Influence of Proterozoic Belt-Purcell Rift System on Phanerozoic Facies, Isopachs, Structures and Hydrocarbon Prospectivity in Montana*

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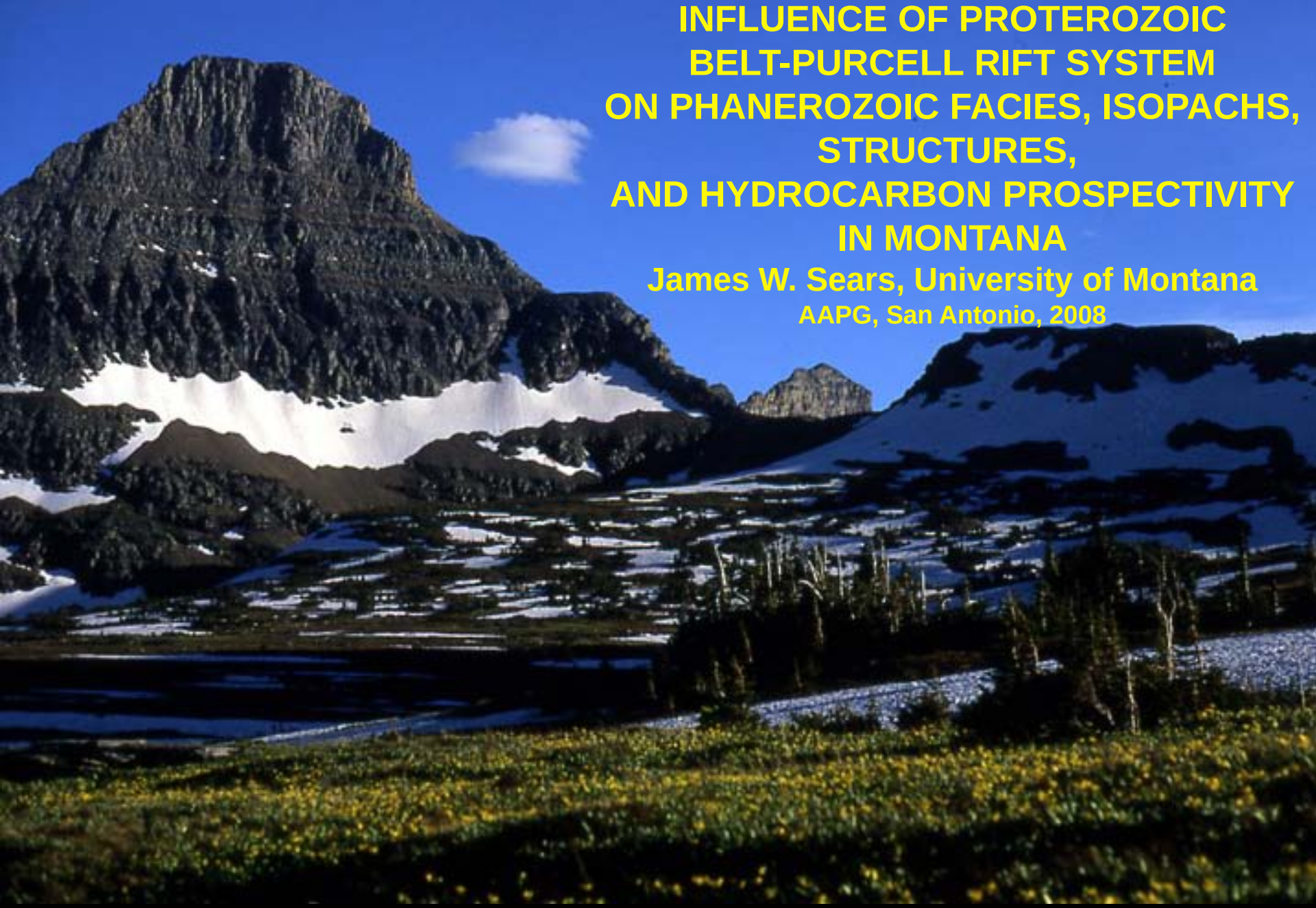
Abstract

The Proterozoic Belt-Purcell Basin of NW USA and SW Canada originated at a triple-rift junction where three continental rift zones intersected to define a triangular graben. The complex internal structure of the triangular rift basin included two deep grabens and a central horst. The architecture of the rift system influenced Phanerozoic sedimentation and tectonics. Two of the rift arms evolved into the Cordilleran miogeoclinal margin, with separation of a conjugate continent, likely the Siberian craton. The third rift arm defines the ESE-trending Montana-Tennessee lineament (MTL). Segments of the MTL now define the Lewis and Clark line, Helena embayment, and Central Montana trough. Tectonic adjustments along the MTL, evident in isopach and facies maps of Phanerozoic periods, indicate that the cratonal blocks on opposite sides were alternately uplifted or depressed as they responded independently to far-field tectonic loads. At times the system was extended as the blocks separated, and at times it was compressed as the blocks converged. These shifts permitted accumulation of evaporites and hydrocarbon source rocks along the Central Montana trough.

The NE block uplifted in response to the Columbian orogeny, with deep middle Jurassic erosion of a broad fore-bulge, then subsided under the load of the foreland basin as the Rocky Mountain fold-thrust belt propagated eastward. Late Cretaceous granitic batholiths injected east along the MTL into central Montana. The SW block was imbricated into the Rocky Mountain foreland basement uplifts. In detail, the shifting of the rift components of the original Belt-Purcell Basin reactivated old faults and compartmentalized the Montana Rocky Mountain fold-thrust belt. The contrasting geologic histories resulted in significantly different hydrocarbon prospectivity on either side of the MTL.

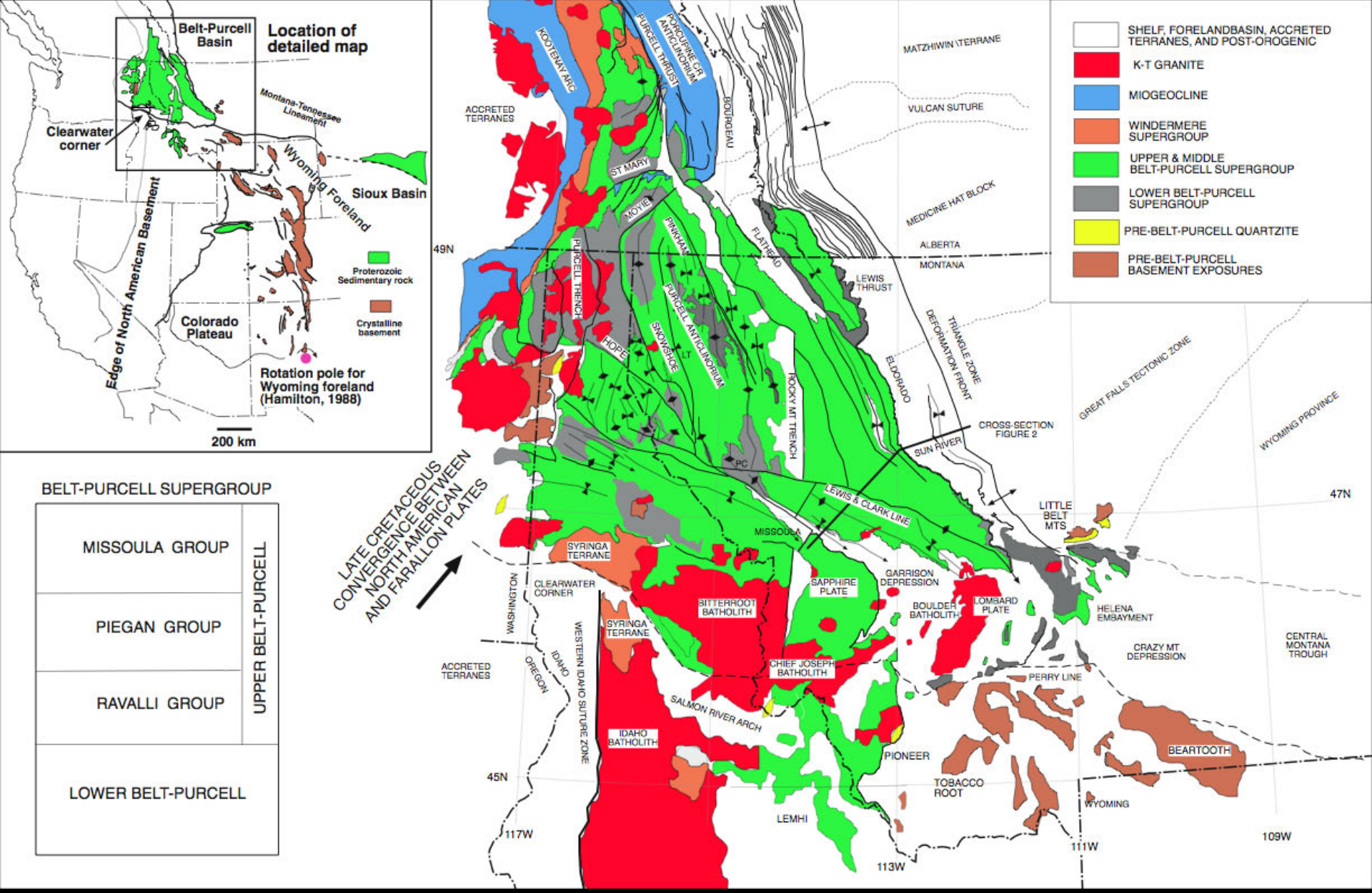


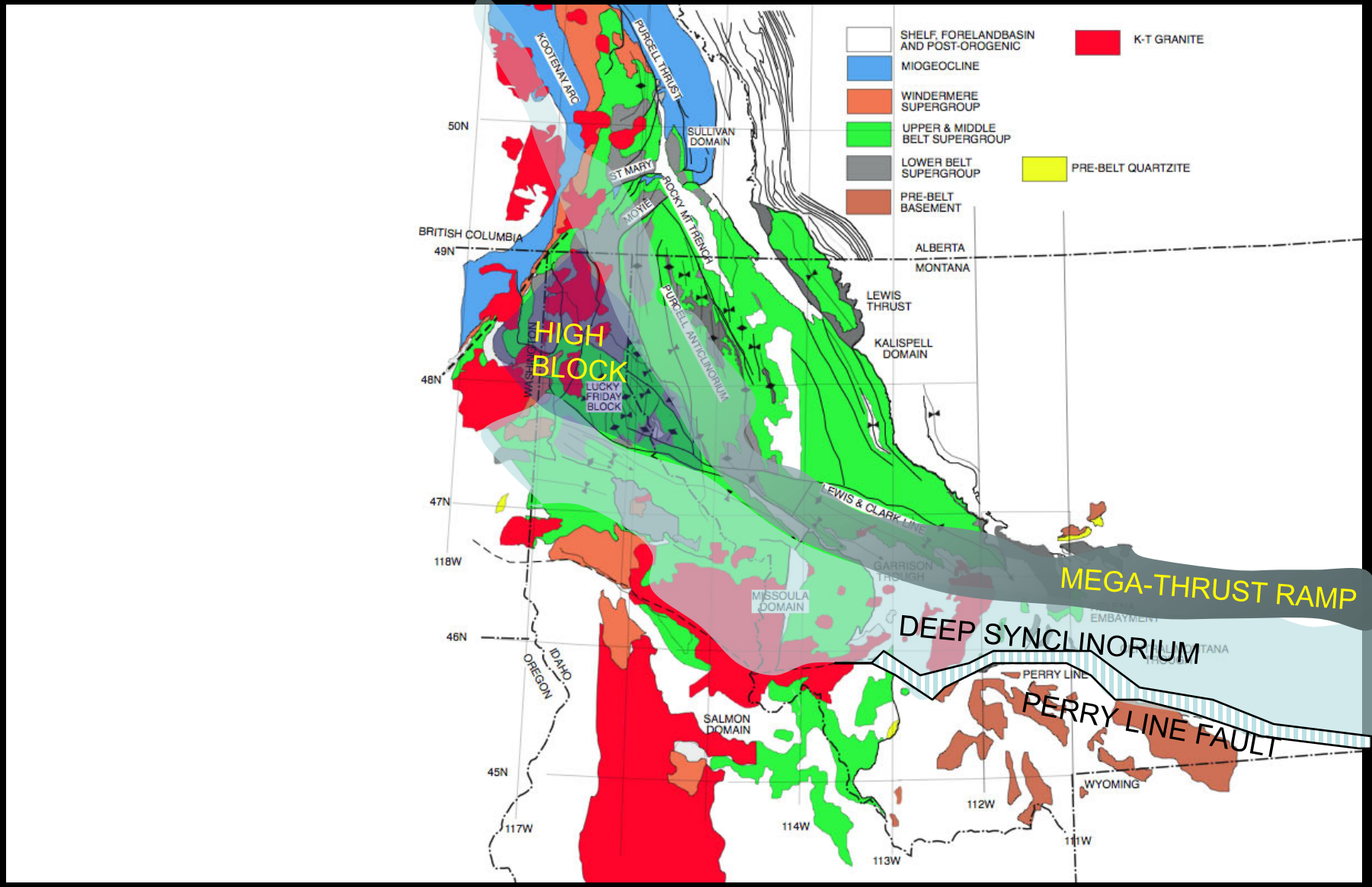
INFLUENCE OF PROTEROZOIC BELT-PURCELL RIFT SYSTEM ON PHANEROZOIC FACIES, ISOPACHS, STRUCTURES, AND HYDROCARBON PROSPECTIVITY IN MONTANA

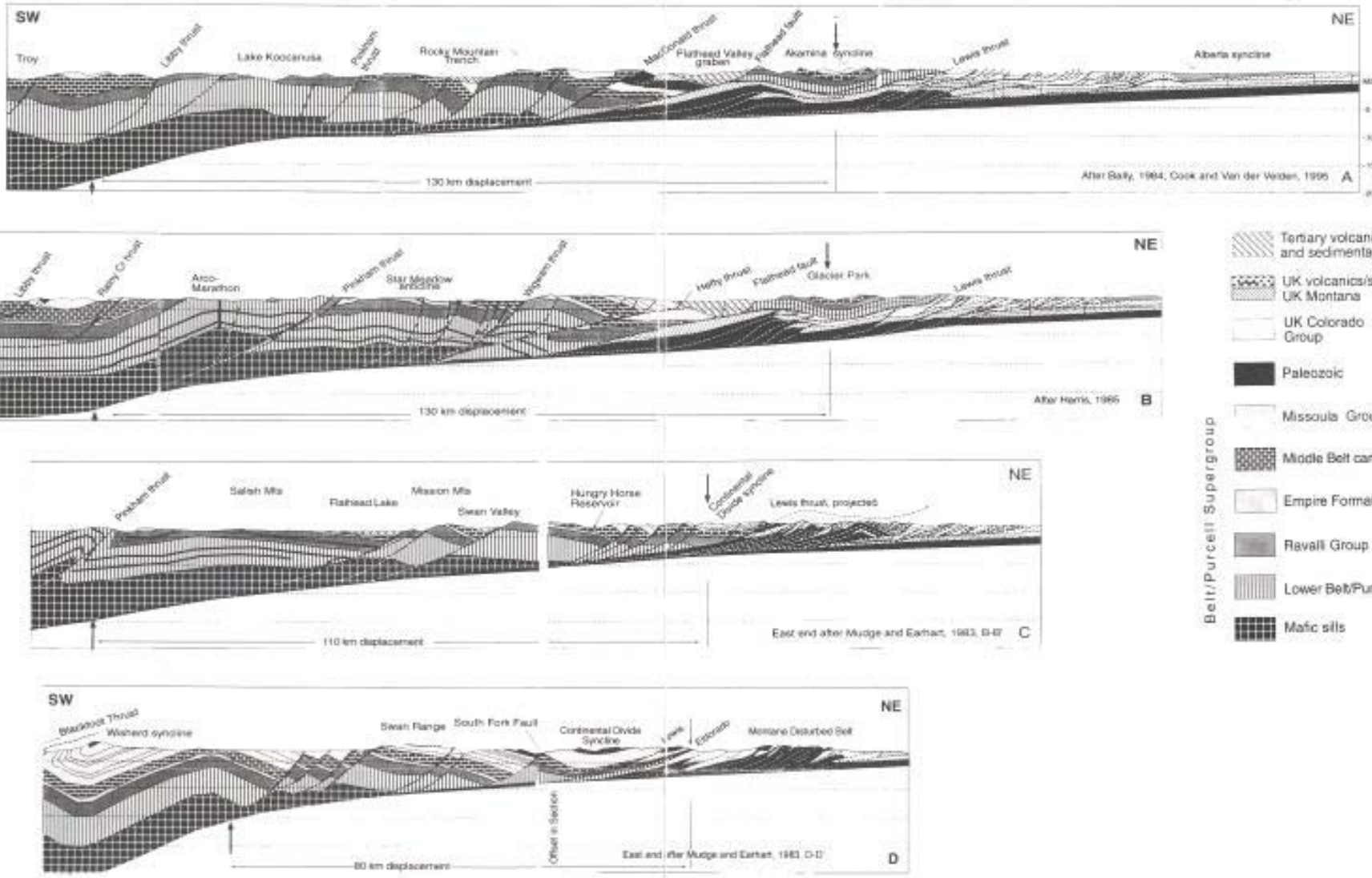
James W. Sears, University of Montana

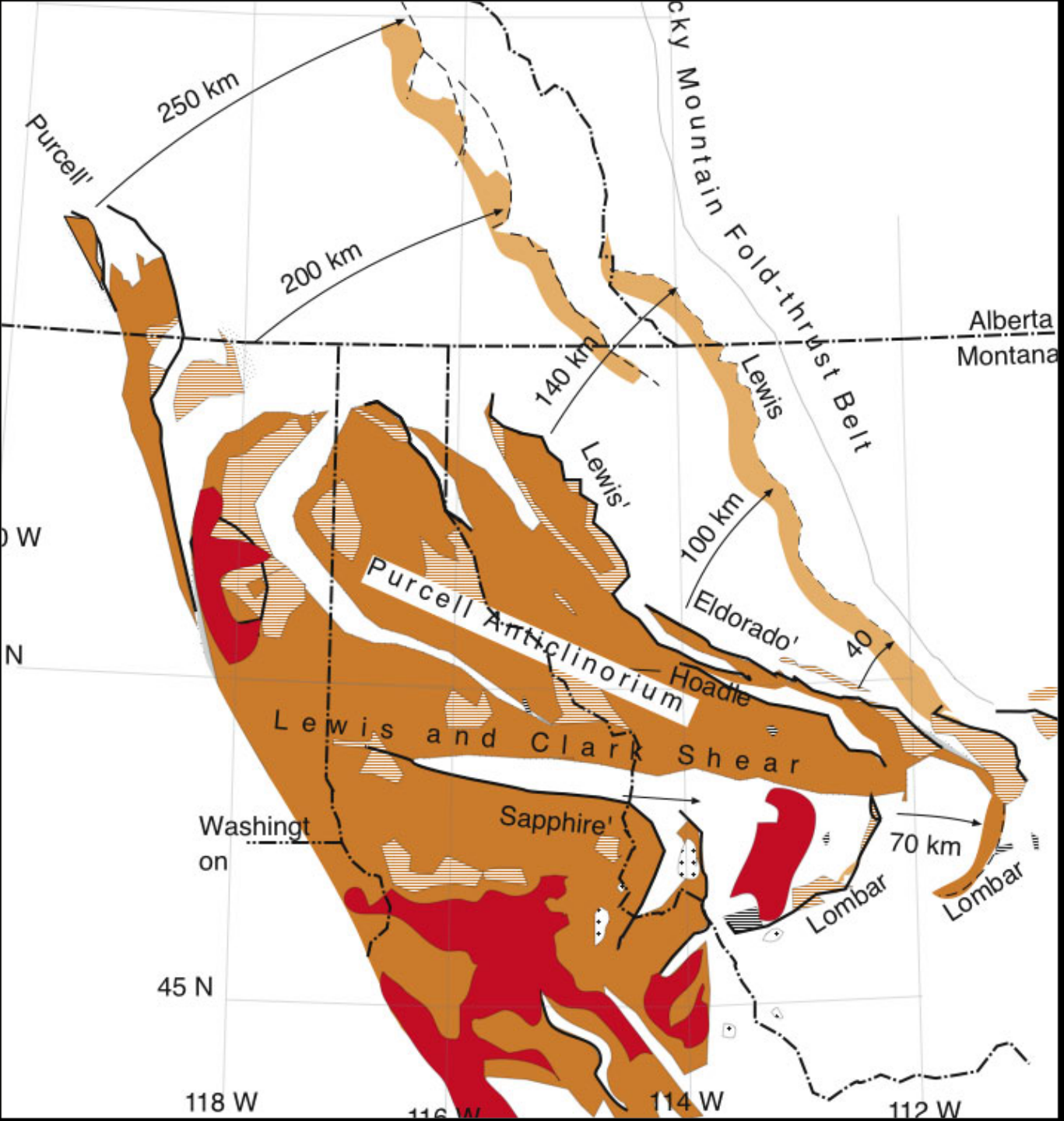
AAPG, San Antonio, 2008

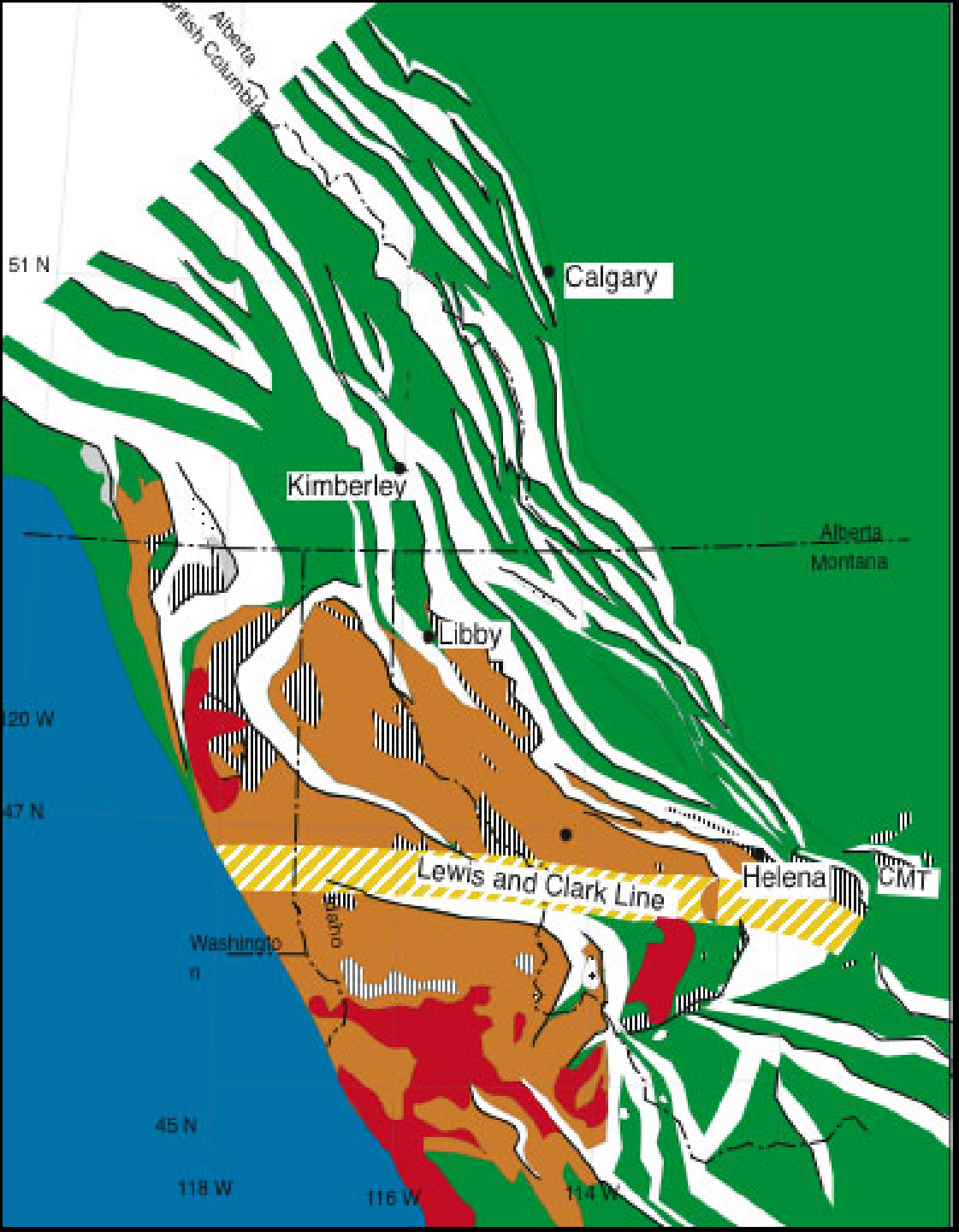

TRIANGLE ZONE
ALBERTA
MONTANA
Area of Fig.2
Spokane
Kalispell
S. Saskatchewan
2uK
1uK
JK
mTvm
TQ
LKg
eTq
Q

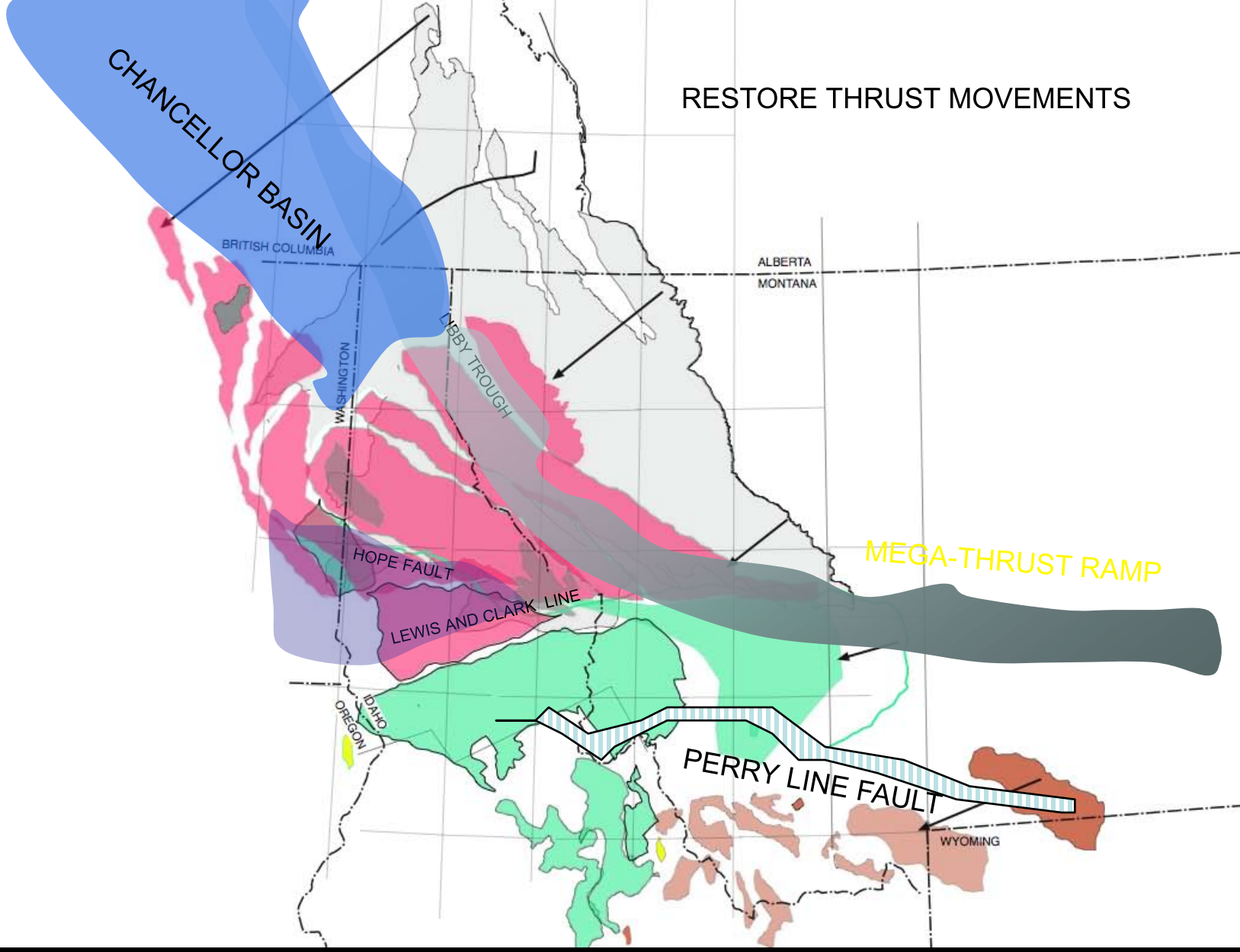

Belt-Purcell Basin
Location of detailed map
Clearwater corner
Montana-Tennessee Lineament
Wyoming Foreland
Sioux Basin
Edge of North American Basement
Colorado Plateau
Proterozoic Sedimentary rock
Crystalline basement
Rotation pole for Wyoming foreland (Hamilton, 1988)
200 km
SHELF, FORELANDBASIN, ACCRETED TERRANES, AND POST-OROGENIC
K-T GRANITE
MIOGEOCLINE
WINDERMERE SUPERGROUP
UPPER & MIDDLE BELT-PURCELL SUPERGROUP
LOWER BELT-PURCELL SUPERGROUP
PRE-BELT-PURCELL QUARTZITE
PRE-BELT-PURCELL BASEMENT EXPOSURES
KOOTENAY ARC
PURCELL THRUST
PORCUPINE CR ANTICLINORIUM
BOUNDARY
ACCRETED TERRANES
ST MARY
MOYIE
PURCELL TRENCH
HOPE
PINKHAM
SNOWSHOE
PURCELL ANTICLINORIUM
FLATHEAD
MATZHIWIN TERRANE
VULCAN SUTURE
MEDICINE HAT BLOCK
ALBERTA
MONTANA
49N
LEWIS THRUST
ROCKY MT TRENCH
ELDORADO
TRIANGLE ZONE DEFORMATION FRONT
GREAT FALLS TECTONIC ZONE
WYOMING PROVINCE
CROSS-SECTION FIGURE 2
SUN RIVER
PC
LEWIS & CLARK LINE
47N
LITTLE BELT MTS
MISSOULA
SYRINGA TERRANE
CLEARWATER CORNER
WASHINGTON
SAPPHIRE PLATE
GARRISON DEPRESSION
SITTERROOT BATHOLITH
BOULDER BATHOLITH
LOMBARD PLATE
HELENA EMBAYMENT
CENTRAL MONTANA TROUGH
CRAZY MT DEPRESSION
SYRINGA TERRANE
ACCRETED TERRANES
IDAHO
OREGON
WESTERN IDAHO SUTURE ZONE
CHIEF JOSEPH BATHOLITH
PERRY LINE
SALMON RIVER ARCH
IDAHO BATHOLITH
PIONEER
BEARTOOTH
TOBACCO ROOT
WYOMING
LEMHI
45N
117W
113W
111W
109W
LATE CRETACEOUS CONVERGENCE BETWEEN NORTH AMERICAN AND FARALLON PLATES
BELT-PURCELL SUPERGROUP
MISSOULA GROUP
PIEGAN GROUP
RAVALLI GROUP
LOWER BELT-PURCELL
UPPER BELT-PURCELL

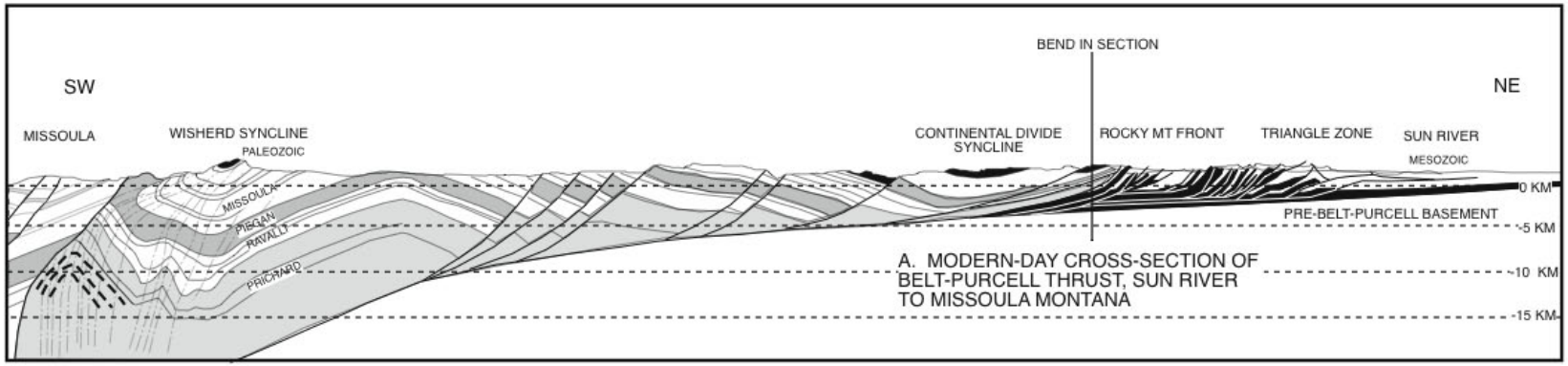

SHELF, FORELANDBASIN AND POST-OROGENIC
MIOGEOCLINE
WINDERMERE SUPERGROUP
UPPER & MIDDLE BELT SUPERGROUP
LOWER BELT SUPERGROUP
PRE-BELT BASEMENT
K-T GRANITE
PRE-BELT QUARTZITE
KOOTENAY ARC
PURCELL THRUST
SULLIVAN DOMAIN
ST MARY
MOYIE
ROCKY MT TRENCH
PURCELL ANTICLINORIUM
BRITISH COLUMBIA
ALBERTA
MONTANA
LEWIS THRUST
KALISPELL DOMAIN
HIGH BLOCK
LUCKY FRIDAY BLOCK
LEWIS & CLARK LINE
GARRISON TROUGH
MISSOULA DOMAIN
EMBAYMENT
MEGA-THRUST RAMP
DEEP SYNCLINORIUM
PERRY LINE
PERRY LINE FAULT
SALMON DOMAIN
IDAHO
OREGON
WYOMING
50N
49N
48N
47N
46N
45N
118W
117W
114W
113W
112W
111W

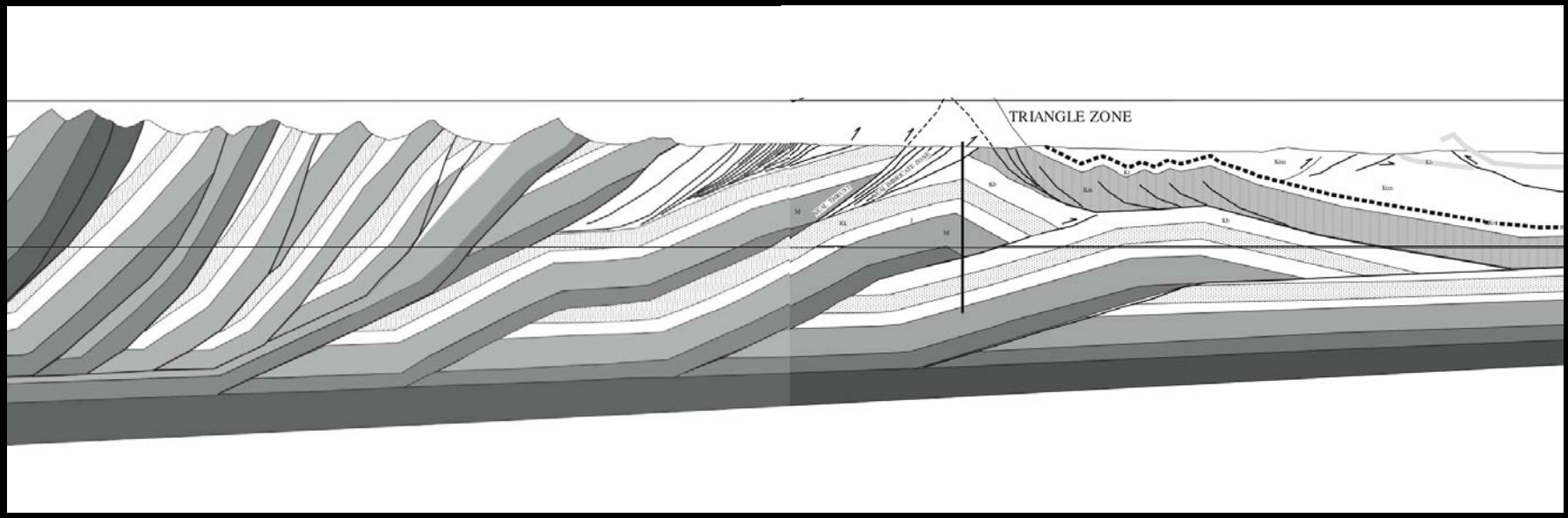

SW
NE
Troy
Libby thrust
Lake Koocanusa
Purcell thrust
Rocky Mountain Trench
MacDonald thrust
Flathead Valley graben
Flathead fault
Akamina syncline
Lewis thrust
Alberta syncline
130 km displacement
After Bally, 1984; Cook and Van der Velden, 1995
A
SW
NE
Libby thrust
Rocky Cr thrust
Arco-Marathon
Prichard thrust
Star Meadow anticline
Wigwam thrust
Hefty thrust
Flathead fault
Glacier Park
Lewis thrust
130 km displacement
After Harris, 1986
B
Prichard thrust
Salish Mts
Flathead Lake
Mission Mts
Swan Valley
Hungry Horse Reservoir
Continental Divide syncline
Lewis thrust, projected
NE
110 km displacement
East end after Mudge and Earhart, 1983, D-D'
C
SW
NE
Blackfoot Thrust
Washed syncline
Swan Range
South Fork Fault
Continental Divide Syncline
Lewis
Eldorado
Montana Disturbed Belt
Offset in Section
80 km displacement
East end after Mudge and Earhart, 1983, D-D'
D
Tertiary volcanic and sedimentary
UK volcanics/sills UK Montana
UK Colorado Group
Paleozoic
Missoula Group
Middle Belt carbonate
Empire Formation
Ravalli Group
Lower Belt/Purcell
Mafic sills
Belt/Purcell Supergroup

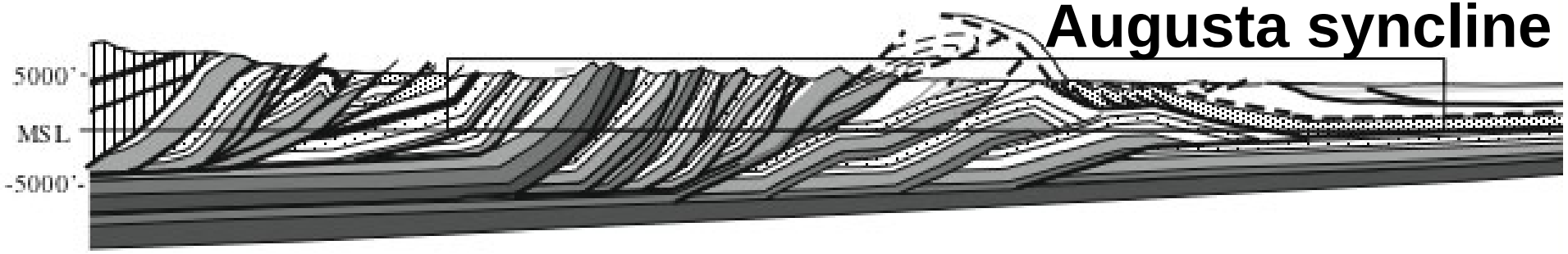

250 km
Purcell'
200 km
Alberta
Montana
140 km
Lewis'
Lewis
Rocky Mountain Fold-thrust Belt
100 km
Eldorado'
40
Purcell Anticlinorium
Hoadle
Lewis and Clark Shear
Sapphire'
Washingt
on
70 km
Lombar
Lombar
45 N
118 W
114 W
112 W


Alberta
British Columbia
51 N
Calgary
Kimberley
Alberta
Montana
Libby
120 W
47 N
Lewis and Clark Line
Helena
CMT
Washington
Idaho
45 N
118 W
116 W
114 W


RESTORE THRUST MOVEMENTS
CHANCELLOR BASIN
BRITISH COLUMBIA
ALBERTA
MONTANA
WASHINGTON
LIBBY TROUGH
HOPE FAULT
LEWIS AND CLARK LINE
MEGA-THRUST RAMP
IDAHO
OREGON
PERRY LINE FAULT
WYOMING

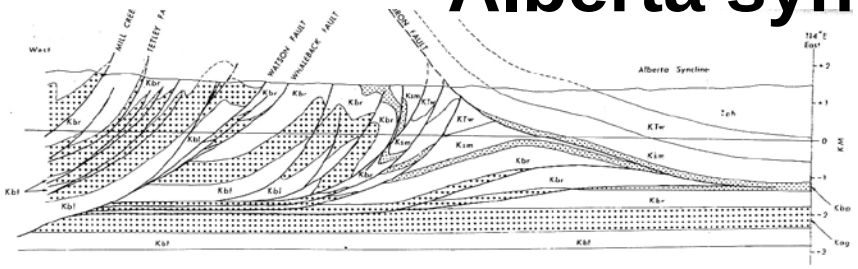

BEND IN SECTION
SW
NE
MISSOULA
WISHERD SYNCLINE
PALEOZOIC
CONTINENTAL DIVIDE SYNCLINE
ROCKY MT FRONT
TRIANGLE ZONE
SUN RIVER
MESOZOIC
MISSOULA
PIEGAN
PAVALLI
PRICHARD
0 KM
PRE-BELT-PURCELL BASEMENT
-5 KM
-10 KM
-15 KM
A. MODERN-DAY CROSS-SECTION OF BELT-PURCELL THRUST, SUN RIVER TO MISSOULA MONTANA


TRIANGLE ZONE



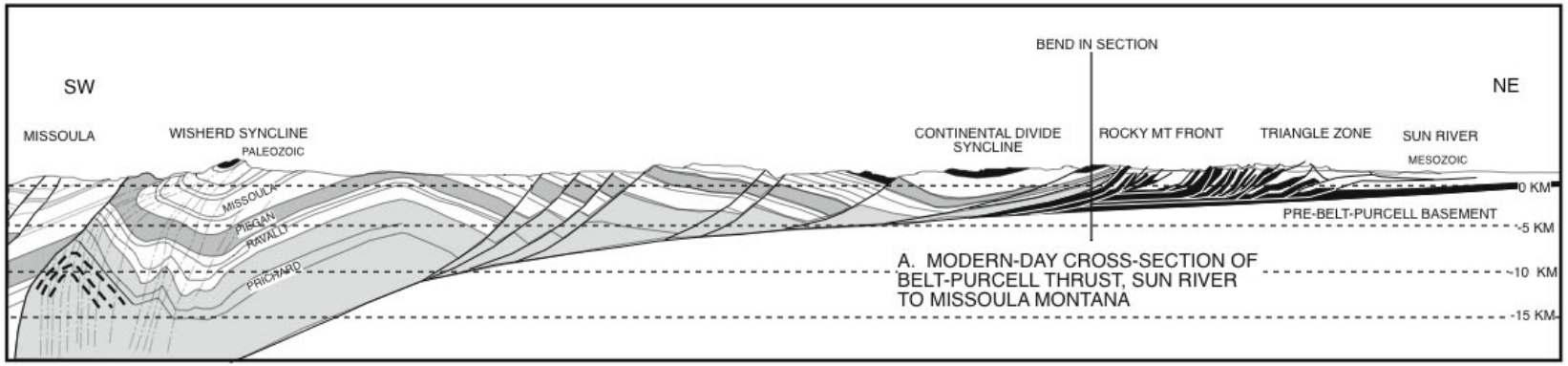
Triangle zone on Sun River transect

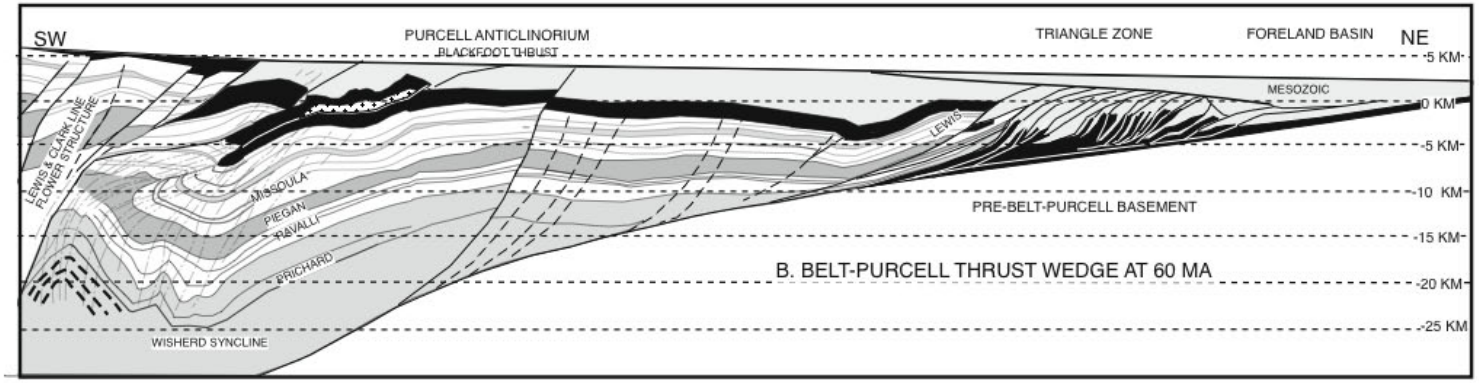
Alberta syncline

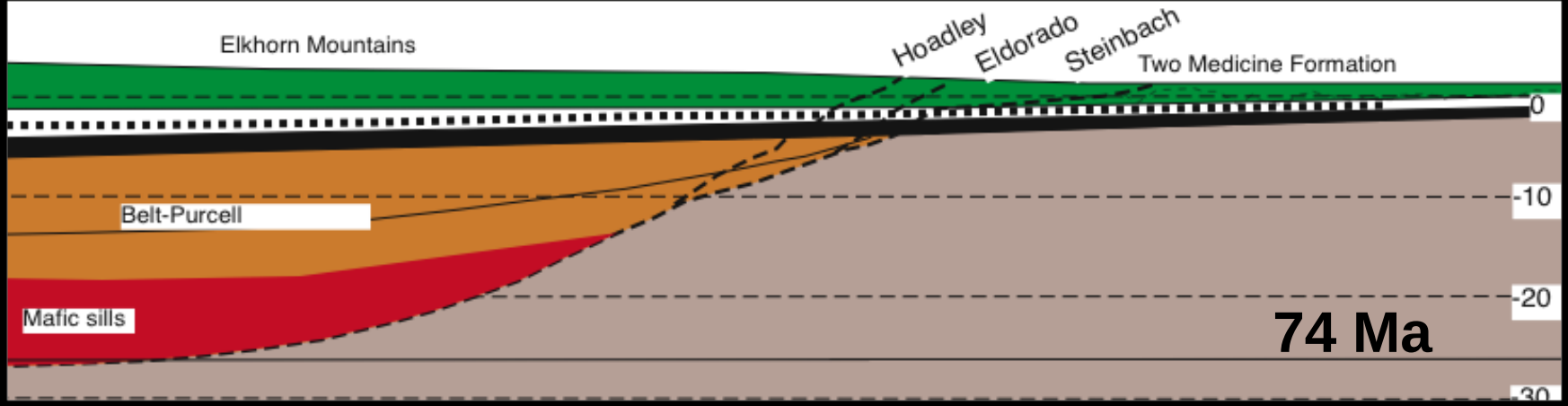


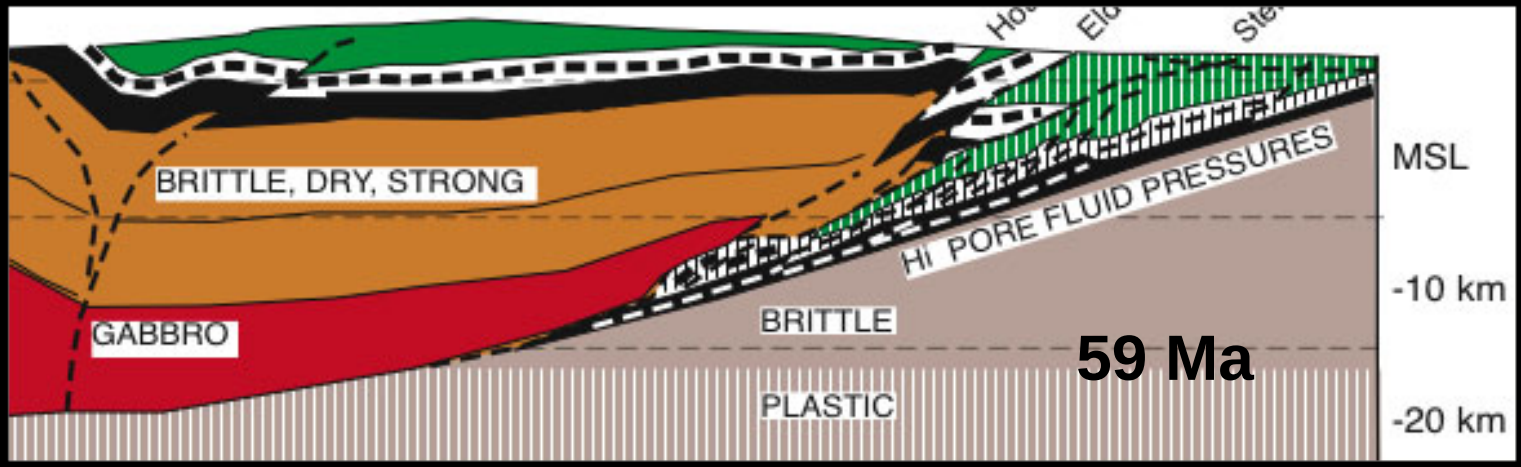
Triangle zone on Calgary transect

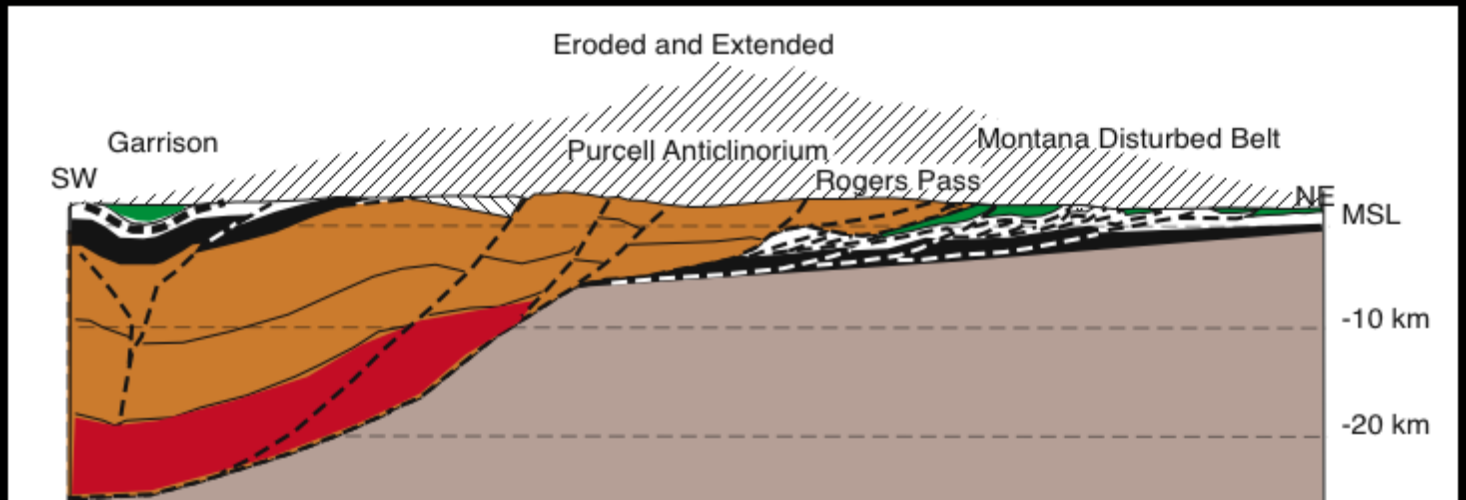
NO BELT SUPERGROUP CLASTS IN LATE K-PALEOCENE FORELAND BASIN

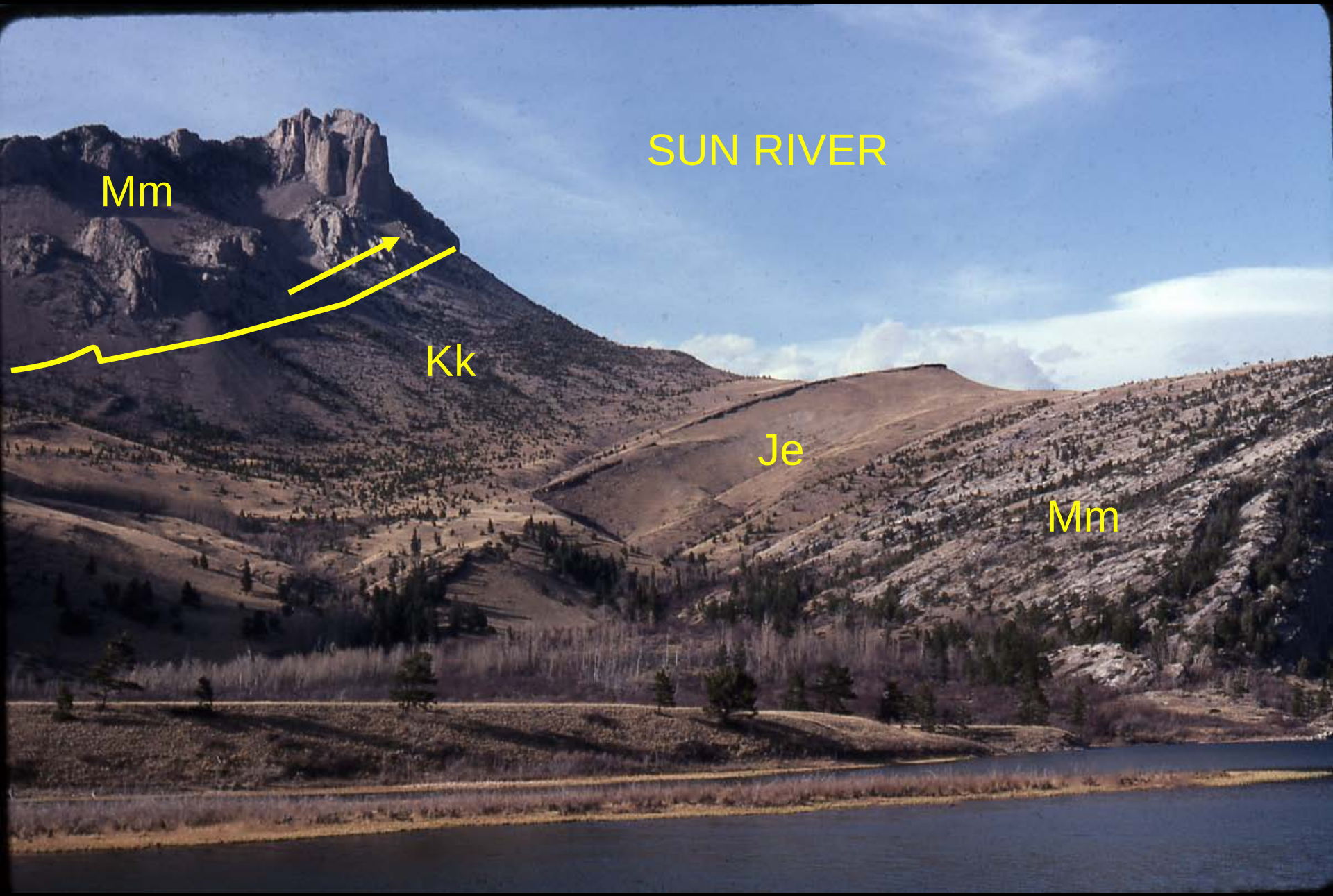

BEND IN SECTION
SW
NE
MISSOULA
WISHERD SYNCLINE
PALEOZOIC
CONTINENTAL DIVIDE SYNCLINE
ROCKY MT FRONT
TRIANGLE ZONE
SUN RIVER
MESOZOIC
MISSOULA
PIEGAN
RAVALLI
PRICHARD
0 KM
PRE-BELT-PURCELL BASEMENT
-5 KM
A. MODERN-DAY CROSS-SECTION OF BELT-PURCELL THRUST, SUN RIVER TO MISSOULA MONTANA
-10 KM
-15 KM

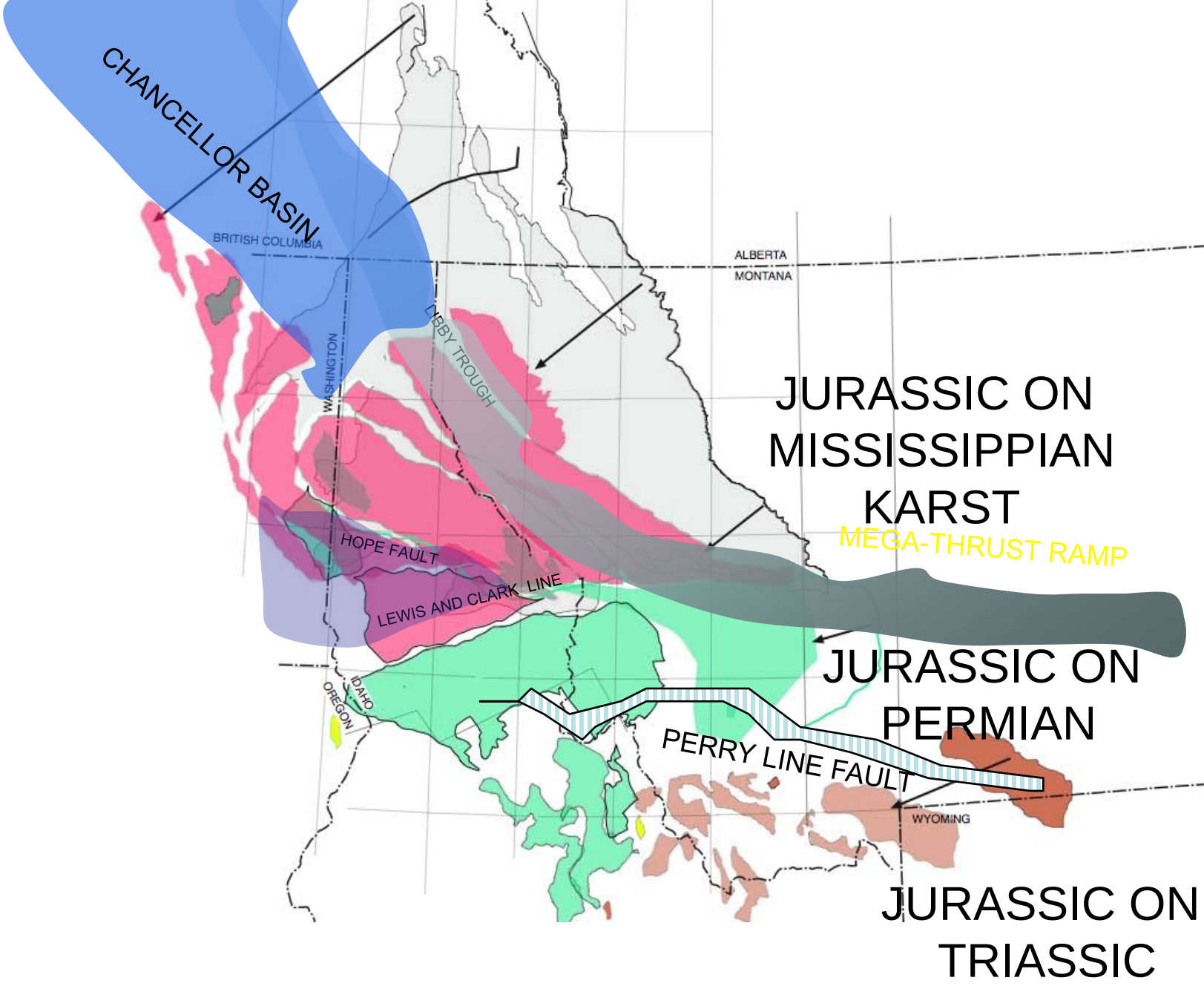

SW
PURCELL ANTICLINORIUM
BLACKFOOT THRUST
TRIANGLE ZONE
FORELAND BASIN
NE
-5 KM
MESOZOIC
0 KM
LEWIS & CLARK LINE
FLOWER STRUCTURE
LEWIS
-5 KM
MISSOULA
-10 KM
PIEGAN
PRE-BELT-PURCELL BASEMENT
RAVALLI
-15 KM
PRICHARD
B. BELT-PURCELL THRUST WEDGE AT 60 MA
-20 KM
WISHERD SYNCLINE
-25 KM

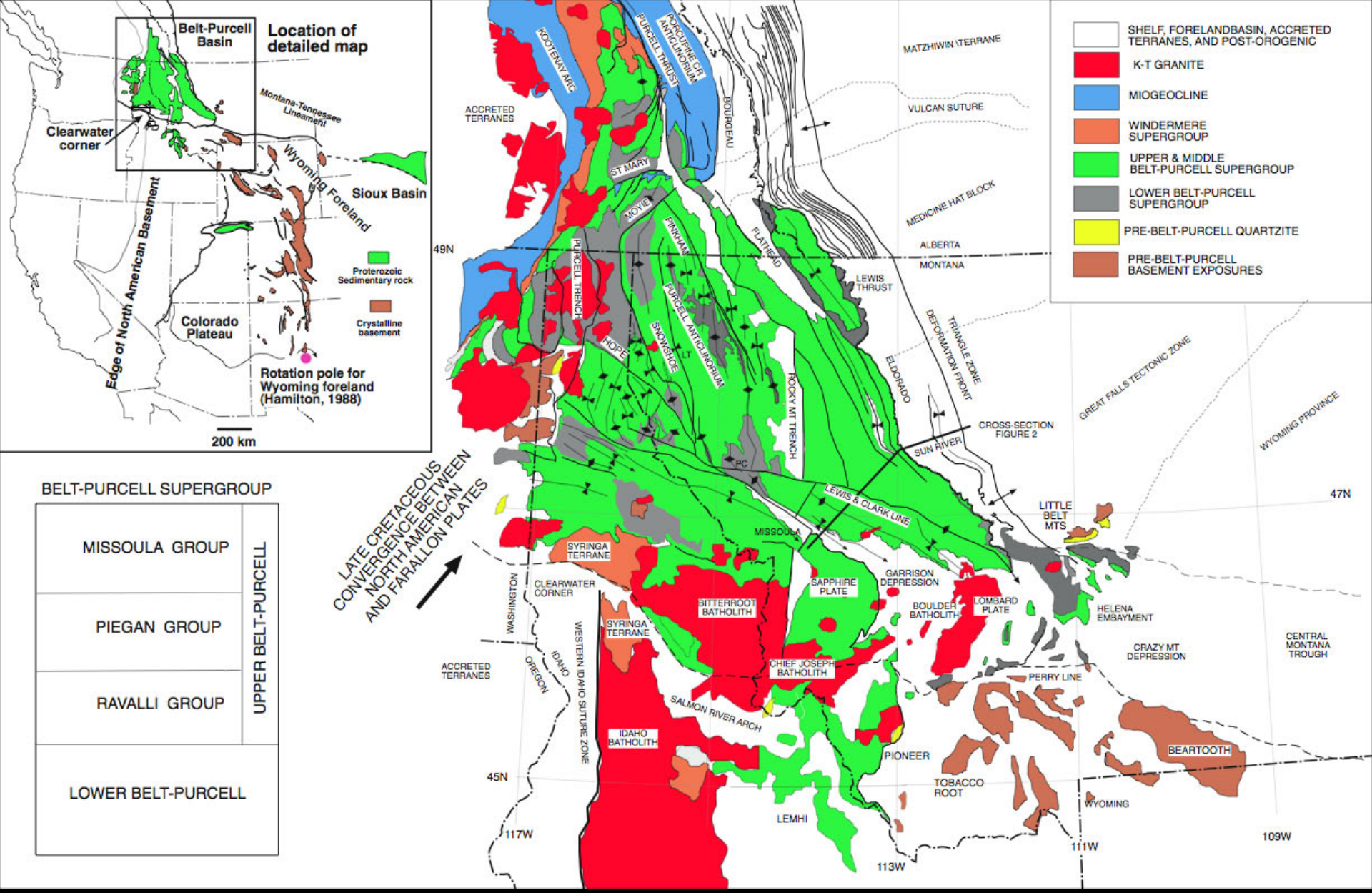

Elkhorn Mountains
Hoadley
Eldorado
Steinbach
Two Medicine Formation
0
-10
-20
-30
Belt-Purcell
Mafic sills
74 Ma


BRITTLE, DRY, STRONG
HI PORE FLUID PRESSURES
MSL
-10 km
-20 km
GABBRO
BRITTLE
PLASTIC
59 Ma


Eroded and Extended
Garrison
SW
Purcell Anticlinorium
Rogers Pass
Montana Disturbed Belt
NE
MSL
-10 km
-20 km


SUN RIVER
Mm
Kk
Je
Mm


CHANCELLOR BASIN
BRITISH COLUMBIA
ALBERTA
MONTANA
WASHINGTON
LIBBY TROUGH
JURASSIC ON MISSISSIPPIAN KARST
MEGA-THRUST RAMP
HOPE FAULT
LEWIS AND CLARK LINE
IDAHO
OREGON
JURASSIC ON PERMIAN
PERRY LINE FAULT
WYOMING
JURASSIC ON TRIASSIC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Montana-Tennessee Lineament
Wyoming Foreland
Sioux Basin
Edge of North American Basement
Colorado Plateau
Proterozoic Sedimentary rock
Crystalline basement
Rotation pole for Wyoming foreland (Hamilton, 1988)
200 km
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PRE-BELT-PURCELL QUARTZITE
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PURCELL THRUST
PORCUPINE CR ANTICLINORIUM
BOUNDARY
ACCRETED TERRANES
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PURCELL ANTICLINORIUM
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OREGON
WESTERN IDAHO SUTURE ZONE
CHIEF JOSEPH BATHOLITH
PERRY LINE
SALMON RIVER ARCH
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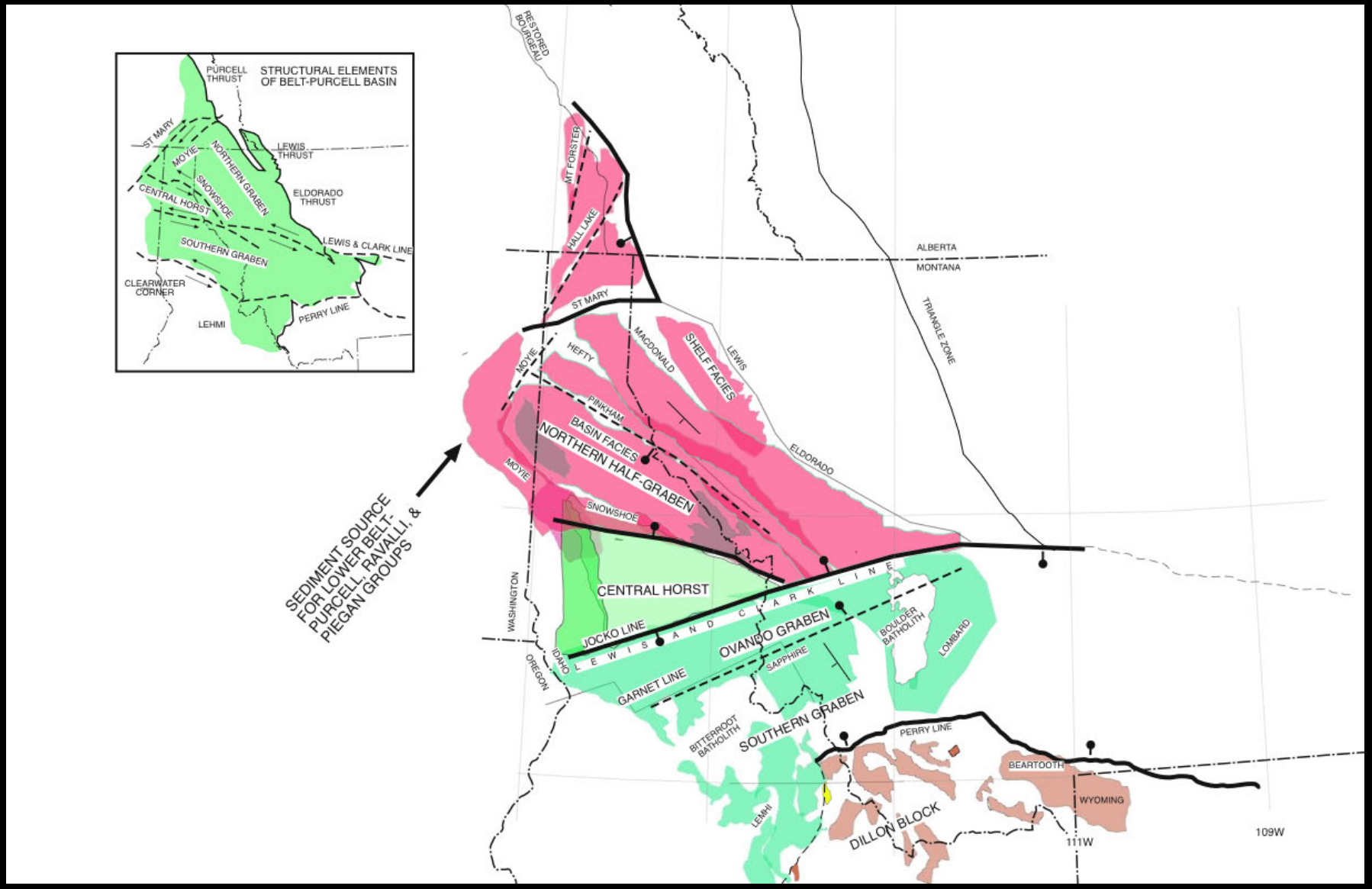
LOWER BELT-PURCELL
UPPER BELT-PURCELL


STRUCTURAL ELEMENTS OF BELT-PURCELL BASIN
PURCELL THRUST
ST MARY
MOYIE
NORTHERN GRABEN
LEWIS THRUST
SNOWSHOE
CENTRAL HORST
ELDORADO THRUST
SOUTHERN GRABEN
LEWIS & CLARK LINE
CLEARWATER CORNER
PERRY LINE
LEHMI
SEDIMENT SOURCE FOR LOWER BELT-PURCELL, RAVALLI, & PIEGAN GROUPS
RESTORED BOUNDARY
MT FORSTER
HALL LAKE
ALBERTA
MONTANA
ST MARY
HEFTY
MACDONALD
SHELF FACIES
LEWIS
TRIANGLE ZONE
PINKHAM
BASIN FACIES
NORTHERN HALF-GRABEN
ELDORADO
SNOWSHOE
CENTRAL HORST
WASHINGTON
JOCKO LINE
LEWIS AND CLARK LINE
OVANDO GRABEN
BOULDER BATHOLITH
LOMBARD
IDAHO
OREGON
GARNET LINE
SAPPHIRE
BITTERROOT BATHOLITH
SOUTHERN GRABEN
PERRY LINE
BEARTOOTH
WYOMING
LEHMI
DILLON BLOCK
111W
109W