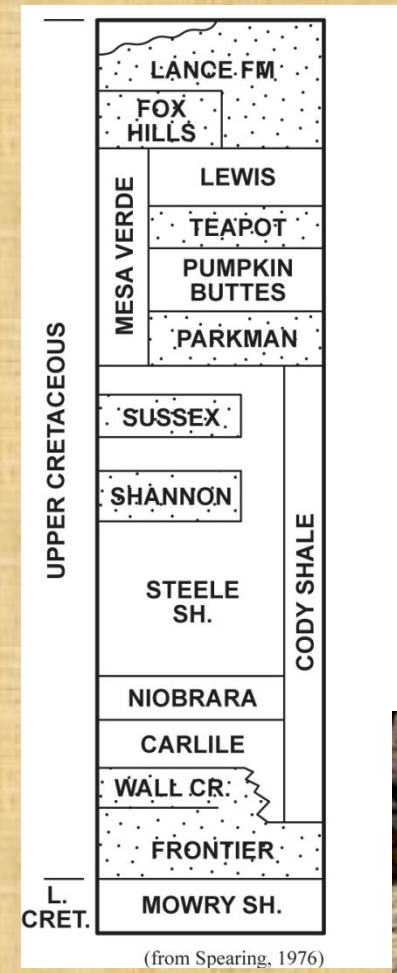
Tensleep Fracture Data Sites



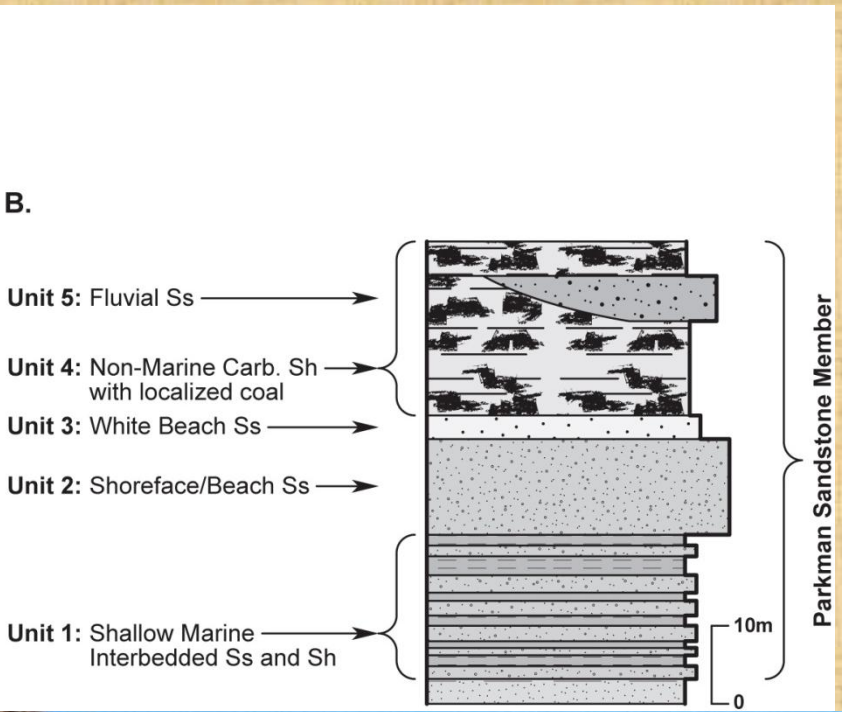
Teapot Dome



Fracturing in Cretaceous strata



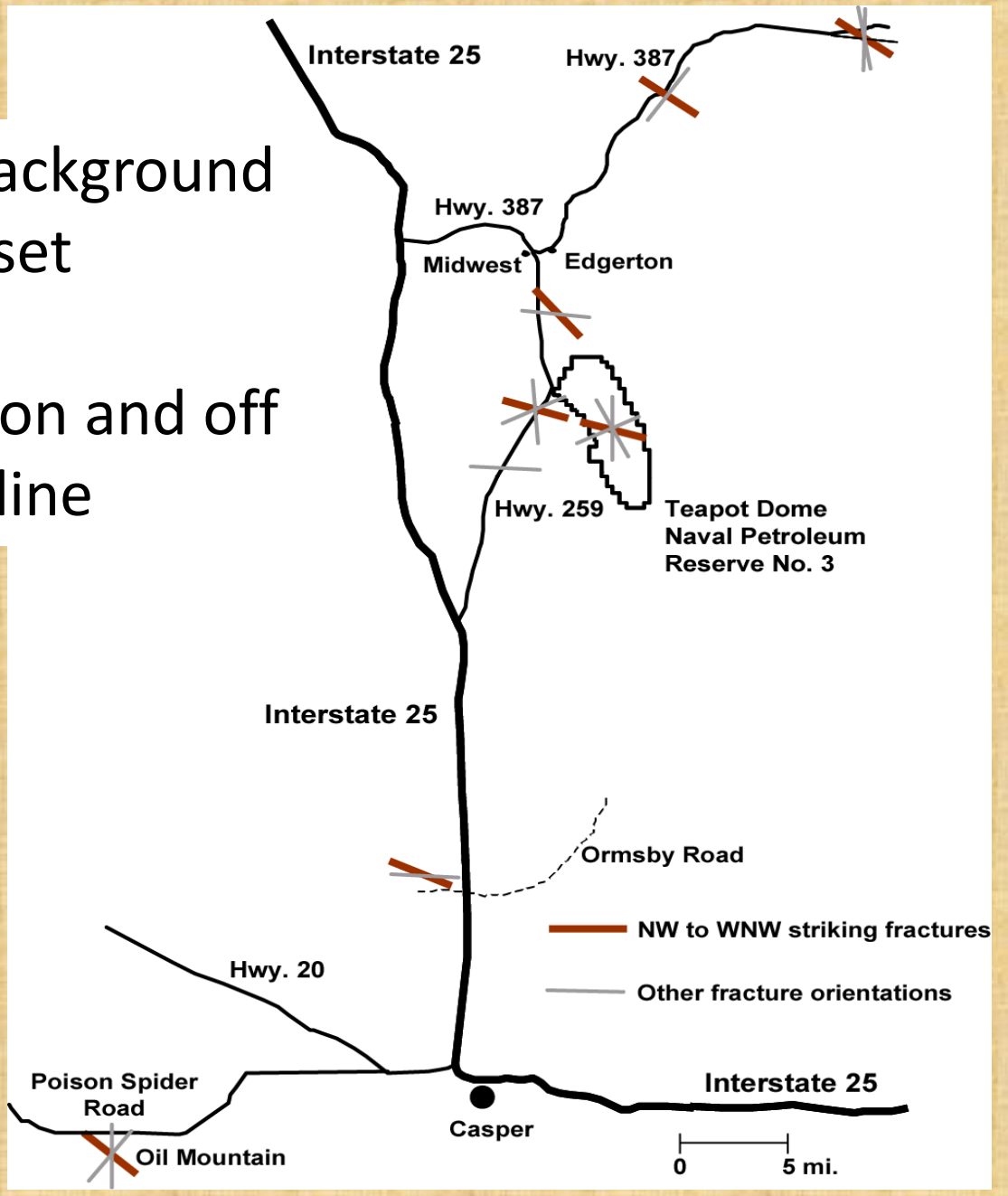
(from Spearing, 1976)



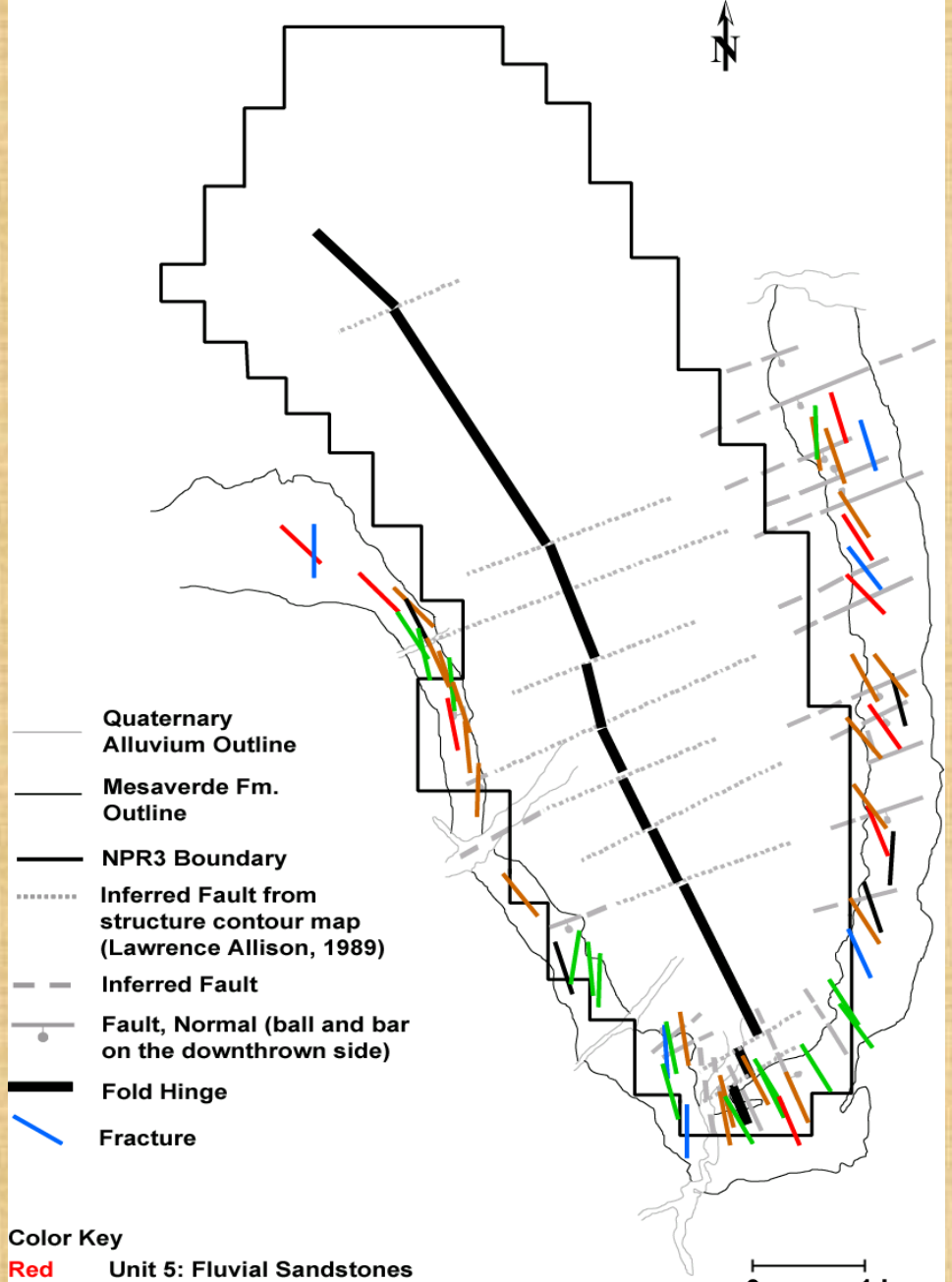
Cooper, 2000

-Older, background regional set

-Present on and off the anticline



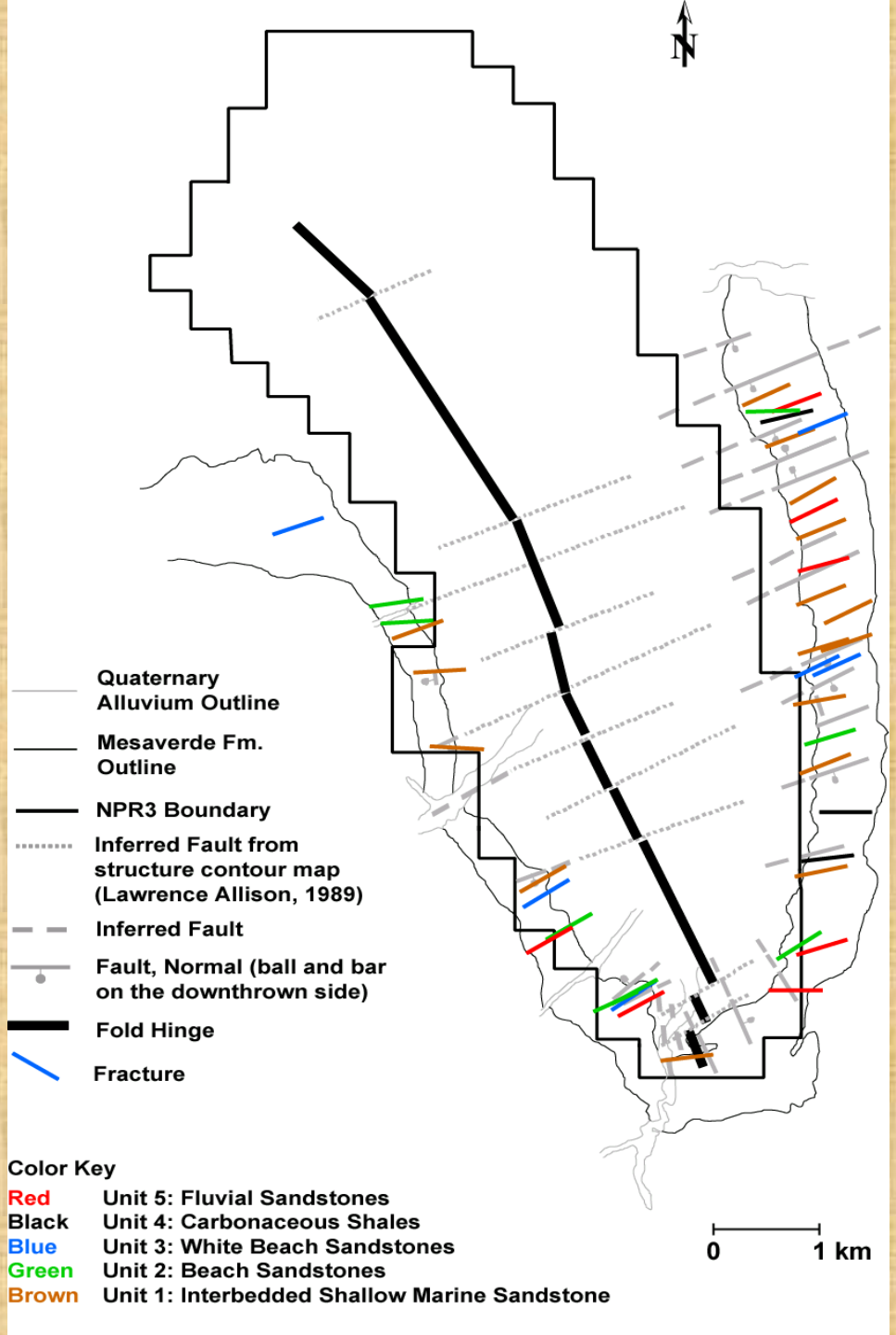
Cooper, 2000



Hinge-Parallel

Cooper, 2000

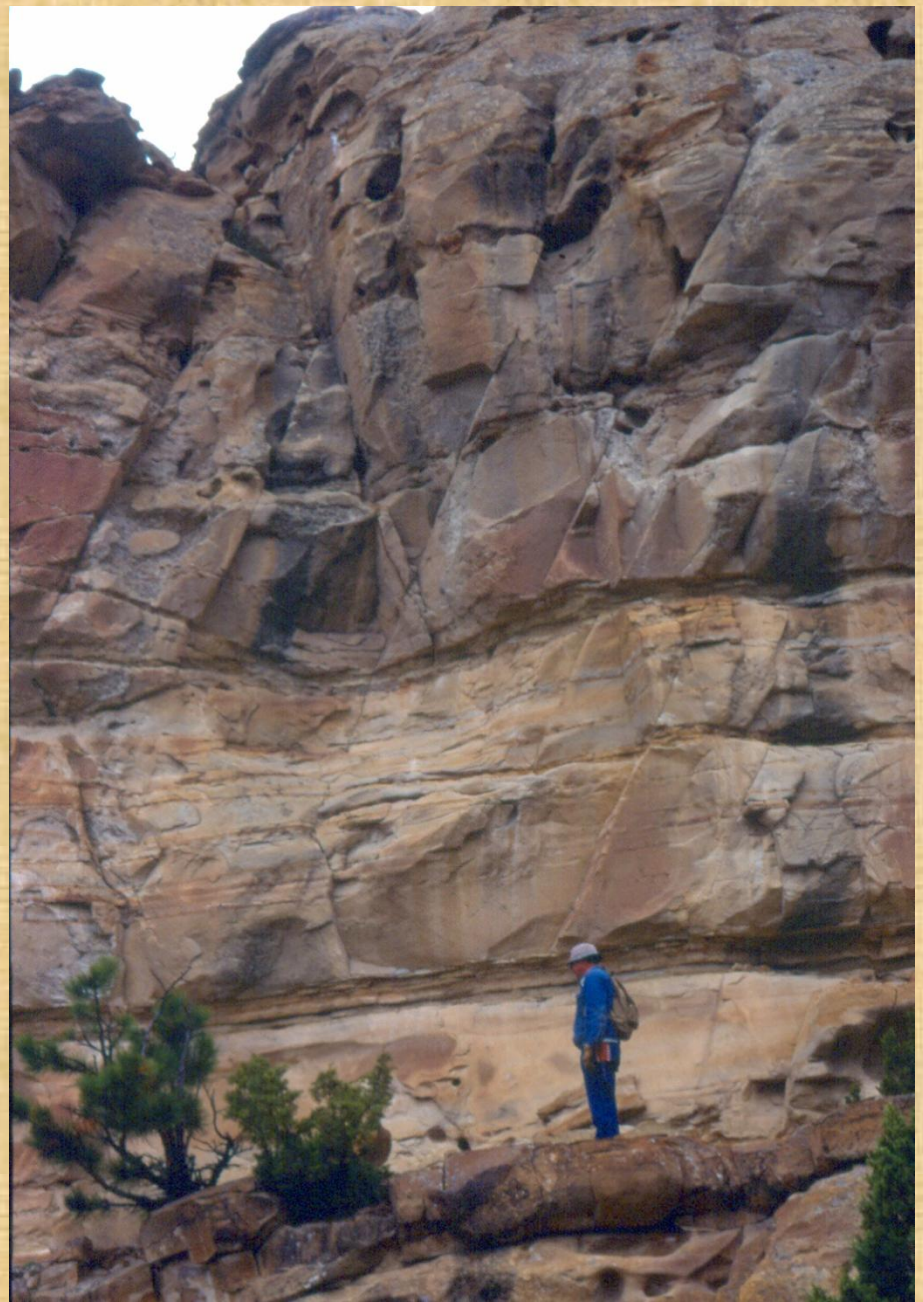
Hinge-Normal

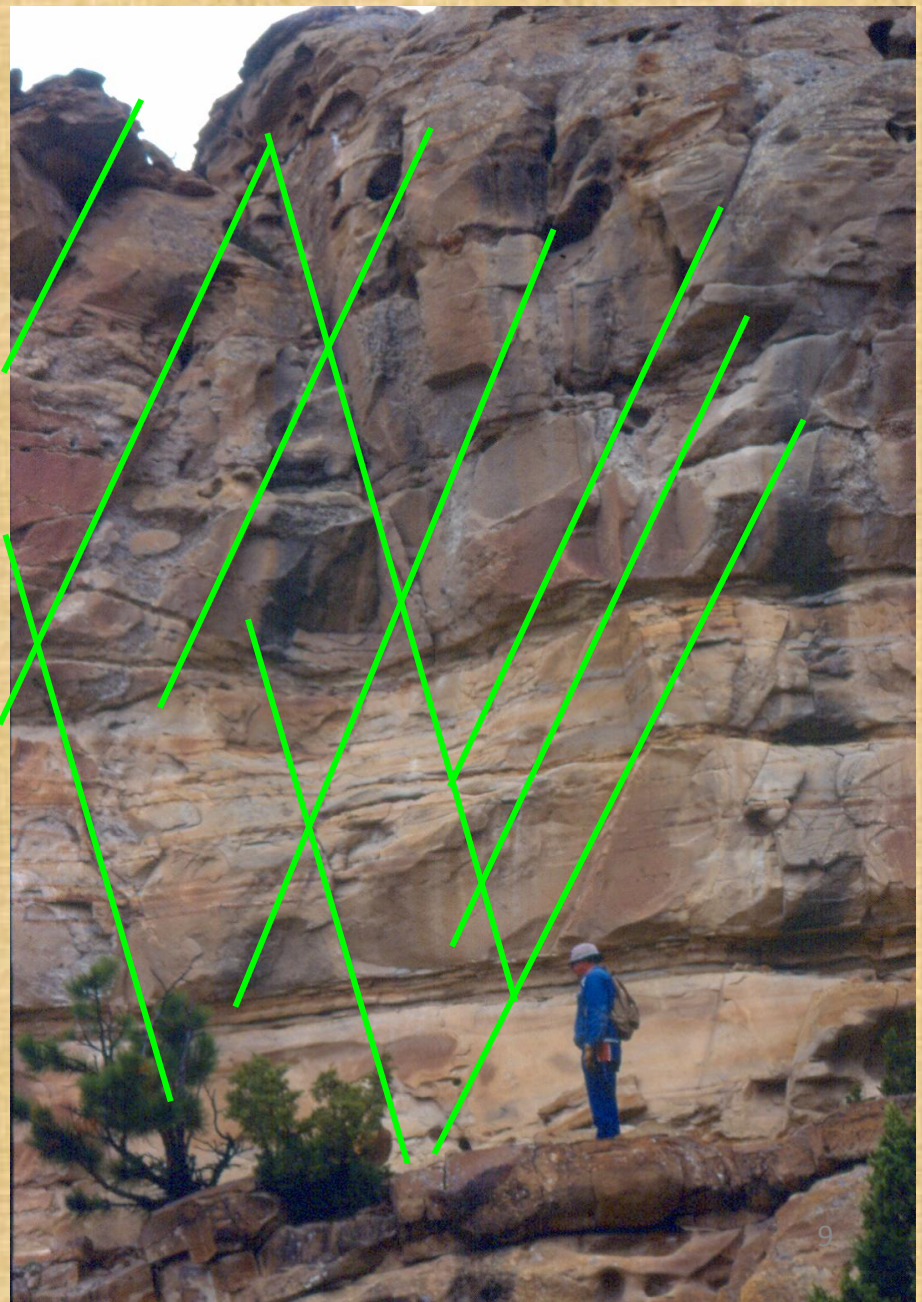


Cooper, 2000

Most are extension fractures

Conjugate Shear Fractures: Lateral Extension

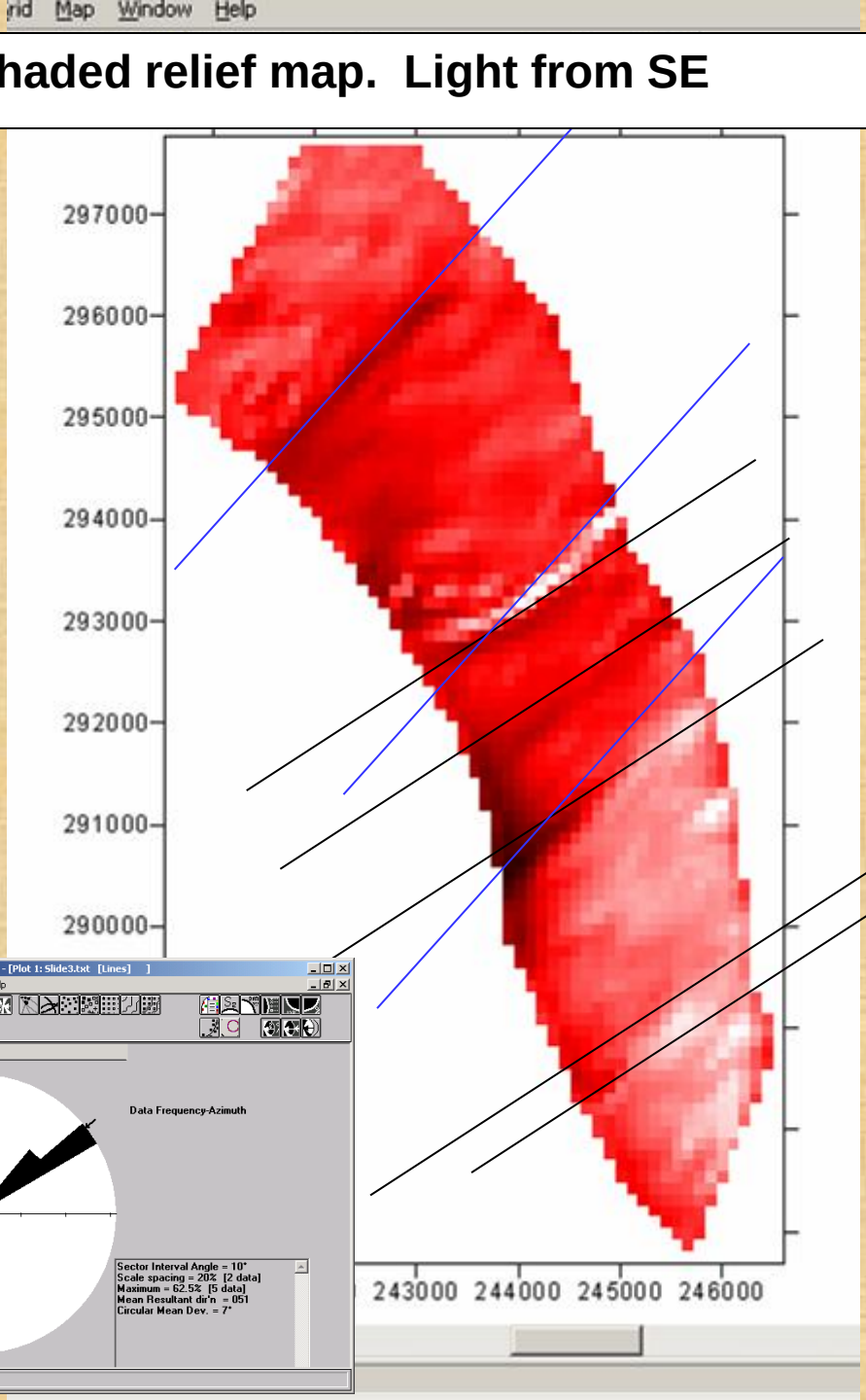




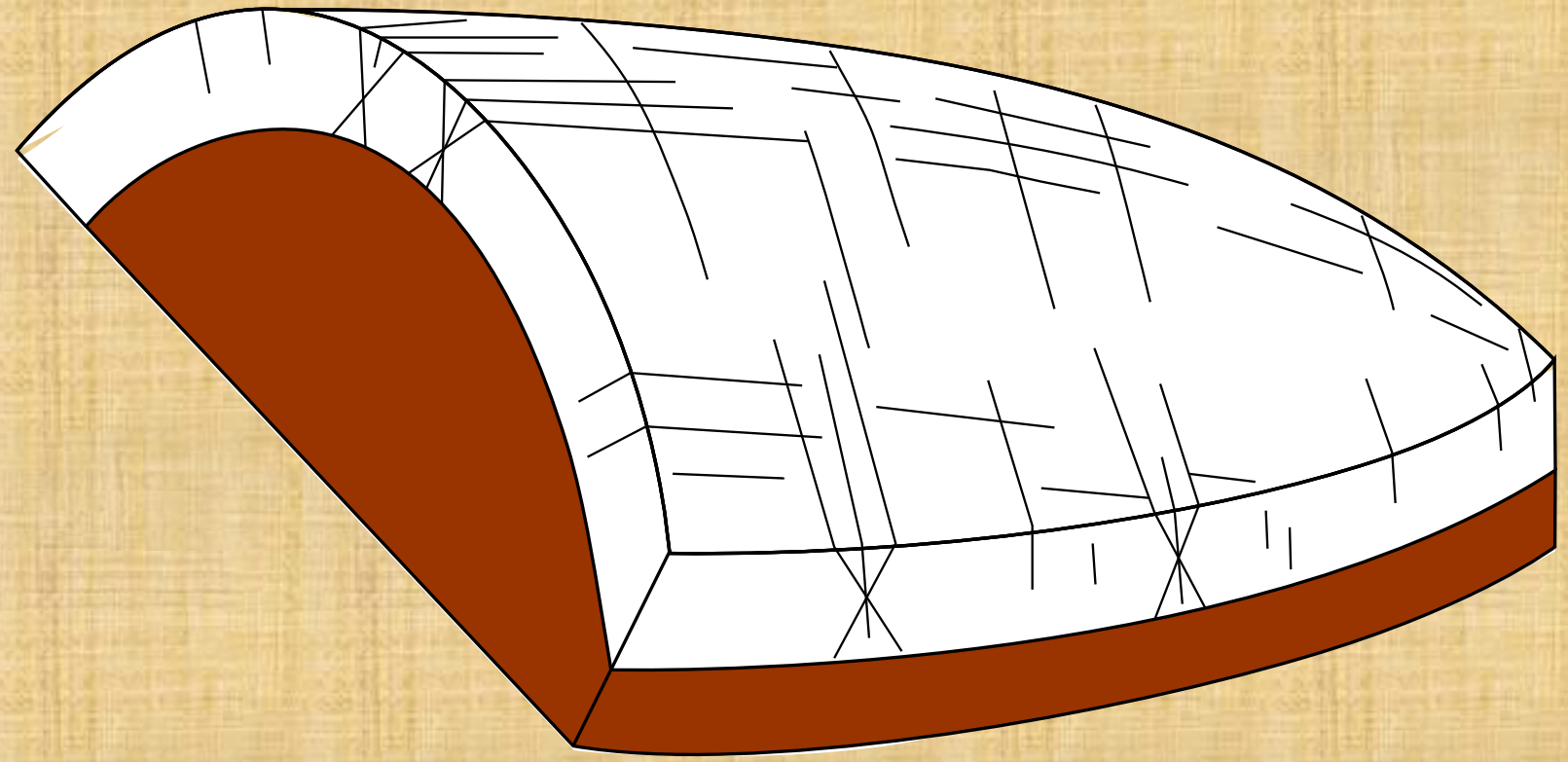

Graben fault-dropped
into the rim rock

Faults in the shales

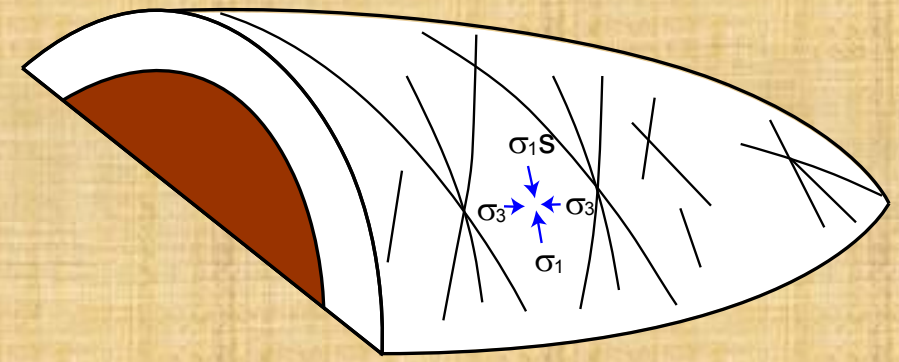
Shaded relief map. Light from SE



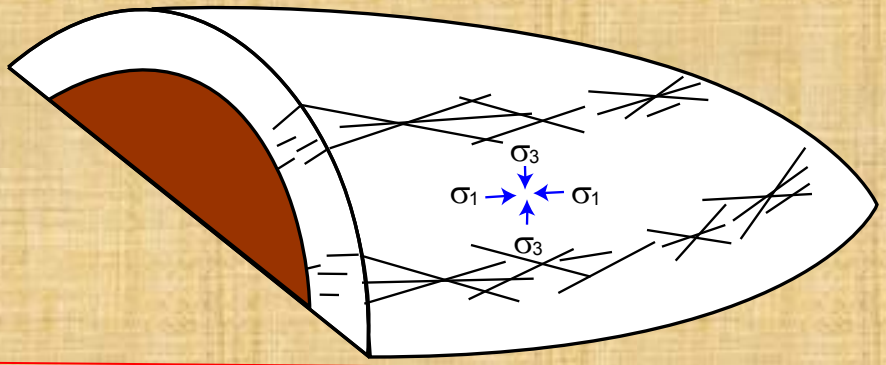
Bi-directional, synchronous extension

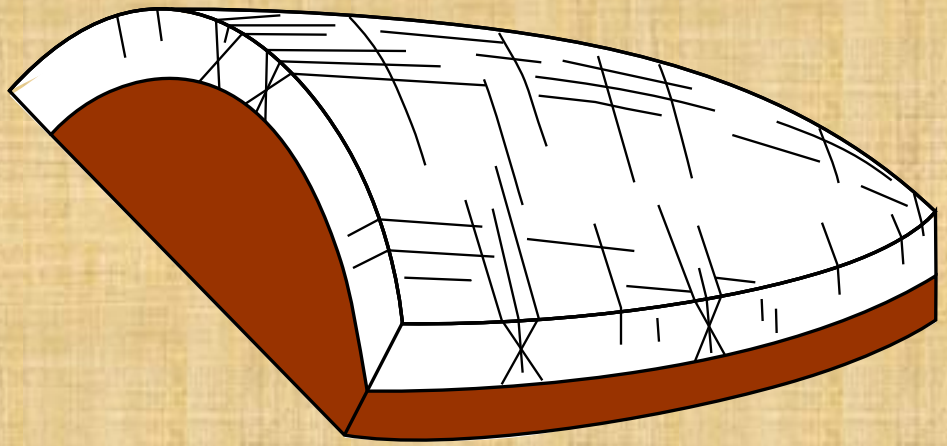


Cooper, 2000



Stearns and Friedman, 1972

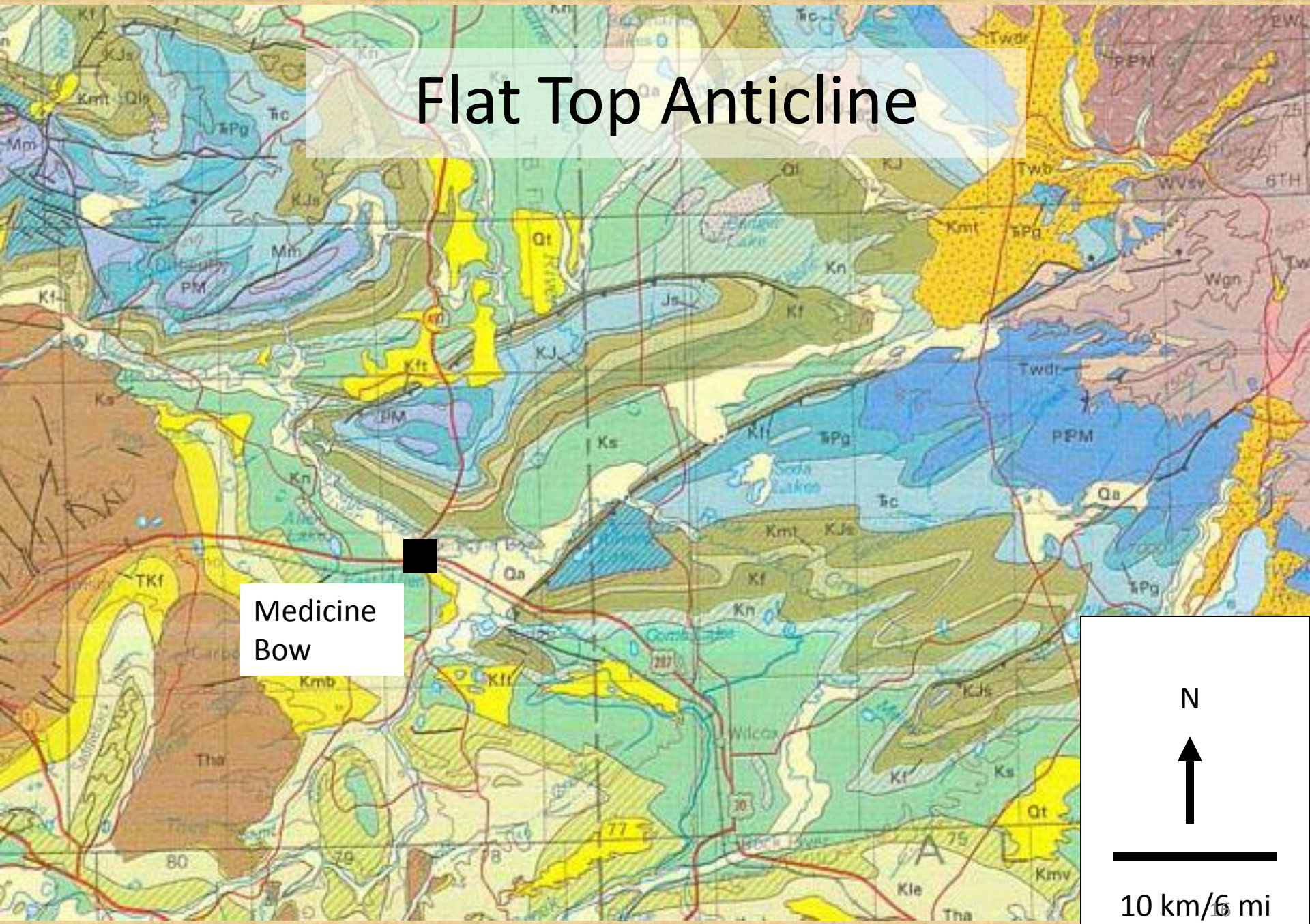




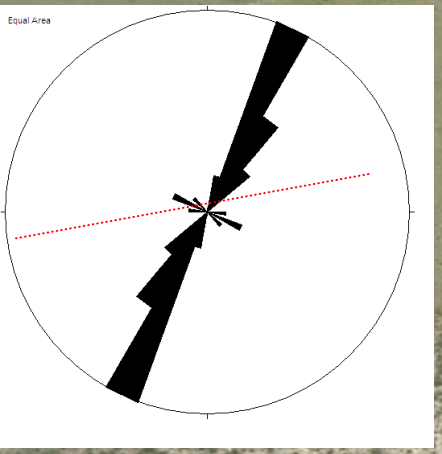
Cooper, 2000


T 153-805
OHIO-1924

Flat Top Anticline




Flat Top Anticline

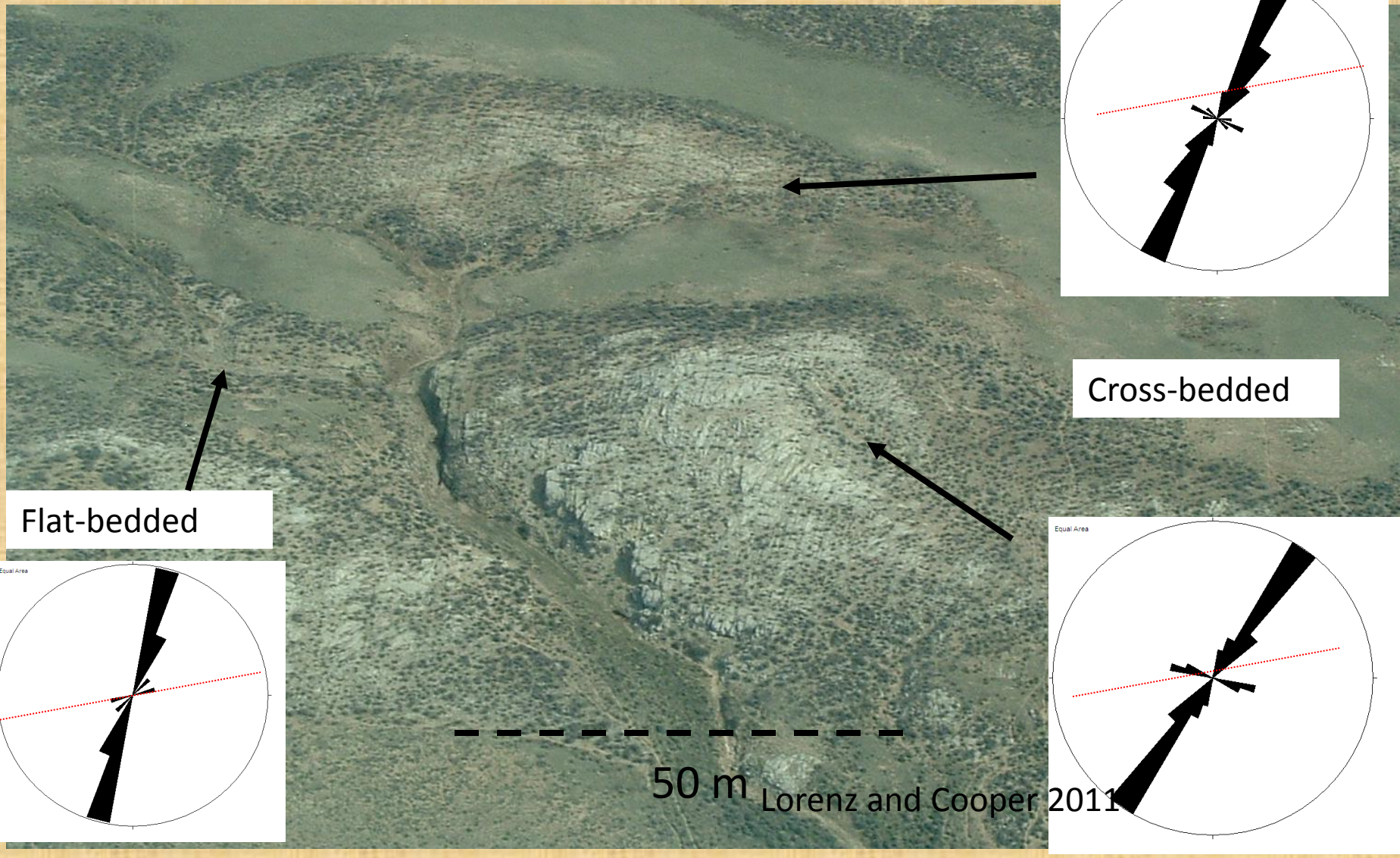


Simple fractures on the backlimb

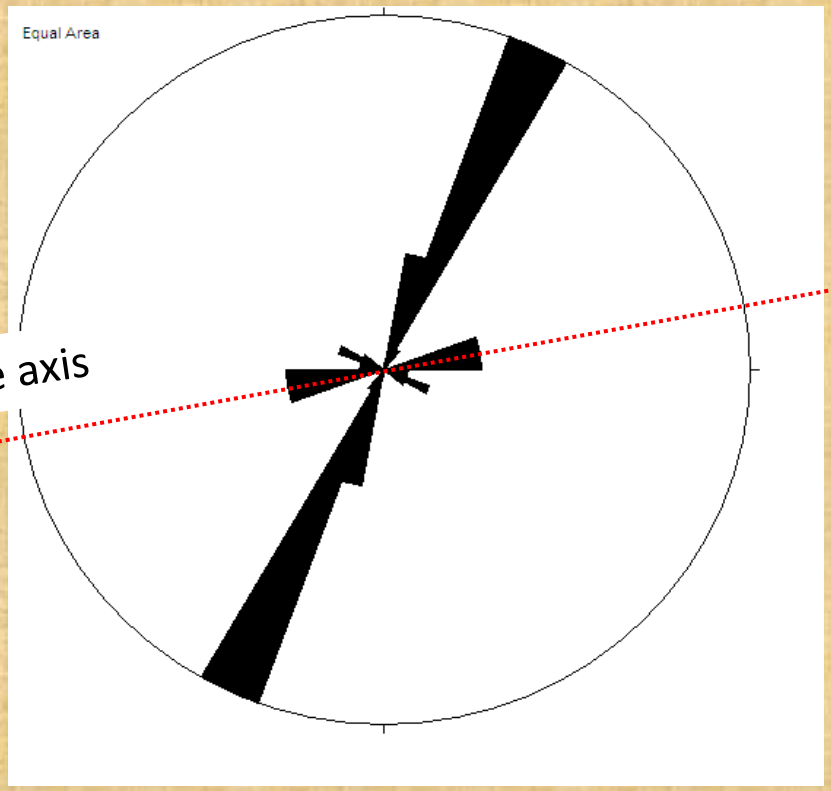
25 m

Lorenz and Cooper 2011

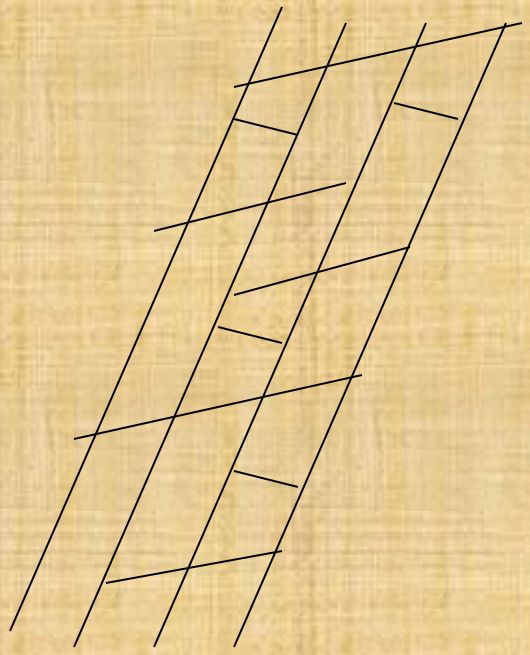
Facies makes no difference



Three fracture sets on the crest



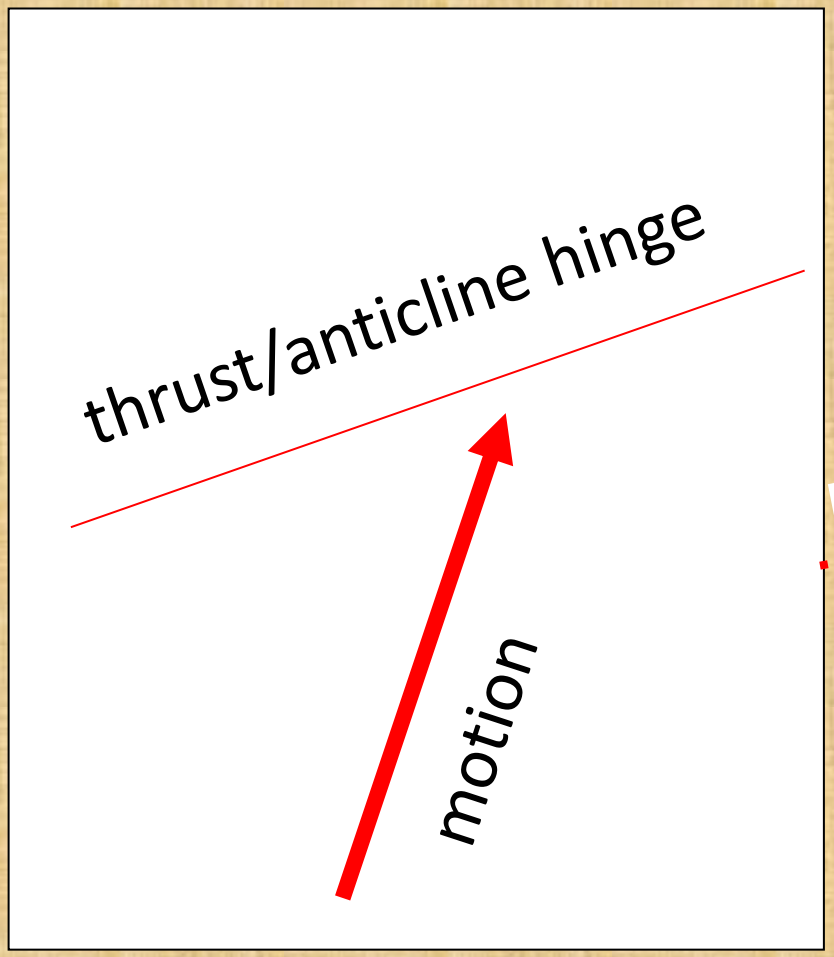
Anticline axis

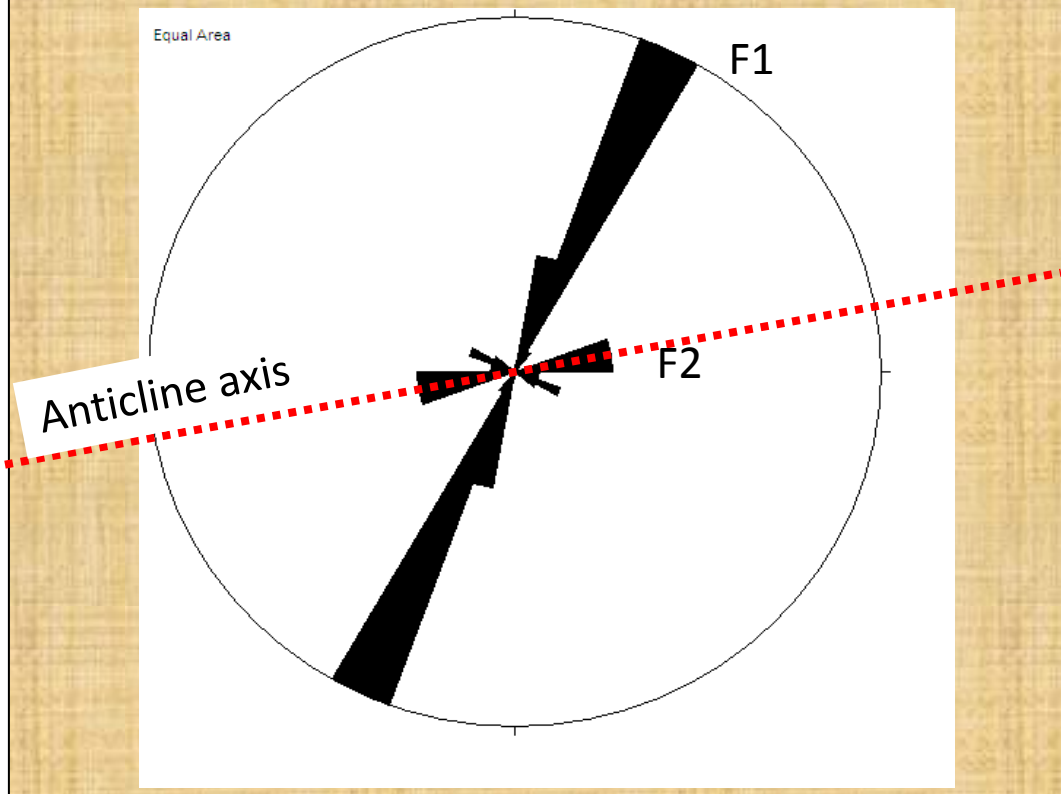


Average spacing 0.7 m. Bed thickness 1.2 m.

Lorenz and Cooper 2011

Thrust translation was *oblique* to the thrust front





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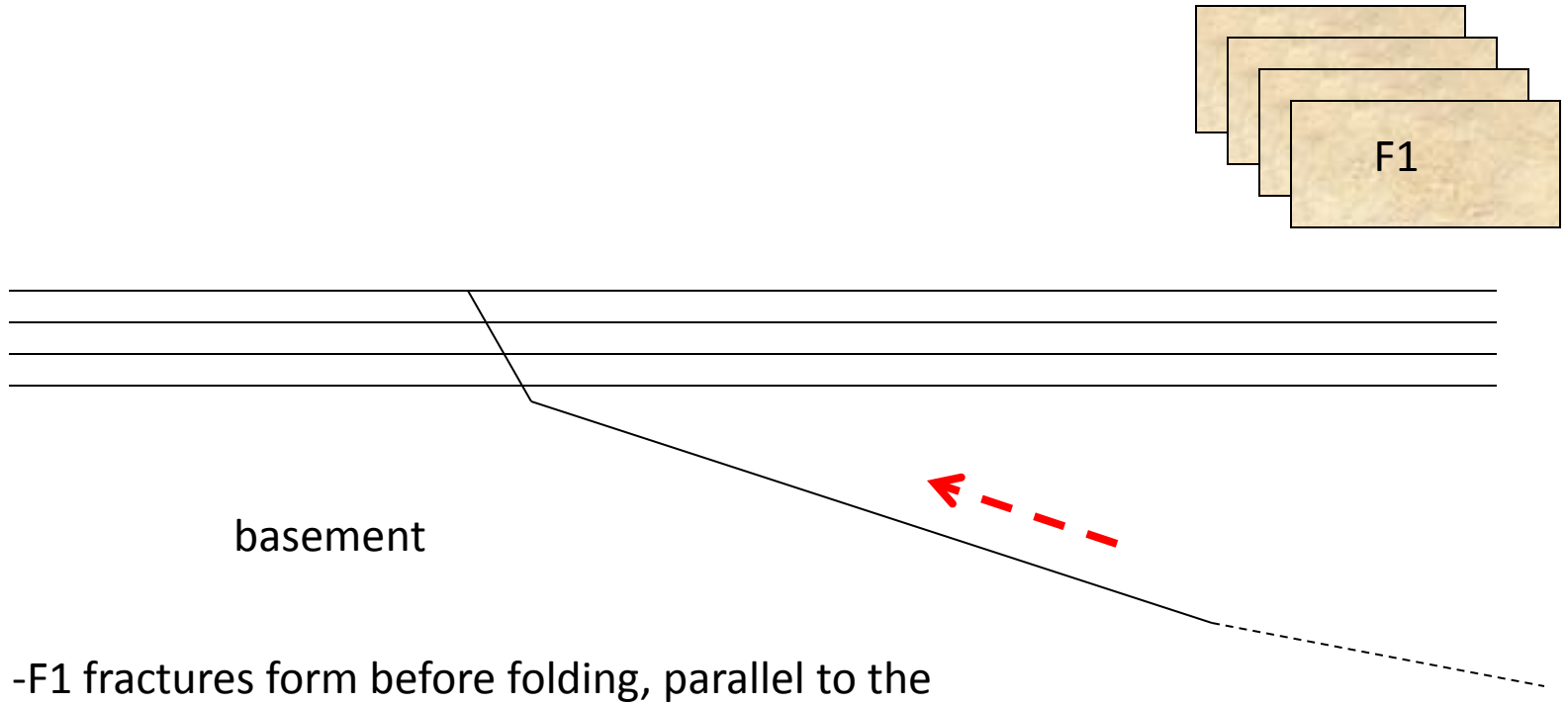
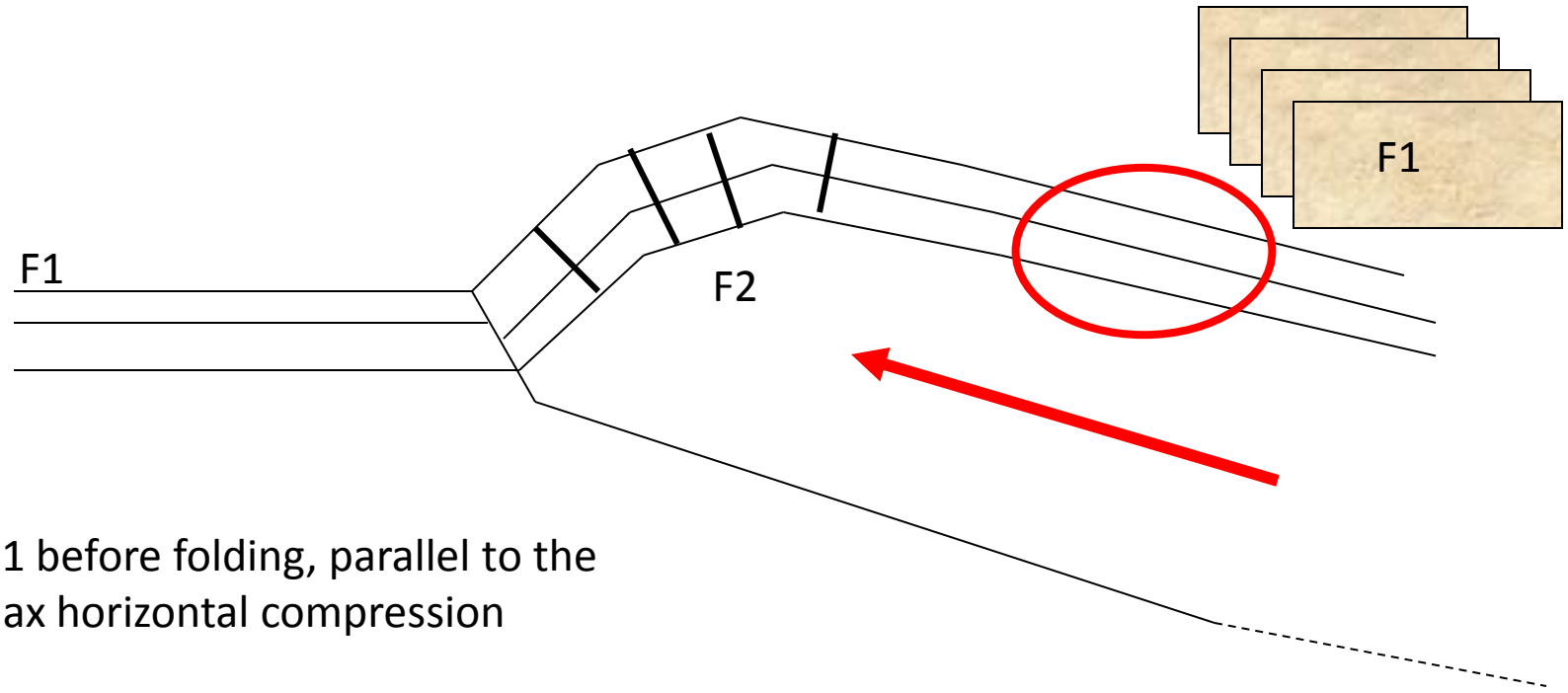
Crossbed-parallel and oblique shear

Early fractures



-F1 fractures form before folding, parallel to the max horizontal compression that initiates thrusting and folding: hinge normal

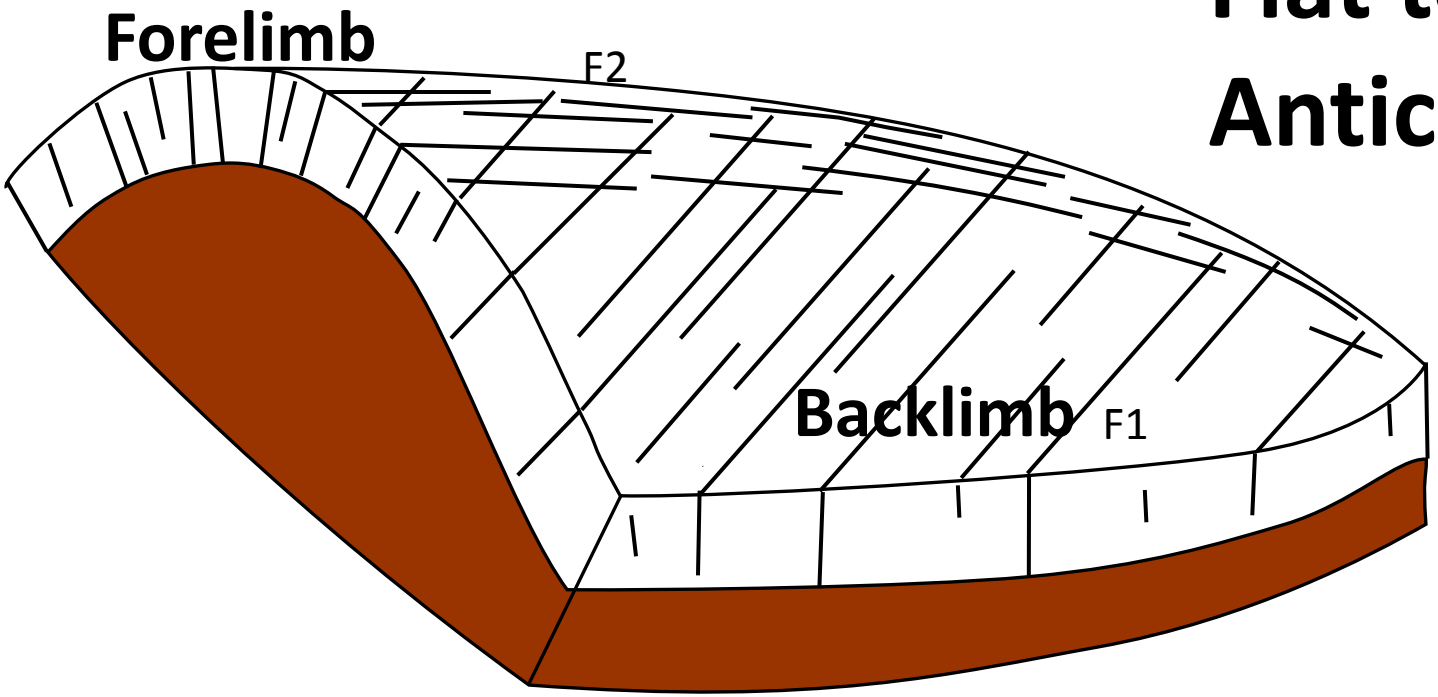
Extension Fractures

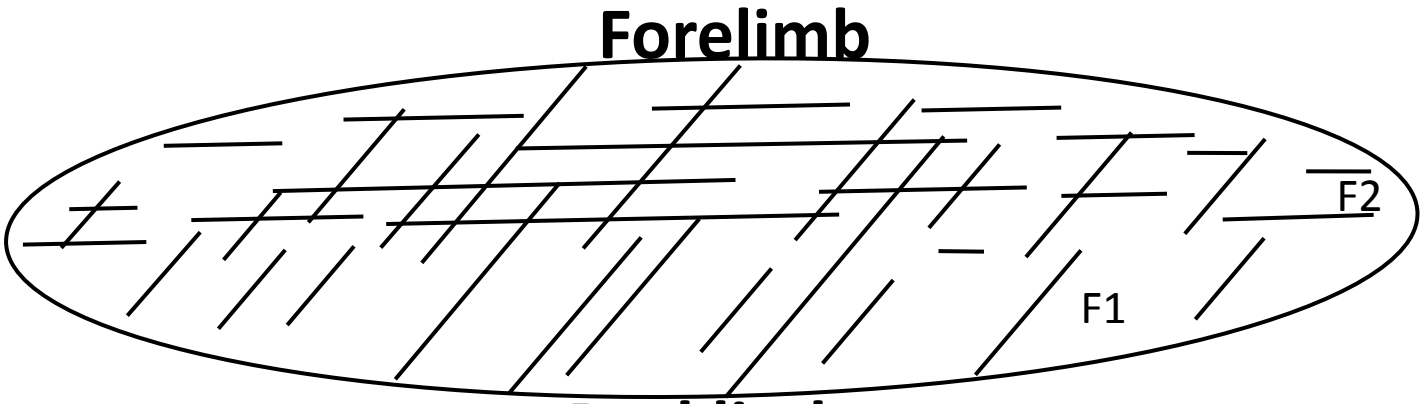


-F1 before folding, parallel to the max horizontal compression

-F2 during folding due to flexure

Flat top Anticline





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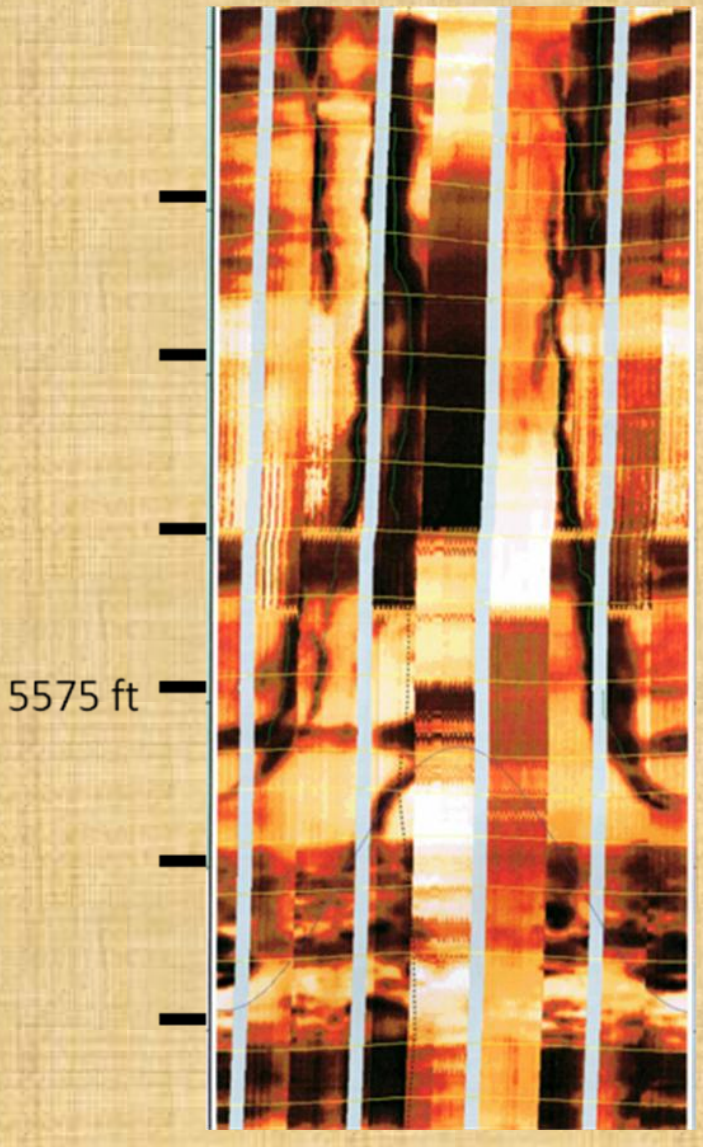
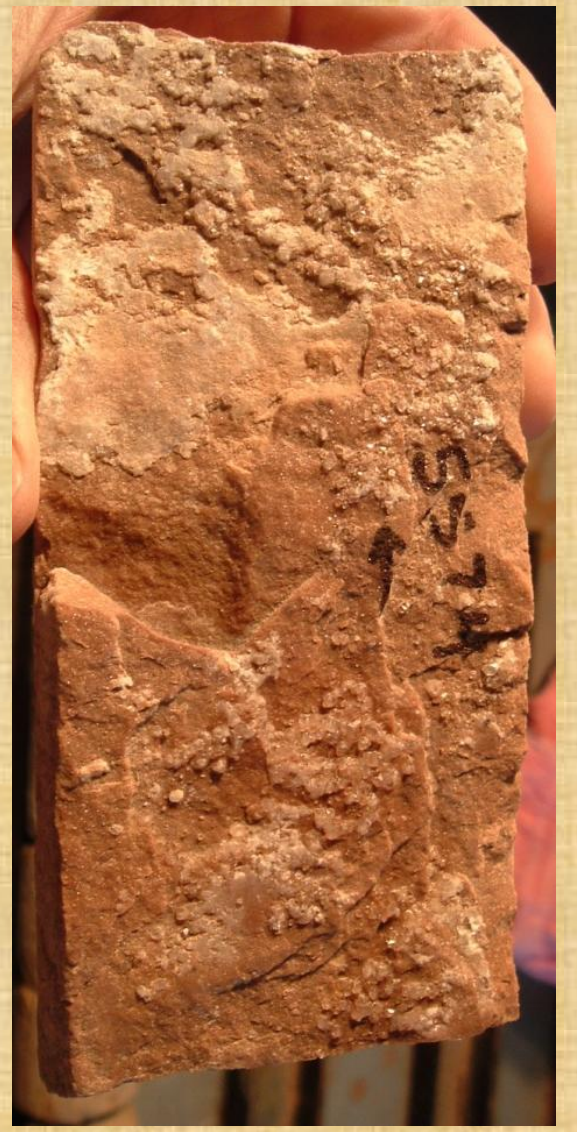
Let’s dig deeper at Teapot

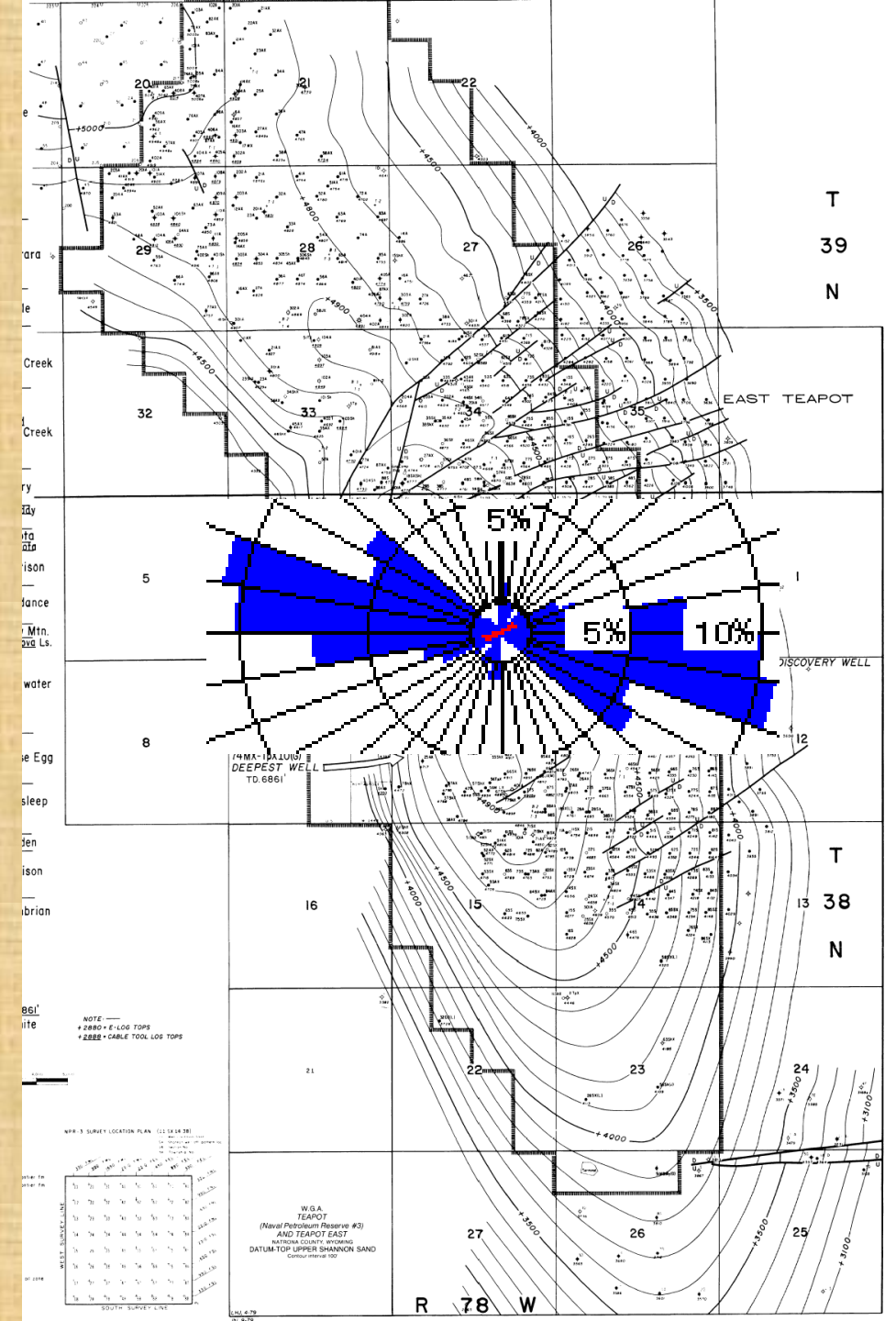




Teapot Dome

N

6 mi/10 km

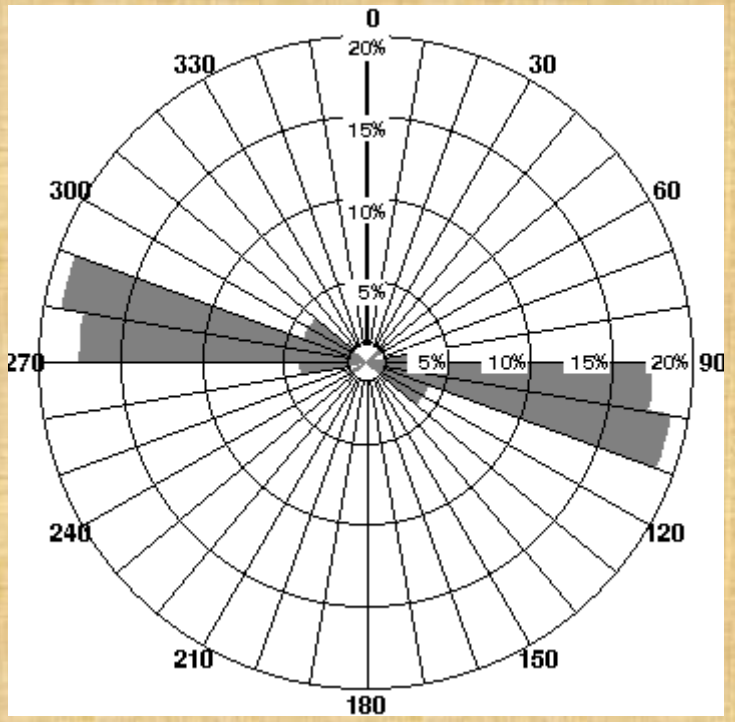


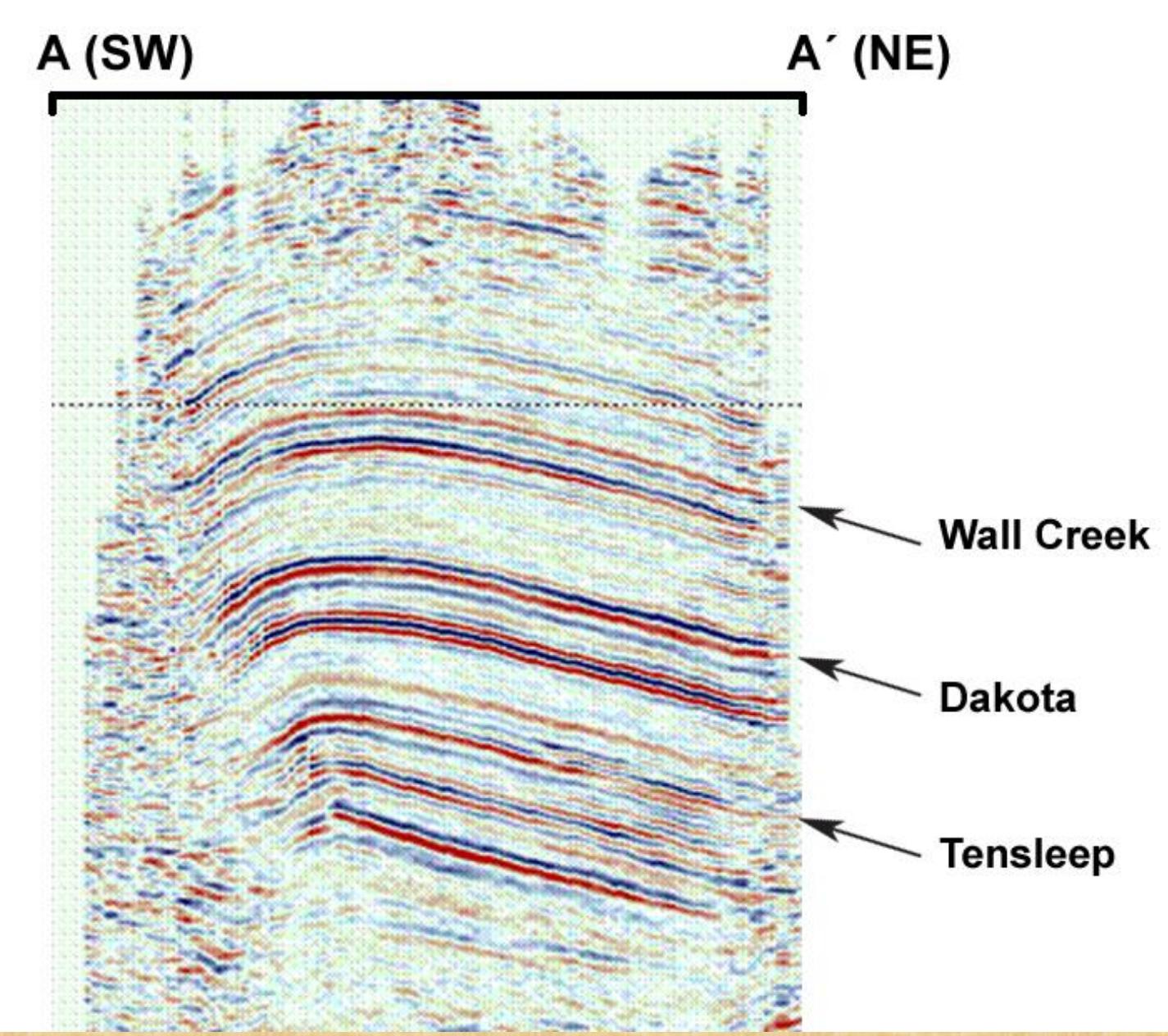
WNW Tensleep fractures

Hinge-oblique

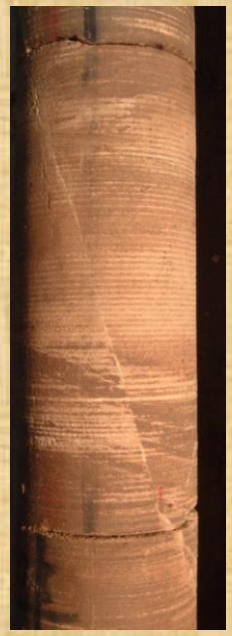
Maximum horizontal stress also WNW

WNW trends
-max stress
-surface pre-fold fractures
-dominant Tensleep fractures



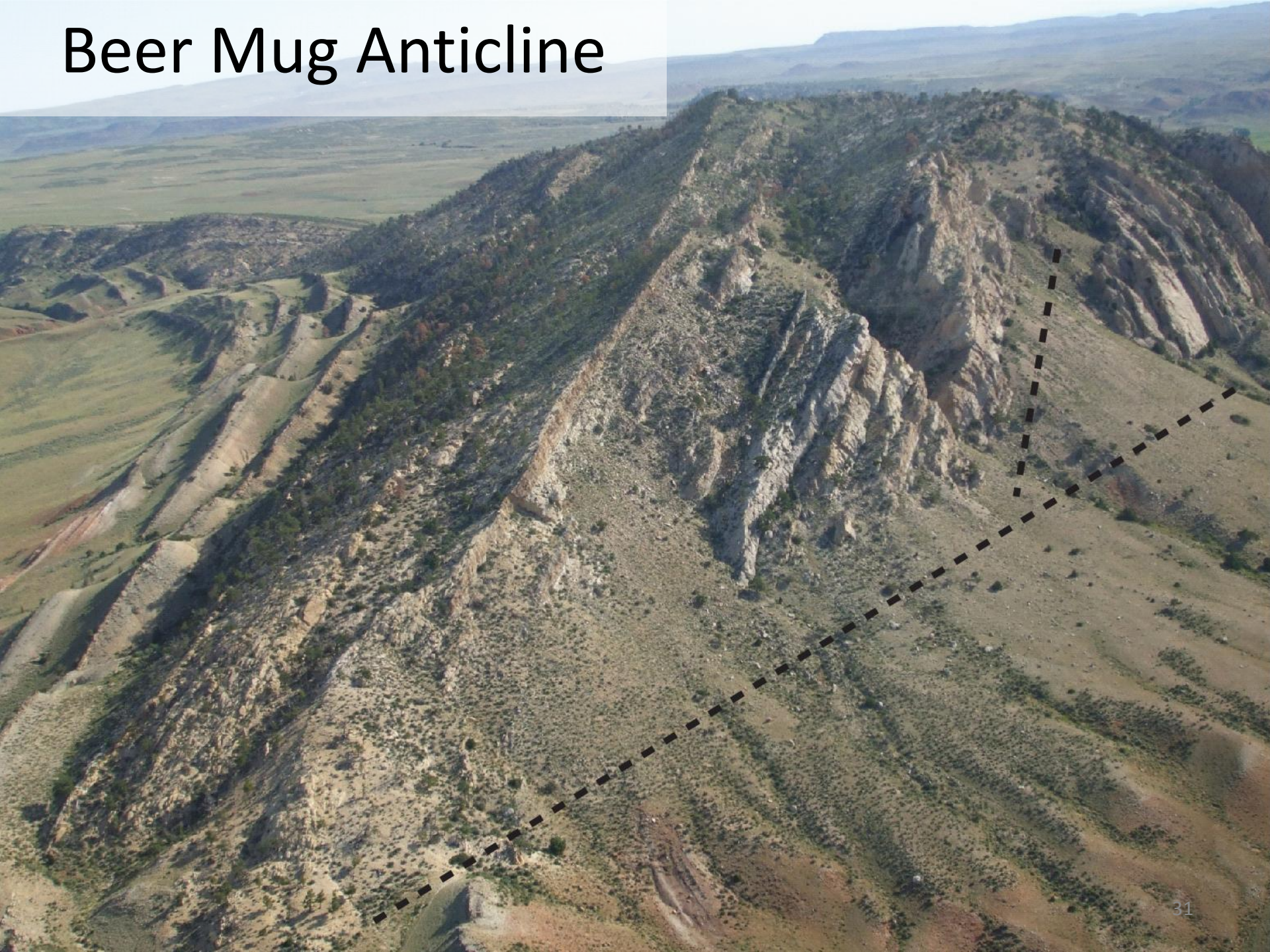

A (SW)
A´ (NE)
Wall Creek
Dakota
Tensleep

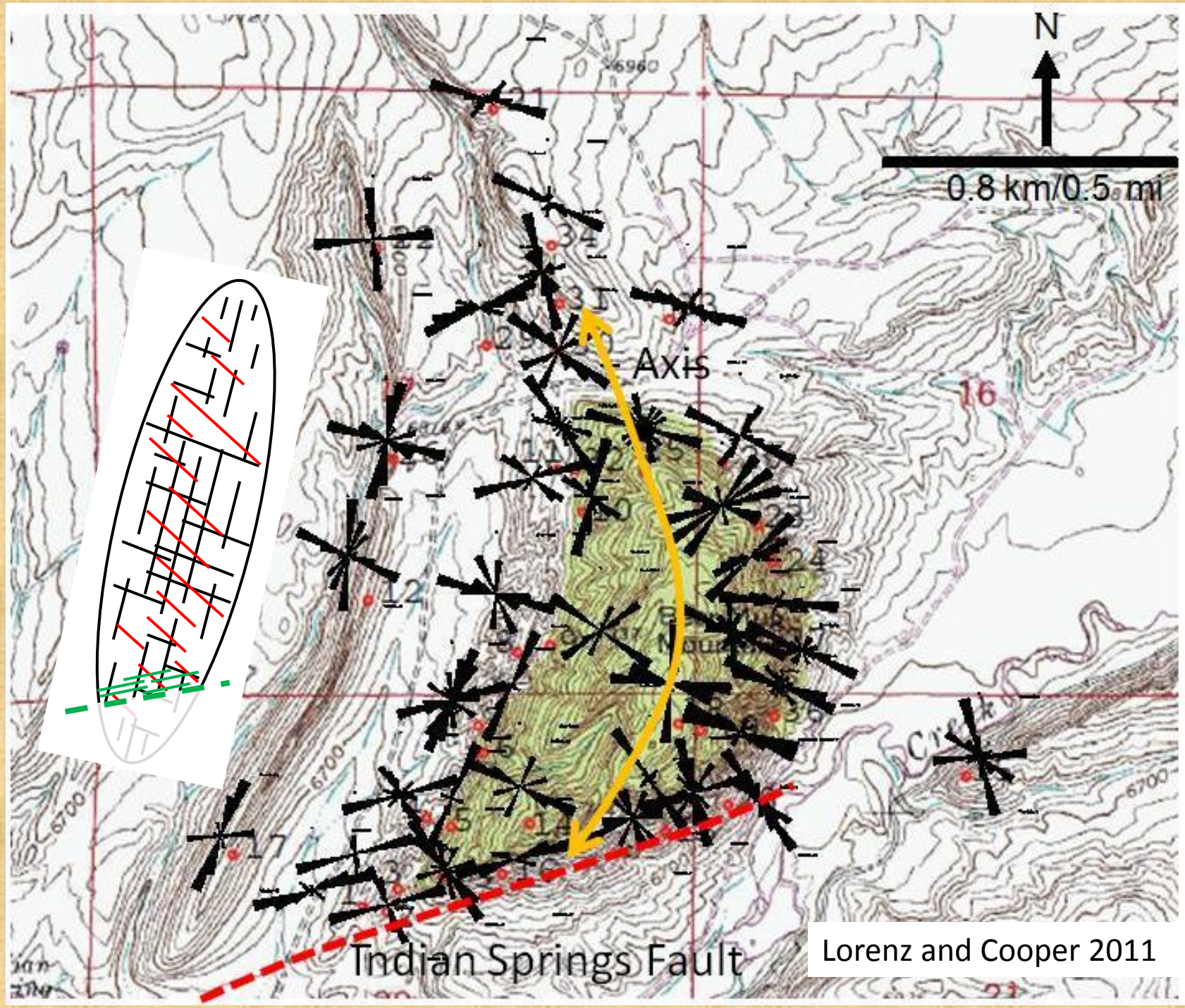
Conceptual fracture model



1. Horizontal compression
   - Regional extension fractures
     - Tensleep and Cretaceous strata
   - Oblique thrusting on inherited structure
2. Folding begins above the thrust
   - Fracturing continues in the deep Tensleep on the planar backlimb
   - Folding and bilateral extension in shallow strata

Beer Mug Anticline




N
0.8 km/0.5 mi
Axis
Indian Springs Fault
Lorenz and Cooper 2011

Take-aways

- Different models for fractured anticlines
- The model can change with depth
- Need a structural history and some data