Climatic And Tectonic Controls On Jurassic Intra-Arc Basins Related To Northward Drift Of North America

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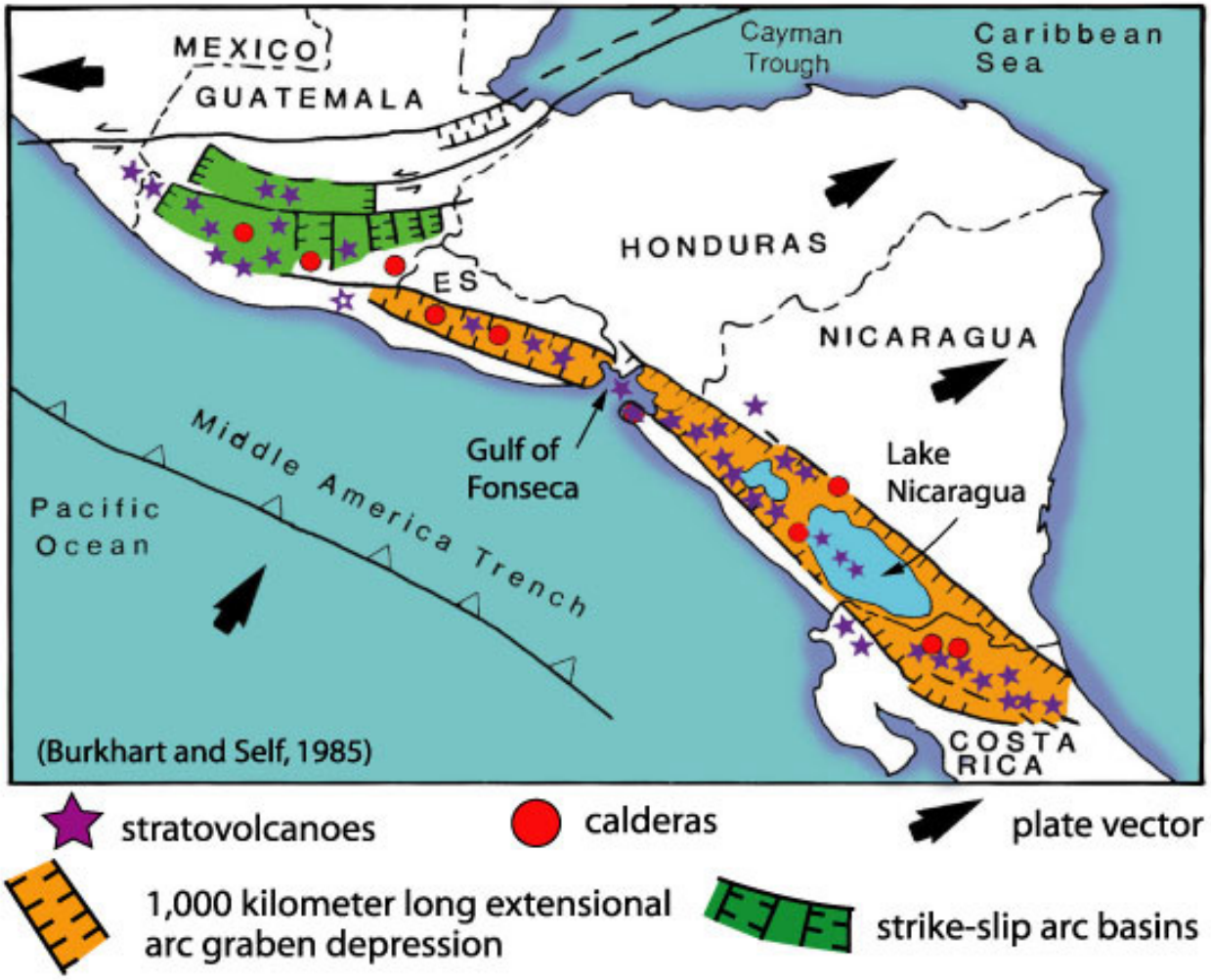
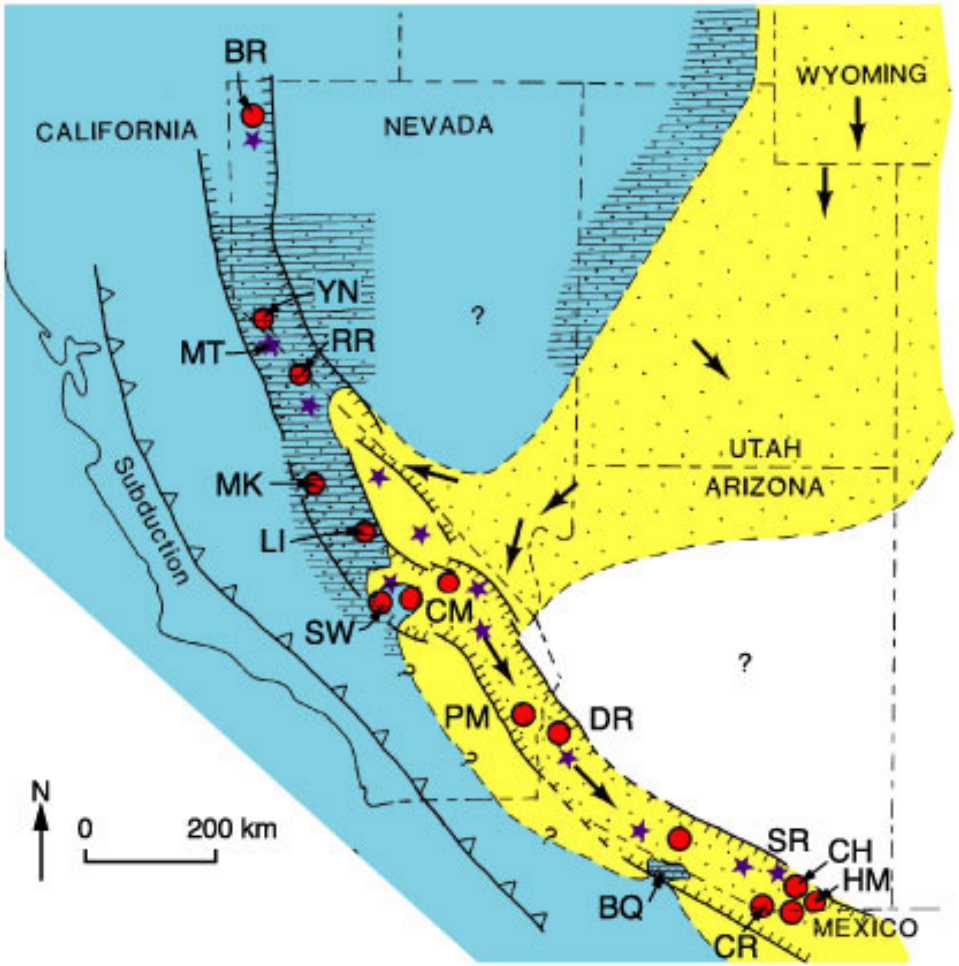
Santa Barbara, CA


MEXICO
GUATEMALA
Cayman Trough
Caribbean Sea
HONDURAS
ES
NICARAGUA
Gulf of Fonseca
Lake Nicaragua
Middle America Trench
Pacific Ocean
(Burkhart and Self, 1985)
COSTA RICA
stratovolcanoes
calderas
plate vector
1,000 kilometer long extensional arc graben depression
strike-slip arc basins

Late Triassic to Middle Jurassic Continental Arc Graben Depression

(Busby-Spera, 1988)



Graben depression

caldera ★ composite volcano

Quartz Arenite
nonmarine
marine

Well-dated localitites (N to S):

BR - Black Rock Desert
YN - Yerington District
MT - Mt. Talac
RR - Ritter Range
MK - Mineral King
LI - Lake Isabella
SW - Sidewinder Volcanics
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Late Triassic to Middle Jurassic Continental Arc Graben Depression

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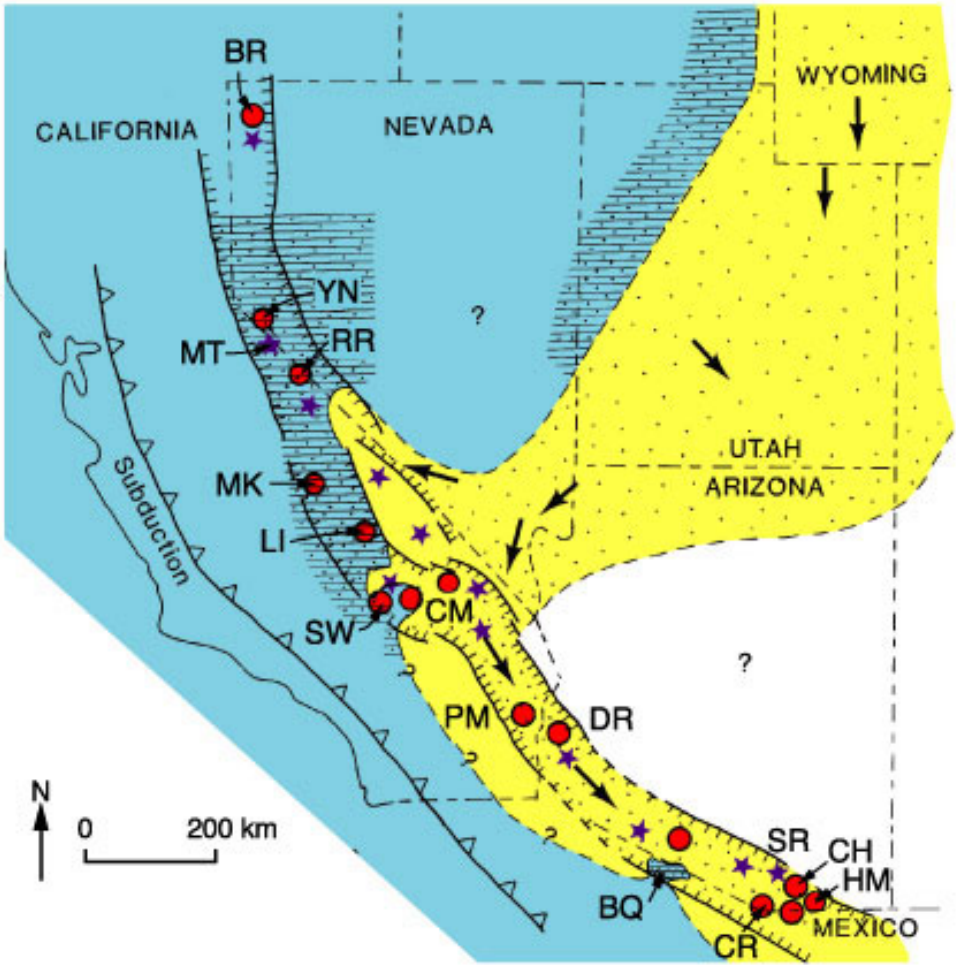

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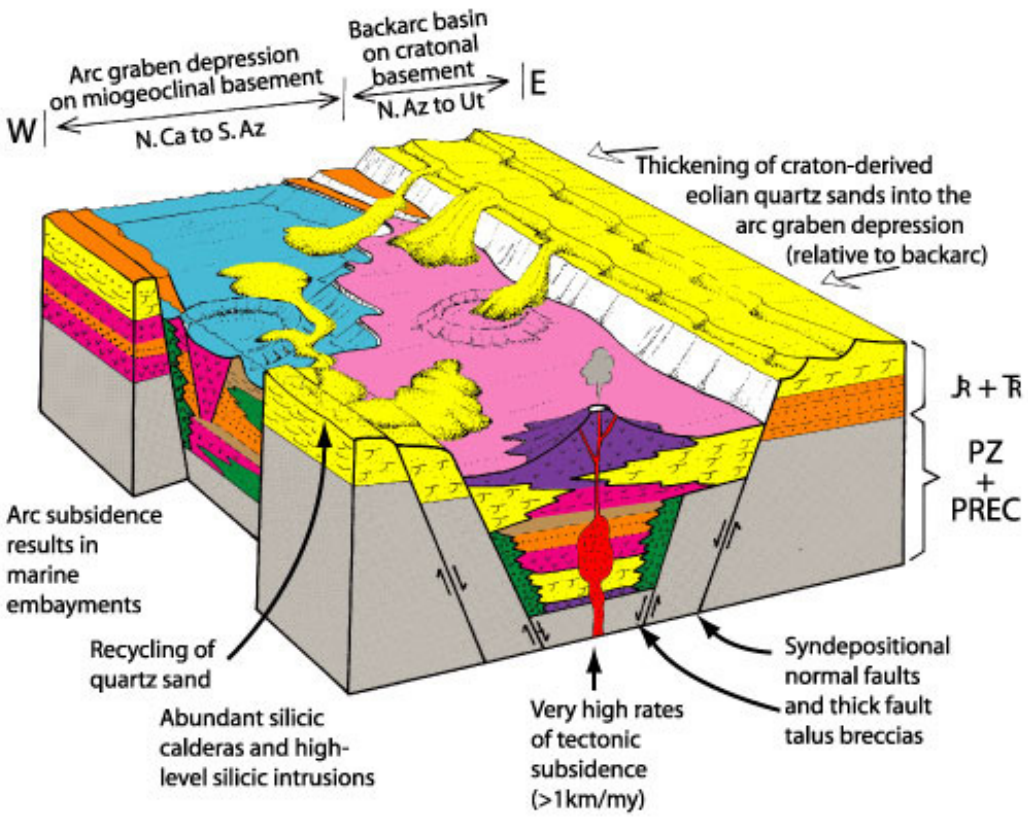
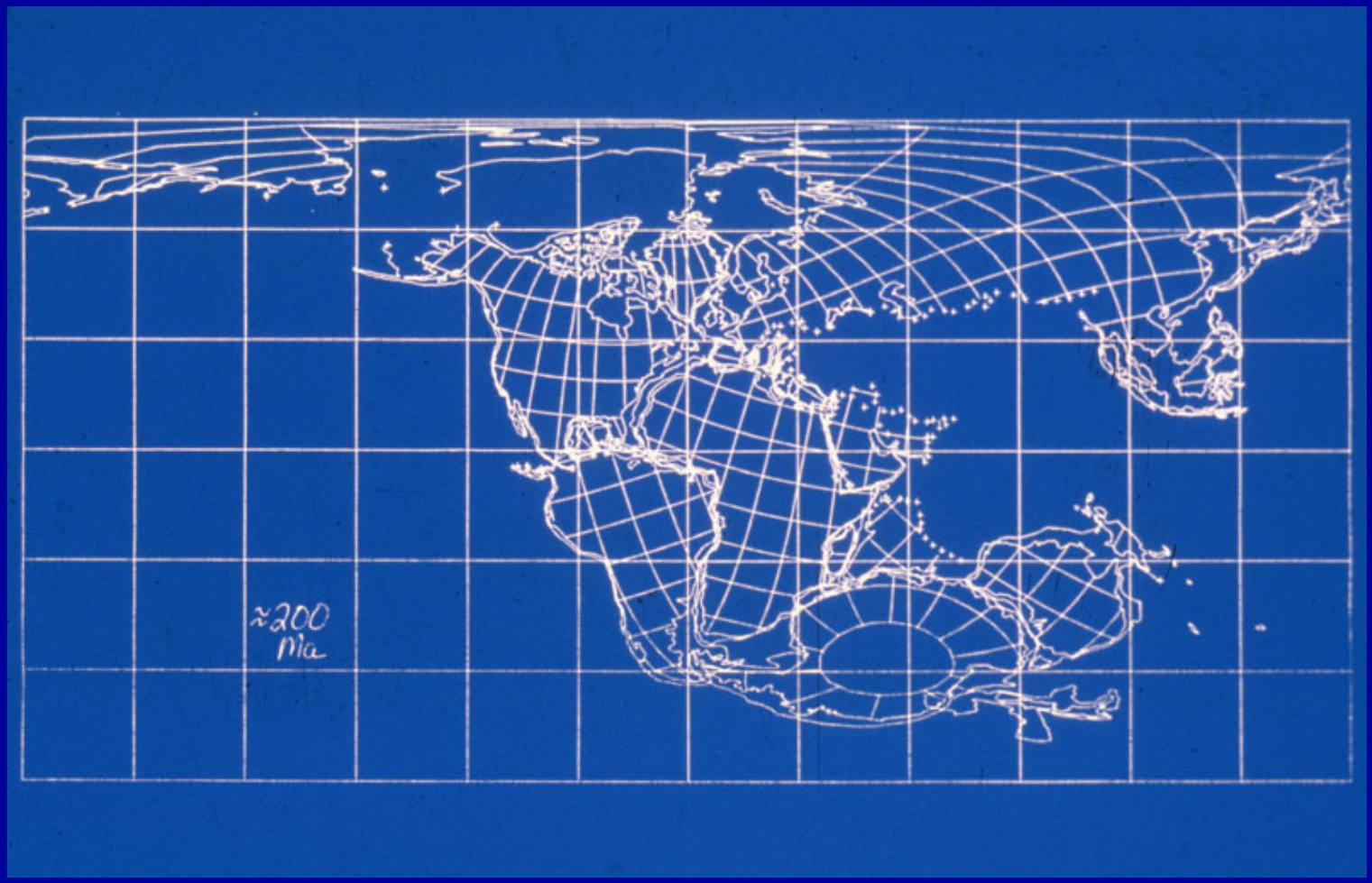
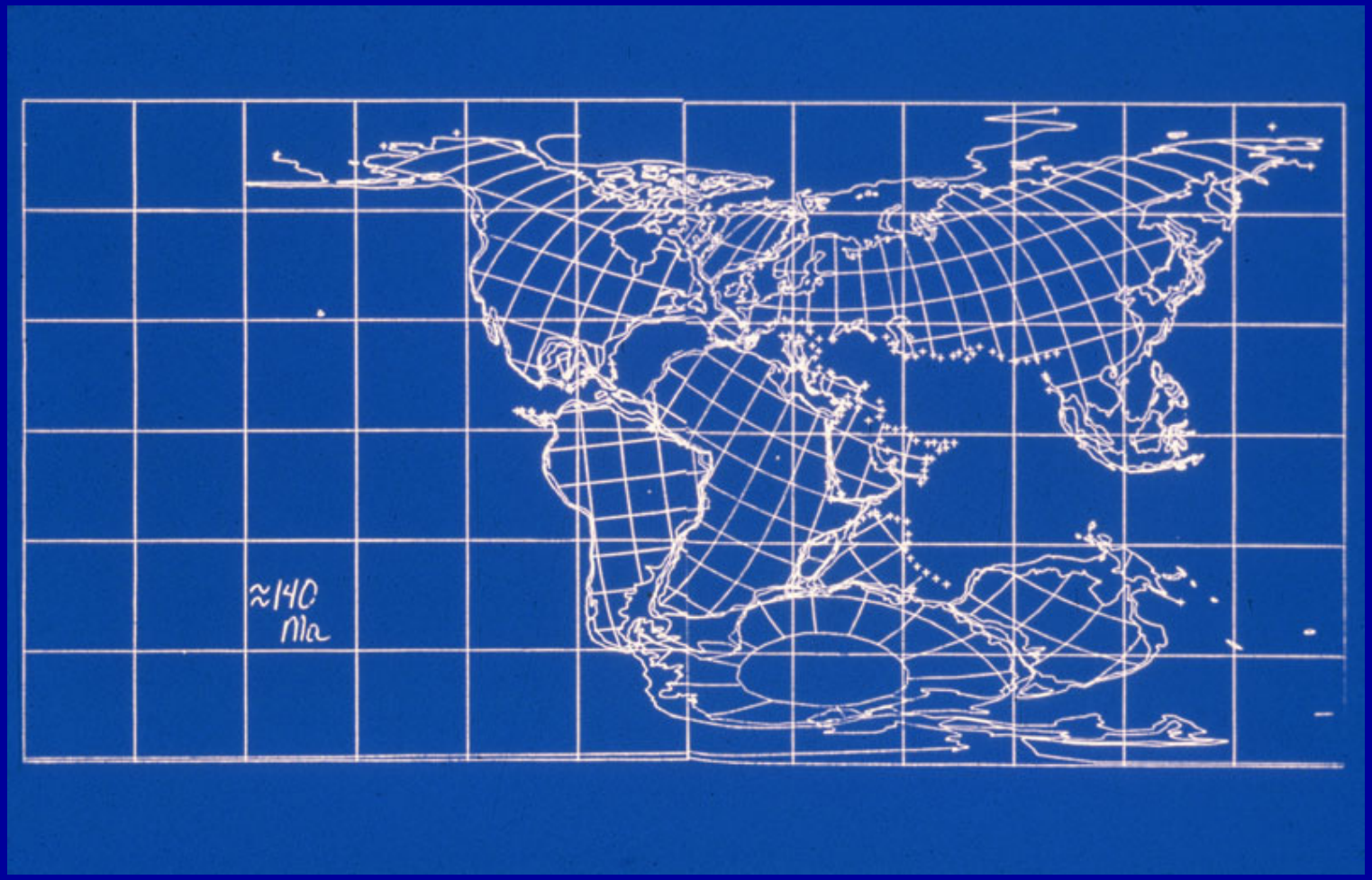
Evidence for Late Triassic to Middle Jurassic Continental Arc Graben Depression, Southwest US and Mexico

(Busby-Spera, 1988)



Oxygen isotope data of Solomon and Taylor (1989) further supports Jurassic arc-rift model. Jurassic arc rifting in arid latitudes caused Fe oxide-rich mineral deposits (Barton and Johnson, 1996)

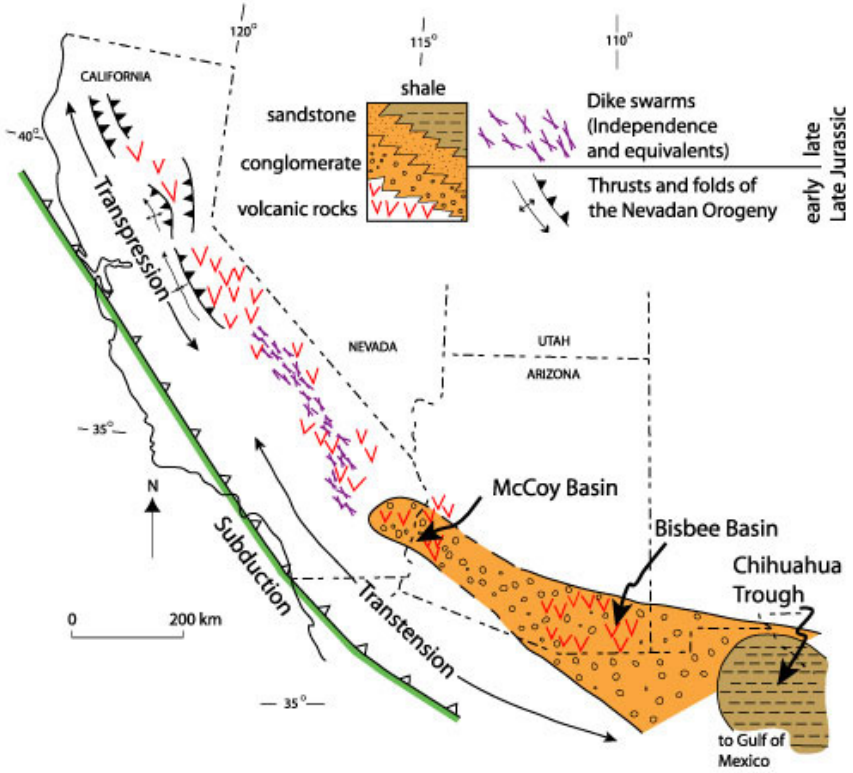

≈200
Ma


≈140
Ma

Continental Arc-Rift Basins

	Early to Middle Jurassic Extensional Arc	Late (?) Jurassic Strike-Slip Arc
volcanic controls	more voluminous, widespread, and continuous eruptions => scarps buried by pyroclastic deposits	more restricted eruptions in space and time, episodic => scarps eroded shedding sediments into the canyons
structural controls	uniformly fast and continuous subsidence => unconformities rare	"porpoising" on all scales, local regions of uplift within basins => numerous big unconformities intrabasinal highs shed sediment
climatic controls	hyperarid: eolianites => "dry" eruptions of welded tuffs, most rheomorphic	wetter climate: sheetwash & channelized HFF & dilute flow => "wet" eruptions of nonwelded tuffs, plinian, & phreatoplinian fall

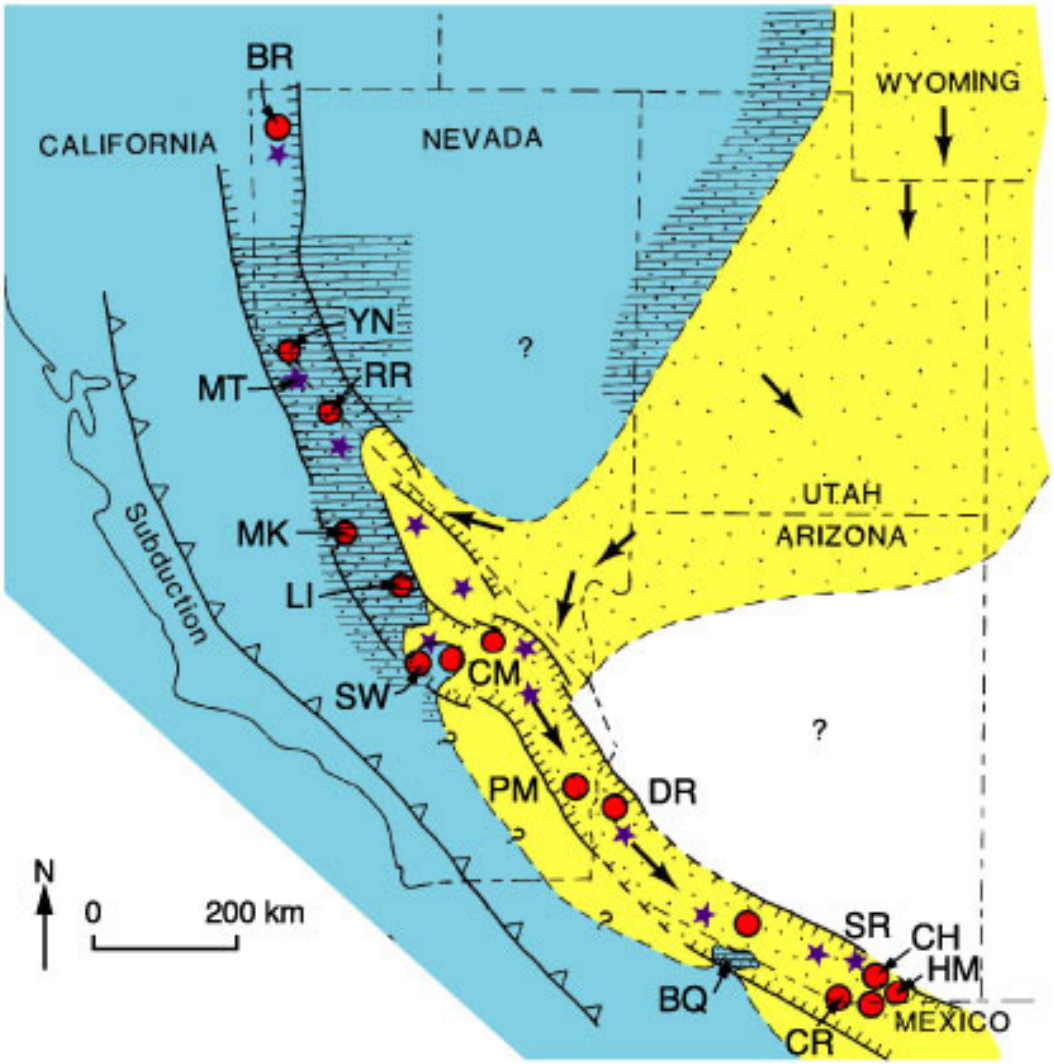
Late Jurassic Transpressional to Transtensional Arc



(Busby-Spera et al, 1990)

Late Triassic to Middle Jurassic Continental Arc Graben Depression

(Busby-Spera, 1988)



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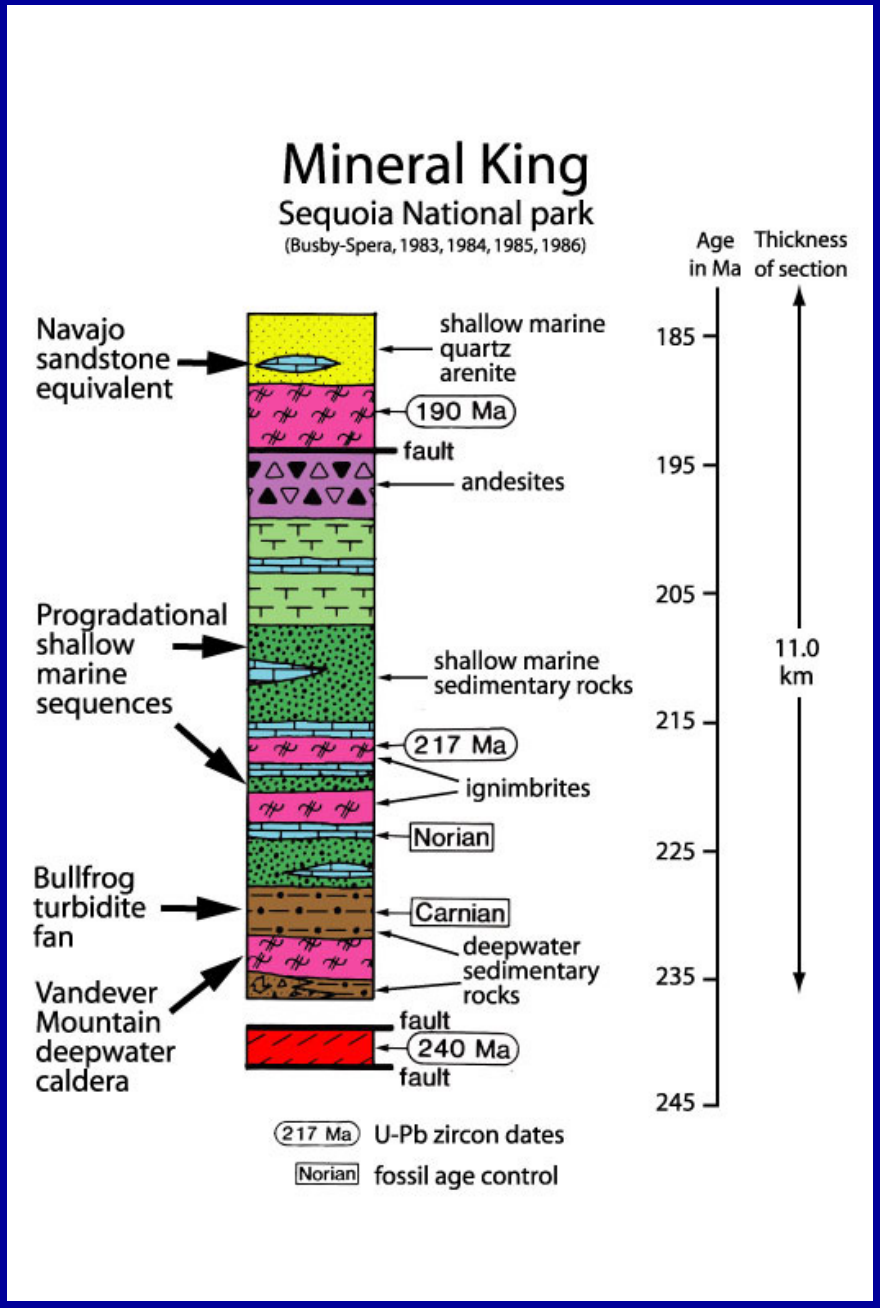
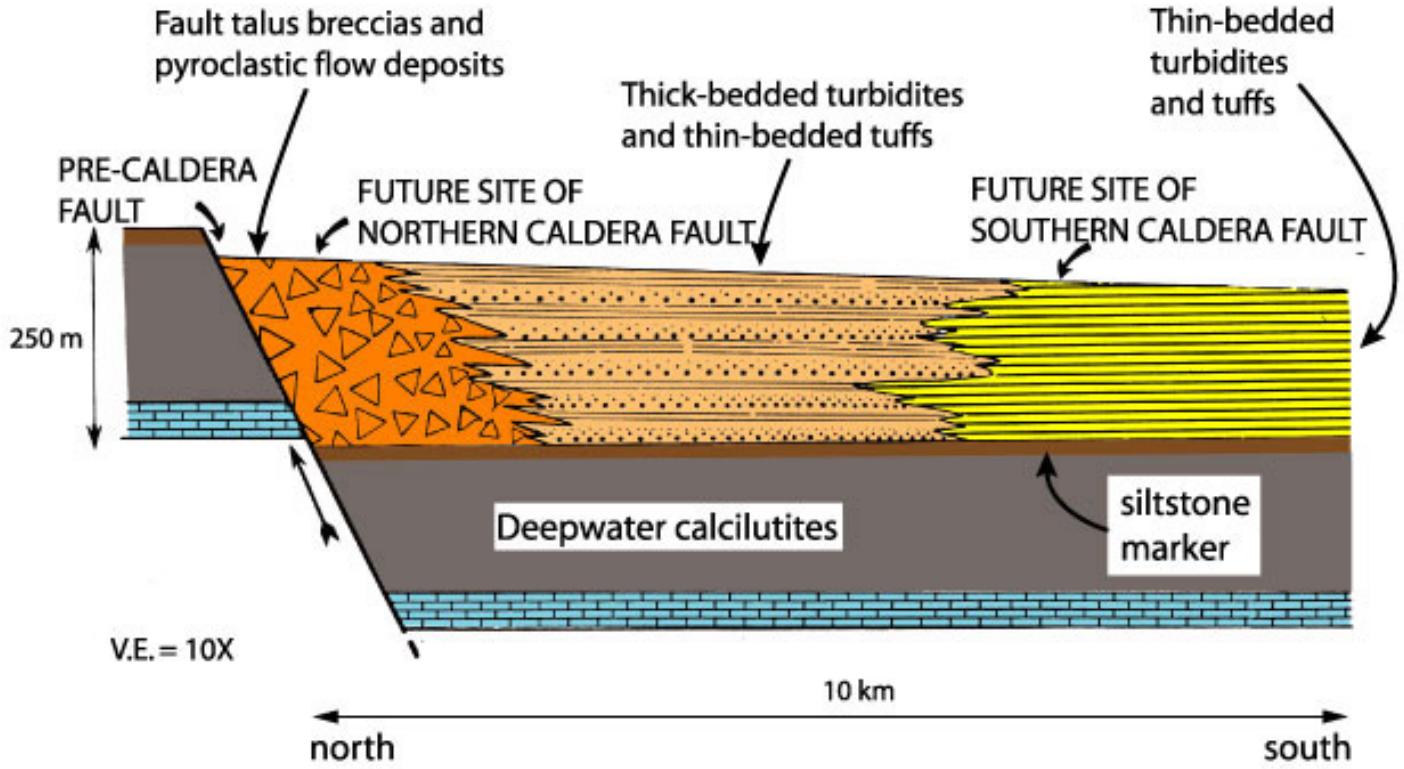
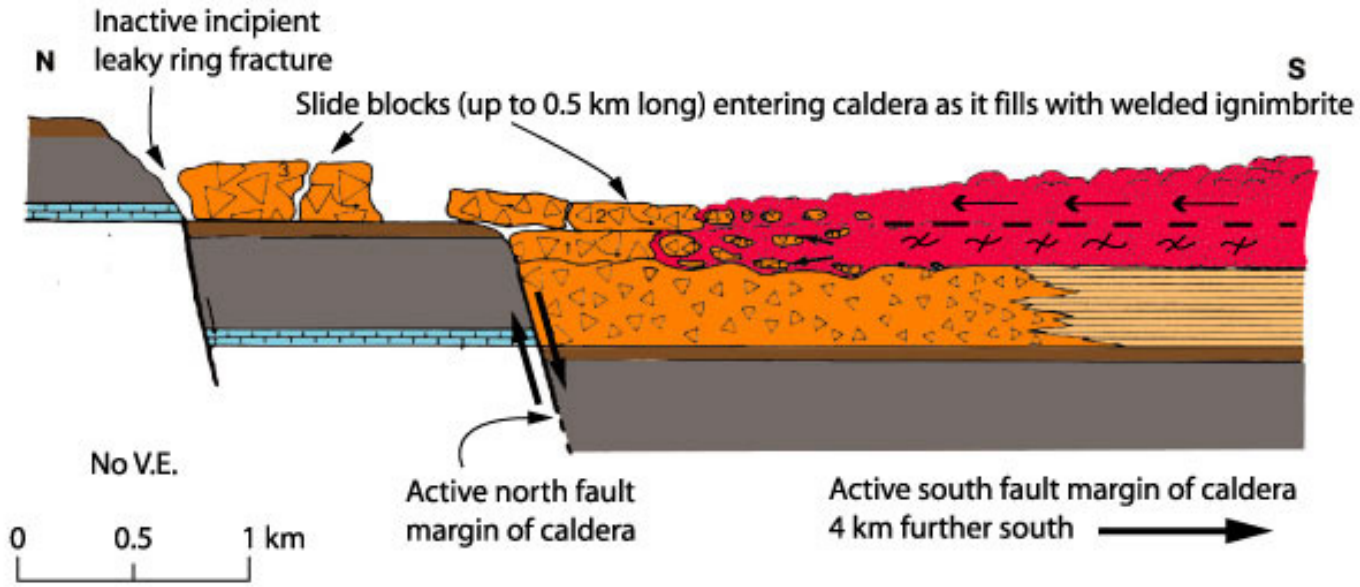

Mineral King
Sequoia National park
(Busby-Spera, 1983, 1984, 1985, 1986)
Age in Ma
Thickness of section
185
195
205
215
225
235
245
11.0 km
Navajo sandstone equivalent
shallow marine quartz arenite
190 Ma
fault
andesites
Progradational shallow marine sequences
shallow marine sedimentary rocks
217 Ma
ignimbrites
Norian
Bullfrog turbidite fan
Carnian
deepwater sedimentary rocks
Vandever Mountain deepwater caldera
fault
240 Ma
fault
217 Ma U-Pb zircon dates
Norian fossil age control

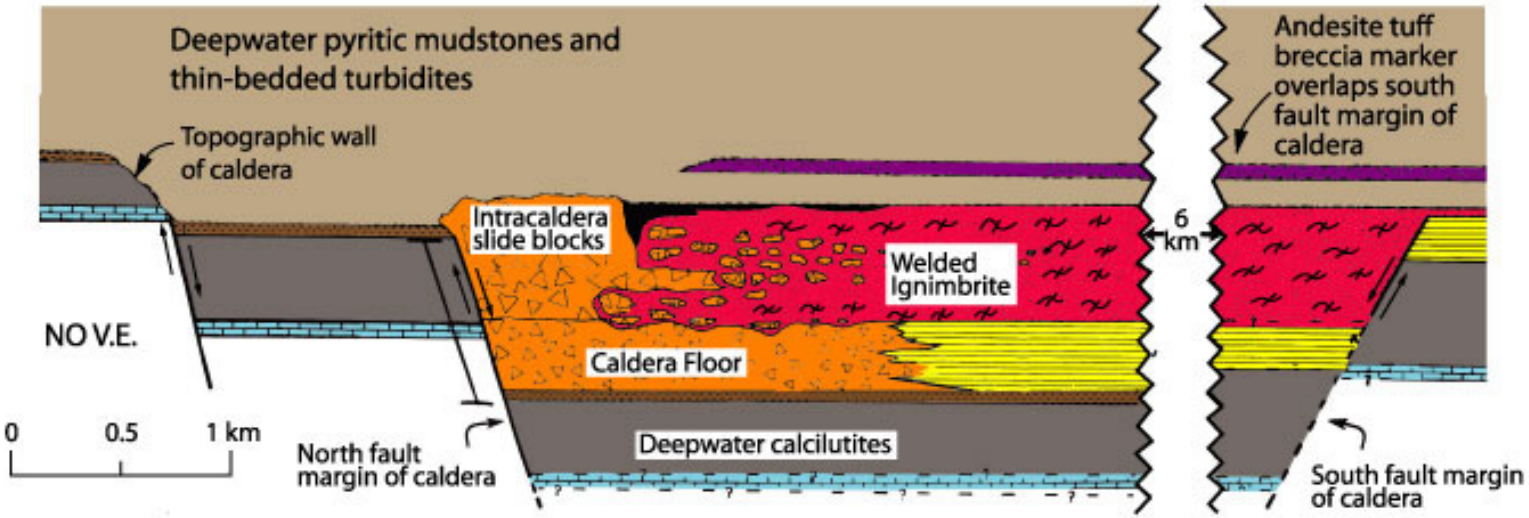
I. Incipient leaky ring fracture at the north margin of the Vandever Mountain deepwater caldera, Mineral King (Sequoia National Park) (Busby-Spera, 1984)

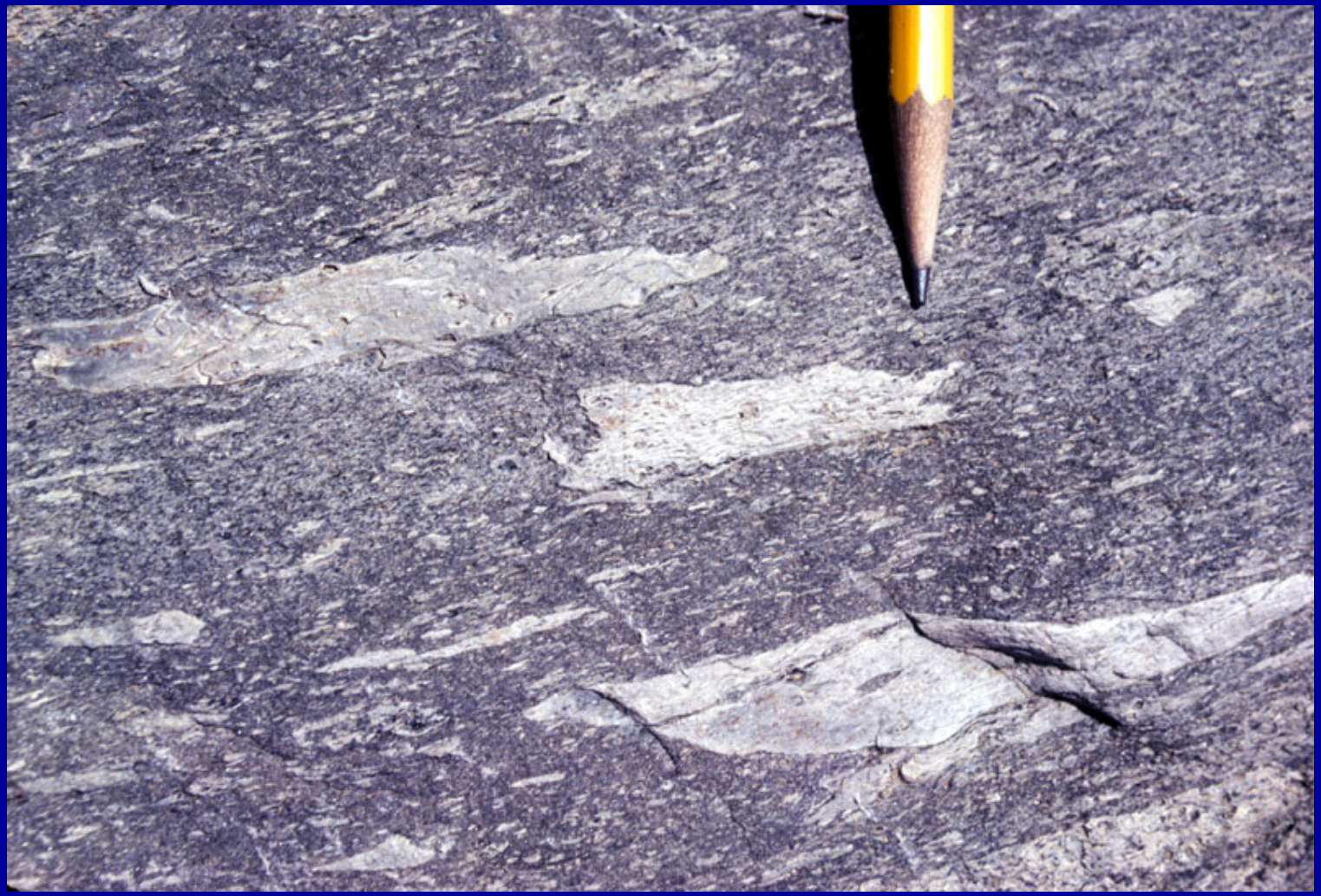


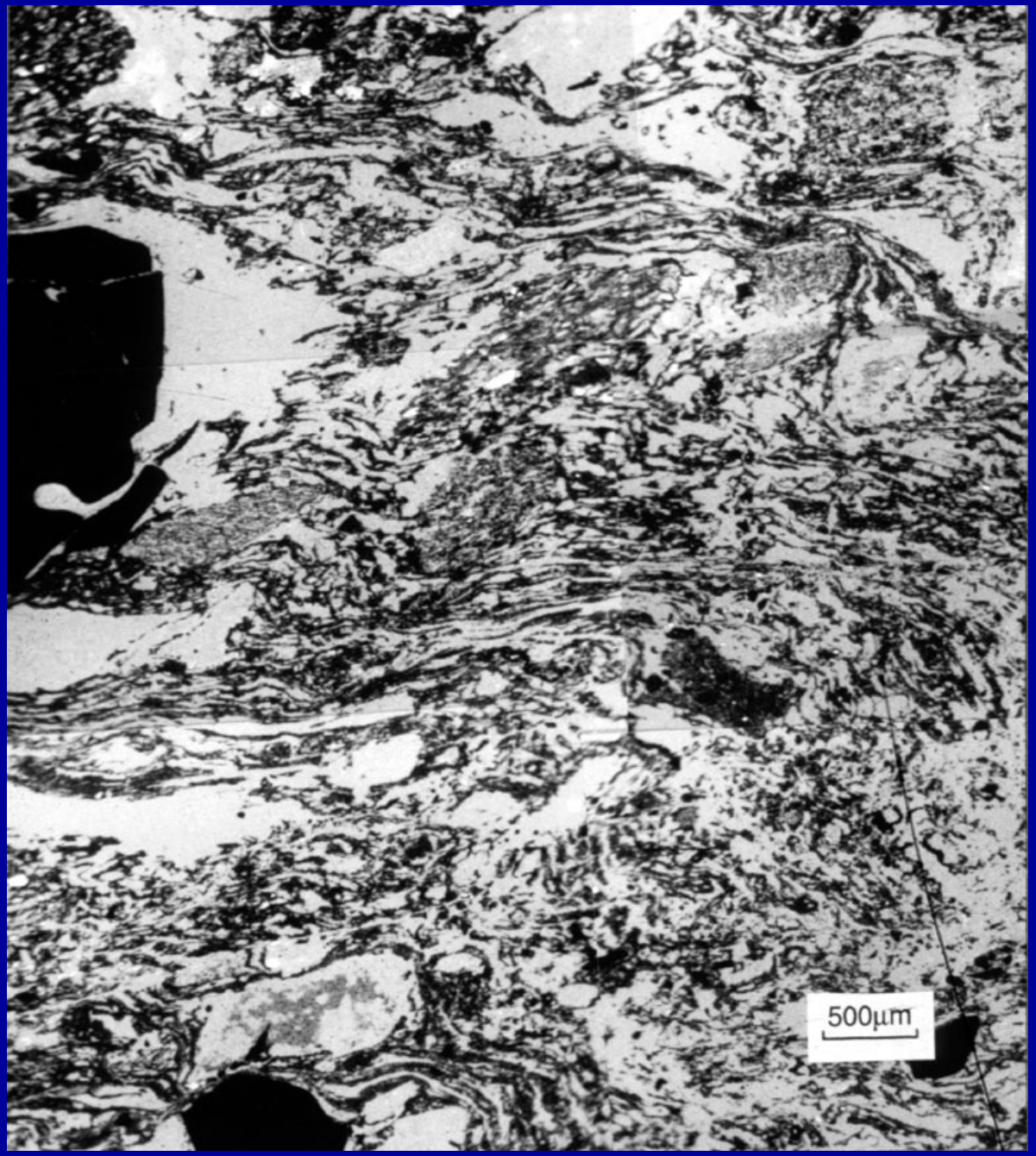
II. Onset of caldera collapse during deepwater eruption of the Vandever Mountain ignimbrite. Note change in scale from (I).

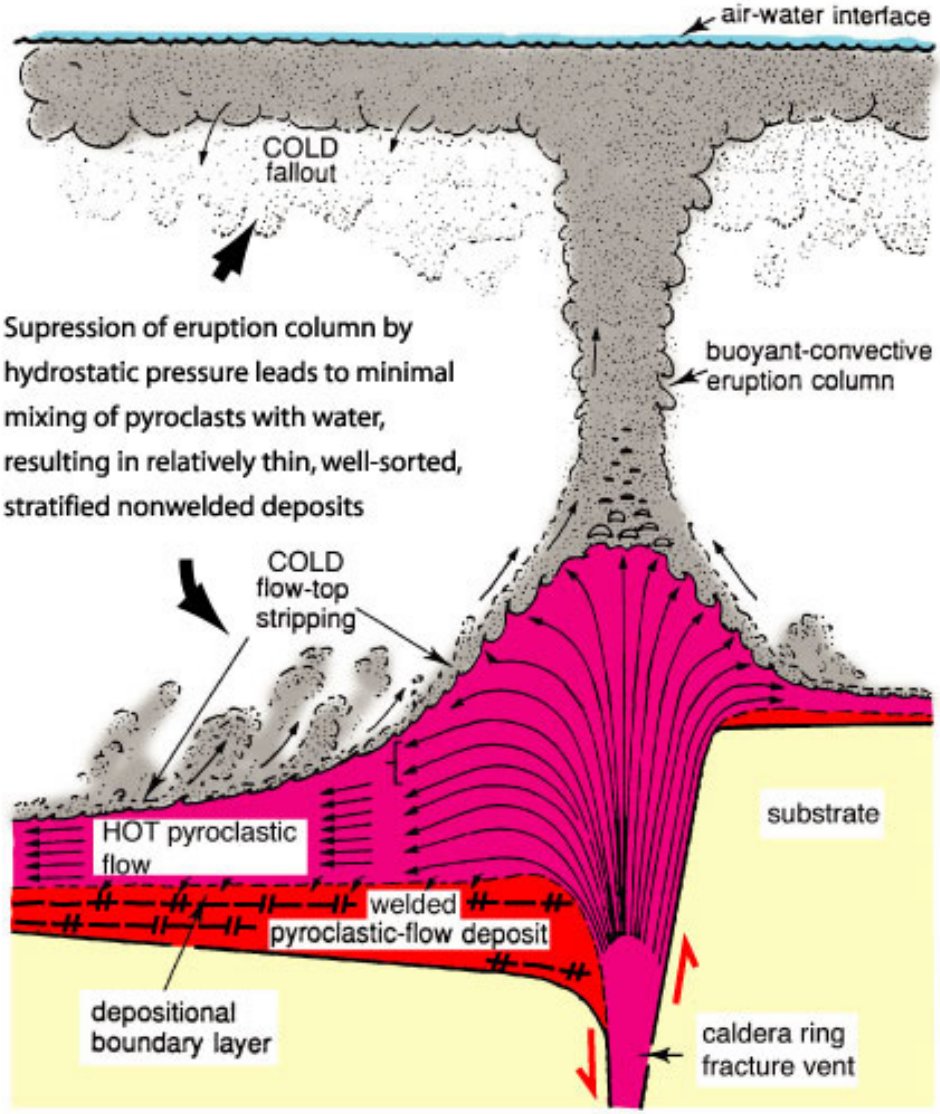


III. Cross-sectional view of a Rhyolite Caldera and Enclosing Deepwater Strata (Busby-Spera, 1984)



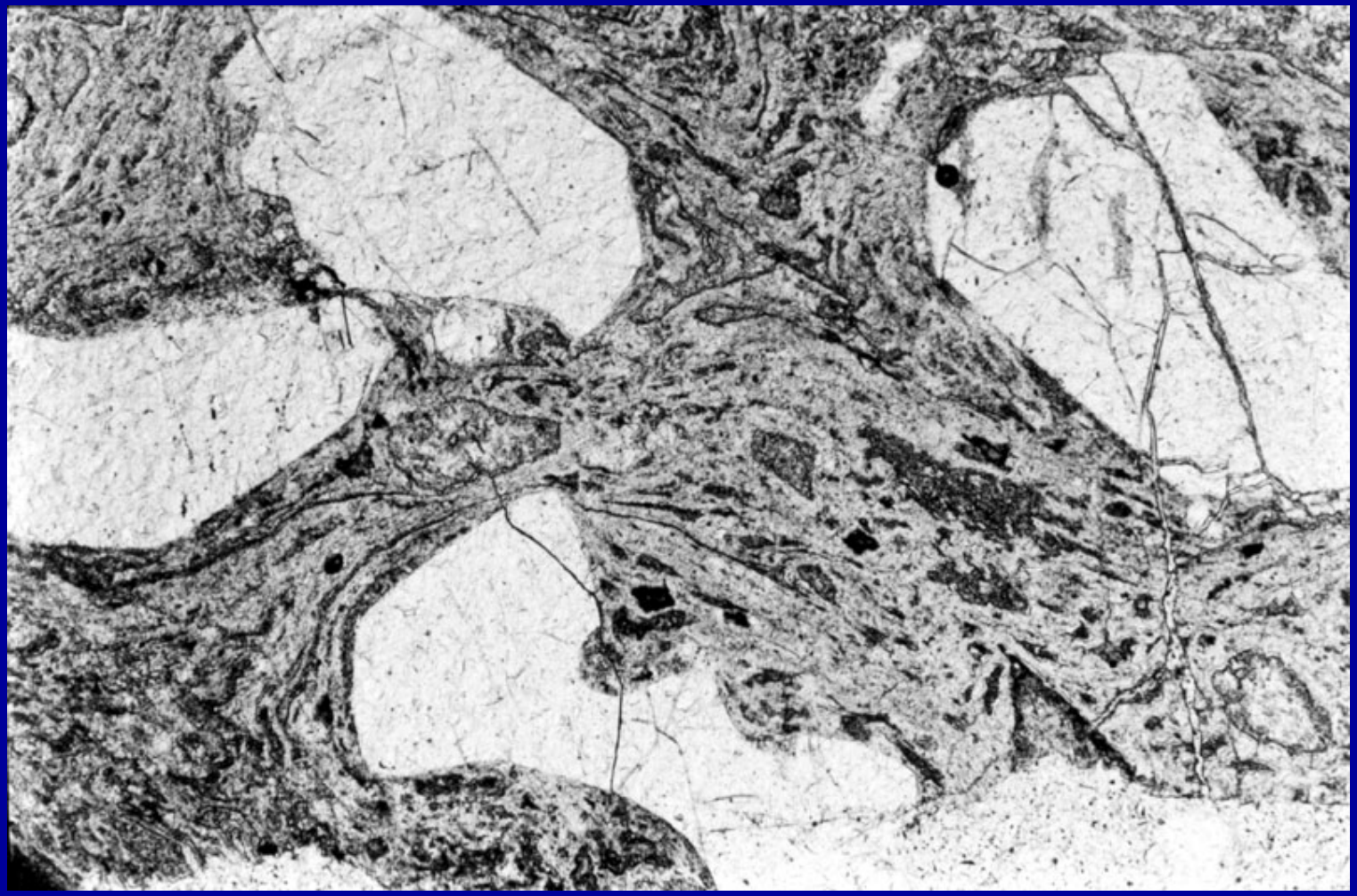


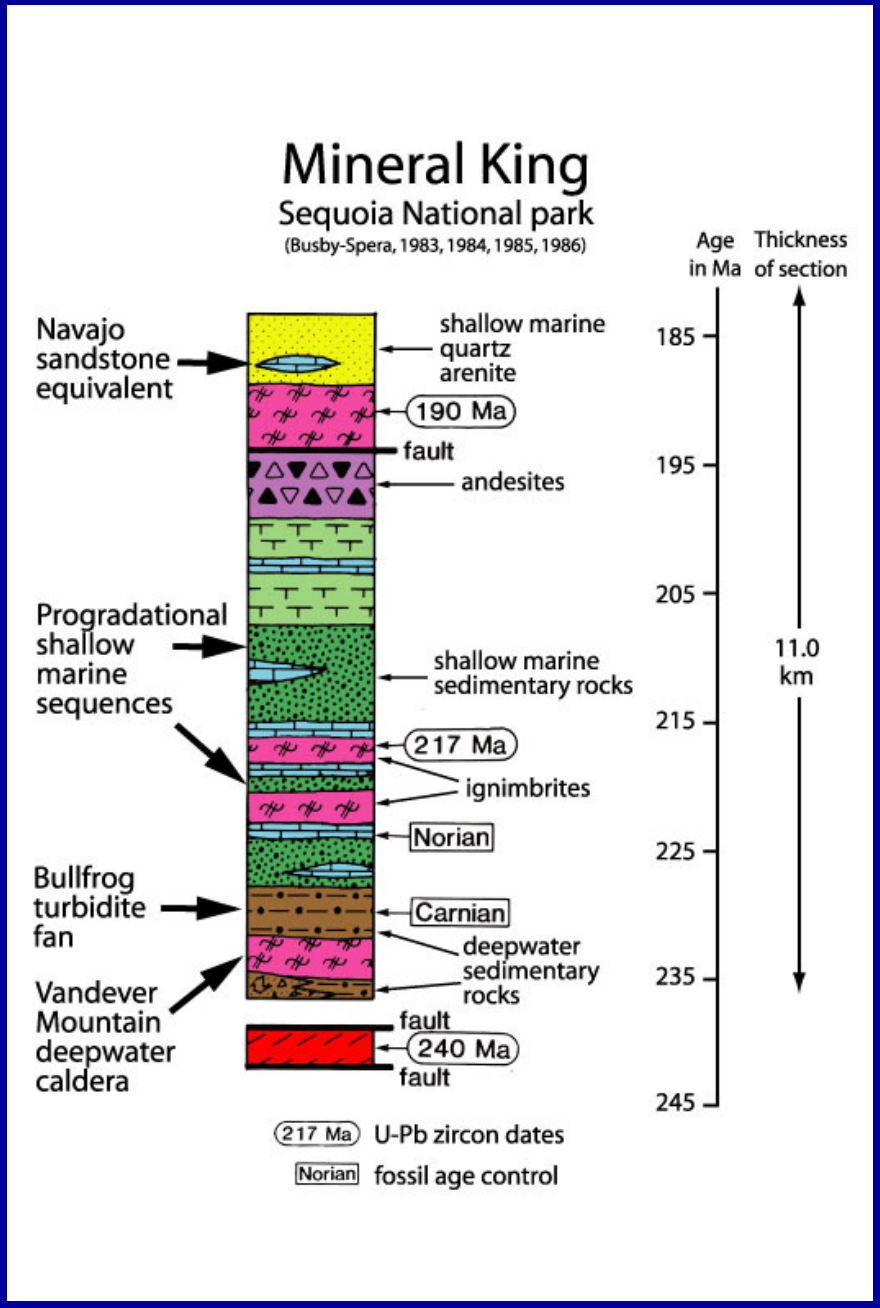

500µm



Deposition of Very Thick, Massive, Unsorted Welded Ignimbrite during High-Mass-Discharge Deepwater Explosive Eruption

(Kokelar and Busby, 1992)




Mineral King
Sequoia National park
(Busby-Spera, 1983, 1984, 1985, 1986)
Age in Ma
Thickness of section
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Navajo sandstone equivalent
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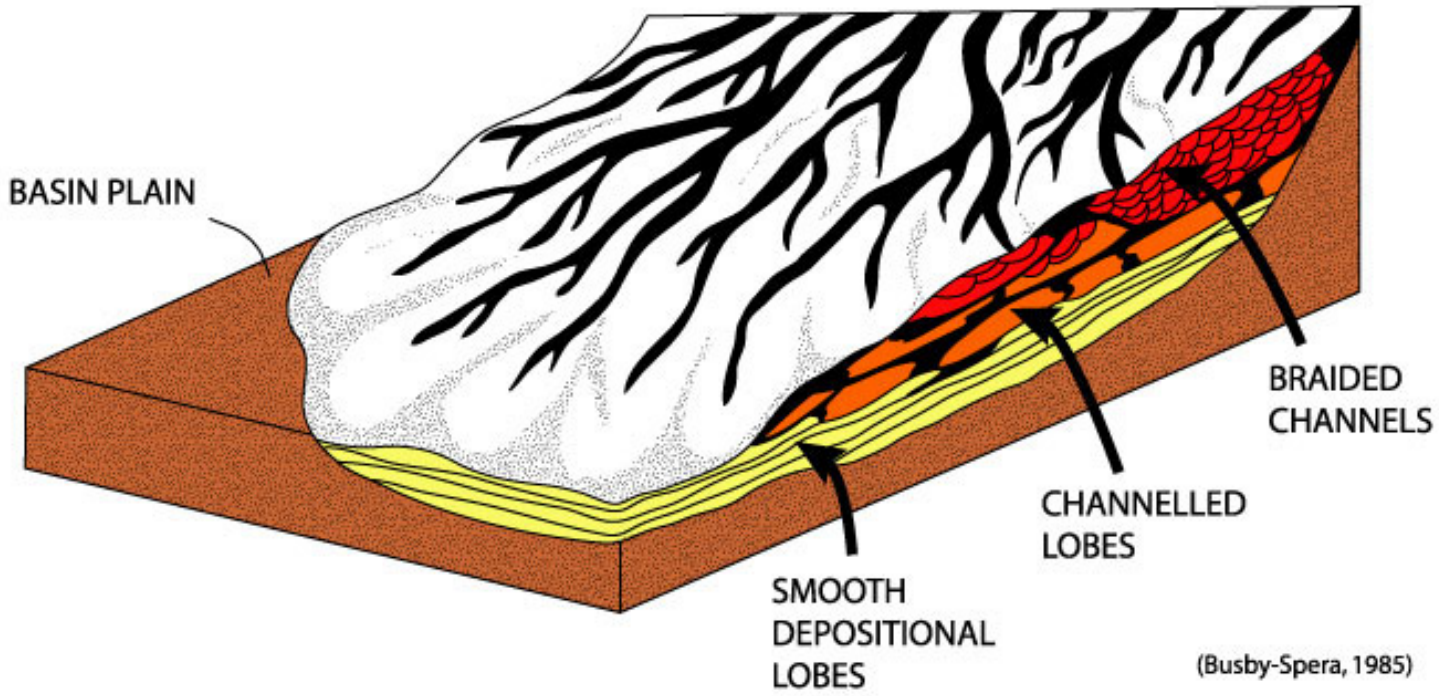
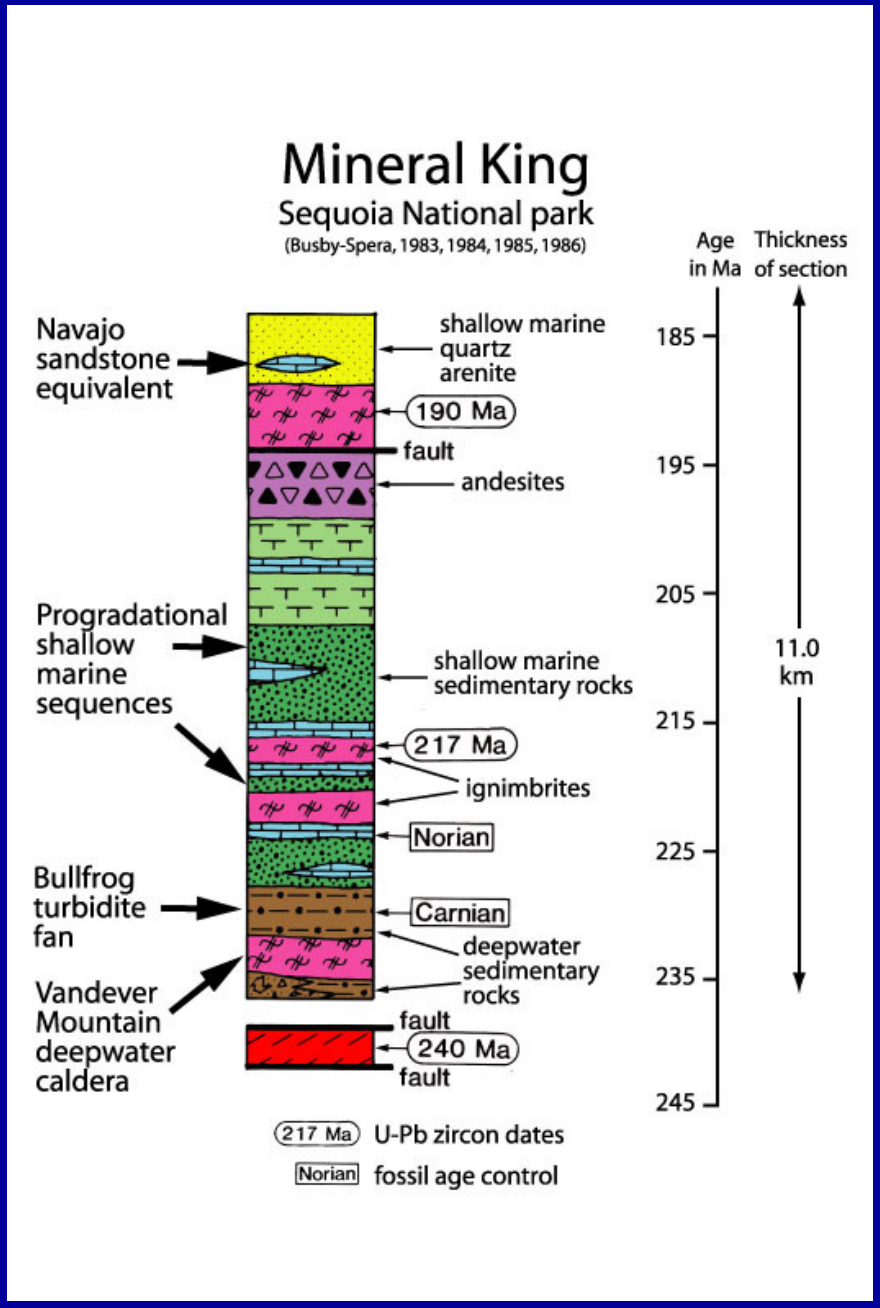
Norian fossil age control

A SAND-RICH SUBMARINE FAN in a RHYOLITE CALDERA COMPLEX
Late Triassic, southern Sierra Nevada, CA:

FED BY LARGE-VOLUME EXPLOSIVE ERUPTIONS



(Busby-Spera, 1985)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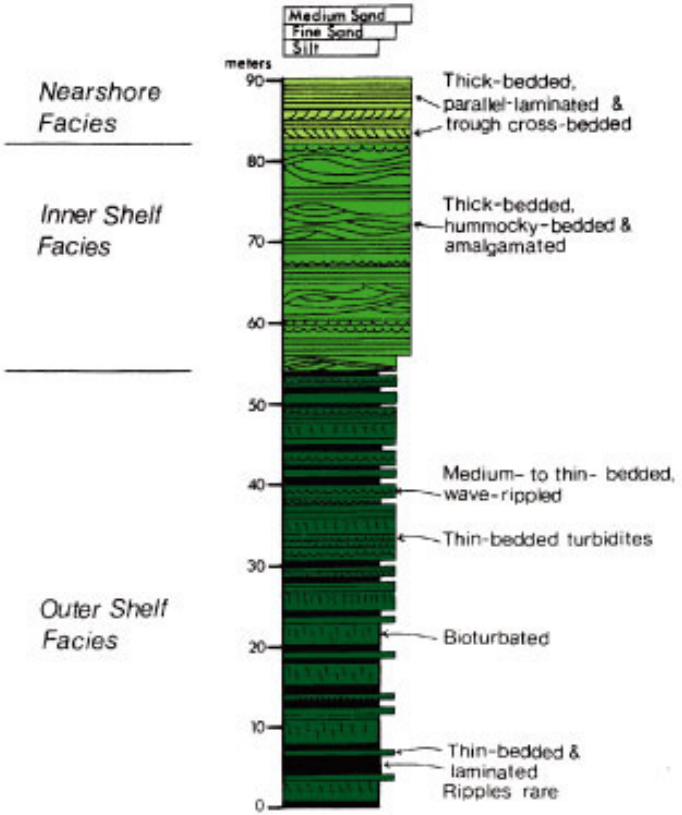
fault
217 Ma U-Pb zircon dates
Norian fossil age control

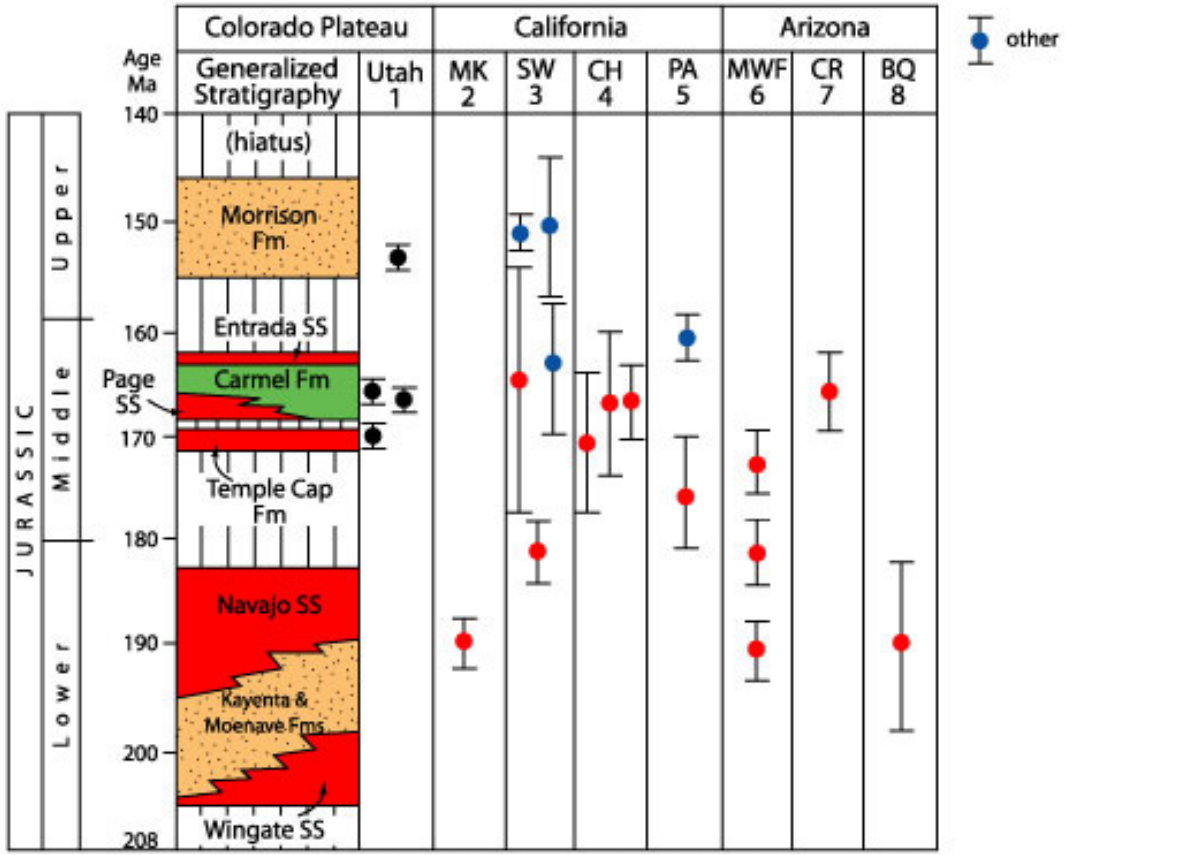
Very Thick Progradational Shallow Marine Sequence:

- high tectonic subsidence rate
- high wave energy



Mineral King, Sequoia National Park
(Busby-Spera, 1984)

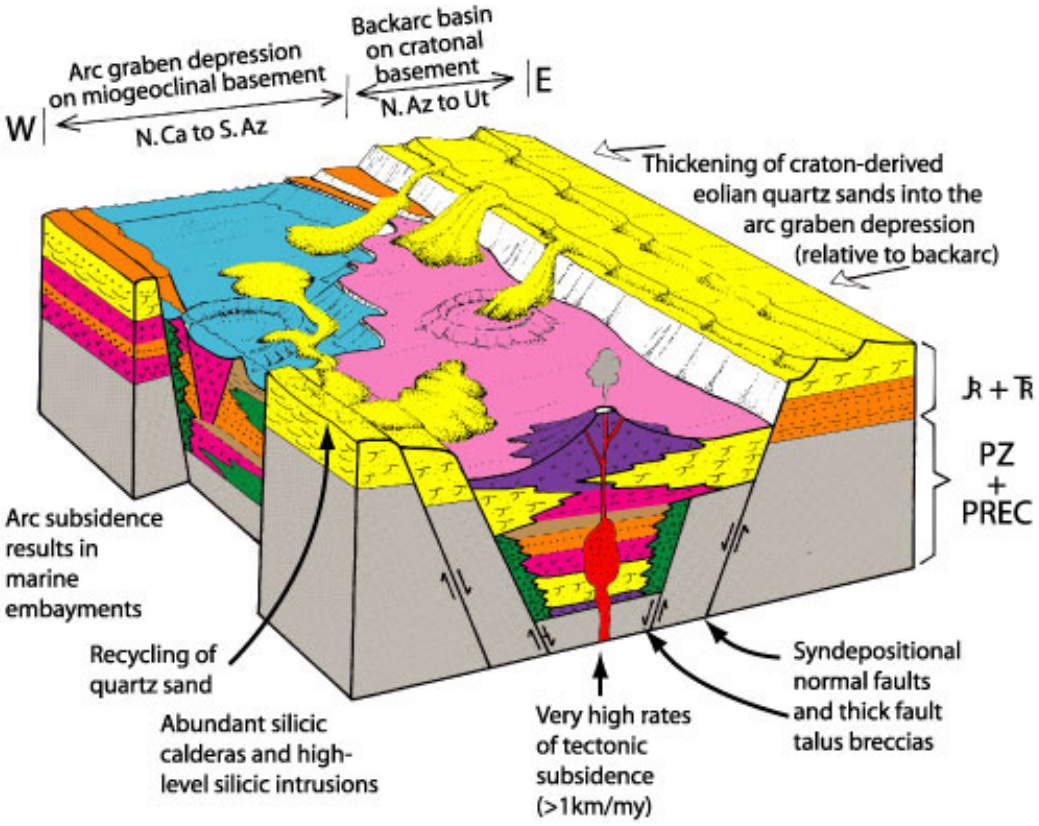
U-Pb Zircon Dates on Jurassic Arc Metavolcanic Rocks



1 - Kowallis et al, 2001 and pers comm.; 2 - Mineral King, Busby-Spera, 1983; 3- Sidewinder volcanic series, Schermer et al, 2002; 4 - Busby et al, 2002; 5 - Palen Mtns, Adams et al, 1997; 6 - Mt. Wrightson Fm, Riggs et al, 1993; 7 - Cobre Ridge caldera, Riggs et al, 1993; 8 - Babquivari Mtns, Haxel et al., 1987

Evidence for Late Triassic to Middle Jurassic Continental Arc Graben Depression, Southwest US and Mexico

(Busby-Spera, 1988)



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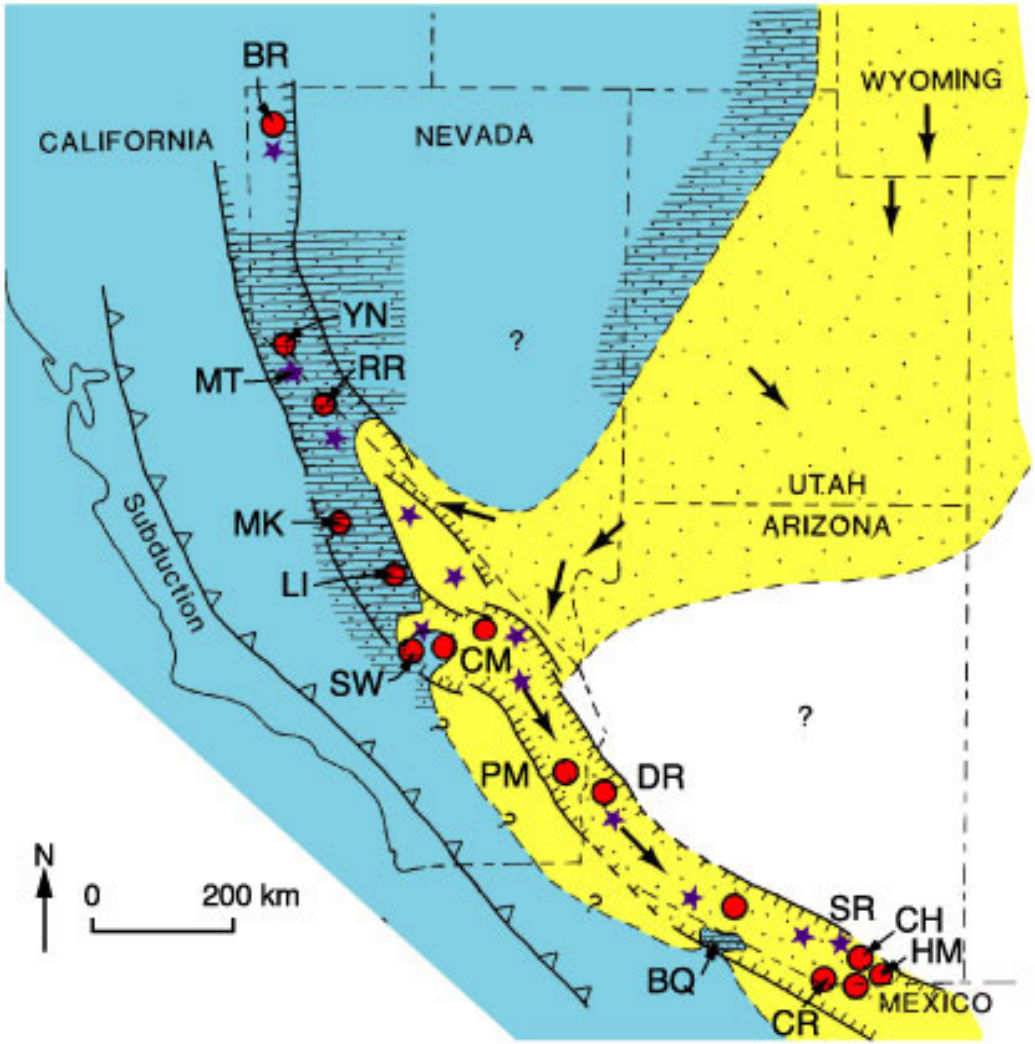

Graben depression

caldera ★ composite volcano

Quartz Arenite nonmarine

marine

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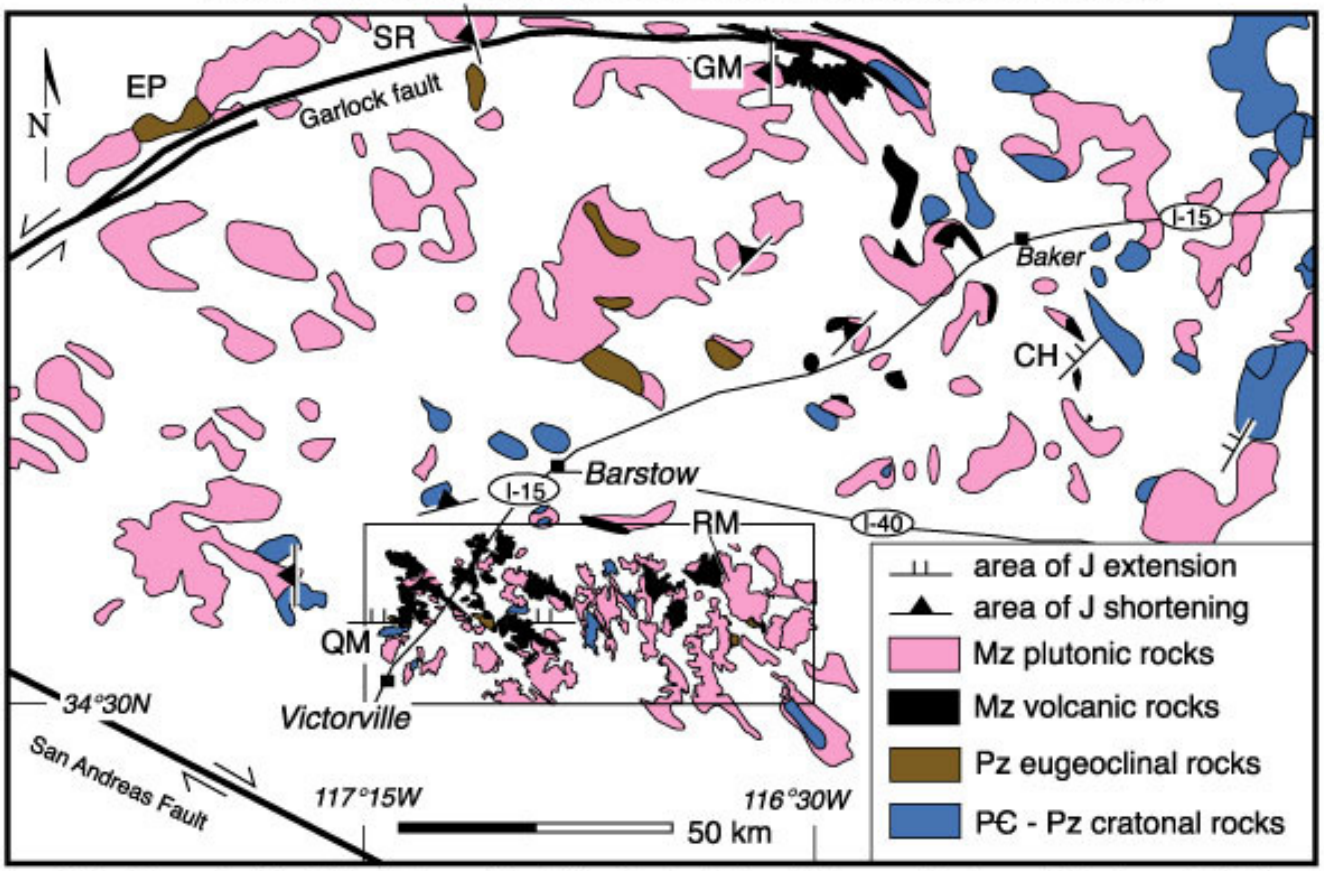
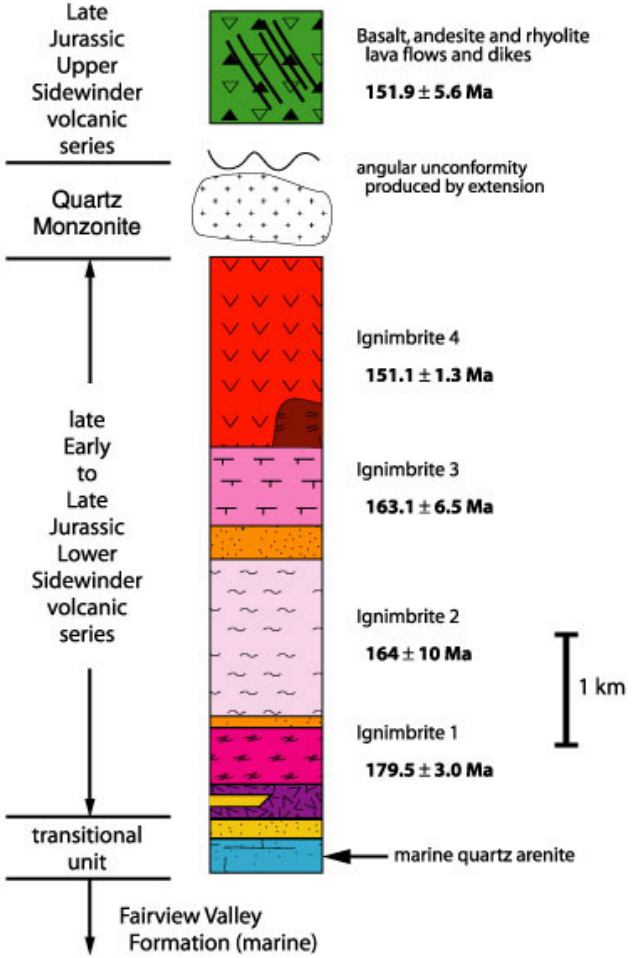
Sidewinder Volcanic Series, Central Mojave Desert



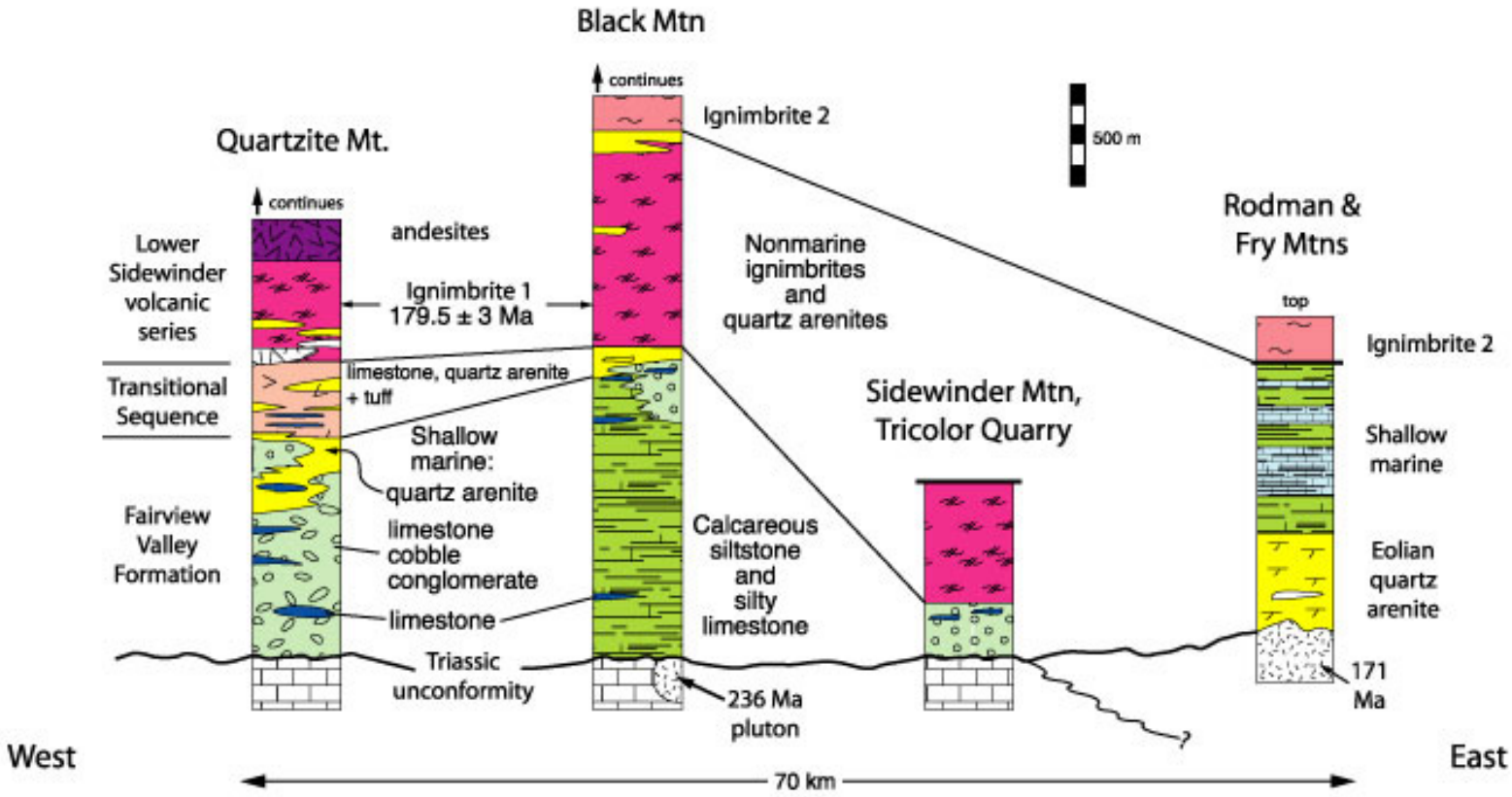
QM = Quartzite Mtn, RM = Rodman Mtn, CH = Cowhole Mtns (Schermer, Busby and Mattinson, 2002)

Stratigraphy and U-Pb Zircon Dates from the Sidewinder Volcanic Series, Central Mojave Desert

(Schermer, Busby and Mattinson, 2002)



Gradational Interfingering Contact between Fairview Valley Formation and Sidewinder Volcanic Series (Schermer, Mattinson and Busby, 2002)



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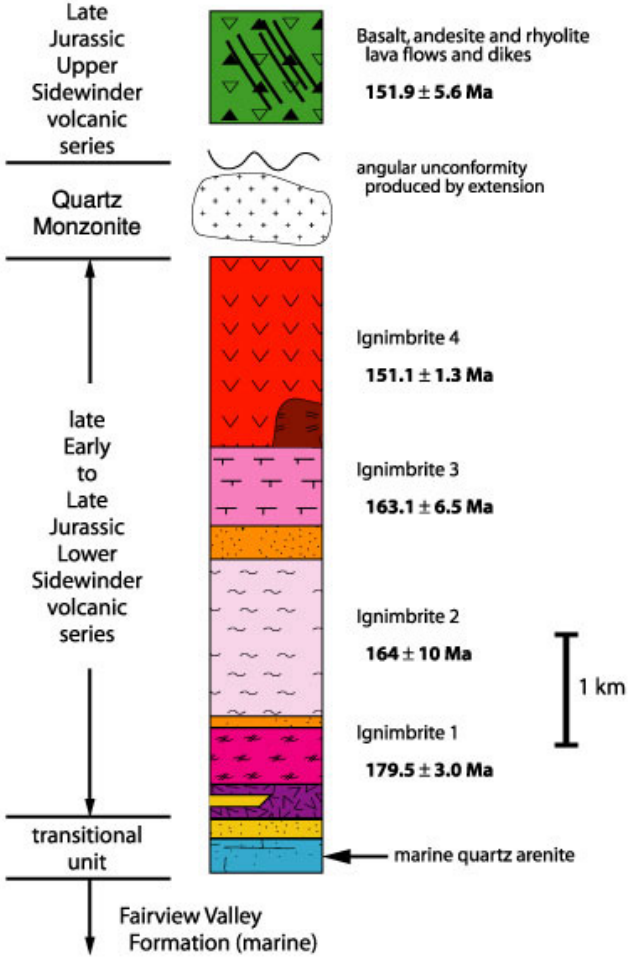
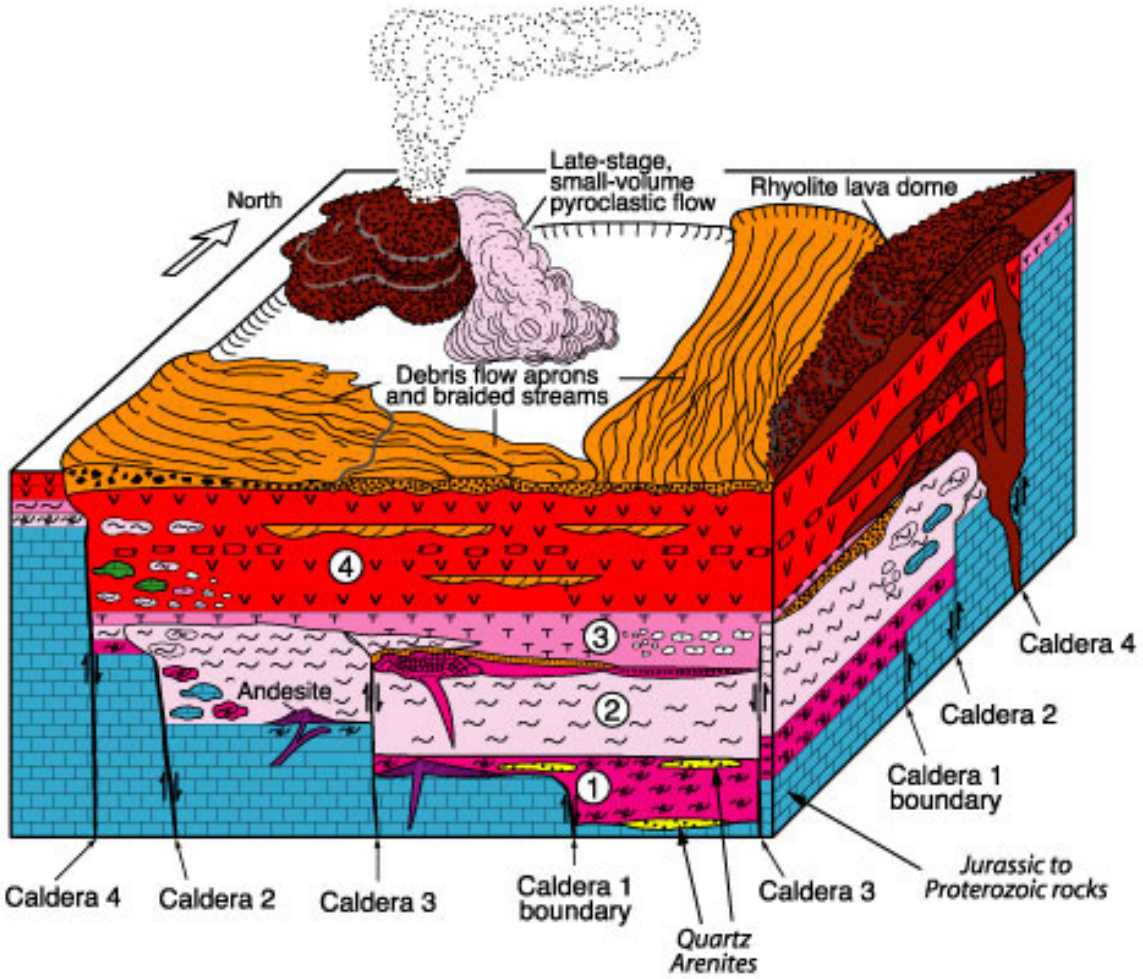




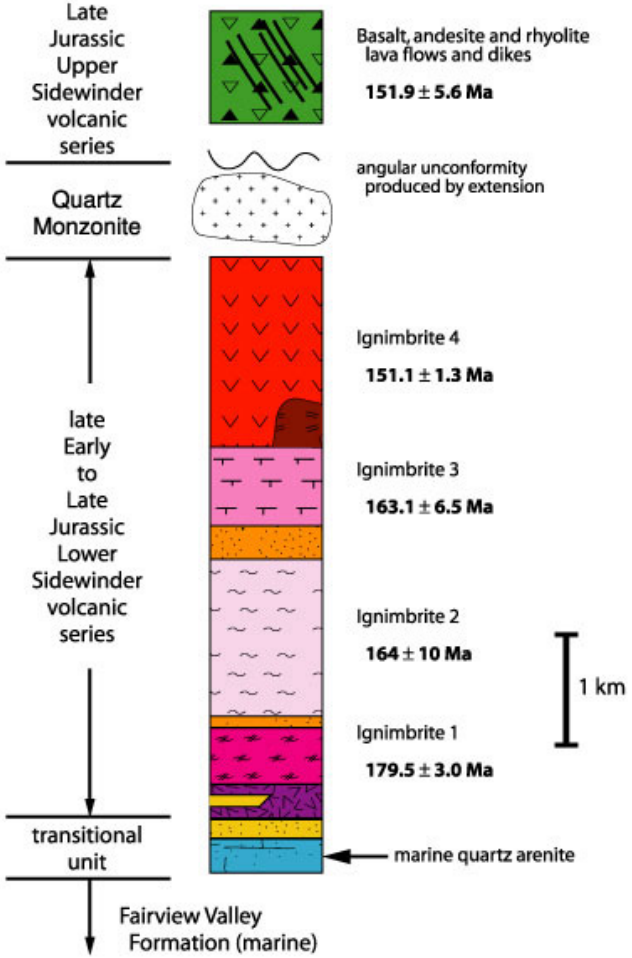
Middle Jurassic Lower Sidewinder volcanic series, Central Mojave Desert:

Collapse of four nested silicic calderas during initial stages of extension at 180 to 151 Ma

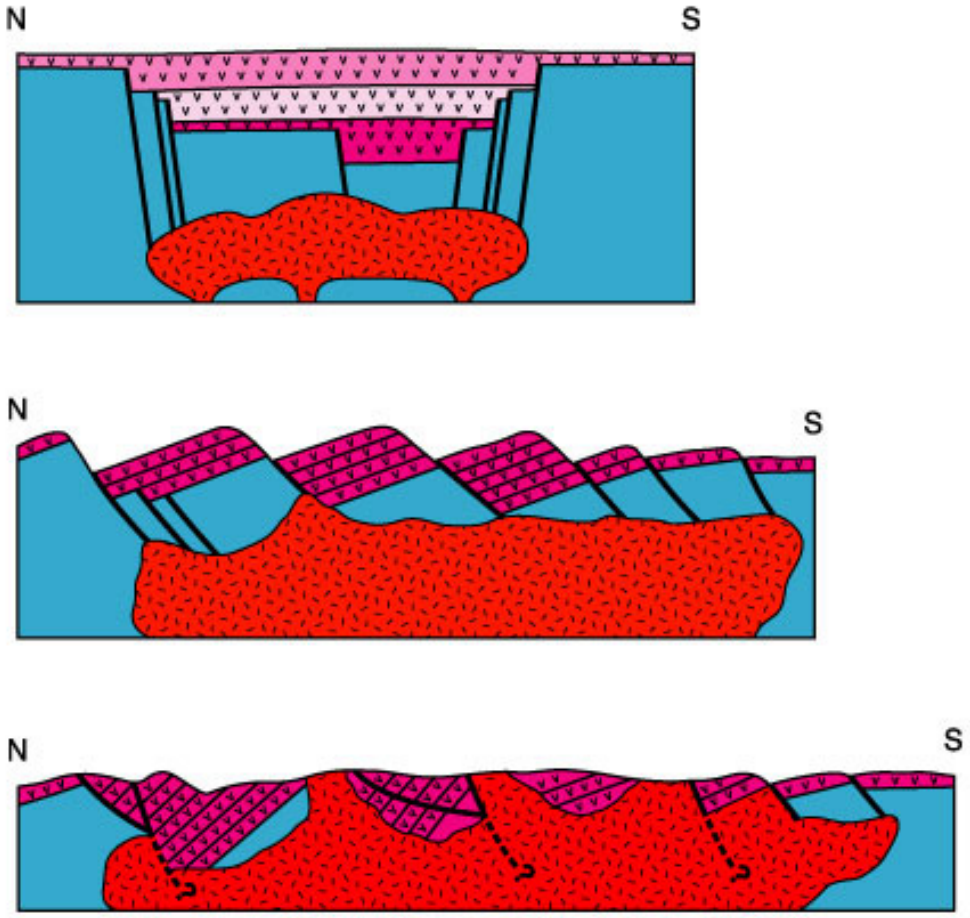
(Schermer and Busby, 1994)

Stratigraphy and U-Pb Zircon Dates from the Sidewinder Volcanic Series, Central Mojave Desert

(Schermer, Busby and Mattinson, 2002)



Caldera Collpase and Pluton Emplacement and Unroofing During North-South Extension in the Central Mojave Desert at ~151 Ma (Schermer and Busby, 1994)



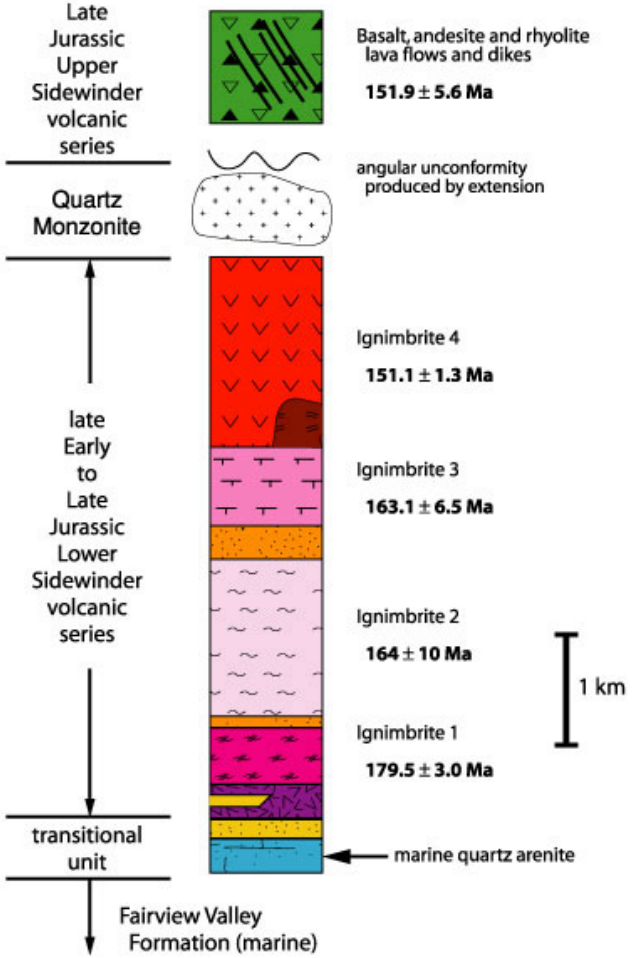
A. Multiple caldera collapse and initial north-south extension (Lower Sidewinder Volcanic Series)

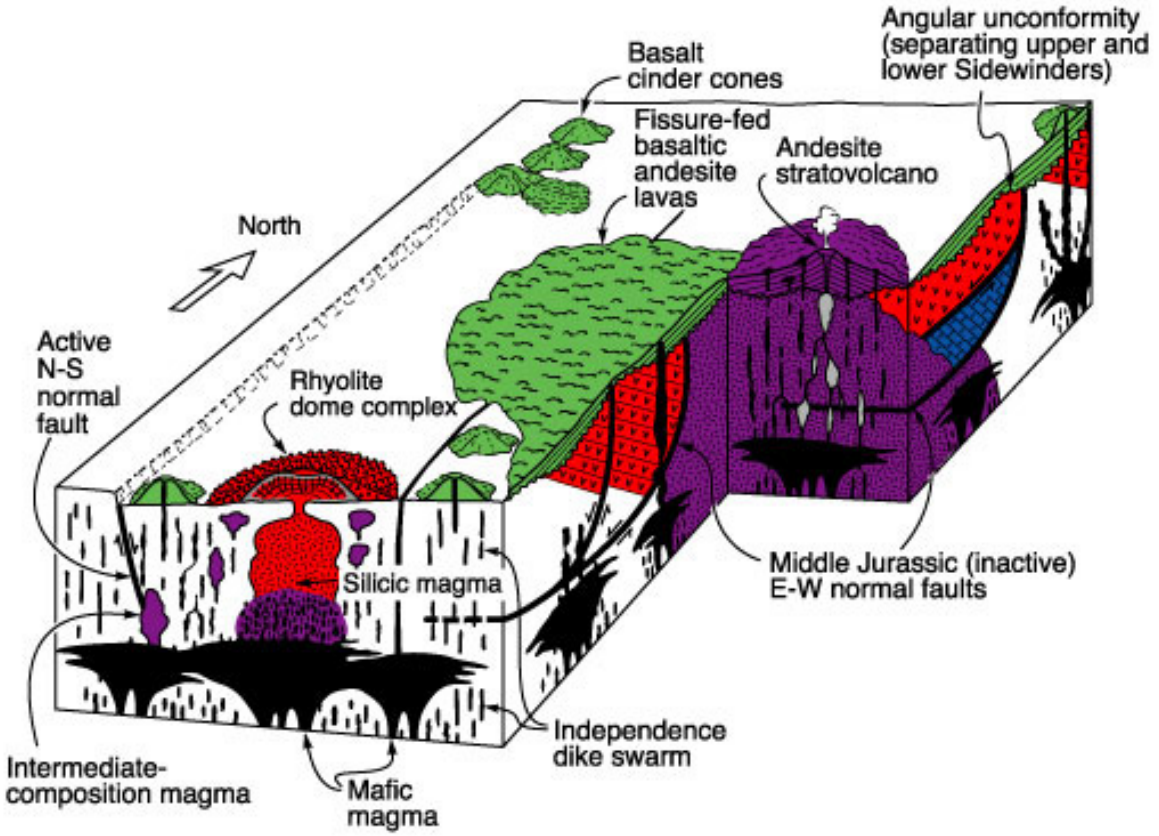
B. Continued batholith intrusion and main phase of north-south extension (about 15%)

C. Partial unroofing of batholith before extension ends.

Stratigraphy and U-Pb Zircon Dates from the Sidewinder Volcanic Series, Central Mojave Desert

(Schermer, Busby and Mattinson, 2002)

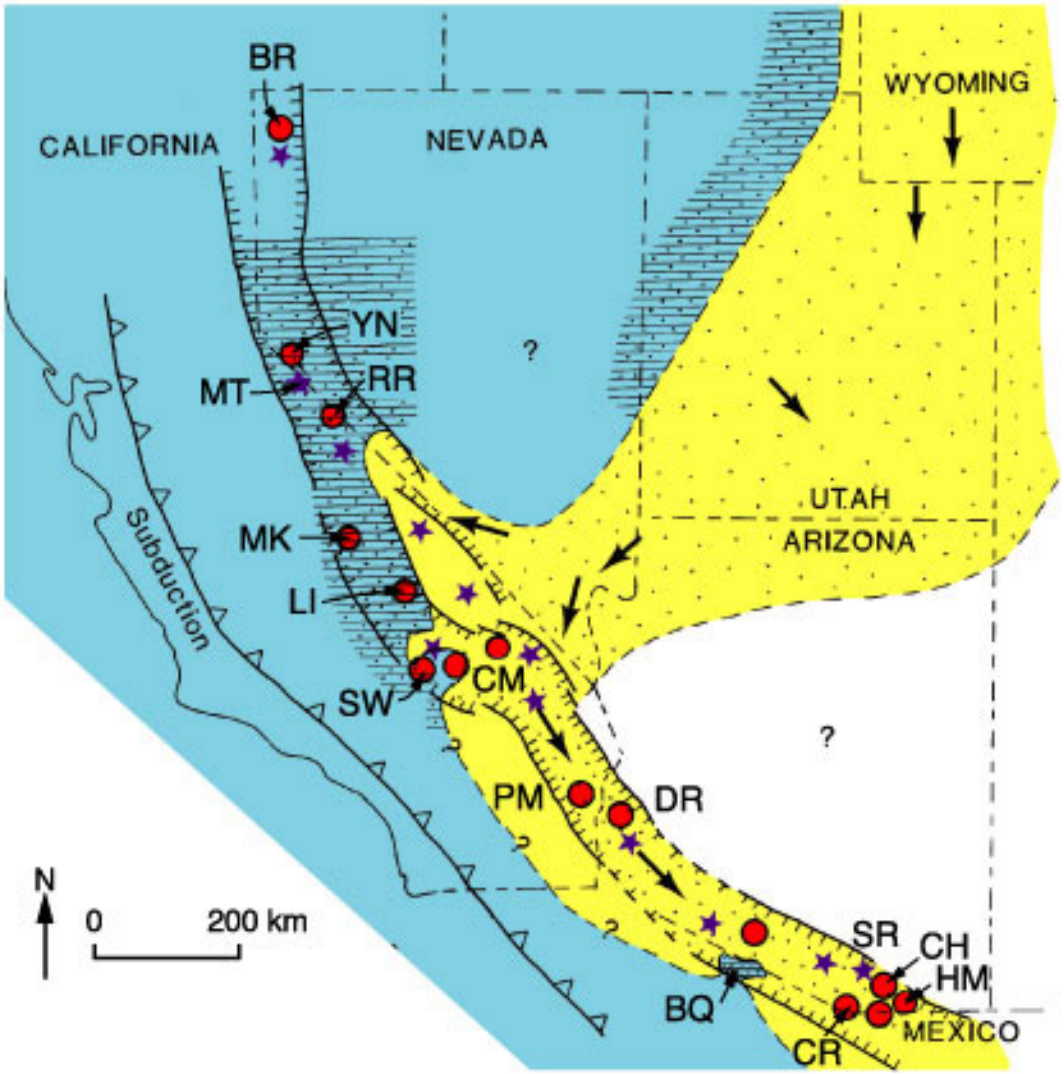




Late Jurassic Upper Sidewinder Volcanic Series, central Mojave Desert: Independence dike swarm and its plutonic and eruptive equivalents emplaced during east-west extension at ~149 Ma (Schermer and Busby, 1994).

Late Triassic to Middle Jurassic Continental Arc Graben Depression

(Busby-Spera, 1988)



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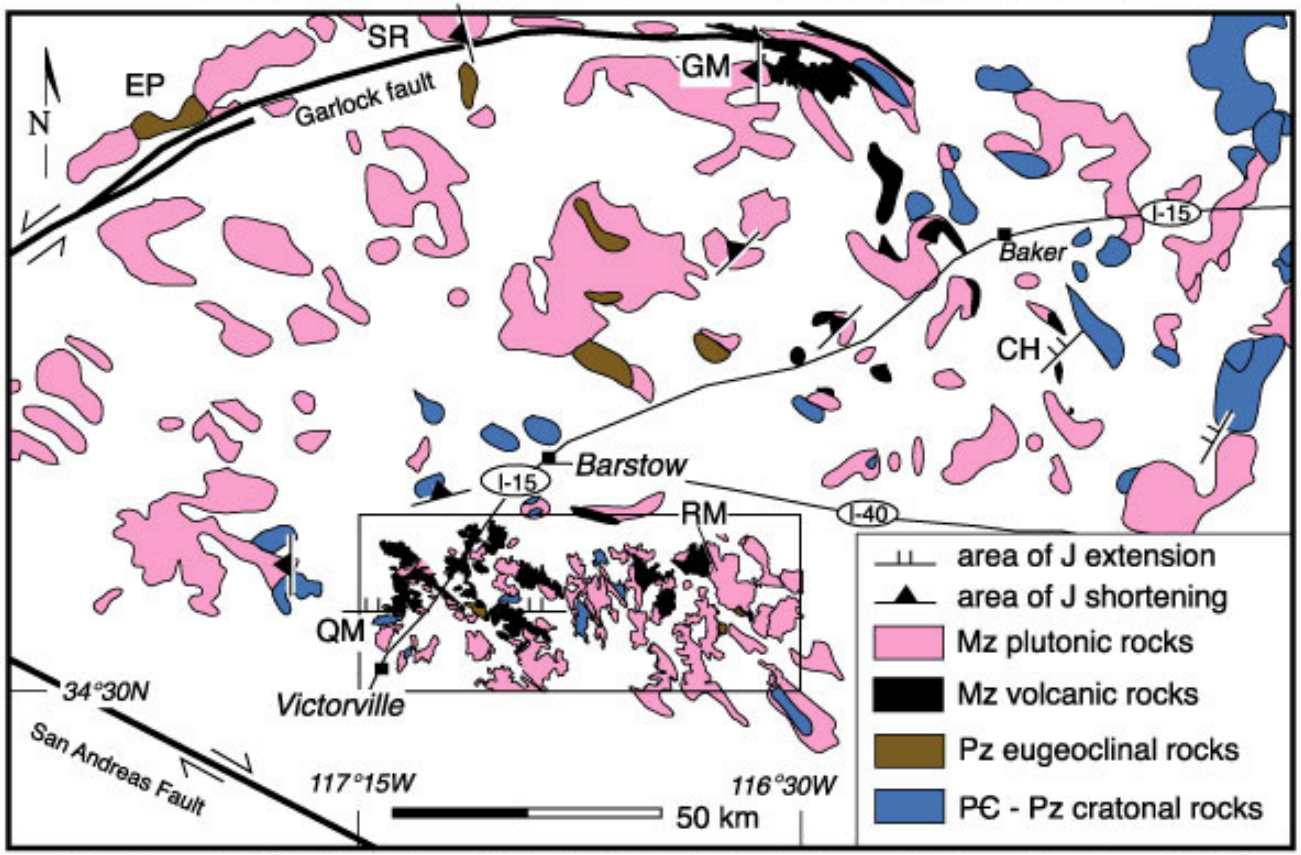
Sidewinder Volcanic Series, Central Mojave Desert



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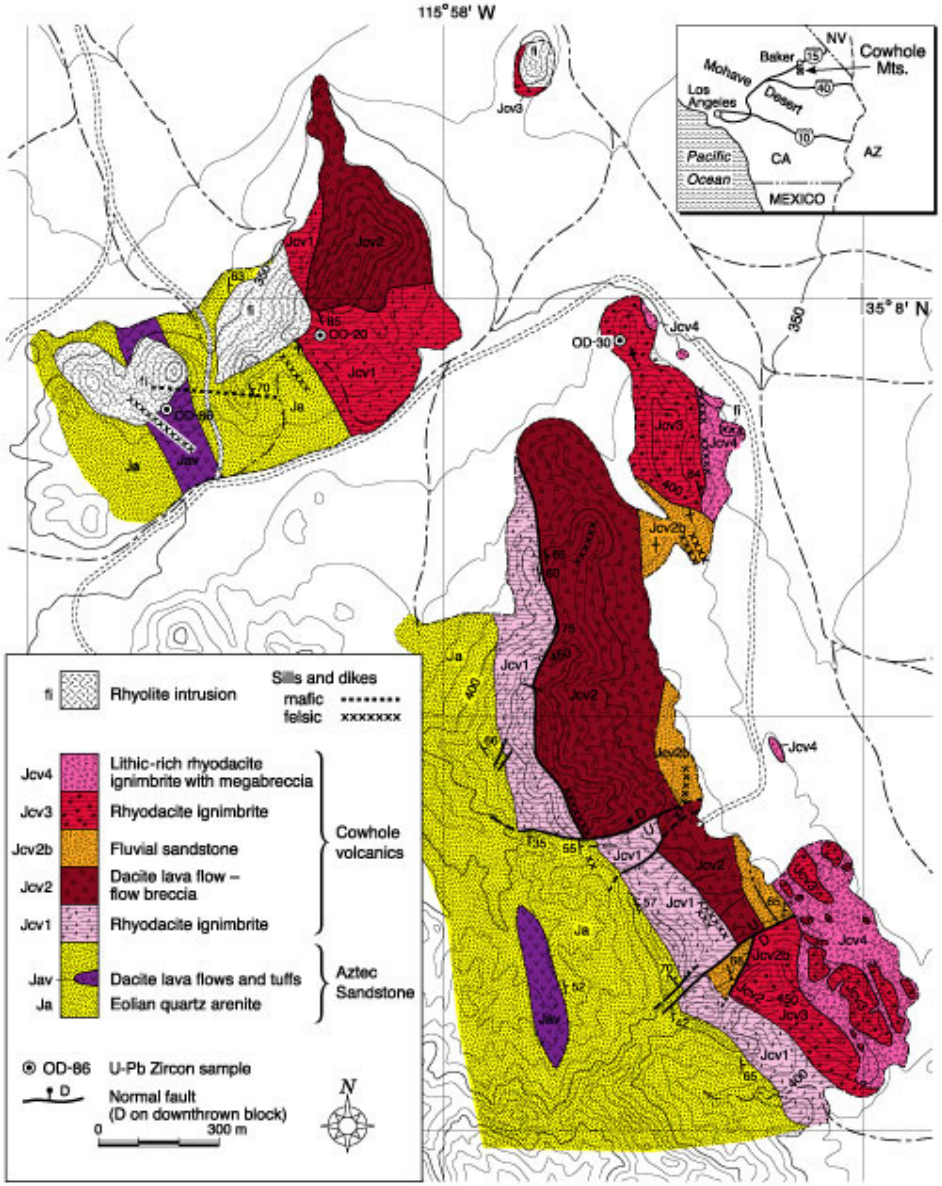
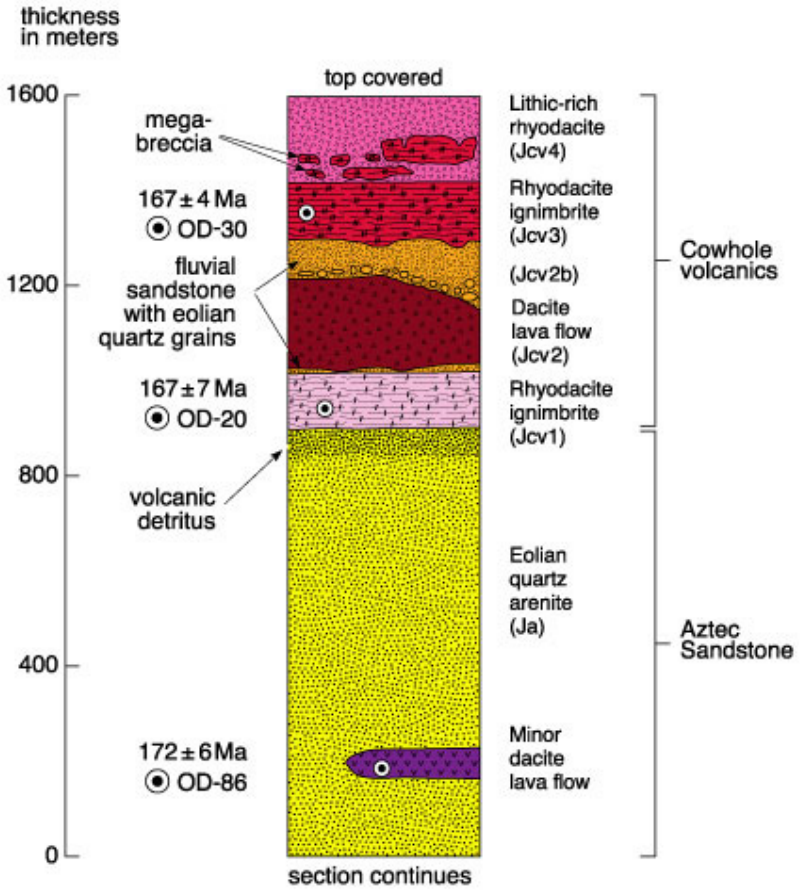
Aztec Sandstone and Cowhole Volcanics

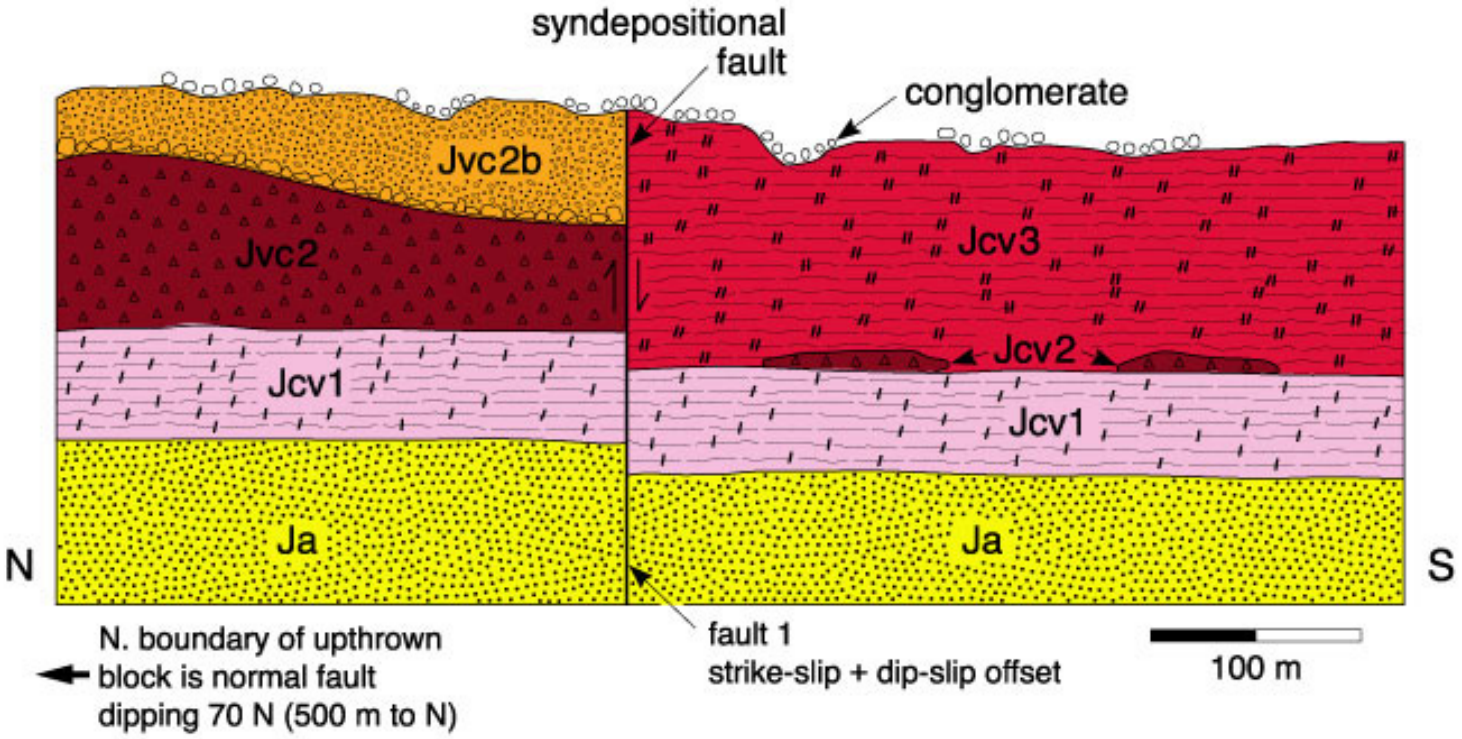
(Busby et al, 2002)



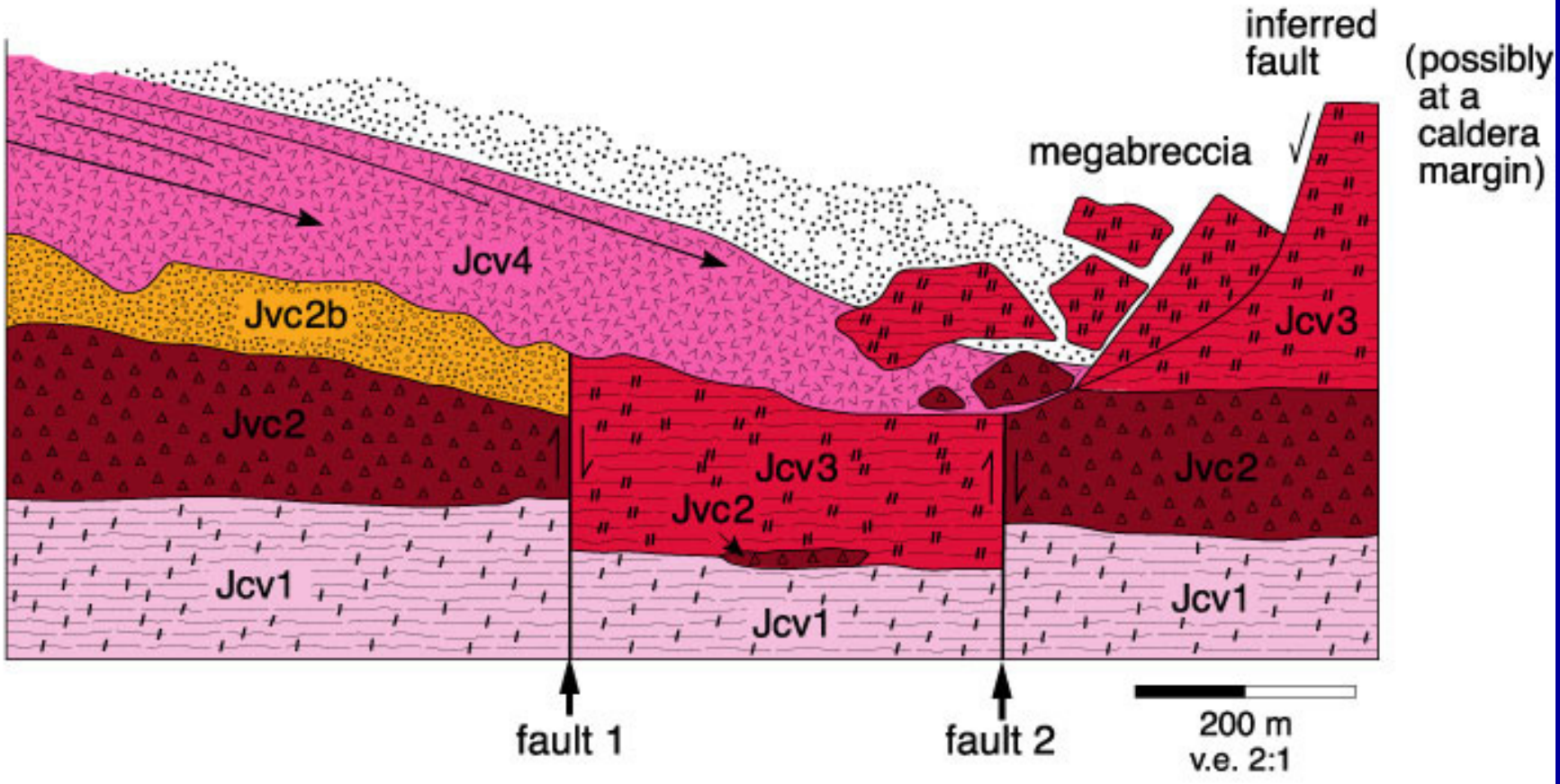
Jurassic Strata in the Cowhole Mountains, Eastern Mojave Desert (Busby et al, 2002)



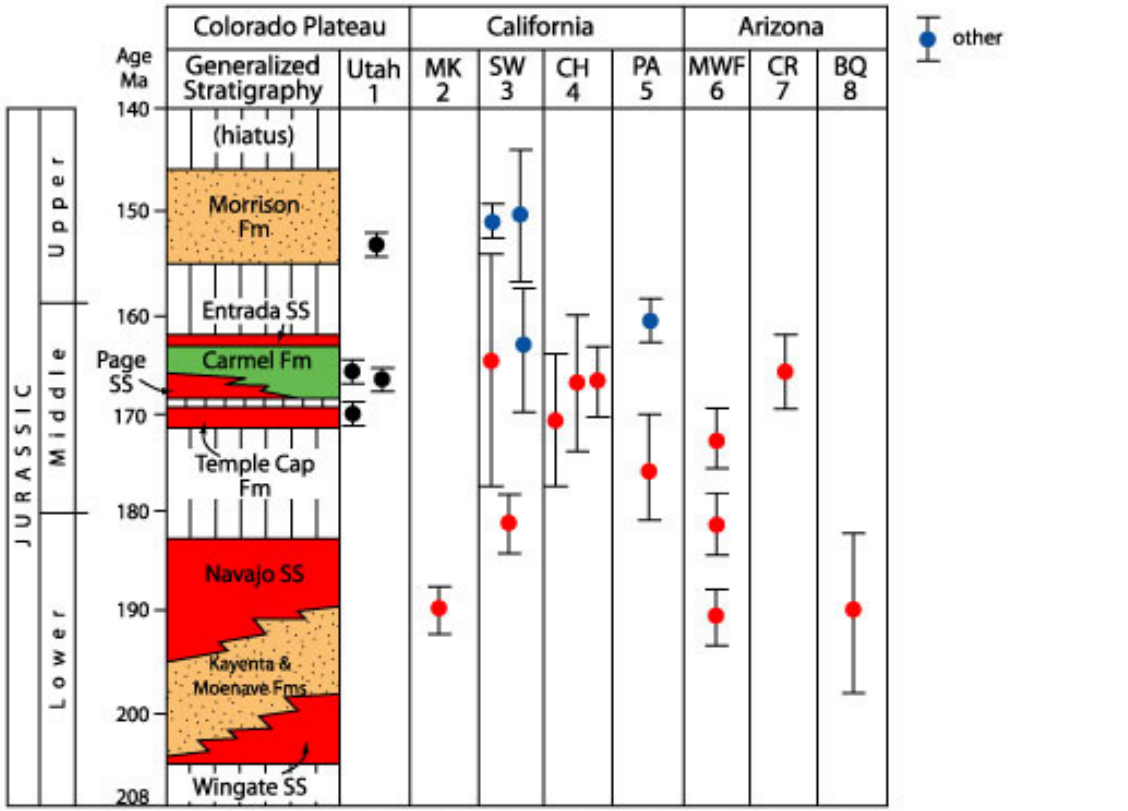
I. Erosion of Cowhole volcanics unit 3 (ignimbrite, 125 m thick) from upthrown block and deposition of cobble-boulder lag across fault 1.



II. Deposition of Cowhole volcanics unit 4 (ignimbrite) across now-inactive fault 1 concurrent with avalanching of units 2 and 3 from active fault 2.



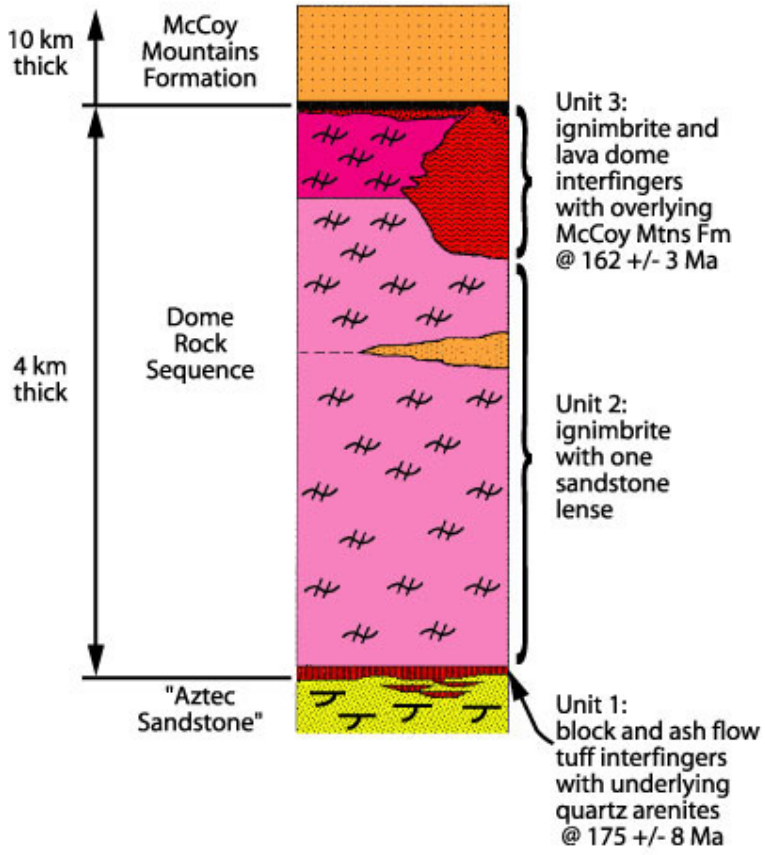
U-Pb Zircon Dates on Jurassic Arc Metavolcanic Rocks



1 - Kowallis et al, 2001 and pers comm.; 2 - Mineral King, Busby-Spera, 1983; 3- Sidewinder volcanic series, Schermer et al, 2002; 4 - Busby et al, 2002; 5 - Palen Mtns, Adams et al, 1997; 6 - Mt. Wrightson Fm, Riggs et al, 1993; 7 - Cobre Ridge caldera, Riggs et al, 1993; 8 - Babquivari Mtns, Haxel et al., 1987

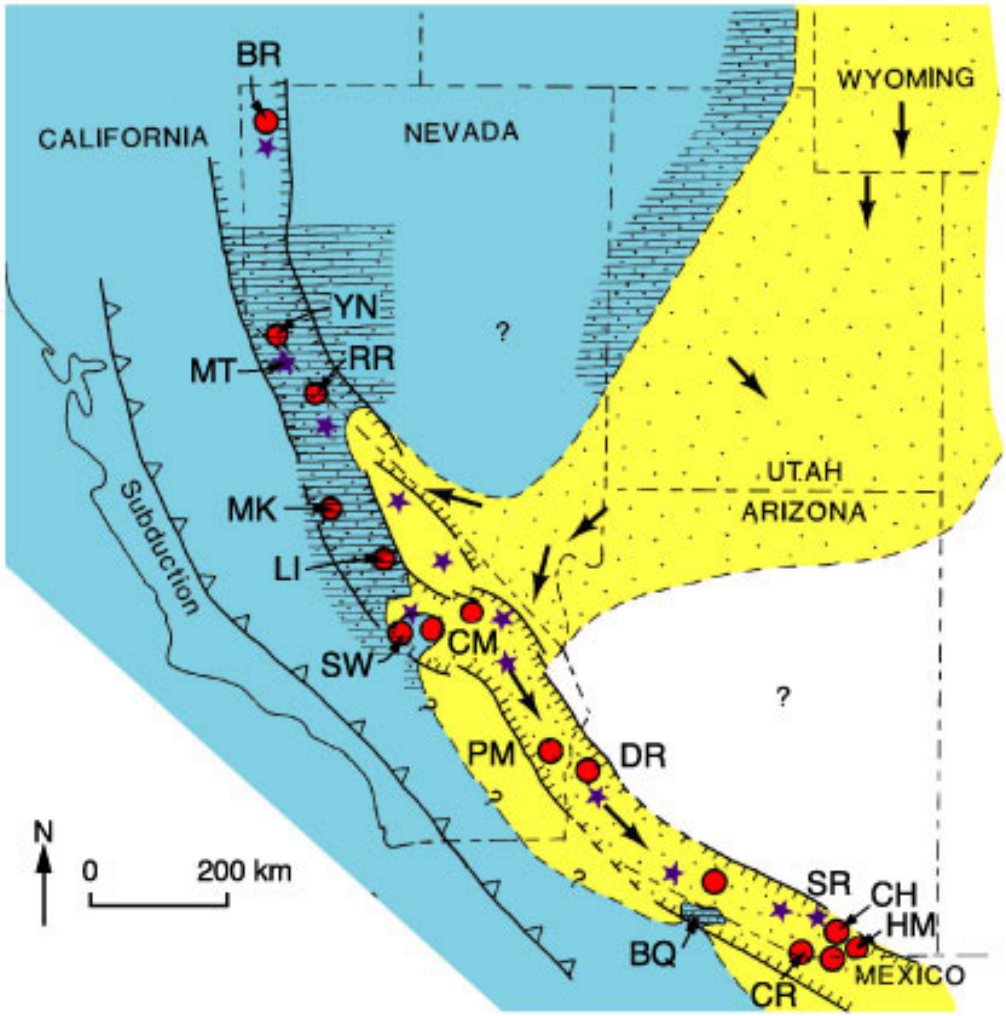
Palen Mountains, Southeast California

(Adams, Busby and Mattinson, 1997)



Late Triassic to Middle Jurassic Continental Arc Graben Depression

(Busby-Spera, 1988)



Graben depression

caldera ★ composite volcano

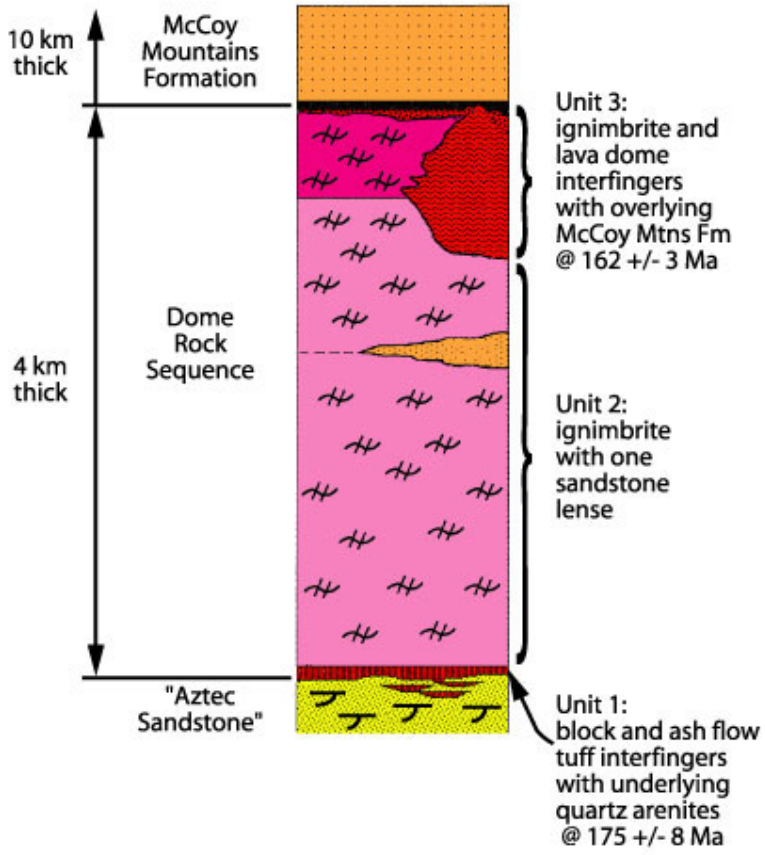
Quartz Arenite
nonmarine
marine

Well-dated localitites (N to S):

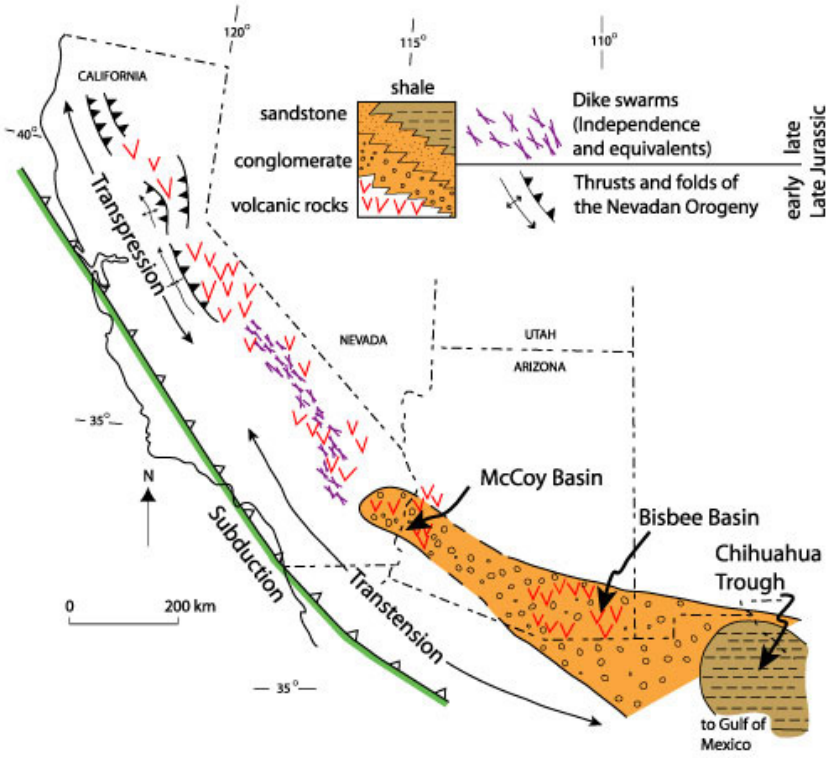
BR - Black Rock Desert
YN - Yerington District
MT - Mt. Talac
RR - Ritter Range
MK - Mineral King
LI - Lake Isabella
SW - Sidewinder Volcanics
CM - Cowhole Mtns.
PM - Palen Mtns.
DR - Dome Rock
SR - Santa Rita Mtns.
BQ - Baboquivari Mtns.
CR - Cobre Ridge
CH - Canelo Hills
HM - Huachuca Mtns

Palen Mountains, Southeast California

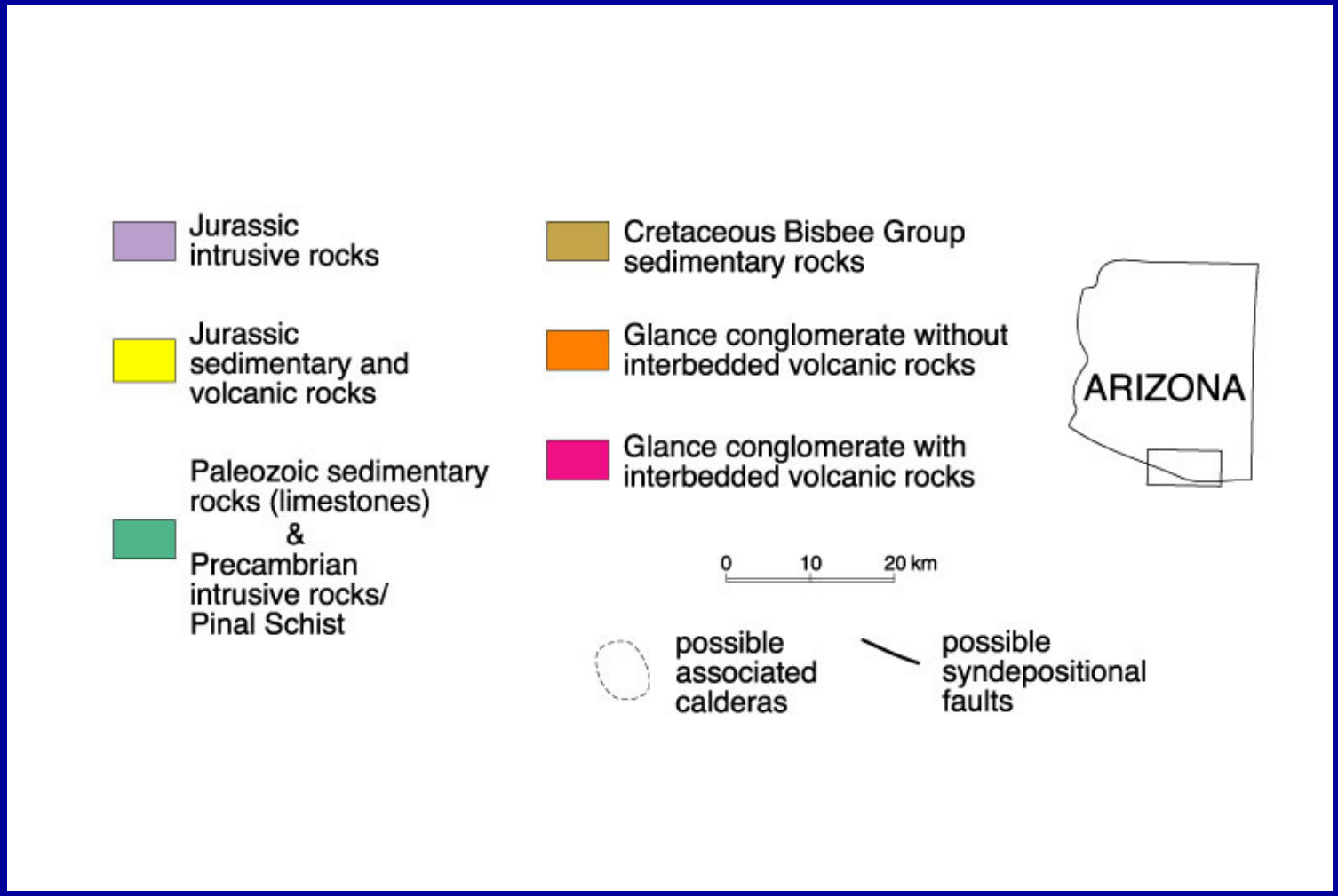
(Adams, Busby and Mattinson, 1997)

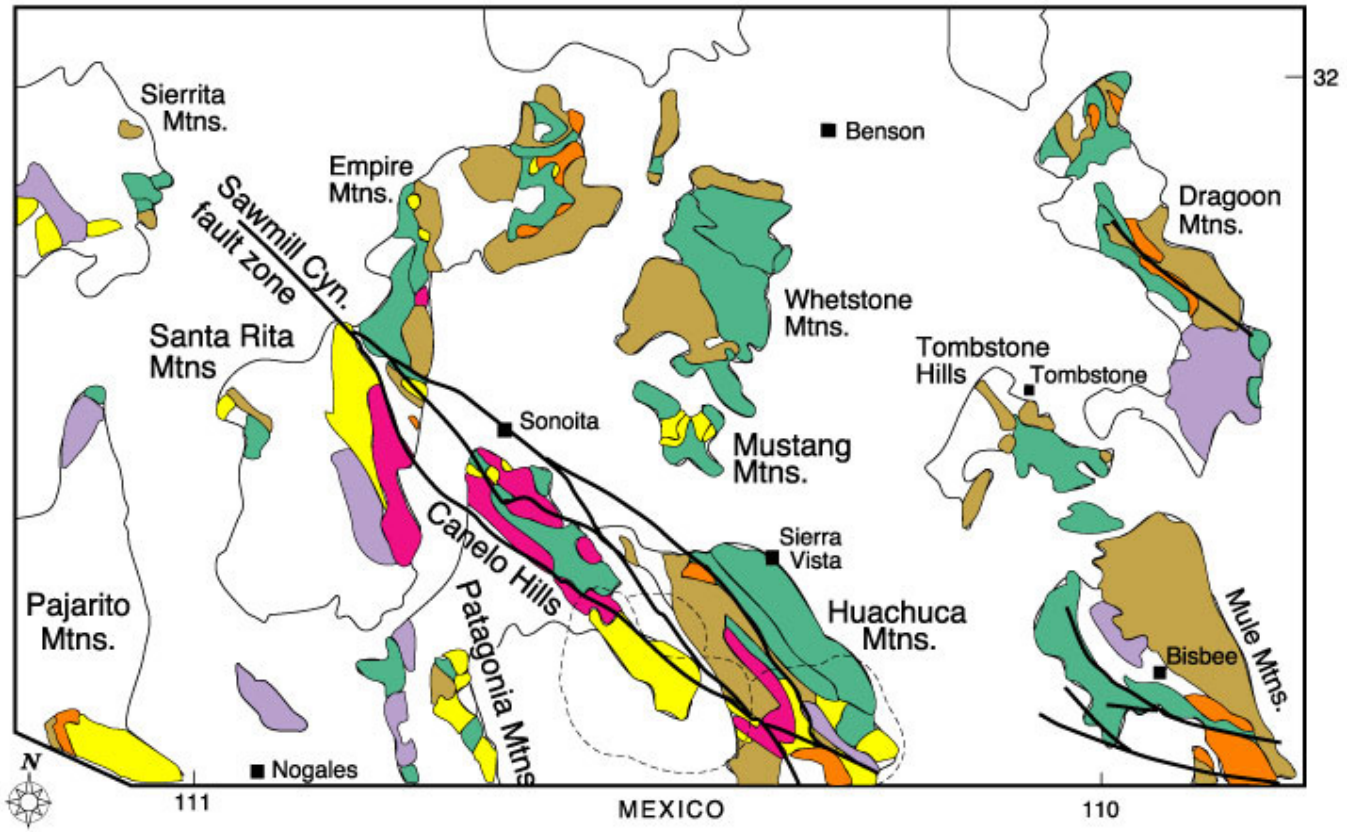


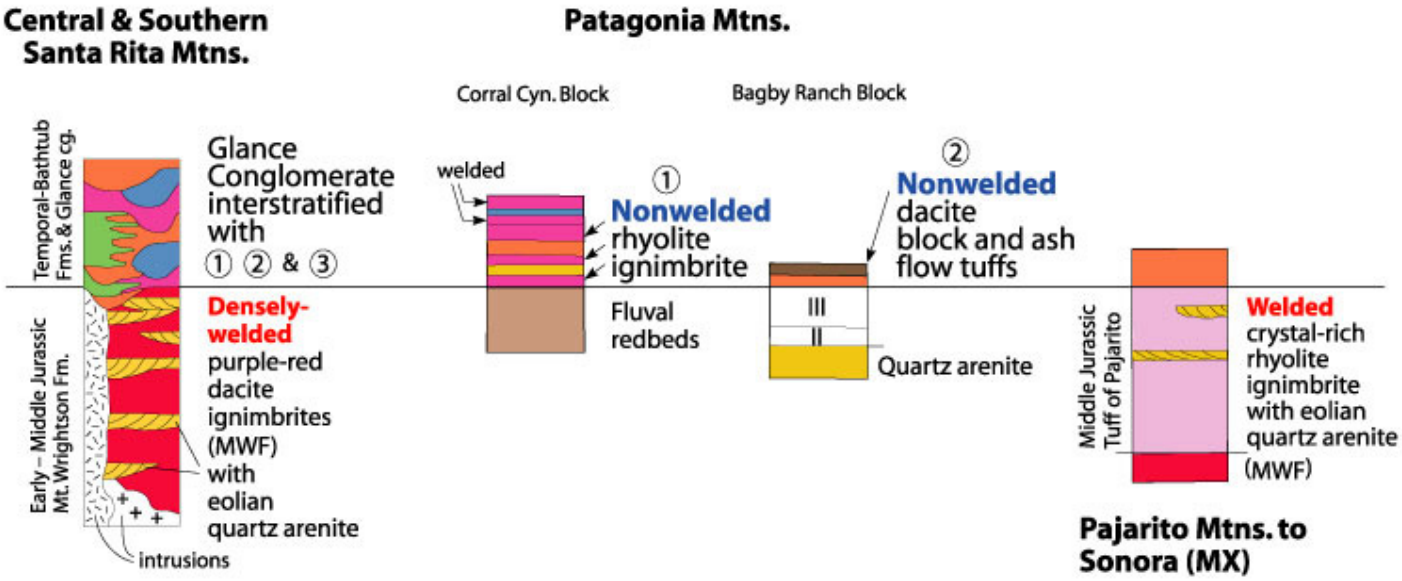
Late Jurassic Transpressional to Transtensional Arc

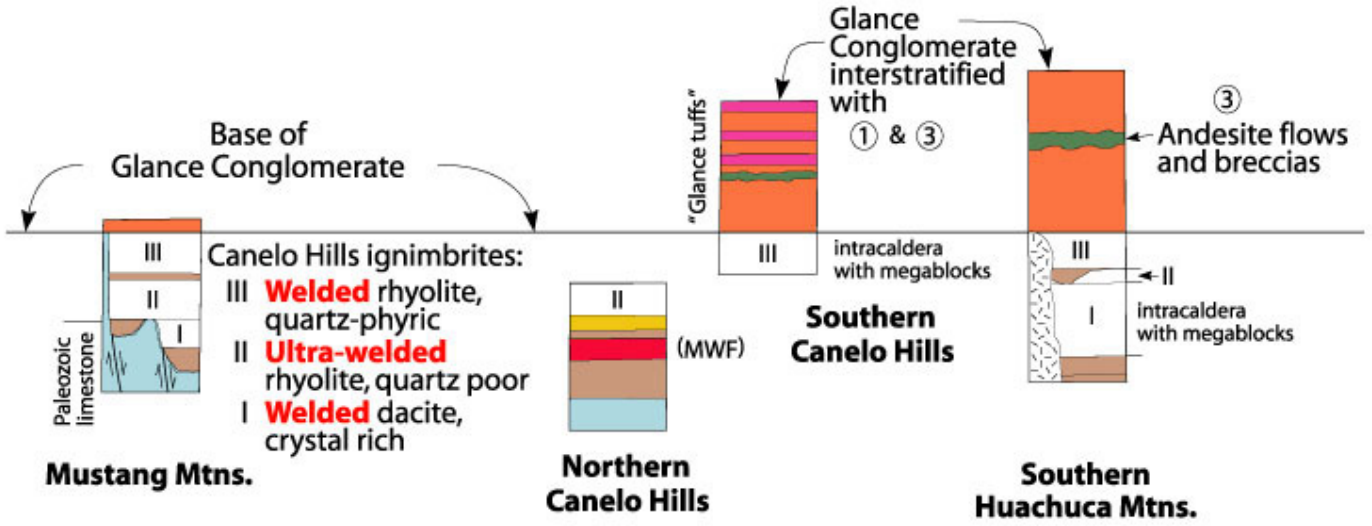


(Busby-Spera et al, 1990)


Jurassic intrusive rocks
Jurassic sedimentary and volcanic rocks
Paleozoic sedimentary rocks (limestones) & Precambrian intrusive rocks/ Pinal Schist
Cretaceous Bisbee Group sedimentary rocks
Glance conglomerate without interbedded volcanic rocks
Glance conglomerate with interbedded volcanic rocks
ARIZONA
0 10 20 km
possible associated calderas
possible syndepositional faults

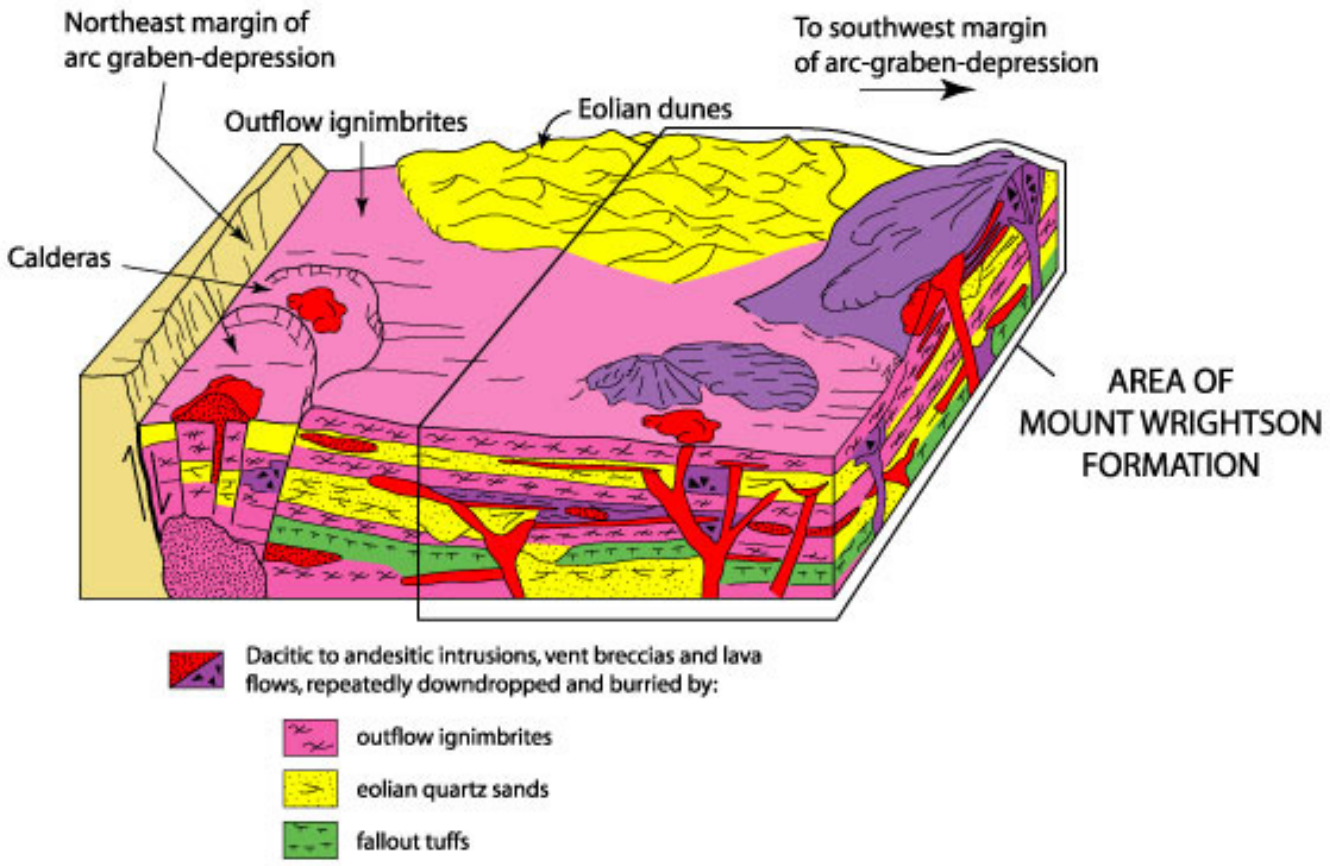

Sierrita Mtns.
Empire Mtns.
Sawmill Cyn. fault zone
Santa Rita Mtns
Benson
Whetstone Mtns.
Dragoon Mtns.
Tombstone Hills
Tombstone
Sonoita
Mustang Mtns.
Canelo Hills
Sierra Vista
Huachuca Mtns.
Mule Mtns.
Bisbee
Pajarito Mtns.
Patagonia Mtns
Nogales
N
111
MEXICO
110
32


Central & Southern
Santa Rita Mtns.
Patagonia Mtns.
Corral Cyn. Block
Bagby Ranch Block
Temporal-Bathtub Fms. & Glance cg.
Glance Conglomerate interstratified with ① ② & ③
welded
①
Nonwelded
rhyolite
ignimbrite
②
Nonwelded
dacite
block and ash
flow tuffs
Early – Middle Jurassic Mt. Wrightson Fm.
Densely-welded
purple-red
dacite
ignimbrites
(MWF)
with
eolian
quartz arenite
Fluval
redbeds
III
II
Quartz arenite
intrusions
Middle Jurassic Tuff of Pajarito
Welded
crystal-rich
rhyolite
ignimbrite
with eolian
quartz arenite
(MWF)
Pajarito Mtns. to
Sonora (MX)


Base of
Glance Conglomerate
Glance
Conglomerate
interstratified
with
① & ③
"Glance tuffs"
③
Andesite flows
and breccias
Canelo Hills ignimbrites:
III Welded rhyolite,
quartz-phyric
II Ultra-welded
rhyolite, quartz poor
I Welded dacite,
crystal rich
Paleozoic
limestone
III
II
I
(MWF)
intracaldera
with megablocks
Southern
Canelo Hills
intracaldera
with megablocks
Mustang Mtns.
Northern
Canelo Hills
Southern
Huachuca Mtns.

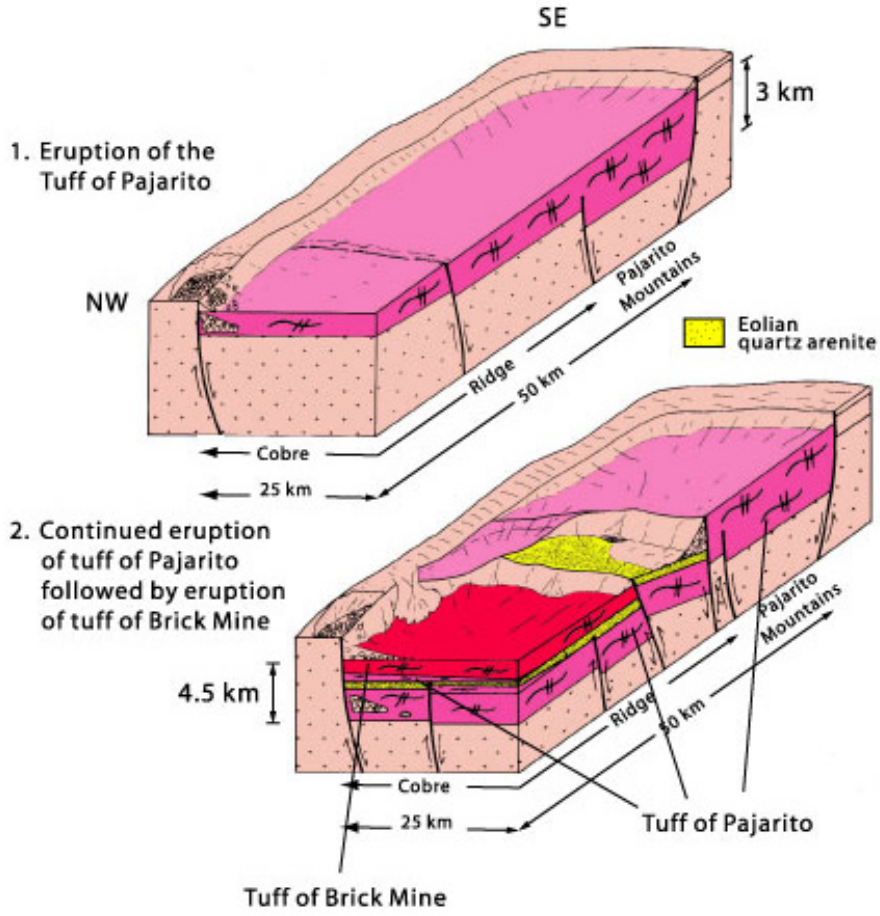
Early to Middle Jurassic Multivent Complex within a Subsiding Continental Arc Graben in Southern Arizona

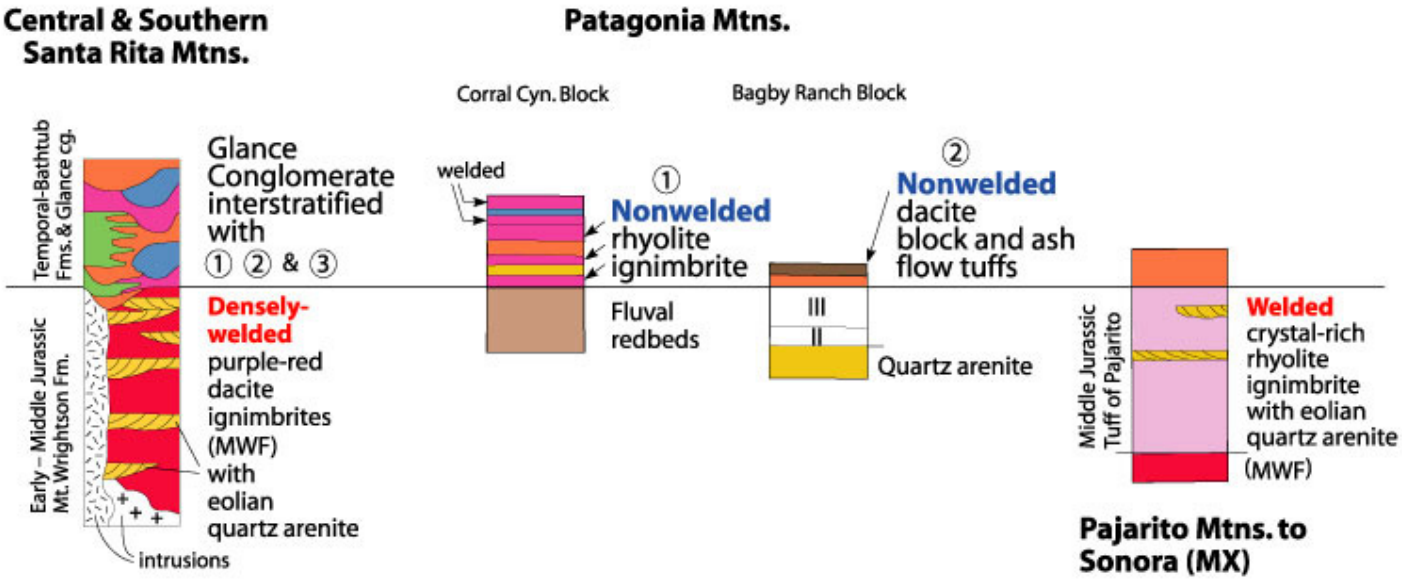
(Riggs and Busby-Spera, 1990)



Middle Jurassic Cobre Ridge Caldera, Southern Arizona (Riggs and Busby-Spera, 1991)

Large size, rectilinear shape and great thickness of fill suggest regional structural control.

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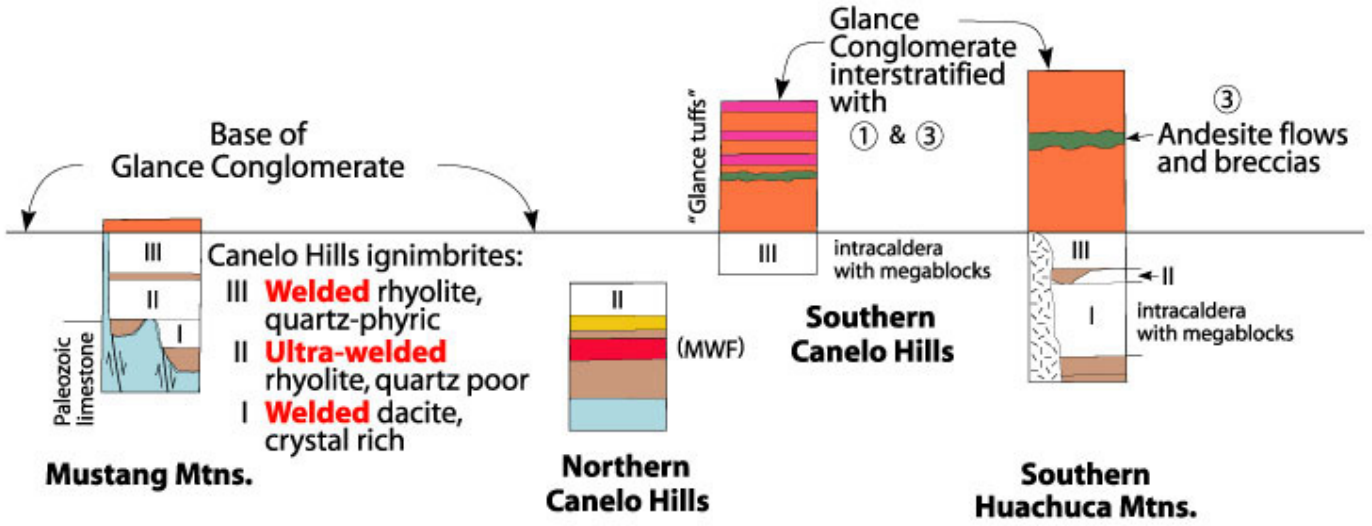
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with megablocks
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Southern
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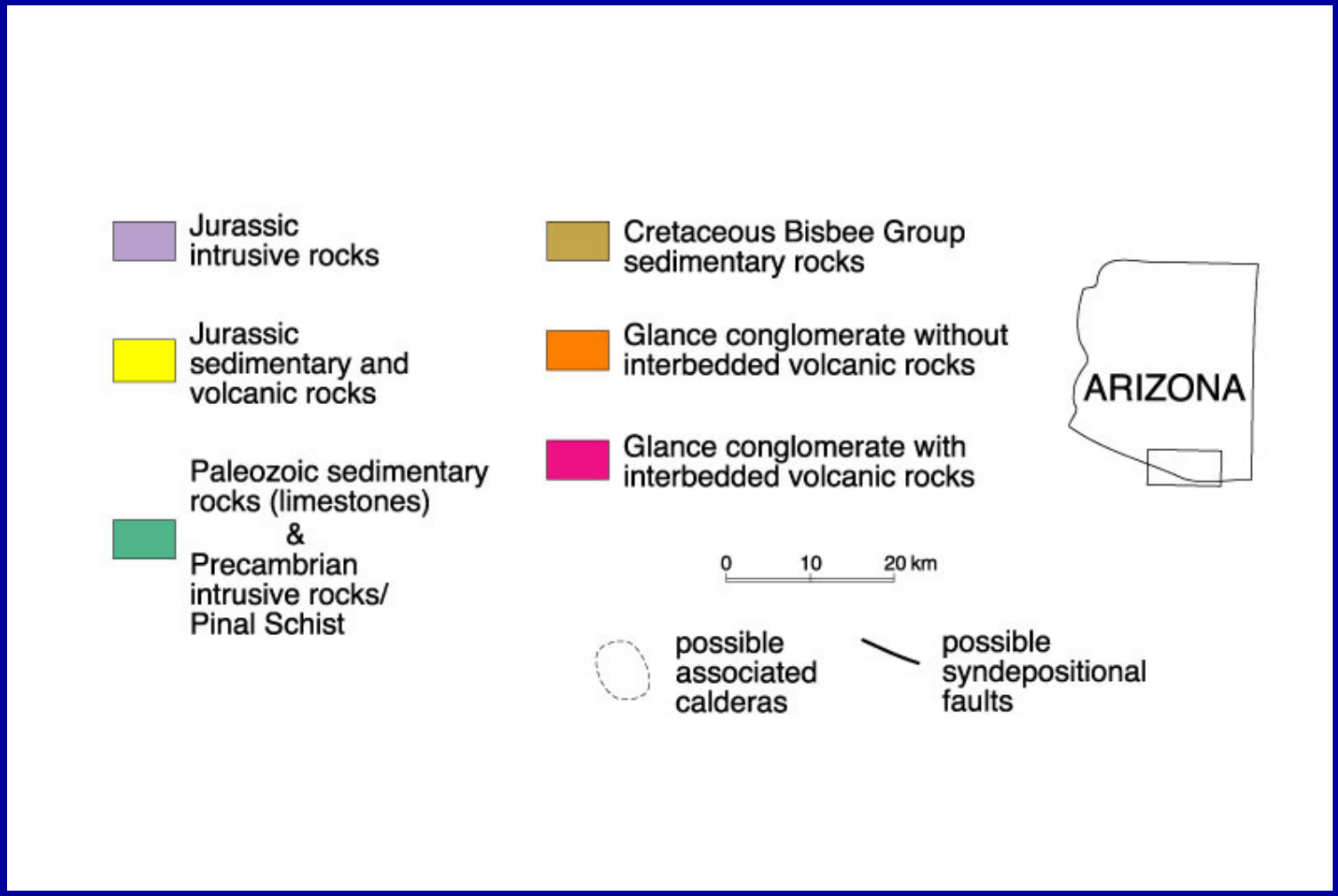
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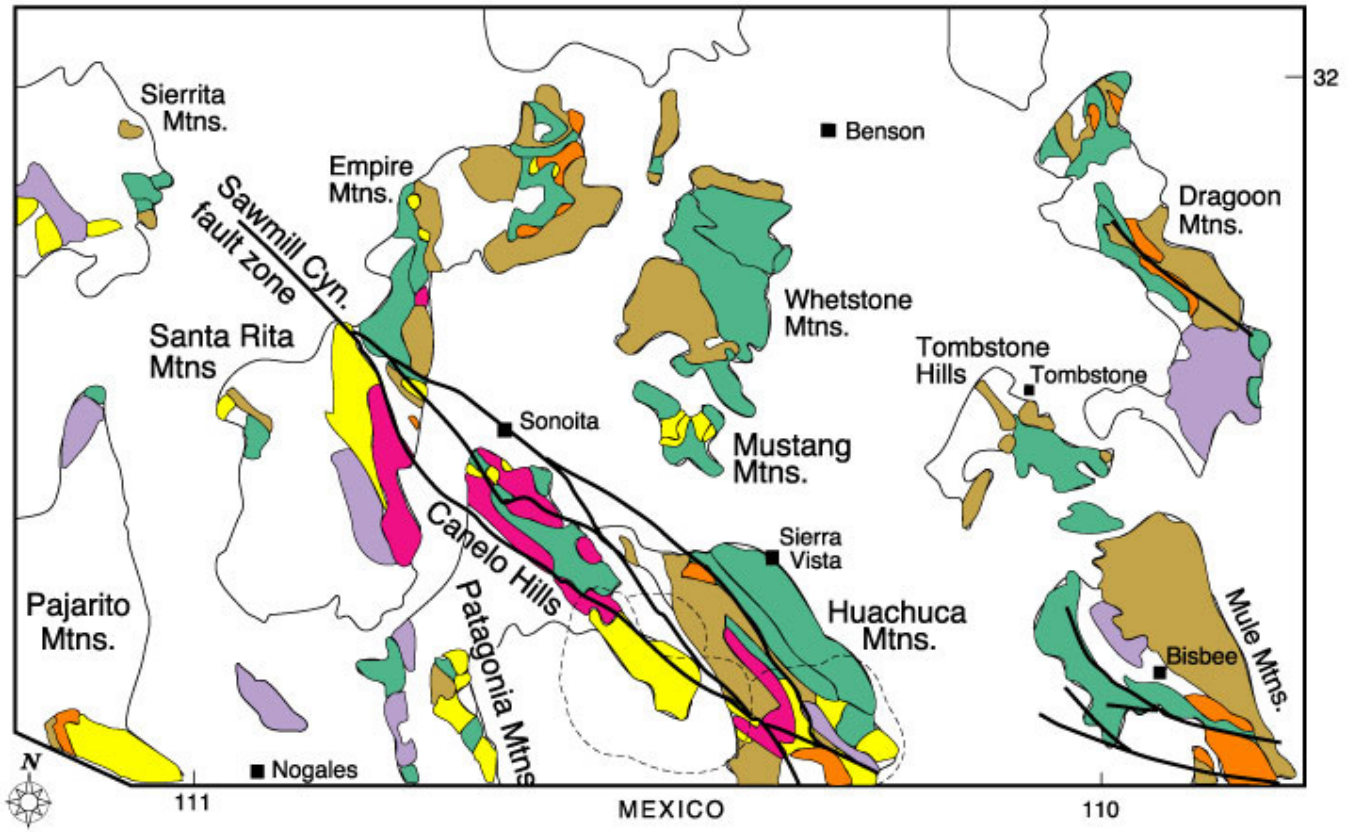
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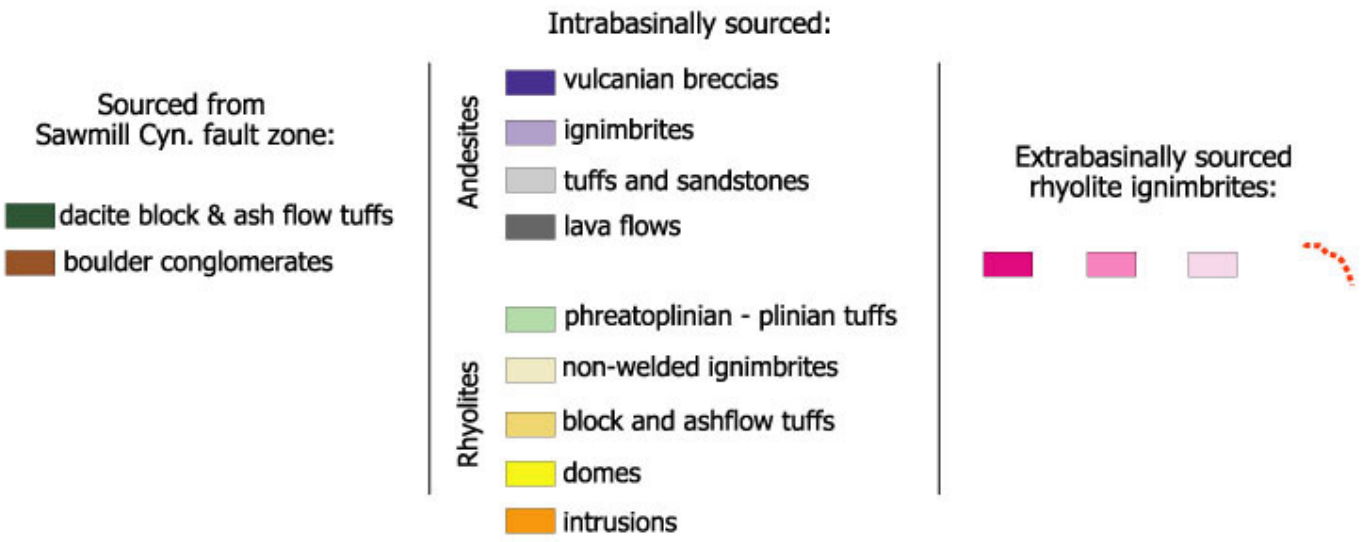
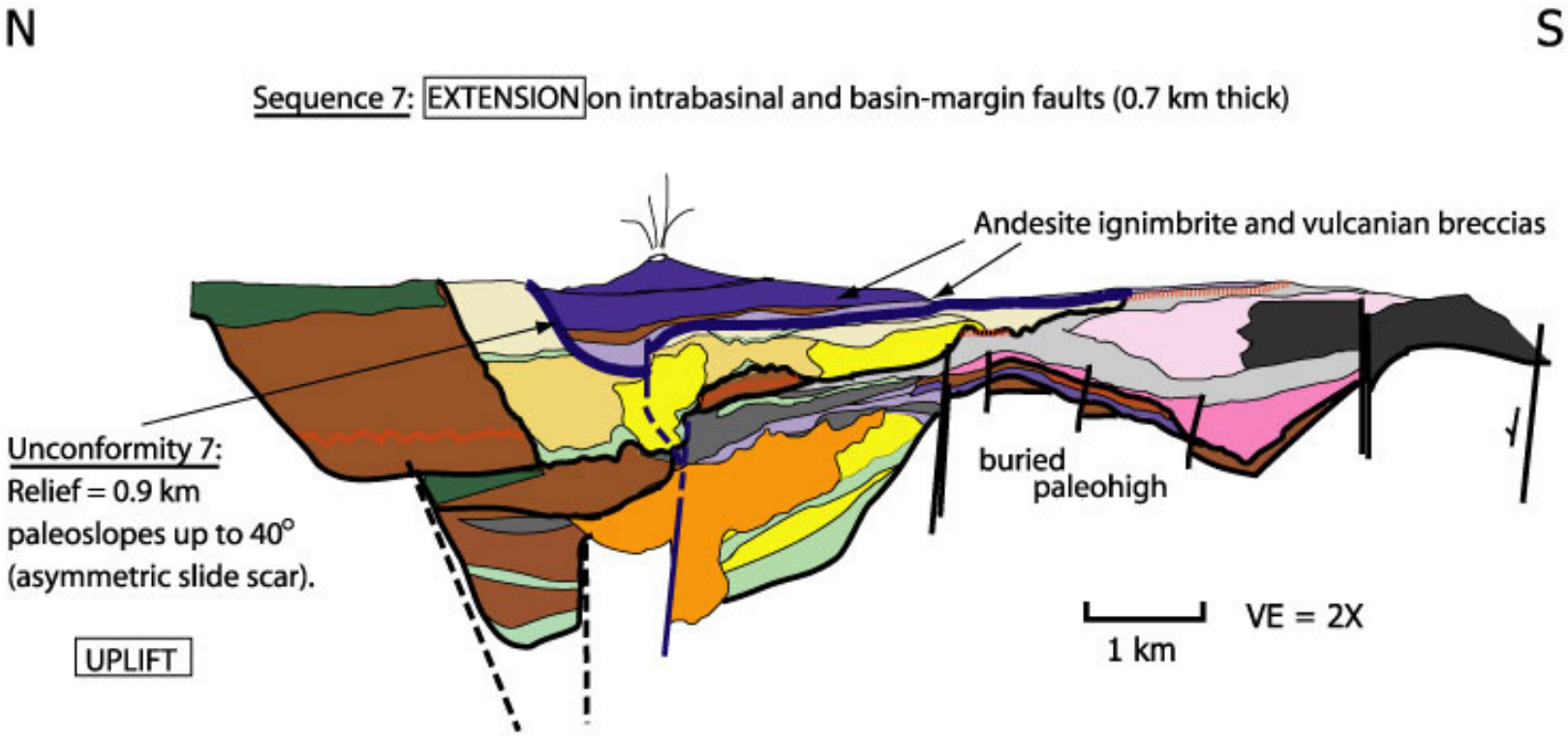
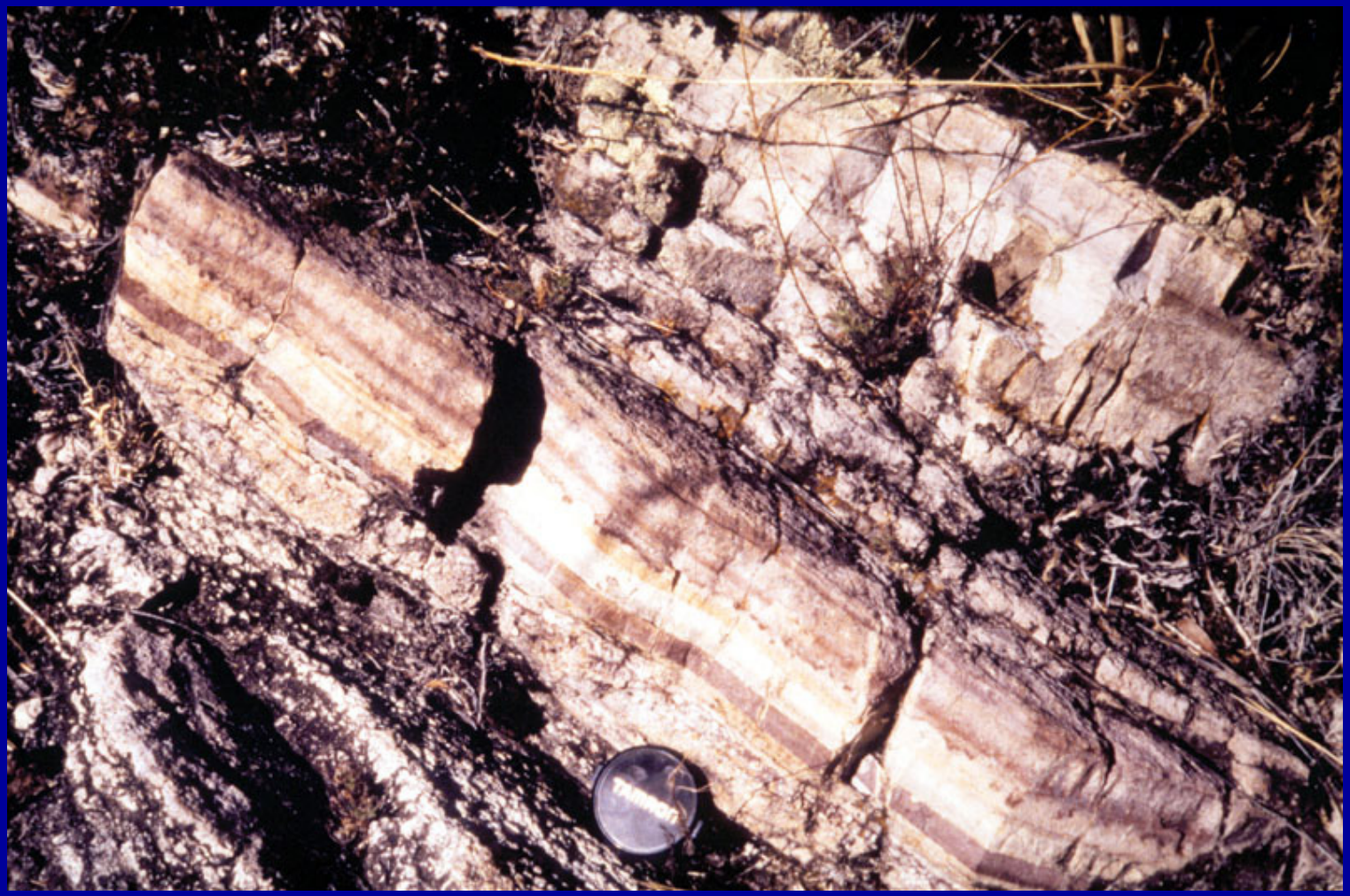
Patagonia Mtns
Nogales
N
111
MEXICO
110
32

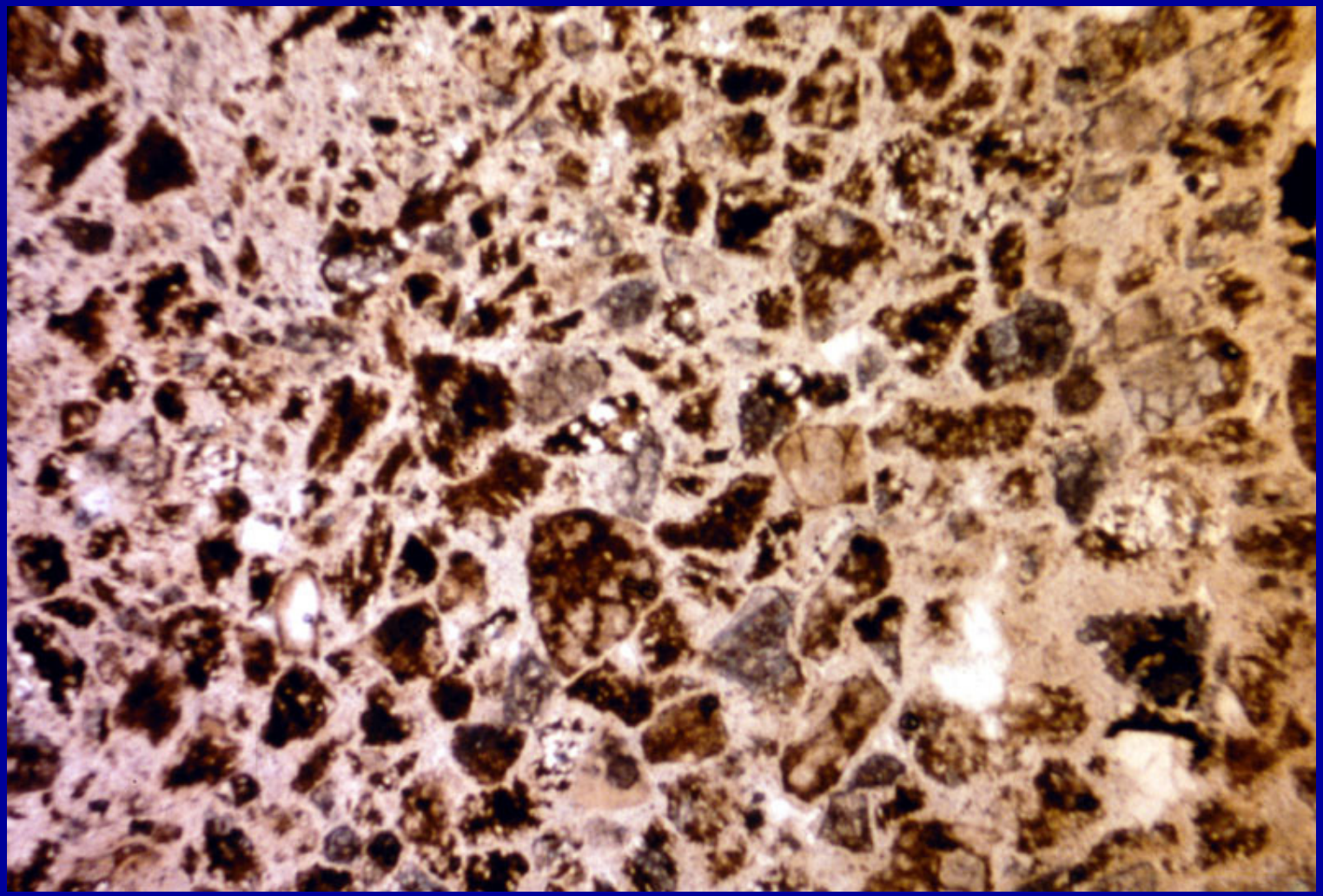
Temporal - Bathtub - Glance Formations
Santa Rita Mtns, Southern Arizona

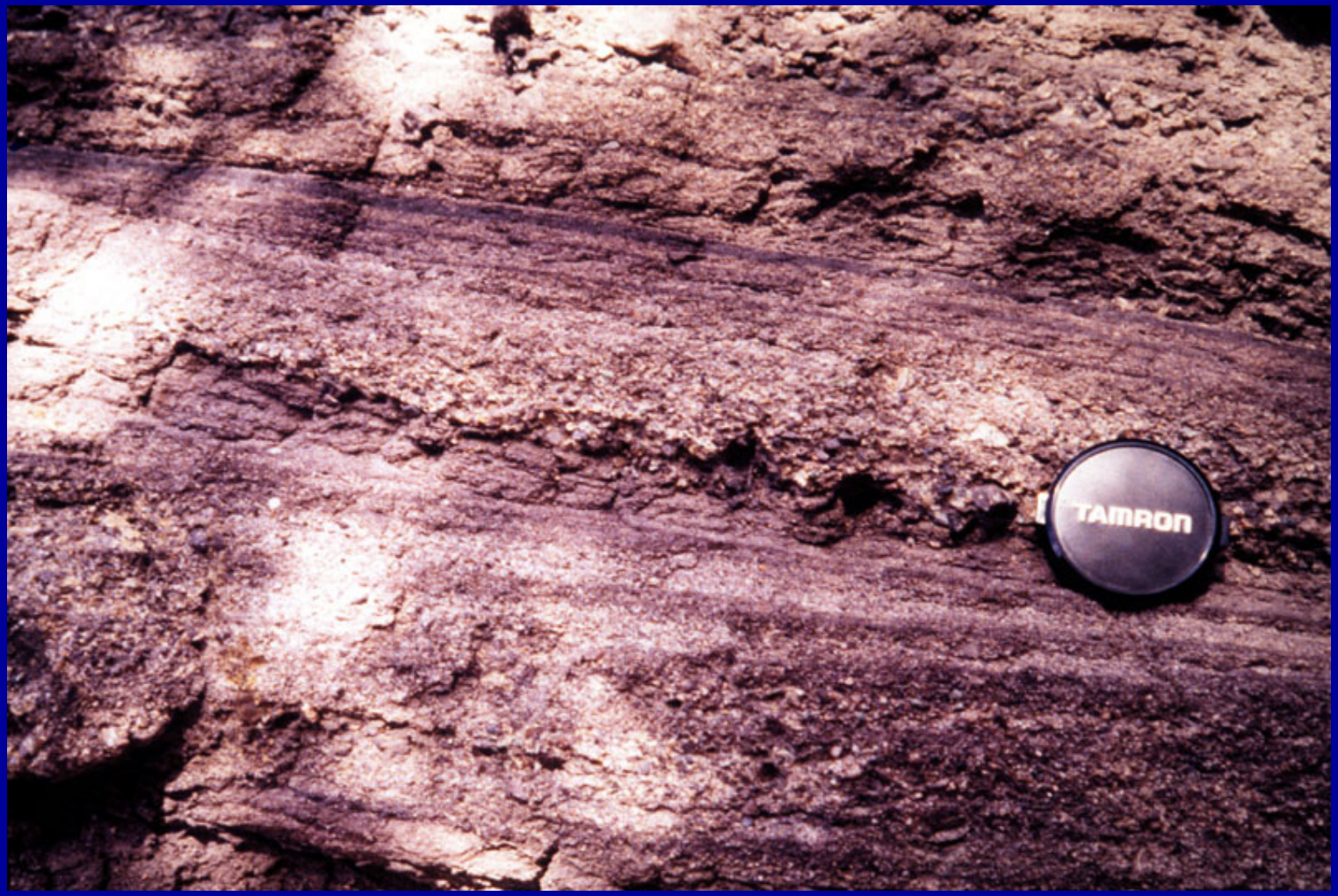
(Bassett and Busby, in review)

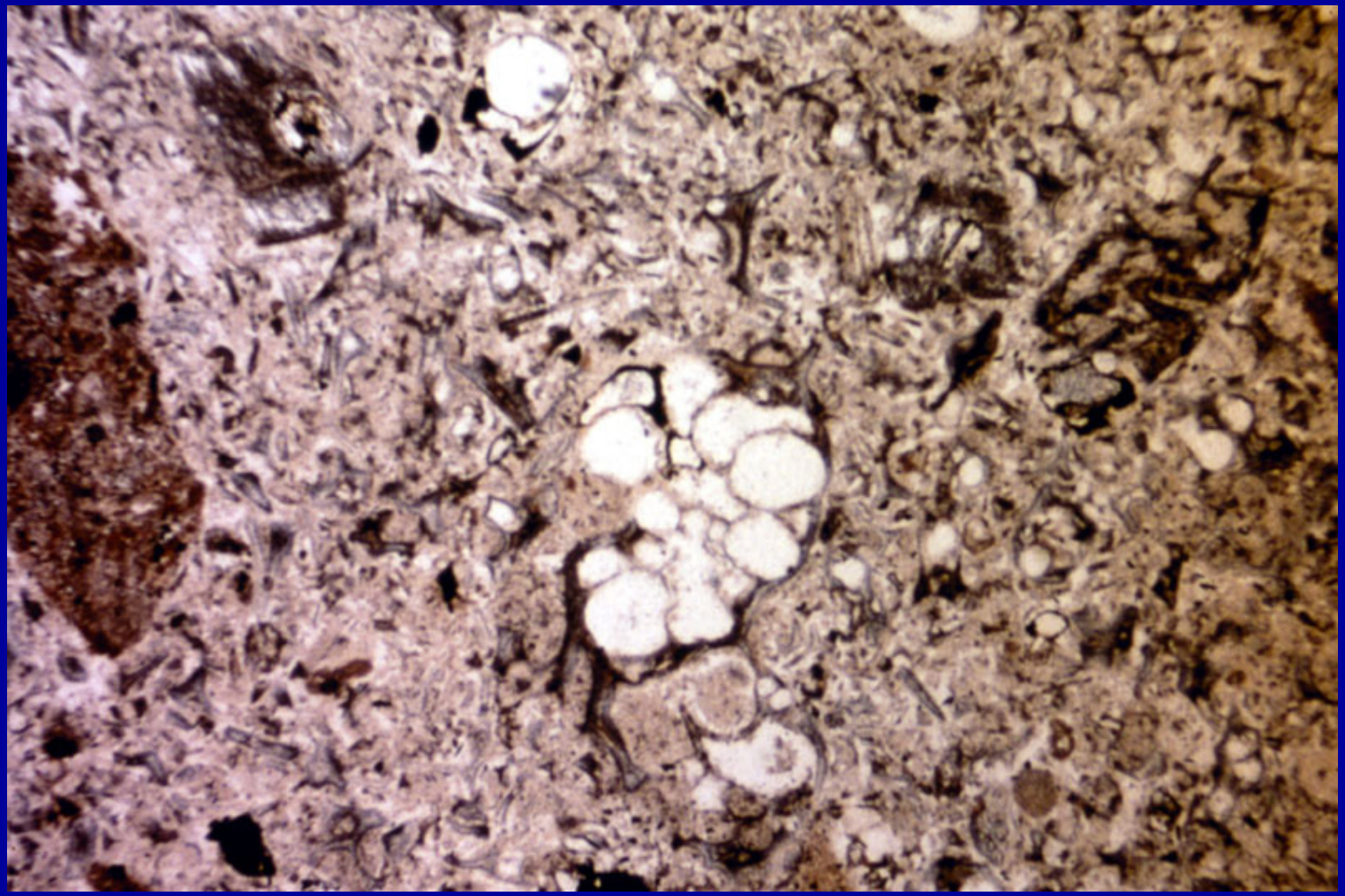



N
S
Sequence 7: EXTENSION on intrabasinal and basin-margin faults (0.7 km thick)
Andesite ignimbrite and vulcanian breccias
Unconformity 7:
Relief = 0.9 km
paleoslopes up to 40°
(asymmetric slide scar).
buried
paleohigh
UPLIFT
1 km
VE = 2X



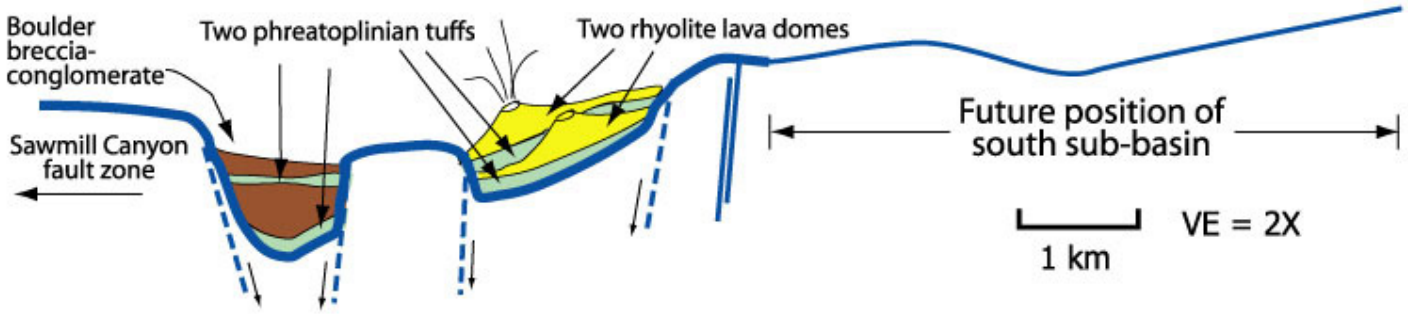



TAMRON



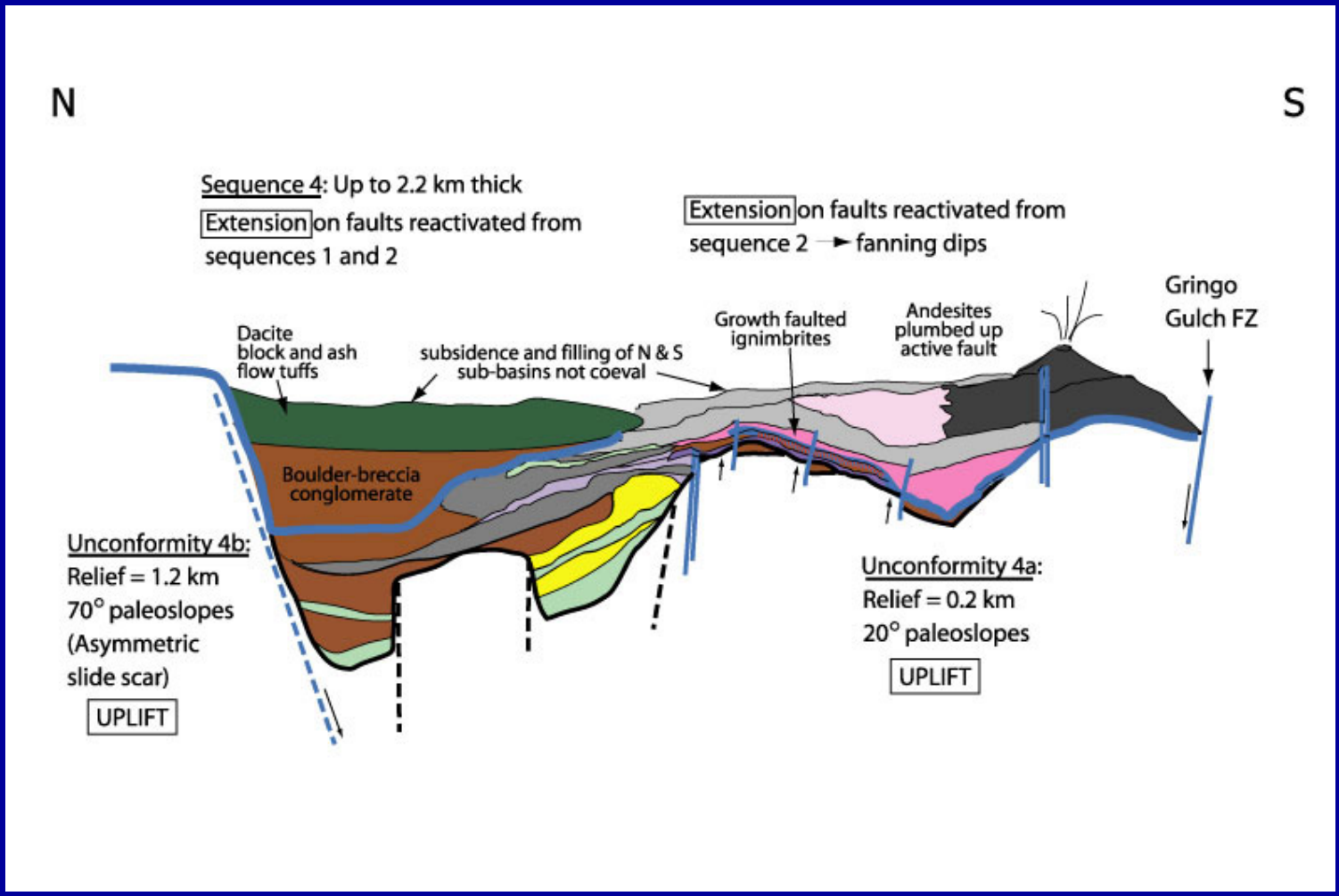
N S

Sequence 1: Extension and subsidence of two troughs (1.5 km deep).



Unconformity 1: Relief = 1.7 km through underlying Mount Wrightson Fm
Slope gradients up to 70°

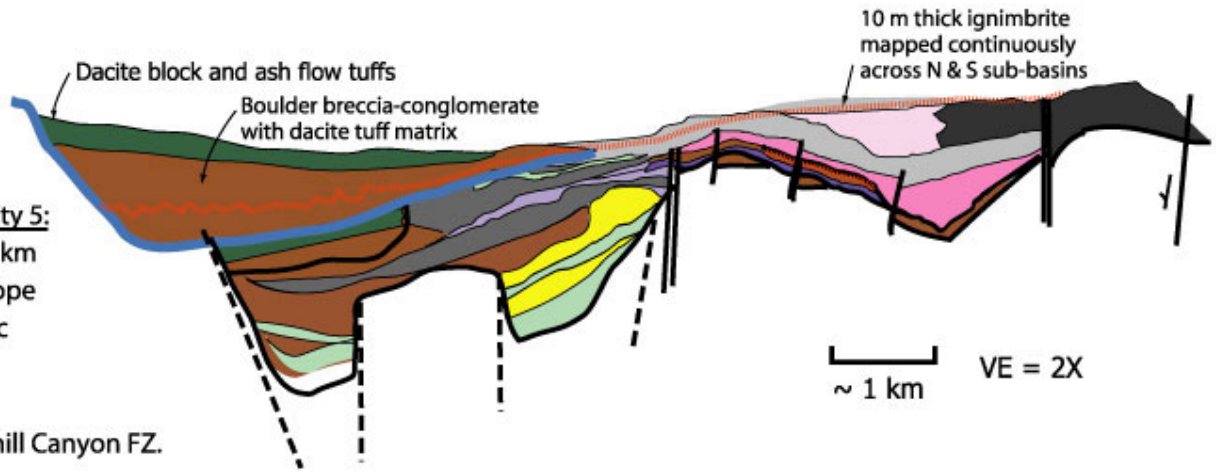
UPLIFT


N
S
Sequence 4: Up to 2.2 km thick
Extension on faults reactivated from sequences 1 and 2
Extension on faults reactivated from sequence 2 → fanning dips
Gringo Gulch FZ
Dacite block and ash flow tuffs
subsidence and filling of N & S sub-basins not coeval
Growth faulted ignimbrites
Andesites plumbed up active fault
Boulder-breccia conglomerate
Unconformity 4b:
Relief = 1.2 km
70° paleoslopes
(Asymmetric slide scar)
UPLIFT
Unconformity 4a:
Relief = 0.2 km
20° paleoslopes
UPLIFT

N

S

Sequence 5: 1.7 km thick due to EXTENSION along Sawmill Canyon fault zone: shedding boulder breccia-conglomerate and plumbing dacite domes

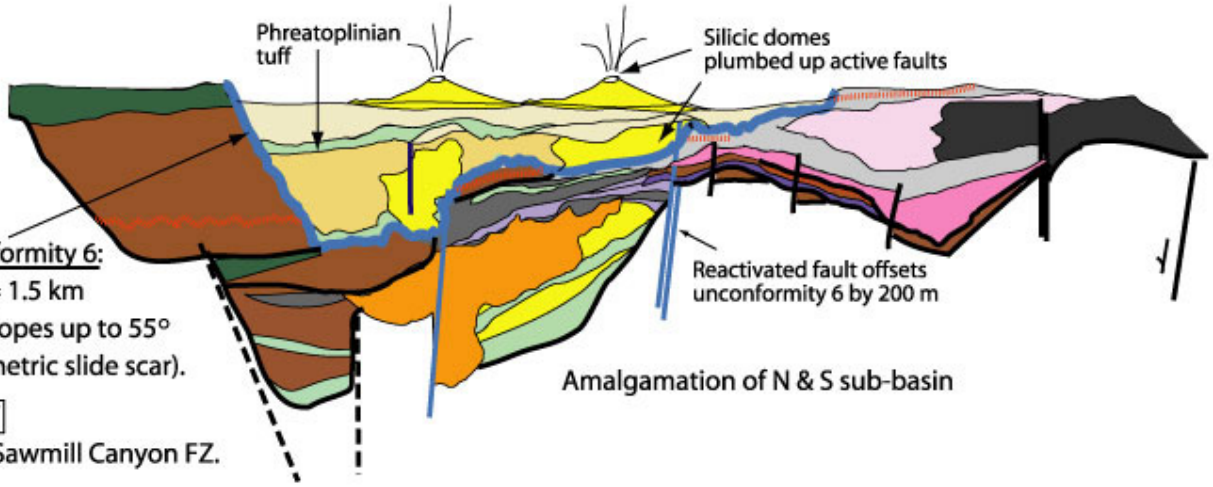


Unconformity 5:
Relief = 1.6 km
49$_o$ paleoslope
(Asymmetric
slidescar)
UPLIFT
along Sawmill Canyon FZ.

N

S

Sequence 6: up to 1.5 km thick SUBSIDENCE along Sawmill Fanyon FZ. Volcanism swamps out "background" breccia-conglomerate influx.



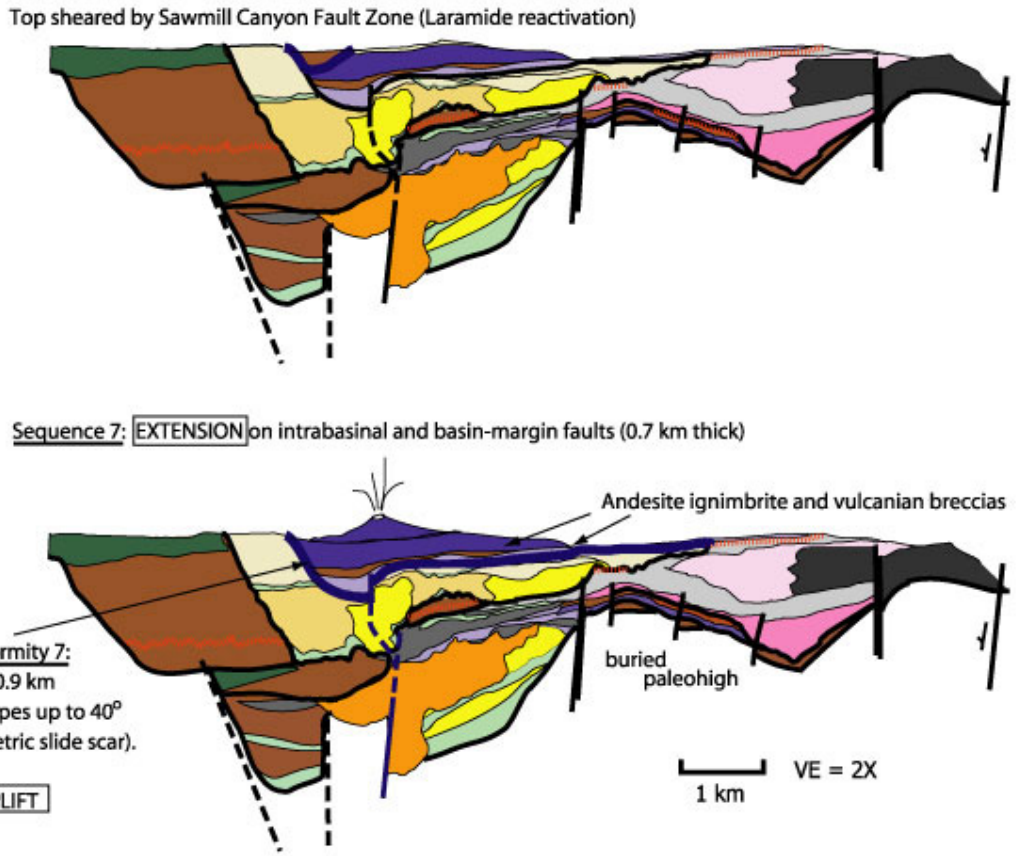
Unconformity 6:
Relief = 1.5 km
paleoslopes up to 55°
(asymmetric slide scar).

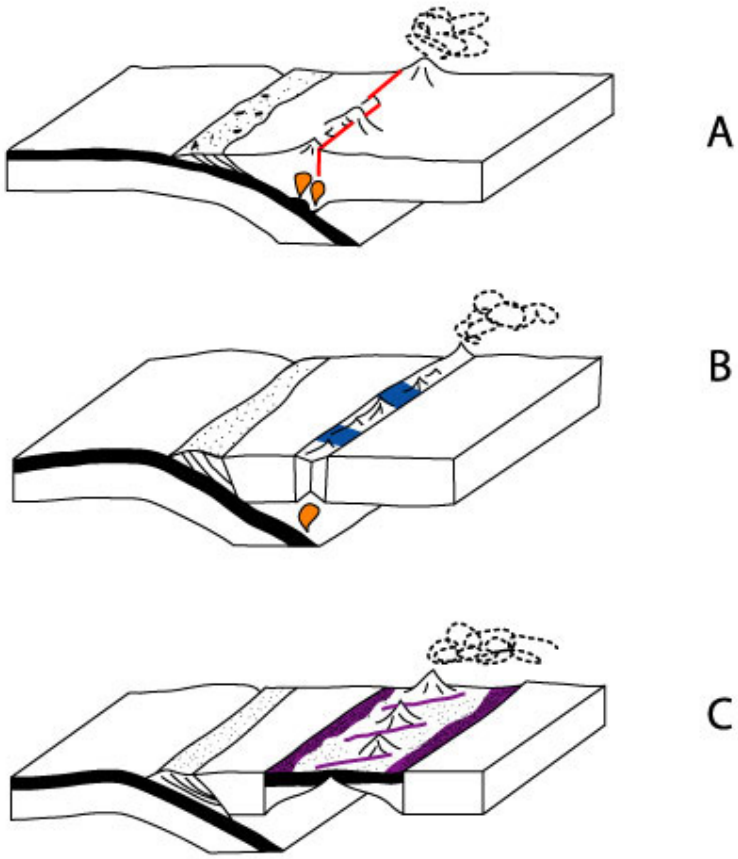
UPLIFT
along Sawmill Canyon FZ.

N

MAP VIEW WITH 2X VERTICAL EXAGERATION

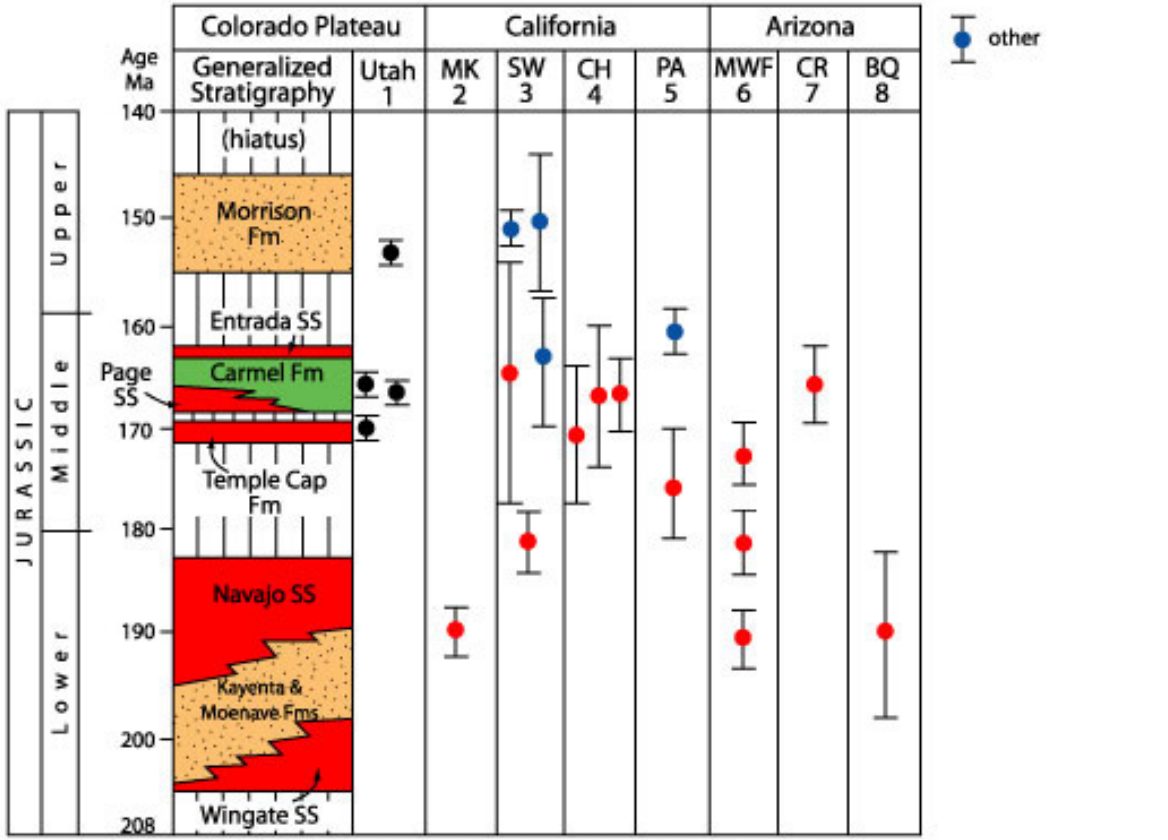
S





Speculative evolutionary model for arc-rift development. We suggest that A) strike-slip faulting is more easily accomplished in the thermally weakened arc crust, B) leading to strike-slip basin nucleation along the arc, and C) a transtensional arc-rift

U-Pb Zircon Dates on Jurassic Arc Metavolcanic Rocks



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Continental Arc-Rift Basins

	Early to Middle Jurassic Extensional Arc	Late (?) Jurassic Strike-Slip Arc
volcanic controls	more voluminous, widespread, and continuous eruptions => scarps buried by pyroclastic deposits	more restricted eruptions in space and time, episodic => scarps eroded shedding sediments into the canyons
structural controls	uniformly fast and continuous subsidence => unconformities rare	"porpoising" on all scales, local regions of uplift within basins => numerous big unconformities intrabasinal highs shed sediment
climatic controls	hyperarid: eolianites => "dry" eruptions of welded tuffs, most rheomorphic	wetter climate: sheetwash & channelized HFF & dilute flow => "wet" eruptions of nonwelded tuffs, plinian, & phreatoplinian fall


19 7:36