

Richard Johnson

GY-540

Summer Field Camp 1973

limestone	Ls	regular	reg
maximum	max	rhyolite	Rhy
member	Mbr	rocks	Rx
metamorphic	met	rounded	rnd
mudstone	Mdst	sandstone	Ss
muscovite	Musc	saturated	sat
nepheline	Neph	secondary	sec
nodular	nod	sedimentary	sed
oölitic	ool	shale	Sh
orthoclase	Orth	serpentine	Sp
outcrop	Otcp	siliceous	sil
pebble	Pbl	siltstone	Siltst
peridotite	Perid	soluble	sol
permeability	Perm	station	Sta
phenocryst	Phen	structure	Struc
phosphatic	phos	tabular	tab
plagioclase	Plag	temperature	T
point	Pt	unconformity	Unconf
porphyritic	porph	variegated	vrgt
probable	prob	vegetation	Veg
pyritized	Py	vertebrate	Vrth
quartz	Qz	volcanic	Volc
quartzite	Qst	sediment.	Sed



NO. 1130

COMPOSITION BOOK

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Richard Johnson

abundant	abnt	crystal	Xl
acicular	acic	crystalline	xln
aggregate	Aggr	diameter	Diam
amorphous	amor	different	diff
amount	Amt	Disseminated	dissem
angle	: <	dolomite	Dol.
angular	ang	elevation	Elev
andesite	And	equivalent	equiv
anhedral	anhed	evaporitic	evap
anhydrite	Anhy	exposure	Exp
approximate	approx	feldspathic	feld
arenaceous	aren	foliated	fol
argillaceous	arg	foraminifera	Foram
arkosic	ark	formation	Fm
asphaltic	asph	fracture	Frac
average	Ave	fragmental	frag
bedded	bdd	glaucinitic	glauc
bedding	Bdg	granite	Gr
bentonite	Bent	granodiorite	Grd
biotite	Bio	granular	gran
bituminous	bit	graptolite	Grap
boulder	Bldr	graywacke	Gwke
brachiopod	Brach	greenstone	Grnst
calcareous	calc	gypsiferous	gyp
carbonaceous	carb	hematitic	hem
cavernous	cav	horizontal	horiz
cemented	cmt	hornblende	Hbl
chalcedony	Chal	hornfels	Hfls
claystone	Clst	igneous	ign
cobble	Cbl	inclusion	Incl
conglomerate	Cgl	interbedded	intbdd
contact	Ctc	intrusion	Intr
cross-bedded	xbdd	irregular	ireg
cross-bedding	Xbdg	joint	Jnt
cross-laminated	xlam	laminated	lam

Library Research next 3 pgs.

Mesa Verde Fm	upper K
Mancos Shale	" "
Pakota S.S.	" "
Morrison Fm	" JR

Summitville Fm.	upper JR
Curtis Fm.	" "

San Rafael gp.

Entrada S.S.	upper JR
Carnel Fm	" "

Navajo S.S.	JR
Kayenta Fm	JR (?) or TR
Wingate S.S.	JR
Chinle Fm pet for mon shinarump "	TR
Moenkopi Fm	Lower TR
Kucab L.S.	fm.

Ulen Canyon gp.

Moenavi

Mesa Verde Fm

Cross & Spencer 1899 (USGS La Plata Folio #60)
alt. shales/sss @ occ. marls or thin lss &
many coal seams. Thickness 1000'+

Mancos Shale

Cross 1899 (USGS Telluride Folio #57)
dk gray or lead colored shales, nearly always
somewhat sandy, contains thin calc layers which
in places become almost l.s. and are very fossiliferous.
sand locally increases to s.s.

Dakota S.S.

FB meek & FV Hayden 1962 (phil. Acad. of
Nat. Sci. Proc. v. 13 pp 419, 420)
yellowish reddish, and occ. white ss @,
at places alternations of variably colored clays
and lignite beds. Thickness 400'

Morrison Fm

G. H. Eldridge 1896 (USGS Mon. 29)
marls, green, drab or gray and gray in lower 2/3
numerous lenticular nodules of ls of char. drab
color & a texture compact, even throughout.
20' above base $\exists$ persistent band of alt. lss &
sss on all sss 10-15' thick - lower 2/3 reptilian
remains - upper 1/3 succession of sss & marls, mainly
sss.

Unimacule Fm

Gilluly, & Reeside
Thin bedded choc. colored sss earthy red brown
ss & shs some gyp & in some sections, a little
ls. Thickness 125-331'

Curtis Fm

Gilluly & Reeside
green-gray cgl/sh. & heavy bedded gray ss
Thickness 76-253'

Entrada S.S.

Gilluly & Reeside 1926 (USGS Press Bull 6064)
Thin bedded red sh & ss at base, heavy massive
red brown earthy ss above, which weathers into
rounded forms & steep cliffs. Thickness 365-840'

Armel Fm

J Gilluly & J B Reeside Jr 1926 (USGS Press
Bull 6064, 1926)
Dense ls & buff & red ss at base, toward top
domin. red & green shale @ thin sss & heavy
beds of gyp. Thickness 200-650'

Navajo S.S.

H. E. Gregory 1916 (USGS WSP 380)
Red ss massive exceedingly cross bedded; locally
thin bedded & greatly reduced in thickness.
(Thickness 400-1000')

Kayenta Fm

A.A. Baker, C.H. Dane, & T. Knight 1931
Irregularly bedded gray to red ss. @ subordinate
sh. Thickness 200-320'

Type locality 1 mi N of Kayenta, Ariz.

Wingate S.S.

Bright red SSS 450' Thick

Chinle Fm

H.G. Gregory 1916 (USGS WSP 380)
up fl red shale & shaly ss
(1) lenses of ls cgl containing red sh.
(2) purple lavender green & lt. colored variegated
shales & ls cgl lenses
(4) char. colored aren. shales at base
(Thickness 400-1000')
+ "Shinarump Congl."

Moenkopi Fm

C.F. Ward. 1901
top 200' dk. char brown argill/saliferous shale
100' soft dk brown argill. SSS

200' dk brown argill sh.
100' white calc sh
100' saliferous argill sh

Karab L.S.

C. Noble, 1928. (USGS Prof Pap. 150 p 41)
very cherty ls. (M.H. Darton 1910) (USGS Bull 435
pp 21, 28, 32)

Prospect Mt. Quartzite Early E

A. Hague 1893 (USGS 3rd Ann Rept. pp 253, 254)

Bedded brownish-white gtzites weathering dk brown
ferroigneous near base, intercalated @ thin layers
of aren. sh. beds whiter near summit. Thick-
ness 1,500'. Oldest sed rx exposed in Eureka
dist.

above: "Prospect Mt L.S." = Eldorado L.S.

mid E. gray compact ls, fine & granular
lt or in color than Hamburg ls., traversed @
thin seams of calate, bedding planes very imper-
fect. Interstratified lenticular or wedge shaped
bodies of shale greatly varying in width. Thickness
3,050'.

210N section

NA CARMEL Fm Jc

480-675' thick sharply terminates Navajo Xbedding
(below)

4 members: (1) Winsor mem. Jcw

180-320' thick

evenly bedded, thinly laminated fine gr.
white-yellow ss. containing red bands & congl.
lenses

(2) Paria River gypsum mem. Jcpr

upper: ls/ls congl.

lower gyp/anh. 40'-60'

"Curtis Fm" in older lit.

contains some fossils

(3) Crystal Creek member Jccc

red to greenish friable ss
choc. sh white

250' thick - older lit: "Entrada Fm." ≡

(4) Kolob L.S. mem. Jck

gray brn argill L.S.

top thinly bedded, platy

abundant marine fossils

200-500' thick

Navajo Fm Jn

overly Kayenta Fm - gradational contact

fine-to med- rounded qtz ss

cemented by FeO on/ & limey mat'l

Thickness 1800-2200'

in general: red but can be white in places

2 imp. recog. char: (1) highly Xbedded
(2) strongly jointed

(not necessary
to diff. for
us.)

members: top: Temple Cap mem. Jntc

soft red ss containing some gypsum and a few
stringers of sh. ext. thinly bedded

200-225' thick

lower 2000':

white portion: Kolob S.S. member

red " " : Kanab S.S. "

(no def. position of boundary betw. these 2 mems; only
on basis of color.)

(red color "probi." due to oxydation - 2ndary - reup)
base maybe T2

Kayenta Fm

a sequence of sed. which grade upward into the
Navajo Fm.

red brown siltst / ss some lt gray silt / ss inter-
bedded into it.

top-drawn arbitrarily (grad. contact) at top of
silt (when more ss than silt ss. ⇒ Navajo)

The contact extends down ~100'

bottom: sandy. ⇒ cliffy units

less cliffy ⇒ siltstones, next lower Fm.

members: 3: top:

(1) upper red mudstone mem.

Jkur

interbedded red mudstones and thin sss, mudstone beds dominate
is slope-former on reentrant-former
thickness ~ 200' ±

- (2) Jks Shurtz S.S. mem.
can pinch to 0-60' thickness => "tongue"
red-lt gray siltstones/sss
- (3) lower red mudstone mem. JKR
exactly like Jkr
∴ if no Jks cannot differentiate = JK
"Kayenta undiff."

Moenave Fm TRmo

- (1) Springdale ss mem.
TRmos

110-175' thick
prominent low ledge-forming ss
pale red to lt brn red v. imp.
silver bearing

- (2) Whitmore point mem.
TRmowp

Thickness no more than 15-75'
slope former
gray-brn to gray red shs/mudstones

- (3) dinosaur canyon mem.
TRmodc

3-400' thick
siltstone & sss (sss never thick: no more than 30')
alt. interbedded lt. brn/red orange.

Chinle Fm TRc 3-500' thick

unconformities at both top and bottom ∴

shp contacts

mems: (1) petrified forest mem.

TRcps

250-360' thick

v. fine gr. siltstones/mudstones/claystones/shs
slope former, fast color break: gray-purple-maroon. grades

- (2) Shinarump mem. (cgl.)

some put wood. 40-150' thick

ss well lithified, hard, conglitic ss
Cliff/ridge former.

golden colored, above choc. colored slopes
abundant lenticular pebble zones esp. in base.
bedding is crudely developed.

gtz pebbles, chert pebbles in sand matrix.

dist. from Navajo: (1) low & bedding

(2) blue grains, and larger.

is stream-channel deposit

snake hideouts common.

Moenkopi Fm TRm

Moenkopi Fm. 1 Km

soft, Thinly bedded red brown or maroon chcc. shales
one of the most conspicuous in SW America.

forms low cliffs & sh slopes.

+1500' Thick - 2100'

6 members:

(1) upper red member: 1 Km ur

550' Thick

Red Band

Red-choc brn, Thin bedded shales @ ss/siltstone @ some gypsum
can have single thin bed of l.s.

id: presence under Shinakump cgl.

if no shin. mem present: we tends to have a few more
massive beds than in other red beds.

(2) Shinabkaib mem. 1 Km s

260' - 750' Thick.

white/gray white/pink & lt red gypsif. sandy sh.
& interbedded gyp.

grad. ↓

(3) middle red mem. 1 Km mr

choc. red to brn shs siltss 300-400' Thick
anhydrite/gypsiferous zones 1"-2" Thick.

more shaley than UR. ⇒ more rounded cliffs.

(4) Uajon L.S. mem. 1 Km v

8-150' Thick forms vertical cliffs

blue gray to gray tan l.s., abundant marine fossils
prominent marker bed. unconf.

abundant marine fossils

can be ≡ 2 units sep. by a gray shaly unit

(5) lower red mem. 1 Km lr

400-500' Thick

red-choc. brown sss, siltss, shs

little more like UR. than m.r. - more cliffy.

(6) Timpanop mem. 1 Km t

0-150' Thick

fills in depressions along Post Kaibab unconf.

(rests unconf. on Kaibab)

2 pts: (A) blue gray l.s. lt sandy shs.

(B) basal cgl.

contains Neokeras sp. a goniatite ⇒

ammonite: a excellent Te marker
fossil.

Kaibab L.S. (Pm) 1 Km

800-1050' Thick

hard gray massive cherty fossiliferous l.s.

2 units sep. by thick gyp./anh. layer ~ 150'
which erodes ⇒ slope.

both upper/lower are cliff formers.

weathered texture: rough dk gray ridges/cliffs

in places: Supai

↓

Coconino

1250-1800' in places.

massive, fine grained, tan, white & yellow
bedded ss contains small yellow brn
spots of FeO

Drilling: St George
(Paikoon Fm) thin bedded ls/dolo.
830' on SW side

Trmv

7/4/73 ① Field Day

3-4° @ 249°

strike N21 W

200 yds N Fredonia Hwy

goose 1/2 m. Gooseberry

3 sandy lms interbedded @ shales

+ thickness 110-120

stop 2

3-4° @ 542° W

50 yd. W Gooseberry mesa

200 yd N Fredonia Hwy

wellbedded y. ss, m. r. red shales

outcrop ~ 3' in wash

30 yds S of fence

lunch -

stop 3

3° 10' N 18° W middle red near top of mem.
dipping SW

150 yds N of Fredonia Hwy

on first major cliff 1st bench

~ 1 mile from SW corner of Gooseberry mesa

stop 4

dip 20° N20W v. top middle red 5-10' from Shnakkai 6 mem

300 yds N of Fredonia Hwy

on 2nd major cliff S of SE spur
of Gooseberry mesa (on the spur)

stop 5

4.00 @ N25W strike SW

on wash first mapping pt

MR

Procedure

(1) get street section

(2) get Aerial photos of area

(3) compare topo maps + aerial maps (famil. @ area) + Field

(4) put nadirs on topo maps

(5) plan traverses

(6) put see they write-on jink on maps

(7) → field & sit on high pt. & trace contacts
on vellum

(8) ± make traverses: record strike/dip

(9) → bk & transfer vellum maps to main map &
place strikes/dips on it.

Field Day 2 8/5 7/5/73

drive around: reconnaissance →

stop 1 on look near dry lake - I mapped & Rattle snake

stop 2 " Timpanoap / Kaibab near bottom corner (SW) of our
map - I mapped Redo in camp

Timpanoap contact / LR by wash / canal W of canal W of dirt rd
let Linda & Rich at for a long traverse → b/c to main rd

stop 3 Timpanoap mem.

4° @ N50W dry wash x dirt road
~ 50 yds - NE new main rd

~ 1 mile W of Gooseberry mesa

stop 4 pull off 2nd on wire main rd close to Hurricane
cliff 3° @ N80W Kaibab li.

stop ⑤ pull off (last) near top of 'Hurricane up grade'
Baugh/Timponeap contact 1st bench

Kalab: dip 10°40' @ N22E

stop ⑥ 4 on map Timponeap
2.5° @ N65E

stop ⑦ 10° @ N150E L.R.
1st 5 on map
along long rd.

stop ⑧

20° @ N45W 1st mt

Alidades 7/8/73

telescopic alidade - mapping at any scale and the map
is produced as you go.

- (1) Reconnaissance area w/ topographic section
- (2) Aerial photos (analysis)
- (3) Sketches of topographic features

dip 17° @ N68W Tmo between faults NW
side of top map

1030 AM.

stayed lunches, etc. in mine

apparent lith. chg: springsdale mem. @ mine ✓

upper pt. of hill: ss. 1/2 red to pink, ^{to brown} granitic
& calc. ges., 1-2 to heavy mine, some (small) low
& cross bedding, ~~thick~~ ~~beds~~ up to 6-10'

- | | | | | |
|---|-----------|---|-----------------------|--------|
| ① | dip 13.5° | ④ | N68W N112W | Spdale |
| ② | 19.5° | ① | N64W N111W | Spdale |
| ③ | 22° | ④ | N60W N118W | Spdale |
| ④ | 14° | ④ | N58W | Spdale |

conduit ~ 2.5 miles NE of Hurricane mem rd. along Rt.
Virgin Ls. mem. Moenkopi Fm.
for conduit reconnaissance.

W side of N79E @ 23 1/2°
north pt of hole
in anticline
Shinarump

Bryce Canyon Area

Iron Springs Fm. K

"wasatch" applied
in Bryce - East
of Hurricane Fault

Wasatch - Claron Fm.

12-oligocene

400-1400' ↑

Bryce - canyon - clastic (more)

more liney S of Bryce

sequence of

Freshwater lss lime pebble cgl
some calcite ss
basal ss/gutrite cobble cgl.

unweathered: pale red
yellow
gray
white

weathered: pink/red (FeO)
unit becomes clastic with 6 mi W
of Bryce

Iron Springs Fm. K

Kaparewits mem. (ss) 1200' (K)

forable fine-nd grained, buff to white, cross bedded
ss. 1d: basal cgl. 1-40' abundant pebbles of lss, chert
freshwater land snails & ostracods (turtles)
clear plant impressions
forms gentle slopes (friable)

Vahwape ss - Straight Cliffs mem.

massive (1800') ss.

alt massive tan or yellow gray ss @ interbeds of
sh. (ss - 1-80' single beds - lenticular)

in ss - iron stone concretions @ (sometimes) ammonites.
major cliff former piles of overlapping wedges of ss/sh

tragic shale member (E)

1000' + numerous carbonaceous gyserifous early shale
with lignite + bituminous coal 3-7 beds < 4' thick

ss lenses: coarse - fine grained, drab - tan leds 2-20' thick.

Dakota ss mem

4-108'

blanket ss. ss - friable - no ledges

forms rounded slopes

cgl: pebbles: ls frags @ miss/penn fossils

Ignimbrites

Nevada / Utah

✓ volcano-sedimentary rocks:

volcanic mat'l transported by surface processes
non-sorted sheet-like pyroclastic deposit, prob.
of nuee ardente origin

✓ old lit: "ash flow" to "fs"

occur in thin sheets "thin dm. 5000 to 200' thick.

✓ all wedge out against or thin out over topographic
hills

✓ controlling factor of thickness: surface topography

✓ Eruption: very viscous mat'l → plugs up vent → explosive
in pelee type eruption - mat'l is very hot &
completely gaseous thus are non-viscous, so they
form the ignimbrites

✓ groundmass: many X-line frags
+ thick mat'l/s (old wall mat'l) (accessory ^{ejecta} mat'l)
+ "ground sweep" (accidental ejecta)
+ pumice frags - irregular flattened discoids
or obsidian flakes / layers
"flamee"

✓ characteristics:

(1) shared structure - broken up xls

flattened glass shards / pumice frags

(2) frags drape over / compressed under xls

(3) groundmass: highly chyd @ X-line frags

✓ method:
compaction
heat welding

- It. from
- ✓ layering? Top top units roll - swept away by succeeding flows
- (1) soft incoherent ash & lapilli, readily eroded
abundant frags of pumice
↑
grades
 - (2) Thick ~~thick~~ to mod. welded zone
pumices welded together and glass shards welded
disrupt chg. ↓
 - (3) highly welded dk. gray / blk.
"vitrophyric zone"
welding - contains scarious frags
completely altered to obsidian flow
10-100' thick
 - (4) "40 100's of feet
non-welded tuffaceous mat'l but abundant
sweep / secondary / accidental ejecta

Lahar Deposit

1Ks. like lithified landslide

heated gw. → flashes to steam - expands in a fraction
of clay & drives it apart → drives (and slide) steam -

mod flow) (a) baked mud & clay matrix) Liberty Pit
ELY, Nevada
Section Robinson Mining District

Ely L.S. Penn. 2300'

massive cliffs

gray - med. gray - med. grained shaley L.S.
contains gypsum / and is basin L.S.

most important host rock containing porphyry Cu
mag. geo. incl. mag.

Chairman Shale 200-1500' Miss

dk shale / bent up, poorly exposed.

shallow water

black fissile shale, some cal. / silt. pts, + fine gr. g. shale units

Joana L.S. Miss. 400'

gray coarse grained calcareous L.S.
mag. geo. incl. mag.

Pilot Shale Miss 350'

calc. sh / lime nodules 5' or 10' blk. fissile sh.
= Chetopa Sh.

Guilmette L.S. < Dev. 2500'

lt. brown - dk gray med gr. massive L.S.

few cels delo

no mineralization - acted on tunnel for min. solns.

Nevada L.S. 2000' + Dev.
undiff. (Dev) dolo/L.S.

Laketown Dolo. 1900' Sil.
lt to red gray med gr massive dolo.

Ely Springs Dolo. 220' Ord.
Eureka Atzite 300' "

Pogo nip Gr. ord

Robinson Mining Dist.

Kurbah L.S. (g.w.)

Pm

Arcturus Fm. upper mem: 1250'
lower mem: 1600'

↑ up/low

upper: calcareous siltstone & ss
middle mkes: gypsum evaporite bed
lower: ls & intercalated ss/silt beds

Rib Hill S.S. 1100' Pm

fine gr. ss, calcareous ss, ls/dolo beds, some siltstone

Riepe Spring L.S. Pm 250'
gray thick bedded L.S.

↓ Ely L.S. (g.w.)

top moen kop ^{finely}
red shale interbedded with ^{inter} thinly bedded siltstone beds &
weathers to "popcorn" surface, forms ^{inter} slope
red to orange

* thin interbeds of tan ~~also~~ micaceous fine ss to siltstone
dip 27° N 0° W

middle member Chinle ^{gray}
lower 1/3 ^{degry}
(blue gray shs) ^{degry} laminated ^{finely} finely bedded, ^{up}
gypsiferous ^{tan} siltstones, popcorn fashion
to 1' thickness

(Bills) 5+2' low pt mid pt middle mem. chinle
15 rods + 2' slope pt. mid pt middle mem chinle
 $\frac{5}{95}$

97' to base upper middle chinle
* offset N 15° W
250'

Offset along base of upper middle chinle
(rip)

upper pt middle mem. Chinle
red ss, constant cliff forms, blue grains
med grained, red ~~also~~ cement / matrix
(silica gss.) abundant "desert varnish"
Thickly to Thinly bedded low & X bedding

Utah

917.92
W 9564
1954

San Francisco Mtn Volcanic Field

tertiary: long erosion - by end of Pliocene = broad erosion surface Arizona → Calif., v. close to sea level.

near close of Ter.

⇒ scattered basaltic lava flows across SW (incl. S.F. mts.) =

First Period Volcanics, basaltic

Black Pt., Citadel & Stitzers mesa flows

2nd Period Volcanics

acid/intermediate lavas

S.F. peaks, O'Leary Peak, Sitgreaves Pk., Kendrick Pk., Mormon Mt.

3rd Period volcanics:

Pleistocene: basaltic

continued to present hundreds of cinder cones

Sunset Crater formed along rift zone from Janus Crater toward O'Leary Pk to NW - rift marked by several small cones

1st activity: old Bonito flow

2nd " : vent-flow - Kana-a flow -

flowed 2 miles NE toward Little Colorado R.

vent located under present location of Sunset C.

3rd activity: Sunset crater, 1000 sq miles ash

4th activity: lava wells up under first Bonito flow - anastomosing structures & some of flow

issues from base of Sunset Crater - marked by line of spatter cones.

Capitol Reef Section

on Anapa Plateau - one of westernmost on Colo. Plat.

Coconino_{pm} Through Flagstaff Ls (early Ter.)

Coconino S.S. 800+ feet exposed along Fire mout R.
white to gray, very fine- to fine-grained, ss,
cross bedding on large scale, pm.

Kaibab L.S. 250-350' pm.

Coconino contact Transitional - (mixed gradational)
lower 100' sandy littoral. unit exposed in stream
valleys in Miners Mountain, forms light-colored
cliffs.

Impure, cherty Ls & dol. @ interbedded ss
& siltst. Gray shale lenses local.

chert nodules/layers/groves abundant near top
of fm. color usually lt orange-gray wht.

TRIASSIC

Moenkopi Fm members (4):

(1) basal red-ben siltstone, thin bedded, fine-
grained, cgl at base. cgl & frags of chert &
qtz from Kaibab Fm. Contact scarred.
45'-108' pale red-ben-orange

(2) Sinbad L.S. member

cliff former, yellow gray to yell. org.,

dolotic ls, ls & calc ss.

Ammonites, pelecypods, gastropods, echinoids
"neekocerat Zone"

Timpoweap = 70-136'

(3) red brn, fine-grained ss, mudstone, and siltstone. forms ledges / box canyons. X bedding and ripple marks common. gtz grained calcite cement - ss. Thick bedded. 300-350'

(4) Red brown mudstone, claystone siltstone forms slope beneath Shinarump or smooth, rounded hilltops. weathers to form "fluted walls". Thin-bedded and fine-laminations, - some "plate beds" of purple, gray & orange. Beds, veinlets and pods of white & pink gyp. common.
313-425'

Total Moenkopi = 766-968'

environment & deposition: broad flat flood plain / tidal flat / marine. Dunal portion reworked, → marine Transg. → mud flat & marine marsh. (salt & casts found in upper members)

Chinle Formation

members:

(1) Shinarump cgl mem.
contact @ Moenkopi erosional to Xular, pronounced score channels.

It gex to yellow, red - coarse-grained, X bedded, ss, local cgl, contains log / plant frags

Arizona
members ↓

Monitor Butte

(2) middle member (3 pts)

(a) green-gray bentonitic claystone and clay ss. pet. wood common

Pet. Forest (b) red-brn, brn, gray-red, orang siltstone & fine ss

(c) ss - ledge former - some cgl. & logs common - 3 toe track / bone / teeth found in unit.

middle member contact @ Shinarump mixed to cont., grad. 255' 345' Thick

(3) Red-brn siltstone, fine ss and green-gray ls lenses 2-3 feet thick. many bone / teeth frags. 90-195'

Gul Rock
Church Rock

Chinle environment / deposition:

Shinarump's erosion & pediment @ NW flowing stream, middle / upper members: fluvatile / lacustrine, stream, X beds show flow from S.

WINGATE GROUP JR?

Wingate SS

ss, large sweeping cross bedding, sharp contact @ Chinle (Unconf.) It orgs to red brn fine ss. No fossils, thought eolian, sand transp. from NW, 320-370'

Kayenta Fm

grad. contact @ Wingate

" " " Navajo.

caps cliff of Wingate, forms dip slopes and benches.

Thin beds, white-red-ben, fine-med. ss

red-ben siltstone ~350'

Prob. fluv. origin, sand from NE.

Navajo SS

grad. contact to Kayenta.

loosely cemented, well-sorted, well rounded gtz
sand, frosted, sweeping x bedding 800-1000'
prob. basically eolian

NO FOSSILS

SAN RAFAEL GROUP JR.

Carmel Fm

forms long dip slopes on back (E) side of
reef

interbedded sss, siltss, claystns, lss & gyp-

rapid lateral Δ

unvariegated colors - gray/yellow/red/white/pink

gyp. beds 30-40'

contact @ Navajo placed at base of right ben
ss but may show up to 30' of grad. contact.

300-1000'

Entrada SS

forms valleys and low hills below more
resistant upper units.

Locally weathers to "Hoodoo" or "Rock baby" landforms
or forms "cathedral" capping mesas.

Ben and red ben, earthy, fine-med. ss
with some siltst./clayst. calcite cement.

Contact @ Carmel app. locally sharp, but grad.,
placed at widespread gypsum bed -
475-780'

Curtis Fm

Gray-yellow-green, glauc. ss @ some
siltstone, contact @ Entrada shp. (uncont.)
marked color break.

calc. cnt. 0-80'

Immerville Fm

pale brown - lt green mudstone,
siltstone & fine ss, very evenly bedded. contact
@ Curtis grad. - placed at top of transition.

Beds poorly consolidated, calcite cement.

Some gyp. Beds 1-2" thick

environment: considered marginal-marine.

~200'

end San Rafael gp.

Morrison Fm

32-15

(1) Salt Wash Member

lenticular, x-bedded, channel ss/cgl

(2) lenticular siltstone and claystone

variegated: red/gray/green/white/pink/yellow etc.

cgl. pebbles = gray chert, but also blk, green,

& red chert.

Some elongate bldgs (?) present - 2' long.

Silicified trees present.

depositional environment: broad fan-shaped alluvial plain.

30 - 236'

(2) Brushy Basin Mem.

variegated claystone, siltstone @ some ss/cgl.

color bands from few" to several feet.

clay - bentonitic - weathers "popcorn"

thin ls in upper part.

wood, bone frags & "gastroliths" common.

coarse contact gradational, placed at top of cgl.

cañon dep. considered flood plain dep. @ local lacustrine conds. Ash fall → bentonitic clay.

Great Sand Dunes, Colo

San Luis valley.

elliptical intramontagne basin 90 mi x 65 mi.

Sangre de Cristos on E

Sawatch Range - N

Taos plateau - S

San Juan mts - W

elevation - 7500' arid climate - annual precip

7-9"

Valley floor Alamosa Basin

Basin almost undissected

contains alluvium sep. by layers of interbedded ls & ft (Sante Fe Fm), possibly miocene. (?)

overlain by fresh water sed. / clay - Alamosa Fm.

- post miocene (?) - pre-glacial

alluvial deposits shifted by wind.

Prevailing wind from SW at L to Sangre de Cristos. Spring/Fall winds exceptionally strong. Periodically summer storm winds come from E/NE.

Great Sand Dunes - 40 sq mi. adjacent to Medano, Mosca, Mosca Passes & Sangre de Cristos.

alluvial depts - source

strong winds from SW

mt passes act as funnels

Dunes largest in U.S. 10-700'

sand - gatz / h. 20 heavy mins.
60-90 mesh size

Transverse Dunes - few isolated barchans
strong E winds - alter shape - roll back to SW -
movement 2-3' / wk.
SW storm - 14 feet in 32 hrs.

Sangre de Cristo

Complexly deformed Penn - Pm strata comprise
the bulk of Sangre de Cristo Mtns. up to 14,000' - contrast
w/ thin Early Paleozoic strata which underlie PE -
but more Pz beds on west side of range.

Sediments derived from Central Colo. through large
"zeugo geosyncline" - yoked to rise of "Front Range"
and "Comanche" blocks in late Pz times. Blocks
in late Pz time. Rapid subsidence - great thickness
of first-cycle, ark deposits.

Strat - conspicuous unconformity separates preponder-
antly clastic Penn/Pm from older Pz (Oz - a few)

Kerber Fm - Morrowan or early Atokan
contains oldest ~~PP~~ strata of Sde. Cresto.
rests unconf. on Miss. or older (pre E) consists
of dk, carb. or coaly sh on ss up to 300'

Deer Creek Fm.

rests on PE on Kerber gr, grn & red
ark. ss, siltstone, cgl. & sh. interbedded
with gr, ls - red beds differentiate Fm.
Kerber and overlying Madera Fm.

313-1119 ft. transition Fm. flatlike to
alt. marine & continental sands. X bedded
& cut/fill conspicuous.
- Atokan (*Fusuline* & *deuxa*)

Madera Fm Permian age

≡ @ mountain of central Colo., grey
fossiliferous LS, interbedded @ grey-green
to grey-green. Ark. ss, cgl. siltstone &
sh. 2,900 ft at Whiskey Creek pass, 3,068'
at La Ueta pass.

3 members recog. In NM line to
Huerfano PK.

Base - grey ls

Mid - Ark. ss

Top - Whiskey Creek pass LS.

Highway 160 follows Madera Fm. @ West La Ueta
Pass - folded into asymmetrical syncline but then
on west by PE, flanked on E by Anticline @ Axis
intruded by felsite stock

grey ls - 533' at La Ueta pass, cyclically
alt. beds of bioclastic ls ss cgl. fossils abundant.
ark. ss - 2369' at La Ueta - interbedded
ss, cgl, grey ls, dark sh & siltstone.

4.1 miles NE - Russell P.O.

marker - shaly ls

"Dictyoelostus bed"

19' Thick, rich fossiliferous, weathers dusky
yellow

Whiskey Creek pass LS

4.3 miles NE Russell, interbedded grey LS

and grey-green ss. 166 ft. distinguished by
content of about 20% pure oolitic ls.

Paso Creek SS

overly Madera, fault contact @ Sangre de
Cristo at La Ueta - non-fossiliferous, grey-
green to grey-green, med. dark grey and pink
ss interbedded dk. sh + 1000'

Mountain Fm

from type locality - Central Colo.

mountain extends to Sangre de Cristo
4,200' at Arkansas R. - 15 mi. S
(near Orient) 80,000'

400' - Base - non red. - quartzose,
micaceous ss.

1200' - Red, yellow, grey ss & cgl
upper ss sh ls some evap.

Sangre de Cristo Fm

Thick sequences of purdon. fluvial, red Ark.
ss & cgl, interbedded @ siltstone, or sh. and a
few thin lss. 9,600' at Whiskey pass Creek.
change to red from grey-green - marks base of
S de C.

Near Crestone - basal S de C called
Crestone cgl Mem. - 6000' massive boulders and
cobble conglomerate @ boulders up to 10' cgl contains
pebbles, cobbles - 2 ft ± coarseness

diminishes N & SE from Crestone.

max 6e in age

wolfcamp - reptile bones near Arks River
near base of Fm.

S de C overlaid by Yaso Fm. (Leonardian) in subsurface
of SW Cole)

Grand Canyon - see Grand Canyon section +
"Grand Canyon Perspectives" G.C.

Redwall LS Mr
members

above: Spai Fm (shs ls)
Kuparuk River

base: Whitmore Wash member

uniformly fine-grained dolomite (E) G.C.

even fine-grained ls (W G.C.)

Thick bedded

forms resistant cliff 100' @ ledge at top

Thunder Springs member

Thin beds/elongate lenses of chert, alt. (W)

ls/dolo layers

chert is white, opaque & porcelain like on fresh surfaces

on weathering: can be white or blk. & brown on surface

CO₂ rock between chert layers: dolomite - E G.C.

ls - W G.C.

ls/dolo layers - Thin 2.5 to 5 cm (1-2") to

15-20 cm (6-8")

Mooney Falls member

200-350'

massive cliffs

beds 3-20'

pure ls. locally dolomitic

microcrystalline to v. coarse-grained

large scale cross bedding locally.

House shoe mesa number

Thickness - 35 - 125'

Thin bedded

weathers into series of receding ledges

mostly microcrystalline ls but contains some fine grained & oolitic L.S.

some places zone of thin bedded chert lenses near base

below: Temple Butte L.S.
(2016) (Dev.)

Grand Canyon - Supai.

contact @ underlying Redwall - unconformable - Karst Surface

E-GC - alternating deep red shaly siltstone slopes separated by 3 major cliffs of fine grained buff ss mostly stained bright red on weathered surfaces.

W-GC more cliff less siltstone slopes
ledges more narrow
+ more ls / beds.

G-C - Hermit Shale

non resistant, shaly siltstone → forms bench or shelf
in W GC - shelf is very wide = Esplanade
Thickness greatly increases in GC → E to W
max 1000'

Cocconino SS G-C

clean well sorted gtz ss. - forms great red wedge across N Ariz. Thins progressively NW - tongue wedges out near Ariz/Utah boundary.

300' at Bright Angel Creek.

large scale wedge planar cross bedding - dips as much as 34°
white cliff faces

also long 11 ripple marks @
rounded crests @ A750/11 @
cliff slopes →

↓
gently curving surfaces
60-70' long
(inclined laminae)

Common dep: colian

poss. Transverse - dunes

but see Barchan locally

all hi & foreset beds dip S $\approx$ source - N

ripple marks = cross winds.

Toroweap / Kaibab Fms G.C.

composed of CO_3 sed dep during 2 Trans during Pn (middle)

BOTH Fms: 3 subdivisions (members)

(1) Gamma - Transgressive seq #

(2) Beta - maximum advance *

(3) Alpha - regressive sea @

↓ up

2 Fms sep by unconformity

* - CO_3 rock in both Fms - cliff former

* Toroweap: w G.C. - narrow L.S. thick cliff former
Brady Canyon mem. fossiliferous esp toward W bedding 2-20'
E - more Mg²⁺ rich & less massive / thick
top placed at first appearance of CO_3 - below Woods Ranch mem.

* maintains thickness thru out canyon but Δ s in composition

ls $\rightarrow$ ssy ls $\rightarrow$ ss

W $\rightarrow$ E

upper boundary: first appearance of vertically continuous carbonate unit above horz. ss
(Sellyman mem.) Torow. red calc. ss
Lower bound. first unit within horz. ss bedding of truncated colonnade

Gamma? both Fms: Thin, weak, slope forming units show evidence of reworking of under lying ss.

contact bet
"Alpha/Beta":
slope / cliff
enconf contact
Kaibab -
beneath falling
usually

Alpha - Thick (both Fms) red beds, thin residual
ss - locally gypsum beds, massive.

are regressive deposits formed as seas withdrew
westward. They form slopes of receding ledges above
The narrow cliffs of CO_3 ex that form Beta mms.

Tonto Group G.C.

↑
↓

Taupeats SS narrow cliff forming unit
Thickness 100 - 300'

chocolate brown, mainly, but in some areas gray to
cream colored to deep red brown.

ss is coarse to medium-grained; coarse particles dominate
except in pts of upper 1/2 - where med. size ges dom.

bedding conspicuous because of contrasts in ϕ of sedimentation
that cause layers to weather into alt. resistant
ledges & shallow recesses

Flat, even beds common

Cross bedding within layers from 1/2 - 2'

in many places Taupeats grades upward into the Bright
Angel though a zone of alt. coarse ss beds & green
shaly mudstones.

Bright Angel shale

mixture of liths:

mudstones / fine-grained sss - dominantly a shaly green mudstone, some of it smooth micaceous & fissile

+ dark magenta sss

gray platy siltss @ brown spots

pale greenish buff crumbly sss

sss @ concentrations of bright green glauconite.

normal slope forming topography interrupted at places by weak ledges or low cliffs formed by relatively resistant sss & siltss.

Mau L.S.

mottled gray ls forms series of resistant cliffs.

thin bedded → thicker bedded

E-EC

W-EC

between major cliff forming units are parting beds of green micaceous shaly mudstone, platy micaceous siltstones, platy silty lss & intraformational flat pebble cgl's.

entire rock sequence forms gradational steps @ underlying Bright Angel sh. - lower boundary of mau placed at base of lowest of the massive ledges of carbonate rock.

Colorado Plateau

(1) Datil Section

minor - largely volcanic

lava flows / ricks / lava capped mesas & buttes

Thick lava flows

mt Tyler Volcanic field

large # of Basalt sheets

GRANTS LAVA FIELD

Zuni uplift: PE

igneous + meta. ex exposed

at center - central core

(9000') surrounded by alt.

lowlands / valleys / crevasses / mesas on the sed. exp.

(2) Grand Canyon Section

highest, structurally

Carboniferous ex dominate at surface - except where covered by volcanics

Colorado R. divides into N & S sections: N: ^{N-S trending} plateaus bounded by series faults & flexures

S: ^{S-E trending} Colorado plateaus: faults & folds unimportant

boundaries:

S: Mogollon Rim (high scarp facing S)

E: Little Colo. R. & Vermilion Cliffs (Wingate)

N: Vermilion Cliffs

W: Grand Wash Cliffs

dominant feature:

Grand Canyon: PE → PM PY @ Ord/Si missing

Zintgral Platforms: (broad flat regions)

lowest: (1) Tonto platform: cut on top of

Tapeats, into Bright Angel shale

(2) Esplanade platform: broad bench underlain by Supai (kanab portion of canyon)

canyon steep on S side, wide on N side of River
E broad tilt of plateau N → S ≈ 30°

N rim as much as 1000' higher

4 plateaus compose ~~the~~ Grand Canyon Section.

W ↑ Shivwits Plateau
Unikaret Plateau
Kanab Plateau
E ↓ Kaibab Plateau may ele. 9000'
+ volcanics
major structural feature: Kaibab monocline
2-5000' relief (struct.)

to S broad flat plateau cut on Coconino SS -
San Francisco Plateau & Coconino Plateau 7000-7500'

some gently rolling topography
Coc. - just S of G.C.
volcanics unimportant
SF Plat - rest

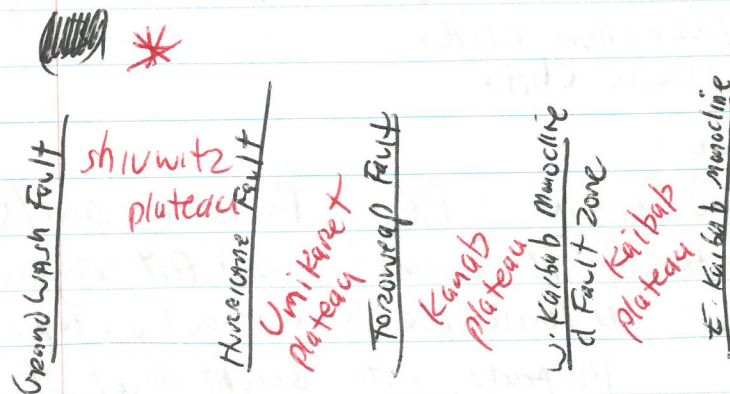
only breaks in S plateaus: (1) San Francisco Peaks.

(2) Meteor Crater

pyroxene (oesite) - ~~is~~ ^{is} P SiO₂ polymorph

only natural occurrence = meteorite impact

age - ~ Tahoe Glacial stg ~ 40,000 ybp.



(3) High Plateau Section

Transition between B&R & these Colorado plateaus? char. by complex faults/folds
Fault/Foldline scarp + grabens = B&R.

These differ from N G.C. plateaus:

(1) higher 9-11000'

(2) aligned N-S

(3) underlain by rex of Mesozoic/Cenozoic, not Paleozoic (younger)

3 strips: trending N-S

Westernmost Strip:

S to N: Markagunt, Tushare, Paria, Gunnison

Middle Strip:

Paria, Sevier

Eastern Strip:

Aquarius, Anasazi, Fish Lake, Wasatch

* $\div$ Depression: Sevier - San Pete Valley (Sevier Fault)

Grand Valley (also fault controlled) + Paria Fault.

⊗ western boundary of High plateaus: portion of Hurricane Fault.

Ascent from G.C. to highest of high plateaus = series of S facing cliffs, named by color: (distance = 40-50 miles)

South: each developed on resistant geol. fm.

South: Chocolate Cliffs - Shinarump F

Vermillion - Kayenta/Wingate F

White - Navajo SS F

Gray - K SSS

North Pink - Wasatch, Eocene

(4) Uinta Basin Section

E-W asymmetrical syncline

5000'

Structurally lowest pt. of Colorado Plateau Province
both in & topographically a basin.

ROCKS mainly Paleocene/Eocene

" lake & river delta deposits (continental)

Borders: N: Uinta Mts

W: Wasatch Mts & High Plateaus

E: White River Plateau & West Elk Mts.

SE: Uncompahgre Plateau

S: double escarpment 3000' ↓ to Canyonlands

(1) upper 2000' cliffs
= Pink Cliffs Eocene

(2) Book Cliffs K
Gray =

Green River shales - Eocene

oil
Badland topography developed central pt. Uinta Basin.

(5) Navajo Section

= high as Canyonlands, less dissected, poorly defined
dry washes characteristic.

scarcity of deep canyons -

arid: only San Juan River is permanent
stream.

not as deformed as adjacent areas: so mesa, buttes,
cuestas, rock terraces more common than hogbacks
/homoclinal/ ridges.

Borders: W: Little Colo. R. / Echo Cliffs monocline

3 major structures: (1) Black Mesa Basin - W

90 miles dia. Pn-Tec - Black mesa - capped

by K marcos sh & mesa Verde SS

(2) De France uplift - syncline N

trending asymmetrical fold - E: De France monocline (Pn-K)

Features: [Painted Desert (E of Echo Cliffs)]

(3) San Juan Basin

E side of De France uplift - small Navajo section

structural depression of ~ 5000'

Ter fill of Rock House

(2) volcanic necks esp.

& " dikes

(4) lava flows

(5) pyroclastic debris

Navajo-Hopi Volcanic Field

(6) Canyonlands Section

boundaries: W - High Plateaus
N - Book Cliffs
S - San Juan R.
E - San Juan mts + Rockies

structures: local upwarps
monoclines on flanks upwarps
salt structures IP
circular uplifts (intrusions)

topography: hogbacks, monoclines/ridges, creosols
incised meanders (esp San Juan R.)

Canyons are more numerous / extensive than anywhere else in
Colo. Plateau.

Marble Canyon

Glen Canyon

Cataract Canyon

Labyrinth Canyon (Green R.)

Canyon of San Juan R.

main streams: Colorado R.

Others: San Juan, Green, Gunnison, Dolores, San Rafael,

Rusty Devil, & Escalante

features: (1) San Rafael Swell
NW corner of section

asymmetrical anticline 50 x 100 mi. trends NE
dips: NW 4-5°

SE 85°
Rocks P → (Hermosa Fm) → JR - Navajo - main
resistant Fm.

(2)

monument upwarp

only to E Karab uplift in structural relief
asymmetrical @ steepest dips on E side ^{hogbacks} 50° - W side 2°
best exposure - canyon of San Juan R.
P → Pn rx - most surface: Pn
& Te JR

(3) Henry mts.

"laccolithic mts" - actually the major doming was
produced by small stocks - laccoliths present on
flanks

Henry mts uplift - NW-SE direction - near center
of broad regional basin = Henry basin.

each of Henry mts is a structural dome 6-10 mi dia
at center of which is a stock + radial drainage

(4) Paradox Salt Basin

SE Utah / SW Colo

lies W of E 11 to Uncompaghee Plateau
forms rectangular tract 150 x 60-70 miles

La Sal (laccolithic mts) lie near center of basin -
most of features all related to flowage/solnot
salt/gypsum.

structures: anticlines/synclines

pierced by:

Paradox Esc. member of P. Hermosa.

anticlinal structures: "valleys" - Salt, Paradox, Gypsum
Valleys incl. collapse features
synclines betw = flat topped mesas

(5) Upheaval Dome

lies in & between juncture of Colorado & Green R.

conical dome surrounded by ring syncline
2 mi wide $\nearrow$ 1/2 mi wide

center Pt. Cutler $\rightarrow$ J. Navajo (am)
(white rim ss rim)

outward dips range 30-90°
commonly 40-60°

inward dip - syncline: 15-30°

prob. salt dome - true prokeros: cryptovolcanic structure

Sierra Nevada

massive fault block 400 mi long x 40-80 mi wide
down tilted to W.
may not be that N

Sierra Nev uplift terminates S at junction of Garlock
& San Andreas Faults.

n. end of Sierra Nevada - abrupt - older rx of S. Nevada
disappears beneath volcanic rx of Cascade Range &
Modoc Plateau.

Rx are mostly plutonic - "Sierra Nevada Batholith"
(mesozoic)
not single batholith but represents several
intrusions of rx of varying composition occurring
over a fairly long geol. timespan.

Resting on the xline ^{esp W} are scattered patches of
Cocene fluviatile sands, Quaternary, Pliocene, Miocene
volcanics, & Quat. glacial deposits/alluvial gravels.

esp. N - small areas of meta-sed/meta-rg rx - of
Paleozoic/mesozoic ages forming inclusions, root
pendants, and screens on batholith. These rep. rx
intruded by the batholith - what is left of them.

slates/phyllites/graywackes & lavas/tuffs

Algozoll: prob. mainly Miss

on flanks Sierra Nevada rx = Si/Oval rx

mesozoic: slates, graywackes, volcanic rx of T₂ JR

Pure older rx meta. during Neovadan Orogeny late Jr
early K. → folded mts - the rx are remnants of these
mts.

Sierra Nevada very asymmetric E-W profile -

↗ abrupt E front, steep
more gentle/longer W back slope - av grad 100'/mi - 2°-3°

Rises higher above immediate surroundings than any other mt front

in U.S. as much as 11,000' relief

front is Fault scarps

structure thus like BAR - but not in that province - on
basis of sheer magnitude.

Uplift of Sierra Nevada -

prob. T₂/Quat. time - in standstill/uplift
cycles.

San Diego Area & N (from narrow belt)

W side peninsular Ranges - narrow strip coastal/
lowland. - cut into these rx (K, T₂) are
Marine Terraces esp La Jolla, San Diego,

3 Terraces recog. N of San Diego R.:
highest Poway 1200'
↓ Linda Vista 300-500' (inland) @ Beach ridges
lowest La Jolla

S. San Diego River:

<u>name</u>	<u>altitude range</u>
OTAY	430-325'
SUB-OTAY	425' ~
Avonsdale	200-250'
Chula Vista	100-130'
Nestor	25-100'
Tijuana	20-50'
modern Coastal Flats	0-20'

Peninsular Ranges Calif.

elongate ranges and intermontagne valleys whose trends
are controlled by various faults, branching off
|| to San Andreas Fault.

Ranges/valleys terminate N by Transverse Ranges

These mts are the N extension of a longer range
existing in Baja, Calif.

Most important of individual ranges:
Santa Ana, San Jacinto, Santa Rosa

Province: uplifted / westward tilted plateau which has
been broken into several large elongate sub-
parallel blocks by major faults that trend NW

The faults are active, late Cenozoic but independently.

Within ranges are numerous basins / valleys - grabens.

Rocks: igneous, meta-sed., meta-ig. Mesozoic / Paleozoic, but K & Cen. marine / non-marine sed rx
are present along ocean.

Peninsular Ranges: simplified: large K batholithic
mass, now badly broken by faults, that was intruded
into a series of slightly older meta-morphosed sed.
rx & volcanic rx.

Salton Trough section B&R Province SE Calif.

wedge shaped depression from Gulf of California (S)
to San Geronimo Pass (N).

structure: complexly faulted graben.

topography: basin bounded by:

W: Peninsular Ranges

N&E: San Bernardino Mts & Chocolate Mts

port below S.L. 85 x 30 mi.

lowest elevation - 273'

divisions: N ↓ Coachella Valley ← thickness of sed
Salton Sink → ~20000'
Imperial Valley ← (seismic)
Colorado R. Delta.

palaeolake: Lake Cahuilla - shore line 40-50' above
S of Imperial Valley, Salton Sea, & S pt. of
Coachella Valley.

Esate Imp valley: Algodones Dunes = brackish water
(40 miles x 3-6 miles) Lake Cahuilla

possibly the lake was maintained by Colo R. discharge
into Salton Trough previous to its discharge into
Gulf of Calif, as at present (sic)

present Salton Sea formed by Colo. R. floods between
1904 & 1907

Richard Johnson
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To: Staff and Graduate Assistants

From: James L. Eades

Subject: Quarter

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rock hammer
lenses(5)
② 1/2H
② Ray pack

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