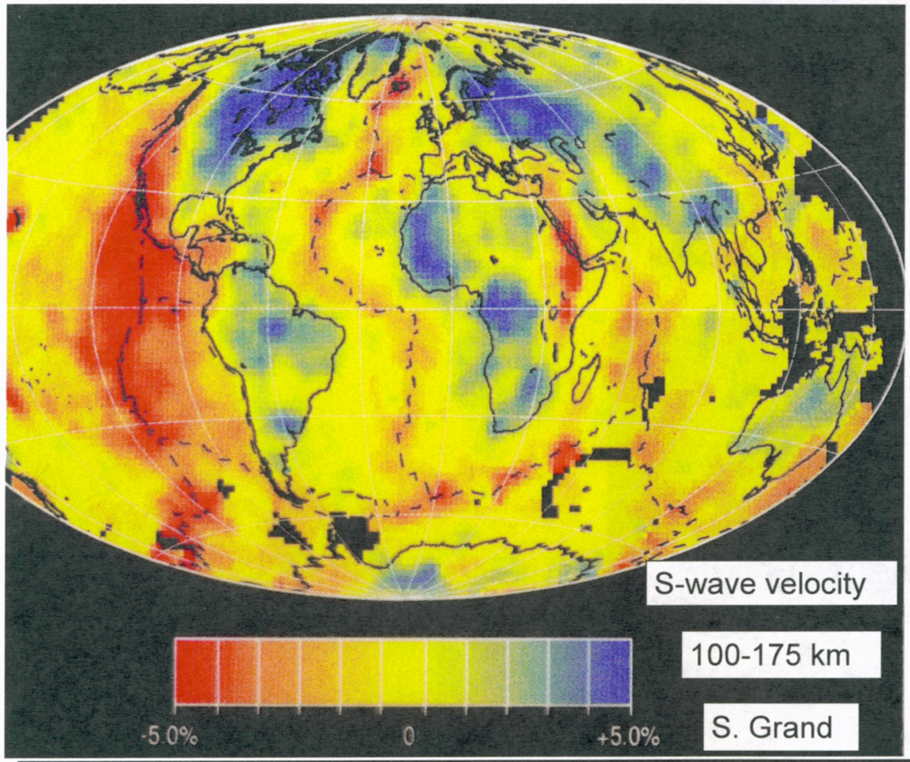
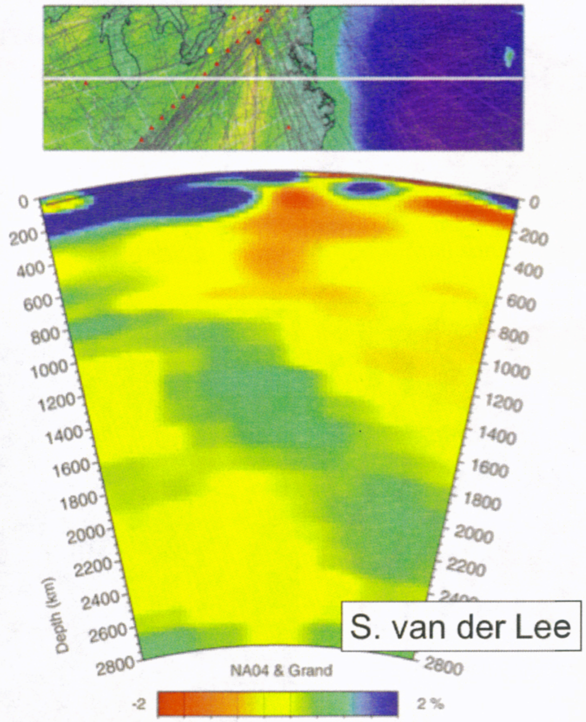
Cratons: Ancient crust and thick (stable and strong) mantle lithosphere

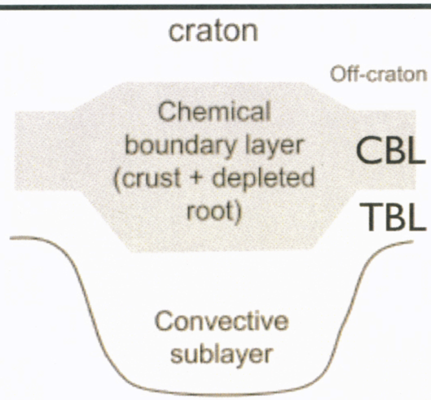
The key is the mantle lithosphere, which has had ~20% (basaltic) melt removed



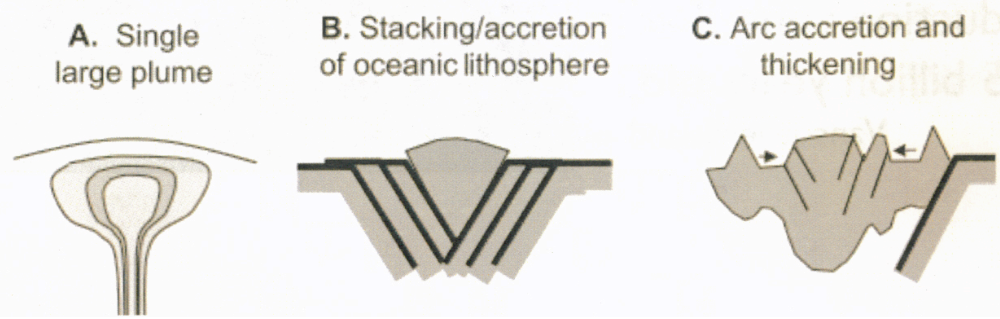


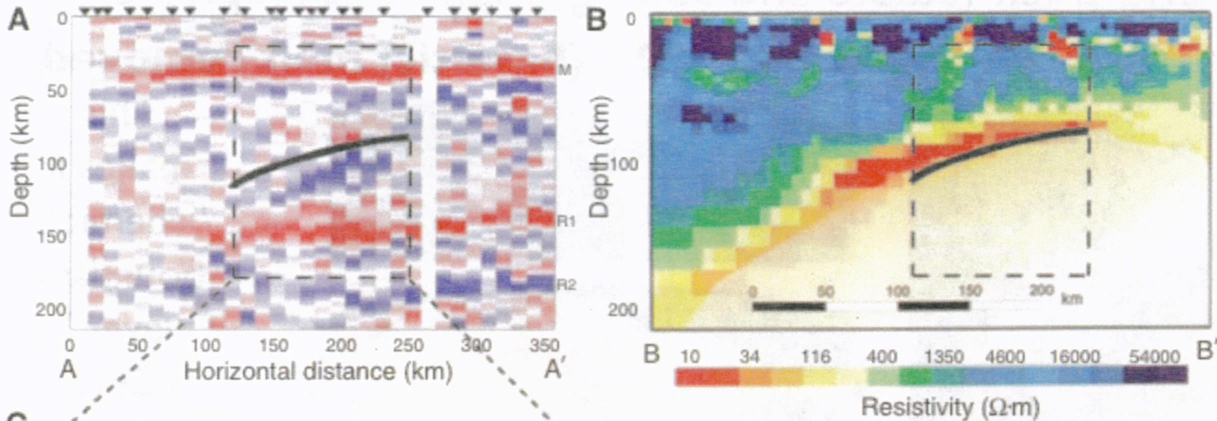
This makes a "chemical boundary layer" (CBL),

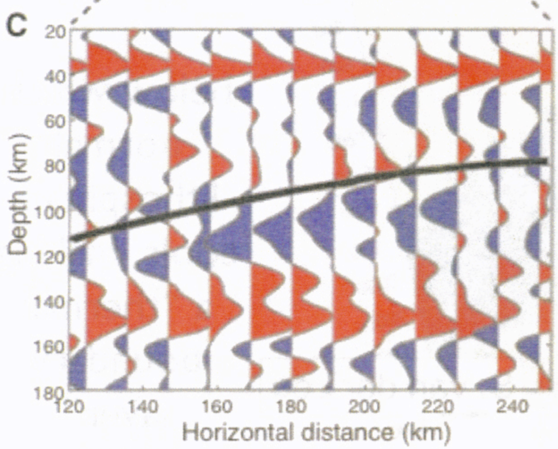
below which normal lithosphere cools, making a "thermal boundary layer" (TBL)

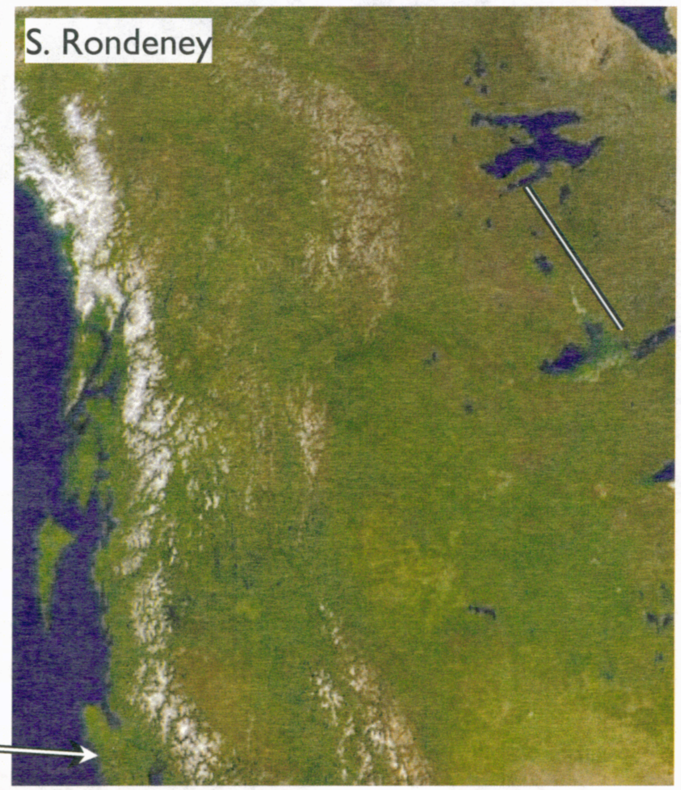


Proposed ways of making cratonic mantle CBL



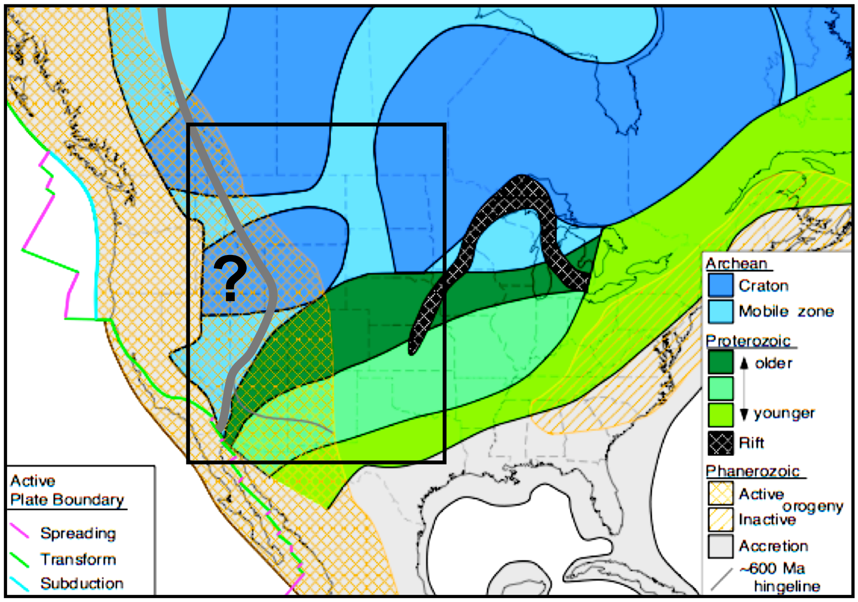






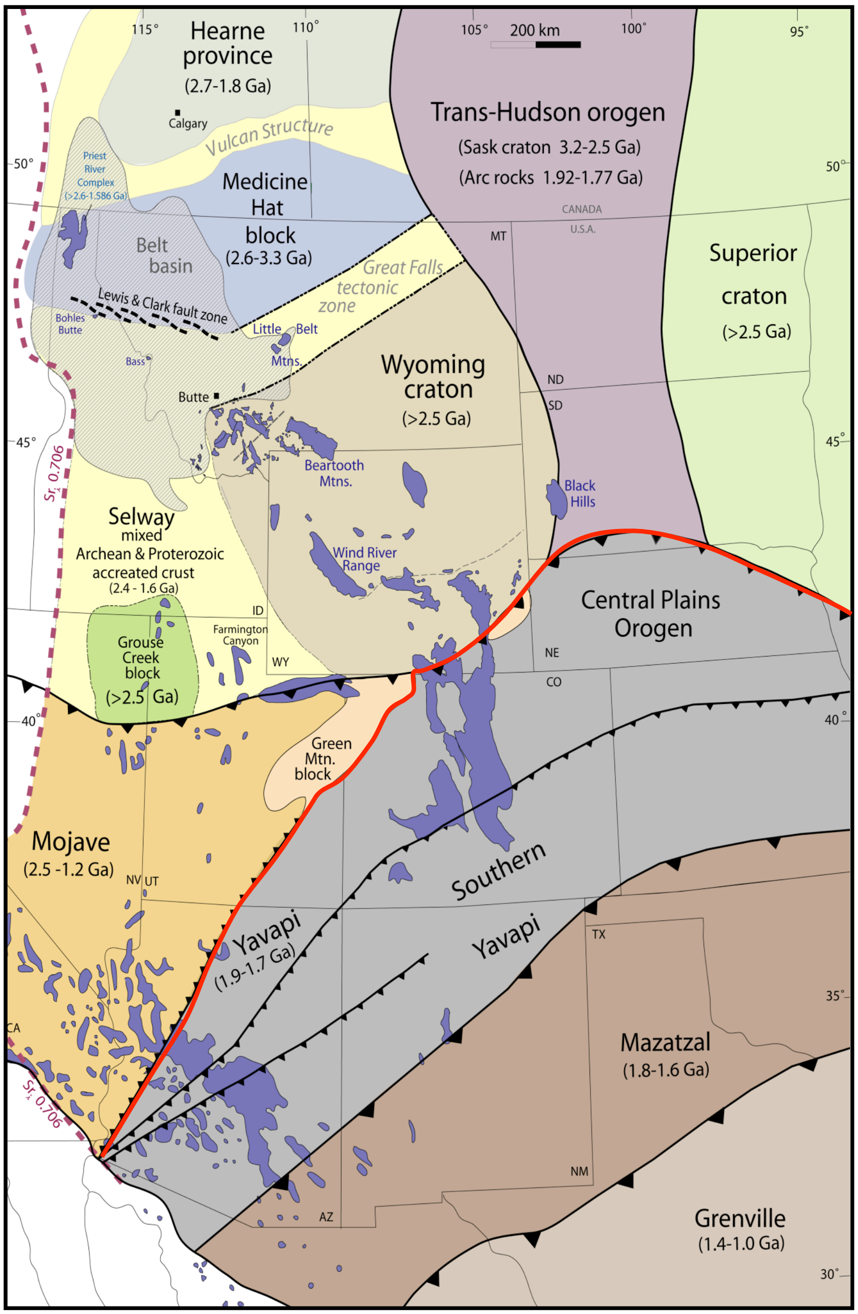
Seismic and resistivity image of a Canadian subduction zone that is 3.5 billion years old.

Vancouver Island



Notice the difference between the **Archean** (cratons and mobile belts) and the **Protorozoic** (accreted belts, often volcanic arcs).

In the Archean, many of the mobile belts were volcanic arcs,
but through the ages, repeated deformation of these weaker zones has made highly deformed zones.

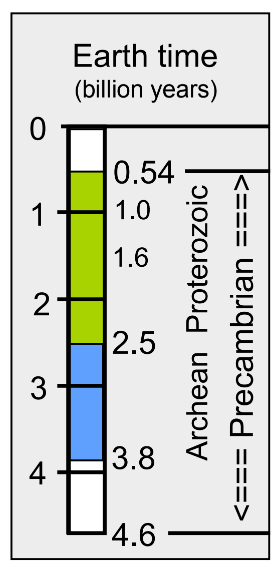


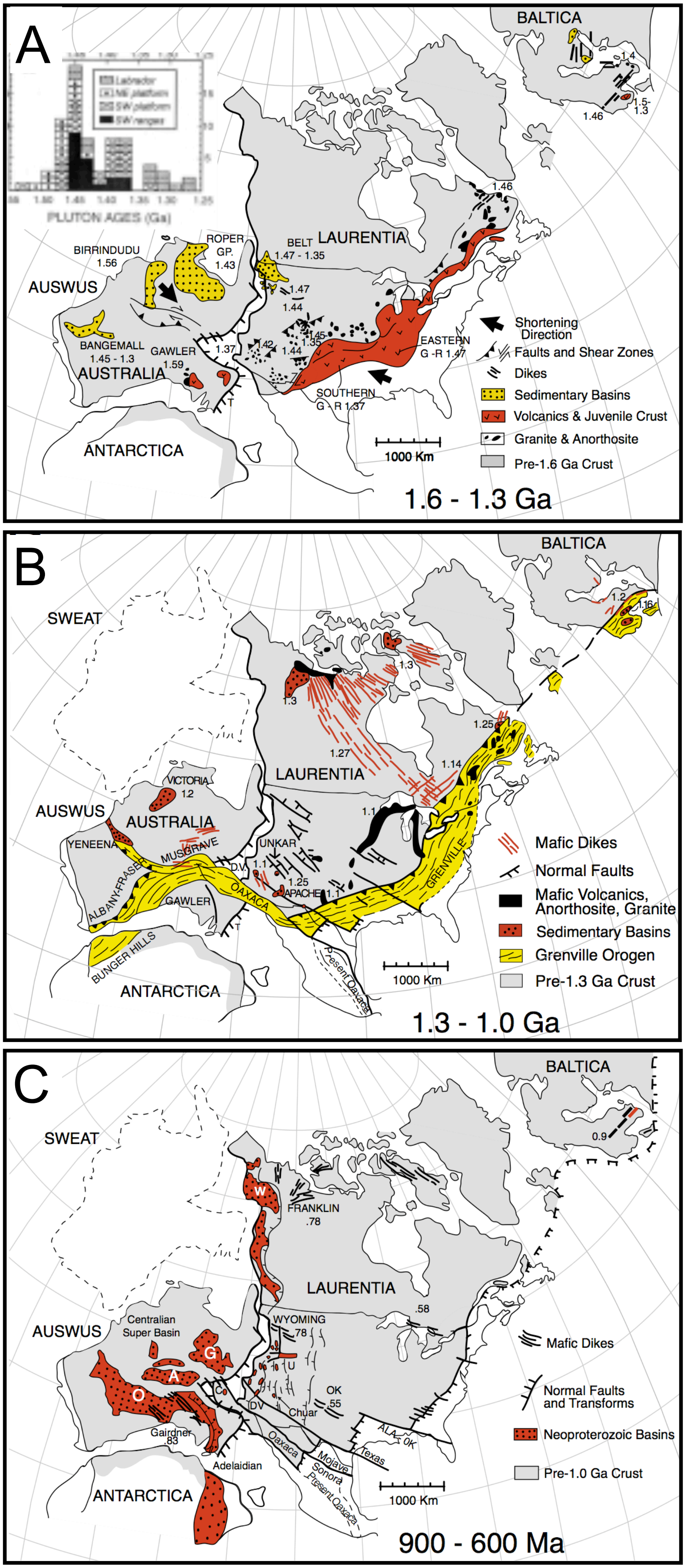
Foster et al., 2006

Some details

The ***Belt Basin*** is a thick sedimentary unit about 1.4 b.y. old that was deposited on North America before its western margin rifted away.

The western edge of Precambrian North America is mostly obscured by sedimentary cover. Its location is often inferred by a chemical indicator carried by magma as it samples the lithospheric mantle on its way up. The most commonly used indicator is uses Strontium, commonly called the **Sr 0.706 line** (initial $^{87}Sr/^{86}Sr = 0.706$).



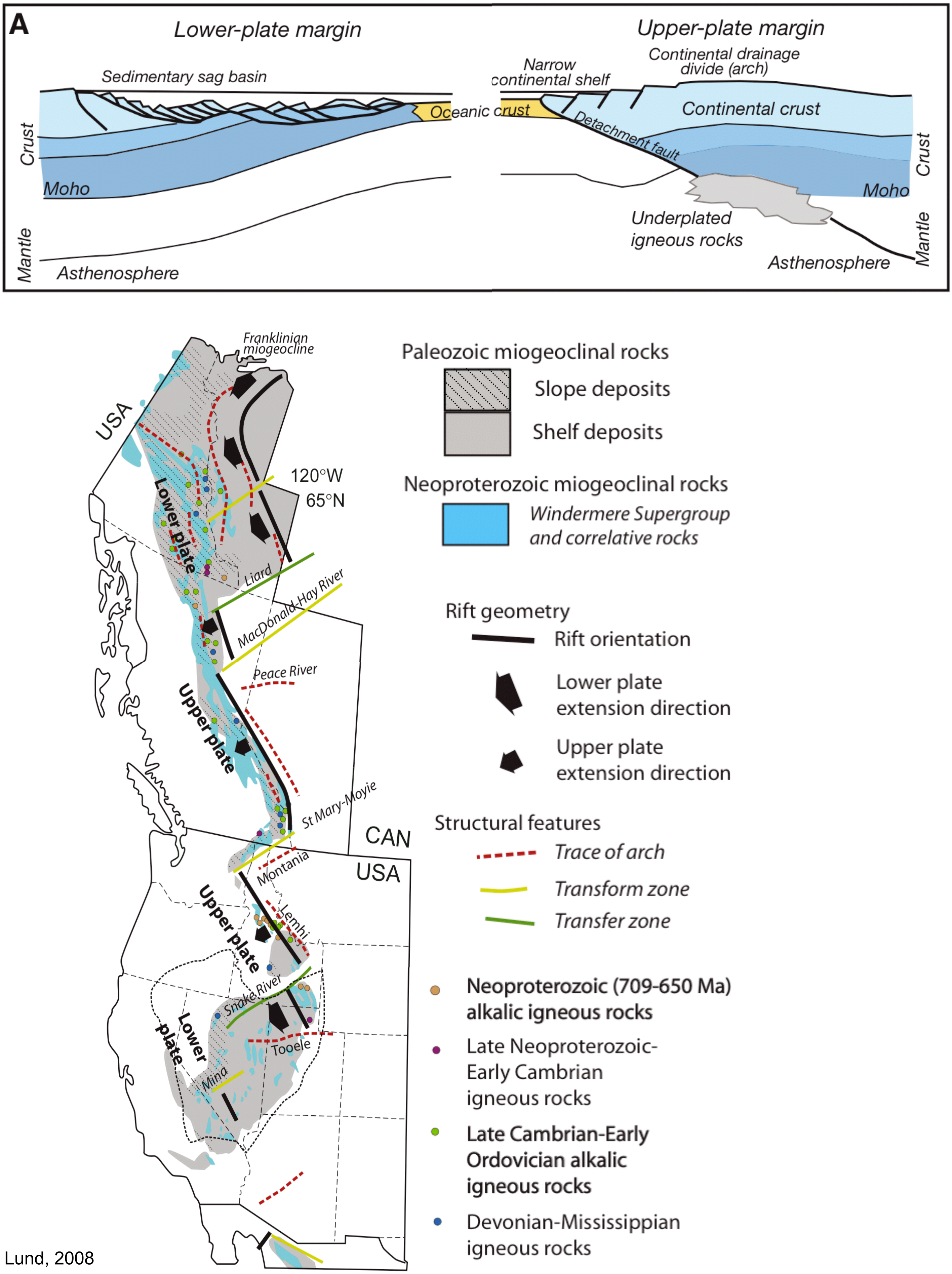


Trying to match:

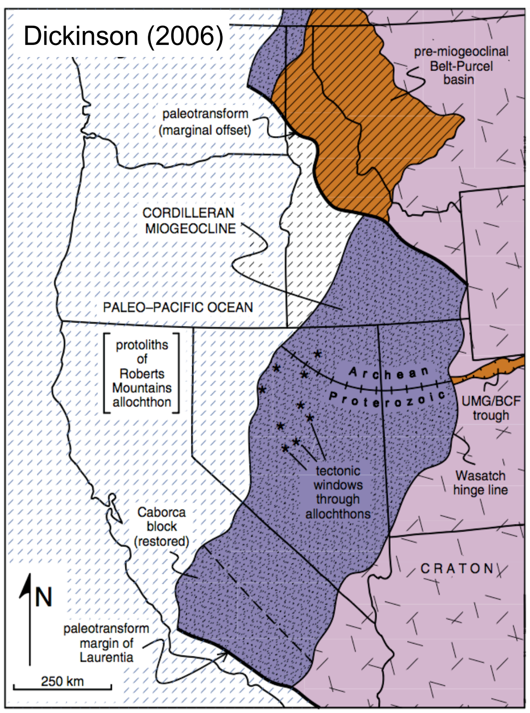
(A & B) Laurentia belts that trend across the future Rift, and

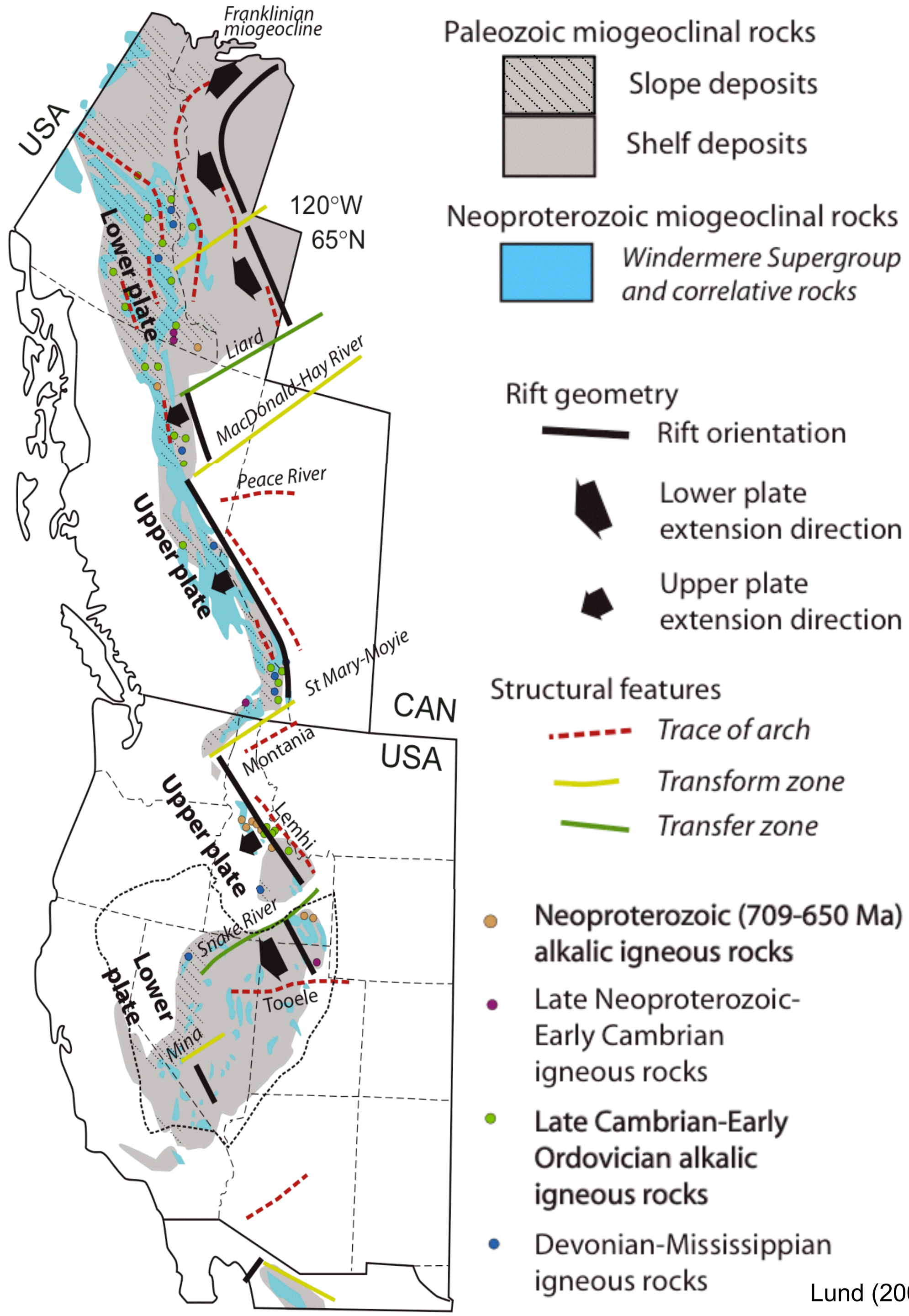
(C) the sediments and structures associated with the Rift

Karlstrom et al., 1999


A
Lower-plate margin
Sedimentary sag basin
Crust
Moho
Mantle
Asthenosphere
Oceanic crust
Upper-plate margin
Narrow continental shelf
Continental drainage divide (arch)
Continental crust
Detachment fault
Crust
Moho
Underplated igneous rocks
Asthenosphere
Mantle
Franklinian miogeocline
USA
120°W
65°N
Lower plate
Liard
MacDonald-Hay River
Peace River
Upper plate
St Mary-Moyie
CAN
USA
Montania
Lemhi
Upper plate
Snake River
Tooele
Lower plate
Mina
Paleozoic miogeoclinal rocks
Slope deposits
Shelf deposits
Neoproterozoic miogeoclinal rocks
Windermere Supergroup and correlative rocks
Rift geometry
Rift orientation
Lower plate extension direction
Upper plate extension direction
Structural features
Trace of arch
Transform zone
Transfer zone
Neoproterozoic (709-650 Ma) alkalic igneous rocks
Late Neoproterozoic-Early Cambrian igneous rocks
Late Cambrian-Early Ordovician alkalic igneous rocks
Devonian-Mississippian igneous rocks

Lund, 2008


Dickinson (2006)
pre-miogeoclinal Belt-Purcel basin
paleotransform (marginal offset)
CORDILLERAN MIOGEOCLINE
PALEO-PACIFIC OCEAN
protoliths of Roberts Mountains allochthon
Archean
Proterozoic
UMG/BCF trough
tectonic windows through allochthons
Wasatch hinge line
Caborca block (restored)
CRATON
N
paleotransform margin of Laurentia
250 km


Franklinian miogeocline
USA
120°W
65°N
Lower plate
Liard
MacDonald-Hay River
Peace River
Upper plate
St Mary-Moyie
CAN
USA
Montania
Upper plate
Lemhi
Snake River
Lower plate
Tooele
Mina
Paleozoic miogeoclinal rocks
Slope deposits
Shelf deposits
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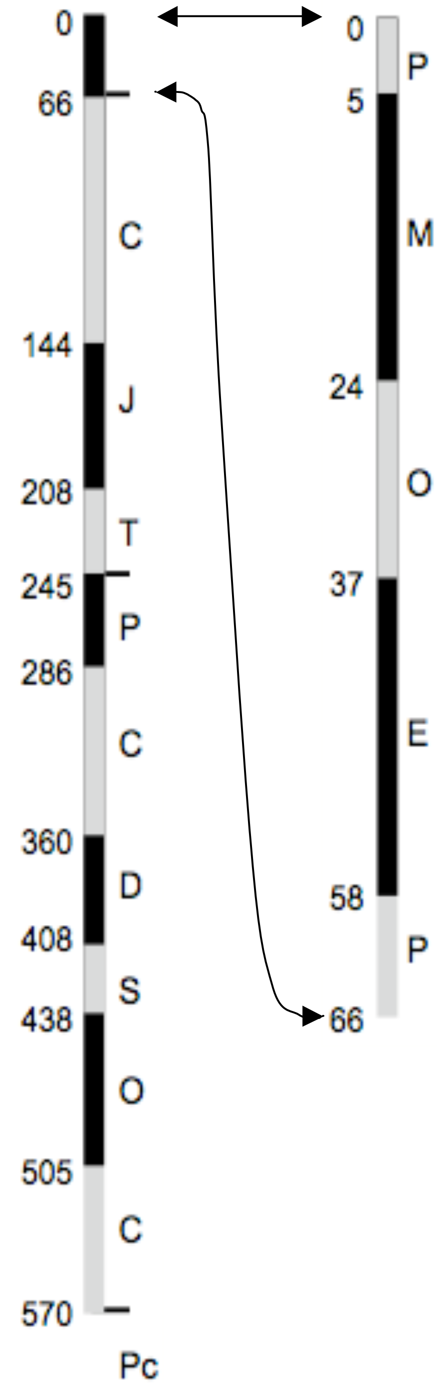
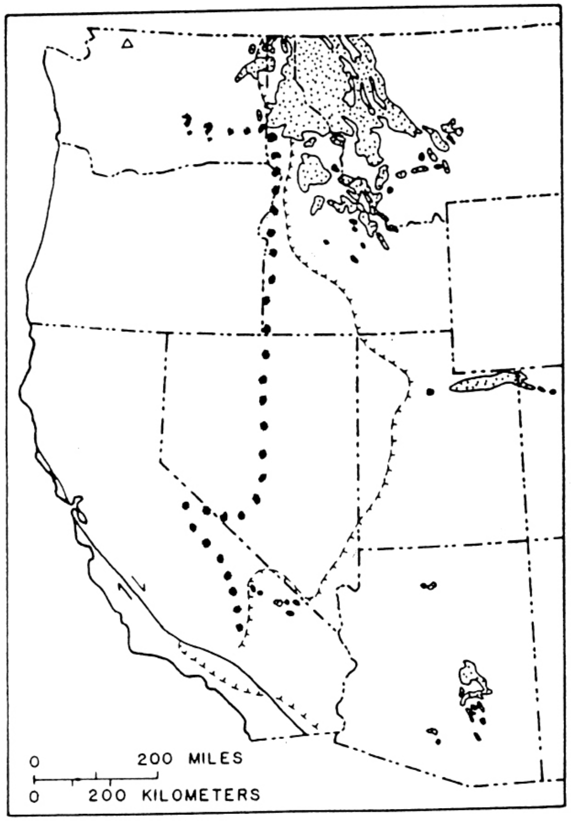
Late Cambrian-Early Ordovician alkalic igneous rocks
Devonian-Mississippian igneous rocks

Lund (2008)



0
66
C
144
J
208
T
245
P
286
C
360
D
408
S
438
O
505
C
570
Pc
0
P
5
M
24
O
37
E
58
P
66

The ~600 M.Y.B.P. Rift



OUTCROP OF BELT SUPERGROUP
AND TEMPORALLY EQUIVALENT ROCKS

APPROXIMATE WESTWARD EXTENT OF OUTCROPS
OF PRECAMBRIAN CRYSTALLINE BASEMENT ROCKS

ISOLATED OUTCROP OF PRECAMBRIAN
CRYSTALLINE BASEMENT ROCKS

SAN ANDREAS FAULT
ARROWS INDICATE RELATIVE MOVEMENT

Presumed westward limit of PЄ basement

Figure 1. Distribution of crystalline basement rocks (2,400-1,450 m.y.) and Belt-age (1,450-900? m.y.) unmetamorphosed sedimentary and volcanic rocks in the western United States. Based in part on King (1976) and Armstrong(1975).

MAXIMUM ORIGINAL
EASTWARD EXTENT

Trempealeauan Stage
(upper Upper Cambrian)

Franconian Stage
(middle Upper Cambrian)

Dresbackian Stage
(lower Upper Cambrian)

Upper Middle Cambrian

Lower Middle Cambrian

Lower Cambrian

GENERALIZED DISTRIBUTION OF
TERRIGENOUS DETRITAL SEQUENCE
WHERE IT IS GREATER THAN
300 m THICK

0 200 Miles
0 200 Km

CAMBRIAN AND LATEST PRECAMBRIAN PALEOGEOGRAPHY

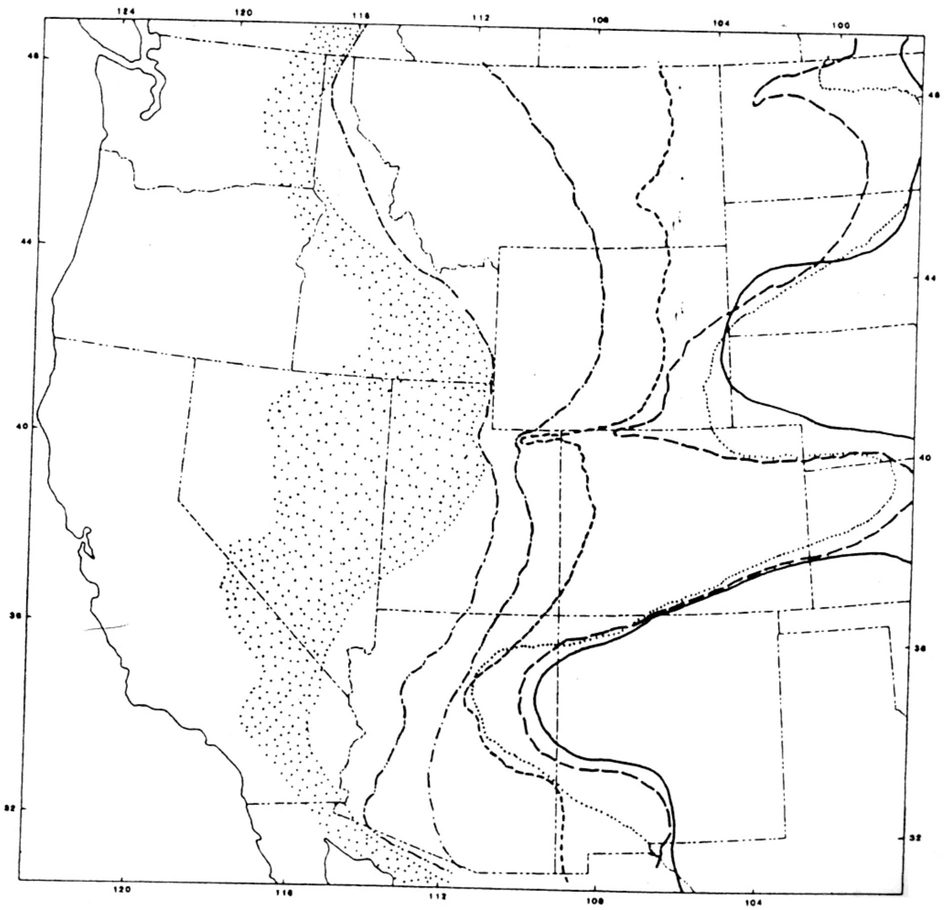
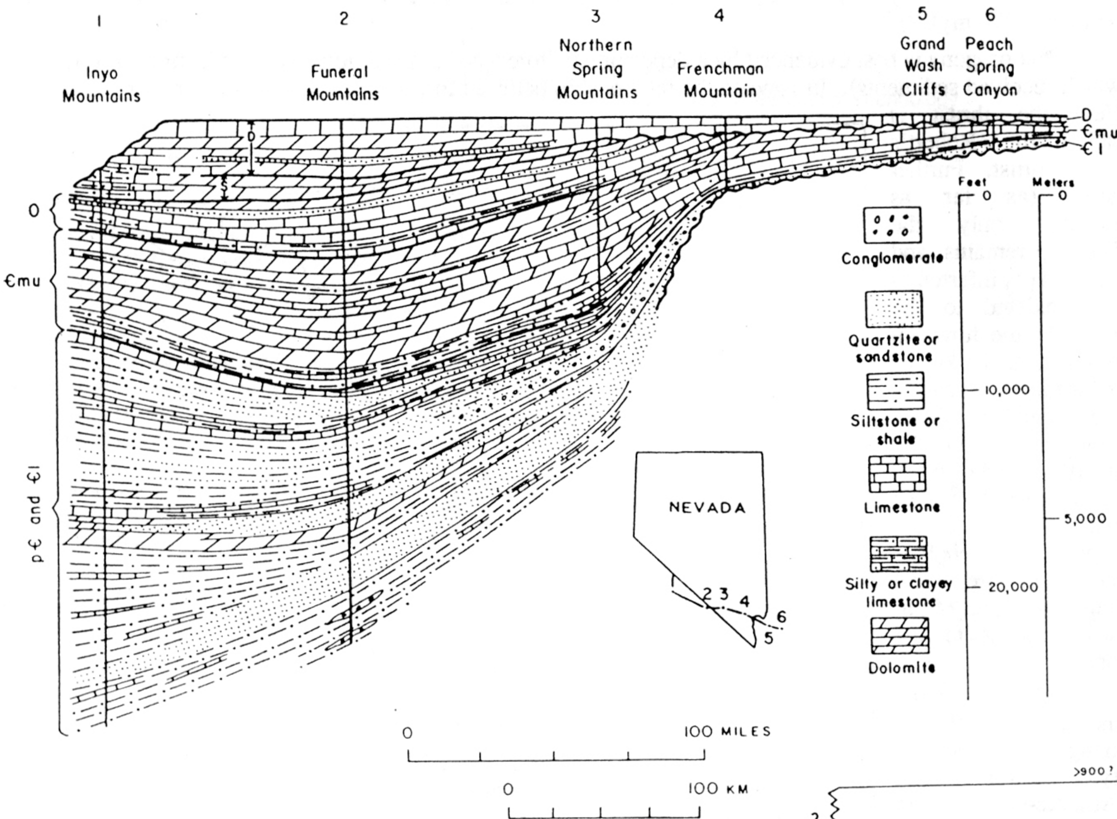


Figure 10. Distribution of miogeoclinal upper Precambrian and Lower Cambrian terrigenous detrital sequence and maximum original eastward extent of Middle and Upper Cambrian stages in the western United States (in part after Lochman-Balk, 1972).

Figure 7. Cross section of upper Precambrian and lower Paleozoic rocks in the southern Great Basin (after Stewart and Poole, 1974). Symbols: p€ and €l, upper Precambrian and Lower Cambrian; €mu, Middle and Upper Cambrian; O, Ordovician; S, Silurian; D, Devonian.



The Paleozoic Wedge

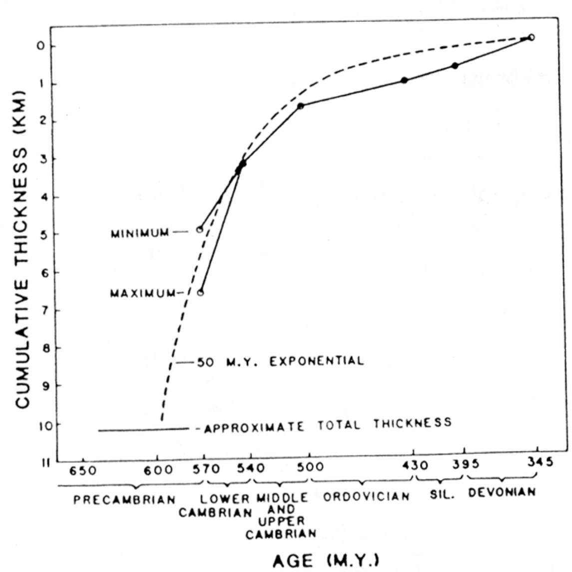


Figure 8. Cumulative thickness with time of upper Precambrian and lower Paleozoic rocks in the White-Inyo Mountains of eastern California.

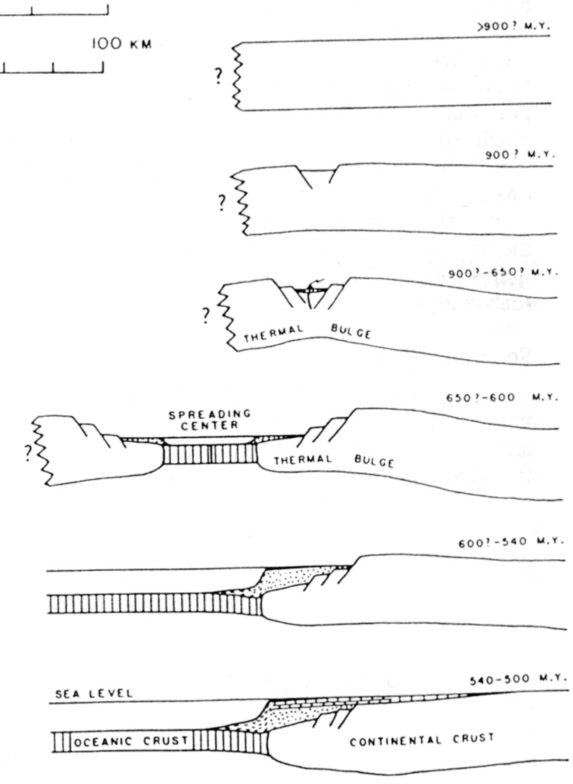


Figure 9. Diagram showing a model of the late Precambrian and Cambrian development of the western United States.

The Antler and Sonoma Orogenies

Antler (~ 370 myBP)

This orogeny is best evidenced by a depositional "foredeep" (crustal downwarping in front of thrust which received sediments). In Nevada the relationship between foredeed and thrust is clearly preserved. Here the thrust is called the Robert's Mtn. Thrust. Further north (as far as Yukon), only the foredeep remains, and the thrust is inferred to have existed to the west. In the foredeep as much as 10 km of sediments accumulated, deriving themselves both from the newly created highlands to the west (which were eroded, in places, to their Precambrian core), and more importantly from the continent to the east.

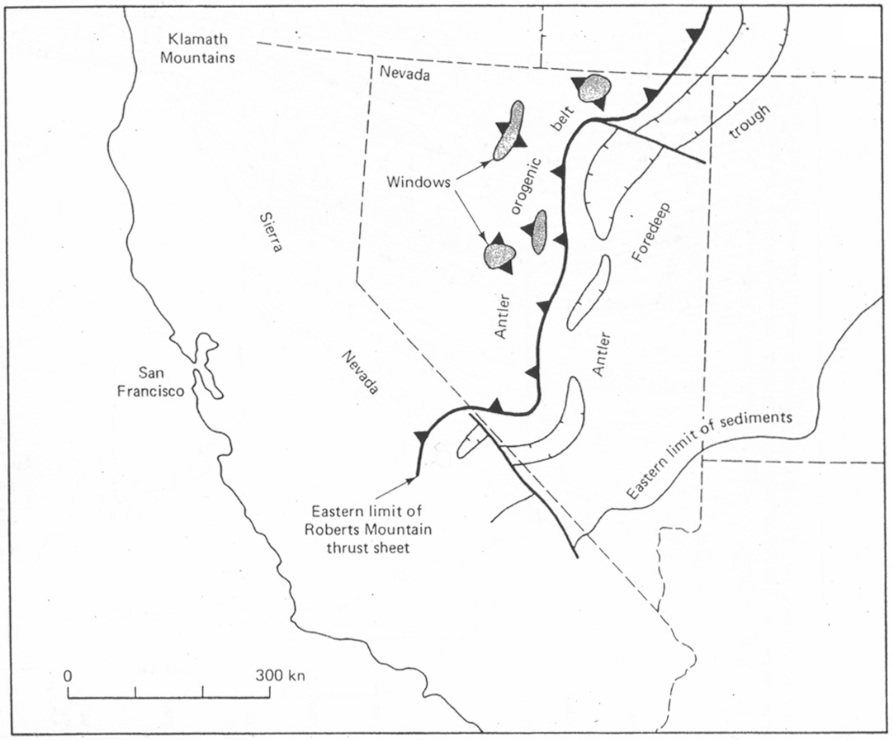


FIGURE 13–6 The Antler orogenic belt in central Nevada and foredeep trough to the east showing the extent of upper Lower Carboniferous strata. Windows through the Roberts Mountain thrust sheet expose autochthonous lower Paleozoic shallow-water carbonates, whereas the structurally overlying rocks are lower Paleozoic deep-water sediments.

This event is the first evidence for a change in tectonic style from an "Atlantic-type" margin to the convergent margin that will shape much of the Cordillera. The cause of this orogeny is something compressive, perhaps the arrival of the early Sierra Nevada/Klamath arc. It has been called "thin skinned" because thin units of the Paloezoic-wedge rock comprised the thrust sheet.

Sonoma (~250 myBP)

This event was very much like the Antler. The thrust in this orogeny (the Golconda Thrust) ran parallel to, but west of the Robert's Mtn. Thrust. It too produced a foredeep that received many kilometers of sediment. Another important observation is that, unlike the Antler, volcanic sediments (derived from the west) are found, arguing for the arrival of part of the Sierra/Klamath arc at this time.