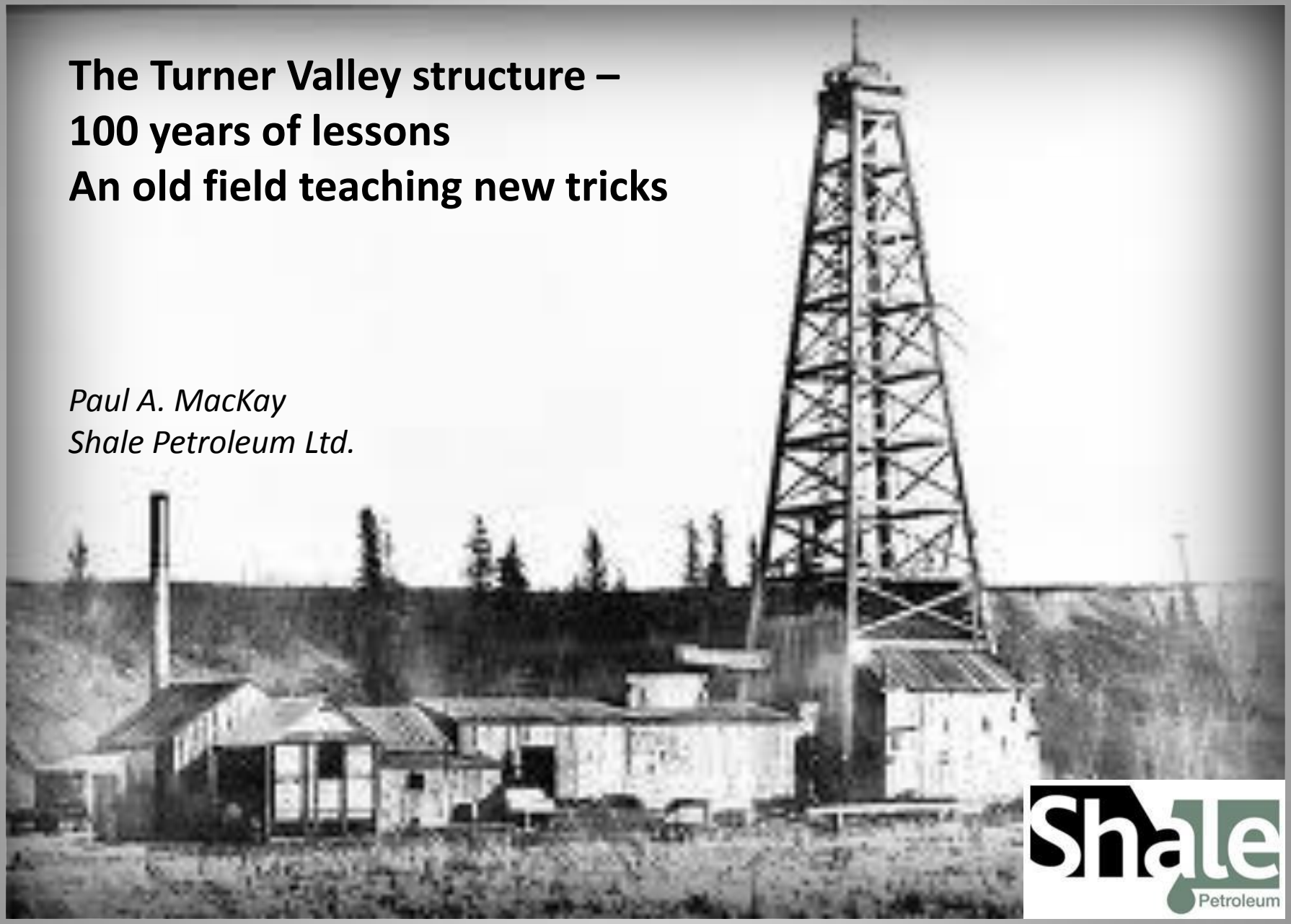
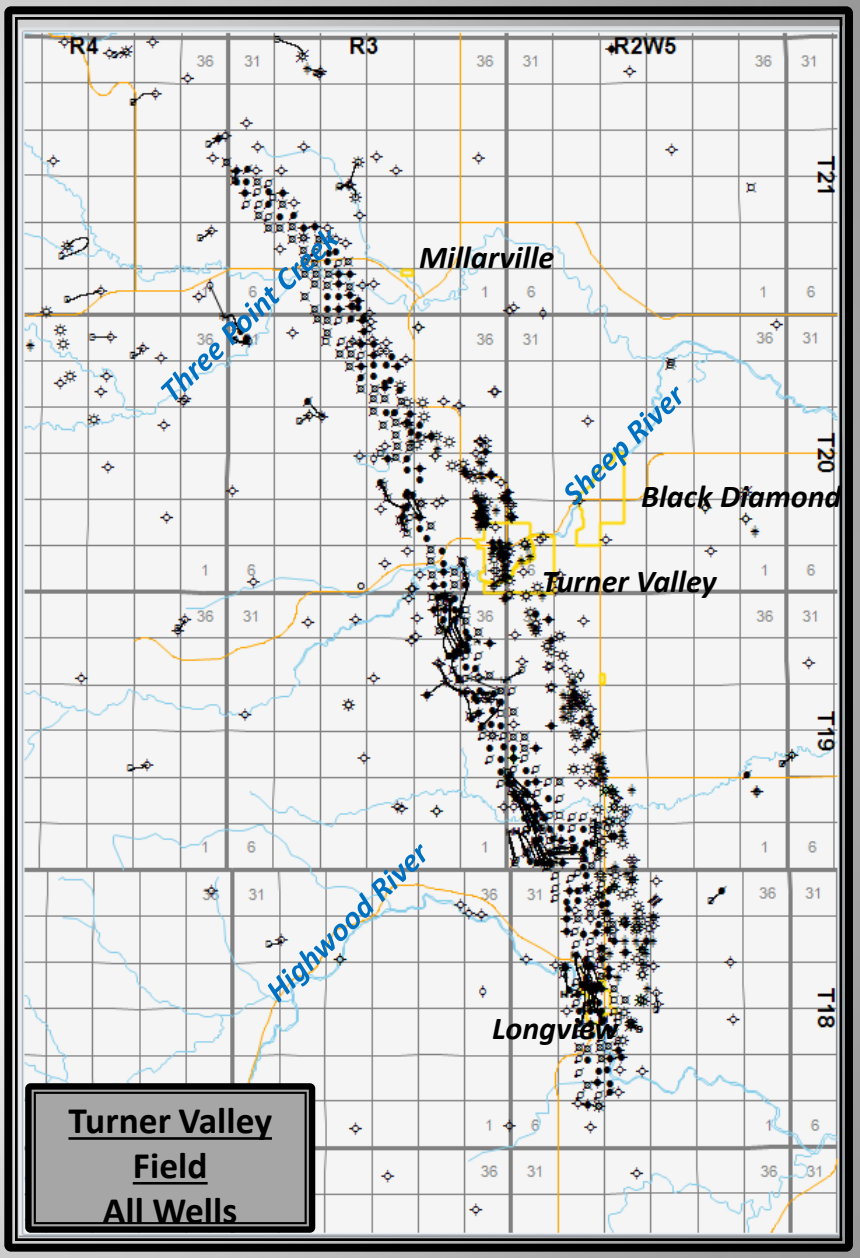
The Turner Valley structure – 100 years of lessons
An old field teaching new tricks

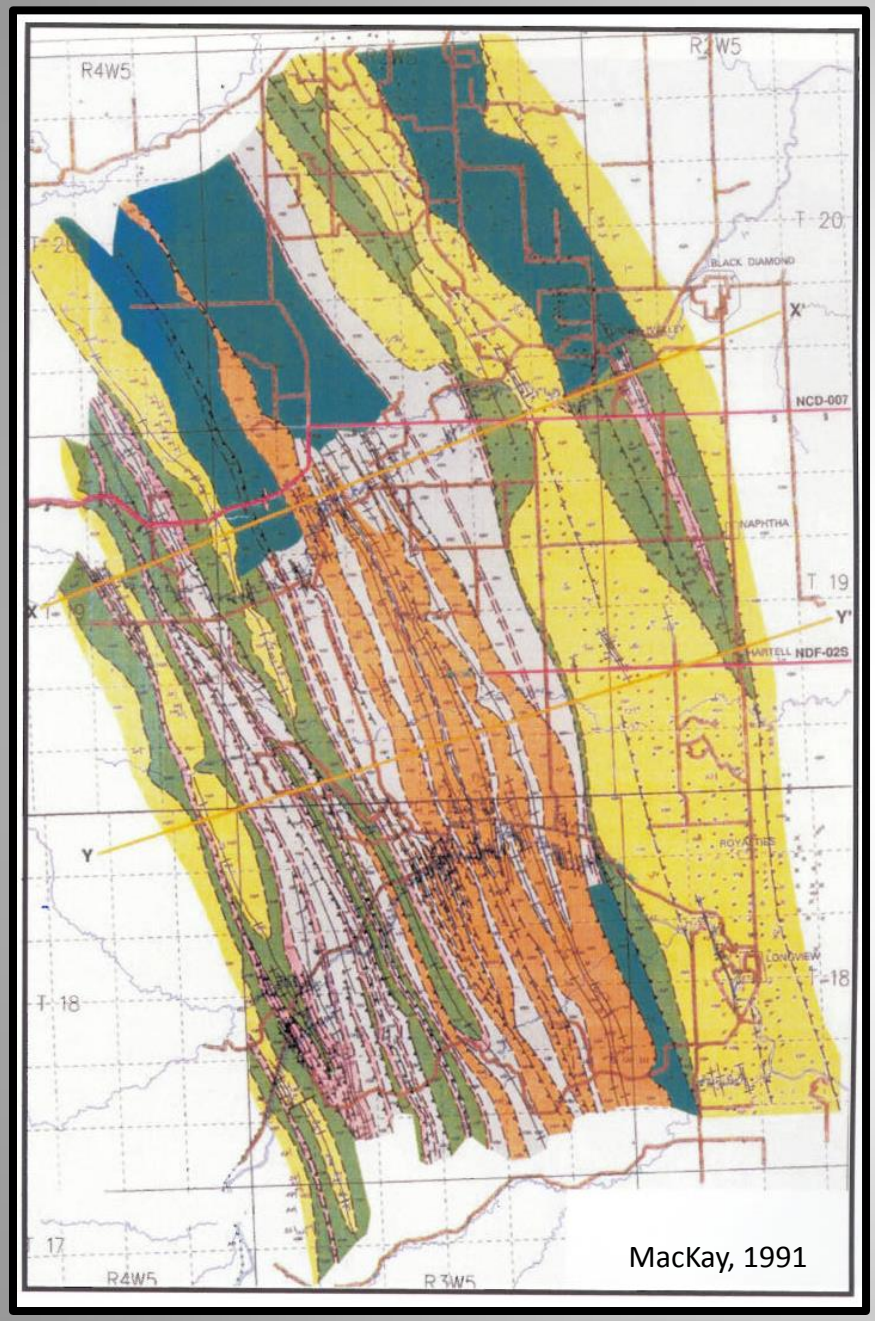
Paul A. MacKay
Shale Petroleum Ltd.

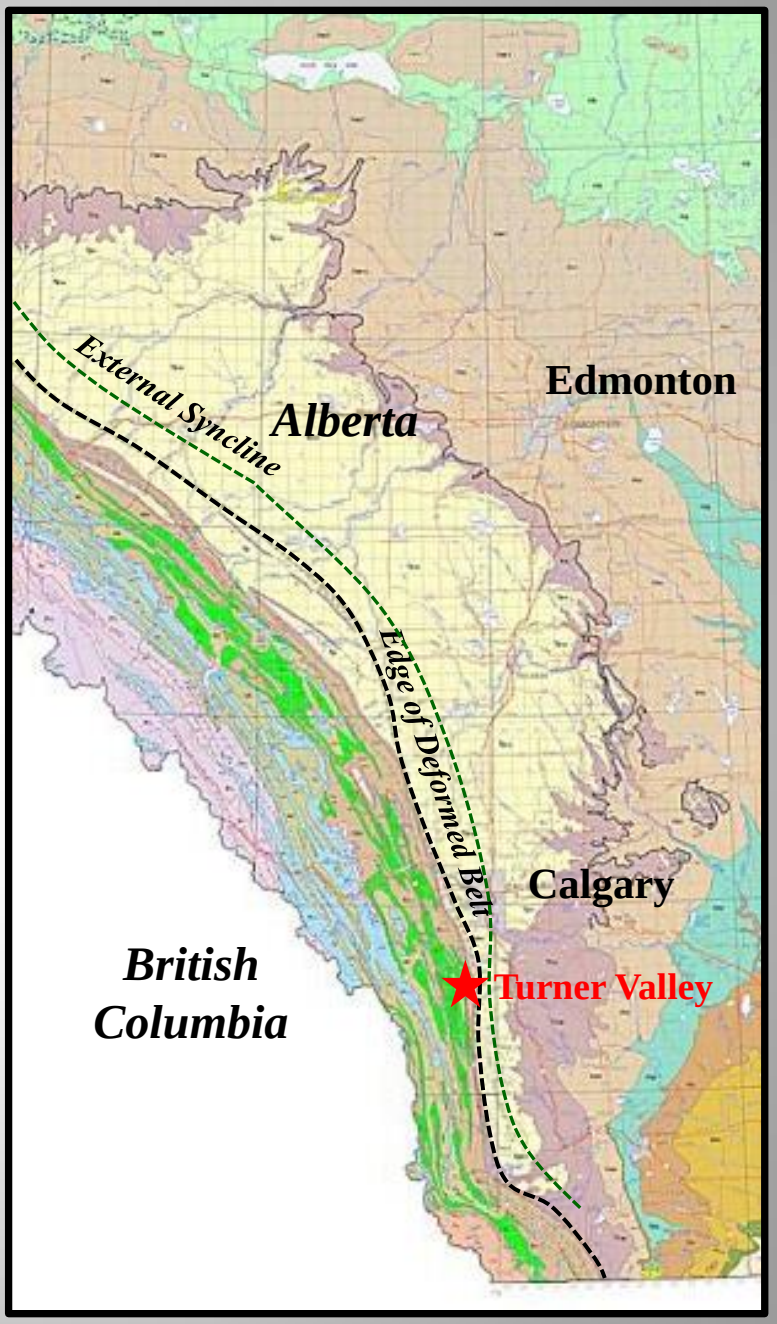


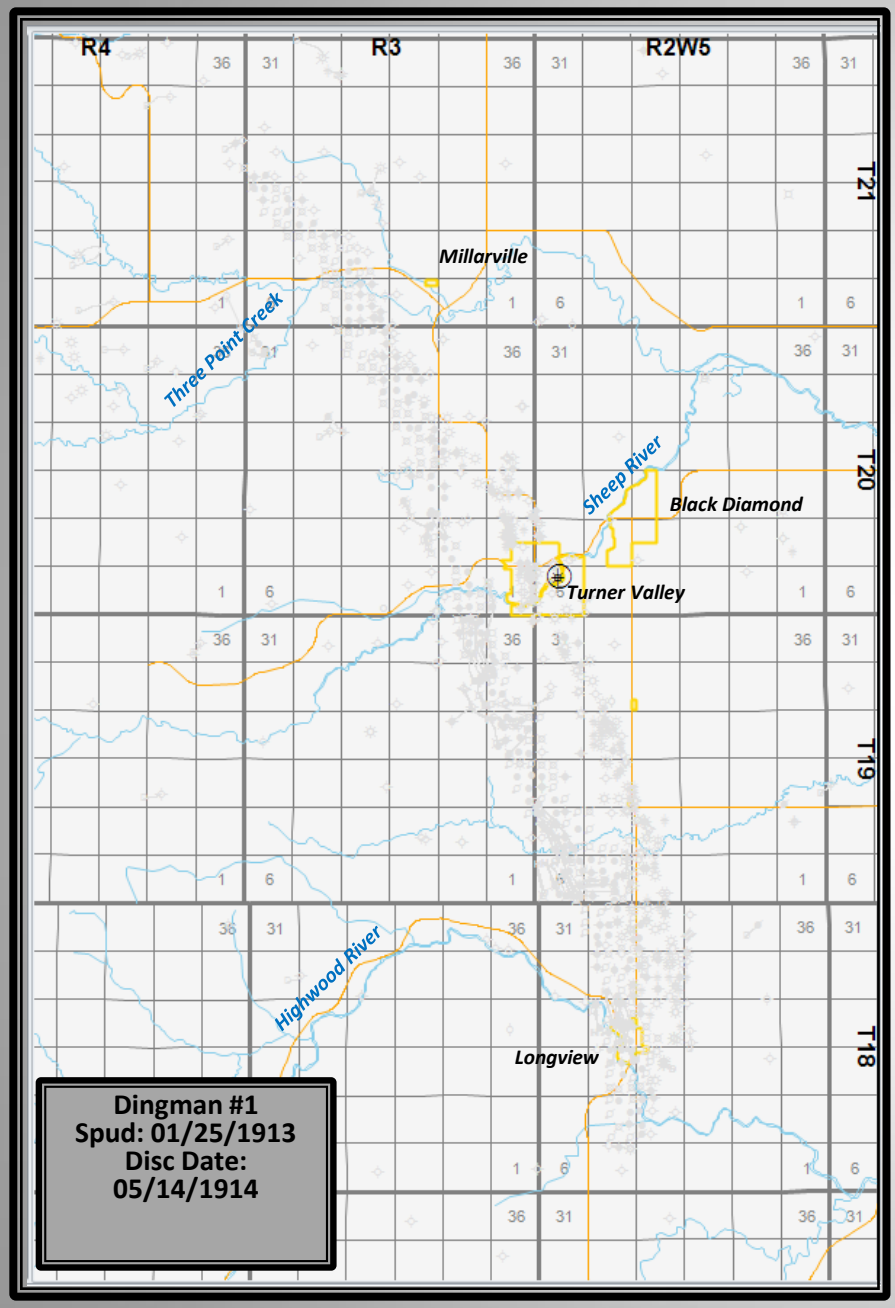
Turner Valley Structure

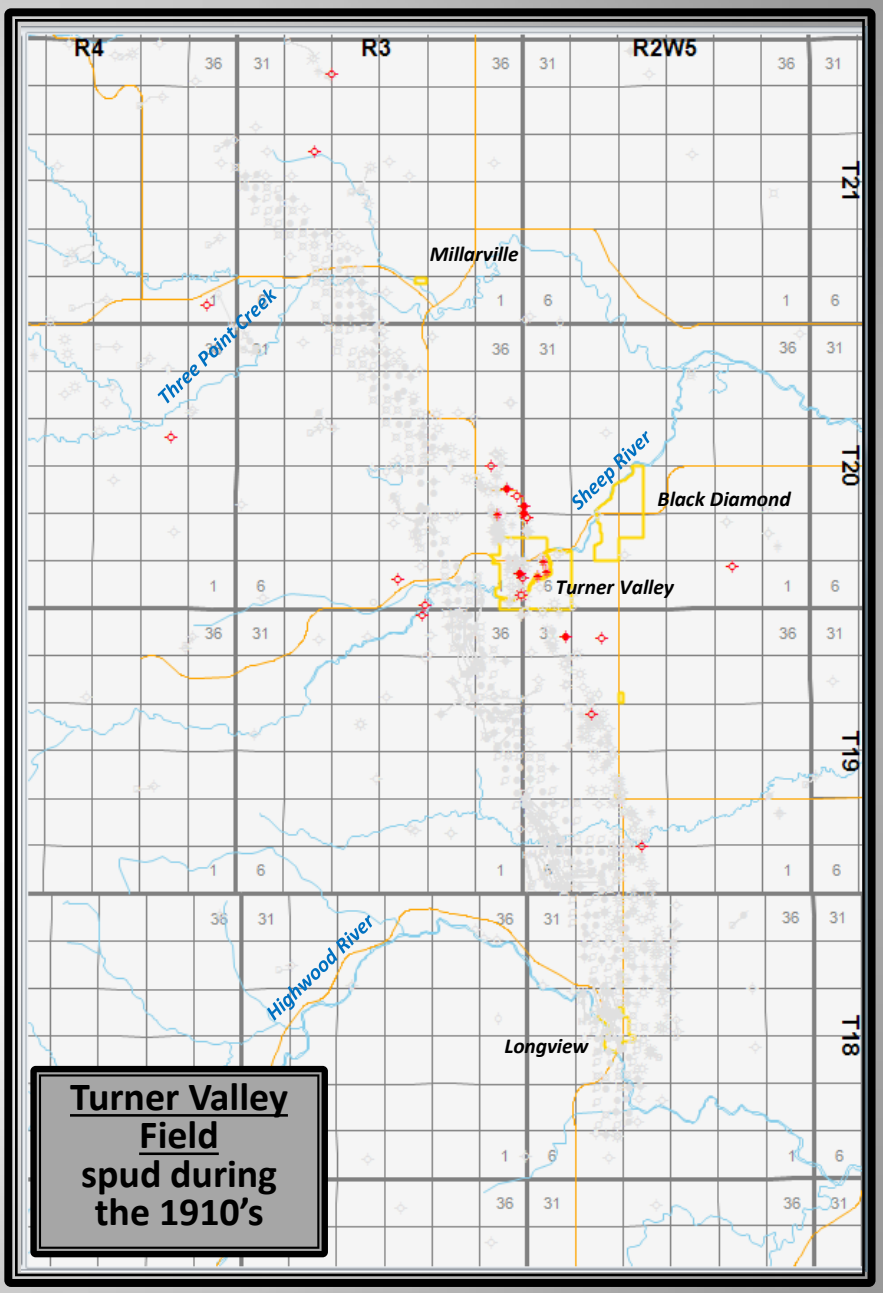
- R.G. McConnell (early 1880's)
  - Noted a reverse in dips along the Sheep River
- W.S. Herron (~1912)
  - Sampled gas seeps and determined that it was not 'swamp gas'
- A.W. Dingman (1913-1914)
  - drilled first well (discovery)
- D.B. Dowling (1914)
  - first geologic map of the 'Sheep River Oil and Gas Field'
- S.E. Slipper (1921)
  - Remapped the Sheep River Oil and Gas Field

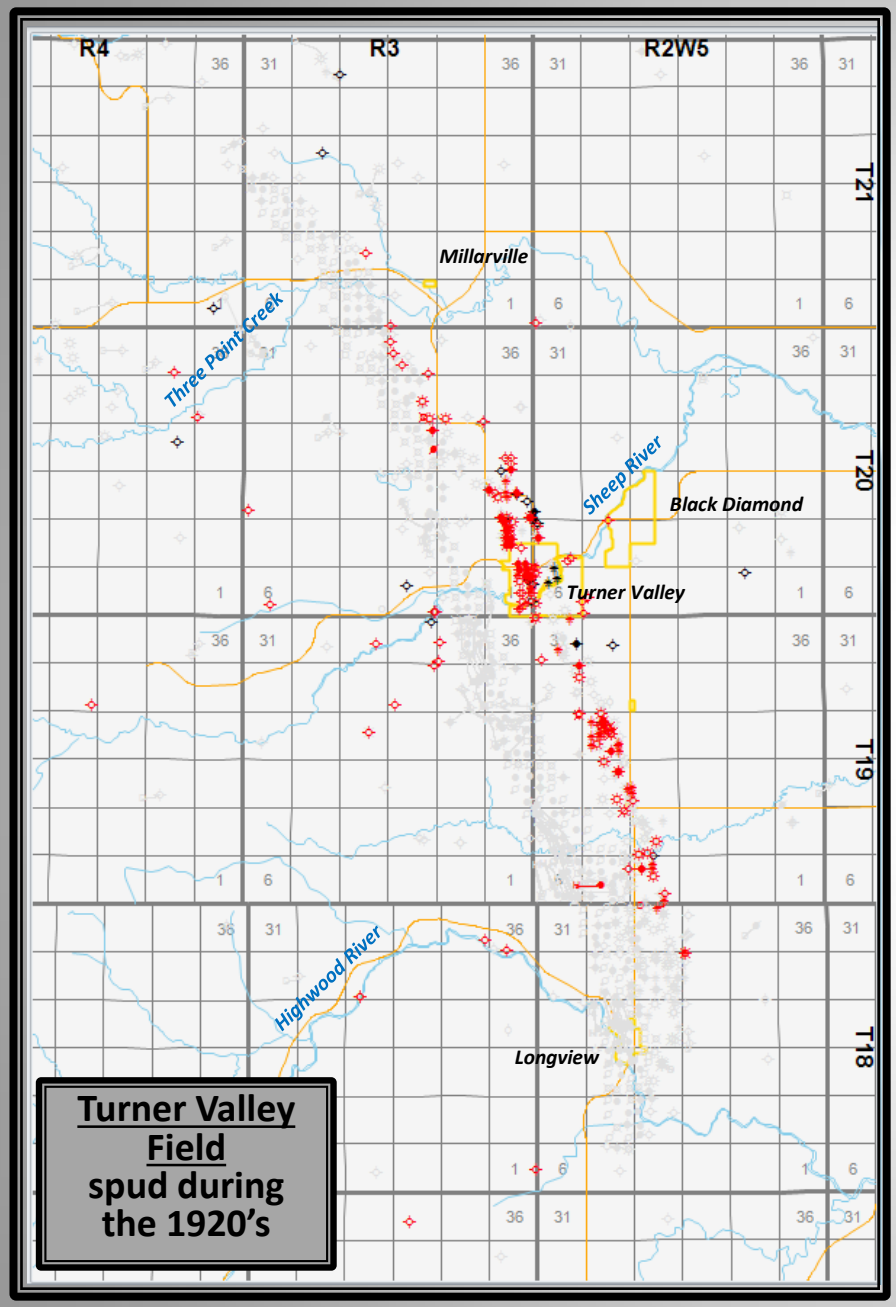


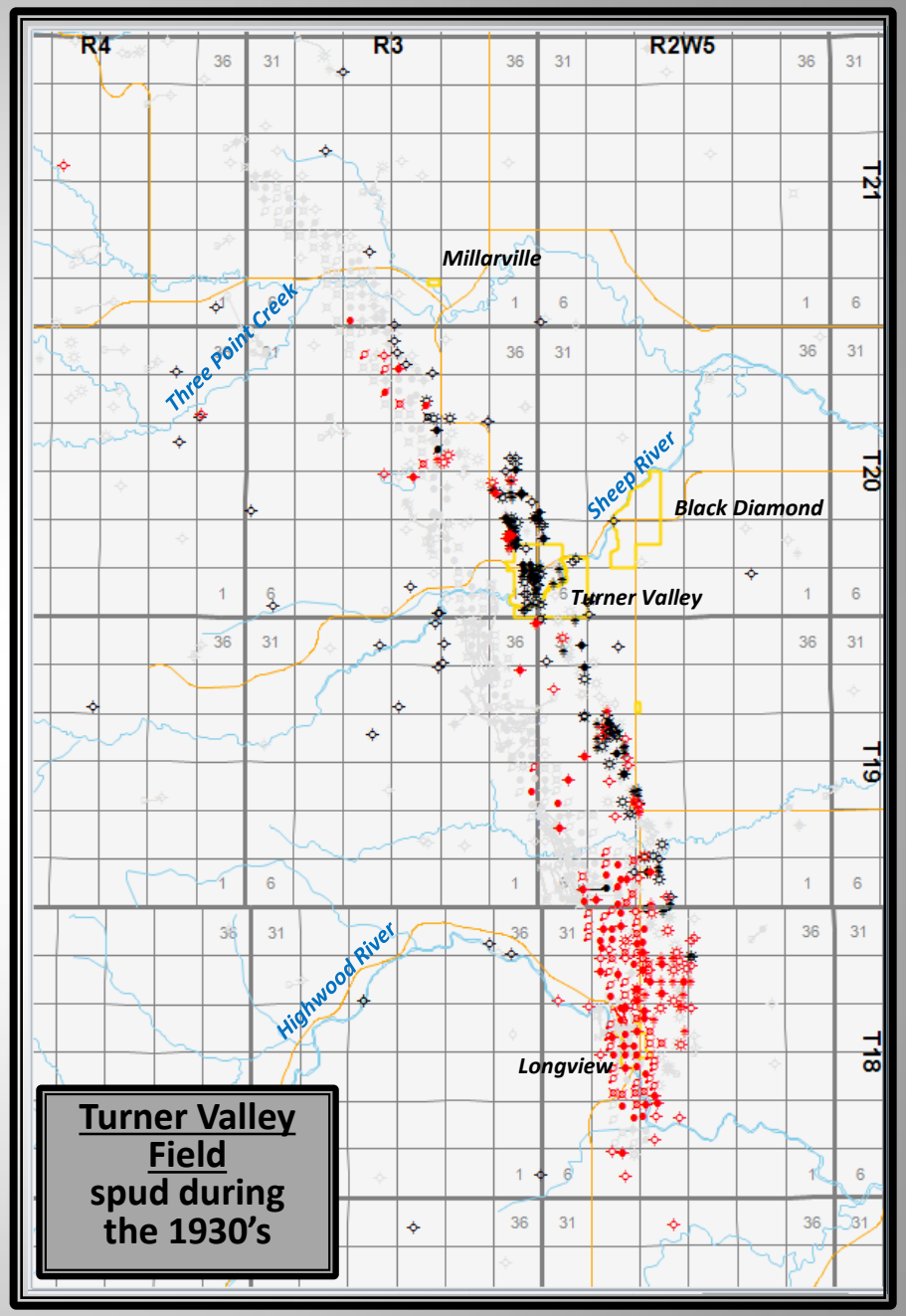

R4W5
R2W5
T 20
BLACK DIAMOND
X'
NCD-007
NAPHTHA
T 19
Y'
HARTELL NDF-025
Y
LONGVIEW
T 18
T 17
R4W5
R3W5
MacKay, 1991


External Syncline
Alberta
Edmonton
Edge of Deformed Belt
Calgary
British Columbia
Turner Valley


R4
R3
R2W5
T21
T20
T19
T18
Millarville
Three Point Creek
Sheep River
Black Diamond
Turner Valley
Highwood River
Longview
Dingman #1
Spud: 01/25/1913
Disc Date:
05/14/1914


R4
R3
R2W5
T21
T20
T19
T18
Millarville
Three Point Creek
Sheep River
Black Diamond
Turner Valley
Highwood River
Longview
Turner Valley
Field
spud during
the 1910's


R4
R3
R2W5
T21
T20
T19
T18
Millarville
Three Point Creek
Sheep River
Black Diamond
Turner Valley
Highwood River
Longview
Turner Valley Field
spud during the 1920's


R4
R3
R2W5
T21
T20
T19
T18
Millarville
Three Point Creek
Sheep River
Black Diamond
Turner Valley
Highwood River
Longview
Turner Valley Field
spud during the 1930's

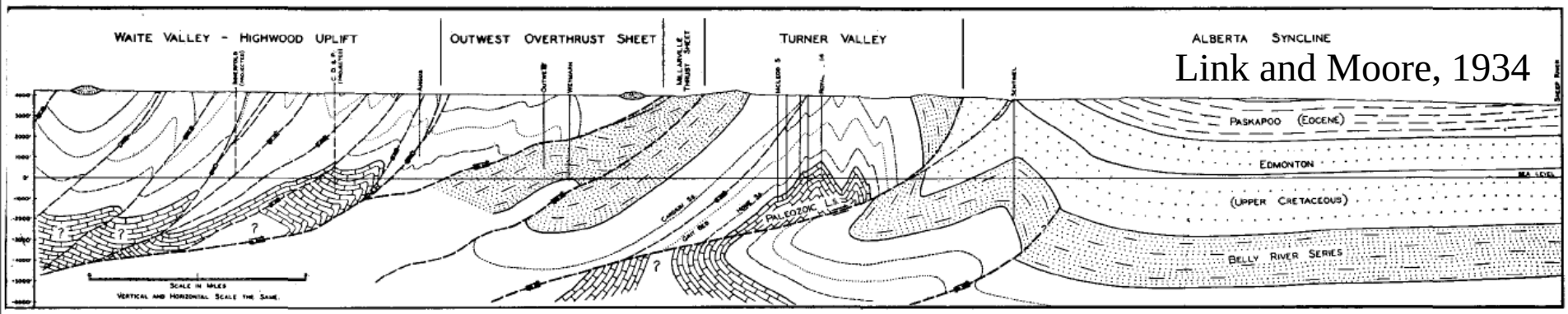


FIG. 2.—Cross section along Sheep River showing relationship of Turner Valley, Inner Foothills, and Alberta syncline. Truncated limestone fold or "roots" from which Turner Valley limestone was torn may lie farther west than indicated in this cross section. Note several overthrust sheets and warping or folding of major sole faults.

Ted Link – numerous interpretations

- **Decapitated Anticline**
- **East dips at foreland edge of deformed belt pose a problem**
- **Tower Anticline inferred by Hume (1940)**

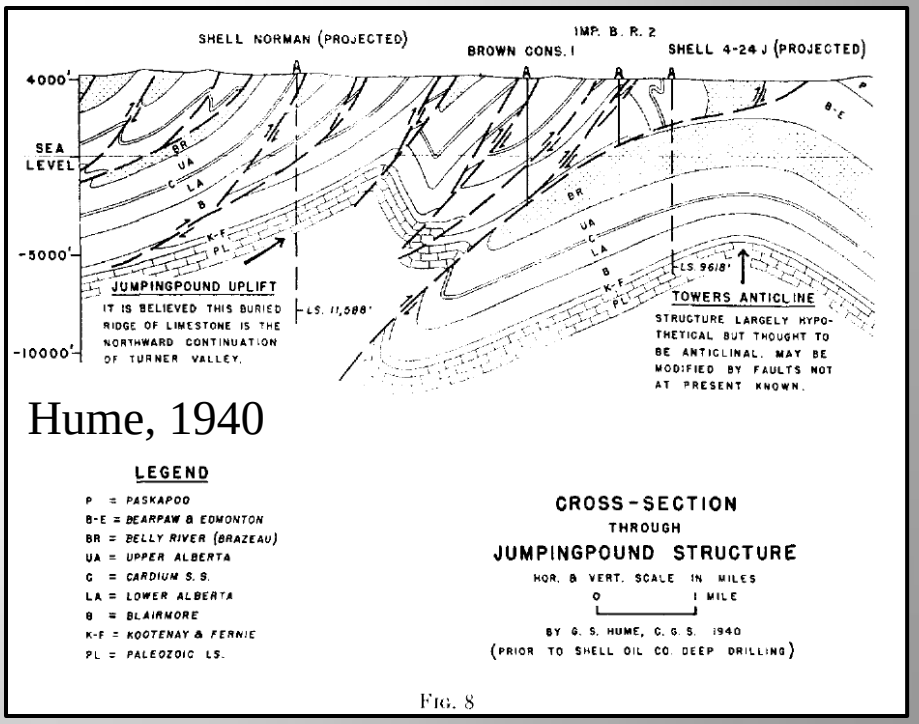
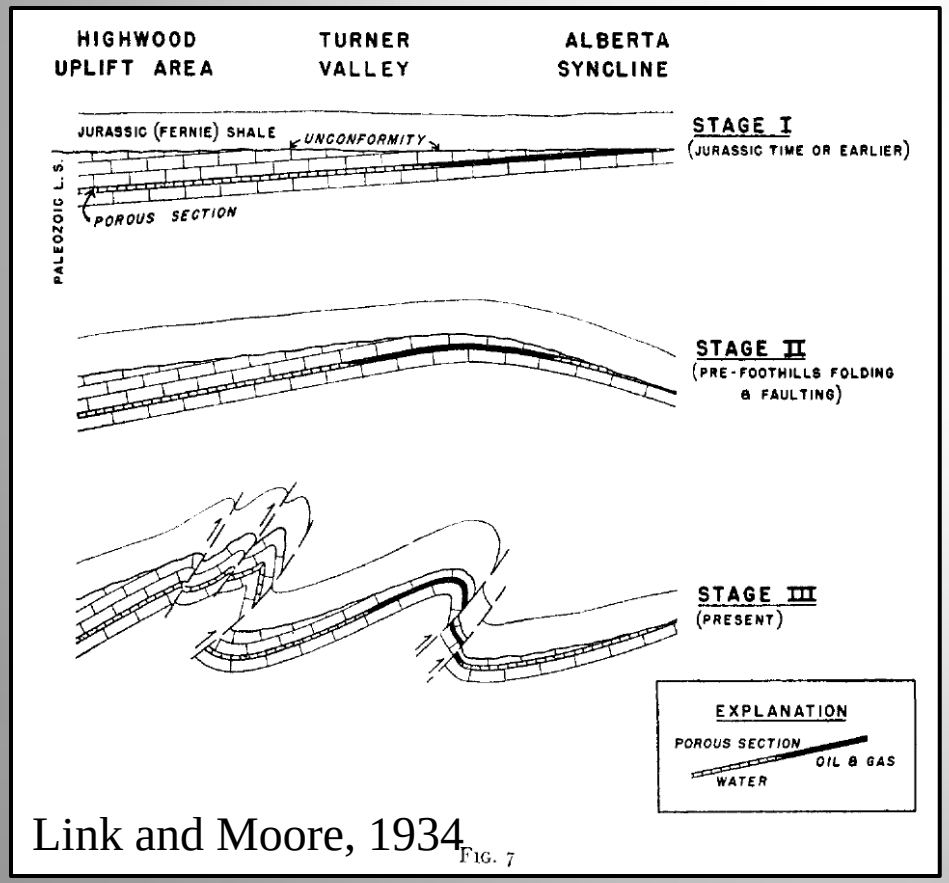


FIG. 8

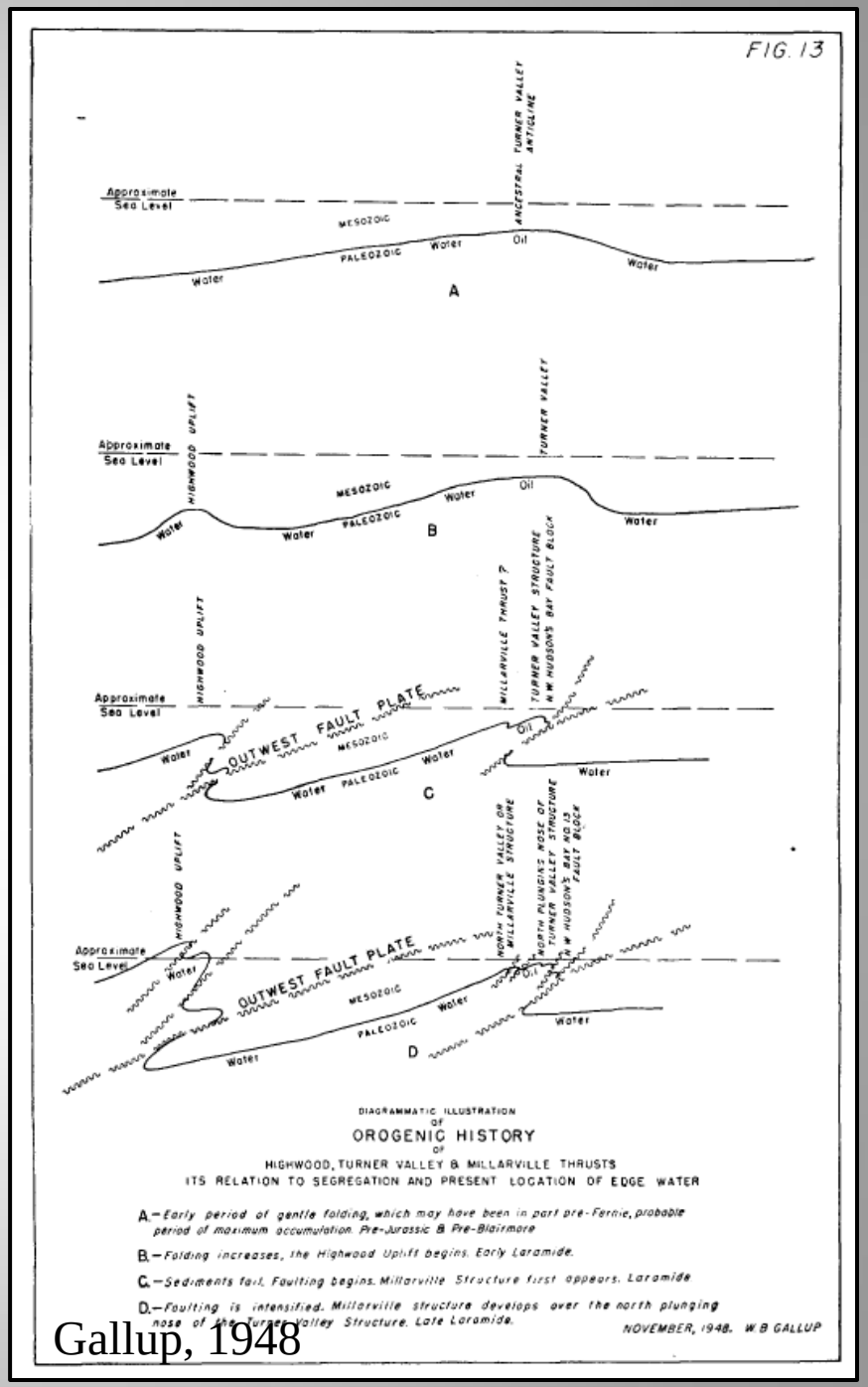
Oil Migration:

- Considered to be pre-thrusting
- Need to explain:
  - Oil in Turner Valley Structure
  - Water in Highwood Structure



Link and Moore, 1934

FIG. 7



Gallup, 1948

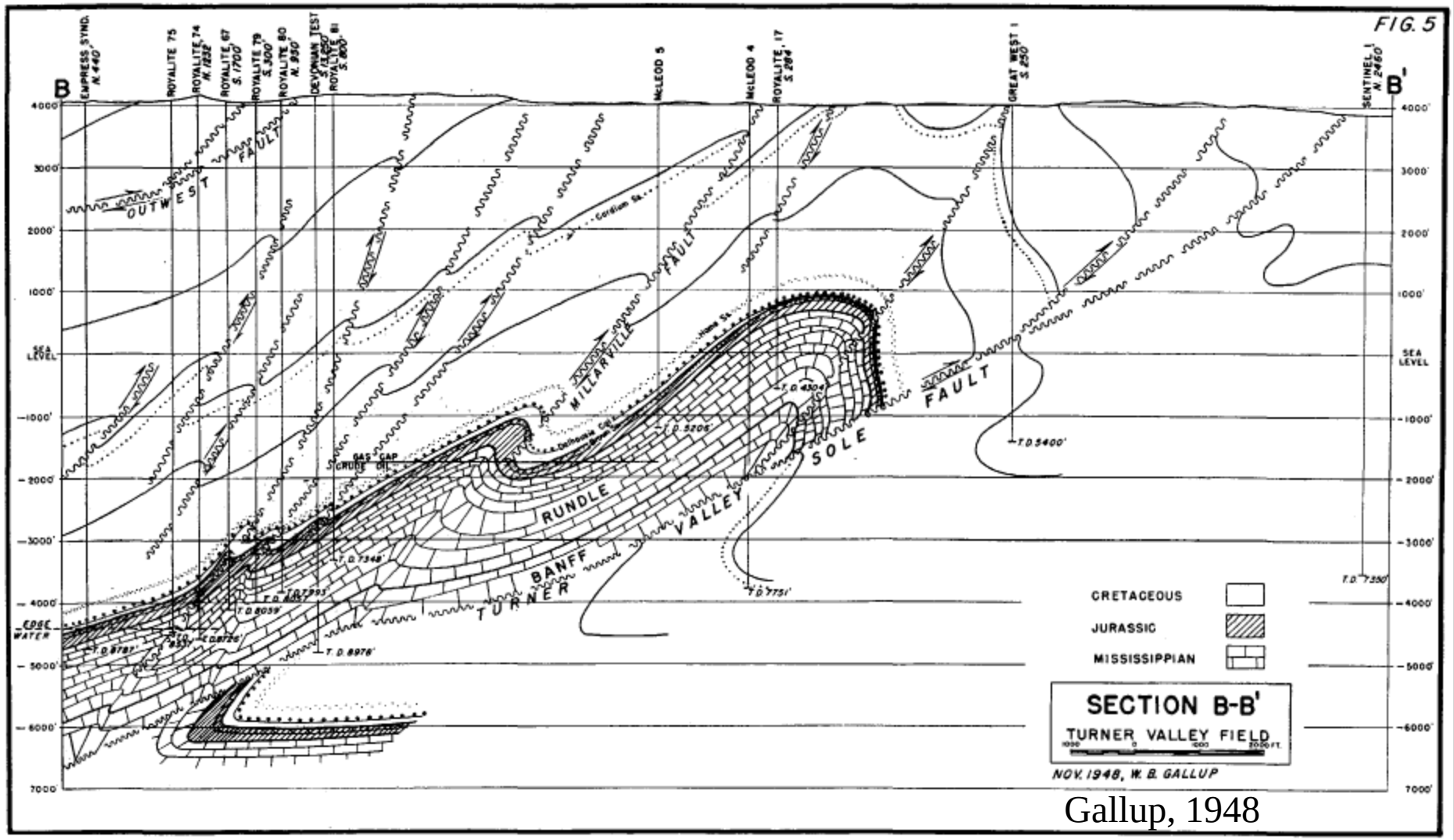
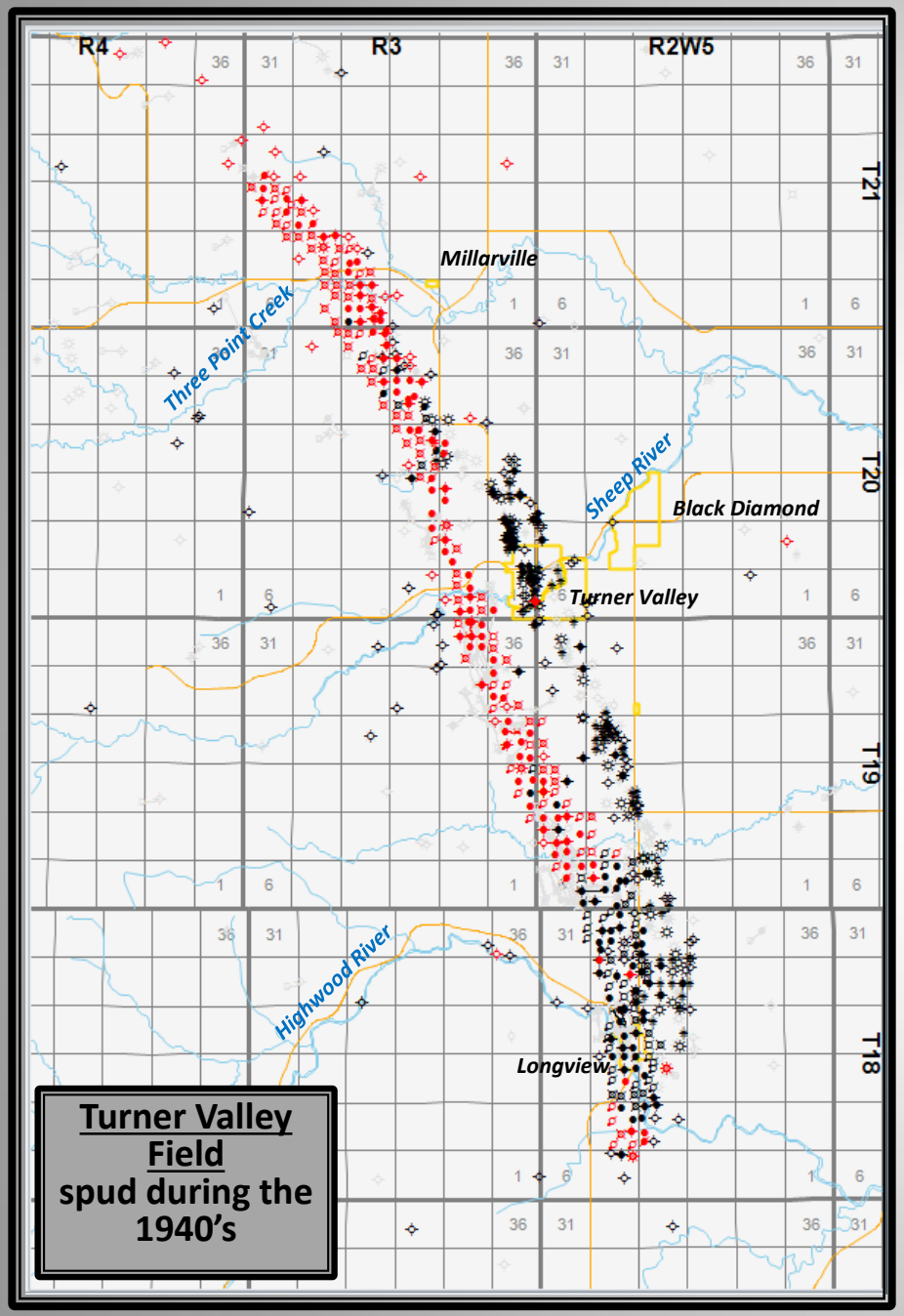
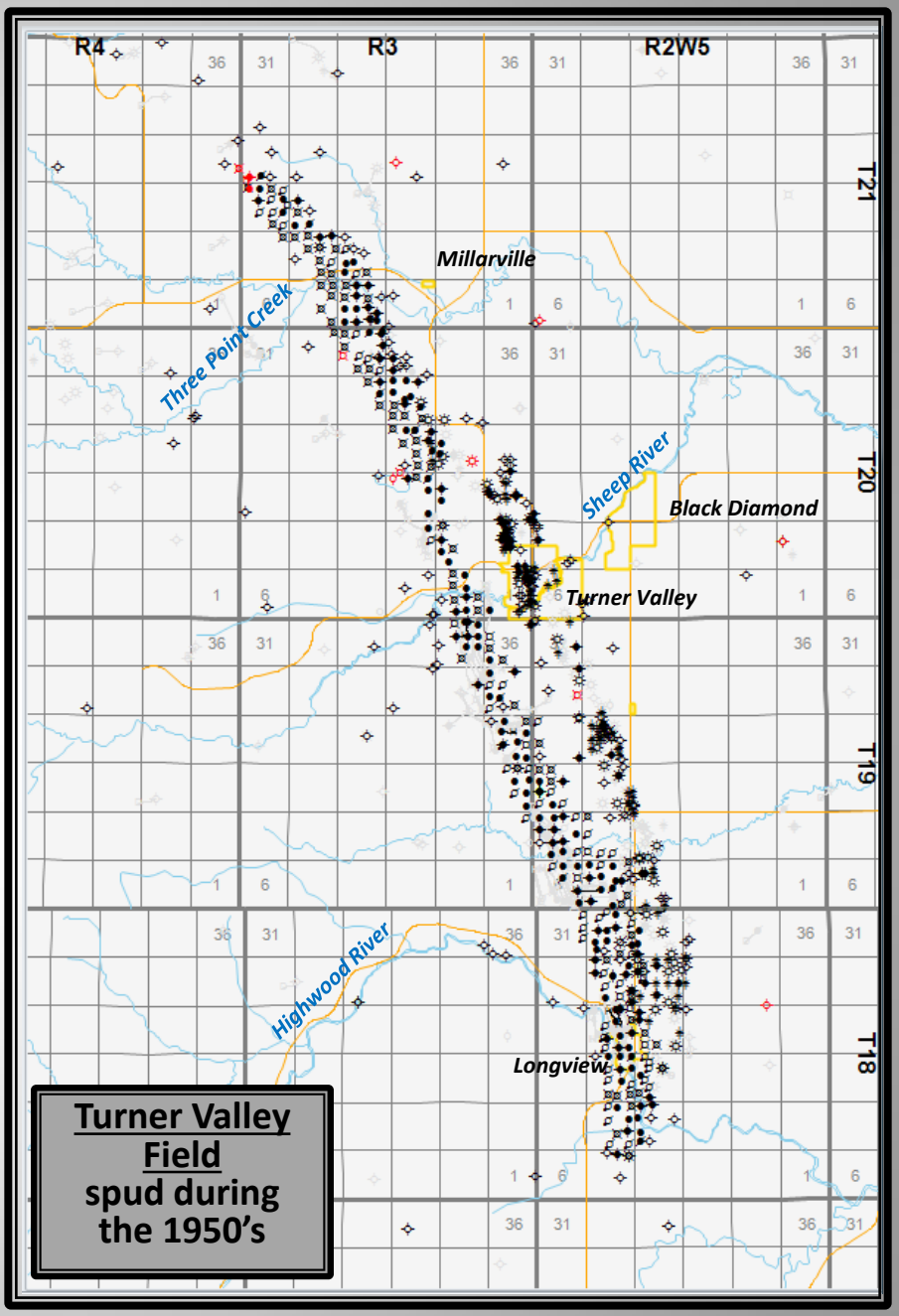


FIG. 5
B
B'
EMPRESS SYND. N. 440'
ROYALITE 75
ROYALITE 74 N. 1232'
ROYALITE 67 S. 1700'
ROYALITE 79 S. 300'
ROYALITE 80 N. 850'
DEVONIAN TEST S. 1,250'
ROYALITE 81 S. 800'
McLEOD 5
McLEOD 4
ROYALITE 17 S. 284'
GREAT WEST 1 S. 250'
SENTINEL 1 N. 2460'
4000'
3000'
2000'
1000'
SEA LEVEL
-1000'
-2000'
-3000'
-4000'
-5000'
-6000'
7000'
EDGE WATER
OUTWEST FAULT
MILLARVILLE FAULT
FAULT
GAS CAP
CRUDE OIL
RUNDLE
BANFF
TURNER VALLEY SOLE
T.D. 5206'
T.D. 4304'
T.D. 5400'
T.D. 7348'
T.D. 7793'
T.D. 8039'
T.D. 8726'
T.D. 8976'
T.D. 7751'
T.D. 7350'
CRETACEOUS
JURASSIC
MISSISSIPPIAN
SECTION B-B'
TURNER VALLEY FIELD
NOV. 1948, W. B. GALLUP

Gallup, 1948



Turner Valley Field
spud during the 1940's



Turner Valley Field
spud during the 1950's

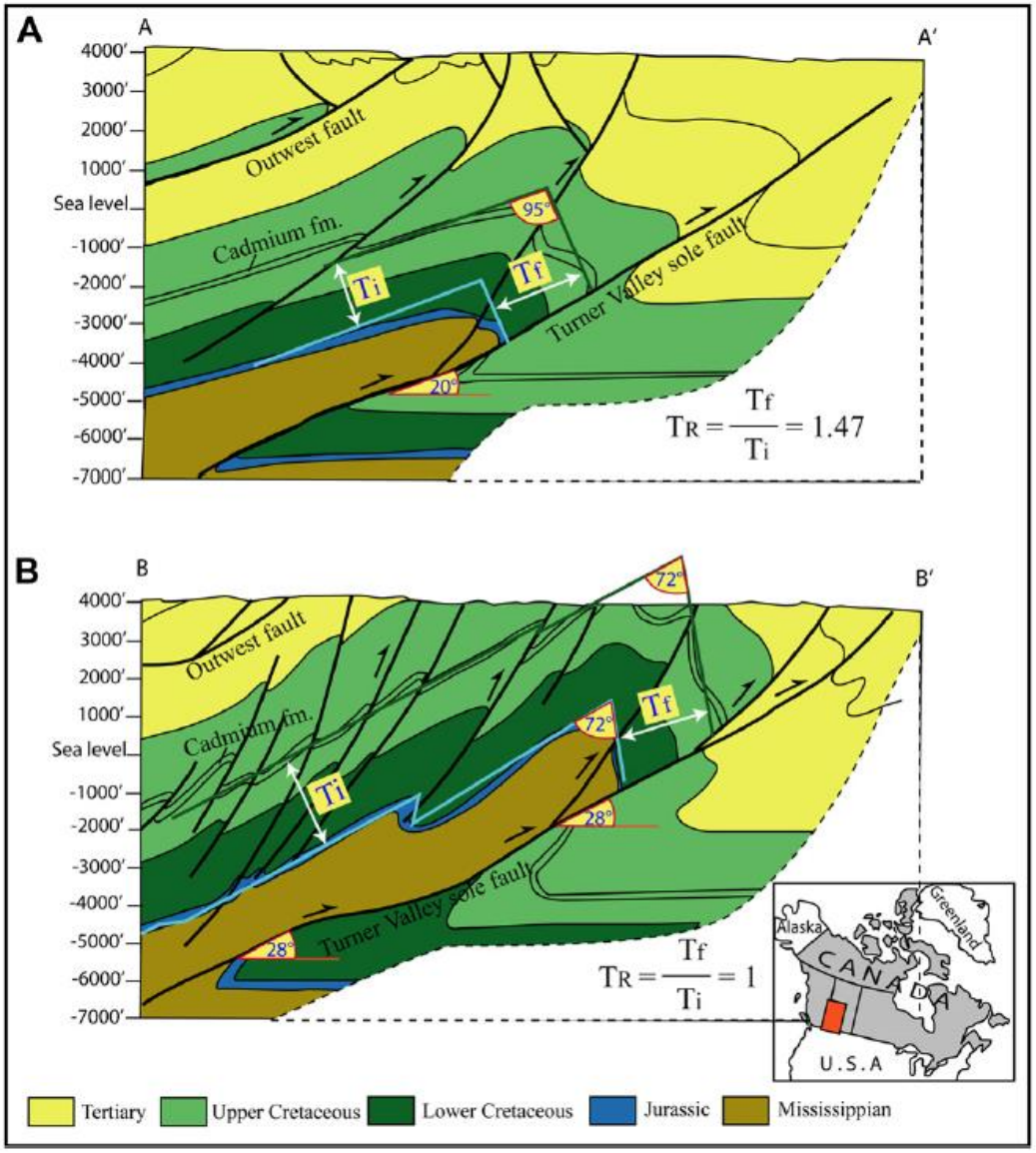
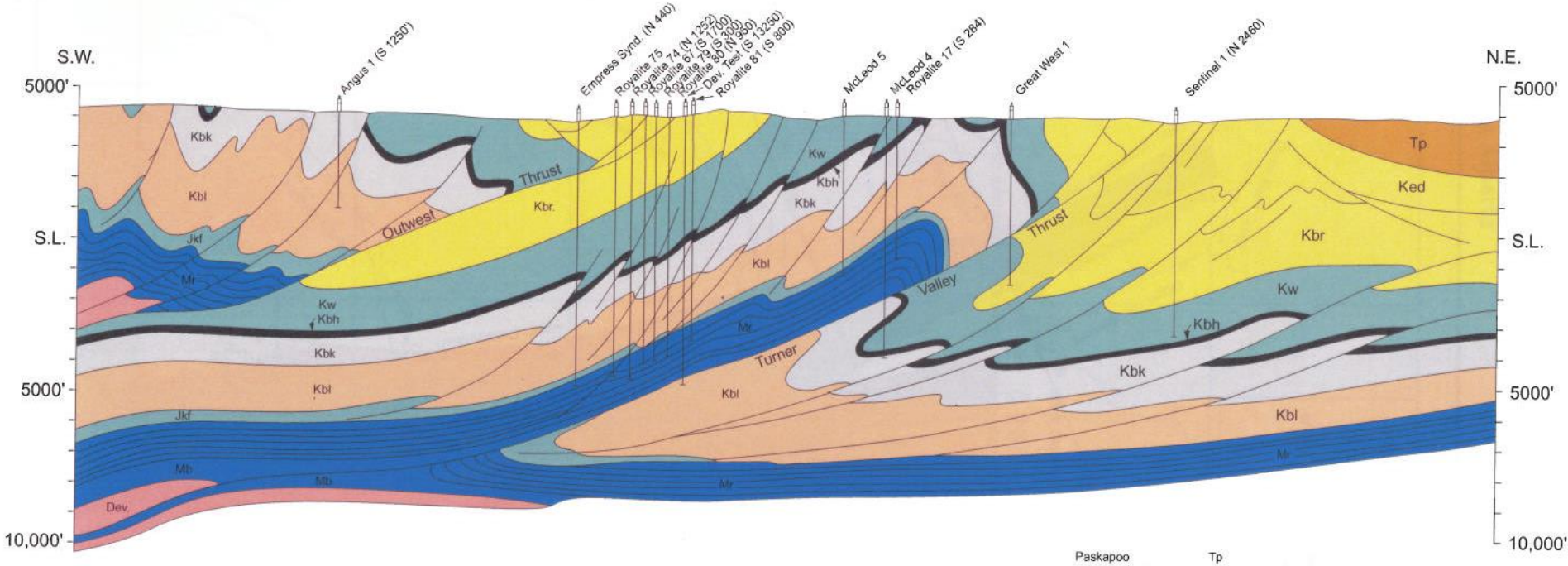
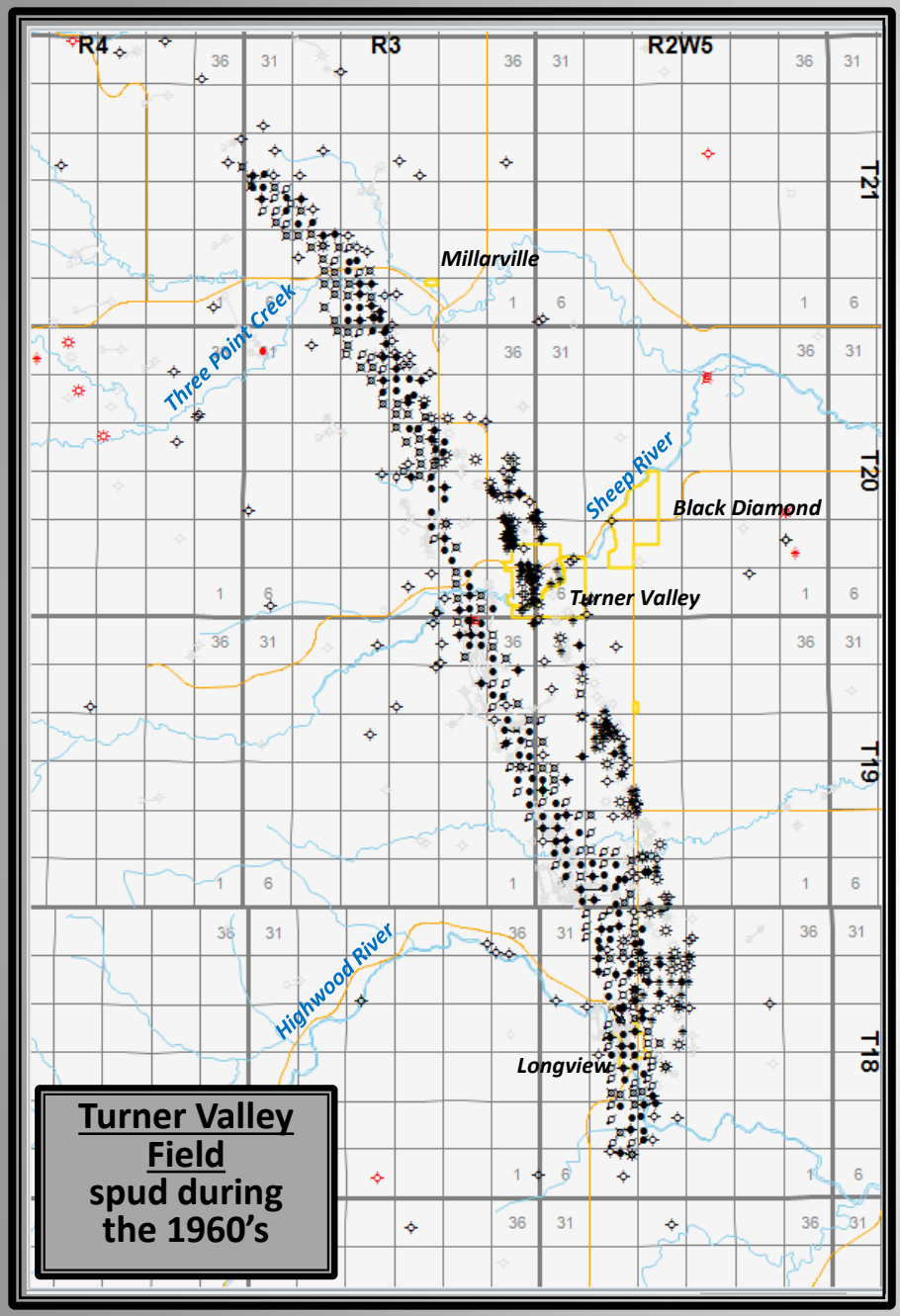
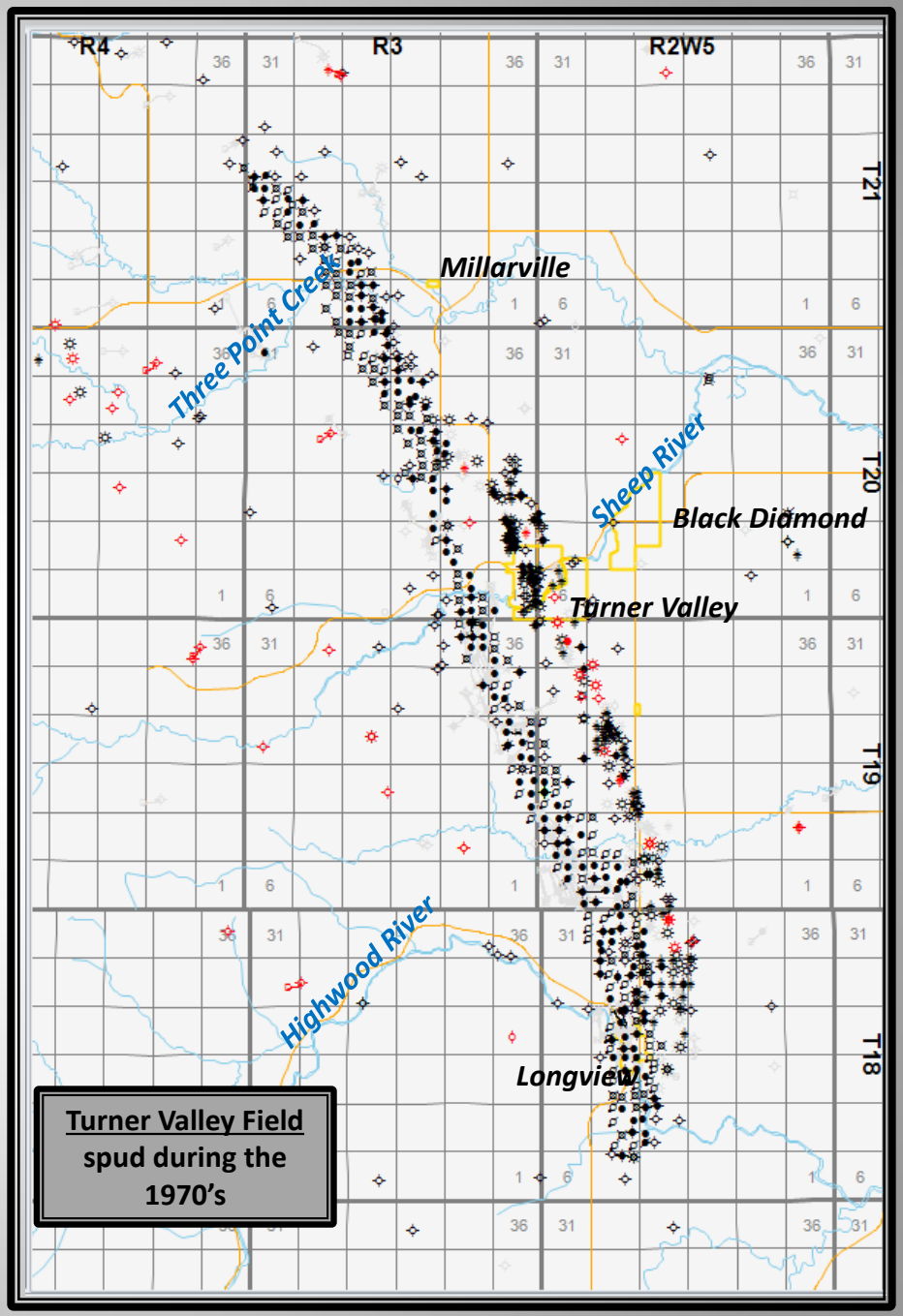


Fig. 5. Cross-sections through the Turner valley anticline, Alberta Foothills (modified from Gallup (1954) and Mitra (1990)). In the cross-section (a), the ramp and interlimb angles are 20° and 95°, respectively. Using these parameters, Eq. (10) gives a thickness ratio of 1.59 for the Jurassic layers, in agreement with the 1.5 value measured in the forelimb. Along the second profile (b), the thickness of the Jurassic layers remains nearly constant ($T_R = 1$) for ramp and interlimb angles of 28° and 72°, respectively. This is also in agreement with our calculation showing a thickness ratio of 0.98 in the forelimb.


S.W.
N.E.
5000'
S.L.
5000'
10,000'
Angus 1 (S 1250')
Empress Synd. (N 440)
Royalite 75
Royalite 74 (N 1252)
Royalite 67 (S 1700)
Royalite 79 (S 300)
Royalite 80 (N 350)
Dev. Test (S 13250)
Royalite 81 (S 800)
McLeod 5
McLeod 4
Royalite 17 (S 284)
Great West 1
Sentinel 1 (N 2460)
Thrust
Outwest
Valley
Turner
Thrust
Kbk
Kbl
Jkf
Mr
Kw
Kbh
Kbr
Tp
Ked
Mb
Dev
0
5000
Feet
Author: F. G. Fox
May 1958
Paskapoo Tp
Edmonton - Bearpaw Ked
Belly River Kbr
Wapiabi Kw
Bighorn Kbh
Blackstone Kbk
Colorado
Blairmore Kbl
Kootenay - Fernie Jkf
Rundle Mr
Banff Mb
B



Turner Valley Field spud during the 1960's



Turner Valley Field spud during the 1970's

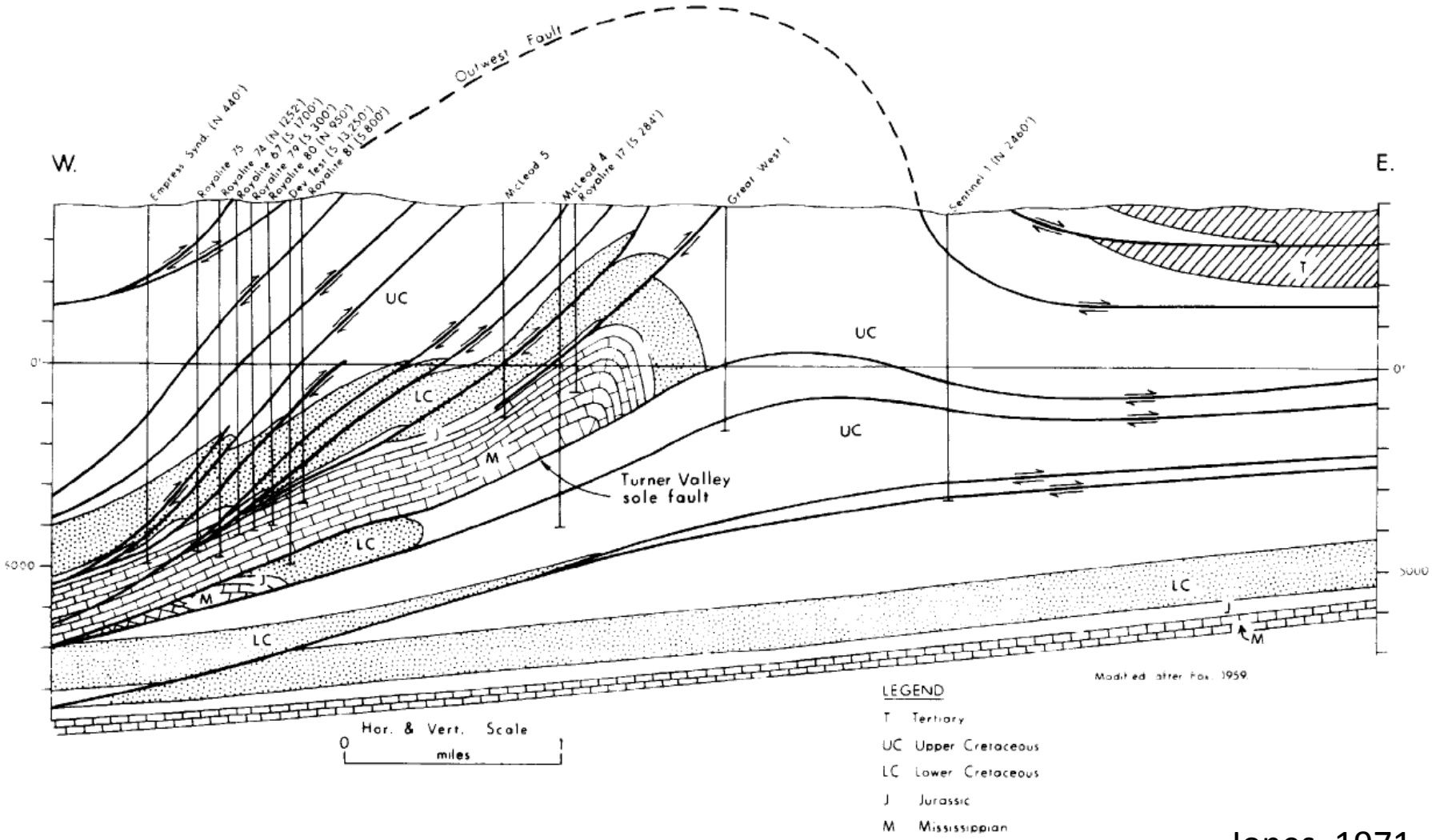
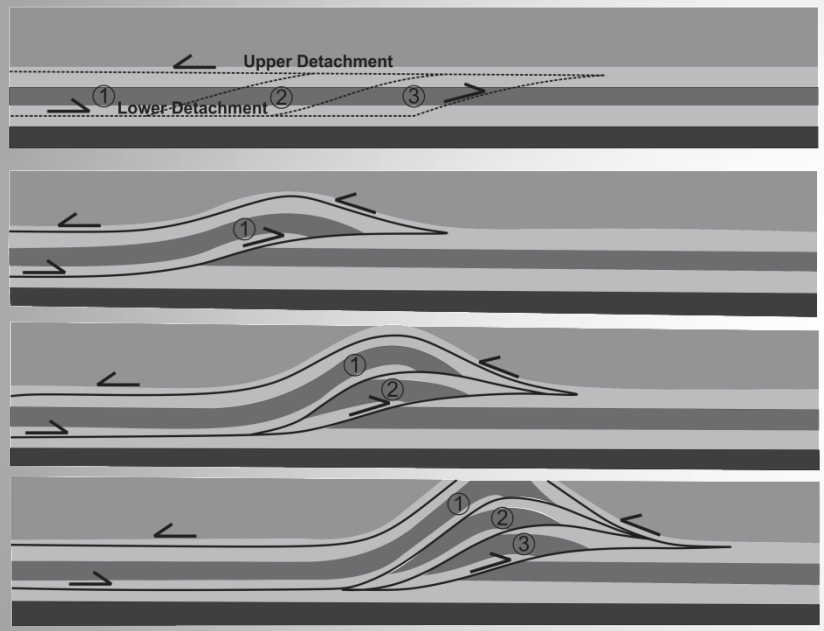


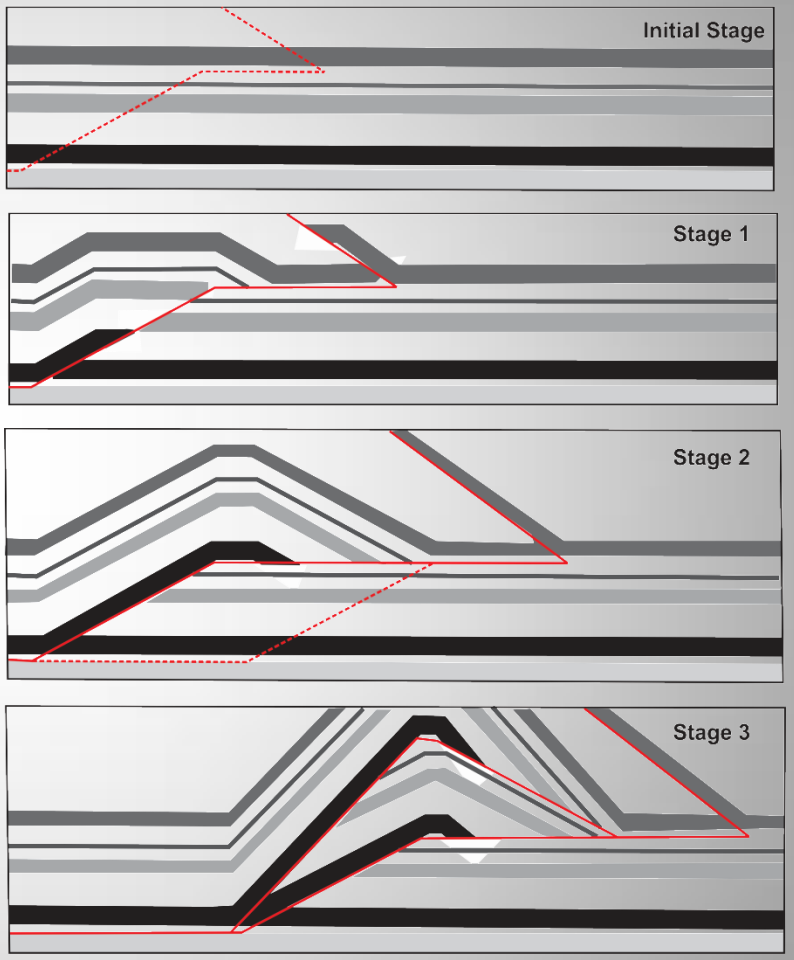
FIG. 9.—West-east cross section through Turner Valley structure, interpretation involving folded faults.

Jones, 1971

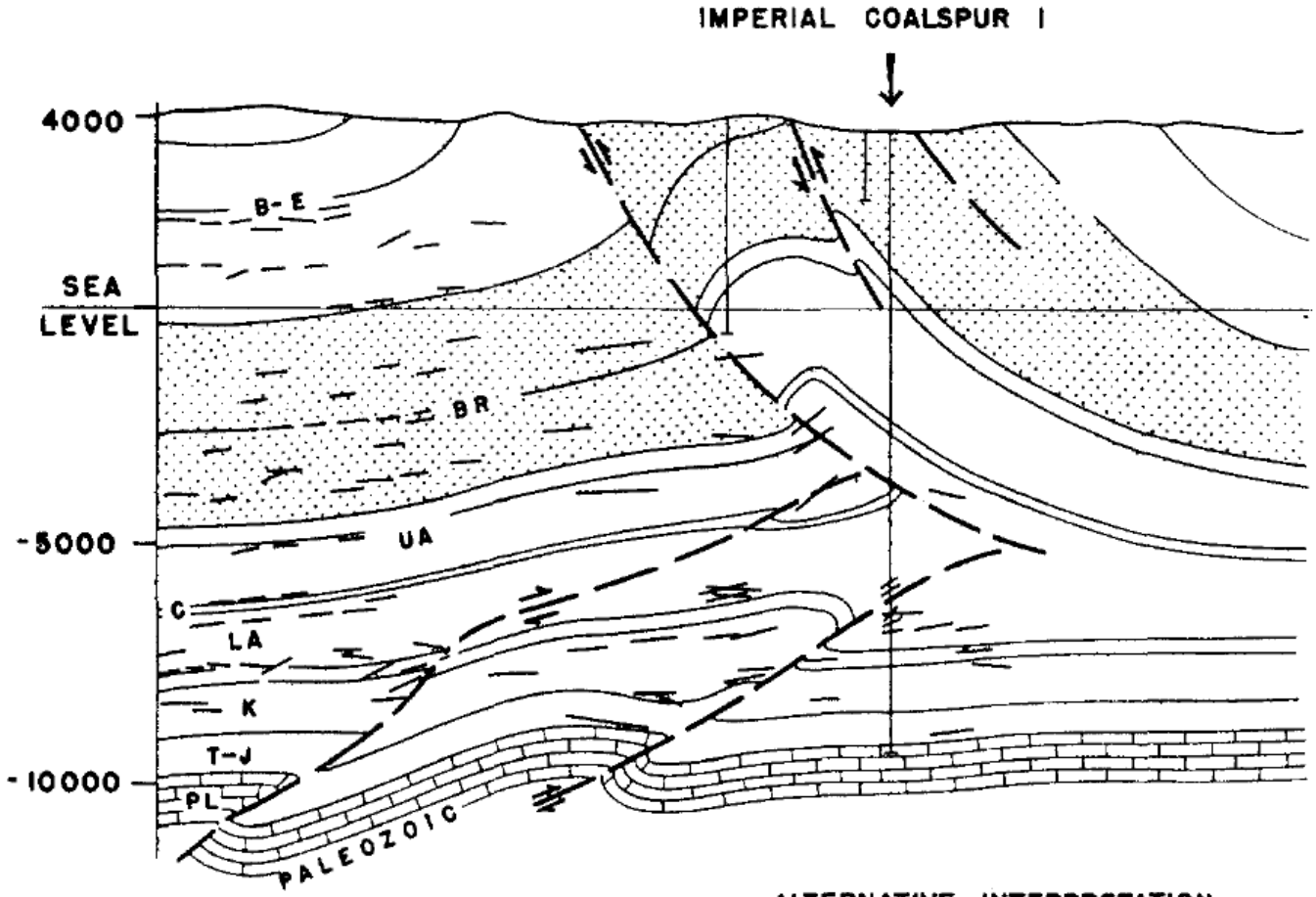
Triangle Zones – Wedge Tectonics



Jones, 1982



Charlesworth and Gagnon, 1985



ALTERNATIVE INTERPRETATION

COALSPUR STRUCTURE

HOR. & VERT. SCALE IN MILES

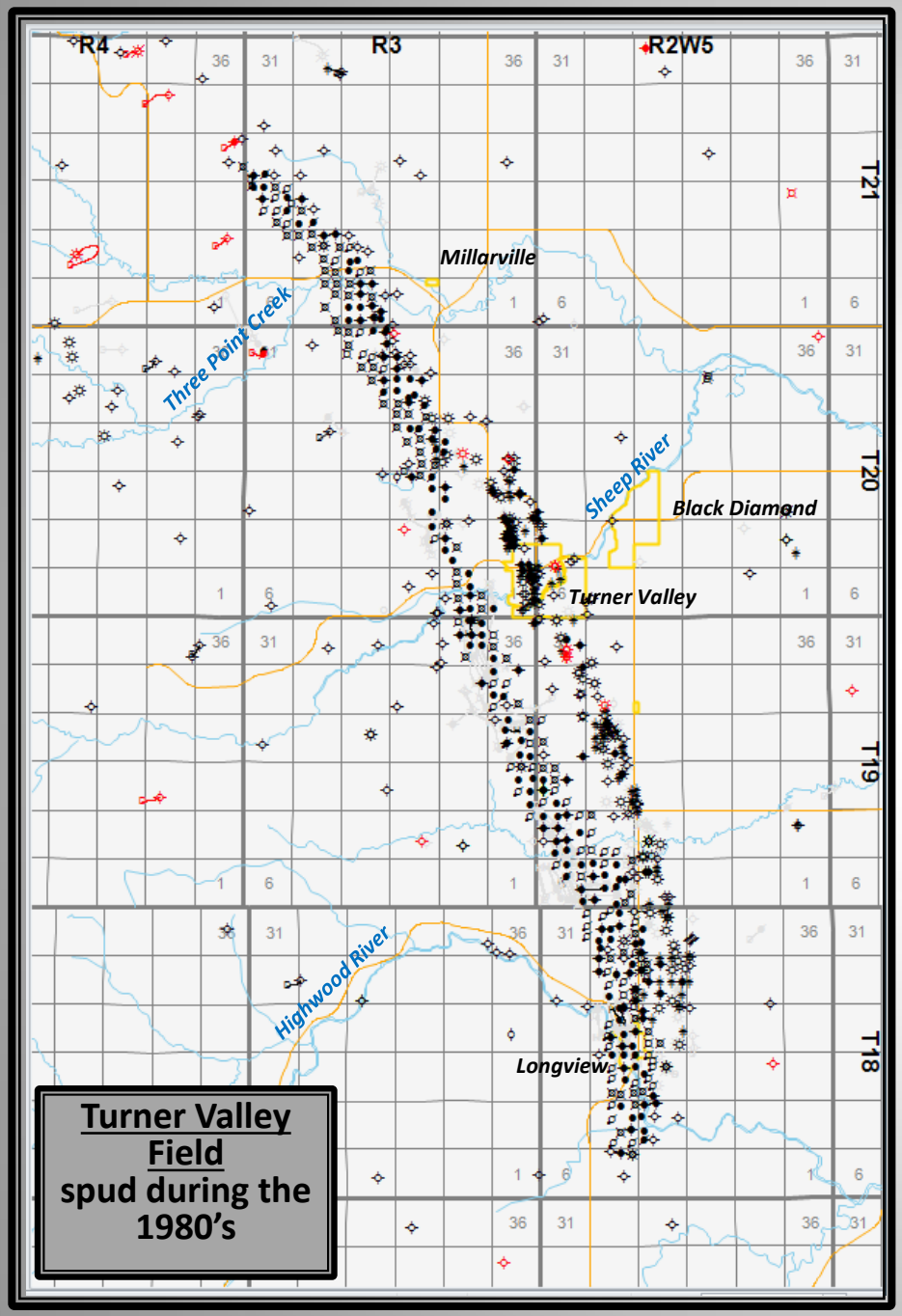
0 — 1 MILE

THEO A. LINK, 1947

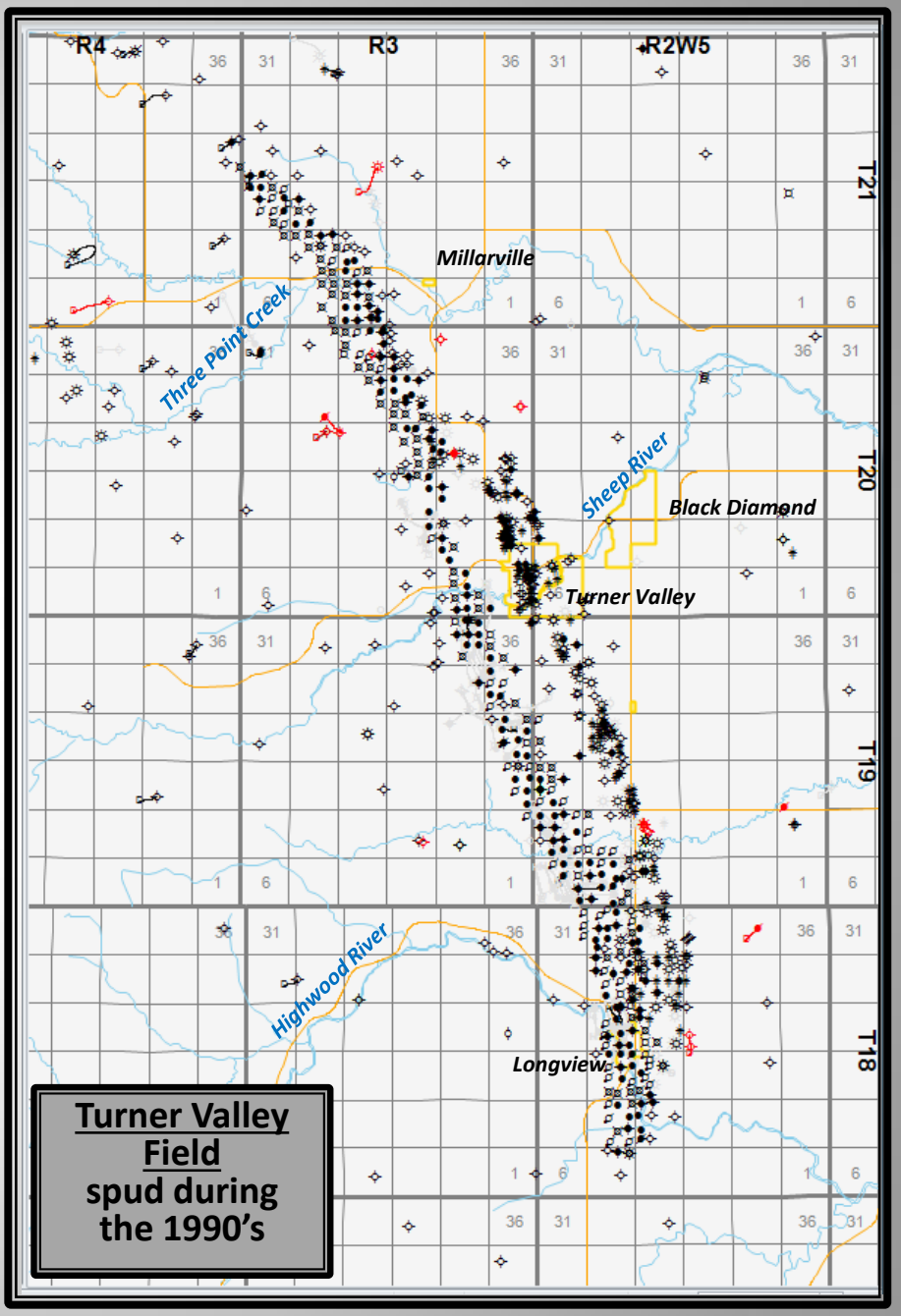
SEISMIC REFLECTIONS

LEGEND

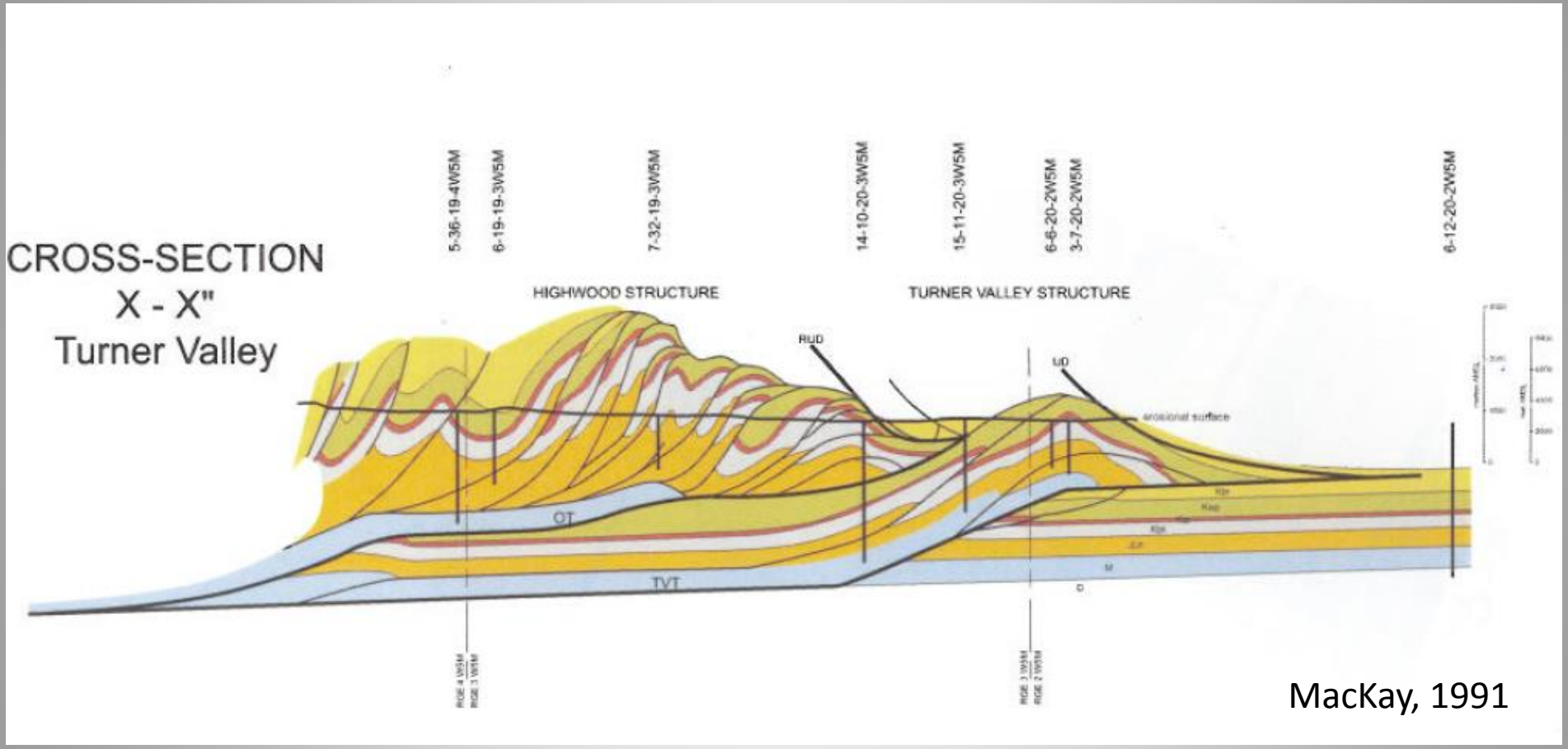
B-E = *BEARPAW & EDMONTON*
BR = *BELLY RIVER (BRAZEAU)*
UA = *UPPER ALBERTA*
C = *CARDIUM S.S.*
LA = *LOWER ALBERTA*
K = *KOOTENAY – BLAIRMORE*
T-J = *TRIASSIC – JURASSIC*
PL = *PALEOZOIC LS.*



Turner Valley Field
spud during the 1980's



Turner Valley Field
spud during the 1990's


CROSS-SECTION
X - X"
Turner Valley
5-36-19-4W5M
6-19-19-3W5M
7-32-19-3W5M
14-10-20-3W5M
15-11-20-3W5M
6-6-20-2W5M
3-7-20-2W5M
6-12-20-2W5M
HIGHWOOD STRUCTURE
TURNER VALLEY STRUCTURE
RUD
UD
erosional surface
OT
TVT

MacKay, 1991

Vertical cross-section X-X' Turner Valley

Upper Cretaceous

- Kbr Belly River Formation
- Kwp Wapiabi Formation
- Kcr Cardium Formation
- Kbk Blackstone Formation
- JK Jurassic/Lower Cretaceous
- M Mississippian
- D Devonian
- C Cambrian

scale

feet

5 000 0 5 000 10 000

metres

2 000 0 2 000 4 000

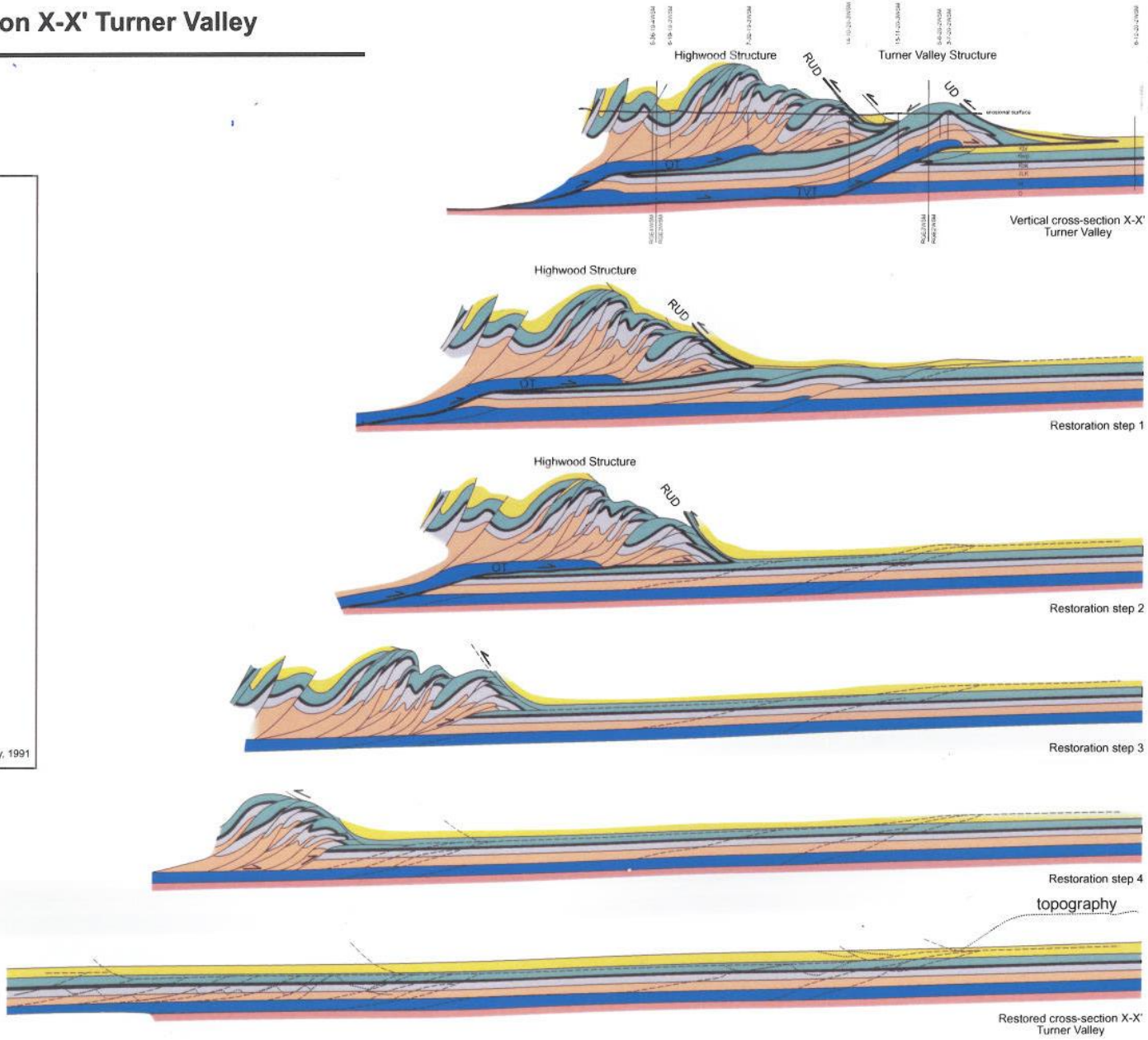
TVT Turner Valley Thrust

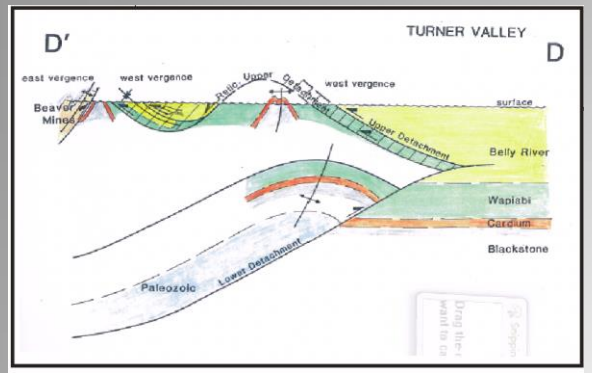
OT Outwest Thrust

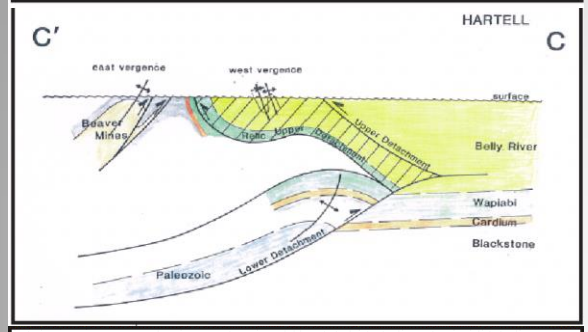
UD Upper Detachment

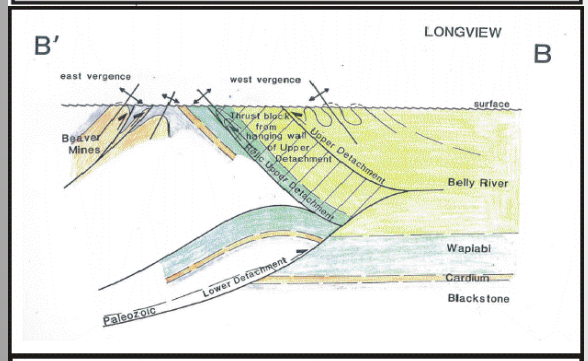
RUD Relic Upper Detachment

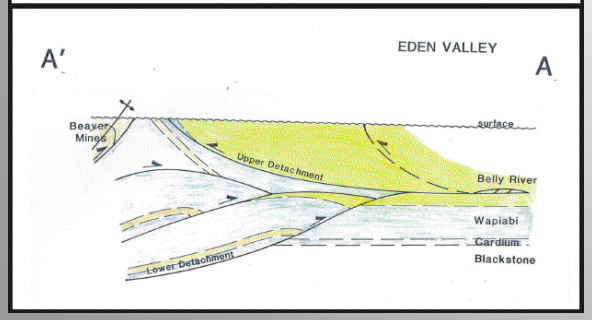
P. A. Mackay, 1991

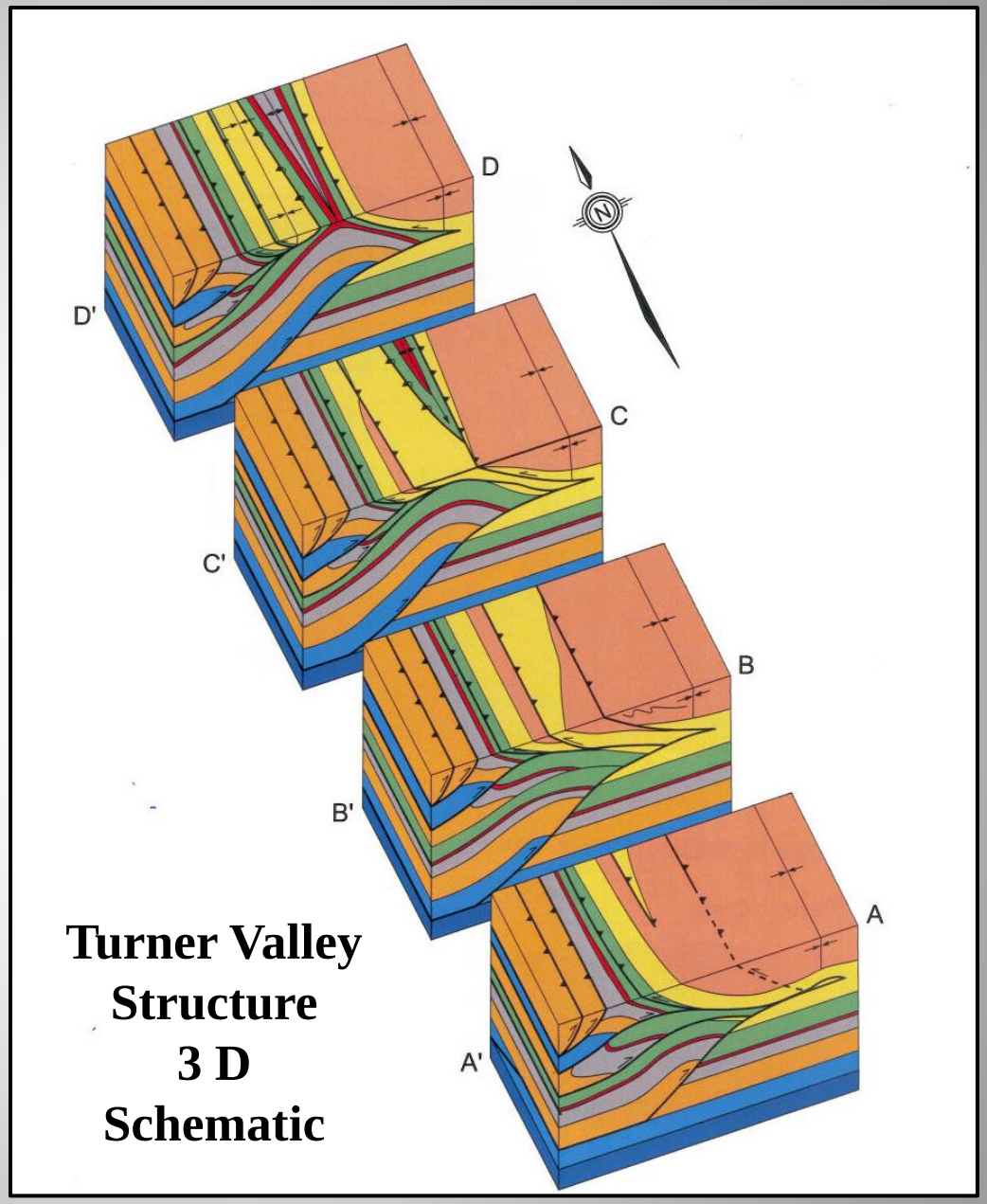






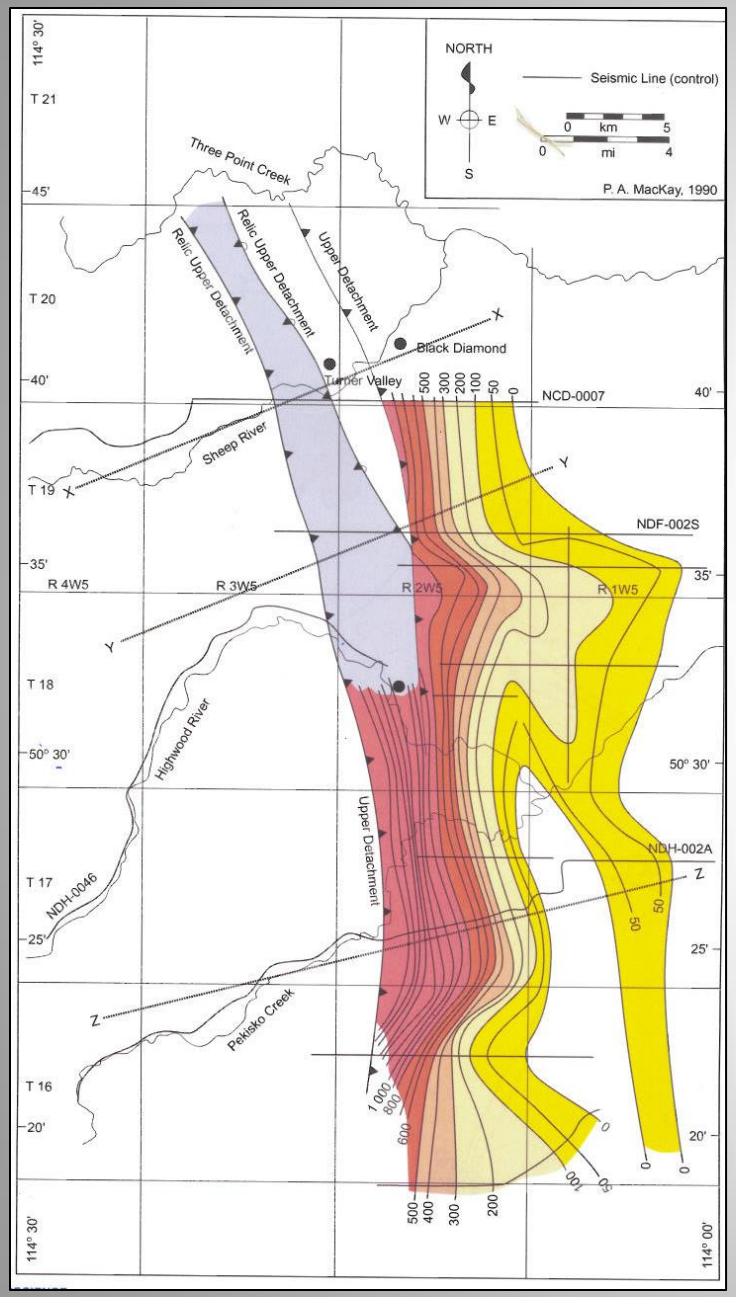


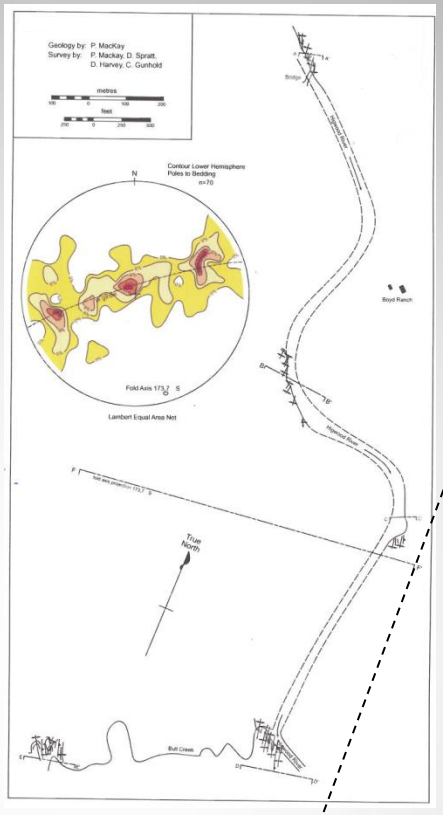


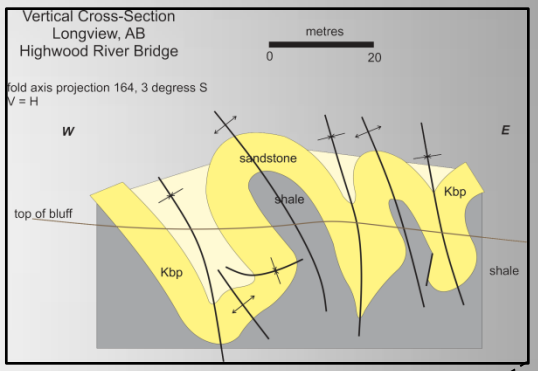


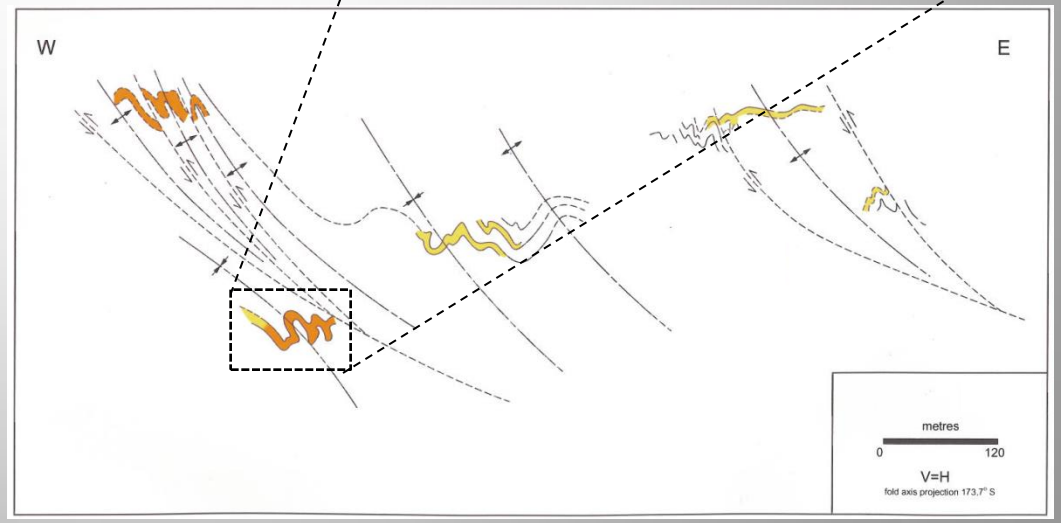
Turner Valley Structure 3 D Schematic

Hinterland Vergence Above the Wedge

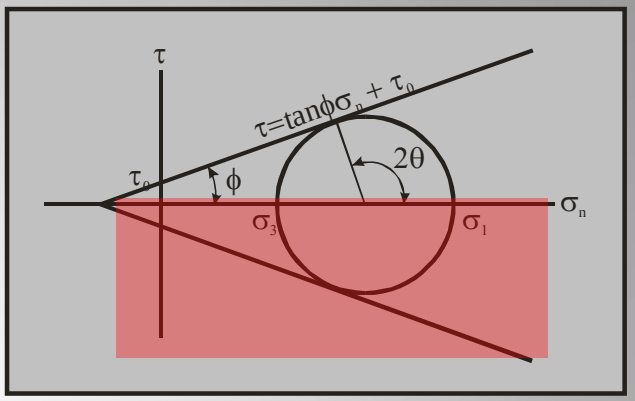


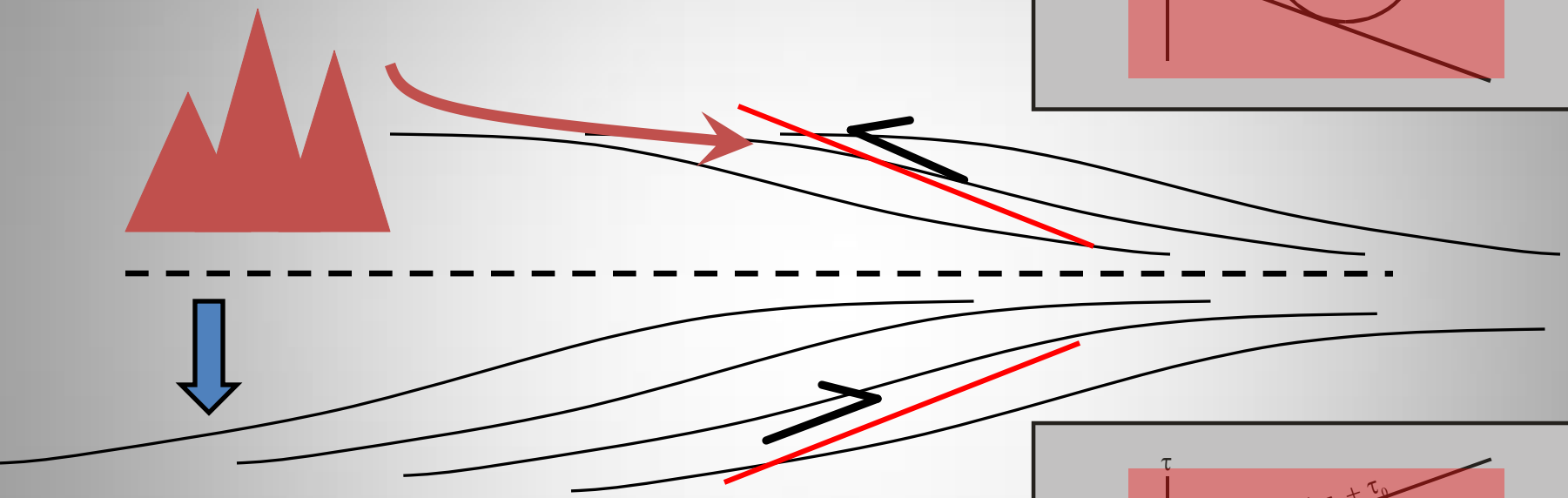


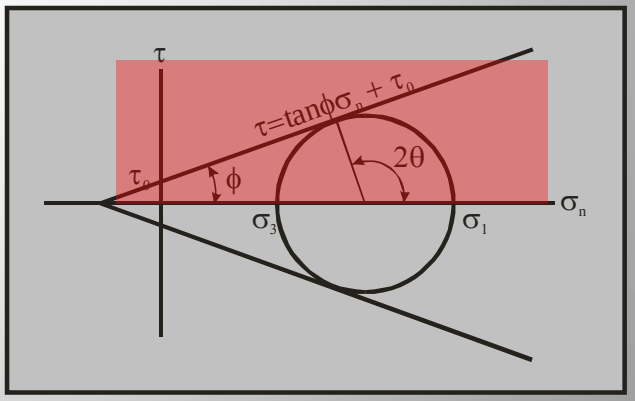


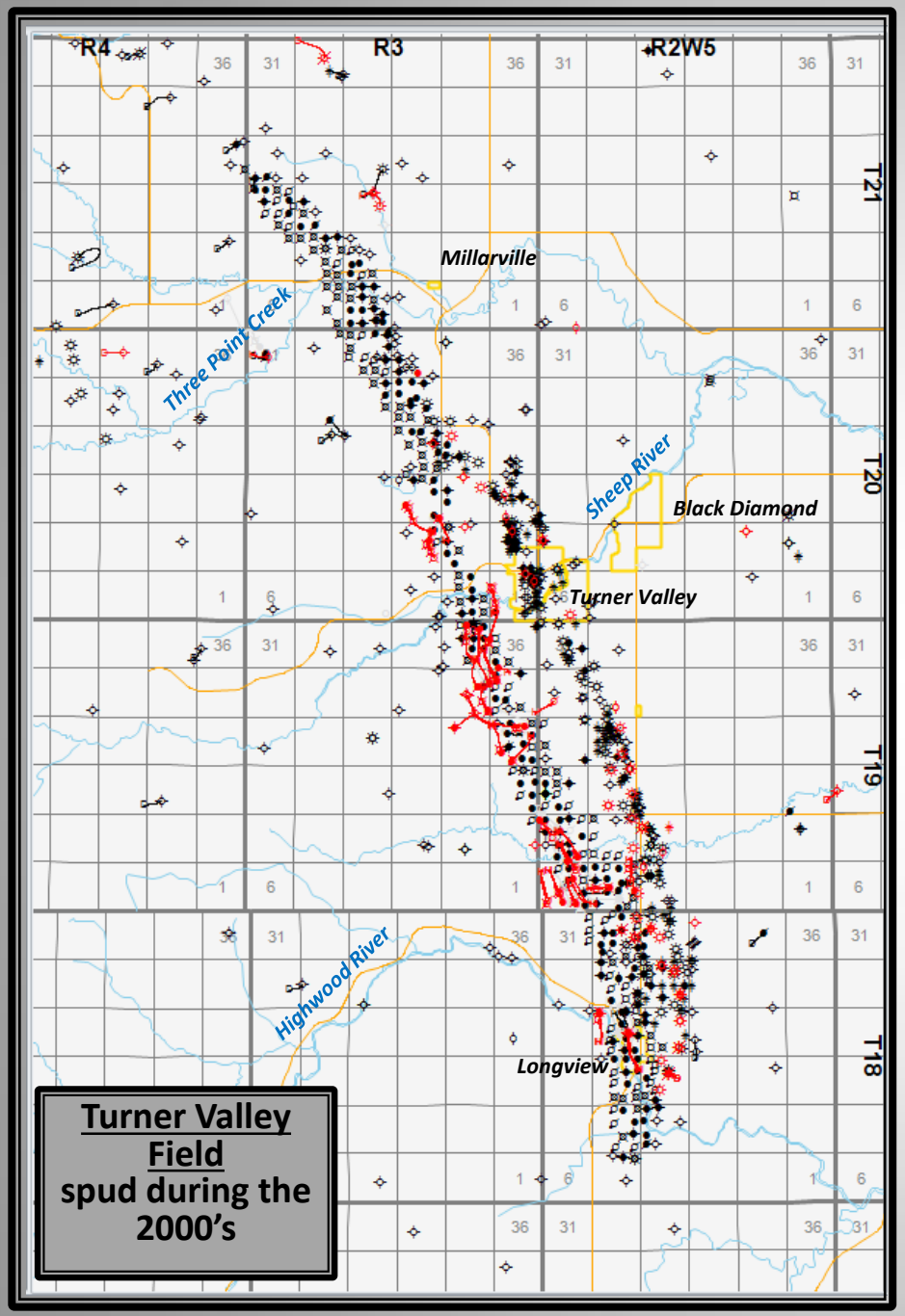


Anisotropy favours one sided failure

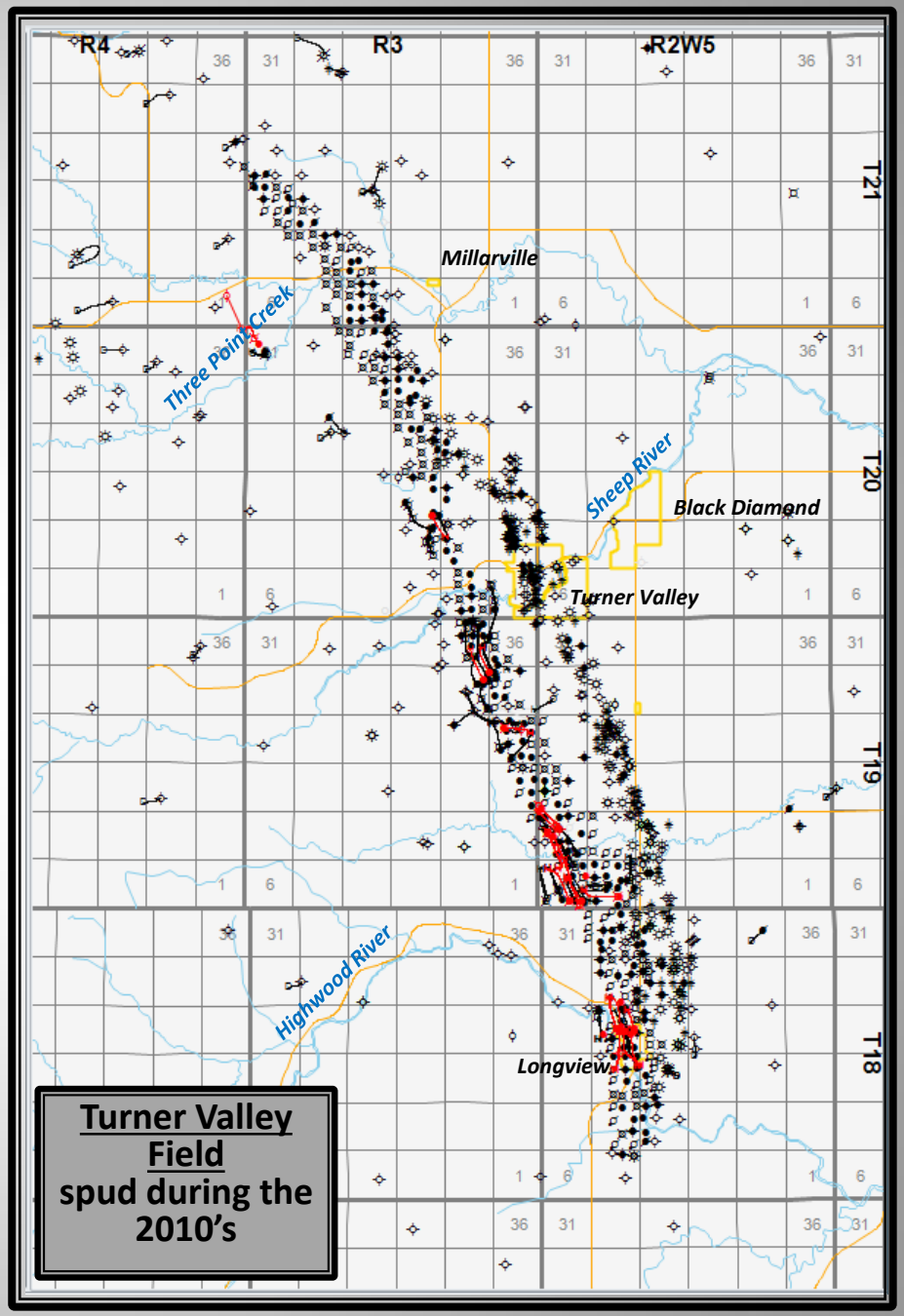








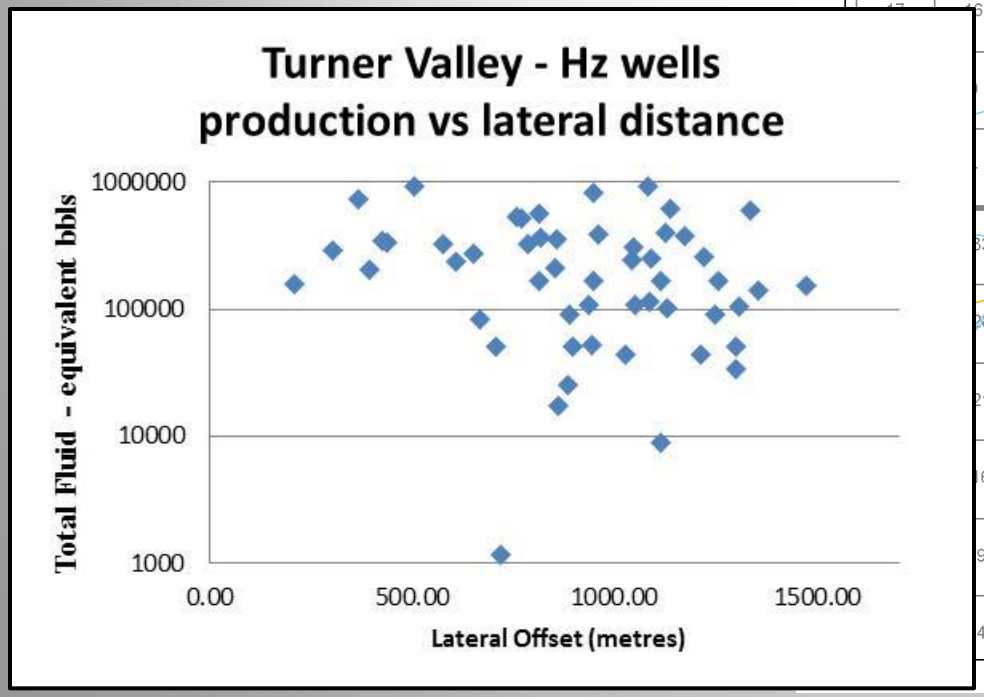
Turner Valley Field
spud during the 2000's

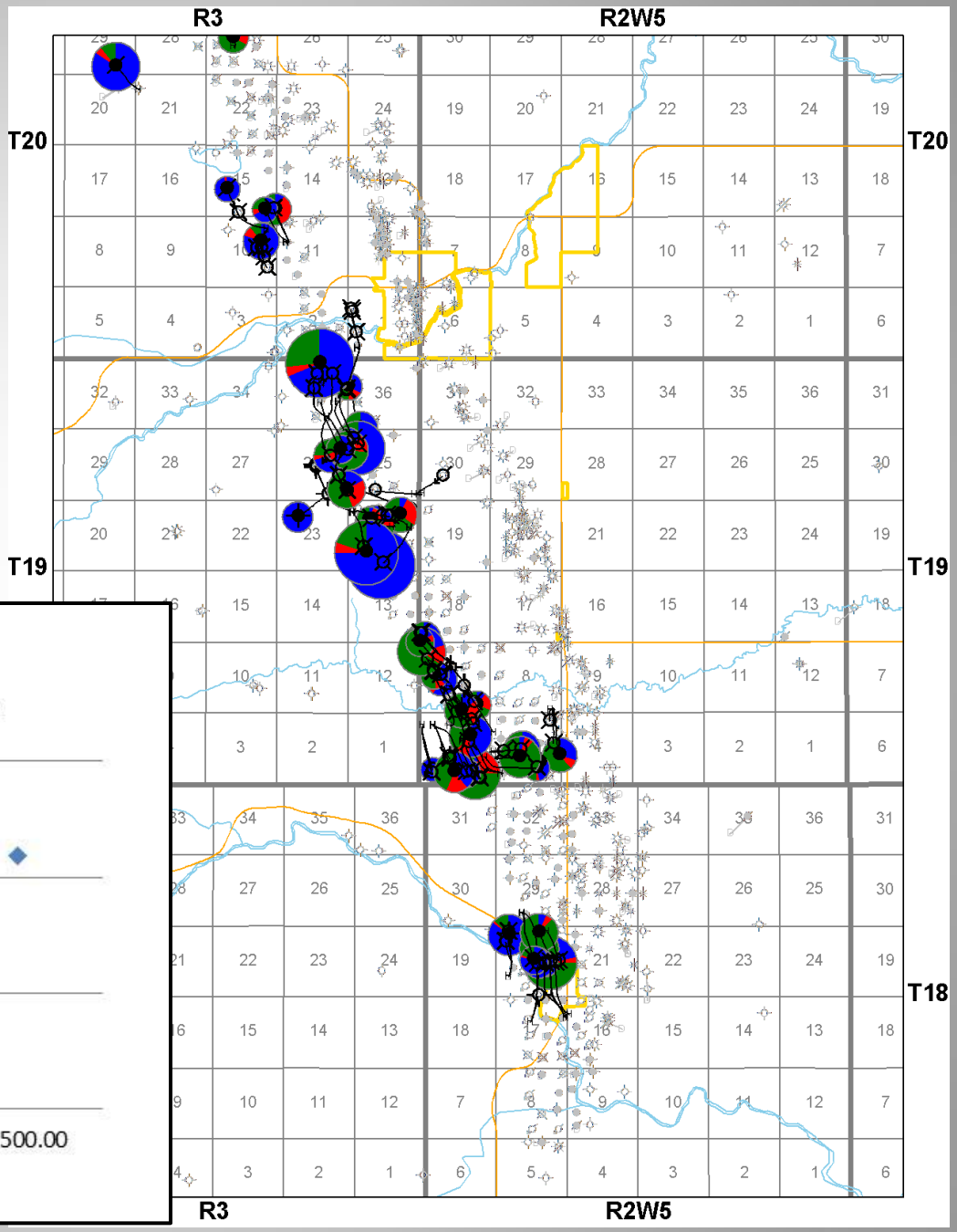


Turner Valley Field
spud during the 2010's

Horizontal Wells in Turner Valley

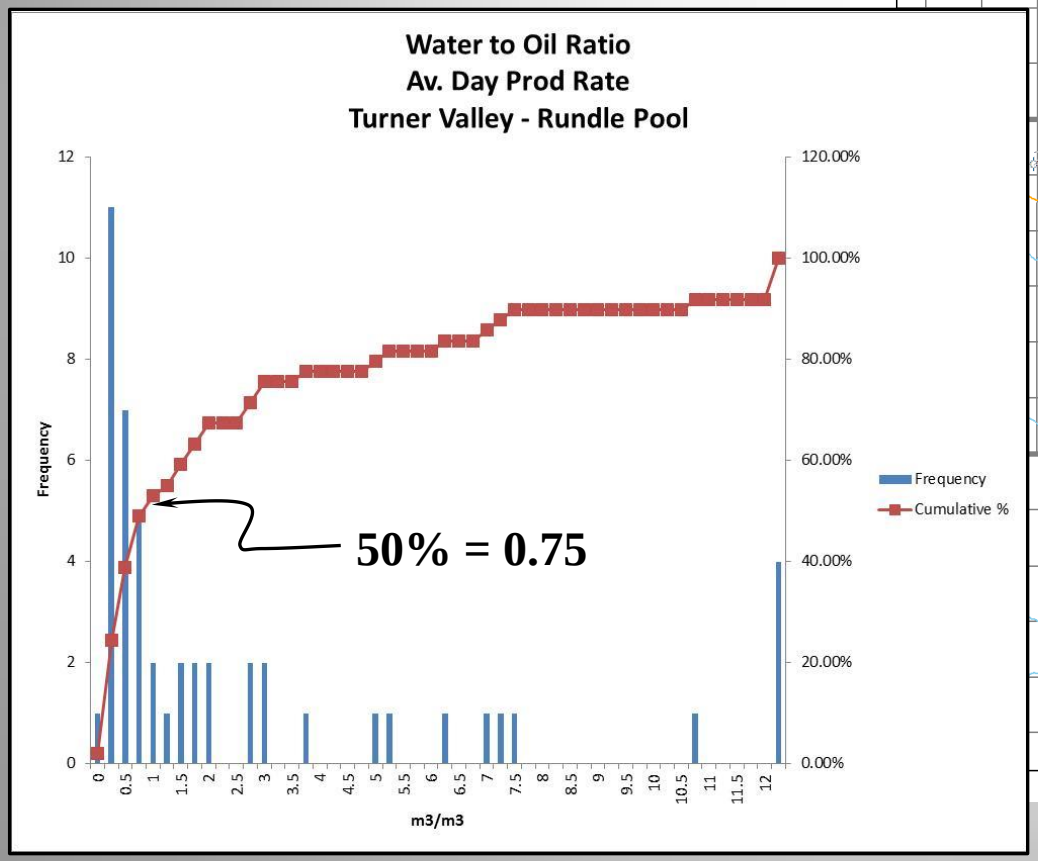
- Production does not appear to be directly related to Horizontal distance

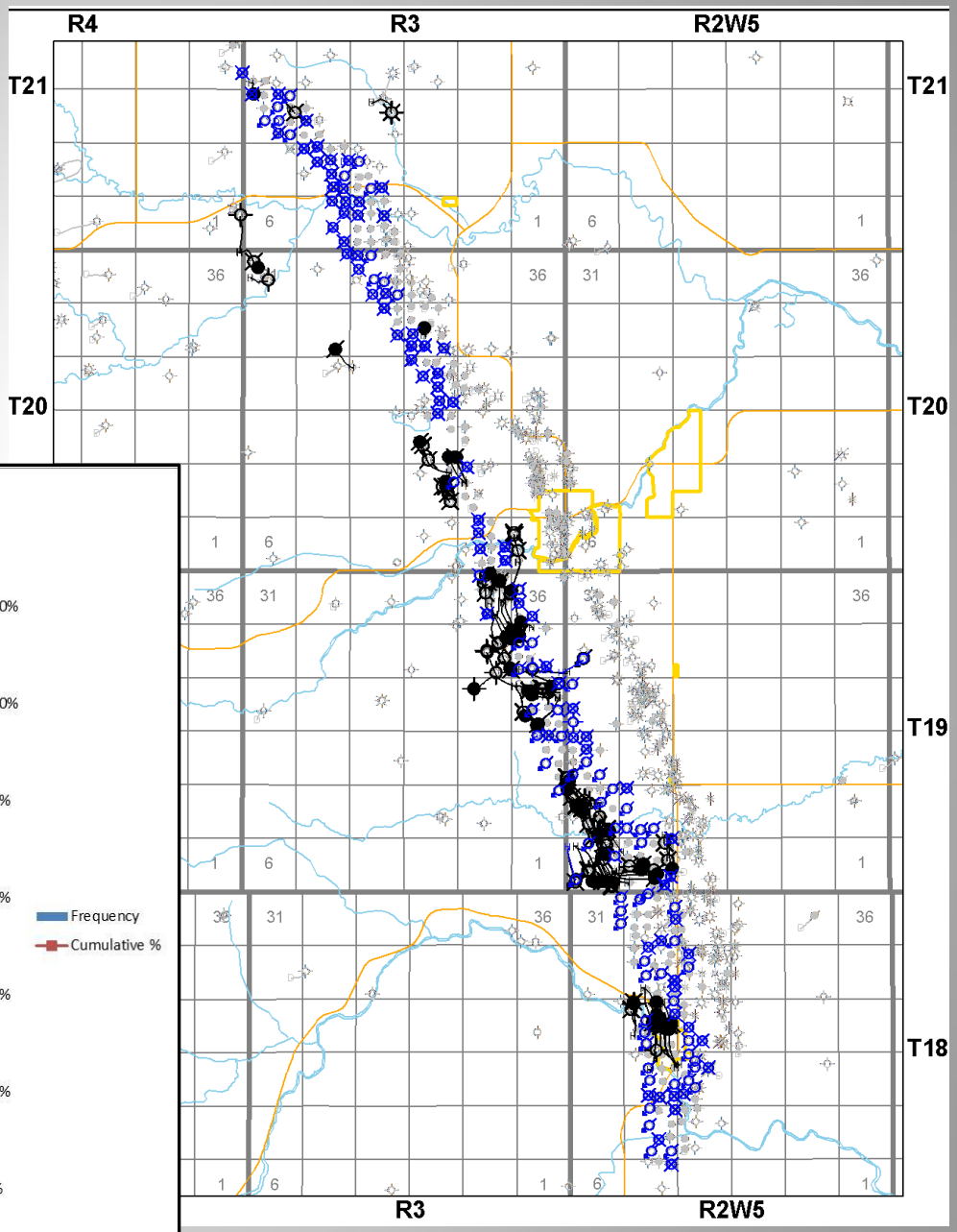




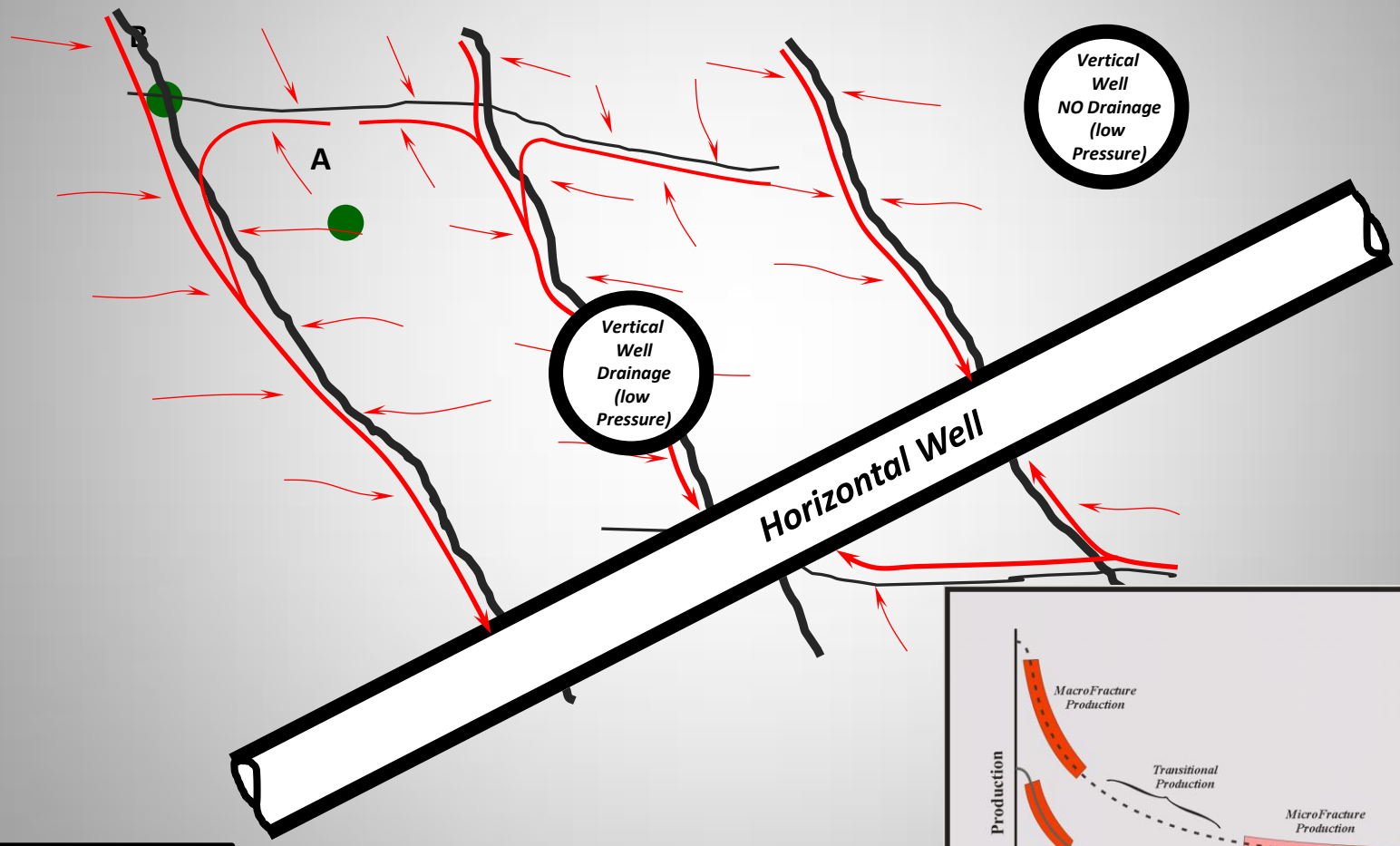
Horizontal Wells in Turner Valley

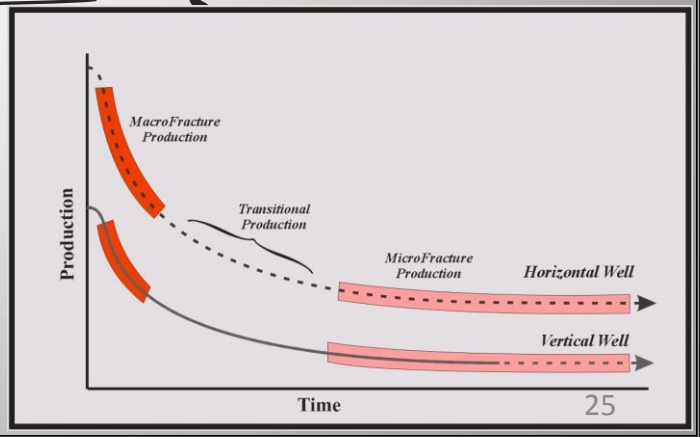
- Oil production does not appear to be overly impacted by previous water flood





$$\vec{Q} = \frac{-\vec{k}A}{\mu}\frac{(P_b - P_a)}{L}$$





Conceptual View of a Fractured Reservoir

Plan View

Doubtless many additional questions will arise in the minds of those continuing this research. Whether we shall be able to find all the answers, or enough answers to formulate guiding principles in the search for new fields, remains for the future, but in the writer's opinion the possible economic value of further inquiry certainly would justify the effort required for intensive research.

- A.J. Goodman, 1945