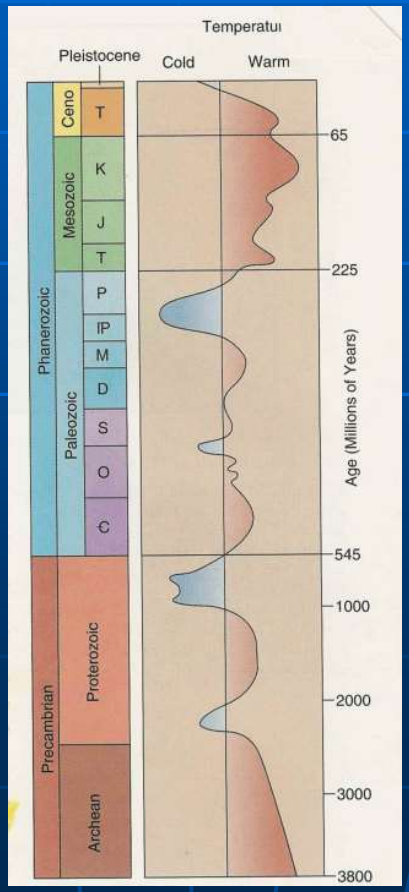
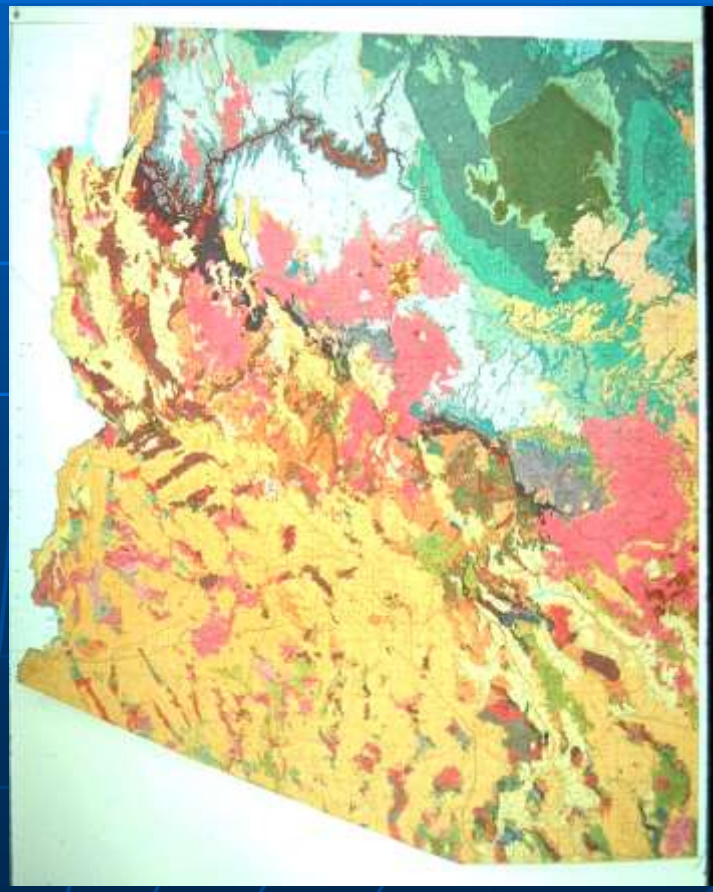
Tucson Geologic History: Precambrian

Dr. Jan C. Rasmussen
www.janrasmussen.com





Arizona physiography

- Depends on plate tectonics through geologic history
- Big environmental changes through geologic time
- Seas in, seas out
- Warm periods and ice ages

Arizona Physiographic Provinces

Colorado Plateau Province

- canyons
- horizontal sediments
- broad warping

Transition or Central Highlands Province

- lots of faulting
- mostly mountains
- rugged terrain (high relief)

Basin & Range Province

- fault block mountains
- broad alluvial valleys
- sand, clay, salt & gravel - fill up to 10,000 feet thick

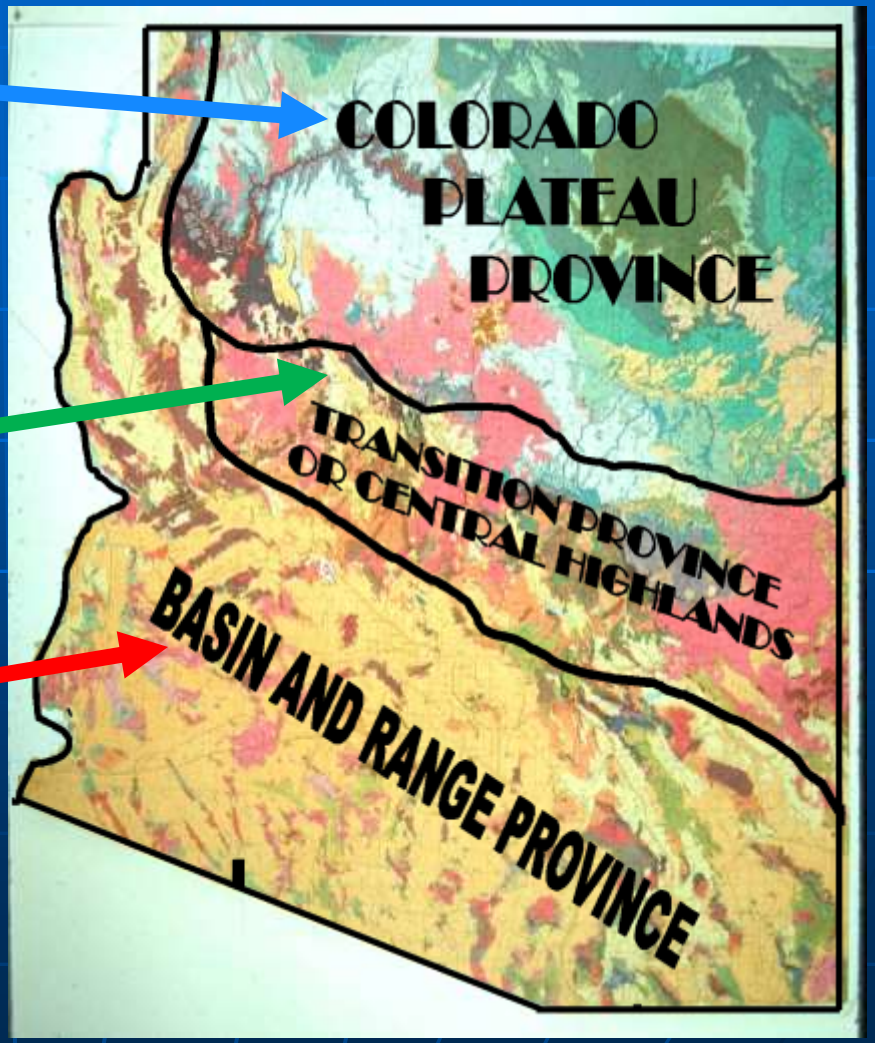
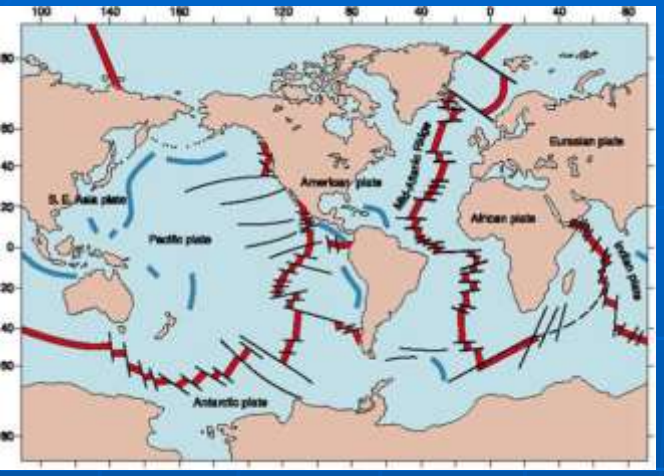
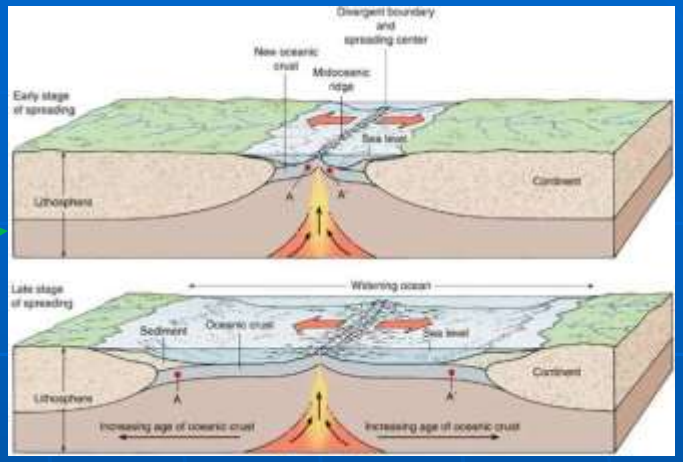
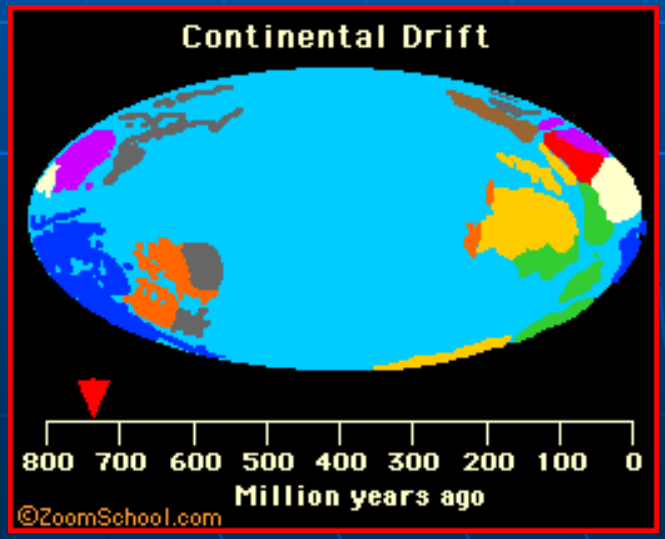


Plate Tectonics

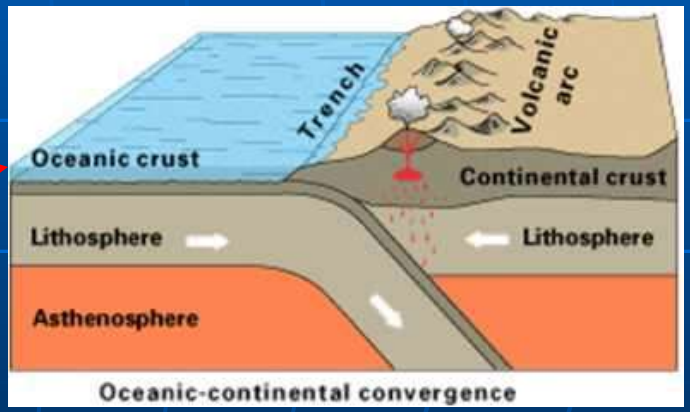


Sea floor spreading and mid-ocean ridge volcanism

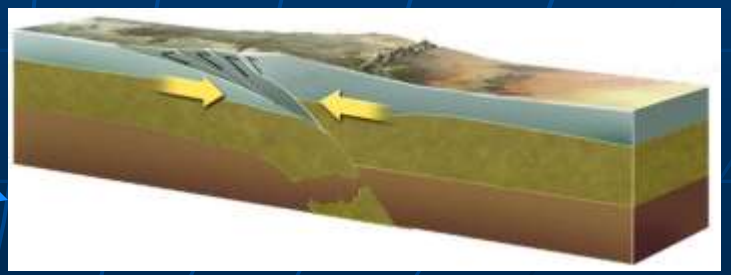




Subduction, Volcanoes, Mountains



Continent-continent collision and very tall mountains



Temp. & Geologic Time Scale

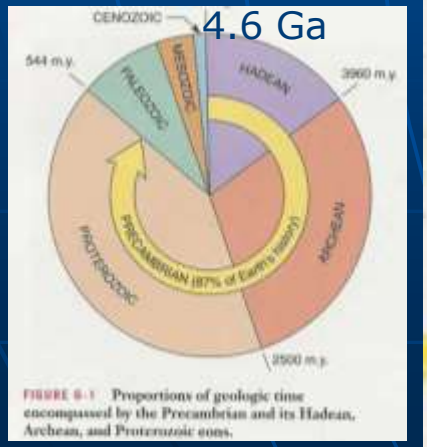
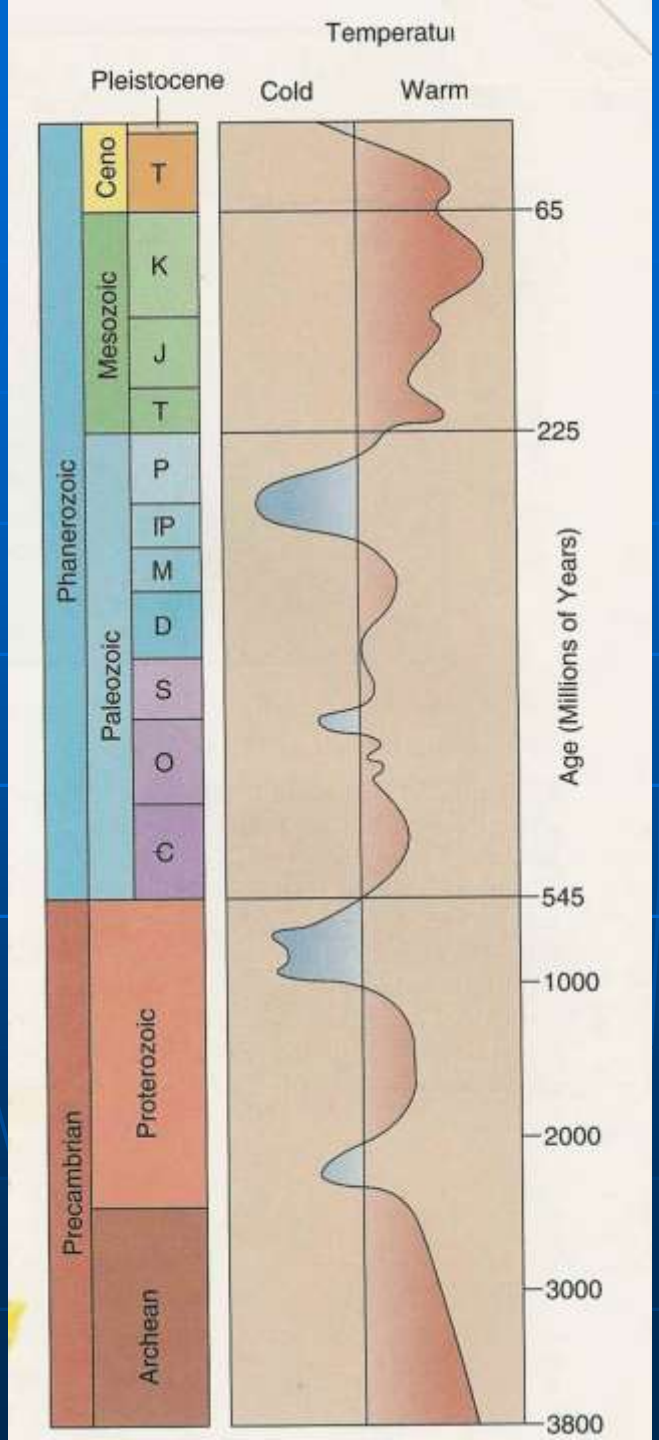
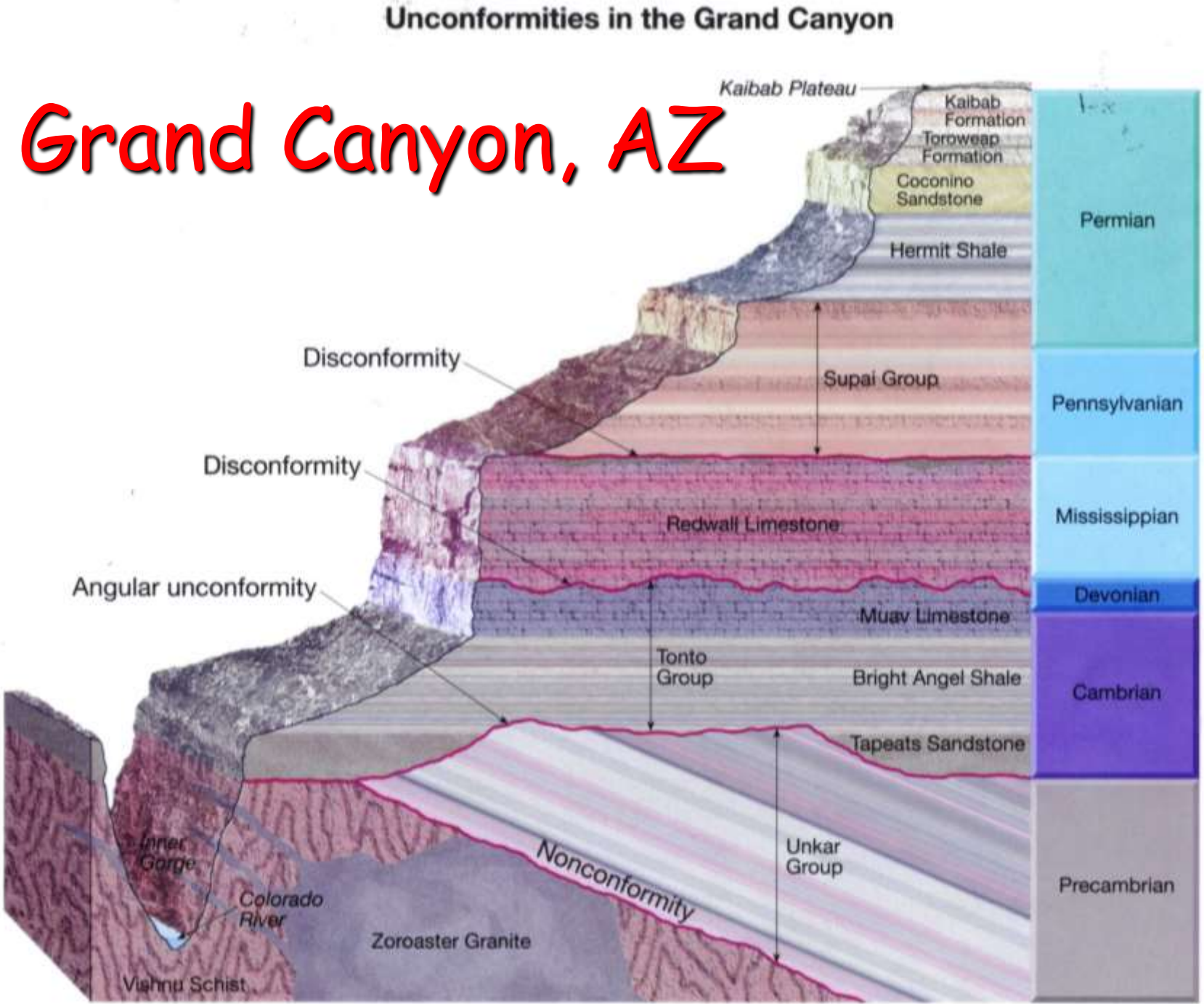


FIGURE 6-1 Proportions of geologic time encompassed by the Precambrian and its Hadean, Archean, and Proterozoic eons.

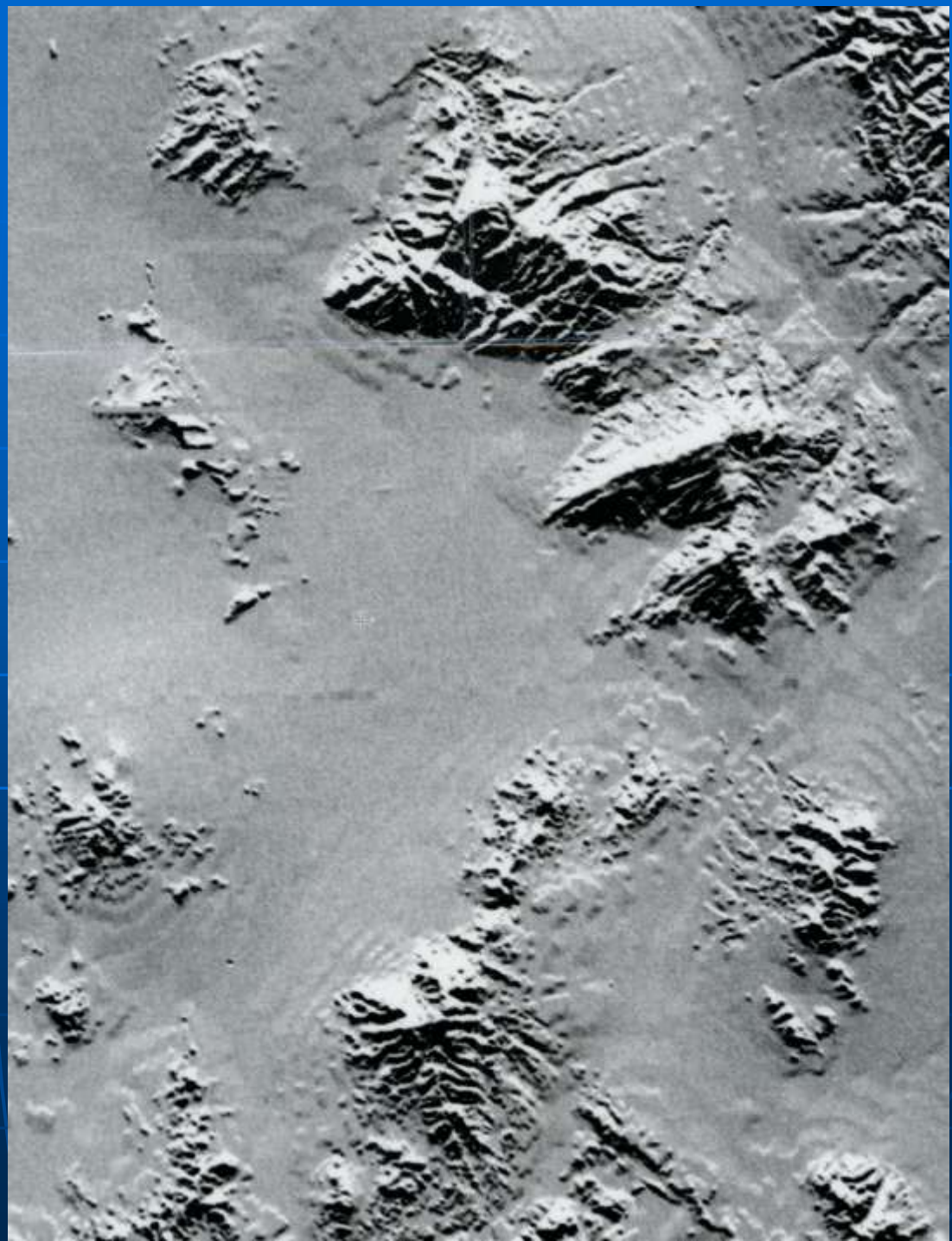


EON	ERA	PERIOD		EPOCH		Ma
Phanerozoic	Cenozoic	Quaternary		Holocene		0.01
				Pleistocene	Late	0.8
					Early	1.8
		Tertiary	Neogene	Pliocene	Late	3.6
					Early	5.3
				Miocene	Late	11.2
					Middle	16.4
					Early	23.7
				Oligocene	Late	28.5
					Early	33.7
			Paleogene	Eocene	Late	41.3
					Middle	49.0
					Early	54.8
				Paleocene	Late	61.0
					Early	65.0
	Mesozoic	Cretaceous		Late		99.0
				Early		144
		Jurassic		Late		159
				Middle		180
				Early		206
		Triassic		Late		227
				Middle		242
				Early		248
	Paleozoic	Permian		Late		256
				Early		290
		Pennsylvanian				323
		Mississippian				354
		Devonian		Late		370
				Middle		391
				Early		417
		Silurian		Late		423
				Early		443
		Ordovician		Late		458
				Middle		470
				Early		490
		Cambrian		D		500
				C		512
				B		520
				A		543
Precambrian	Proterozoic	Late				900
		Middle				1600
		Early				2500
	Archean	Late				3000
		Middle				3400
		Early				3800?

Grand Canyon, AZ

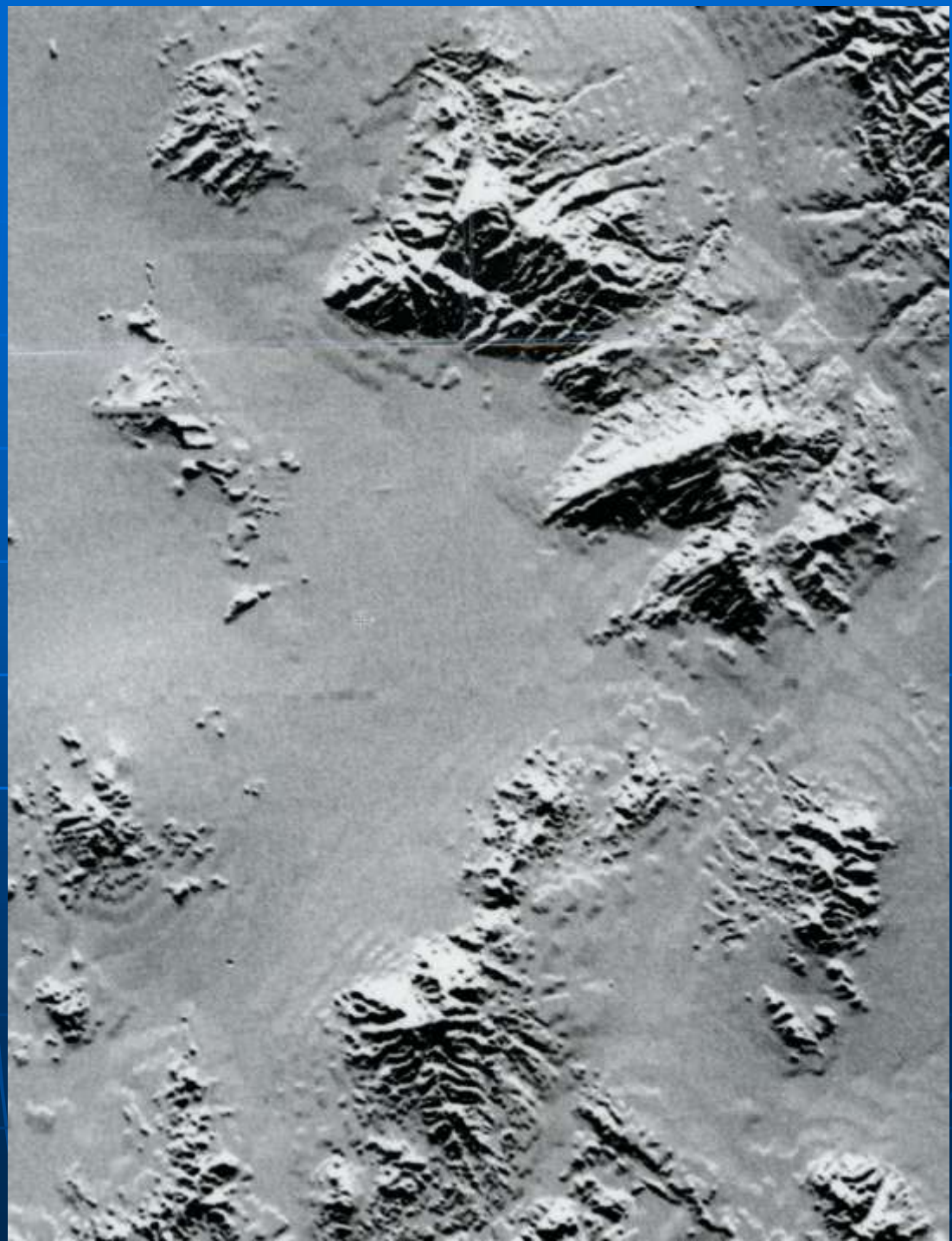


Tucson area Mountains



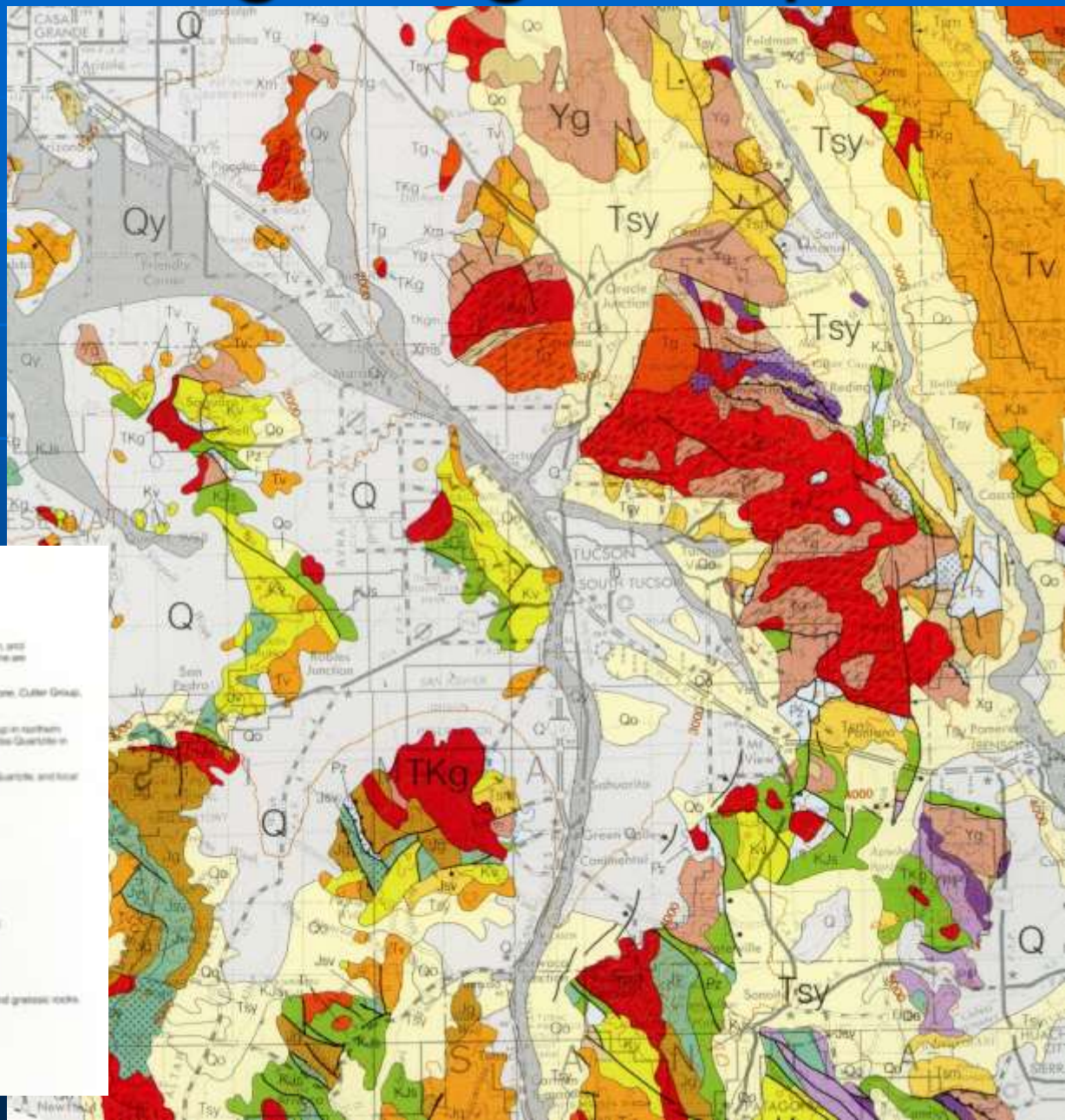
Tucson area Mountains

Tucson area Mountains



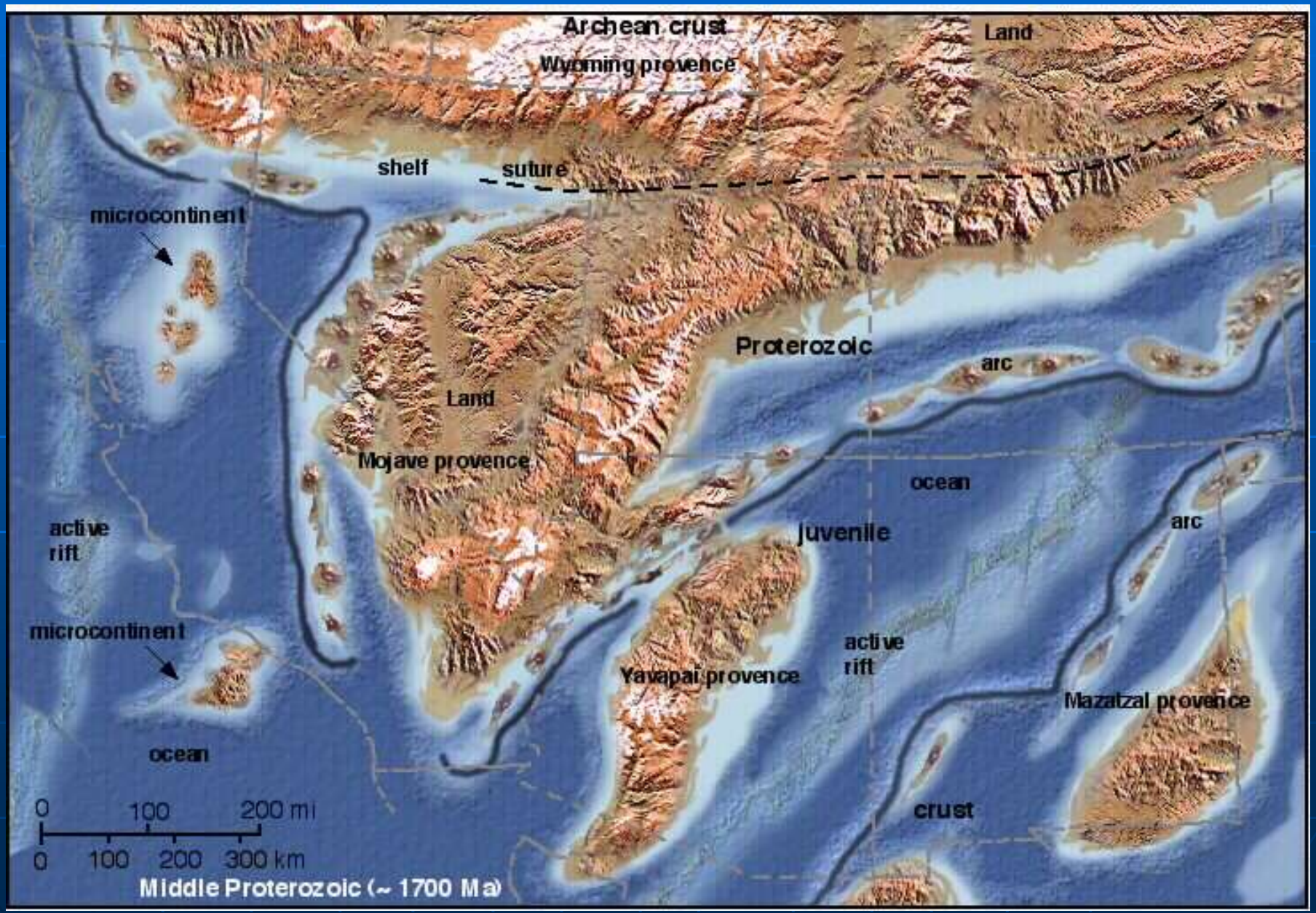
Tucson area geologic map

Learn to read Arizona geologic map



Grand Canyon formations

Meso-proterozoic (1.7 Ga)



PreCambrian Arizona

Inner Gorge - metamorphic rocks

Mountain building episode in younger PreCambrian (older Proterozoic)

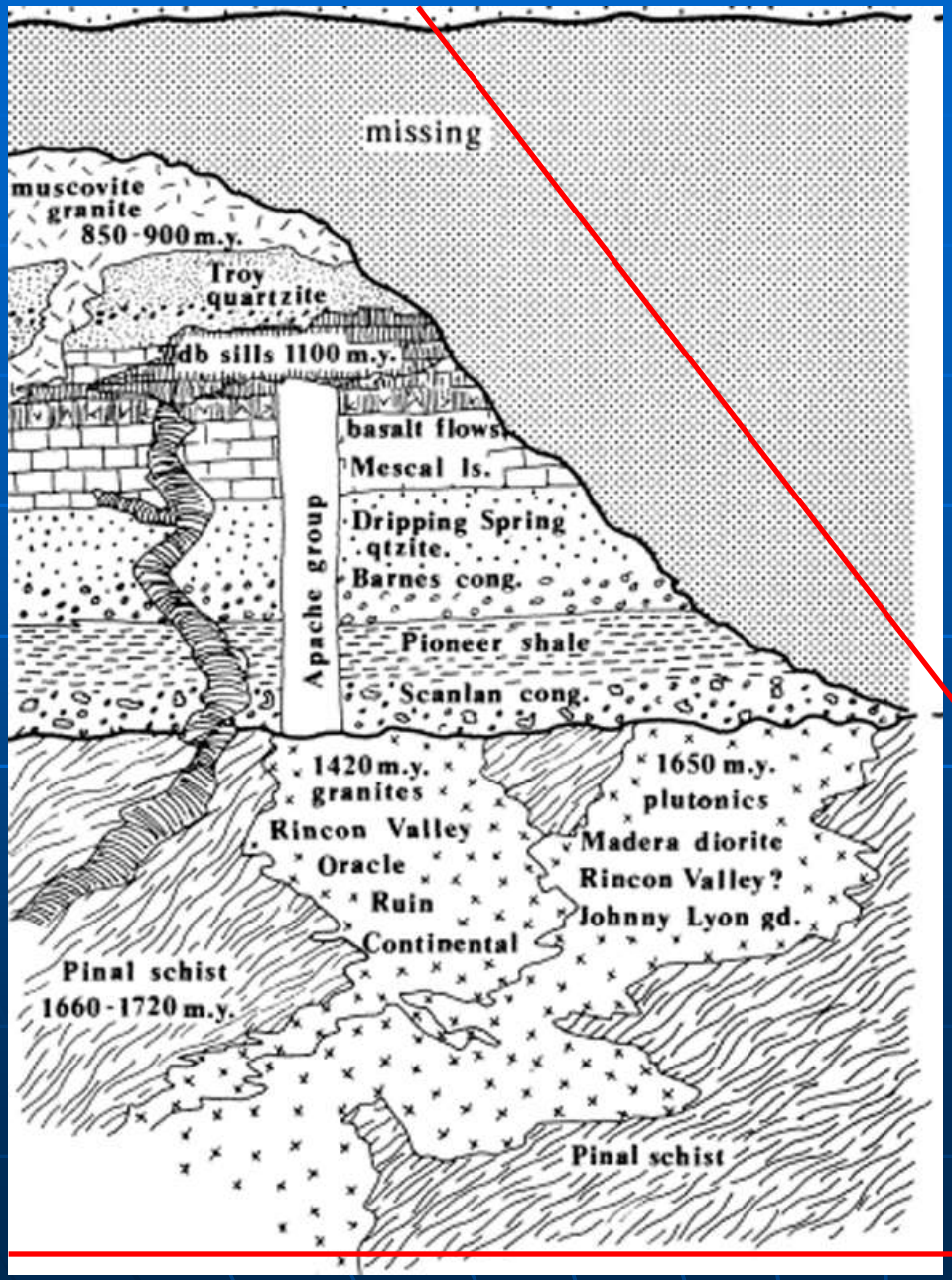
- 1.7 billion years – Mazatzal Orogeny produced Rocky Mt.-style mountains
- Metamorphism, folding, later intrusion of granitic rocks

Inner Gorge Grand Canyon, black Vishnu Schist, intruded by white Zoroaster Granite, Tapeats Sandstone deposited on unconformity

Vishnu Schist - Grand Canyon

Intruded by pink Zoroaster Granite (1400 Ma)

Precambrian



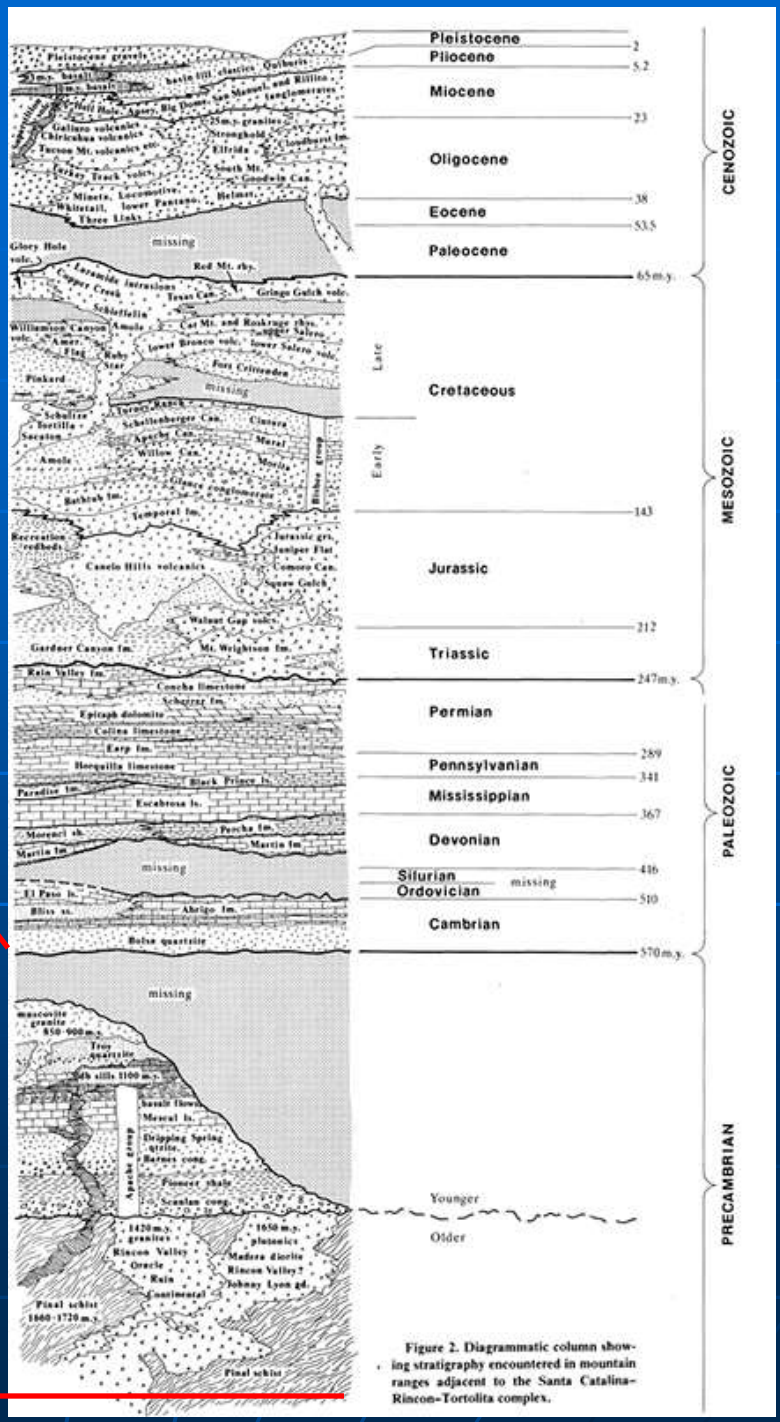


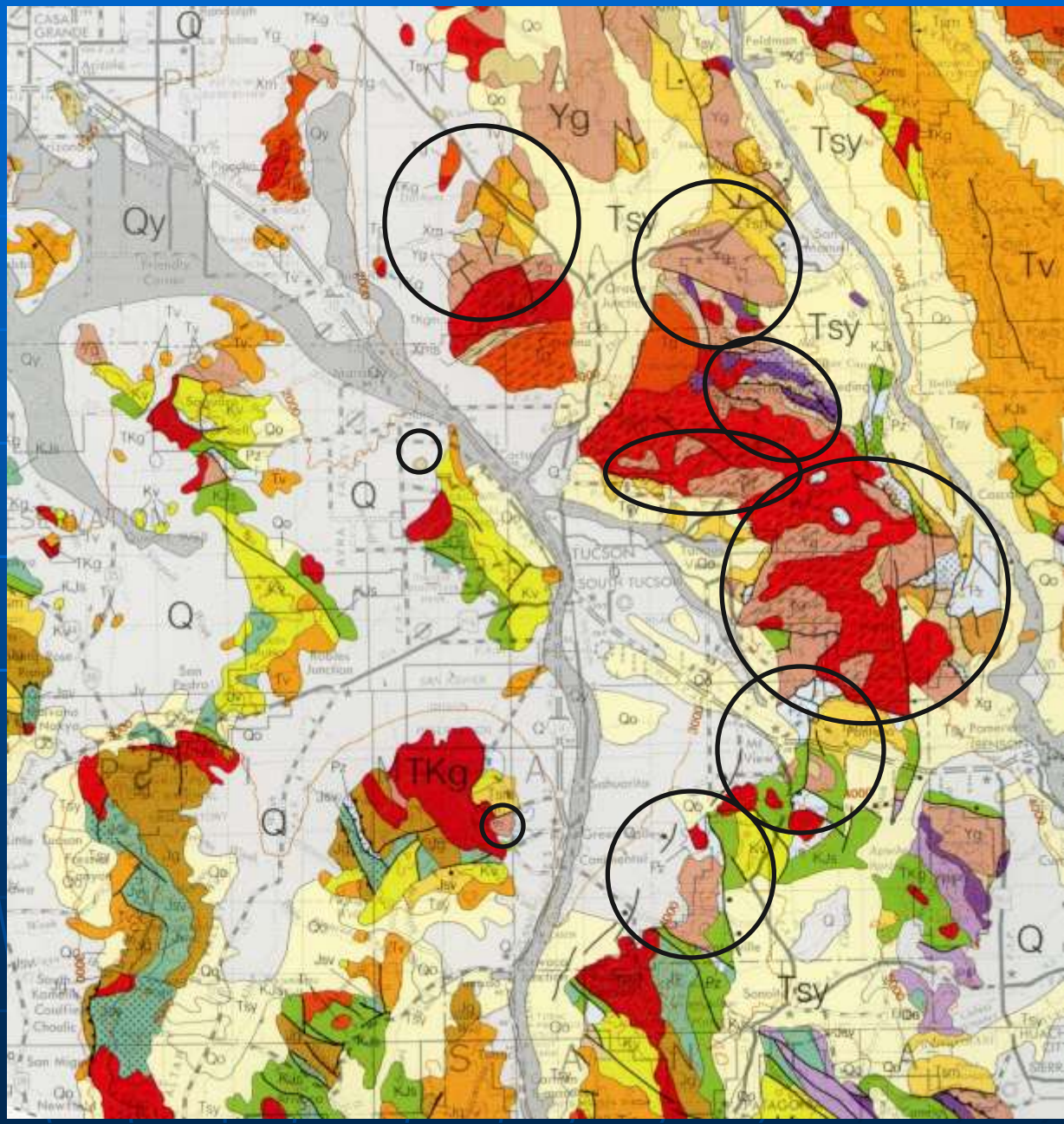
Figure 2. Diagrammatic column showing stratigraphy encountered in mountain ranges adjacent to the Santa Catalina–Rincon–Tortolita complex.

Tucson area Precambrian

1695 – Pinal Schist - Xm

1625 – Johnny Lyon Granodiorite - Xg

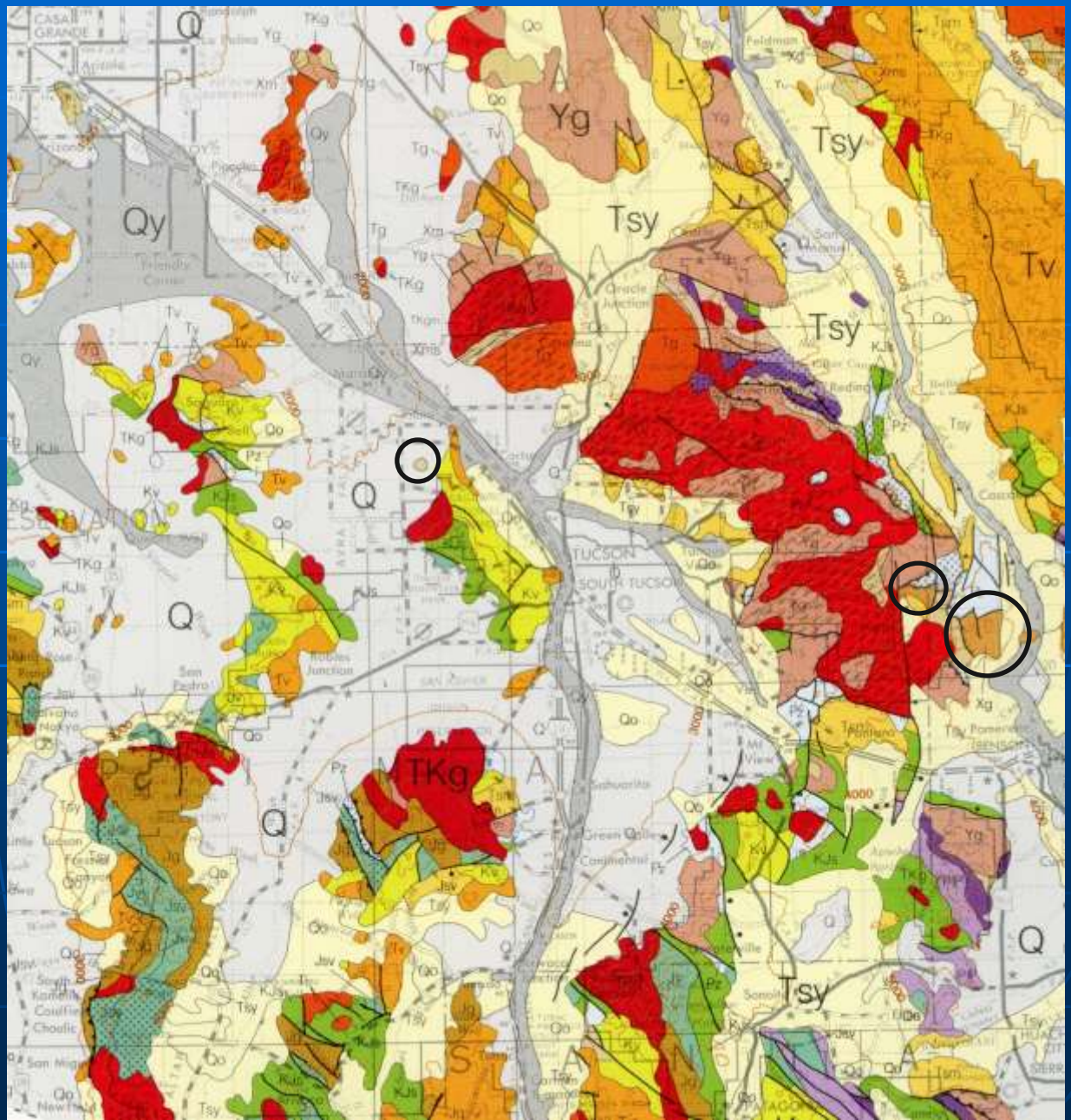
1400 – 1450 Ma - Yg Oracle Granite Yg brown Continental Granodiorite



Tucson area Older Precambrian

Pinal Schist Xm
1695 Ma

Johnny Lyon
Granodiorite Xg
1625 Ma



1. LAYING THE FOUNDATIONS

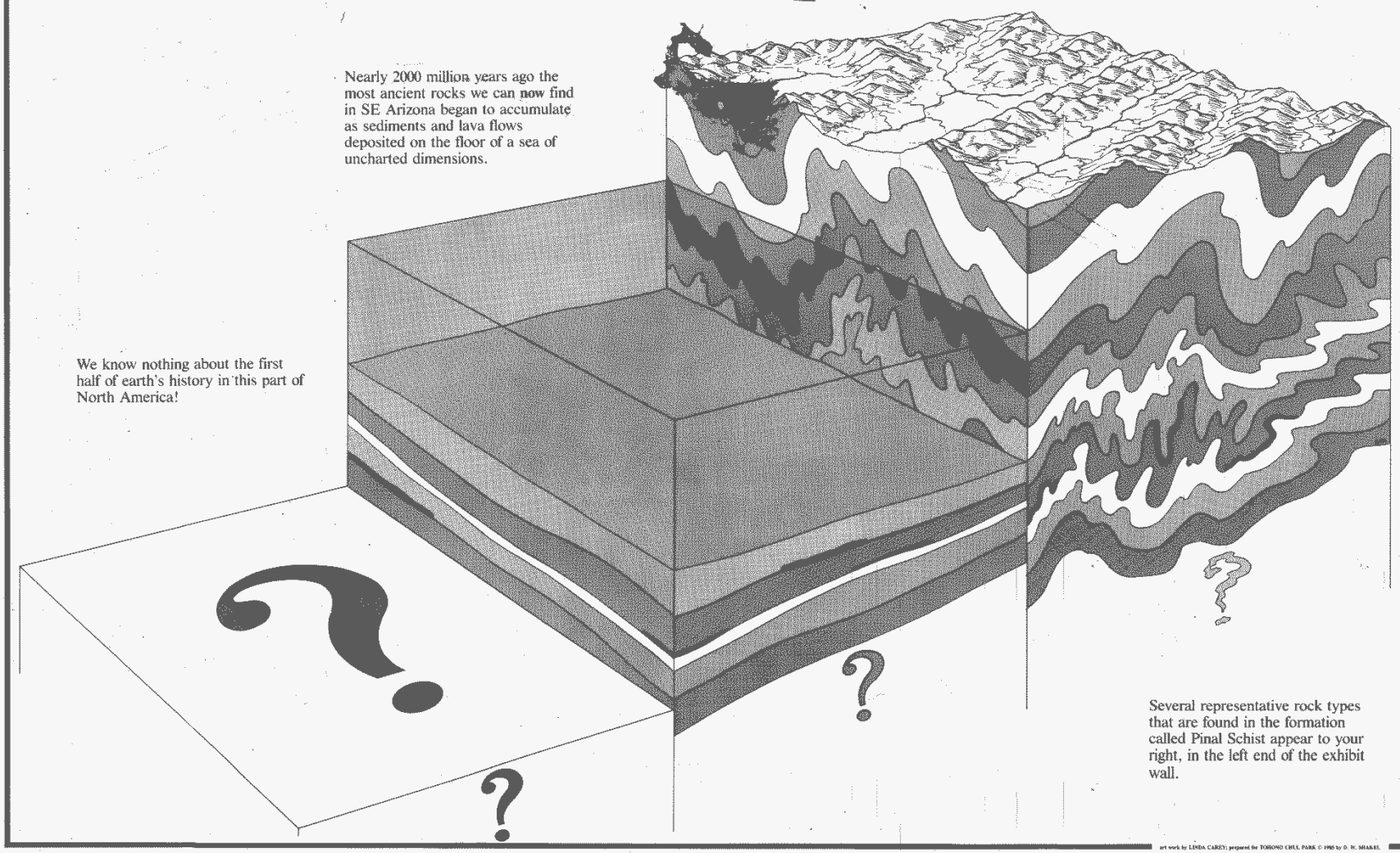
SANTA CATALINA MOUNTAINS REGION
"older" Precambrian (>1700 million years ago)

By 1700 million years ago these sediments and lavas were intensely deformed and metamorphosed, forming the roots of a great mountain range oriented WSW to ENE across much of what is now the American southwest. These various metamorphic rocks are now collectively known as **Pinal Schist**.

Today, Pinal Schist forms most of the Pinal Mountains, south of Globe, and can also be found in small areas in the northern Santa Catalina Mountains.

Nearly 2000 million years ago the most ancient rocks we can now find in SE Arizona began to accumulate as sediments and lava flows deposited on the floor of a sea of uncharted dimensions.

We know nothing about the first half of earth's history in this part of North America!

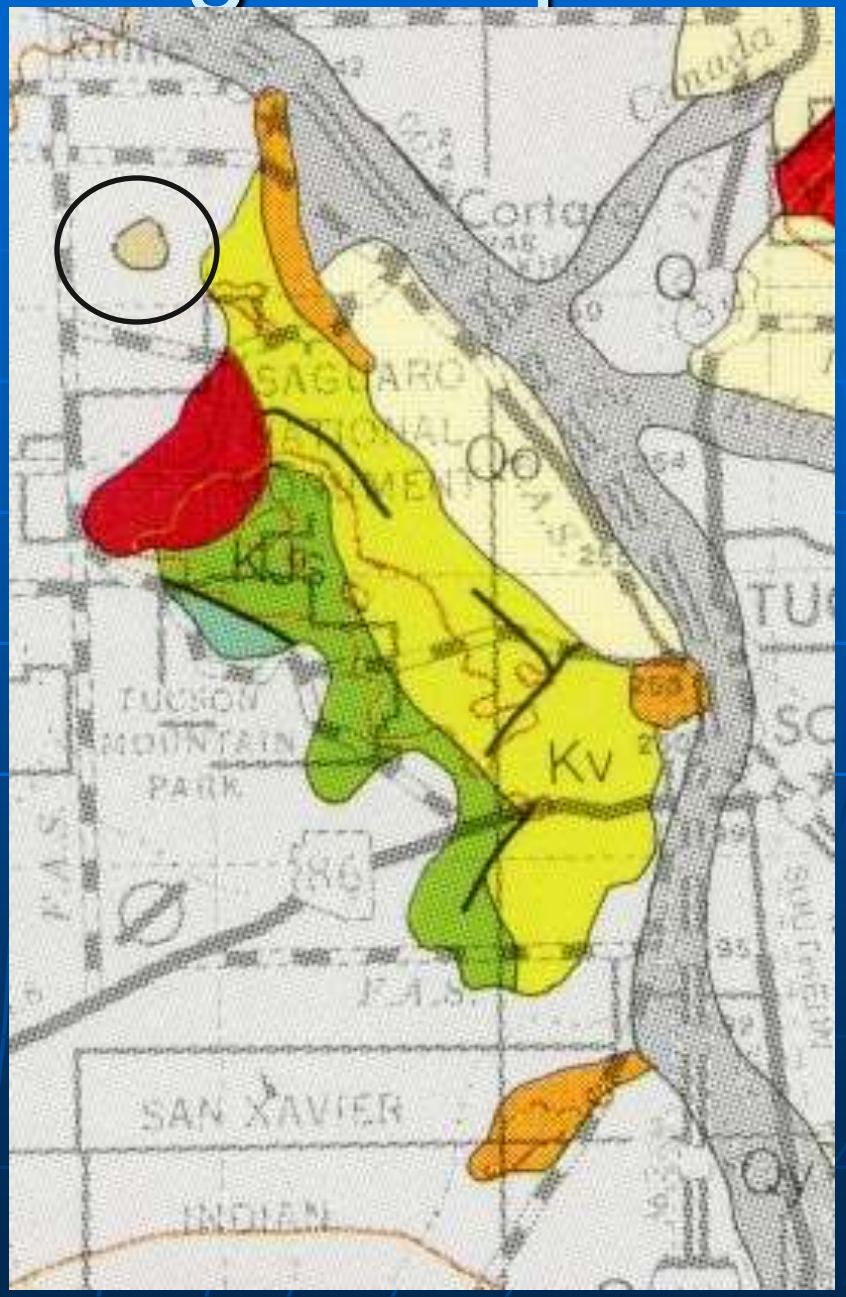


Several representative rock types that are found in the formation called Pinal Schist appear to your right, in the left end of the exhibit wall.

Tucson Mts. Geologic Map

Pinal Schist 1720-1660

Pinal Schist – underlying the limestone at the Twin Peaks limestone mine – in the West Peak



Pinal Schist - 1695 Ma

1625 Ma granodiorite - Johnny Lyon granodiorite, Rincon Valley granodiorite

2. FINISHING THE BASEMENT

SANTA CATALINA MOUNTAINS REGION
"older" Precambrian (~1650-1450 million years ago)

Several times during the next quarter billion years numerous **plutons** of granitic magma solidified beneath great caldera-forming volcanoes. These plutons were emplaced within the previously metamorphosed rocks of the already ancient mountain roots.

The 1450 million years old **Oracle Granite** is an example of one of these Precambrian granite plutons.

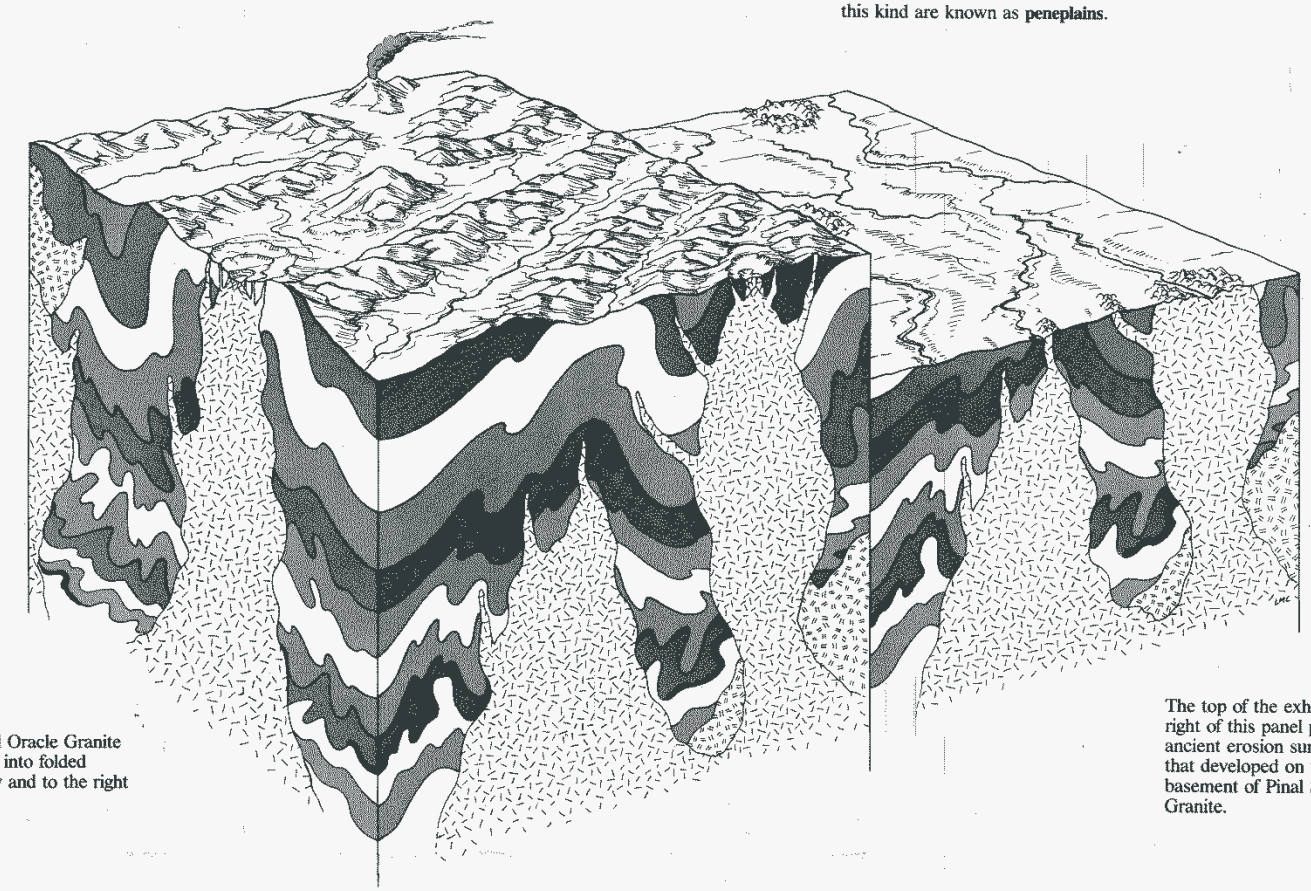
Oracle Granite forms the northern foothills of the Santa Catalina Mountains, including the area surrounding the town of Oracle, for which this rock mass was named.

About 1400 million years ago the geologic dynamics of this region became still, and a long siege of erosion began.

This resulted in a progressive wearing down and ultimate leveling of the ancient mountains, until the entire region was finally reduced to a rather monotonous lowland, drained by sluggish streams, and nearly at sea level. Landscapes eroded to featureless lowlands of this kind are known as **peneplains**.

This great ancient peneplain was devoid of any forms of plant or animal life more complicated than microbes.

Pinal Schist together with Oracle Granite and other ancient granites of the region collectively constitute a **crystalline basement** for southern Arizona — the foundations upon which all younger rocks of the region will be laid.

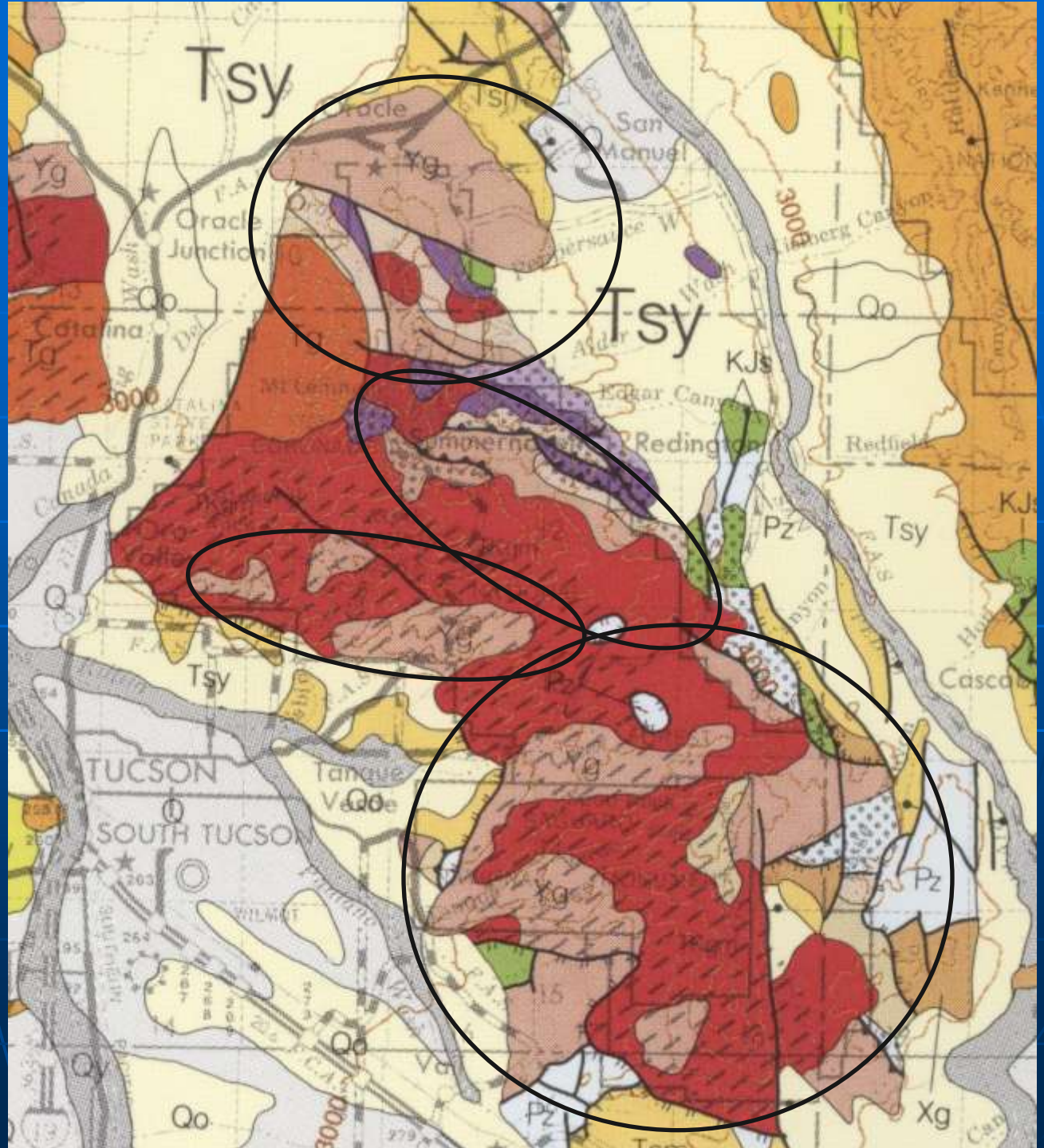


In the exhibit wall Oracle Granite is shown intruded into folded Pinal Schist below and to the right of this panel.

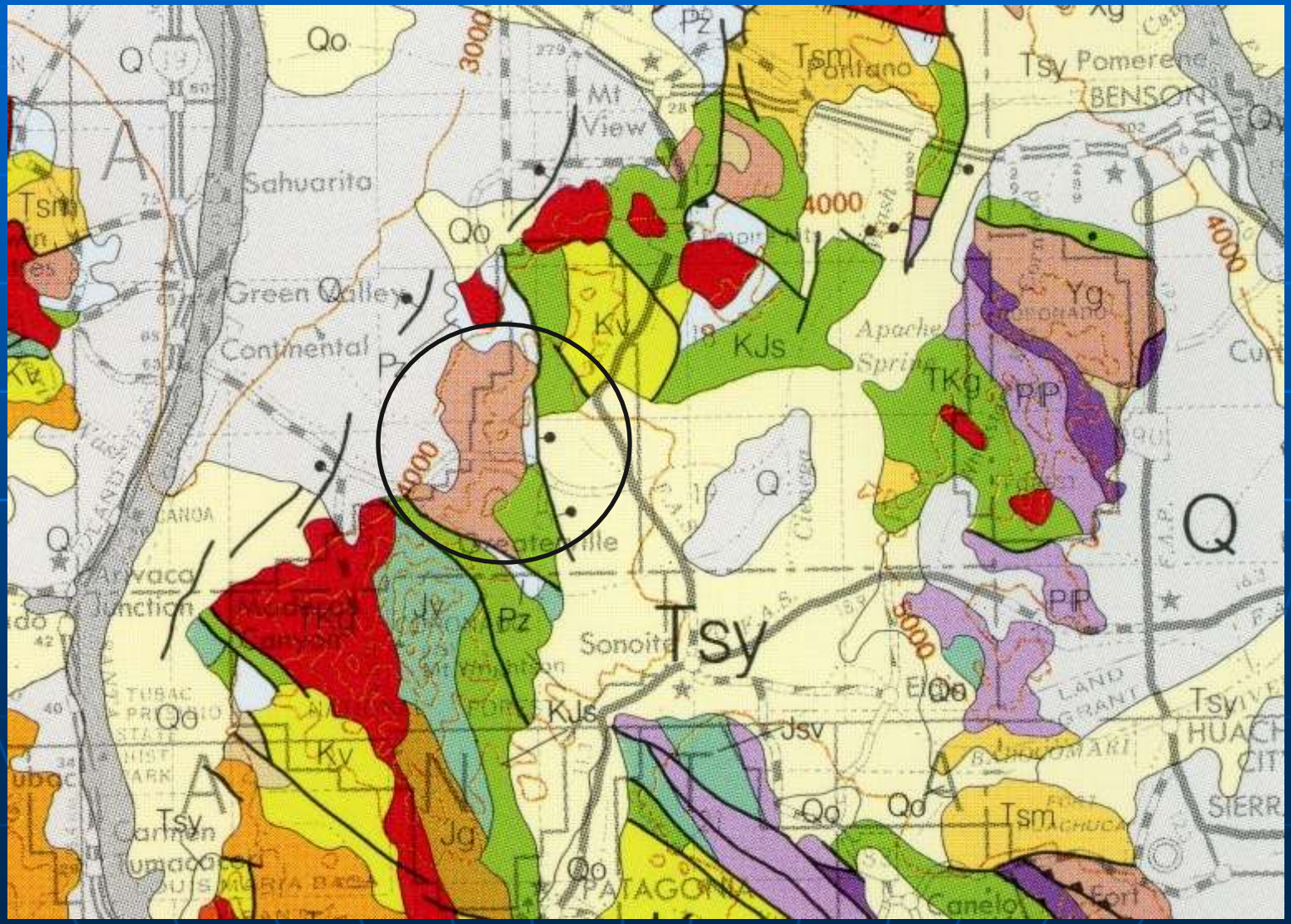
The top of the exhibit wall to the right of this panel portrays the ancient erosion surface or peneplain that developed on this crystalline basement of Pinal Schist and Oracle Granite.

Santa Catalina - Rincon Mts. Proterozoic ~ 1440 Ma

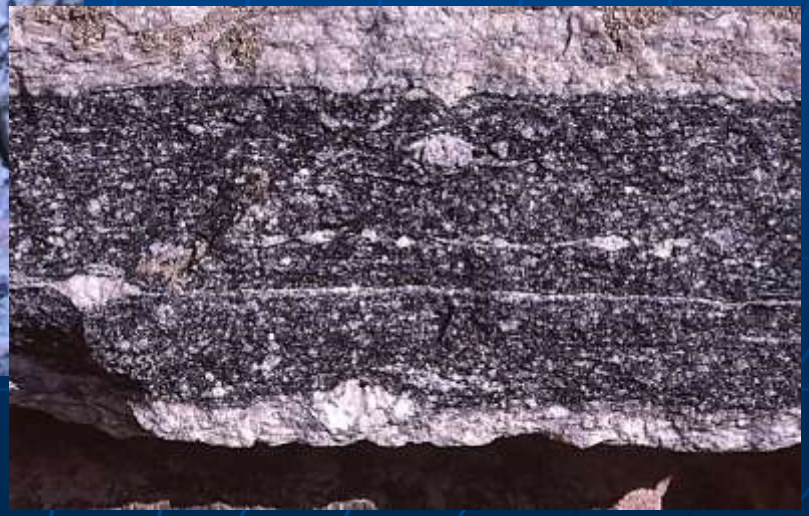
Oracle Granite Yg



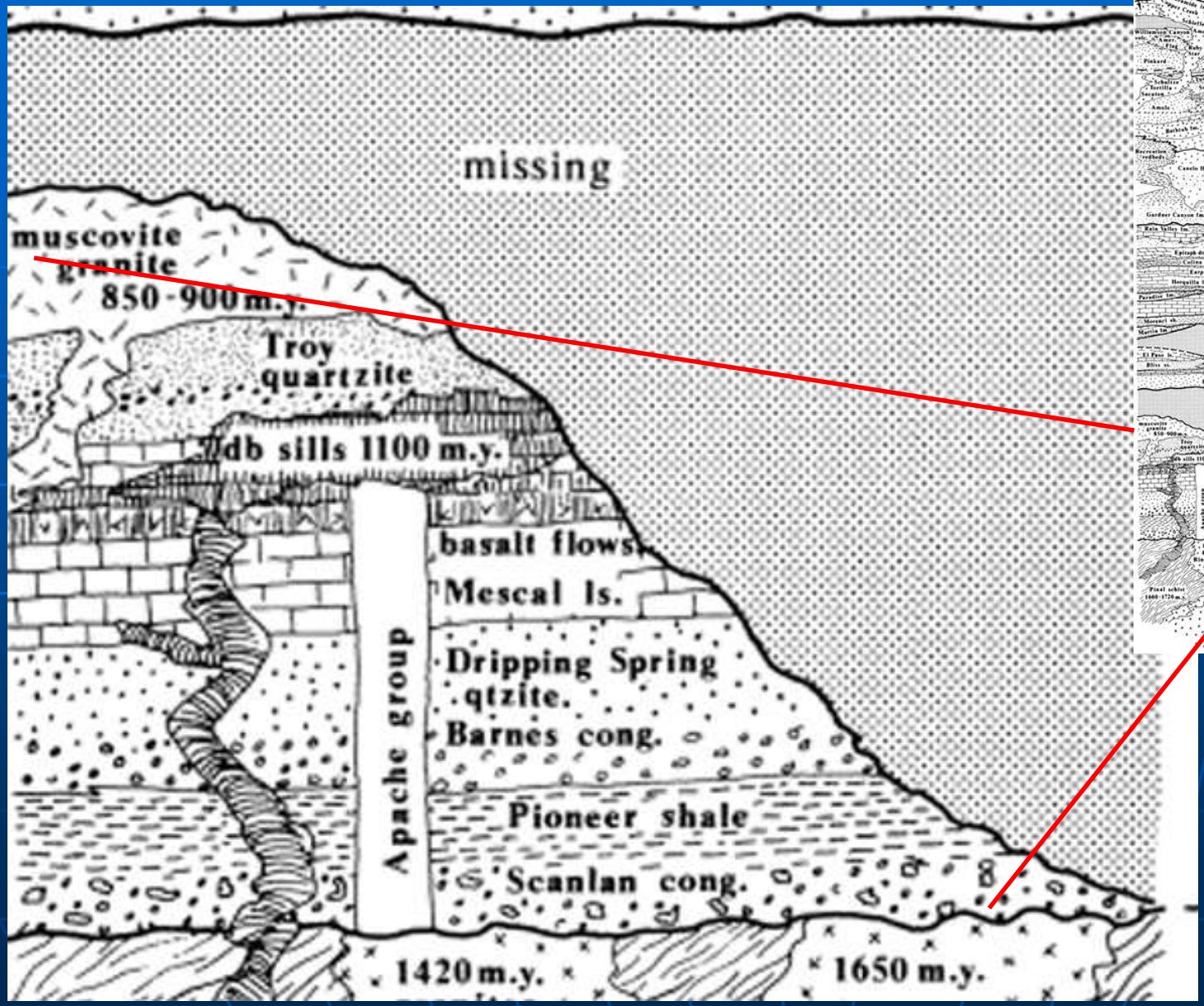
Santa Rita Mts. Proterozoic – Continental Granodiorite ~1420 Ma



Oracle Granite, 1420 Ma
Continental Granodiorite, 1400-1450 Ma
Rincon Valley Granodiorite, 1420 Ma



Younger Precambrian 1100 Ma



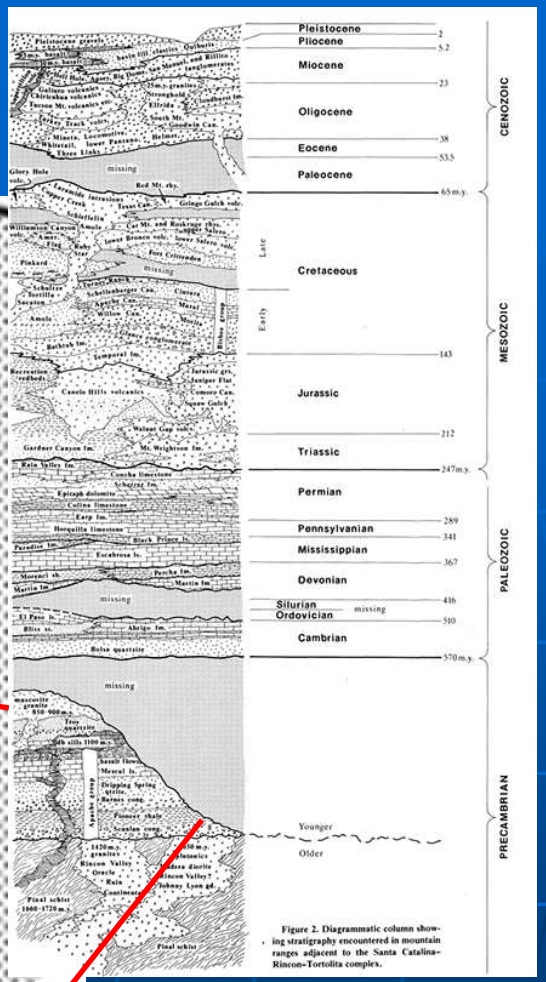


Figure 2. Diagrammatic column showing stratigraphy encountered in mountain ranges adjacent to the Santa Catalina–Rincon–Tortolita complex.

3. DEPOSITS IN ANCIENT SEAS

SANTA CATALINA MOUNTAINS REGION
"younger" Precambrian (~ 1400-800 million years ago)

Shallow seas eventually returned to this region, and gravel, sand, and mud once again began to accumulate. Late in the history of these seas limestone was deposited, much of it formed by colonies of algae called **stromatolites.** Basaltic lava flows were also extruded at a few places.

The piles of sediments and occasional lava flows that accumulated in these ancient seas were eventually compacted and cemented into a sequence of rock formations known today as the **Apache Group.**

Today, rocks of the Apache Group are especially well exposed far to the north of Tucson in Gila County.

Apache Group rocks are also preserved in the northern parts of the Santa Catalina Mountains: they form most of the higher ridge crests in the northern Santa Catalinas, east of the upper Cañada del Oro and north of Marble Peak. Apache Group rocks also form most of the hilltops you look down onto from the "San Pedro Overlook", on the Mt. Lemmon Highway.

About 1275 million years ago, the relative geologic quiescence that prevailed during the encroachment of the Apache seas was interrupted by vertical movements of great blocks of crust. Fractures along which such movements take place are called **faults.**

In many places, faults formed conduits for the passage of heavy, iron-rich magmas from deep within the earth's mantle. This molten material cooled to form dark basaltic rocks with a distinctive texture of interlocking elongate crystals of a white mineral called **plagioclase.** These rocks are called **diabase.**

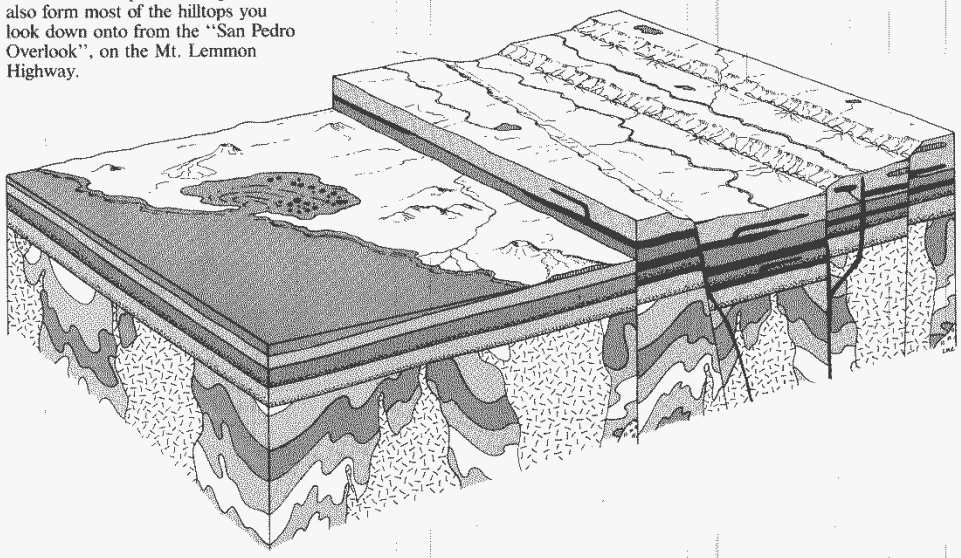
Where diabase froze into solid rock within fault zones, or in other cracks and fissures which cut discordantly across granite or sedimentary layers, the resulting plutons are called **dikes.** More commonly, this diabase magma wedged between horizontal strata and flowed laterally for great distances to form tabular bodies oriented parallel to the sedimentary layering. These concordant layers of igneous rock are known as **sills.**

In the northern Santa Catalina Mountains diabase is frequently found as dikes that cut across Oracle Granite and other rocks older than Apache Group. Farther north, sills of diabase form readily noticeable dark layers in the walls of Salt River Canyon.

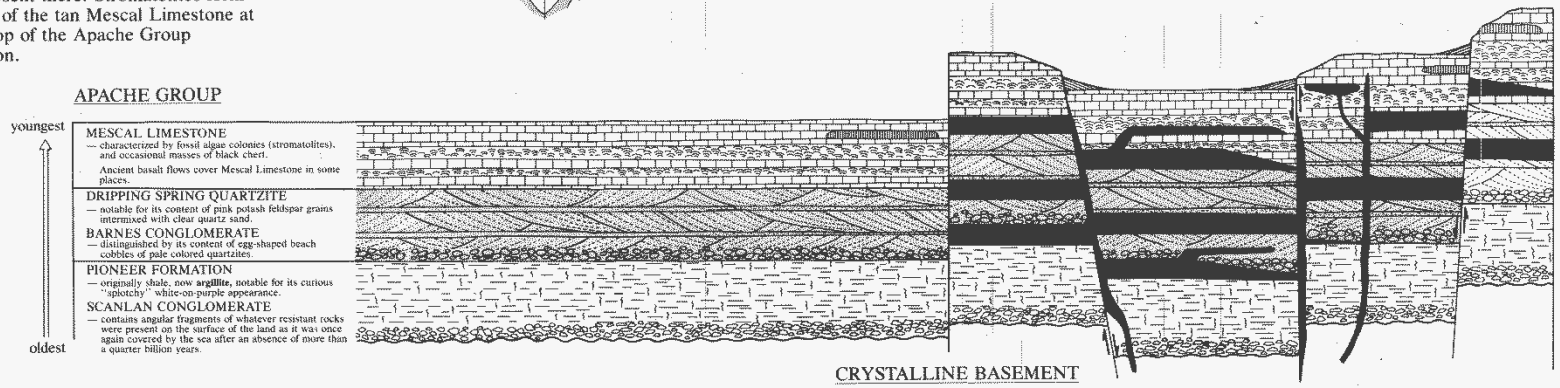
The profound contact between Apache Group and underlying crystalline basement is called a **nonconformity.**

In the exhibit wall, that contact can be seen near the top of this panel, where the lowest part of the Apache Group (Scanlan Conglomerate) lies nonconformably on Oracle Granite.

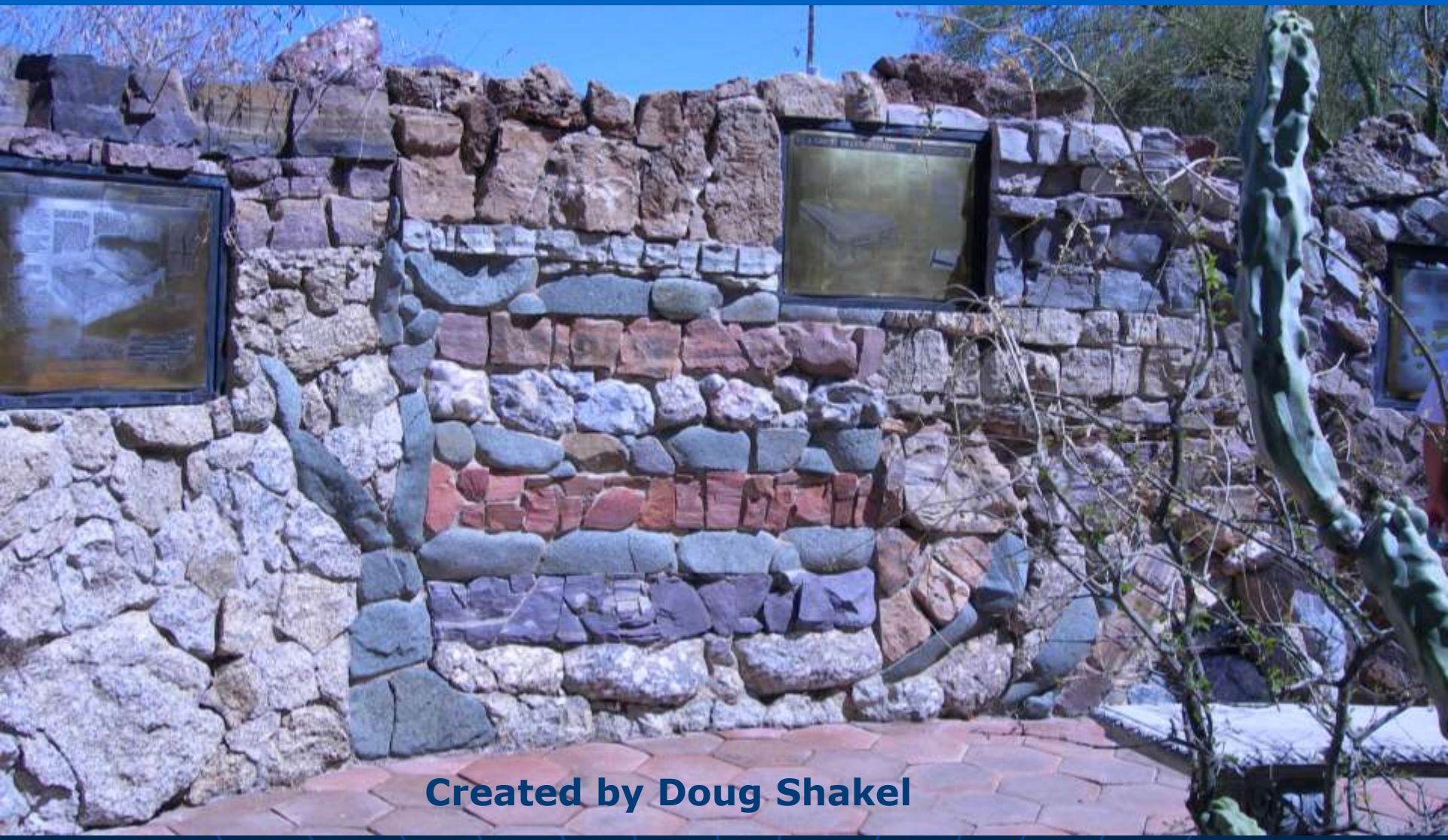
A different variety of Scanlan Conglomerate lies nonconformably on basement to the right of a fault zone about one quarter of the distance between this panel and the next. The entire Apache Group is present there. Stromatolites form most of the tan Mescal Limestone at the top of the Apache Group section.



Diabase forms branching dikes in the exhibit wall on either side of this panel, and also fills most of the fault zone to your right. Diabase also forms several sills between layers of the Apache Group to the right of this fault zone.



Catalina Rock Wall – Tohono Chul Park – Ina/Northern

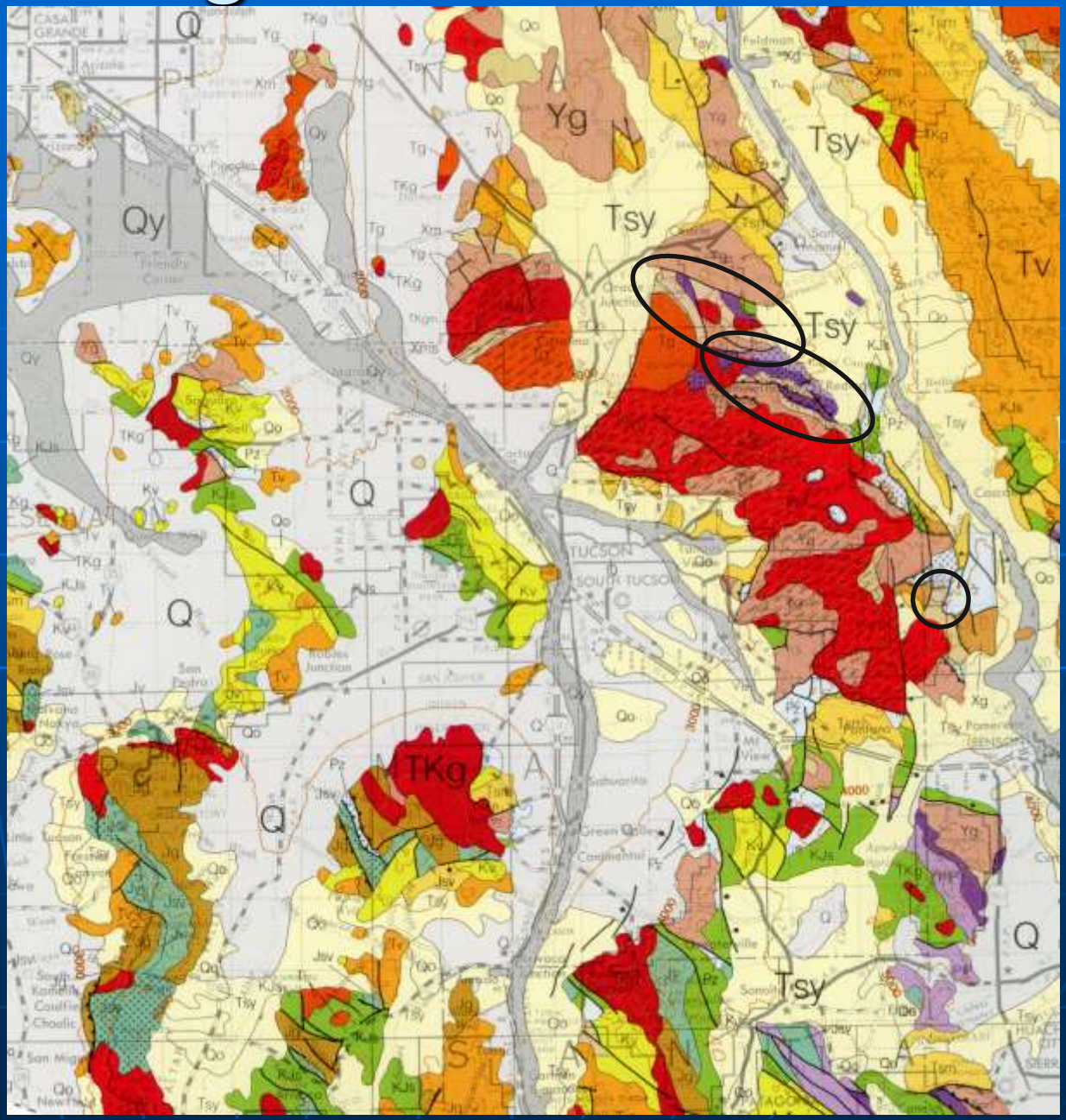


Created by Doug Shakel

Meso-proterozoic (1.1 Giga-annum [Ga])

Tucson - Younger Precambrian

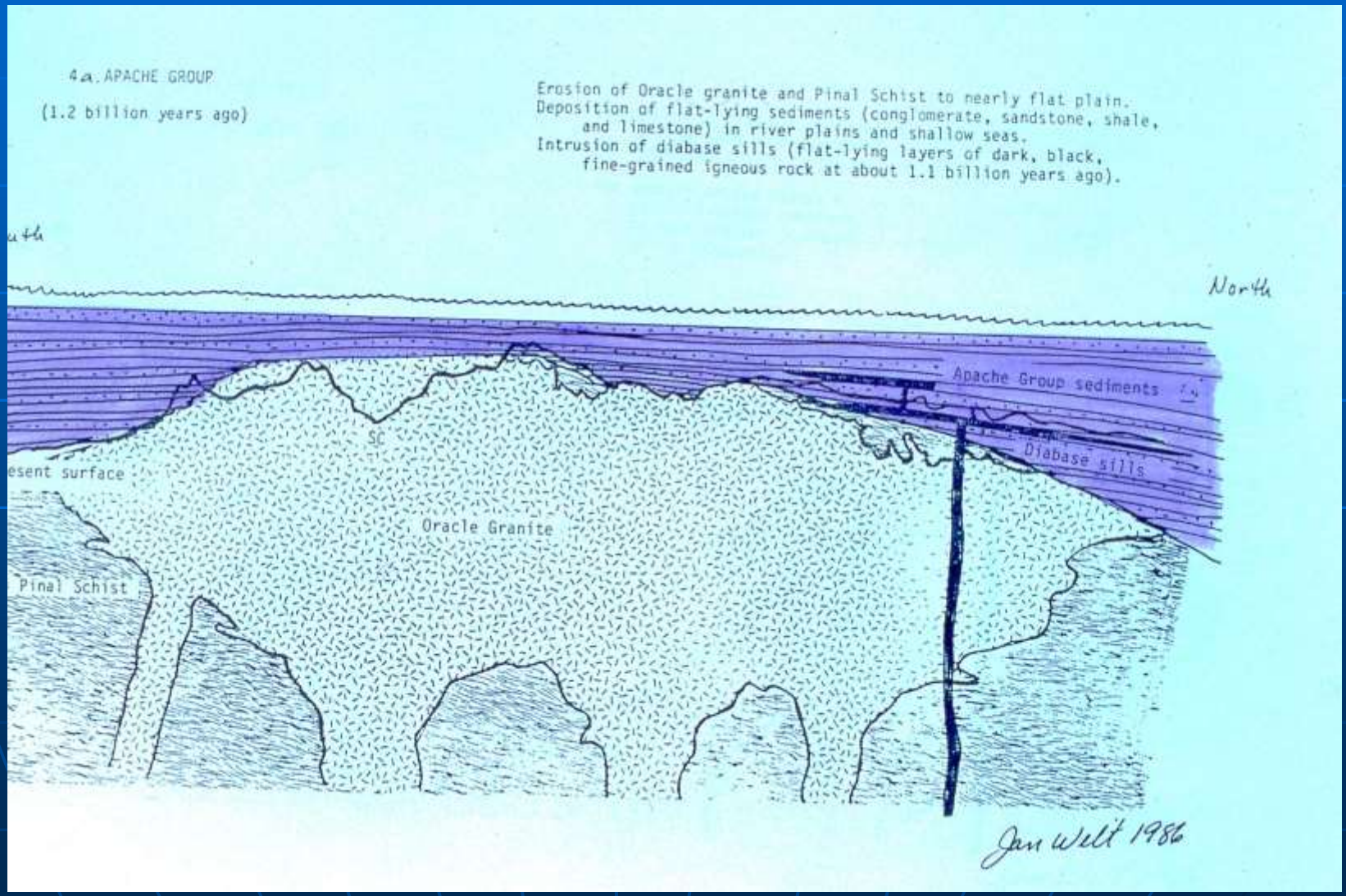
Apache Group Ys 1100 Ma



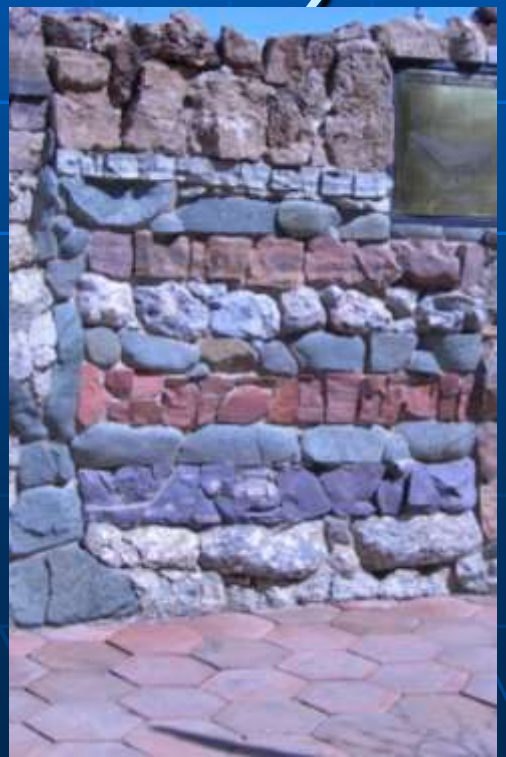
Grand Canyon Group

- 1.1 billion years ago - Fault block mountains (4,000’ offset)
- about 10,000 ft thick
- Eroded away to a nearly flat surface before the deposition of the Tapeats Sandstone 500 million years ago.

Apache Group sedimentation



Apache Group (1100 Ma)



		Unconformity			
MIDDLE PROTEROZOIC		Diabase			
		Intrusive contact			
		Troy Quartzite	Quartzite member	0–150	0–365
			Chediski Sandstone Member	0–210	
			Arkose member	0–140	
		Unconformity			
	APACHE GROUP	Basalt			0–115
		Unconformity			
		Mescal Limestone	Argillite member	0–30	75–130
			Unconformity		
			Basalt	0–35	
			Unconformity		
			Algal member	12–40	
			Lower member	45–82	
		Unconformity			
		Dripping Spring Quartzite	Upper member	55–130	140–215
			Middle member	40–110	
			Barnes Conglomerate Member	0–18	
		Unconformity			
		Pioneer Shale			45–155
			Scanlan Conglomerate Member	0–15	
		Unconformity			
		Granitic rocks			
		Intrusive contact			
EARLY PROTEROZOIC		Sedimentary and volcanic rocks, locally foliated			

Apache Group, Mt. Lemmon

Scanlon Conglomerate

Pioneer Shale

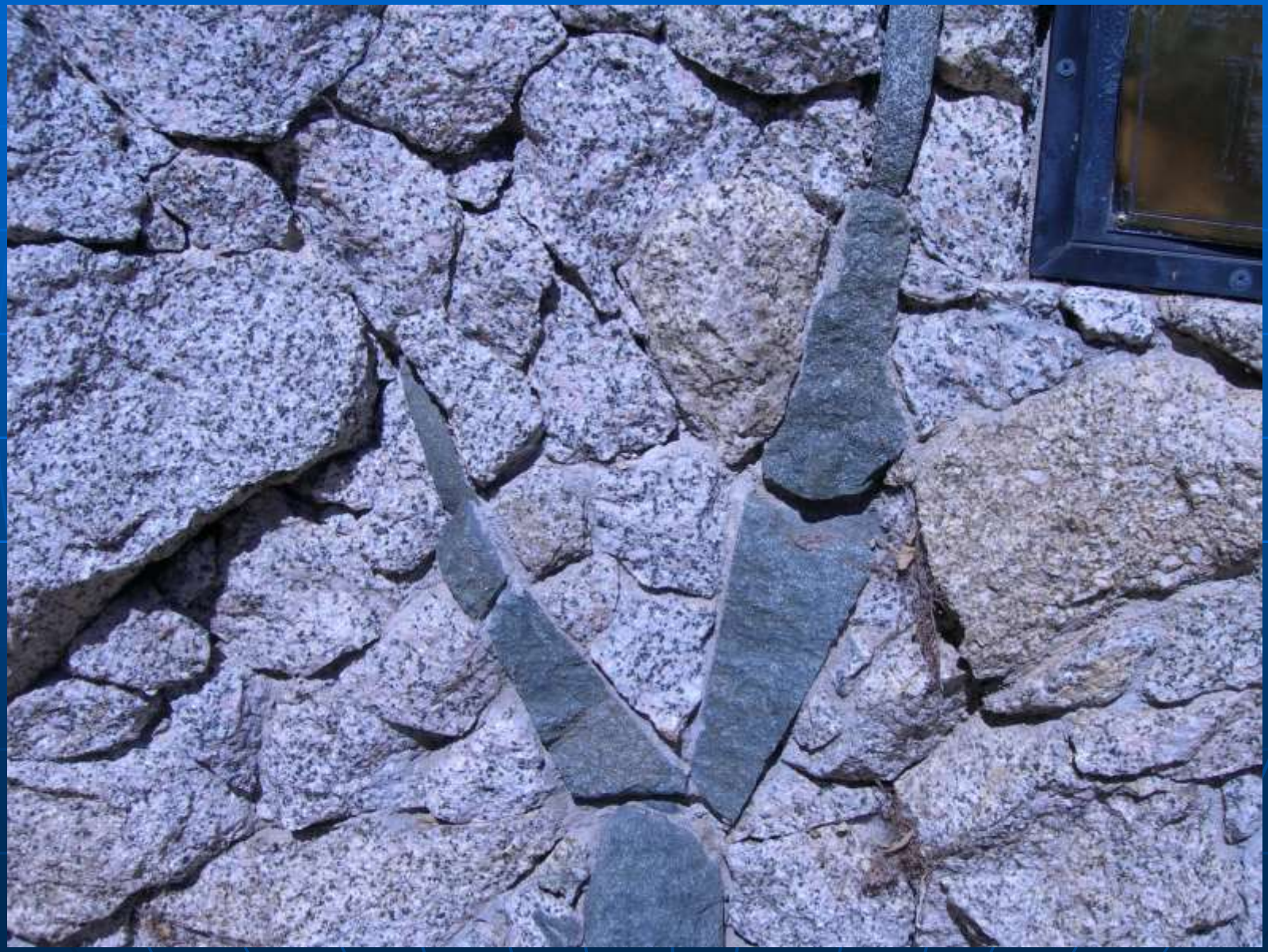
Barnes Conglomerate

Dripping Spring Quartzite

Basalt

Mescal Limestone Argillite

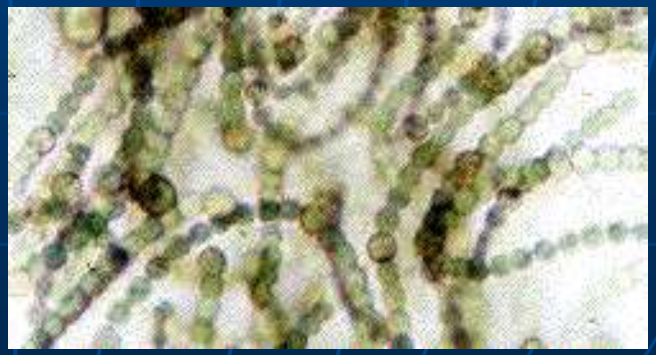
Basalt – intrusive Diabase



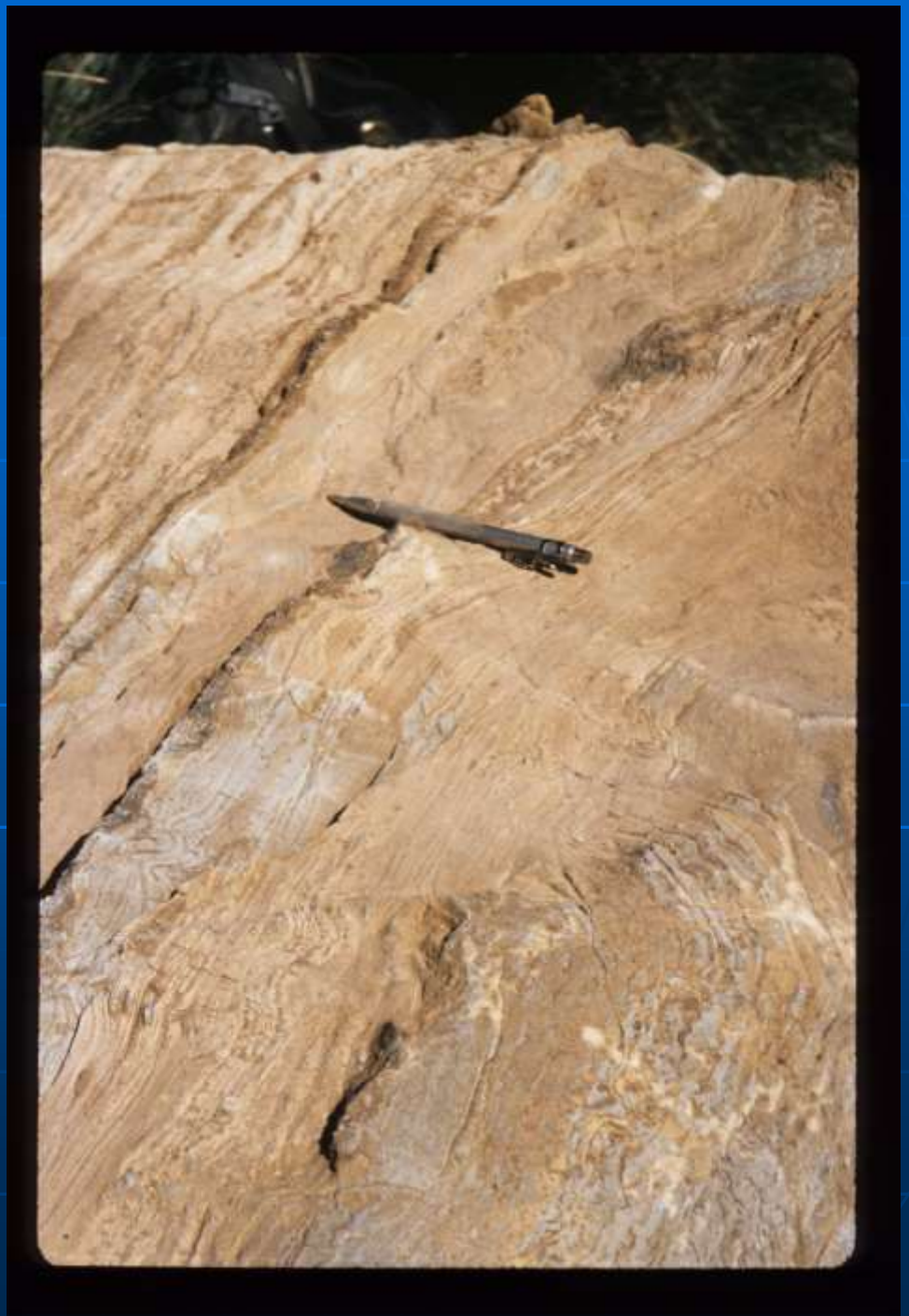
Mescal Limestone - algal

Blue-green algae gave O_2

- Photosynthesis by blue green algae (cyanobacteria) since 3.5 billion yrs ago
- When pigments developed in cells, they could absorb and process light.
- The products of this process were energy and oxygen.
- Between 2.4 – 2.2 billion years ago, the greater numbers of cyanobacteria increased production of oxygen.
- By 1.8-1.6 Ga, O_2 rose from 1% to 15%.
- Stromatolites deposited layers of calcium carbonate in layers.

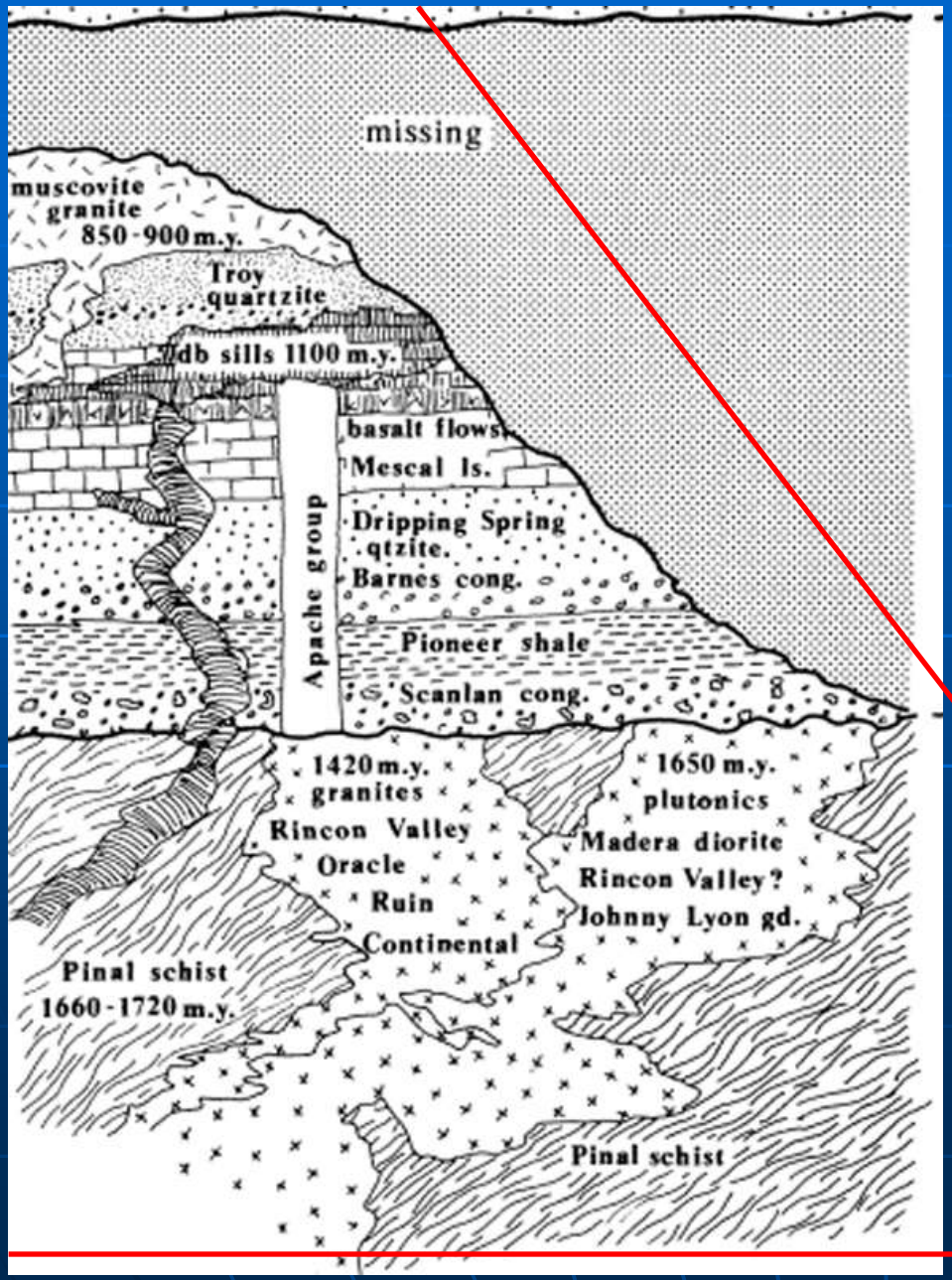


Stromatolites



Troy Quartzite

Summary Precambrian



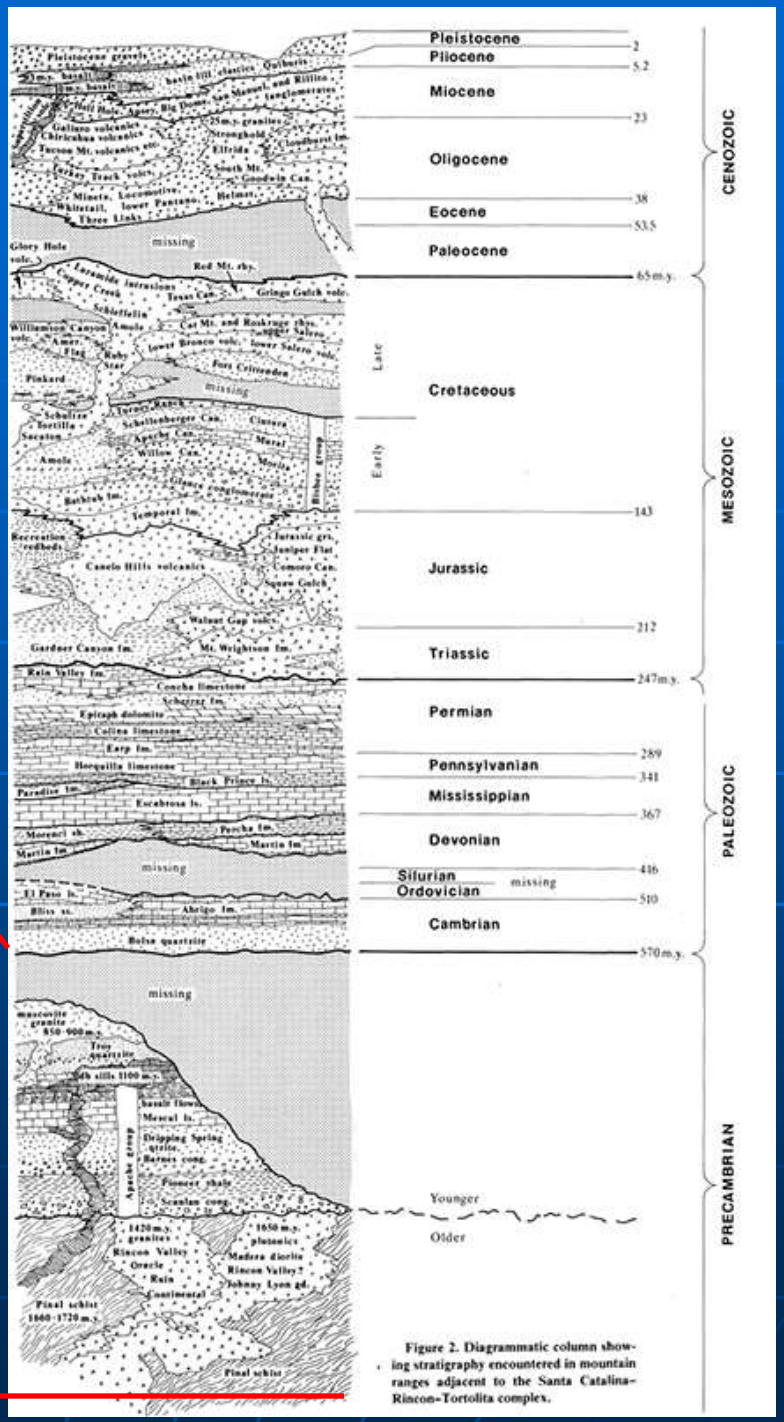


Figure 2. Diagrammatic column showing stratigraphy encountered in mountain ranges adjacent to the Santa Catalina–Rincon–Tortolita complex.

Summary Tucson area Precambrian

1695 – Pinal Schist - Xm

1625 – Johnny Lyon Granodiorite - Xg

1400 – 1450 Ma - Yg Oracle Granite Yg brown Continental Granodiorite