GEOLOGY OF THE BLACK ROCK DESERT

By

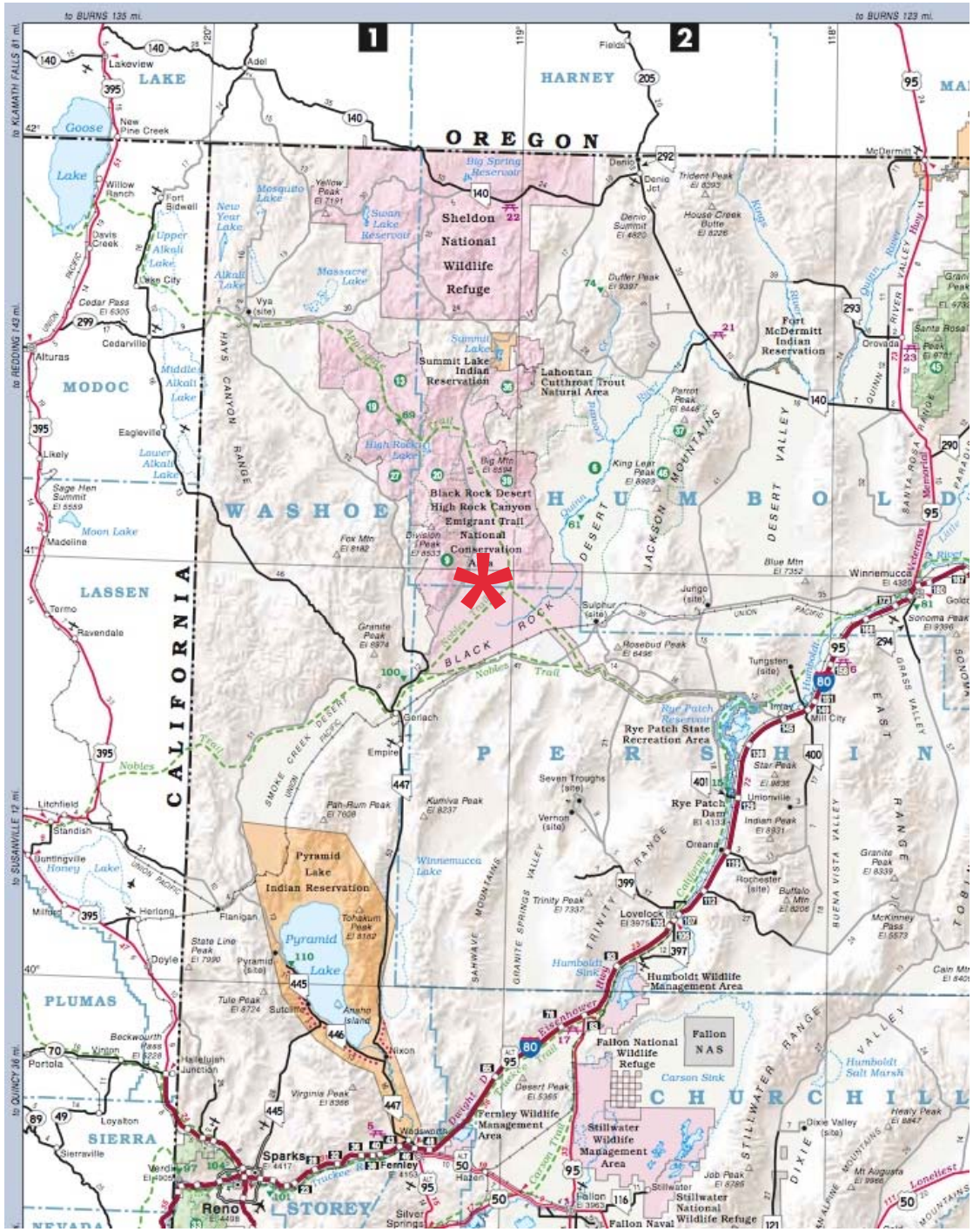
Cathy Busby
Professor of Geology
University of California
Santa Barbara

http://www.geol.ucsb.edu/faculty/busby

BURNING MAN EARTH GUARDIANS PAVILION 2012

LEAVE NO TRACE

Please come find me and I'll give you a personal tour of the posters!



You are here! In one of the most amazing geologic wonderlands in the world!

Fantastic rock exposure, spectacular geomorphic features, and a long history, including:

1. PreCambrian loss of our Australian neighbors by continental rifting,

2. Paleozoic accretion of island volcanic chains like Japan (twice!),

3. Mesozoic compression and emplacement of a batholith,

4. Cenozoic stretching and volcanism, plus a mantle plume torching the base of the continent!

Let’s start with what you can see on the playa and from the playa:

the Neogene to Recent geology, which is the past ~23 million years (= Ma).

Note: Recent = past 15,000 years

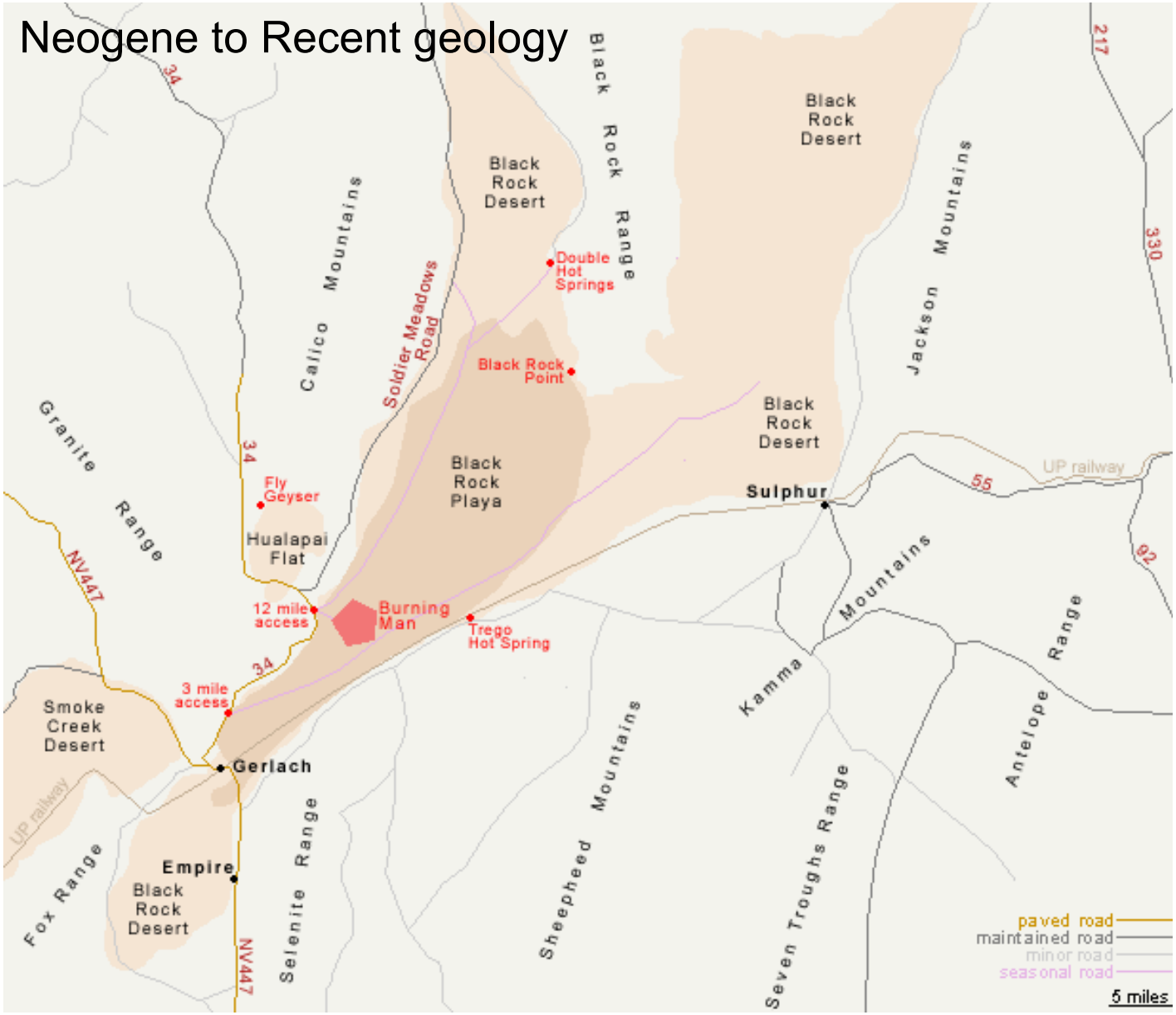
http://www.terragalleria.com

Eon	Era	Period	Millions of years ago	Major appearances
Phanerozoic	Cenozoic	Quaternary	0.2	Humans
		Tertiary	2.6 3.5	Direct human ancestors
	Mesozoic	Cretaceous	65	Flowering plants in abundance
		Jurassic	142	
		Triassic	206	Birds Mammals and dinosaurs
	Paleozoic	Permian	253	
		Carboniferous: Pennsylvanian	290	
		Carboniferous: Mississippian	323	Reptiles
		Devonian	360	Amphibians (vertebrates on land)
		Silurian	417	
		Ordovician	443	Land plants
		Cambrian	495	Fishes
Pre-Cambrian		Ediacaran	543	Great diversification and abundance of life in the sea
	Proterozoic		620 1,000	Sexual reproduction
	Archean		2,500 3,600	Oldest fossils
Hadean			4,000	Oldest Earth rocks
			4,570	Origin of Earth

Then we'll "build" the terrane you are standing on, beginning with a **BILLION** years ago, moving through the **Paleozoic** (old life, ~540-253 Ma),

Mesozoic (age of dinosaurs, ~253-65 Ma)) and

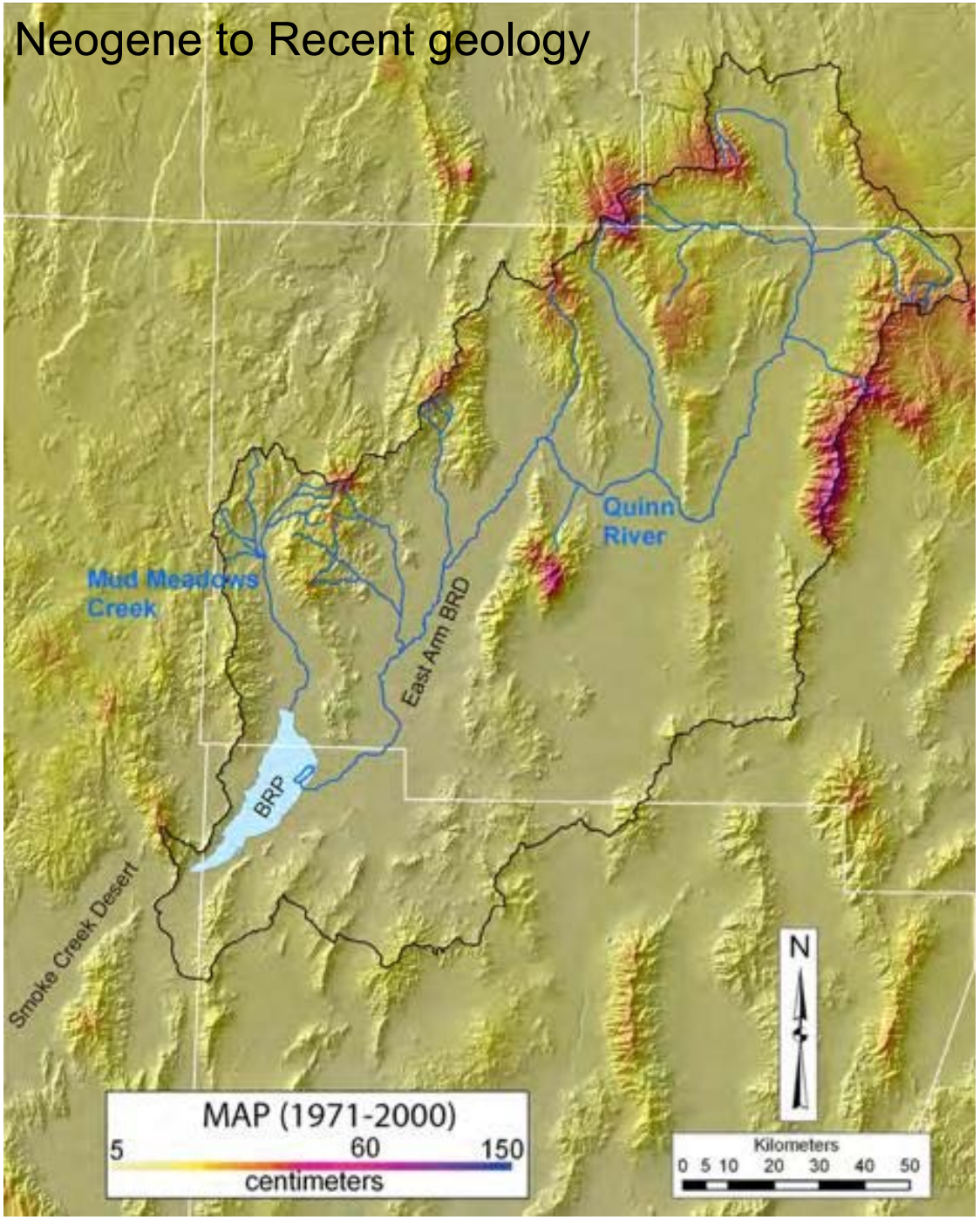
Cenozoic (age of mammals, ~65 -0 Ma).



Black Rock Playa extends 100 miles, from Gerlach to the Jackson Mountains.

The Black Rock Desert is divided into two arms by the Black Rock Range, and covers 1,000 square miles.

Empire (south of Gerlach)has the U.S. Gypsum mine and drywall factory (brand name “Sheetrock”), and there’s an opal mine at base of Calico Mtns.



BRP = The largest playa in North America

“Playa” = a flat-bottomed depression, usually a dry lake bed

3,500’ asl in SW,
4,000’ asl in N

Land speed record: 1997 - supersonic car, 766 MPH

Runoff mainly from the Quinn River, which heads in Oregon ~150 miles north.

Neogene to Recent geology

>15,000 years (**Recent**) ago the Humboldt River flowed into north Lake Lahontan, but since that dried up, the river has diverted south to the Carson Desert sub-basin (Carson Sink). Earliest humans here lived on the Lahontan lake shores.

Lake Lahontan was 500’ deep in the Black Rock Desert, and 900’ deep at present-day Pyramid Lake. Walker Lake also survives. Lake Lahontan dried up due to increased evaporation as the climate warmed.

The highest lake level reached an elevation of about 4370 feet above sea level, evidenced by a wave-built terrace of unsorted gravel called Lahontan Beach. This photo shows numerous flat-lying shoreline deposits. You can also see these at the south end of Death Valley, which held Lake Manly.

View 11 miles north of Gerlach on road 34. Playa is to right. Photo by M. Bilbo.

Neogene to Recent geology, continued

The highest Lahontan Lake levels are also recorded by the “High-Dry” micro-playas just east of the Black Rock (Black Rock hot springs on basin floor in front).

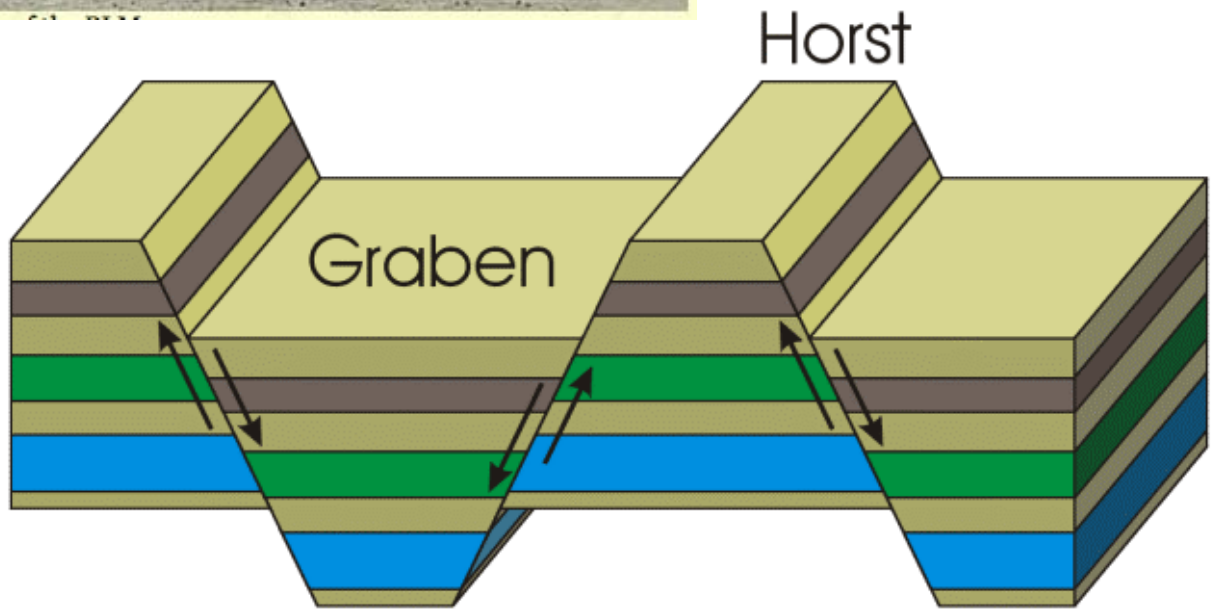
These are perfect, beautiful little playas!

Top photo by Delores Cates, bottom photo by Mike Bilbo.

Over the past ~25 million years (Neogene), the crust has been stretched or **rifted**.

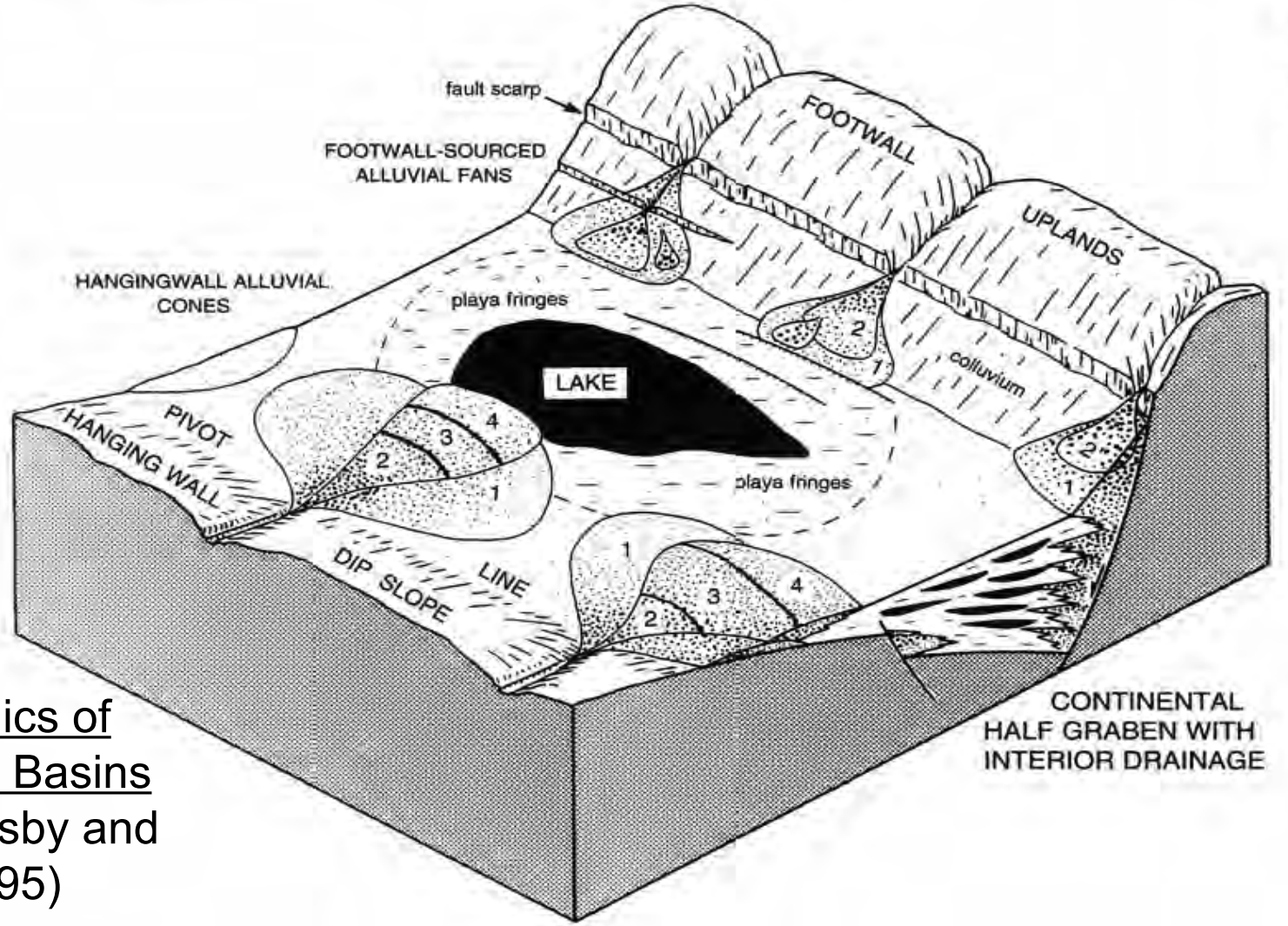
That makes grabens drop down in between horst blocks, along normal faults.

The playa is in a graben. Nevada has a whole series, called the "**Basin and Range**".



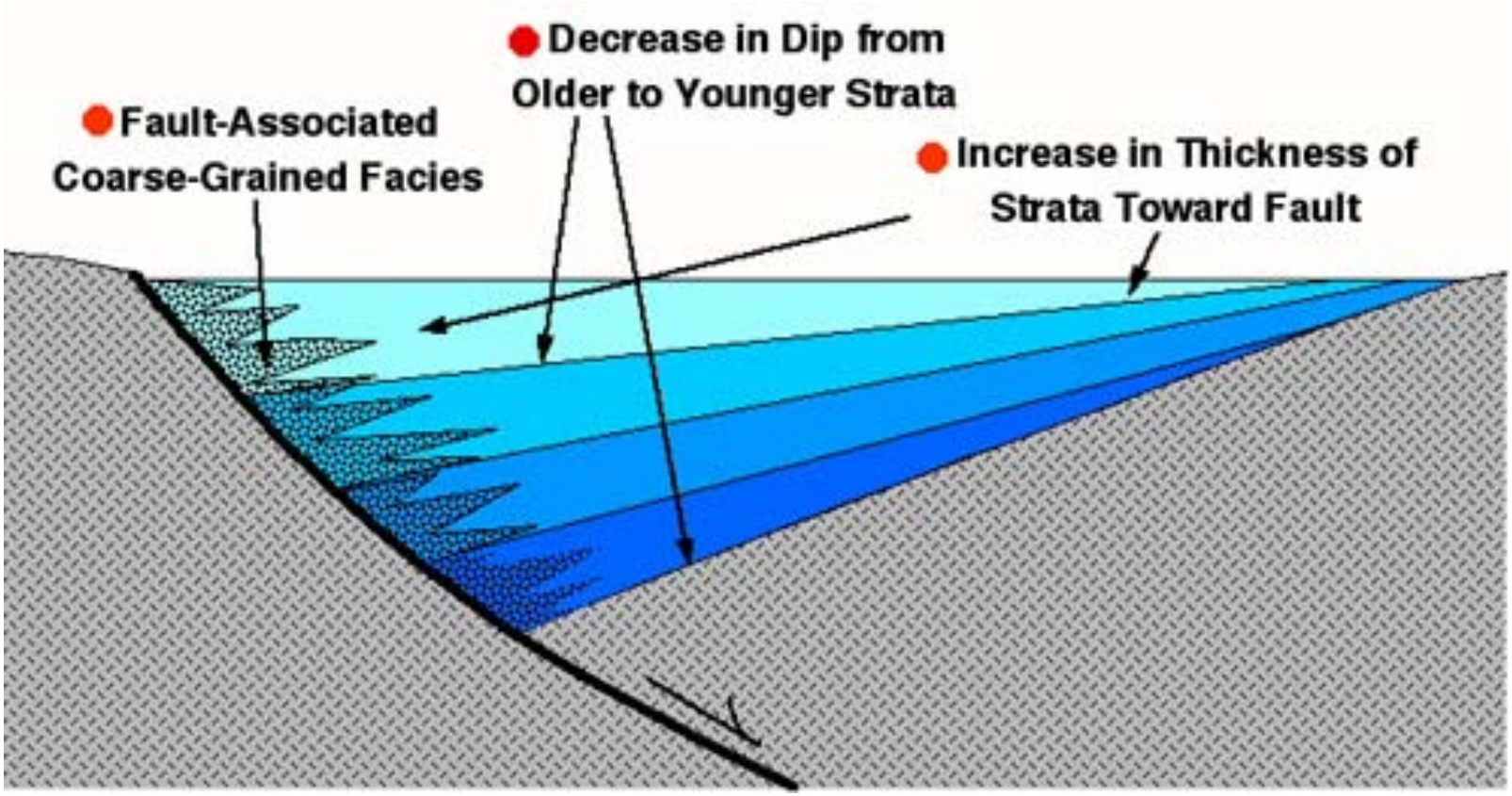
Hot springs of the Black Rock Desert form where hot water comes up along the faults that make the grabens.

Cartoon view of a **typical rift basin**: A high mountain range comes up, next to a basin that sinks along the normal fault. Alluvial fans build out from the mountain front into the basin, and the center of the basin fills with lake sediment.



From Tectonics of Sedimentary Basins edited by Busby and Ingersoll (1995)

Cross section of a **typical rift basin**: thousands of feet of lacustrine silt and clay, with alluvial fans on basin margin. This example is actually from the East African Rift.



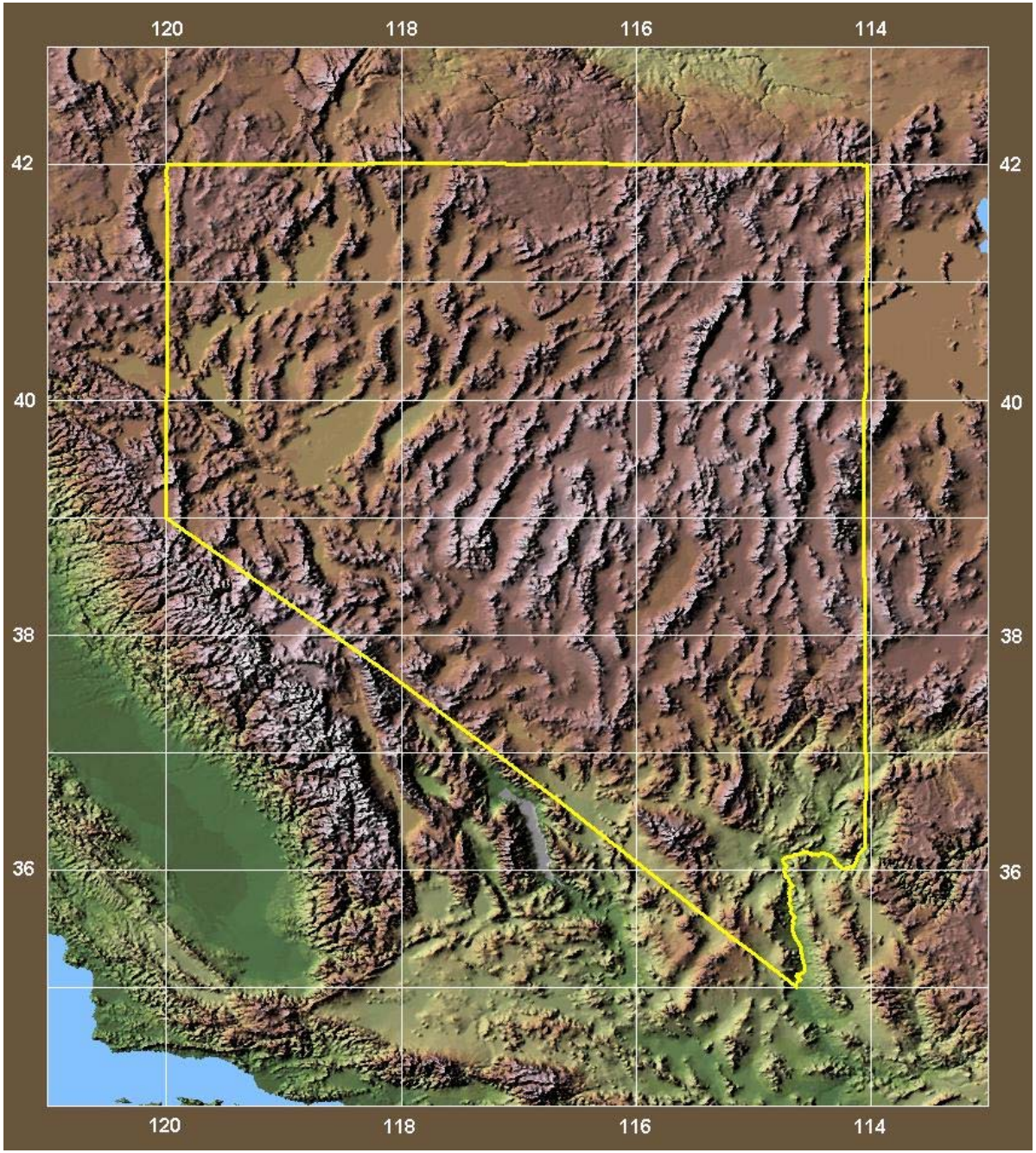
From Ebinger & Scholz, 2012, in Recent Advances in Tectonics of Sedimentary Basins, Busby and Azor editors.

BIG PICTURE TECTONIC SETTING:

Nevada is outlined in yellow.

Ranges of the Basin and Range look like “worms crawling north to Canada” =

ALL NORMAL FAULTS.



BIG PICTURE TECTONIC SETTING - Stretching of Basin and Range, also Rio Grande Rift. The Colorado Plateau in between is too strong to stretch!

Neogene to Recent geology, continued

BIG PICTURE TECTONIC SETTING

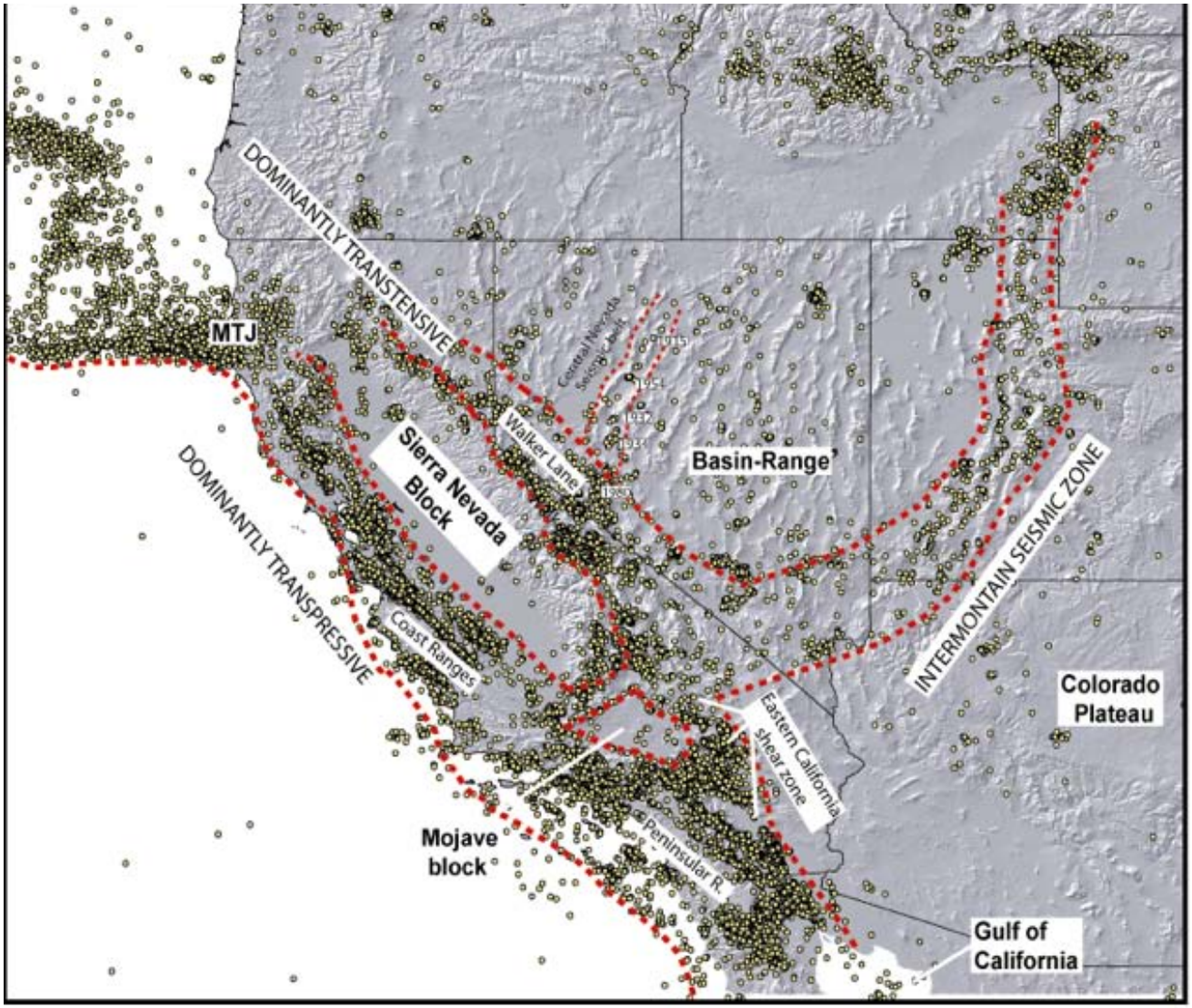
We're on the North American Plate in the Basin and Range,

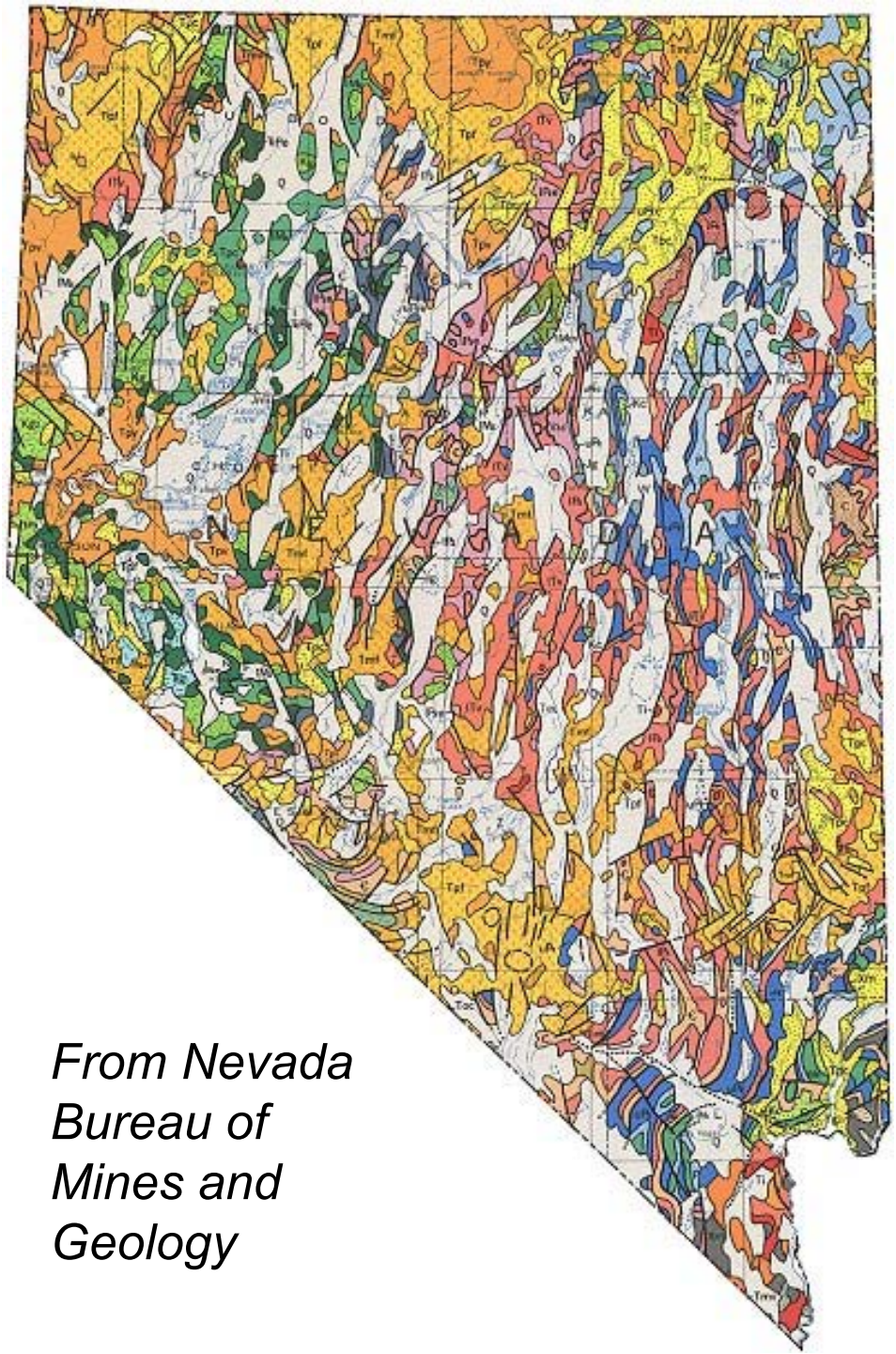
but we're close to the eastern edge of the Sierran Microplate, which has **strike slip faults** (as well as normal faults) that are parallel to the San Andreas Fault = **WALKER LANE BELT**

(from Unruh et al., 2003)

Neogene to Recent geology, continued

Most of the Basin and range is now tectonically dead but the Walker Lane belt is seismically active (dots = earthquakes).





From Nevada Bureau of Mines and Geology

The Neogene (~23 Ma-present) stretching of Nevada is very obvious on the geologic map.

But now let's see how our corner of Nevada has been constructed over the past billion years,

starting with the oldest rocks and working toward the Recent.

Black Rock Desert, from a billion years to now.

Black Rock Desert, from a billion years to now.

Quaternary sediments and volcanic rocks (<2.6 Ma)

Miocene-Pliocene volcanic and sedimentary rocks

Oligocene volcanic rocks

Mesozoic strata and intrusions

Upper Paleozoic accreted oceanic rocks

Lower Paleozoic: accreted continental margin

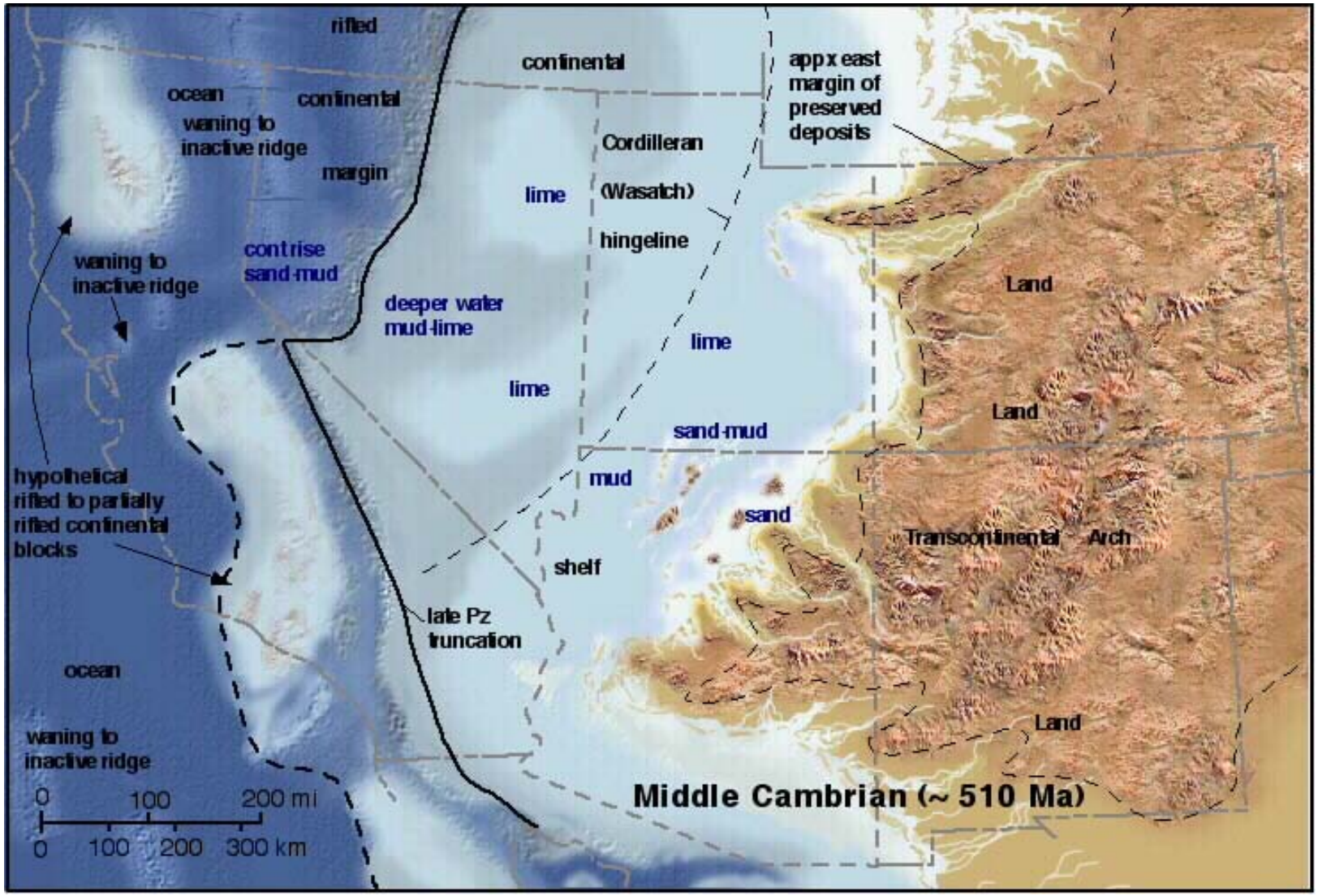
NO PRECAMBRIAN HERE

Black Rock Desert, from a billion years to now.

Rocks from other parts of Nevada show that, a billion years ago, Gondwana (Australia and Antarctica) rifted westward off Nevada and an ocean opened in between.

Black Rock Desert, from a billion years to now.

By Early Paleozoic time (~650 - 450 Ma), an “Atlantic-type” passive margin developed, with a broad continental shelf, and warm water (see outline of Nevada).

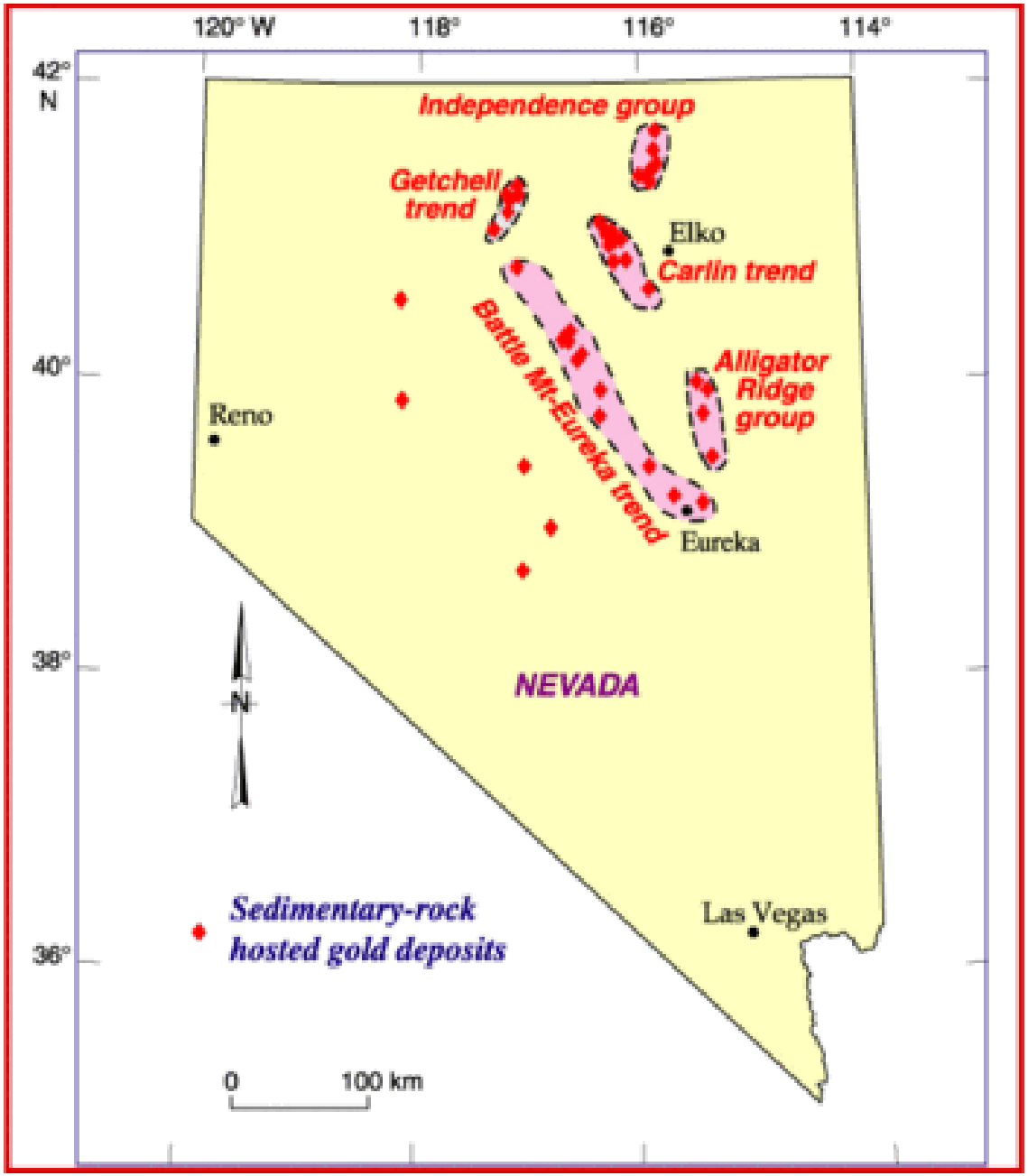


Black Rock Desert, from a billion years to now.

Paleozoic sedimentary rocks host the “Carlin-type gold deposits”, produced by hydrothermal circulation of hot water through them.

Nevada has the largest gold deposit of this type in the world!

The origin of the heat source for the “Carlin Trend” remains controversial.



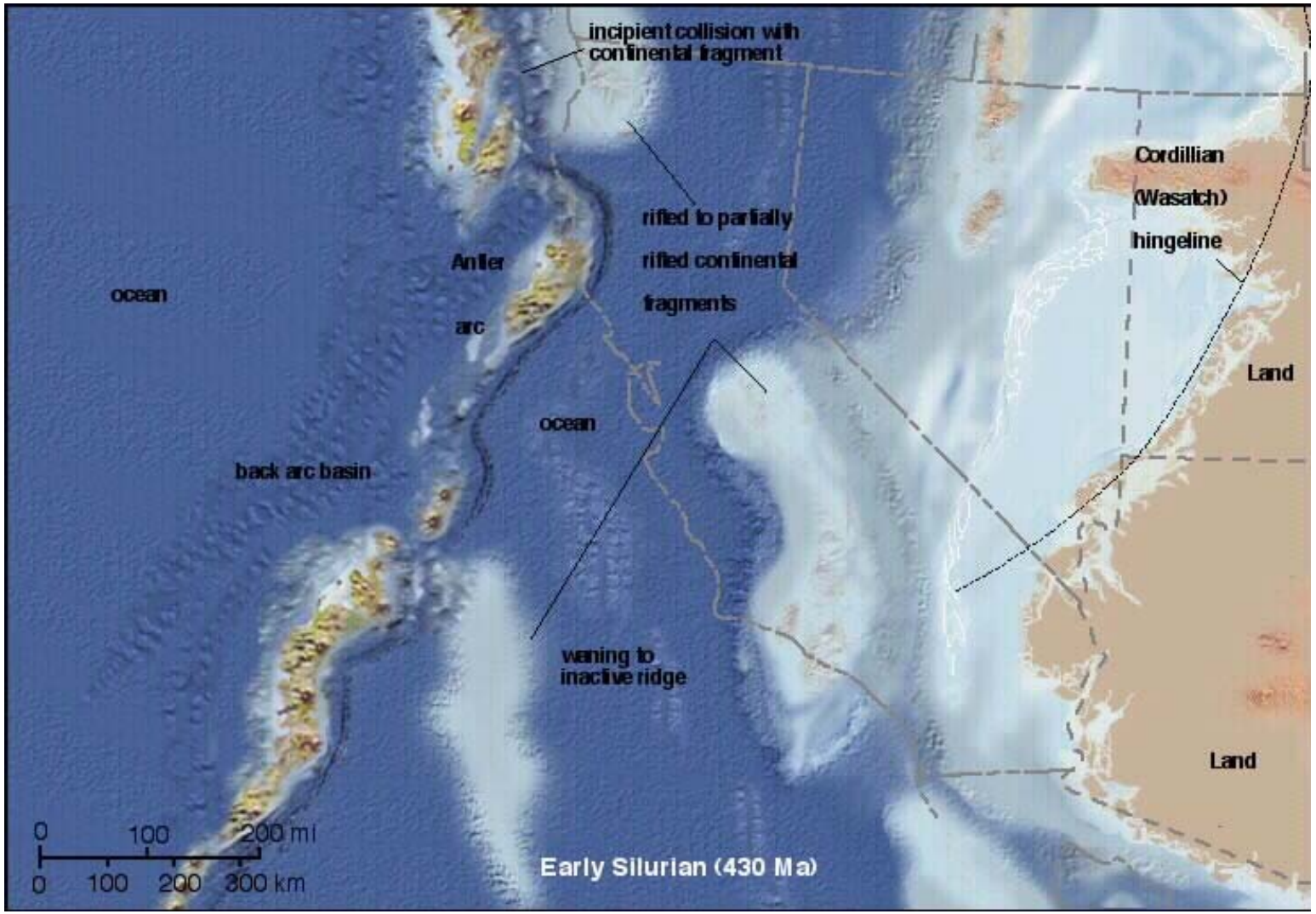
Black Rock Desert, from a billion years to now.

Paleozoic sedimentary rocks deposited on the broad continental shelf are mainly bedded limestones and mudstone. They got folded during the mountain building events (orogenies) in the Late Paleozoic to Mesozoic.

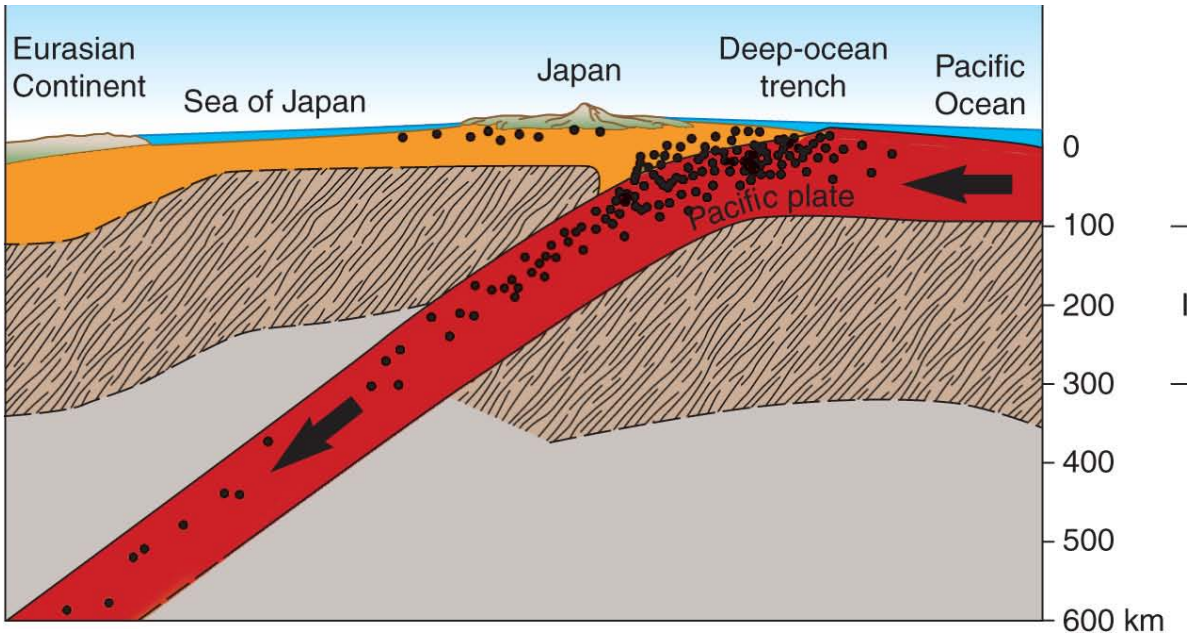
Example from Death Valley, from Miller, 2005.

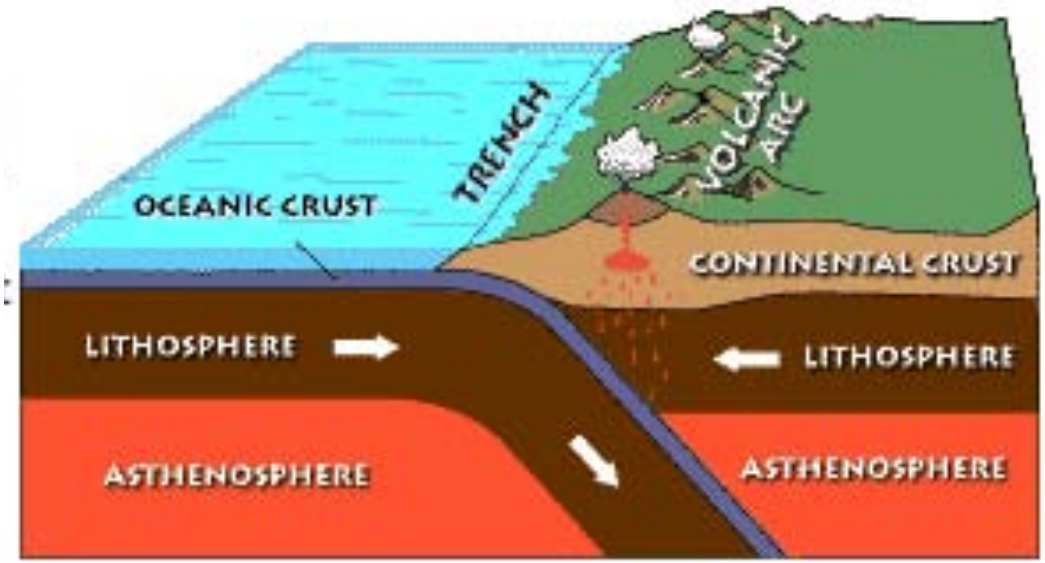
Black Rock Desert, from a billion years to now.

Somewhere offshore of the broad early Paleozoic shelf, an oceanic arc a formed above a subduction zone (see next).



Black Rock Desert, from a billion years to now.





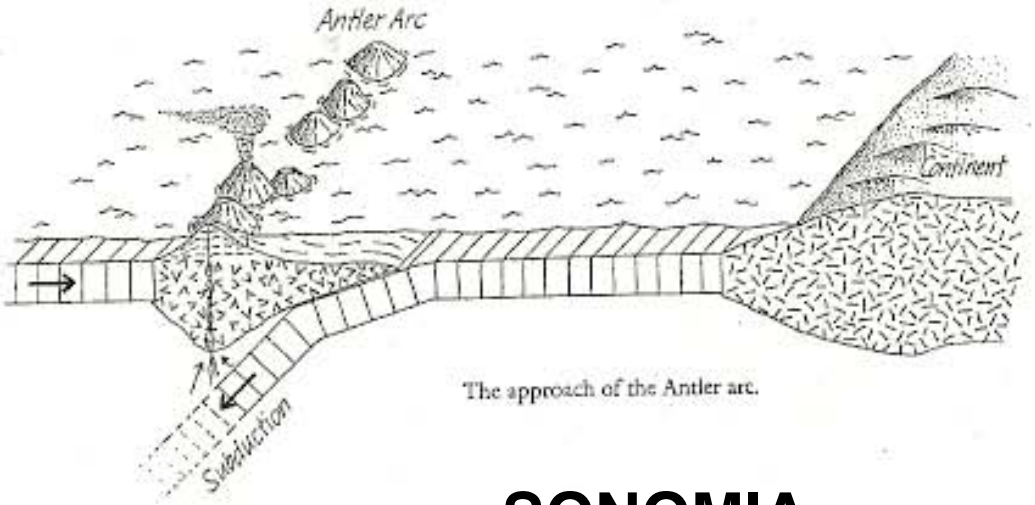
An “arc” is a chain of volcanoes that from above a subduction zone.

Arcs may form islands that lie offshore of a continent like Japan (shown at top)

or they may form above sea level on continental crust (shown at bottom, like the Cascade volcanoes today).

Black Rock Desert, from a billion years to now.

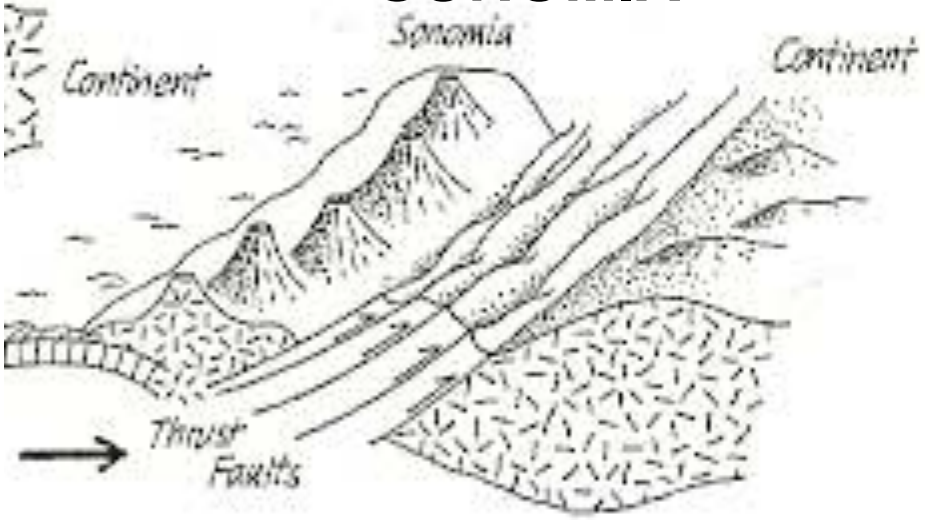
In Middle Paleozoic time, the oceanic/island arc approached and then got pushed up onto Nevada along **THRUST FAULTS**, causing the **Antler Orogeny** (~370 to 340 Ma).



The approach of the Antler arc.

Then in Late Paleozoic time, the same thing happened all over again with a different arc, causing the **Sonoma Orogeny** (~ 250 Ma)

SONOMIA

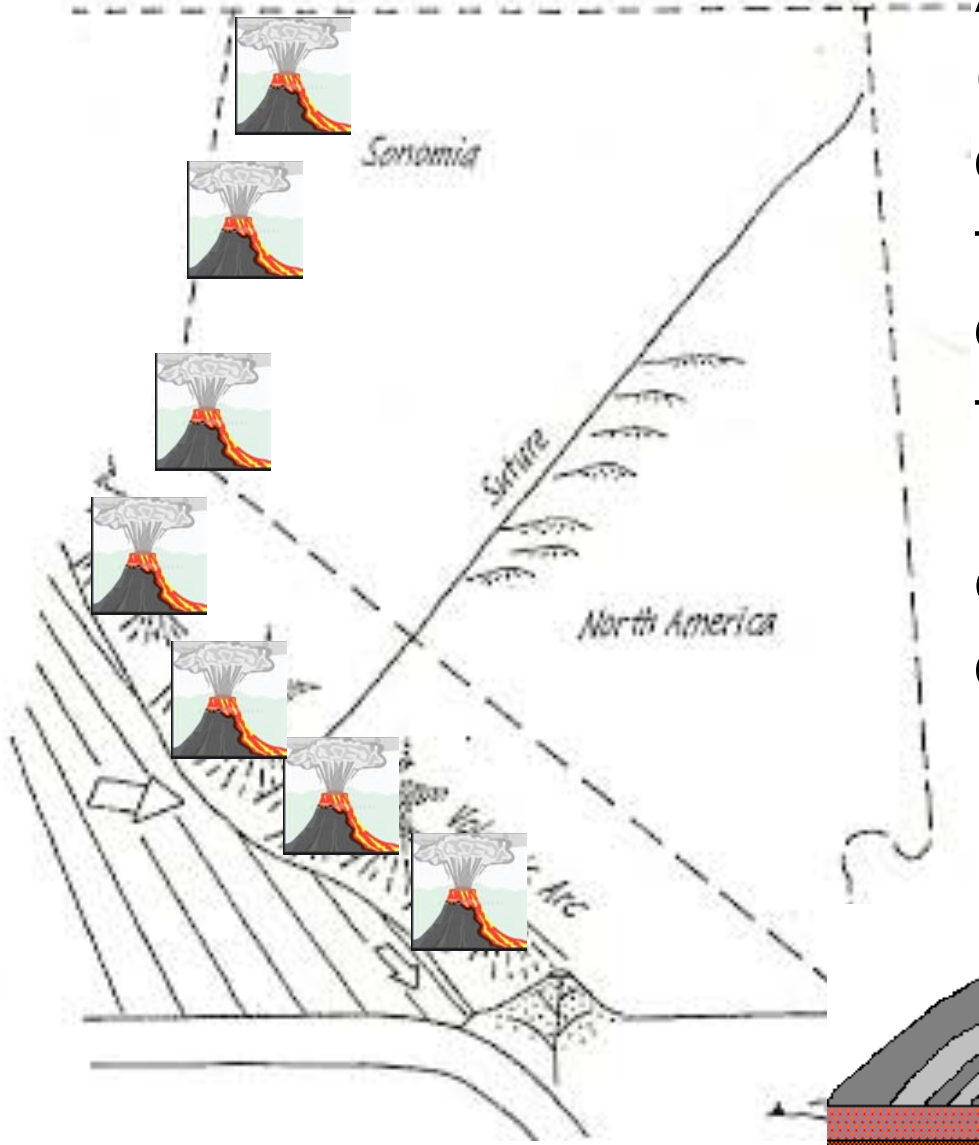


THRUST FAULTS

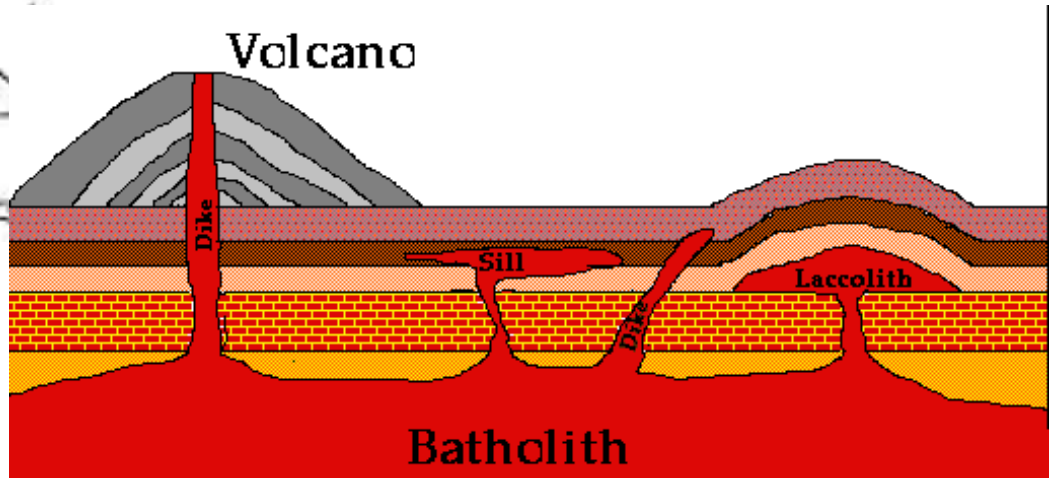
Black Rock Desert, from a billion years to now.

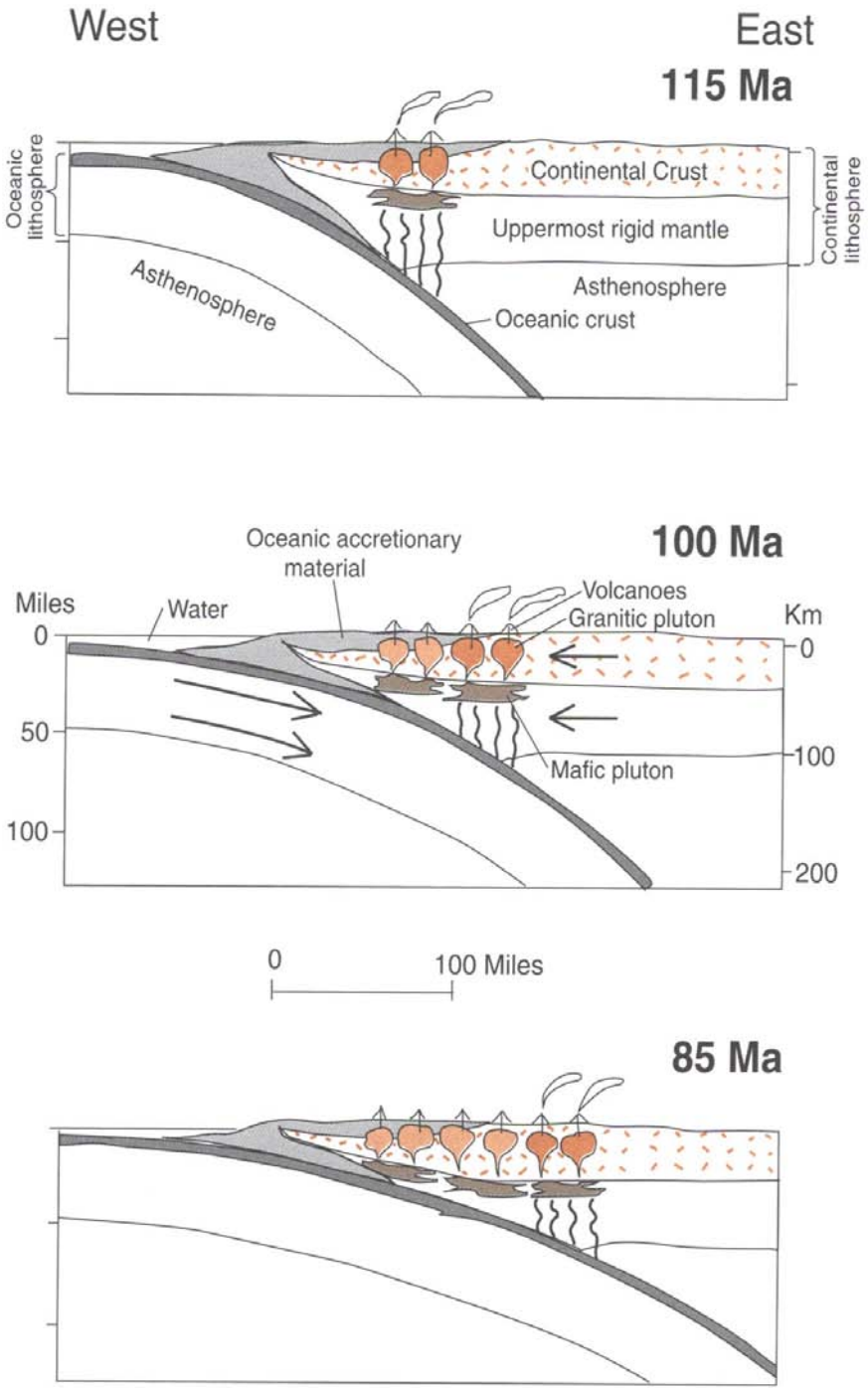
The Black Rock is part of the "**Sonomia**" oceanic rock assemblage. It is Permian volcanic rock - probably a shallow intrusion, not a lava flow.

All through the Mesozoic Era (~251 to 65 Ma), subduction occurred under the edge of the continent, forming a continental arc. This produced the great batholiths of western North America, which got exposed by uplift and erosion of the volcanic cover



Black Rock Desert, from a billion years to now.





During the Mesozoic, the subducting slab got shallower and shallower,

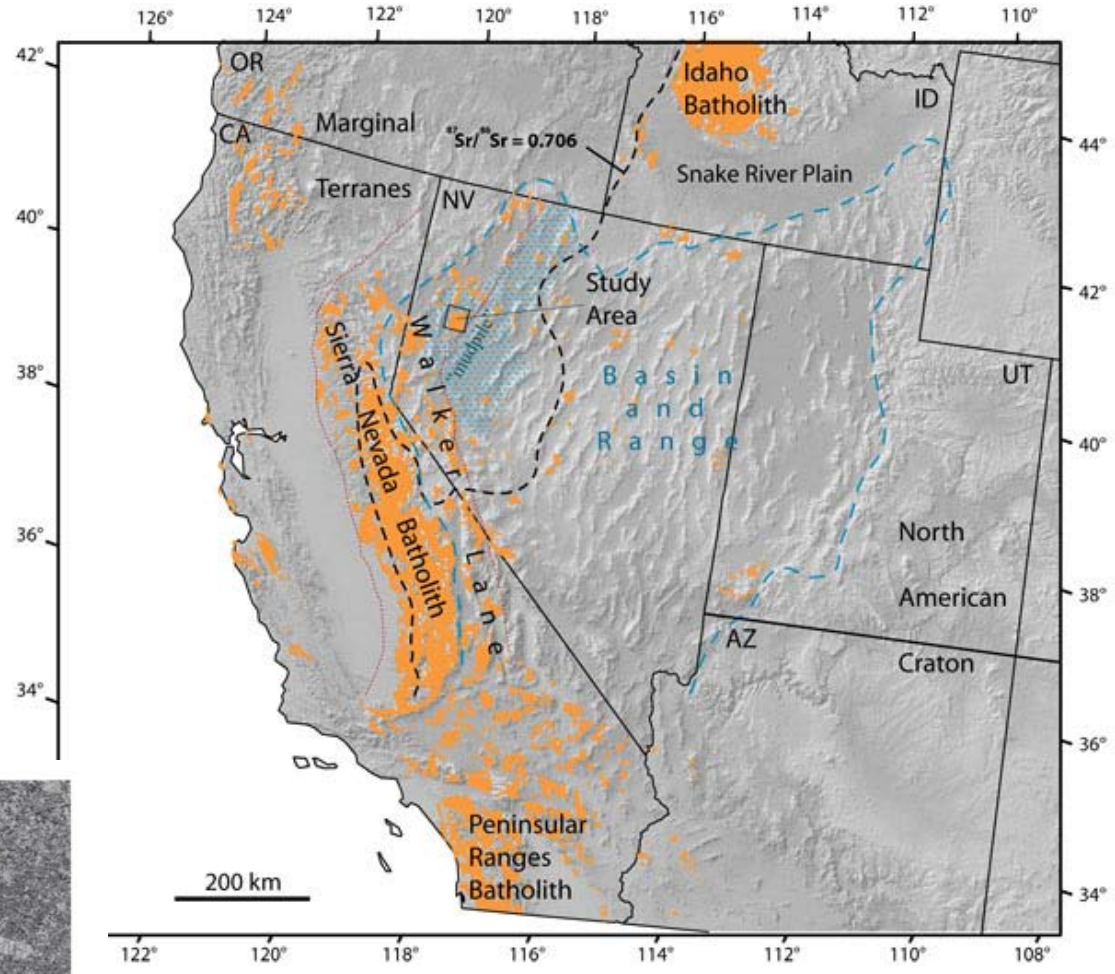
until it was grinding along the base of the continent.

This caused compression of the continent,

causing uplift (orogeny), and erosion of the volcanic rocks arc to expose the batholith below.

Black Rock Desert, from a billion years to now, continued.

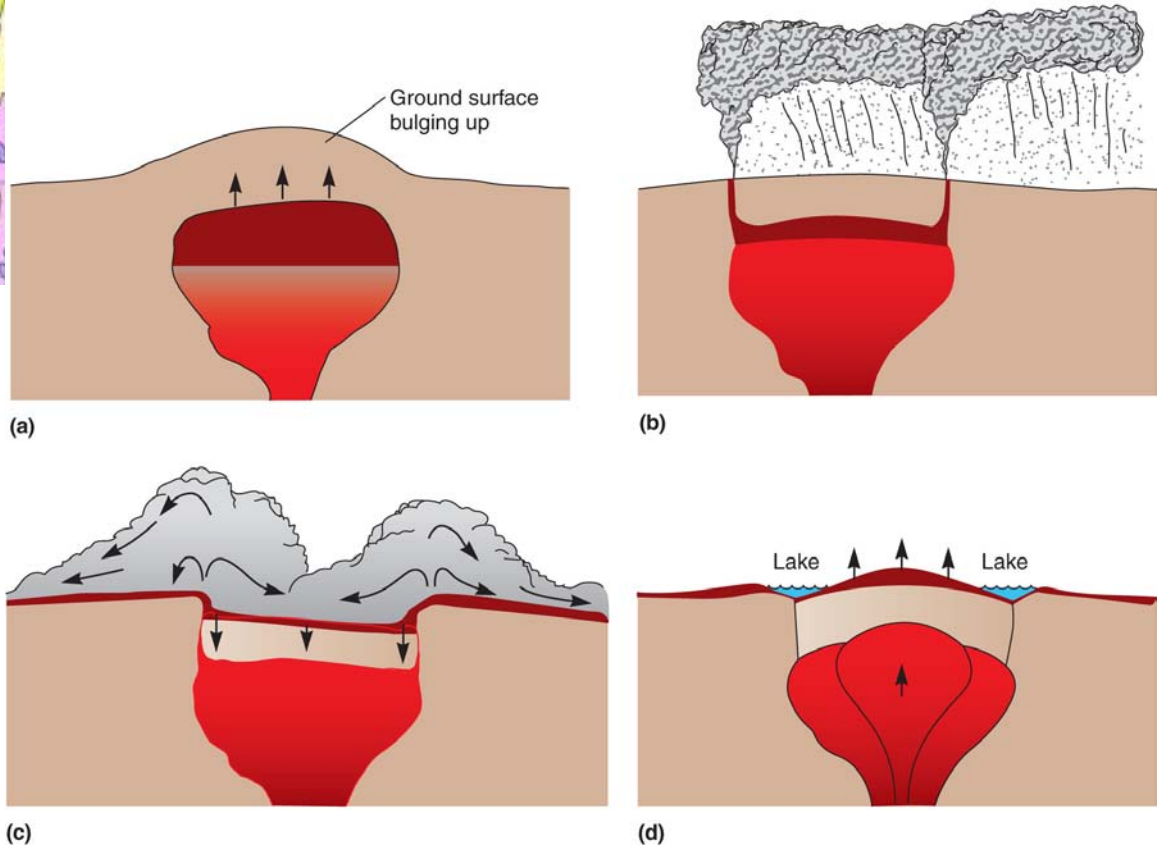
The Mesozoic batholiths are thus the deeply-eroded roots of the Mesozoic subduction volcanoes.



Big pink feldspars in a granite, typical of the batholithic rocks.

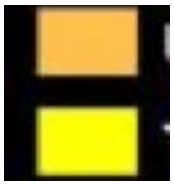
In Oligocene time (~34-23 Ma), giant continental calderas produced SUPERVOLCANOES.

Oligocene volcanic rocks



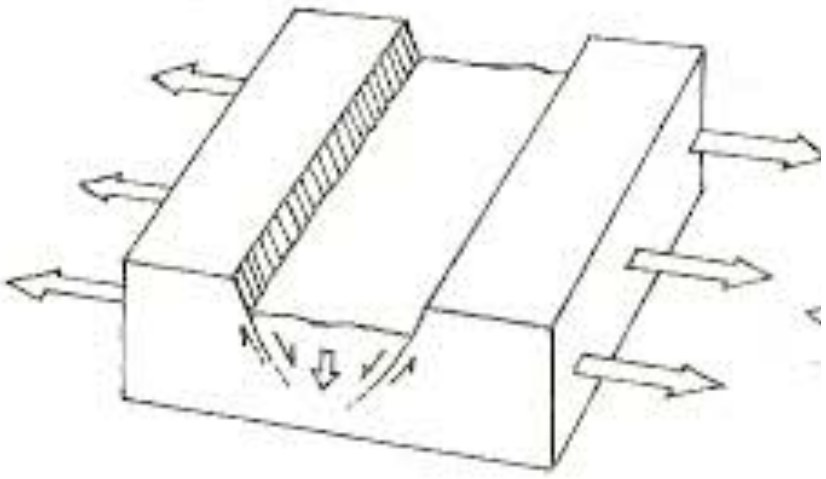
SUPERVOLCANOES produce gigantic, highly explosive eruptions.

Black Rock Desert, from a billion years to now, continued.



Miocene-Pliocene volcanic and sedimentary rocks

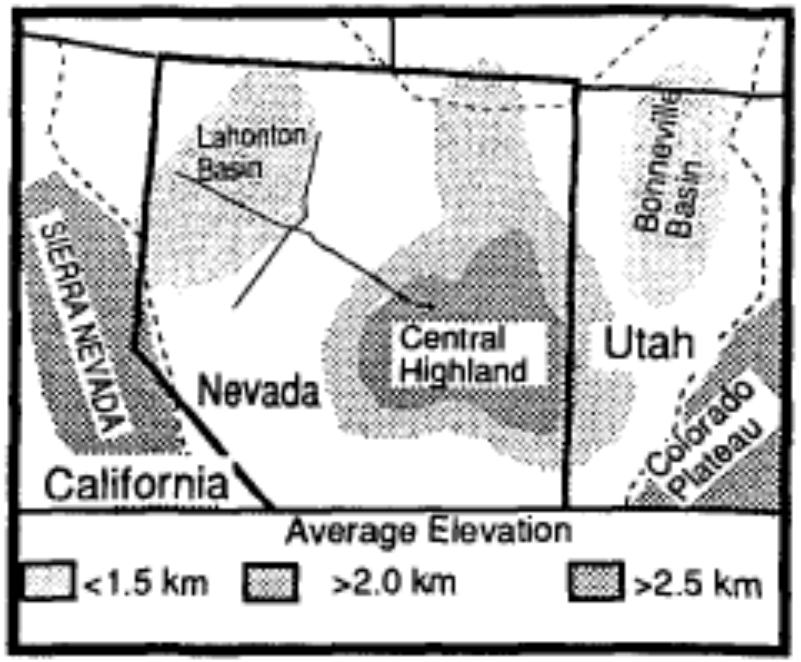
In Miocene and Pliocene time (~23 to 2.5 Ma), Basin and Range Extension was in fill swing! Grabens filled with volcanic and sedimentary rocks.

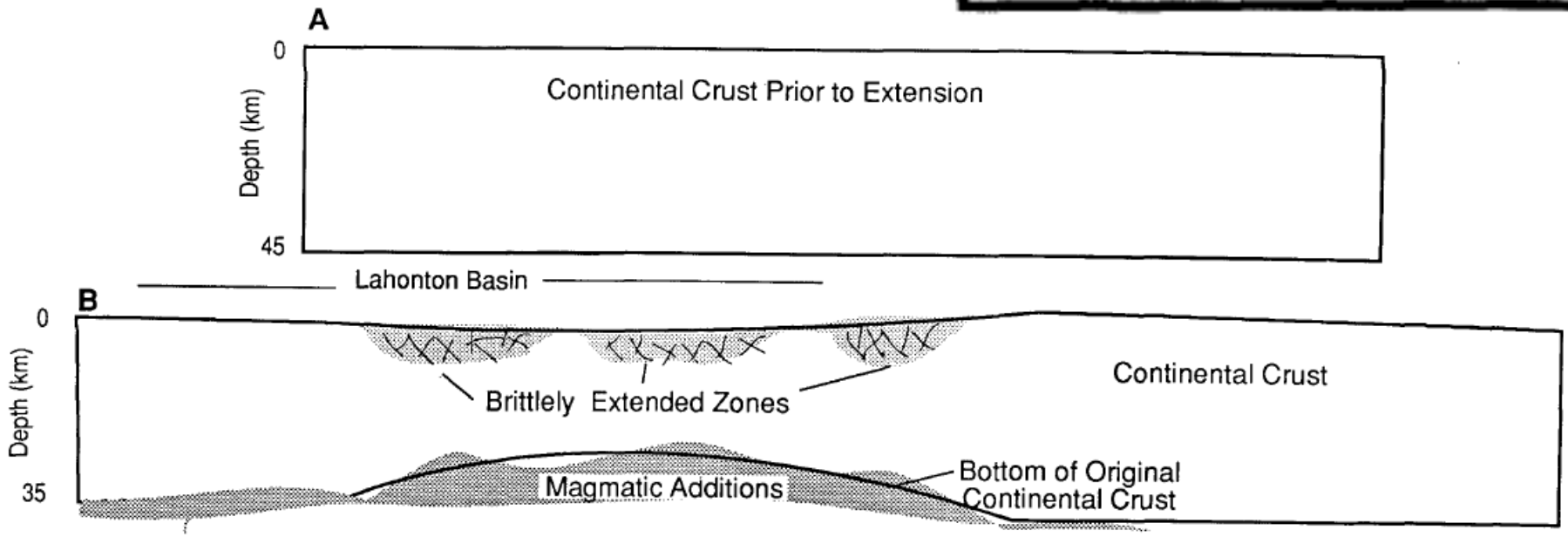


Black Rock Desert, from a billion years to now, continued.

Black Rock Desert, from a billion years to now, continued.

Stretching of the continental crust produced the **Lahonton Basin,** ultimately giving us our playa!

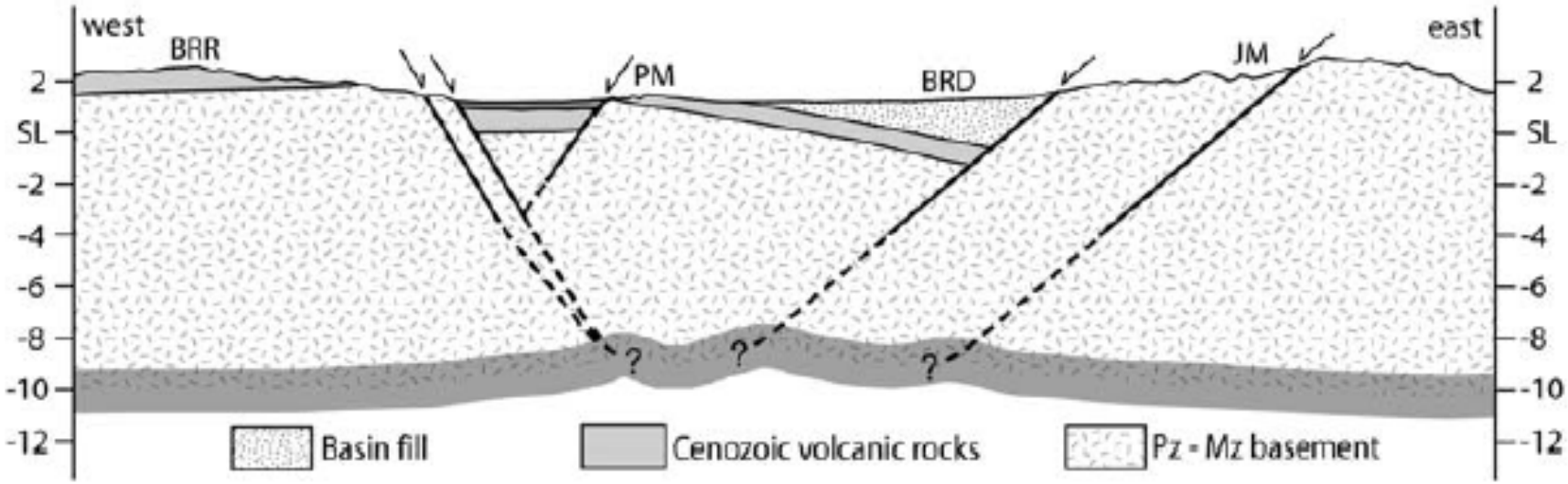




(from Catchings, 1992).

Black Rock Desert, from a billion years to now, continued.

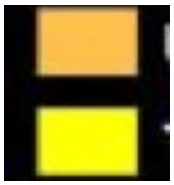
Cross section through Black Rock Range (BRR), Pinto Mountain (PM), Black Rock Desert (BRD), and Jackson Mountains (west to east). Shown to a depth of 12 km.



From Lerch et al. 2008. NOTE: the second author of this paper is a Burner. **Can anyone guess who she is?????**

Vapid Transit by **Elizabeth Miller,** Dwight Harbough & Clay Hamilton

Black Rock Desert, from a billion years to now, continued.

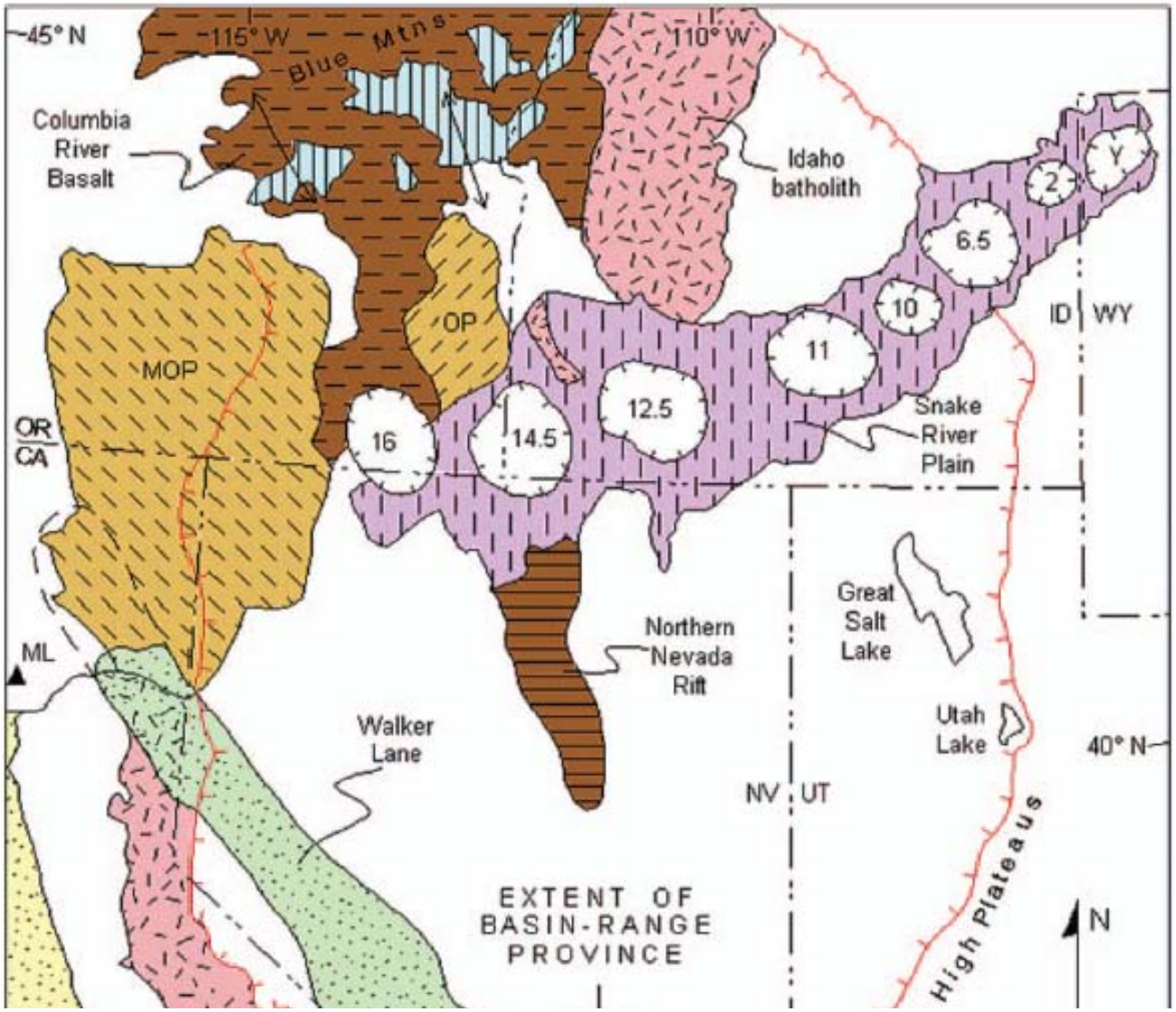


Miocene-Pliocene volcanic and sedimentary rocks

NOTE ALSO:

Some of the volcanic rocks (orange) are related to the Yellowstone hot spot track……

Yellowstone hot spot track: an eastward-migrating series of giant continental calderas (16 Ma in west, Yellowstone in east).



Also

MOP = Modoc Plateau,

a mile-high lava plateau.

Thank you for your interest and have a good burn!

Pleistocene wooly mammoth skeleton excavated from the Black Rock Desert.

THANKS to Dr. Graham Andrews for assistance with poster printing! And to the National Science Foundation for supporting research and outreach.