Terrane

- A crustal block or fragment bounded by faults
- Preserves a geologic history that is distinct from adjacent terranes
- Accreted to a continent by tectonic processes

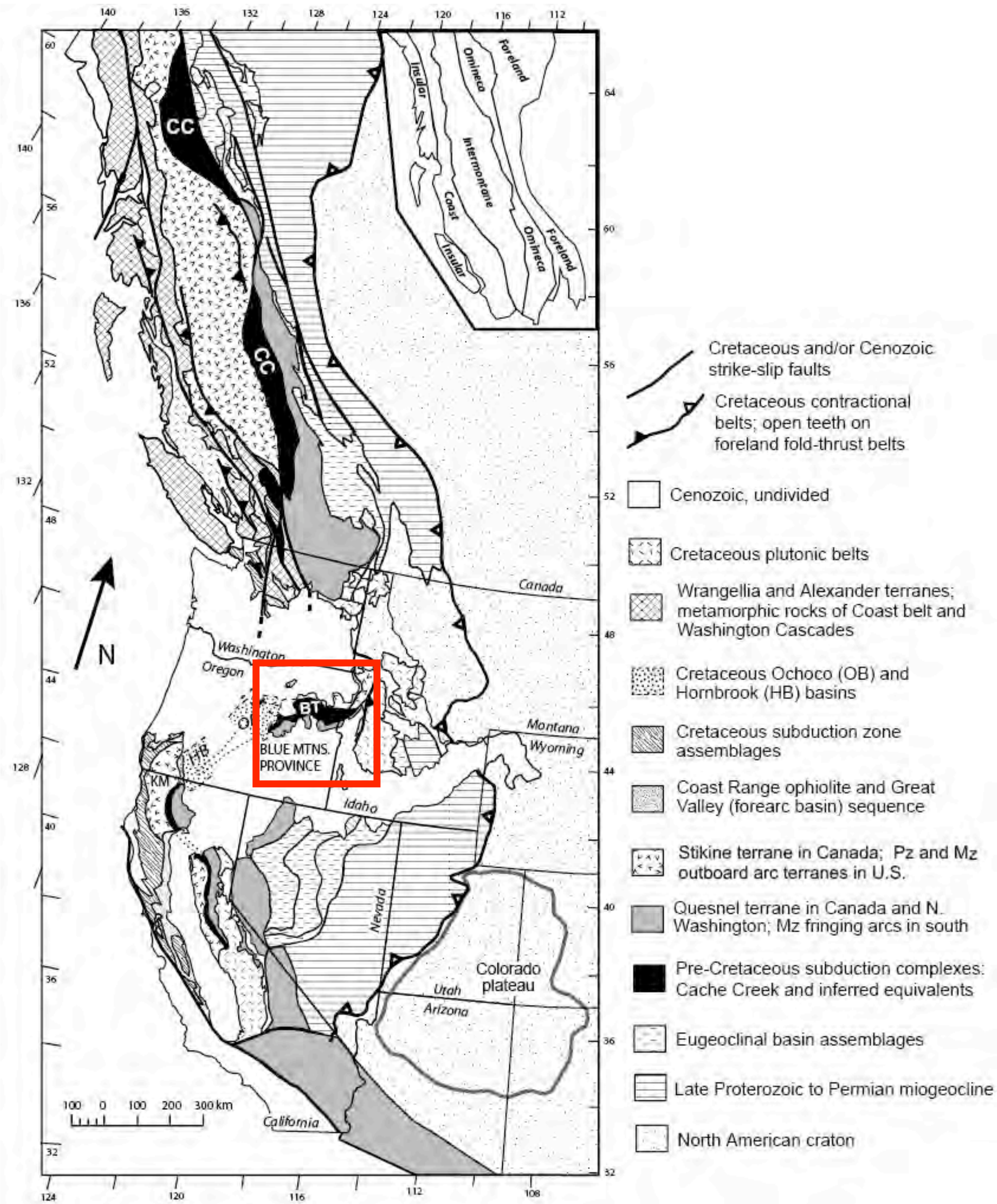
The Blue Mountains:

The Ochocos

The Wallowas

(The Strawberries)

. . .



Dorsey & LaMaskin 2007


The Wallowa Mountains


Hell's Canyon

7 Devil’s Mountains, ID

Cement Plant near Huntington, OR


Blue Mountains, OR

Canyon Mountain Complex, south of John Day, OR
Alternating peridotite (red) and gabbro layers

Paleomagnetism of Permian Wallowa Terrane

Harbert et al 1994

Small digression

5.5. THERMAL REMANENT MAGNETIZATION

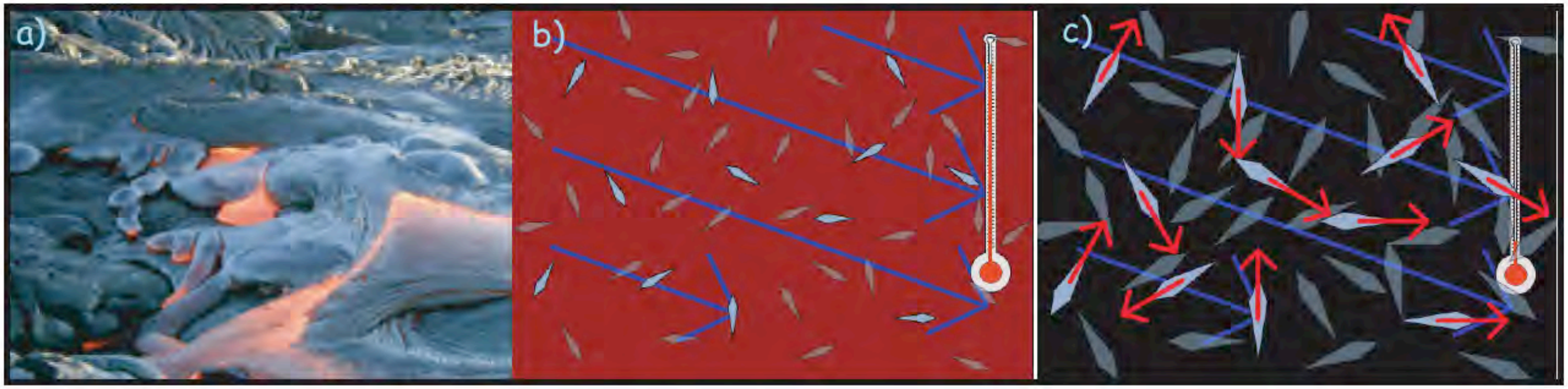


Figure 5.5: a) Picture of lava flow courtesy of Daniel Staudigel. b) While the lava is still well above the Curie temperature, crystals start to form, but are non-magnetic. c) Below the Curie temperature but above the blocking temperature, certain minerals become magnetic, but their moments continually flip among the easy axes with a statistical preference for the applied magnetic field. As the lava cools down, the moments become fixed, preserving a thermal remanence. [b) and c) modified from animation of Genevieve Tauxe available at: http://magician.ucsd.edu/Lab_tour/movs/TRM.mov.

http://earthref.org/MAGIC/books/Tauxe/2005/

5.6 Chemical Remanent Magnetization

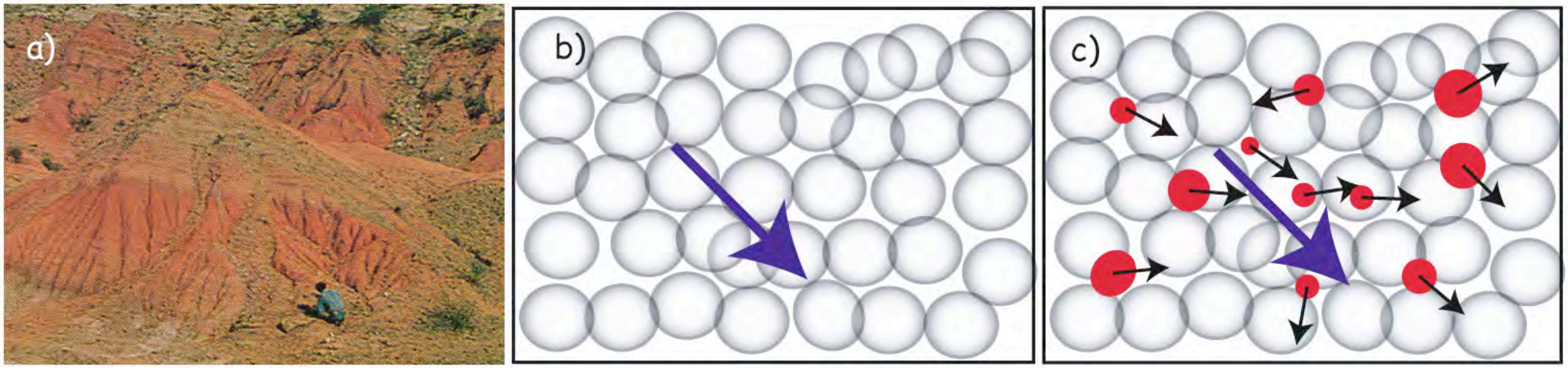


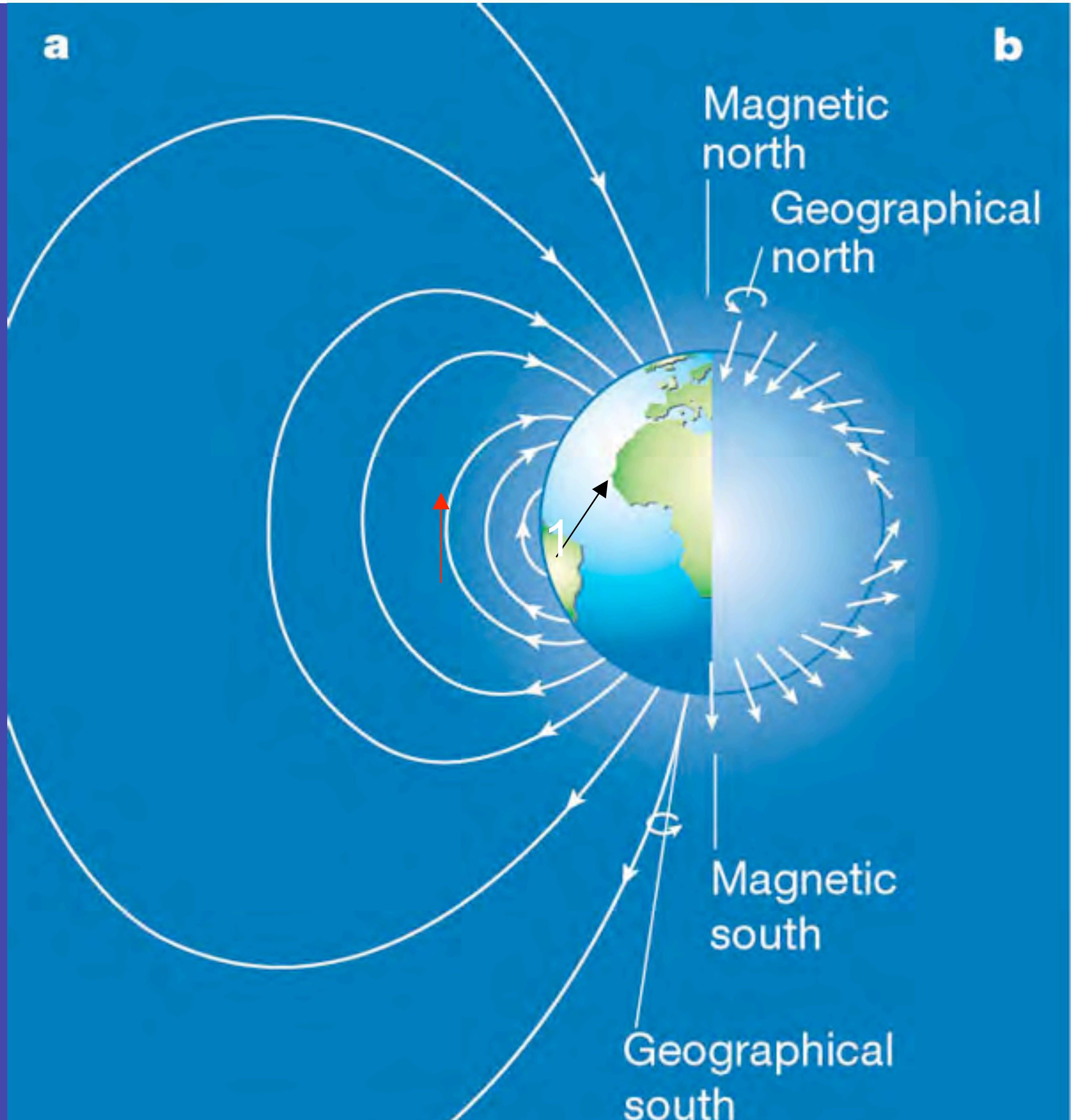
Figure 5.7: Grain growth CRM. a) Red beds of the Chinji Formation, Siwaliks, Pakistan. The red soil horizons have a CRM carried by pigmentary hematite. b) Initial state of non-magnetic matrix. c) Formation of superparamagnetic minerals with a statistical alignment with the ambient magnetic field (shown in blue).

http://earthref.org/MAGIC/books/Tauxe/2005/

Sometime in the geological past …

Magnetic Declination

Magnetic Inclination

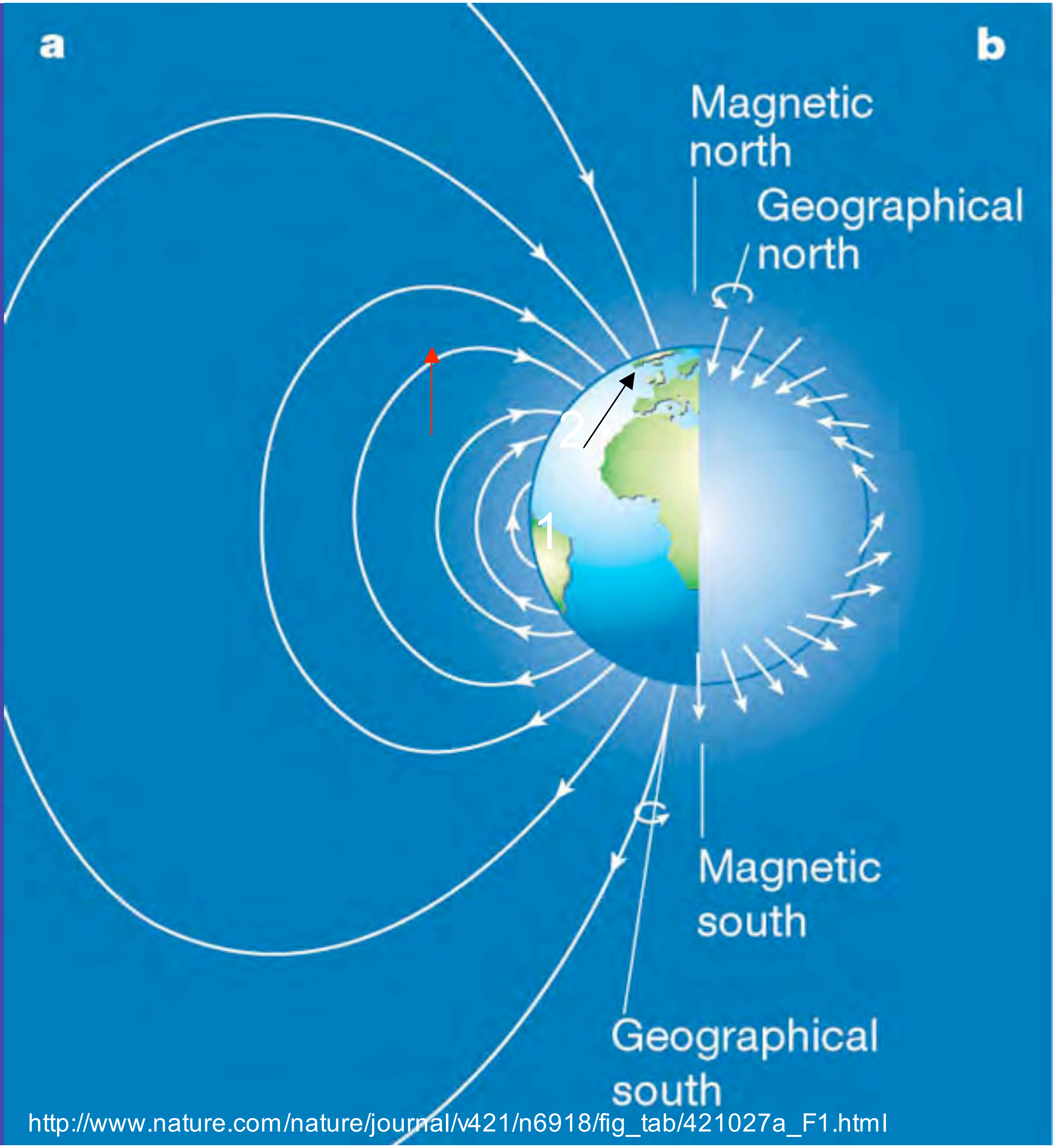


http://www.nature.com/nature/journal/v421/n6918/fig_tab/421027a_F1.html

Plate tectonics moves the plate from (1) to (2)

Magnetic Declination

Paleo-Magnetic Inclination

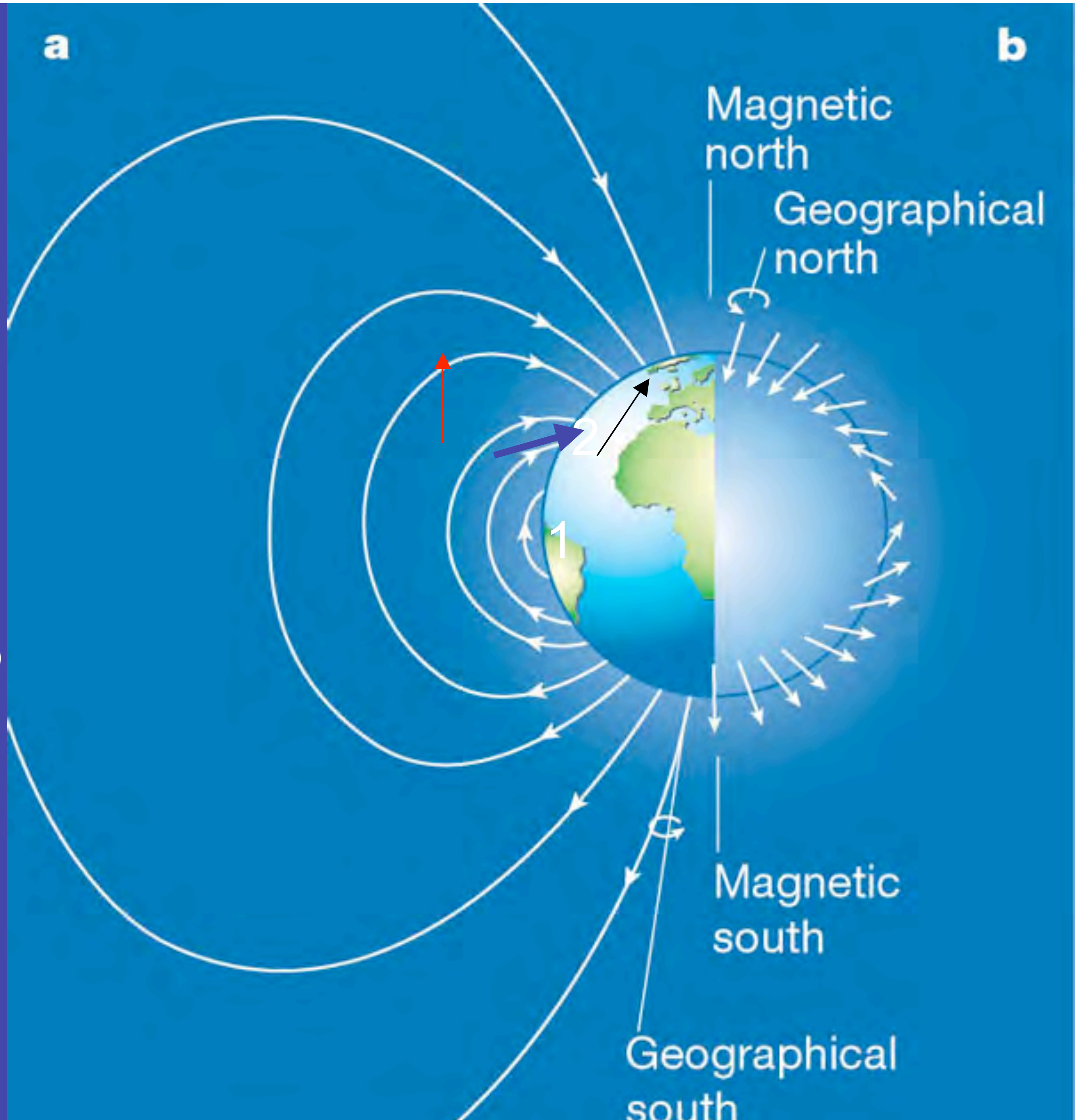


NB difference in magnetic declinations

Magnetic Declination

Paleo-Magnetic Inclination

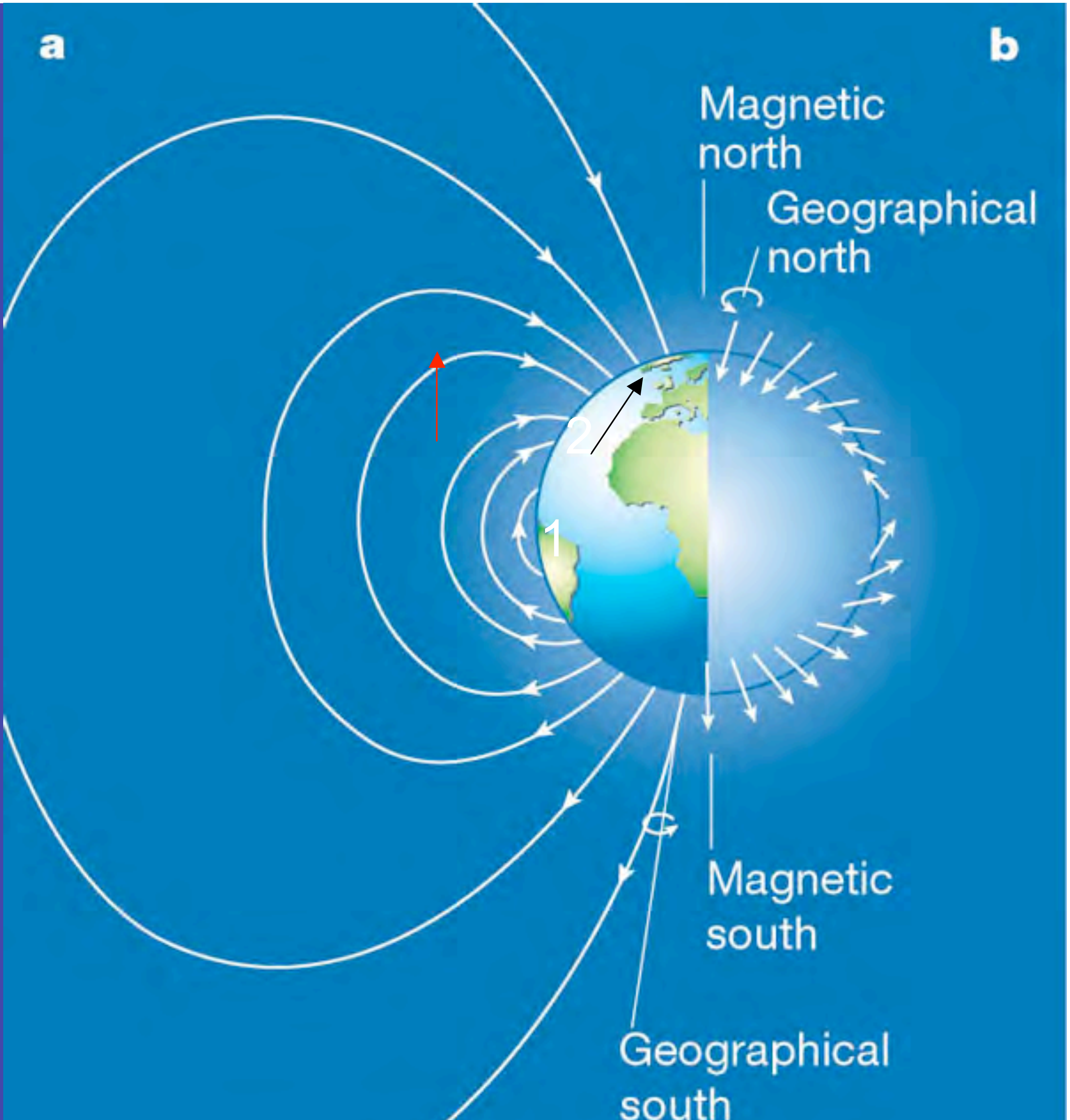
Modern Declination at (2)



http://www.nature.com/nature/journal/v421/n6918/fig_tab/421027a_F1.html

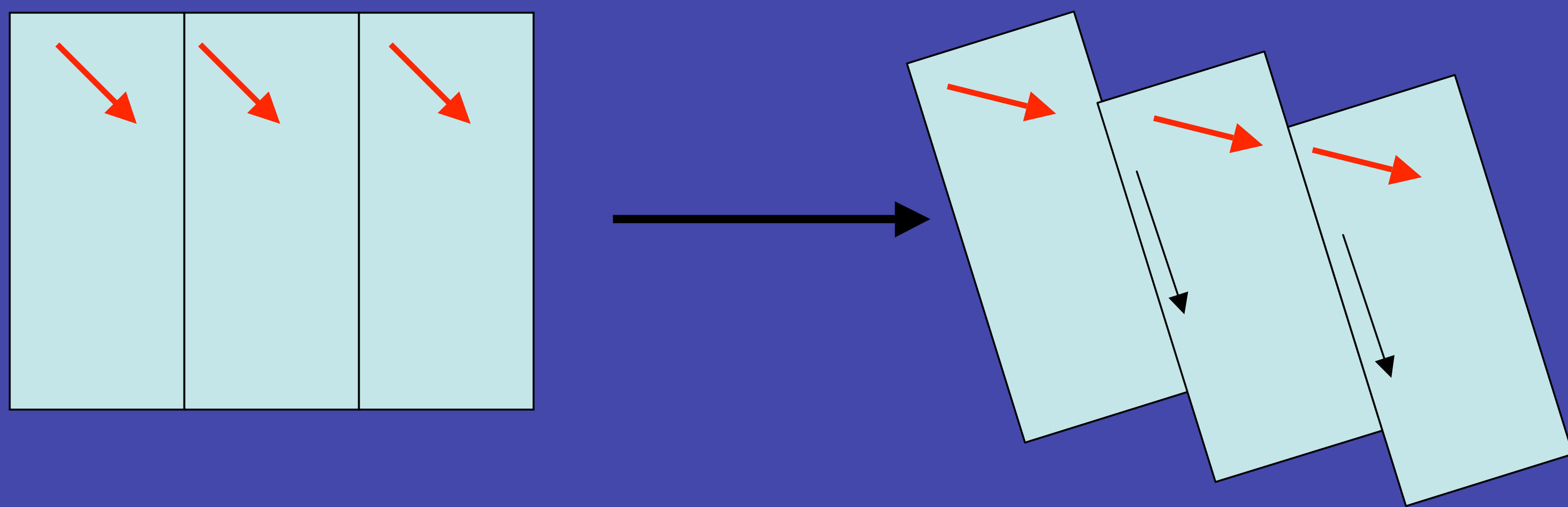
Magnetic Declination

Magnetic Inclination

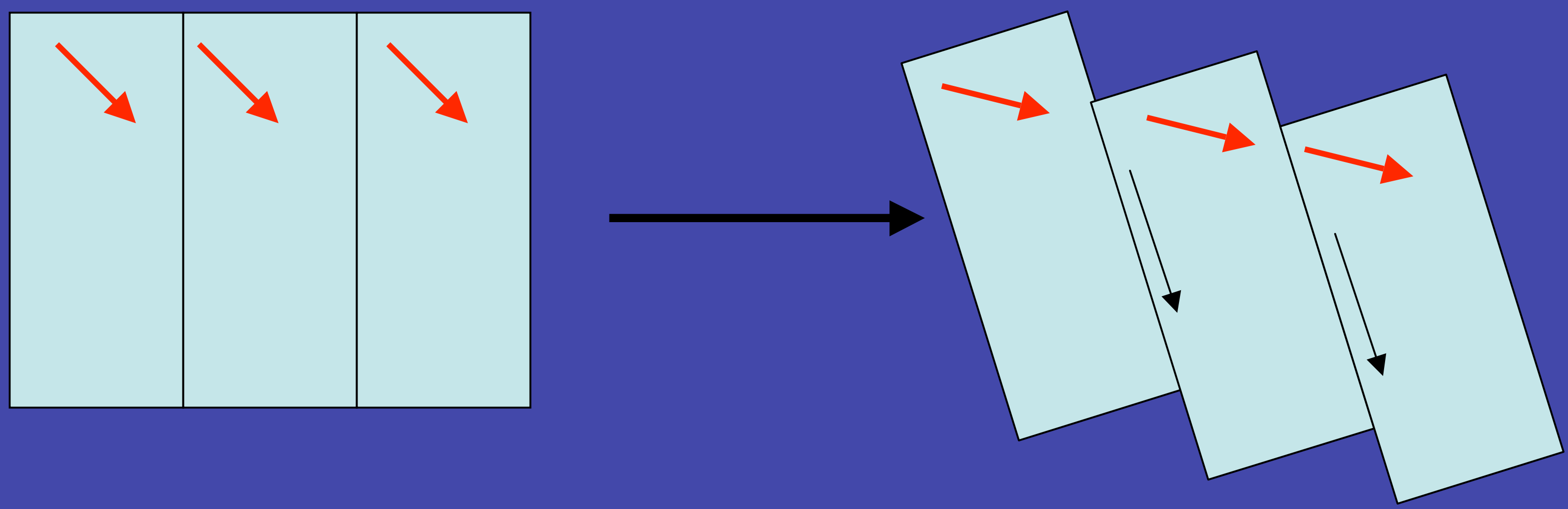


http://www.nature.com/nature/journal/v421/n6918/fig_tab/421027a_F1.html

But there are problems:

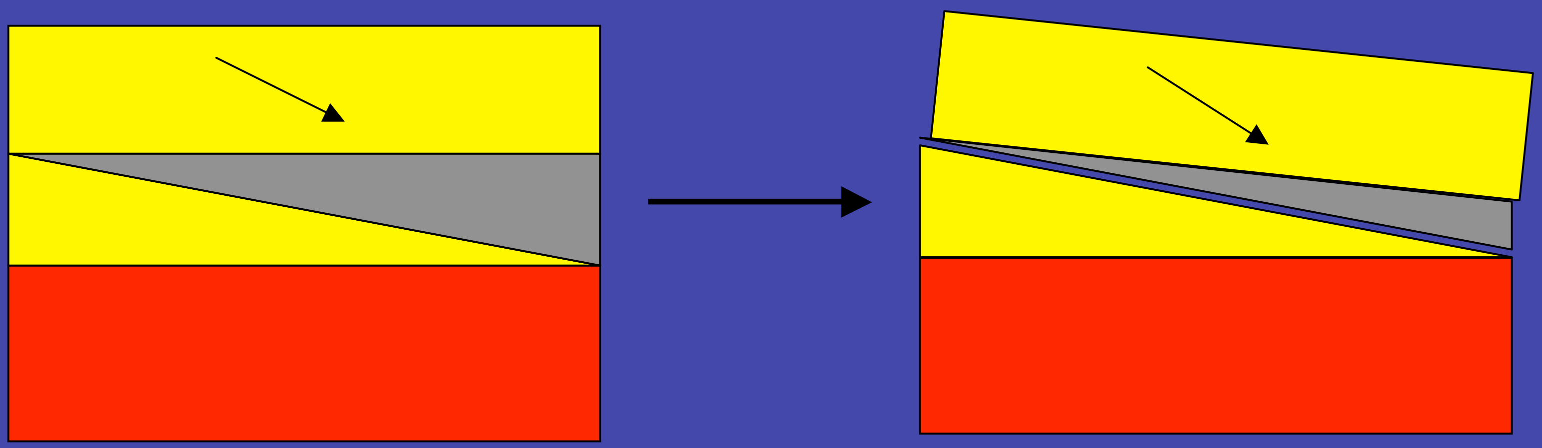


But there are problems:



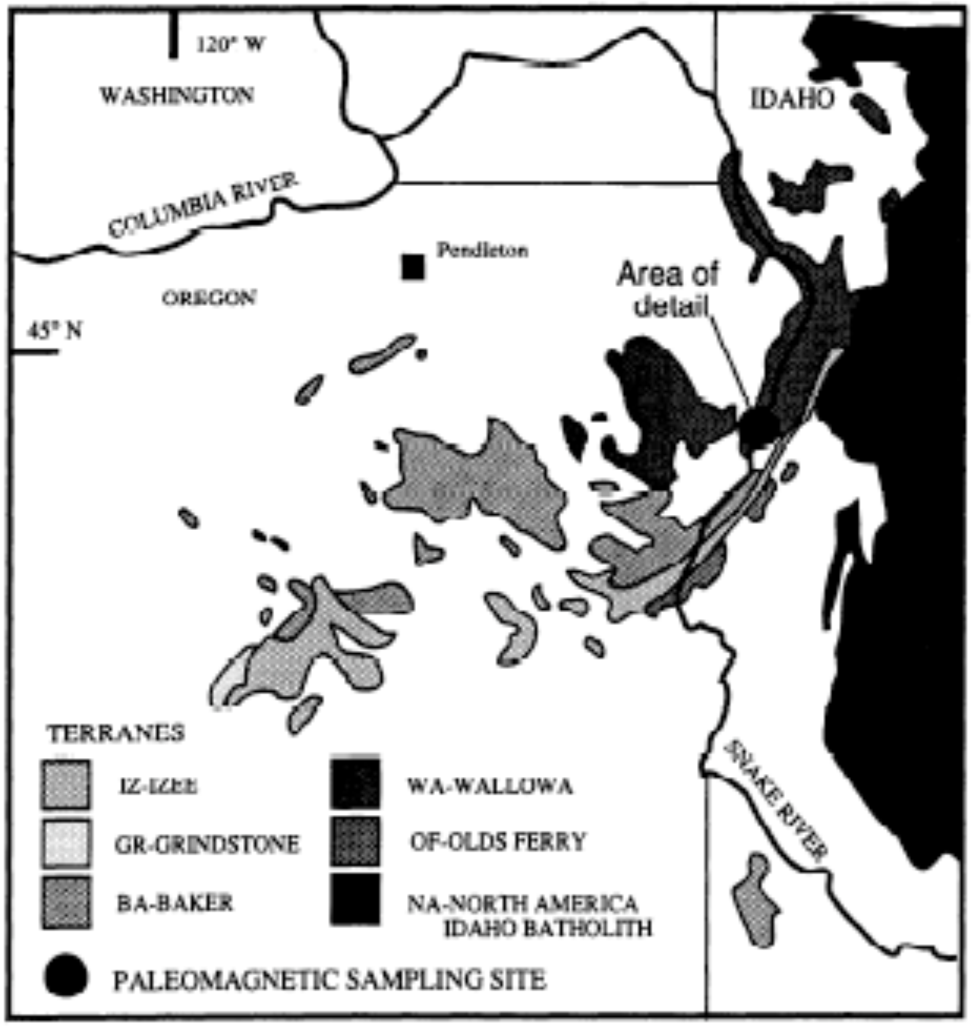
Tectonic deformation will change the measured paleo-inclination. Here faulting leads us to infer the faulted blocks were deposited at a southern paleo-location, where inclinations are not as steep.

There are problems

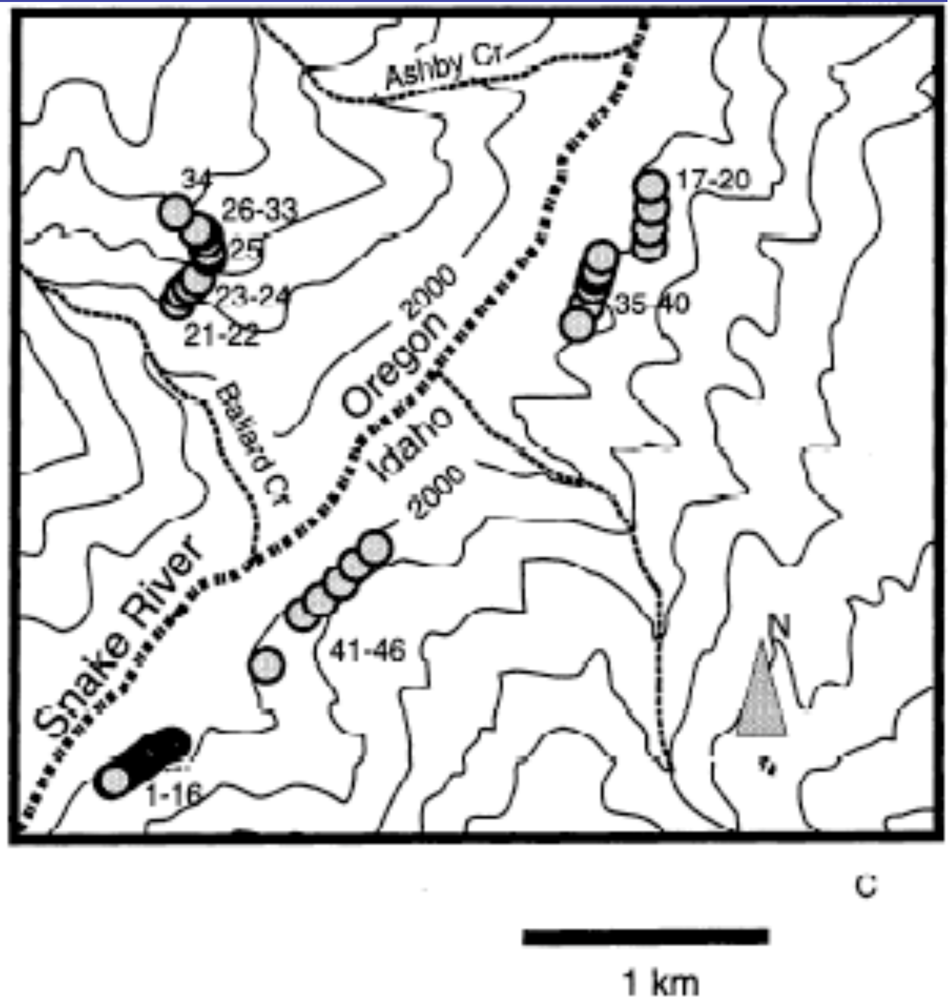


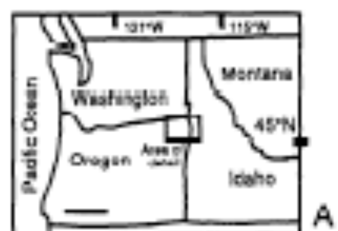
Differential compaction of sediments leads to change in measured paleo-inclination in the overlying beds.

End small digression



Regional geology

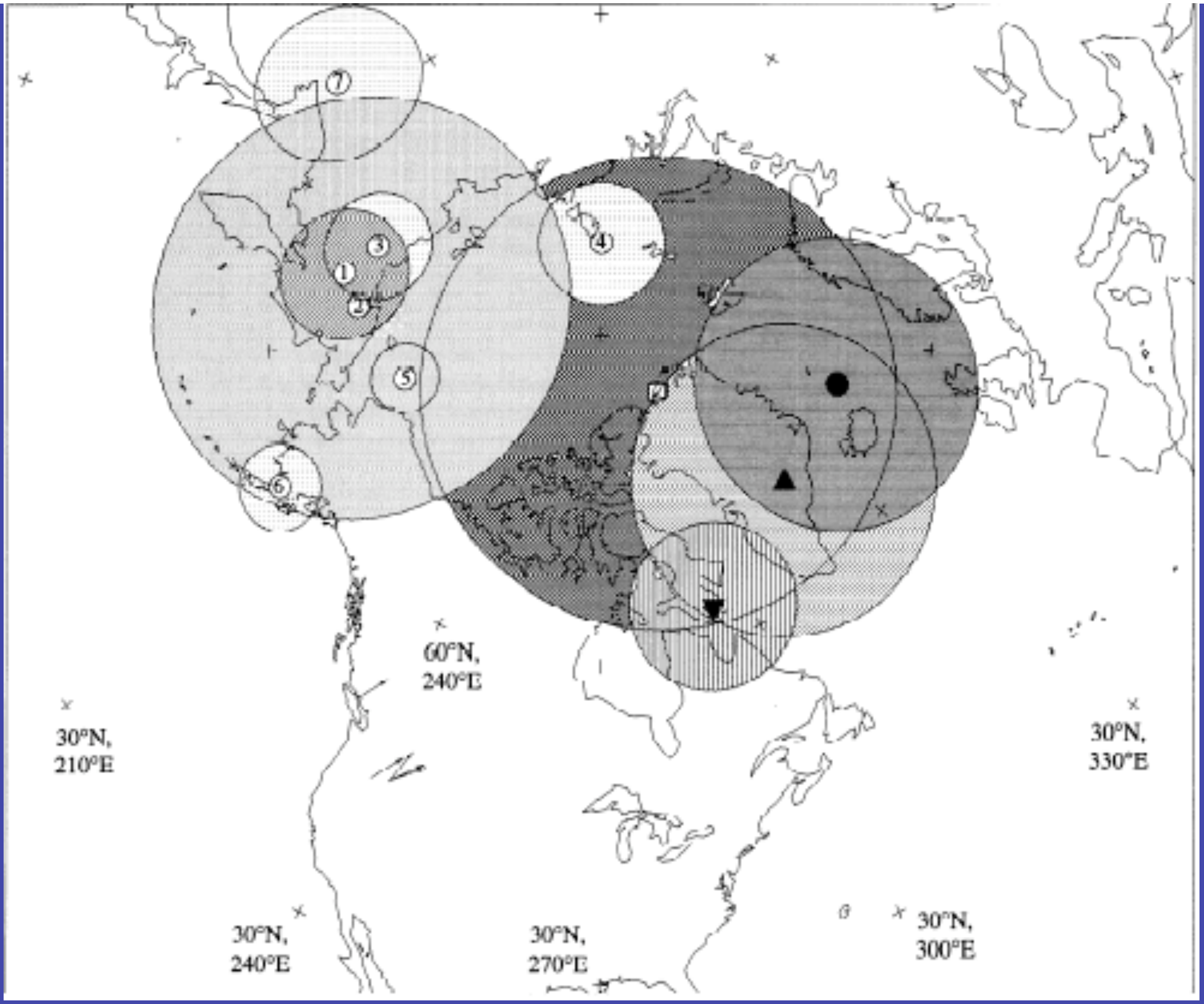




Paleomagnetic Sampling Site
Contour Interval 200'

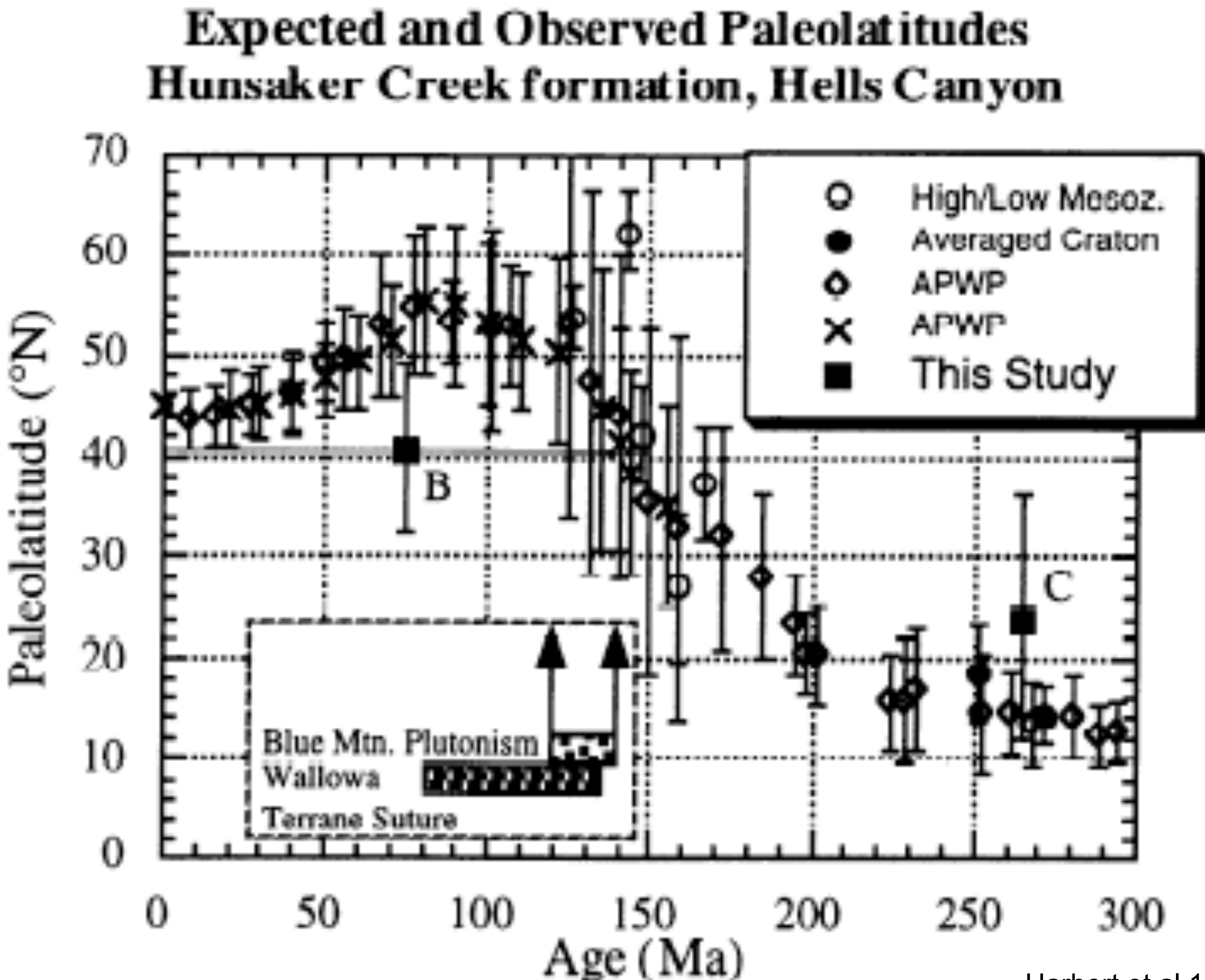
Hell's Canyon sites

Harbert et al 1994

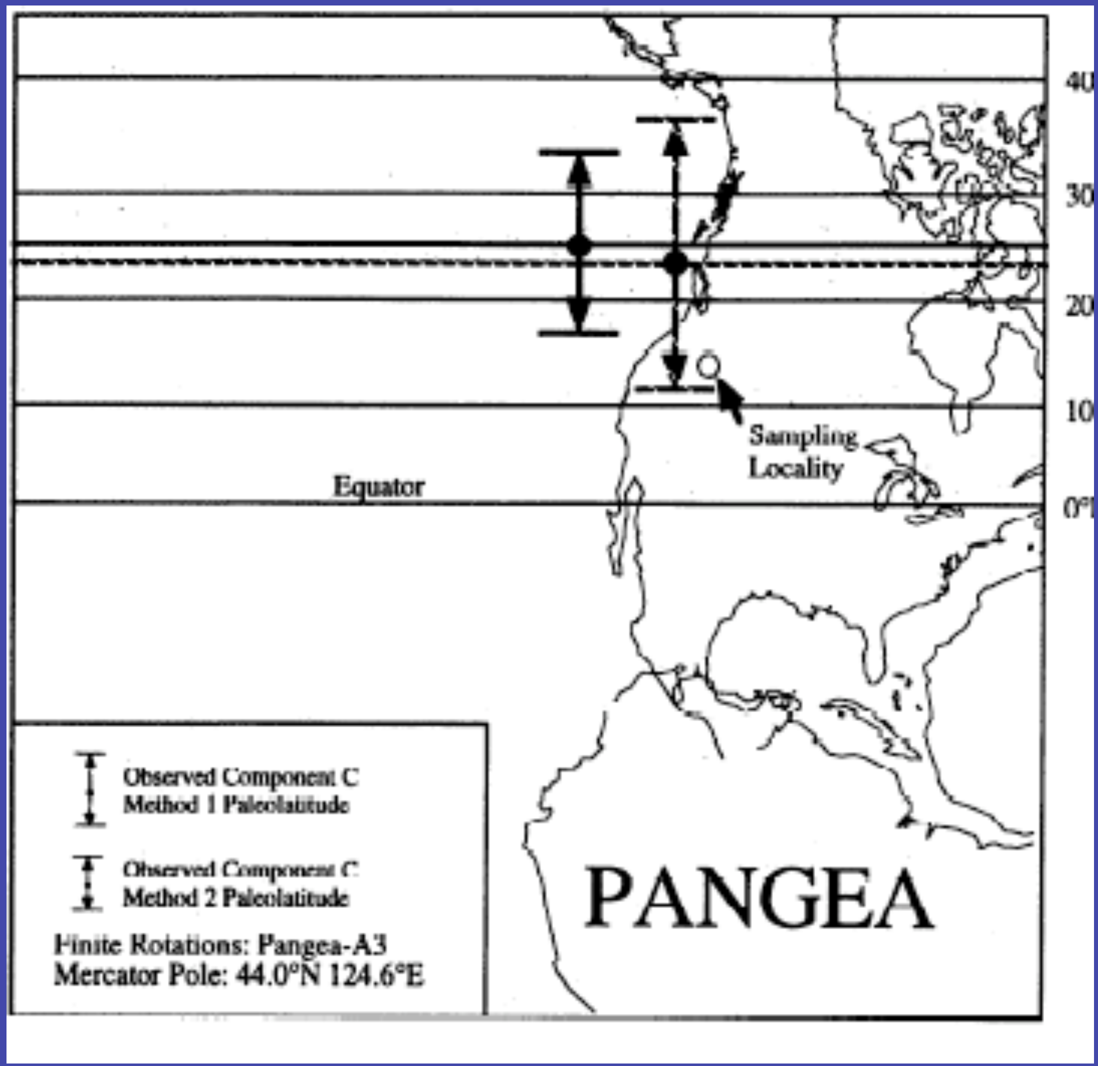


Open square: Paleo-pole this study
1=135MA, 2=131MA, 3-7=OTHER POLES
Inverted triangle=Blue Mt L Jur-E Cret pole

Harbert et al 1994



Harbert et al 1994

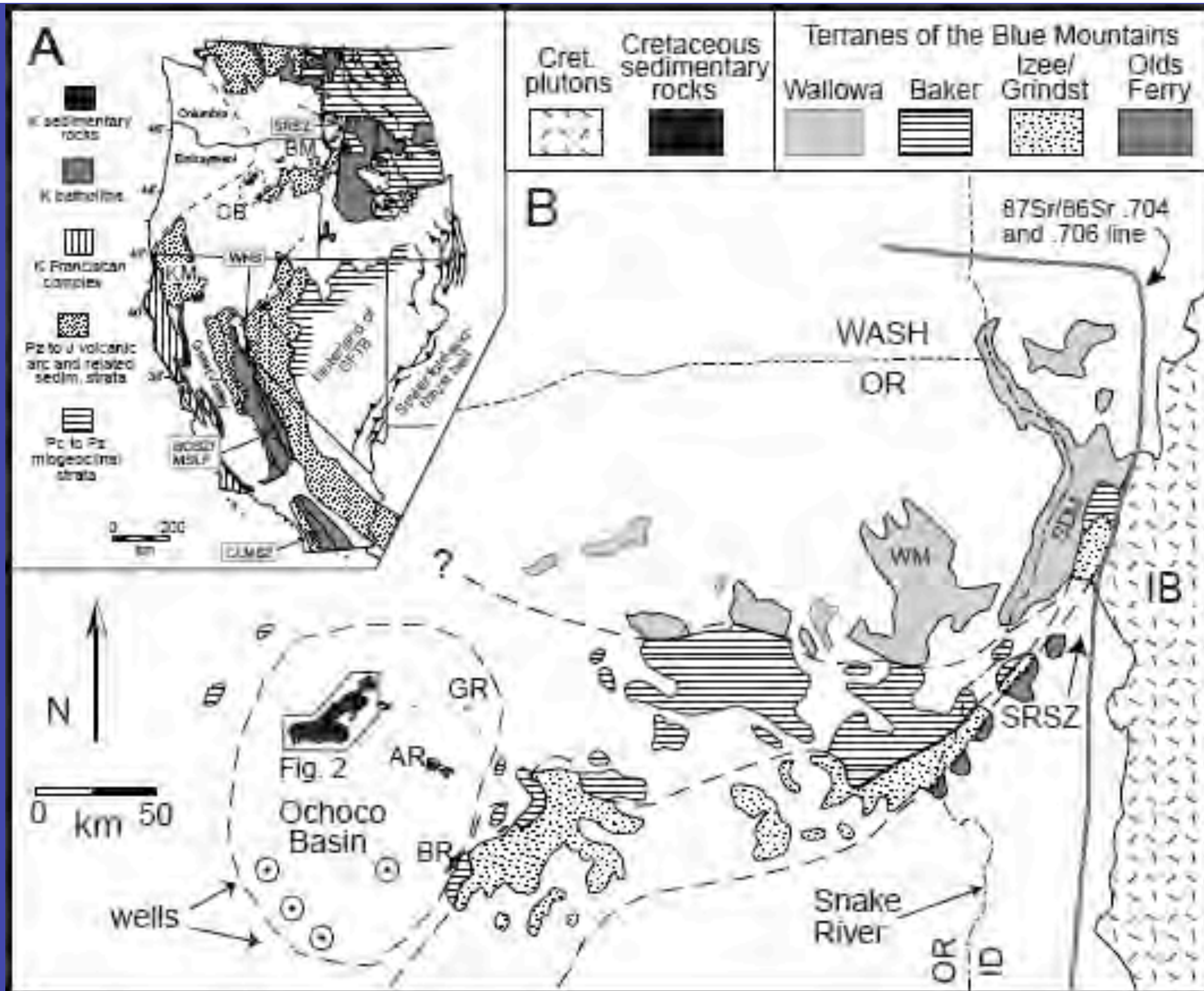


Permian Paleo-pole and Hell’s Canyon Permian paleo-poles: this study suggests Wallowa Terrane formed to NORTH of its present location.

Harbert et al 1994

Cretaceous Tectonics of the Ochoco Basin: Paleomagnetism

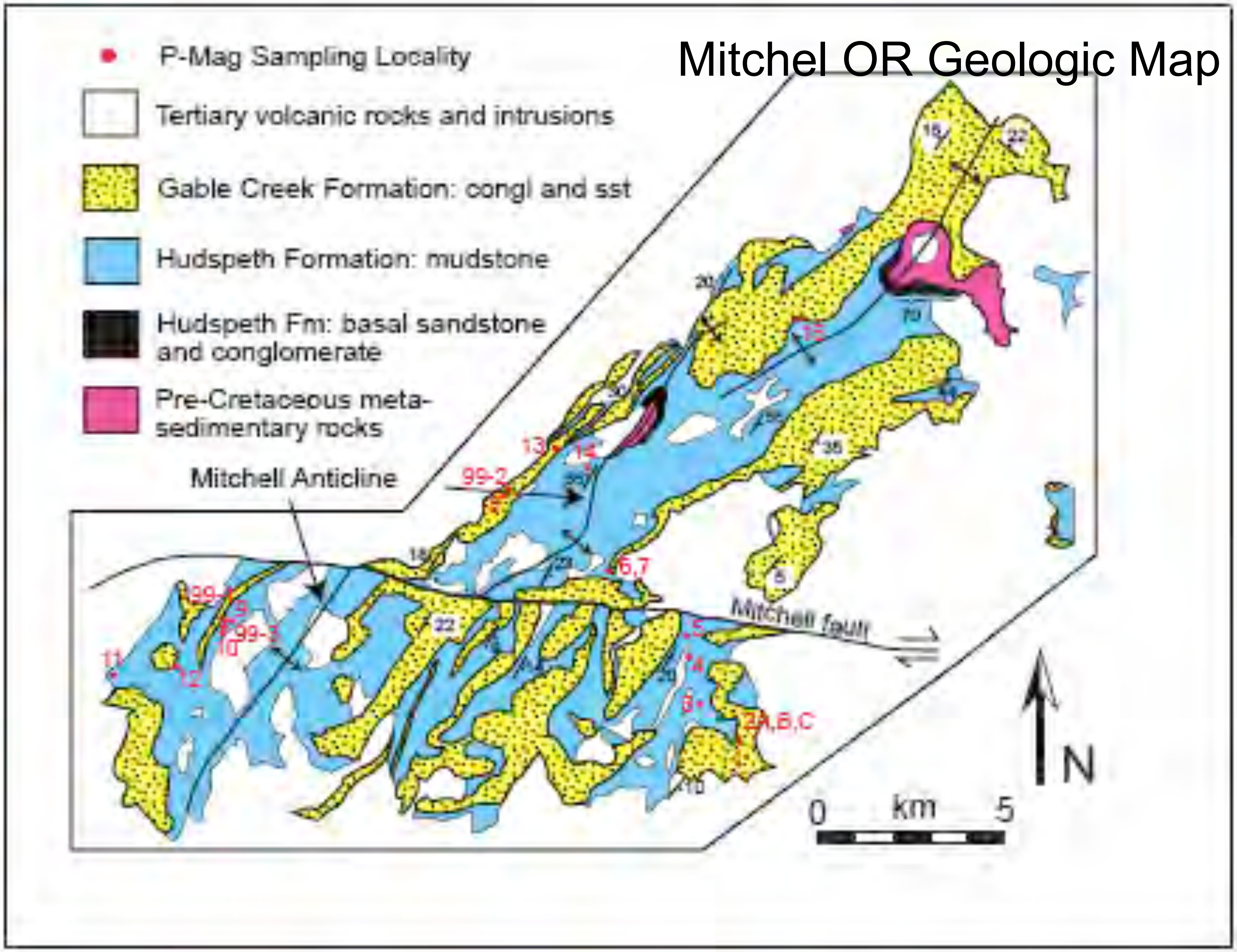
- LaHousen and Dorsey 2005



Pre-Tertiary geology: nb. “Columbia Embayment”

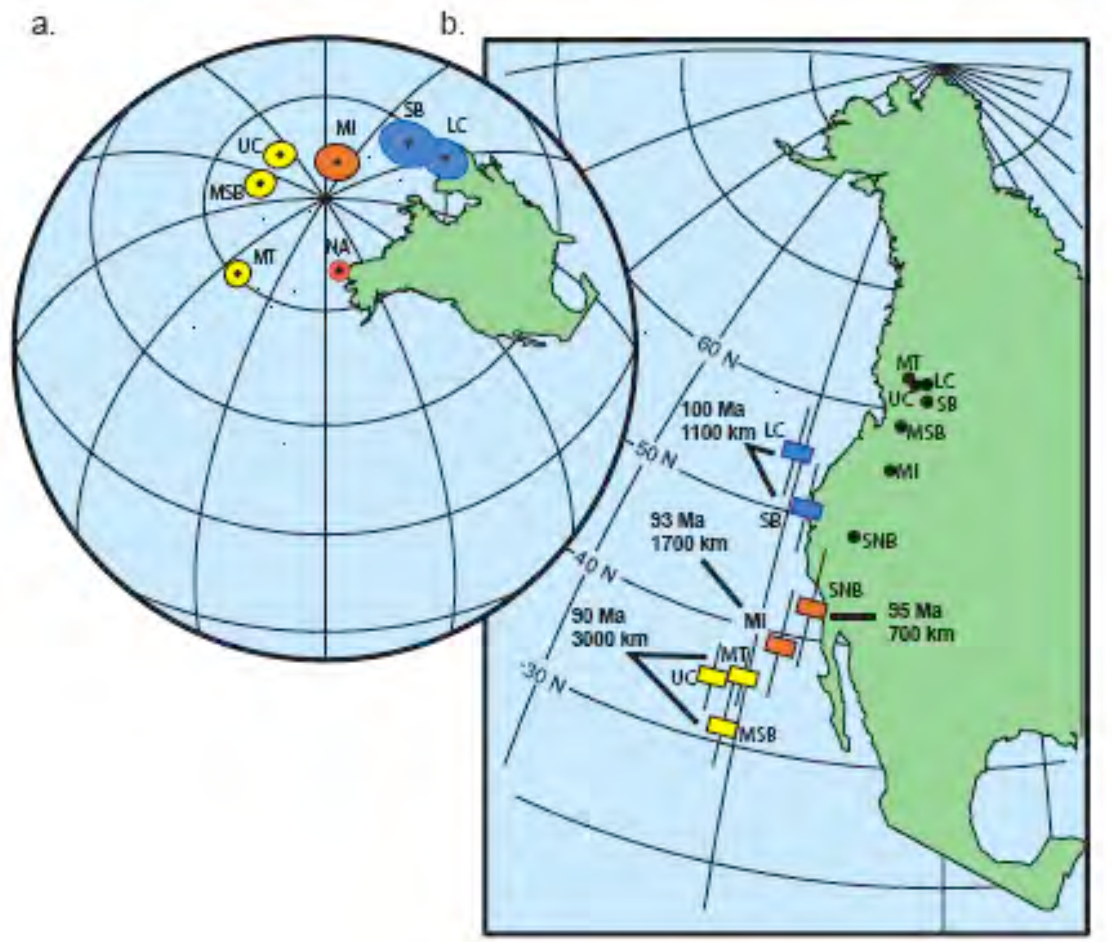
LaHousen and Dorsey 2005

Mitchel OR Geologic Map



LaHousen and Dorsey 2005

a. Paleomagnetic poles
M=this study,
yellow=Insular Terranes
blue=Intermontane terranes

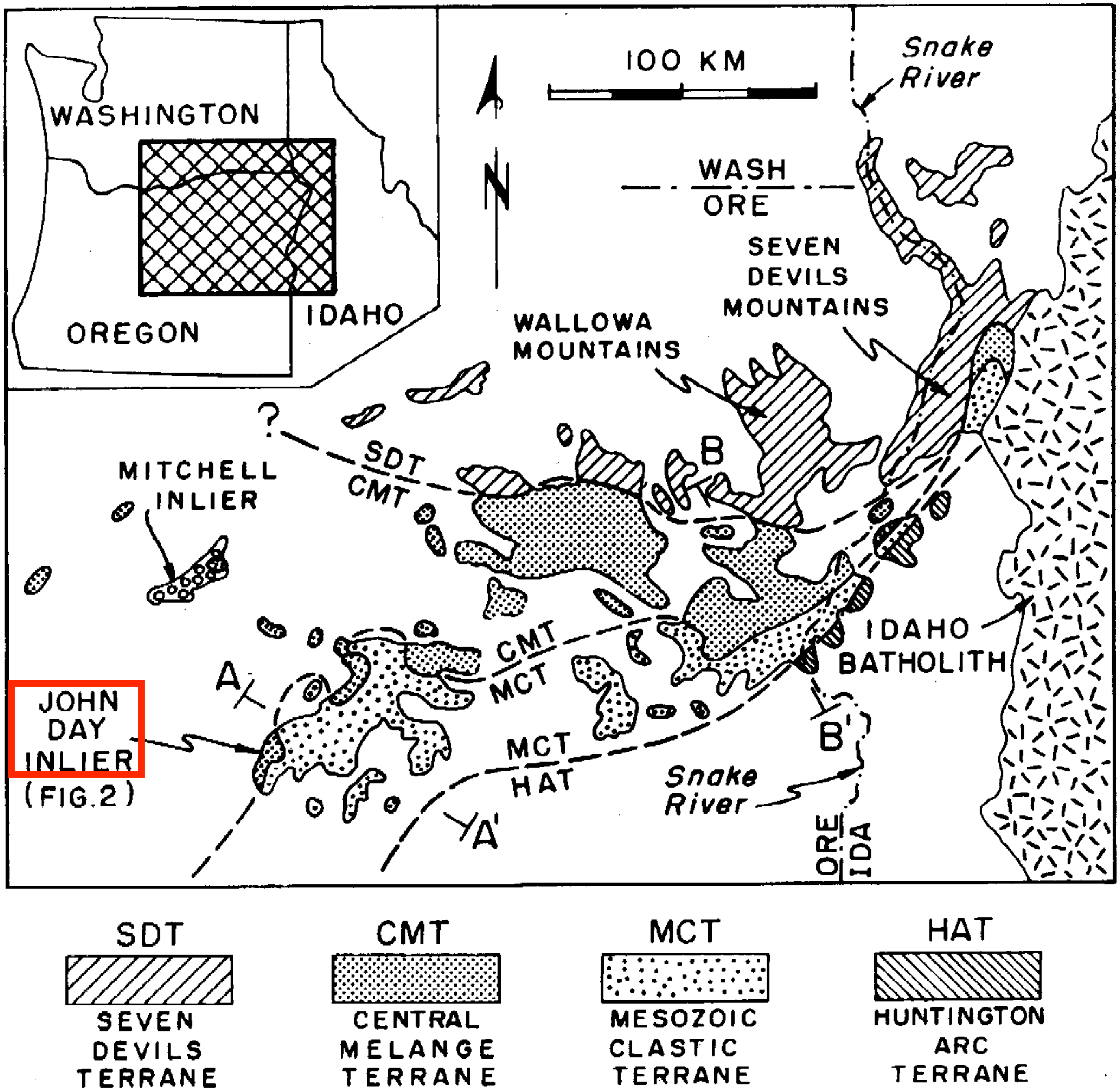


b. Mid-Cretaceous Paleo-geography, with paleo-pole,
Post-Cretaceous Northward movement of terranes

LaHousen and Dorsey 2005

Mesozoic Fore-Arc Basin in Central Oregon

Dickinson 1979



Dickinson 1979

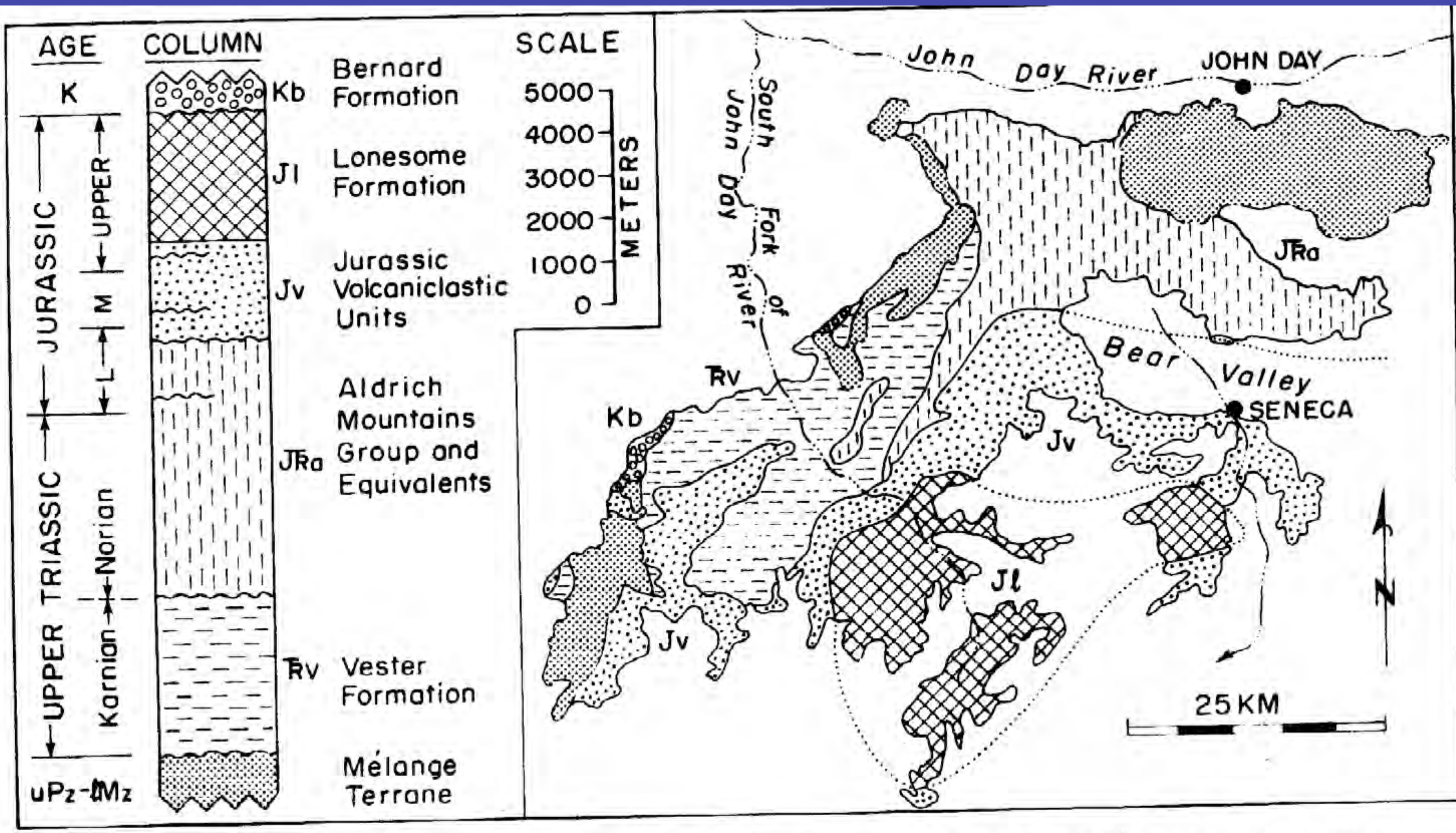


Figure 2. Geologic sketch map and summary column of John Day inlier (after Dickinson and Thayer, 1978). See Figure 1 for location.

Dickinson 1979

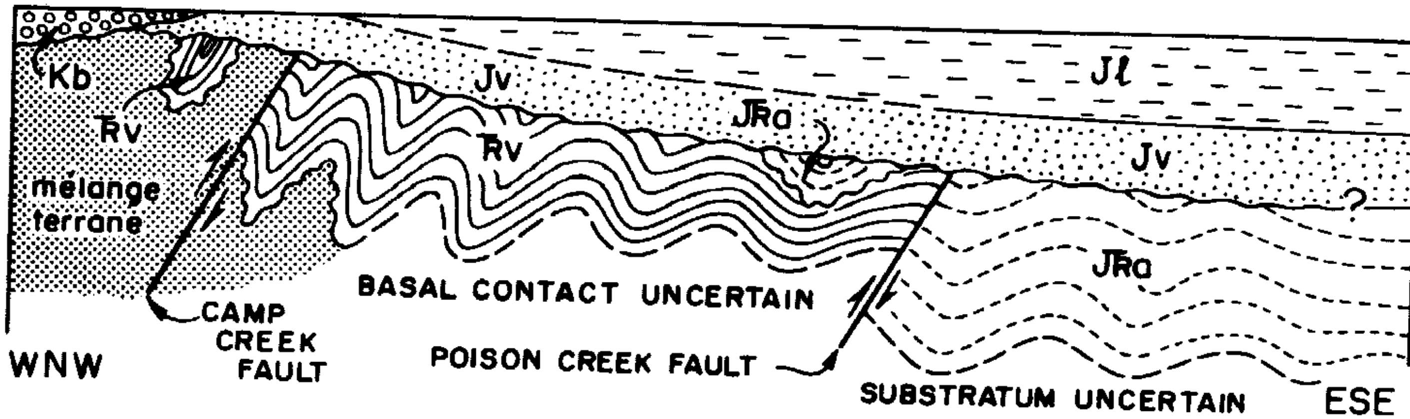


Figure 3. Diagrammatic west-northwest–east-southeast profile showing key stratigraphic and structural relationships in Mesozoic basin of John Day inlier restored as inferred for Late Jurassic time (except that position of overlapping mid-Cretaceous beds is also shown). See Figure 2 for formation symbols. Wavy lines are major unconformities. No vertical exaggeration. Profile length is 45 km.

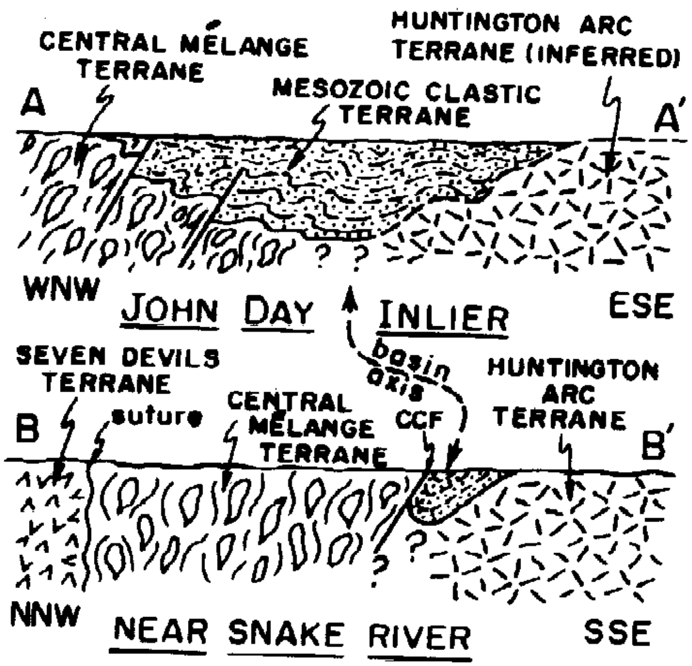


Figure 4. Schematic sections across mid-Mesozoic forearc basin in central (top) and eastern (bottom) Oregon. Volcanic cover not shown. See Figure 1 for locations of A–A′ and B–B′. No vertical exaggeration; each section is 100 km long. CCF = Connor Creek fault.

Dickinson 1979

Introduction to the Blue Mountains

Becky Dorsey
University of Oregon
2007

Vester (Carnian) and Fields Creek (Norian) Fms

Bedded turbidites, argillite, cgl, slumps, & breccias w/ large olistostromes (submarine slide blocks) ... clasts include chert, serpentine, and plutonic rocks from adjacent Baker terrane.

Unstable steep margin of tectonically active marine basin

Dickinson and Thayer (1978)

Martin Bridge L.S.

Widespread regional unit: shallow platform carbonate w/ diverse fauna (corals, sponges, crinoids) and sedimentary structures.

Records end of Mid Triassic arc volcanism … end of subduction due to collision of accretionary prisms.

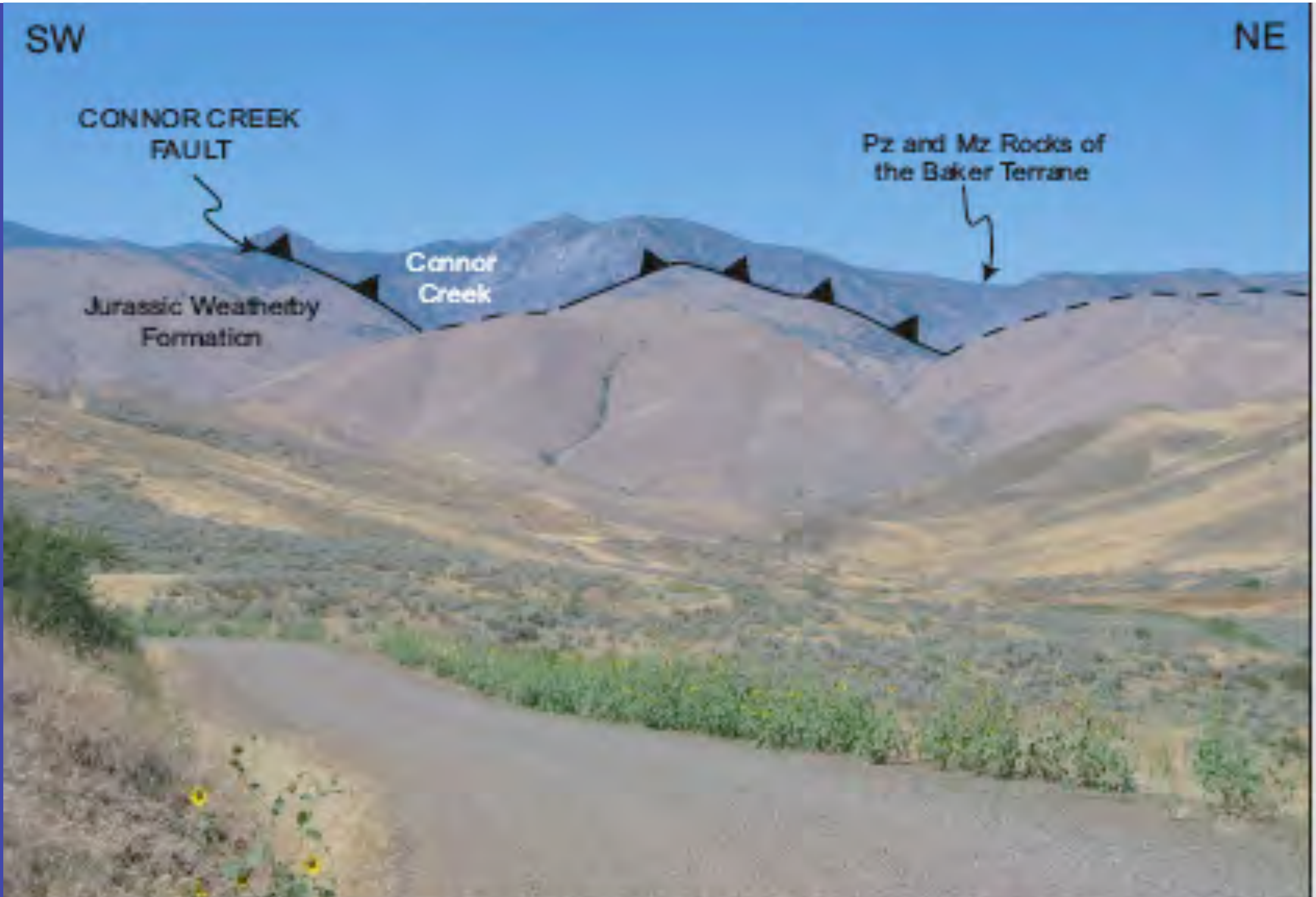
Hurwal Fm

Late Triassic - Early Jurassic

Fine-gr. turbidites & argillite, deep marine basin, partially equivalent to Martin Bridge L.S.

Excelsior Gulch Conglomerate: clasts include limestone, chert, volcanics, plutonic rx … eroded from Baker terrane T.B.
(Follo, 1986; 1992; 1994)

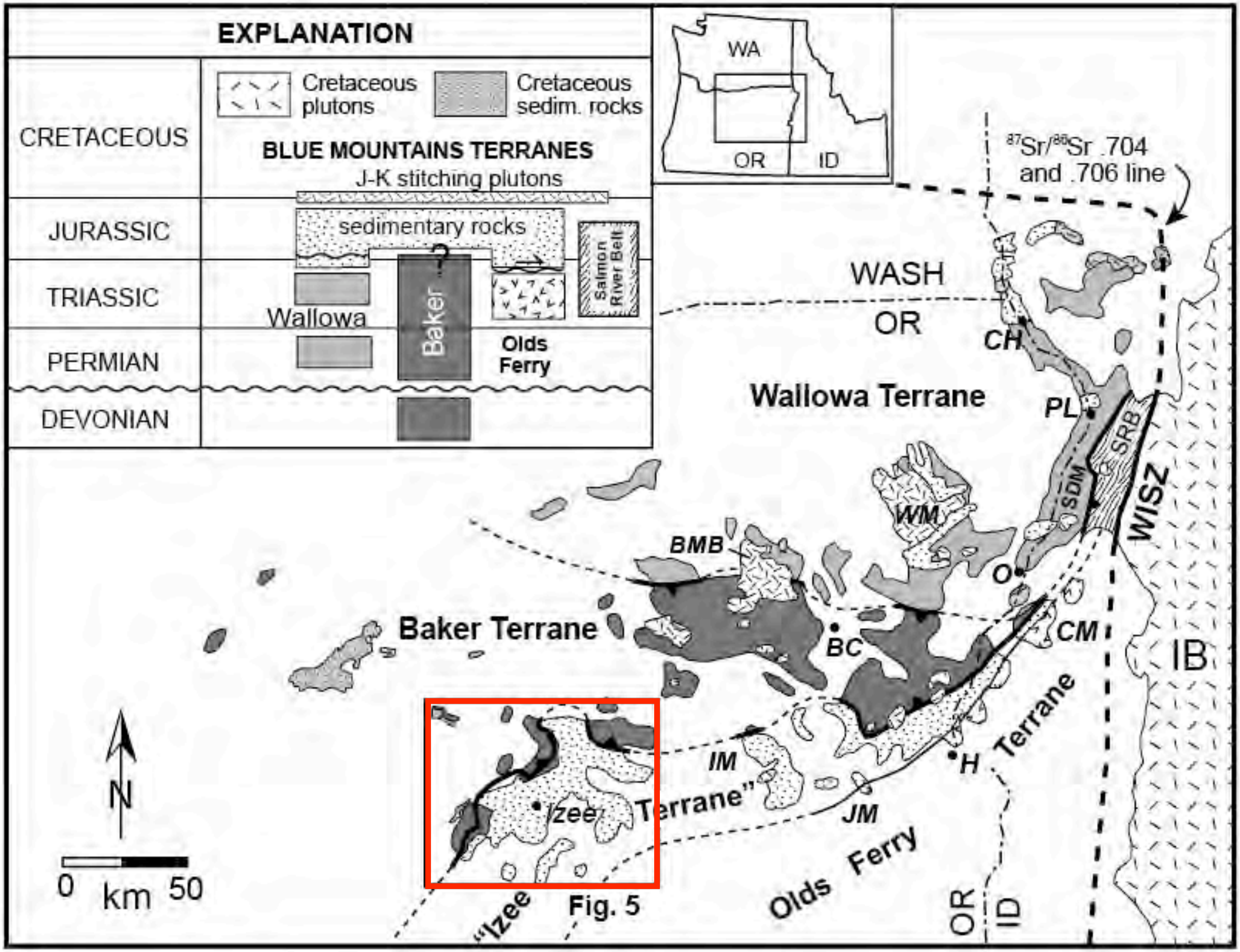
εNd +4 to +2, some mixing with continental clay.



View looking northwest from Washington County, Idaho into Oregon across the Snake River (hidden in foreground). Paleozoic and Mesozoic argillaceous melange, sperpentenites and mafic ophiolitic rocks overlie the Jurassic Wealtherby Formation, forearc basin volcaniclastic turbidite deposits, along the steeply northwest-dipping Connor Creek Fault.

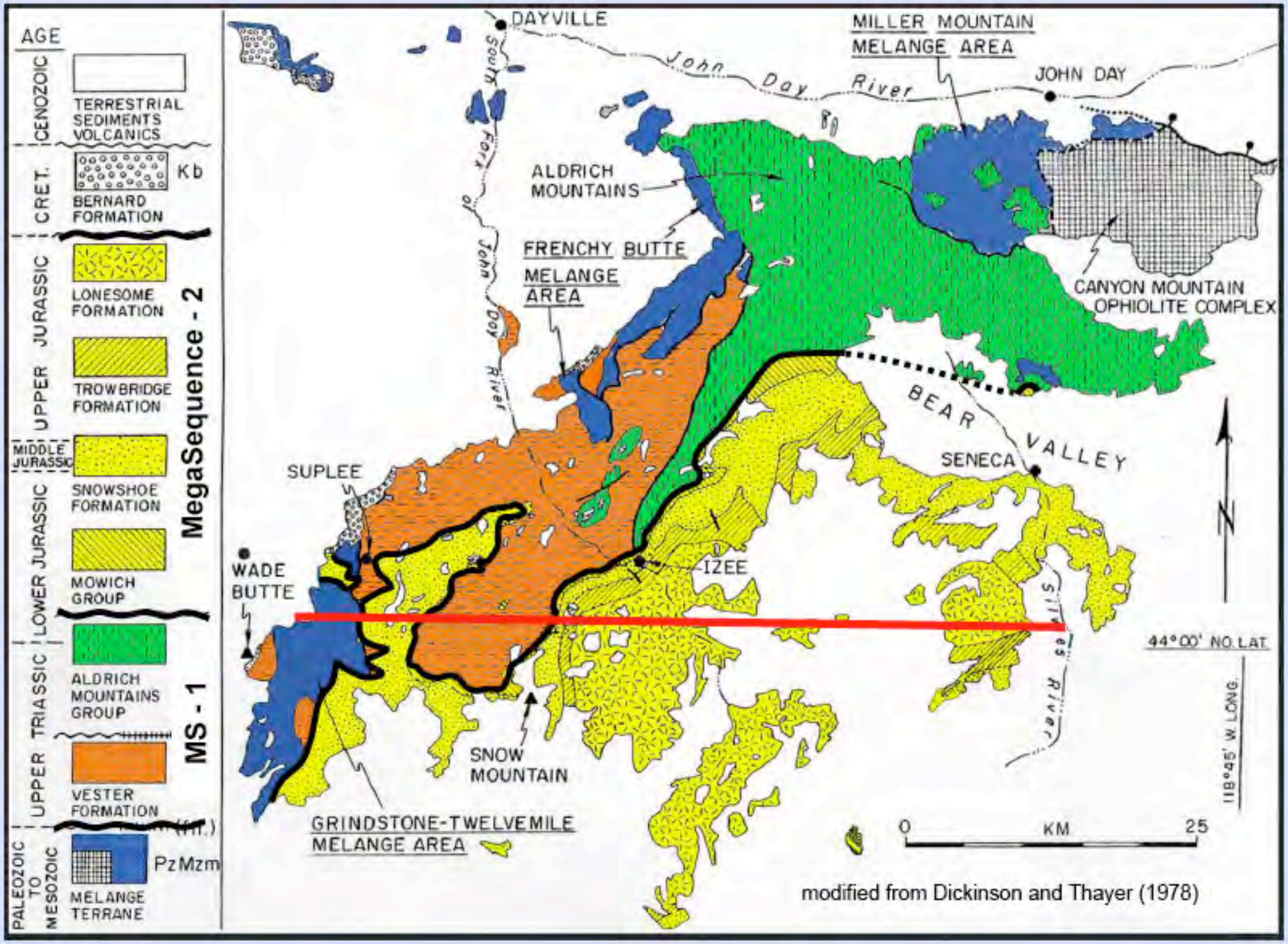
Basinal response to Triassic-Jurassic Collisional Tectonics in the Blue Mountains Province, Northeastern Oregon

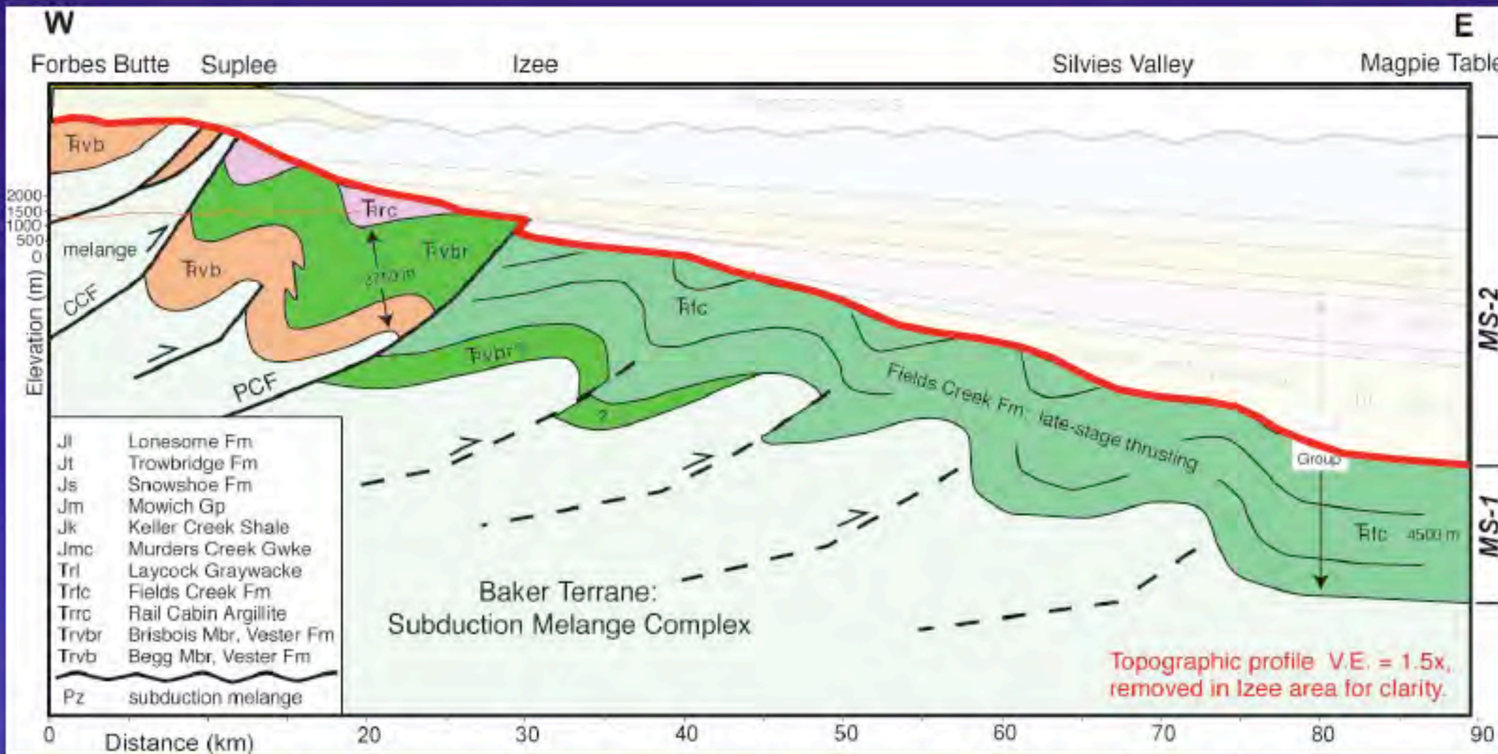
Dorsey and LaMaskin 2007



EXPLANATION
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
DEVONIAN
Cretaceous plutons
Cretaceous sedim. rocks
BLUE MOUNTAINS TERRANES
J-K stitching plutons
sedimentary rocks
Wallowa
Baker
Olds Ferry
Salmon River Belt
WA
OR
ID
87Sr/86Sr .704 and .706 line
WASH
OR
Wallowa Terrane
CH
PL
SRB
SDM
WISZ
WM
BMB
O
CM
BC
Baker Terrane
IB
IM
H
Terrane
Izee
"Izee Terrane"
JM
Olds Ferry
OR
ID
N
0 km 50
Fig. 5

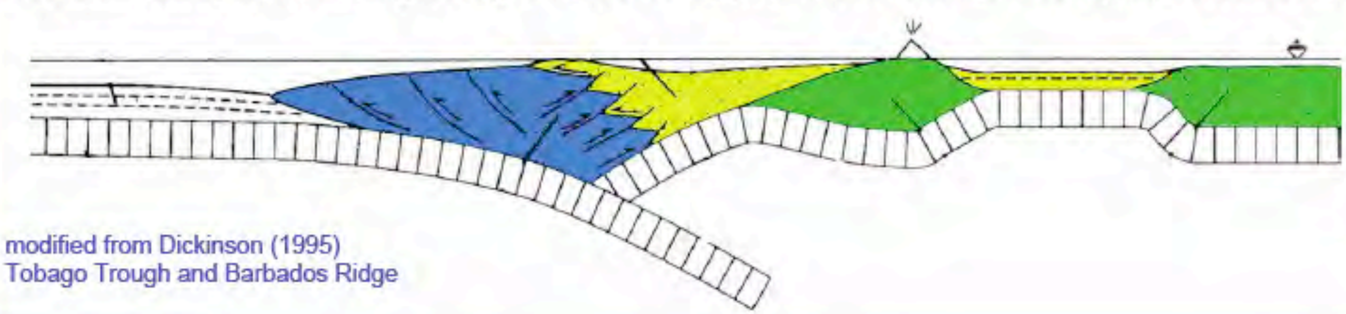
Izee-Suplee area



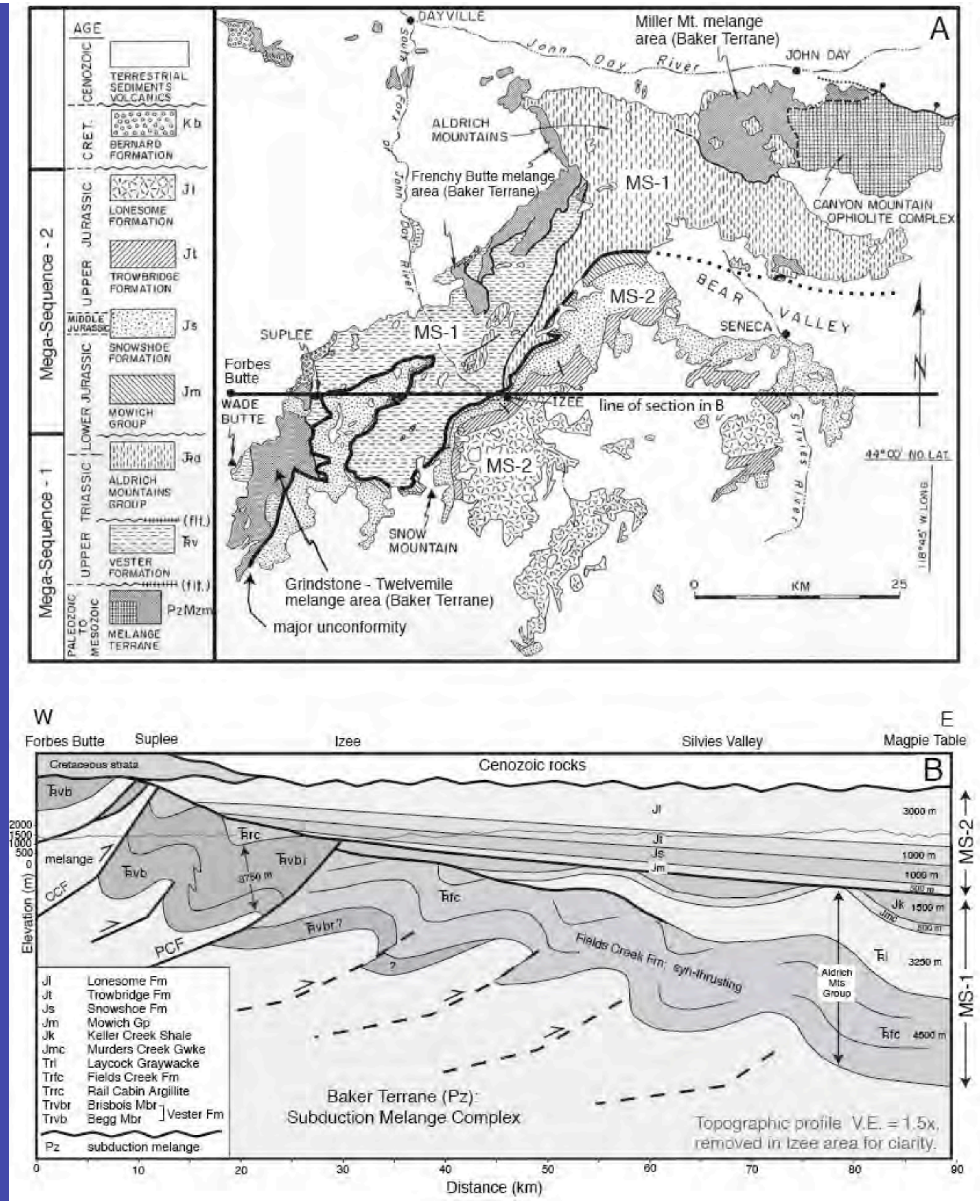


Constructed using data from Dickinson and Thayer (1978), Dickinson and Vigrass (1965), Brown and Thayer (1966)

Dickinson (1979): backthrusting on edge of accretionary prism above "normal" east-dipping subduction zone

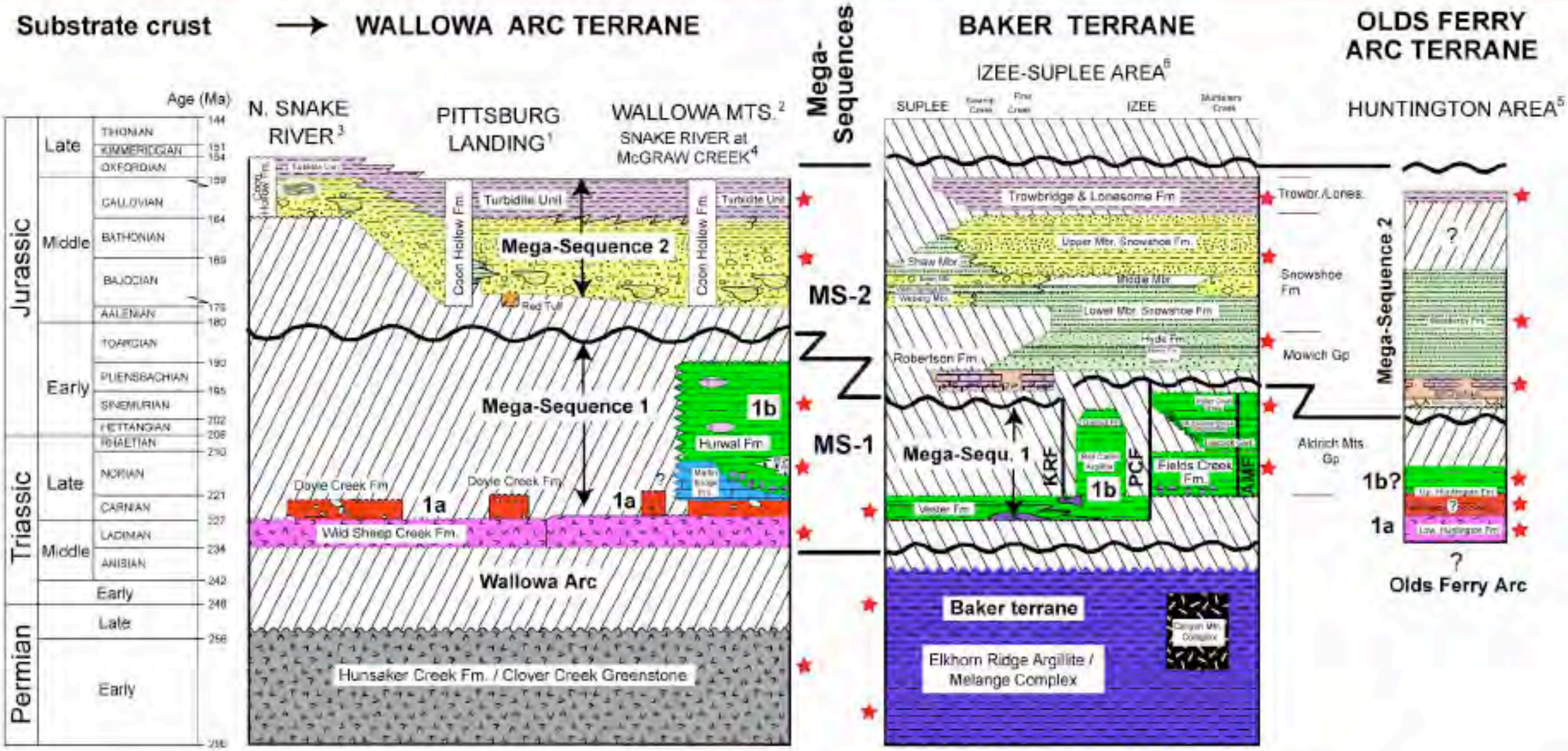


modified from Dickinson (1995)
Tobago Trough and Barbados Ridge



AGE
CENOZOIC
TERRESTRIAL SEDIMENTS VOLCANICS
CRET.
Kb
BERNARD FORMATION
UPPER JURASSIC
Jl
LONESOME FORMATION
Jt
TROWBRIDGE FORMATION
MIDDLE JURASSIC
Js
SNOWSHOE FORMATION
LOWER JURASSIC
Jm
MOWICH GROUP
UPPER TRIASSIC
Ŧa
ALDRICH MOUNTAINS GROUP
(flt.)
Ŧv
VESTER FORMATION
(flt.)
PALEOZOIC TO MESOZOIC
PzMzm
MELANGE TERRANE
Mega-Sequence - 2
Mega-Sequence - 1
DAYVILLE
John Day River
Miller Mt. melange area (Baker Terrane)
JOHN DAY
A
ALDRICH MOUNTAINS
Frenchy Butte melange area (Baker Terrane)
MS-1
CANYON MOUNTAIN OPHIOLITE COMPLEX
MS-2
BEAR VALLEY
SENECA
SUPLEE
MS-1
Forbes Butte
WADE BUTTE
IZEE
line of section in B
MS-2
44°00' NO. LAT.
118°45' W. LONG.
SNOW MOUNTAIN
Grindstone - Twelvemile melange area (Baker Terrane)
major unconformity
0 KM 25
South Fork of John Day River
Silvies River
W
E
Forbes Butte
Suplee
Izee
Silvies Valley
Magpie Table
Cretaceous strata
Cenozoic rocks
B
Ŧvb
Jl
3000 m
Ŧrc
Jt
Js
Jm
Ŧvbi
1000 m
1000 m
500 m
melange
Ŧvb
3750 m
OCF
Ŧfc
Jk 1500 m
Jmc
500 m
Ŧvbr?
PCF
?
Fields Creek Fm: syn-thrusting
Ŧl 3250 m
Aldrich Mts Group
Ŧfc 4500 m
MS-2
MS-1
Elevation (m)
2000
1500
1000
500
0
Jl Lonesome Fm
Jt Trowbridge Fm
Js Snowshoe Fm
Jm Mowich Gp
Jk Keller Creek Shale
Jmc Murders Creek Gwke
Trl Laycock Graywacke
Trfc Fields Creek Fm
Trrc Rail Cabin Argillite
Trvbr Brisbois Mbr
Trvb Begg Mbr
Vester Fm
Pz subduction melange
Baker Terrane (Pz): Subduction Melange Complex
Topographic profile V.E. = 1.5x, removed in Izee area for clarity.
0 10 20 30 40 50 60 70 80 90
Distance (km)

Stratigraphy of the Blue Mountains



★ indicates positions of samples to be collected for provenance analysis

- Norian shallow- to deep-water carbonate facies
- Carnian calcareous volcaniclastic sandstone and conglomerate
- Middle to Upper Triassic volcanic rocks
- Upper Paleozoic peridotite, pryoxenite, and gabbro
- Pz to Lower Jurassic radiolarian chert, argillite, and subduction melange
- Lower to Middle Jurassic shale and siltstone
- Lower Jurassic volcaniclastic sandstone
- Lower Jurassic conglomerate
- Lower Jurassic isolated carbonate mound/ biohermal strata
- Upper Triassic to Lower Jurassic shale, siltstone, and turbidites
- Middle to upper Upper Jurassic shale and sandstone
- Middle Jurassic shale
- Middle Jurassic sandstone and shale
- Middle Jurassic sandstone and conglomerate

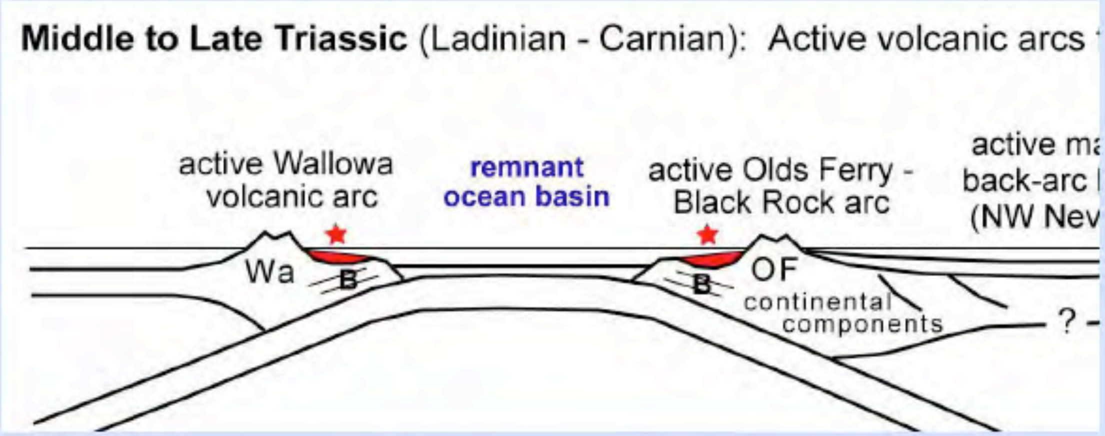
1. White et al. (1992); White (1994); White and Vallier (1994)
2. Follo (1992; 1994)
3. Vallier (1977); Goldstrand (1994)
4. Vallier (1974, 1977)
5. Brooks et al. (1976); Brooks (1979a)
6. Dickinson and Vigrass (1965); Dickinson and Thayer (1978); Dickinson (1979); Imlay (1986); Taylor and Guex (2002)

compiled by Todd LaMaskin

Doyle Creek Formation: forearc basin strata

fine-grained marine turbidites and ...

coarse volcaniclastic sst & pebble cgl

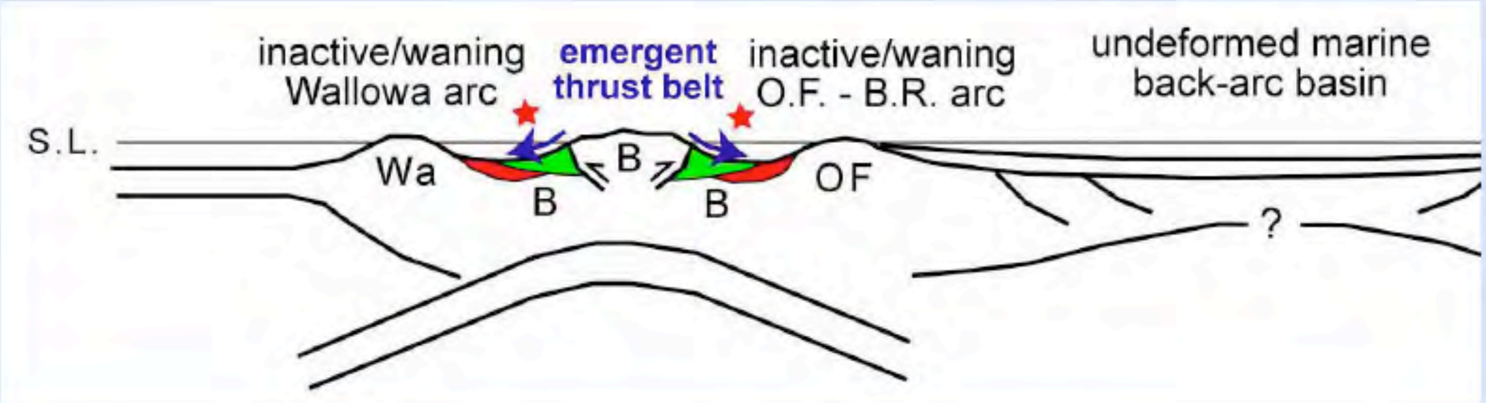


εNd +7 (new results from Vervoort's lab), indicates juvenile crust with no continental input.

Transition to Hurwal Fm

Carbonate turbidites record deepening and foundering of carbonate platform ... why?

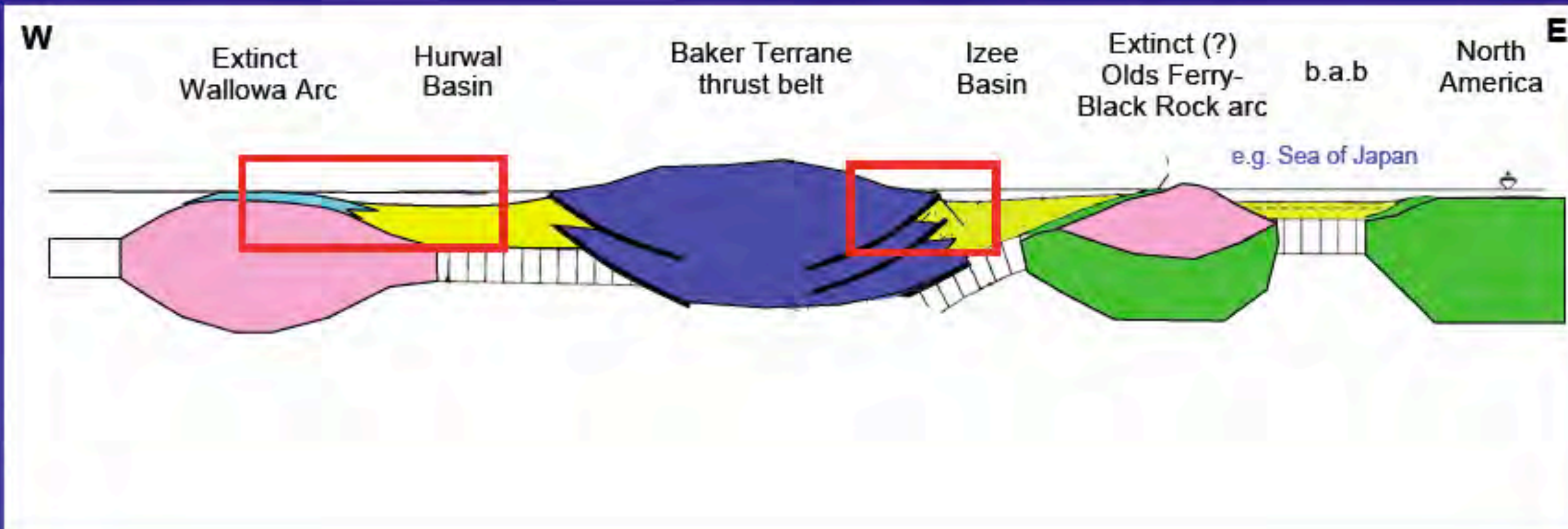
Rise and fall of the Martin Bridge LS may record migration of a flexural bulge due to loading in the Baker terrane thrust belt.

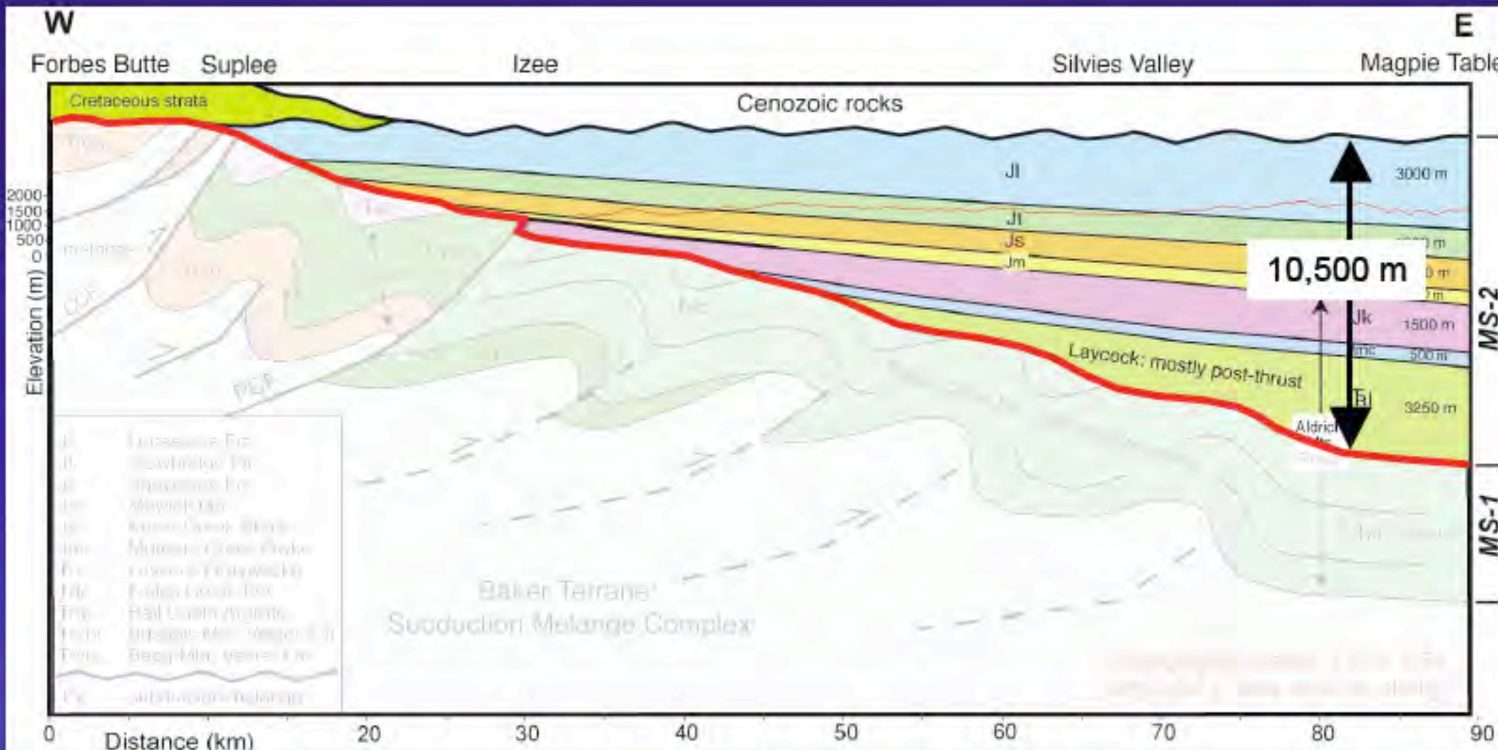


Late Triassic

Dickinson (1979): backthrusting above "normal" east-dipping subducting plate

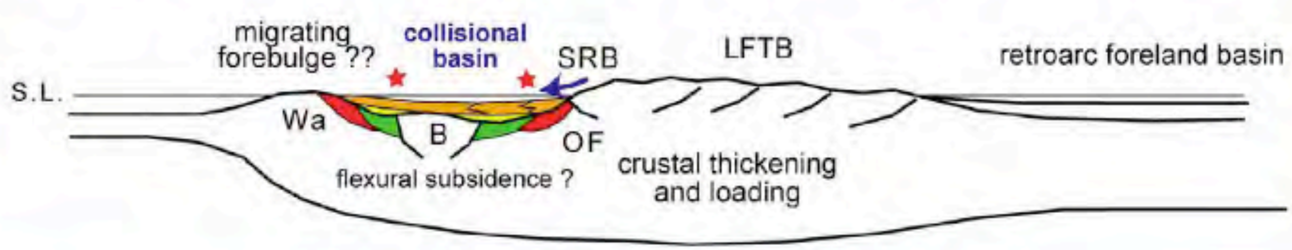
Alternate Hypothesis: doubly vergent Baker t. thrust belt and flanking flexural basins

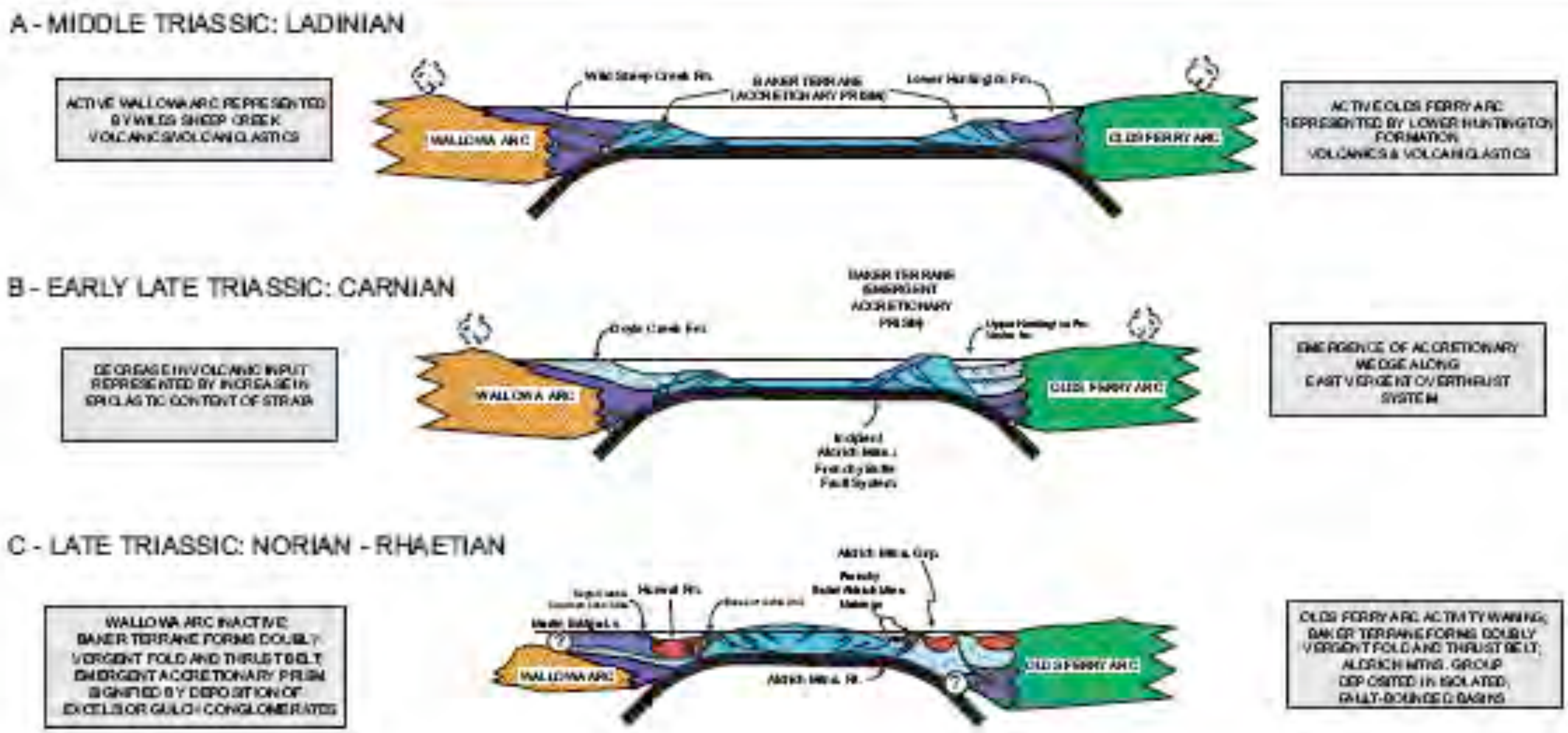




Constructed using data from Dickinson and Thayer (1978), Dickinson and Vigrass (1965), Brown and Thayer (1966)

Early to Late Jurassic: growth and subsidence of collisional basin; thick overlap assemblage




A - MIDDLE TRIASSIC: LADINIAN
ACTIVE WALLOWA ARC REPRESENTED BY WILDS SHEEP CREEK VOLCANICS/VOLCANICLASTICS
WALLOWA ARC
BAKER TERRANE (ACCRETIONARY PRISM)
OLDS FERRY ARC
ACTIVE OLDS FERRY ARC REPRESENTED BY LOWER HUNTINGTON FORMATION VOLCANICS & VOLCANICLASTICS
B - EARLY LATE TRIASSIC: CARNIAN
DECREASE IN VOLCANIC INPUT REPRESENTED BY INCREASE IN EPICLASTIC CONTENT OF STRATA
WALLOWA ARC
OLDS FERRY ARC
EMERGENCE OF ACCRETIONARY WEDGE ALONG EAST VERGENT OVERTHRUST SYSTEM
C - LATE TRIASSIC: NORIAN - RHAETIAN
WALLOWA ARC INACTIVE; BAKER TERRANE FORMS DOUBLY VERGENT FOLD AND THRUST BELT; EMERGENT ACCRETIONARY PRISM SIGNIFIED BY DEPOSITION OF EXCELSIOR GULCH CONGLOMERATES
WALLOWA ARC
OLDS FERRY ARC
OLDS FERRY ARC ACTIVITY WANING; BAKER TERRANE FORMS DOUBLY VERGENT FOLD AND THRUST BELT; ALDRICH MTNS. GROUP DEPOSITED IN ISOLATED, FAULT-BOUNDED BASINS

D - EARLY JURASSIC: PLEINSBACHIAN

TRANSGRESSION OF
HURWAL FM AND BURNT RIVER SCHIST
BASINAL STRATA OVER MARTIN
BRIDGE PLATFORM

CONTINUED FAULTING/DEFORMATION,
PRE-MOWICH UNCONFORMITY
MAY REPRESENT REGIONAL
PARTITIONING OF COLLISIONAL
STRAIN

E - MIDDLE JURASSIC

MIDDLE JURASSIC EROSION
AND THRUSTING?
UPLIFT OF WALLOWA ARC SYSTEM
FOLLOWED BY GRADUAL FOUNDERING
AND SUBMERGENCE OF ARC CRUST
DEPOSITION OF TRANSGRESSIVE
COON HOLLOW FM.

GRADUAL FOUNDERING
AND SUBMERGENCE OF ARC CRUST
SUBSIDENCE AND GROWTH
OF COLLISIONAL BASIN

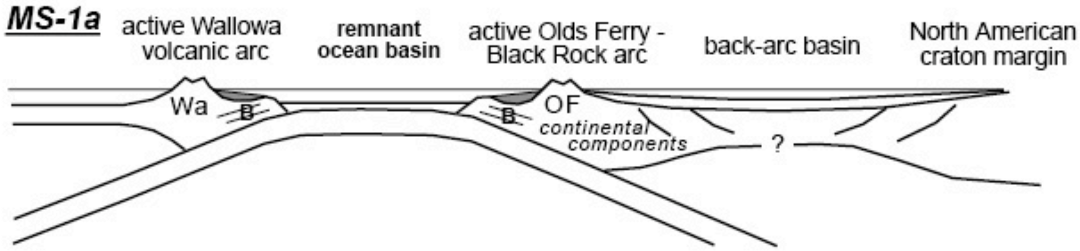
F - LATE JURASSIC

FINAL COLLISION AND THRUSTING OF
BAKER TERRANE OVER ARC TERRANES

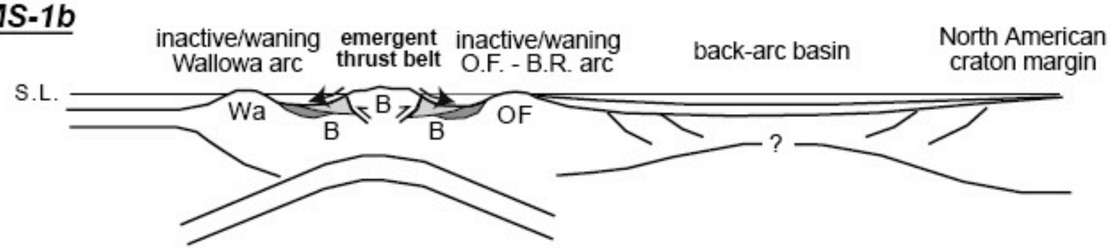
FINAL COLLISION AND THRUSTING OF
BAKER TERRANE OVER ARC TERRANES

West (restored coordinates) **East**

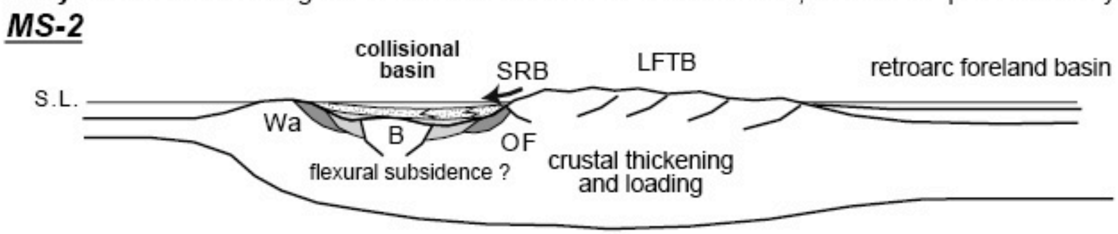
A. Middle to Late Triassic (Ladinian - Carnian): Active volcanic arcs flanking remnant ocean basin



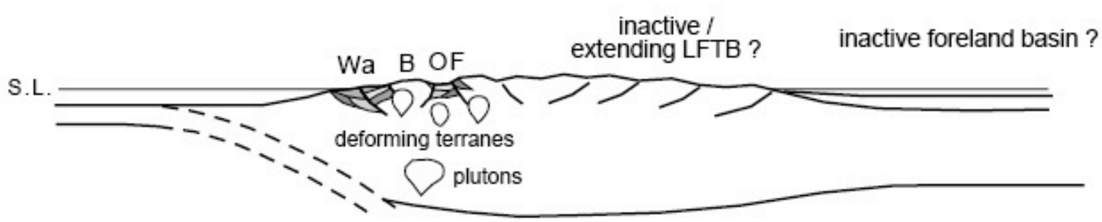
B. Late Triassic (Carnian - Norian): Mollucca Sea-type segmentation due to incipient arc-arc collision



C. Early to Late Jurassic: growth and subsidence of collisional basin; thick overlap sedimentary assemblag



D. Late Jurassic - Early Cretaceous: Thrusting, uplift, metamorphism, and pluton emplacement



Data used in terrane analysis

- Stratigraphy
- Paleontology
- Geochemistry
  - Igneous rock correlations
  - Age dating
- Structural relations
- Paleomagnetism