Course material from Geology 130 - Physiography of the US - 2. 1940-1954

Thwaites, F. T. (Fredrik Turville), 1883-1961
[s.l.]: [s.n.], 1940-1954

GEOLOGY 1 30
PHYSIOGRAPHY OF WESTERN UNITED STATES

Final examination 11 June 54

Write on 10 only and please indicate which you left out. Leave postcard for grade

(1) Describe the origin of the features of Puget Sound including both the major and minor forms such as the shoreline.

(2) Describe not less than three lines of evidence which indicate that faulting and other earth movement is still in porgress on the Pacific coast.

(3) Compare tow theories of origin of the gorge of Columbia River through Cascades

(4) Give two arguments for and three against the importance of wind erosion in Basin and Range province

(5) Give three evidences of the ability of Colorado River to erode the Grand Canyon and ~~xxx~~ two alternative ideas some suggest for its origin.

(6) What three different types of mountains occur in Columbia Plateau giving and locating examples of each

(7) Show with diagram-corss section the relation of the upland surface of Southern Rockies to Colorado Piedmont and High Plains

(8) Compare three different hypotheses of crossing of Uninta Mountans by Green River.

(9) Give two possible explainations of the topography of mountans of central Idaho.

(10) Describe the terraces along the rivers of Missouri Plateau and two possible explanations of their cause.

(11) Explain with diagram the bearing of Boston Mountans of erosional history of Ozark Plateau giving at least two hypotheses

(12) Outline in roper order the evenets of history of topography of Ouachita Mountans

(13) Give in proper order the major steps in development of topography of Sierras in vicinity of Yosemite Valley

(14) Locte as definitely as possible and tell briefly ORIGIN of: (a) Break of the Plains, (b) Devils Tower, (c) White River Badlands, (d) Bitterroot Mountans, (e) Mt. Shasta, (f) Dominguiz Hill, (g) Henry Mountans, (h) Lewis Range, (i) St. Francis Mountans, (j) Olympic Mountains.

Laurentian upland of low hills and many lakes

L. SUPERIOR

L. MICHIGAN

L. HURON

L. ERIE

L. ONTARIO

Georgian Bay

THE LAURENTIDE NATIONAL PARK

LONG ISLAND

Apalachee Bay

THE EVERGLADES

Map of the
LANDFORMS OF THE UNITED STATES

to accompany Atwoods "Physiographic Provinces of North America"
Prepared at the Institute of Geographical Exploration
Harvard University, Cambridge, Mass.

by ERWIN RAISZ
1939

Scale 0 50 100 150 200 Miles
0 100 200 Kilometers

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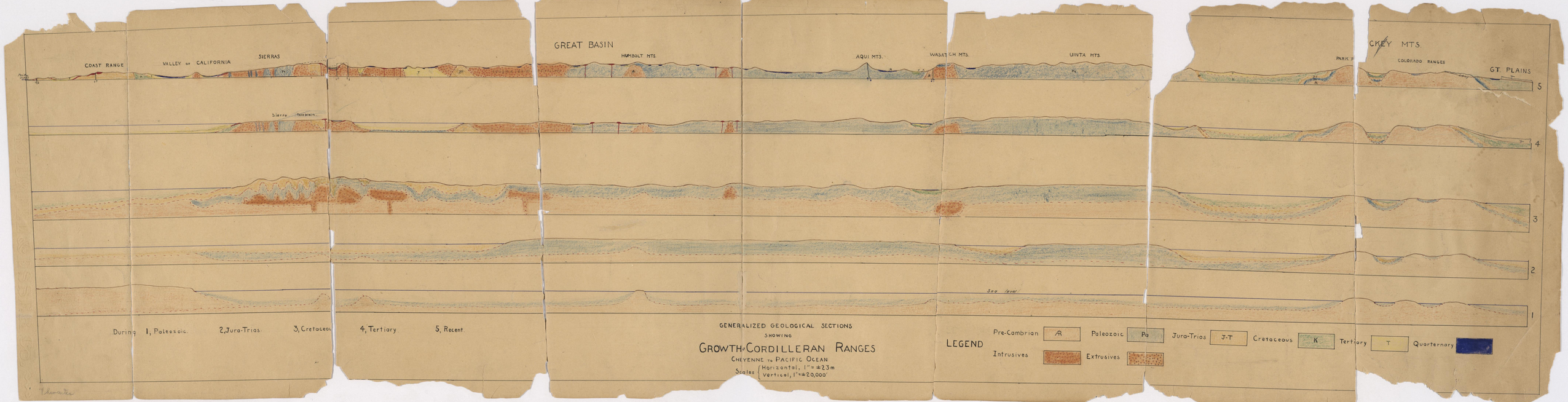

COAST RANGE
VALLEY OF CALIFORNIA
SIERRAS
GREAT BASIN
HUMBOLT MTS.
AQUI MTS.
WASATCH MTS.
UINTA MTS.
PARK R
CKEY MTS.
COLORADO RANGES
GT. PLAINS
Sierra Nevada
Sea level
5
4
3
2
1
During 1, Paleozoic. 2, Jura-Trias. 3, Cretaceou 4, Tertiary. 5, Recent.
GENERALIZED GEOLOGICAL SECTIONS
SHOWING
GROWTH OF CORDILLERAN RANGES
CHEYENNE to PACIFIC OCEAN
Scales { Horizontal, 1" = ±23m
Vertical, 1" = ±20,000
LEGEND
Pre-Cambrian A
Paleozoic Pa
Jura-Trias J-T
Cretaceous K
Tertiary T
Quarternary
Intrusives
Extrusives

Ozarks 631-647

Definition:

Plateau rising above adjacent lower country and composed of nearly horizontal sedimentary rocks

Boundaries:

E. Mississippi alluvial plain with small area E. of Miss R. of Devonian rocks in "Little Egypt"; to N. Miss. River
N. Missouri River which is approximately at border of thick drift except follow drift border SW of St. Louis
W. Edge of Mississippian rocks little topographic contrast except to the SW in Oklahoma where there is a distinct rise
S. S. edge of Boston Mts. topographic and not geologic line

Geology

Mainly carbonate rocks, dolomite + limestone
Structure: dips average only 10 f/m to west but up to 75 f/m to E. dome steeper to E. Rocks nearly level but faulted, few local folds

Pennsylvanian (mainly in Boston Mts.)
Pottsville ss, sh
Morrow sh
Mississippian
Lime, shale, ss to east
Boone chert
Lime and shale
Devonian
Lime and black shale
Silurian
Lime
Ordovician
Lime - Platin = Galena etc.
St. Peter ss
cherty dol. = our Shakopee
Sandstone, Roubidoux = our New Richmond?
Cherty dolomite = Lower Magnesian or Oneota
Cambrian
Dolomite and shale= our Trempealeau, Franconia, Dresbach, Eau Claire
Sandstone = our Mt. Simon
Pre-Cambrian
granite, porphyry in St. Francis Mts. and Spavinaw, Okla.

Topography

General; dome form up to 1700 ft except Boston Mts. about 2400
Radiating drainage except Osage
2 story valleys, many of them meandering. Gentle on uplands, gorge-like below
Karst and springs, natural bridges
2 types of meanders, ingrown and entrenched= record of rejuvination
Cherty soils
St. Francis Mts= exhumed pre-Cambrian mts like Baraboo
Superimposed stream valleys leaving "shut ins."

Salem platform or plateau
= Ordovician upland including some younger rocks

Cambrianto Mississippian with some outliers of Pennsylvanian

Topography
Upland broken by low sandtone cuestas
Highest hills= Boone chert
Solution features
Valleys 300 - 500 ft more abundant to S. in White River basin
Escarpments
Avon where Bonterre dolomite overlies Lamotte ss in St. Francis area
Potosi where lowest chert dolomite overlies Cambrian shales
Crystal where dolomite overlies St. Peter ss
Burlington = edge of area at border of Mississippian

Springfield platform or plateau

= top of Boone chert
leastprominent toward north because formation thins
to S forms a platform along N. side of Boston Mts.

small outliers of Pennsylvanian
solution topography

Boston Mts.

Pennsylvanian strata including sandstones
Elevation to 2250

Level summits slope to S down to Arkansas Valley dip slope
with local fault or monocline

Summit level not all same formation dissection submature

History
2 Dep of bed rocks with erosion intervals
3 Doming prior to erosion after Mississippian
4 Dep. of Pennsylvanian across eroded dome
Erosion
5 6 Is the Salem-Springfield surface an uplifted peneplain?
If so what relation has it to summit of Boston Mts. ?
How could the Bostons survive peneplaination?
Is this surface the ressurected pre-Pennsylvanian surface?
Do the entrenced meanders indicate recent uplift?
Dakes view that two surfaces coincide

663-676

Ouachita (pronounced Washita)

Definition= belt of folded sedimentary rocks similar to Ridge and Valley but west of Mississippi embayment

Boundaries
N. includes Arkansas Valley to foot of Boston Mts.
W- straight line from Muskogee-Atoka
S = border of Coastal Plain
E = border of Coastal Plain

Subdivided into Arkansas Valley and mountains proper
boundary along Poteau R and Petit Jean Cr.

Geology
Cambrian through Pennslvanian sediments

Pennslvania n
Shale with resistant Savanna ss
Hartshorne ss
Jackfork ss very thick and important
Hot Springs ss

Devonian
Arkansas novaculite important
Silurian
Slate with Baylock ss

Orodovician
Shale and chert with Crystal Mt. ss

Cambrian shale

Intrusions of syenite of Cretaceous age. Magnet Cove

Structure very complex with much overturning of folds. Thrusts recognized more commonly in Oklahoma than in Arkansas

Topography
Arkansas Valley
Synclinal mts or mesas, flat tops, 1800-2800 elev.
monoclinal ridges like R and V in miniature
streams in alluvial valleys
Ouachitas proper
Curved ridges with subuniform elevations of crests elev. related to thickness of resistant rock Highest in middle of district decreasing to about 250 ft. at margins

676-689

Ouachitas, final

Novaculite = major ridge-former of central area lies close to Hot Springs ss;
Also Crystal Mt. ss

Basin of Magnet Cove on intrusion

Athens Plateau on Stanley shale and Jackfork ss
Relatively low with even skyline
Valleys to 350 ft. deep have entrenched meanders
Average slope only 20 ft/m compared to 80 ft/m of buried extension beneath Coastal Plain

History
Relation to Appalachian folding
Time of deformation late Pennsylvanian later than the disturbance of Arbuckles
Erosion to lowland surface - evidence the relief of the buried portion
Time prior to Upper Cretaceous (although much was done prior to Lower Cret.)
Jurassic concealed and disturbed with Lower K.
What relation has projection of base of Upper K to mountain tops?
Projection of base of Lower not justified-too much earth movement since
See A. A. P. G. Bull. 22: 953-982, 1938 and 27: 1407-1583
Relation of peneplain to deposition of limestones
Is conclusion that tops of mts = peneplain justified? Alternatives:
(a) Is the subequality of level normal result with this type of geology?
(b) Were the ridges one evened up and then lowered parallel?

Deposition of Coastal Plain- former extent, why no outliers?
Explanations of drainage
3 Radial from uplifted superpeneplain
4 Radial from uplift of Coastal Plain
2 Capture ?
1 Antecedent from prior to folding?

Erosion to Hot Springs level or lower story = Athens Plateau
Does this represent a halt?
Or does it show parallel lowering of an older peneplain on softer rocks?
Or is it natural divide level on weaker rocks?
Relation to sediments of Coastal Plain? to Ozark uplift?

Uplift and subsequent erosion in part supported by entrenched meanders

Great Plains 1-16

Definition High area of relatively low relief, monotonous landscape, short grass

Boundaries
West, foot of mountains
North, international boundary
South, same
East-various lines suggested.
Rainfall
Soil change from accumulating carbonate to decreasing carbonate
Pedocals vs pedalfers Long term average. Cuts across obvious Coastal Plain in S, and in N. extens to E side of Lake Agassiz + S. Dakota
Elevation lines
Escarpments, works well except in Nebraska where use border of glacial drift North part = E edge of plateau or Coteau du Missouri S Dakota = west slope of James valley
from N. line Kansas on escarpments prominent, especially where coincident with a bed rock escarpment

Subdivisions
High Plains or area of outwash from the mountains
Plains border= transitional rough country just E of High Plains
Colorado Piedmont= area where High Plains have been eroded away at foot of mountains
Raton Section= high mesas and canyoned plateaus often confused with mountains
Missouri Plateau = high area N. of High Plains divided into
glaciated Missouri Plateau
unglaciated Missouri Plateau
Black Hills
Pecos Valley similar to Colorado Piedmont
Edwards Plateau = high limestone plateau faulted against Coastal Plain
Central Texas area similar to Plains Border

1954
High Plains
Definition= area of slightly eroded outwash flats or alluvial fans

Boundaries
W= foot of mountains etc
E = E facing escarpment, Break of the Plains
N= Pine Ridge escarpment
S = edge of the outwash deposits

Geology
+52 Late Tertiary clay, sand, gravel resting on irregular surface of consolidated rock, up to 500 ft? thick
Some Pleistocene dunes and river terraces caliche or limestone top loess mantle

Topography
Extensive interstream flats with minor hollows or buffalo wallows some lakes mirage problem dune topography dunes mainly fixed.

16-3x 37 Monday

High Plains, cont.
Topography
flat, surface of accumulation altered by settling, wind erosion, water erosion along gullies and through streams — width of gullies - are streams aggrading?
buffalo wallows
sand dunes now mainly fixed,
lakes, potash, mirage problem
loess plains 100'+ source of dust - gang plank - residual area of H.P.
erosional surfaces in N.; part
Goshen Hole=spring sapping

Plains border
Definition, rough area of hills and cuestas from which Tertiary has been eroded

Boundaries= E. = province border along Dakota ss Smoky Hills,
W. = eroded margin of High Plains Tertiary
N= N. edge Republican Valley in Nebraska
S = tapers to point S of Red Hills area

Geology
Cretaceous and Permian sedimentary rocks
Pleistocene sand of Great Bend region + some Tertiary

Topography Break of the Plains
Rough with cuestas on Cretaceous lss and Dakota ss (Dakota) Smoky Hills, Blue (Benton) Hills, etc.
Very rough on Permian red beds
Sink holes due to salt solution
Red Hills- gypsum
Great Bend lowland 50 m across with no escarpment Arkansas R held up by Flint Hills to E.

1454
Colorado Piedmont
Definition= area from which latest Tertiary is absent locally lower than High Plains farther E.

Boundaries
W = foothills
N = edge of late Tertiary along Col-Wyoming border Neb.
E. = edge of late Tertiary
S. = border of higher rocky Raton section

Geology
Cretaceous and early Tertiary sediments
shale and limestone (some ss) and Pocene conglomerate

Topography = valleys of S Platte + Arkansas
Erosional with many lake basins ascribed towind
Tepee buttes due to lime concretions in shale
Some dunes
Problem: what caused the erosion of Tertiary mantle here?
Uplift? vegetational difference? original slope? Climatic change?

Raton section

Definition= high mesas + volcanic peaks. Area of high relief often confused with true mountains

Boundaries mainly fixed by elevation, also by lack of Tertiary cover

Geology

Pleistocene and Recent lavas
Tertiary gravel(under lavas in part)
Eocene sediments, coal bearing
Tertiary intrusives
Cretaceous sediments including resistant Dakota ss
Jurassic red beds
Permian red beds | New Mexico map calls some of this Triassic

Topography

Mesas, buttes and volcanic cones, not true mountains
Dissected plateaus
Unroofed intrusion of Spanish Peaks with radiating dikes
Las Vegas
Las Vegas
Rxxxk and Chaqua qua plateaus = stripped Dakota ss.
Park Plateau = Eocene formations
Higher mesas including Ocate lava-capped
Deeper valleys reach red beds

History

Erosion of the sedimentary rocks
Surface = level of High Plains, combined erosion and deposition now called a pediment instead of peneplain pediplain
Subsequent erosion with continued vulcanism
Lower pediment terraces
Diversion of head of Cimmaron to Canadia n

P ecos section

Definition= valley of Pecos River at foot of highlands to W.
+ Canadian Valley at N.

Boundaries

Highlands to west
Las Vegas Plateau to N.
High Plains to E. (Llano Estacado)
Stockton Plateau to S. narrow gorge outlet through limestone

Geology

Sedimentary rocks, ss, sh, gypsum, almost horizontal
mainly Triassic red beds some older including limestone on W.(Permian)
1949
Wxxxidaxxaidax Outliers of Cretaceous
Some outliers of Tertiary sediments
Much Pleistocene alluvium and sand dunes

Topography

Uneven, terraces, mesas, canyons except flat on alluvial fill
Extensive dune areas on E.

Edwards Plateau

Definition= high limestone plateau S of High Plains

Boundaries: N. edge of mountain outwash + escarpment on Edwards lime
W highlands W of Stockton Plateau
S Rio Grande Valley
E. Balcones escarpment "mountains"

Geology

Lower Cretaceous -mainly limestone, nearly horizontal
series of faults along Balcones zone

Topography
Outfacing escarpment except W and NW.
Elev. 4000 down to 1000 ft.
Edges dissected
Some plateau upland even near Austin
1000 ft canyon of Pecos
Upland shallow draws or grass valleys- sink holes
Marginal valleys tap springs Narrow V shape at heads,
flat bottoms below springs of Balcones zone

Central Texas
Definition+ area including much rough land, high mesas, etc. N of
Edwards Plateau, S of typical Central Lowland

Boundaries
S escarpment of Edwards lime
W same
E Balcones escarpment
N border of high meaas of Callahan Divide, Brazos R.

Geology
pre-Cambrian granite, gneiss, schist
Paleozoic sediments include some resistant Pennsylvanian ss
some Cambrian ss and ls
Permian of Colorado valley
outliers of Lower Cretaceous limestone

Topography
Comanche Plateau submaturely dissected
Balcones escarpment on E.
Elev top 1800 -800 ft.
W side deeply eroded
Merges on N. into Grand Prairie where altitude is less
S. margin = Colorado R.
Outcrop of Trinity sand on W. = Western Cross Timbers
Callahan Divide
between Colorado and Brazos Rs.
Cross timbers at base of mesas
Colorado Valley
rolling prairie included beause of hills to N.
Llano or Central Mineral District
Basin with isolated mountain remnants mainly Paleozoic
pre-Cambrian less resistant than sediments
pre-Cambrian faulted up then worn lower than sediments

Central Texas, cont.

Palo Pinto district
area of Pennsylvanian rocks W of Comanche Plateau
mesas and canyons

General-many entrenched meanders which date from formation of upland surface now uplifted.

Missouri Plateau
Definition+ area N. of Pine Ridge escarpment

Boundaries
N. Canadian line
E. province boundary
W. same
S Pine Ridge

Geology
Everything from pre-Camrian to Pleistocne including volcanics
pre-Cambrian granite, etc.
Paleozoic sediments includes Madison lime, Mississippian
Ls and ss of Missi Permian
Triassic red beds
Dakota ss and overlying shale and ss
Early Tertiary ss and clay, lignite bearing
Tertiary intrusives and volcanics

Glacial drift

Topography-general
Erosional topography including isolated mountains
Diastropic= B lack Hills
~~Little Rockies~~
Big Snowy
Volcanic= Highwood
Bearpaw+
Intrusives Judith
Sweetgrass

Crazy = part of Rockies and are intrusions!

Unglaciated section
Defintion= area s of drift
Geology see above
Topography
Series of terraces and a lluvial areas
Aldens series-Cypress highest, oldest
Flaxville or No. 1
No. 2
No. 3
Terraces converge eastward
Erosional areas-slag capped buttes
badlands nature, location, cause

72-91

Missouri Plateau, glaciated
definition
boundaries

Geology
Age of drifts disputed. Effect of dry climate on criteria of age.
NE border at edge of Tertiary ss

Topography
Morainal area of the Coteau du Missouri
Ground moraine and other moraines to N.
Lake Souri basin

Black Hills
Definition
Boundary
Geology
Pre-Cambrian granite, gneiss
Cambrian ss
Permian ls, ss Triassic red beds
Dakota ss
Tertiary intrusives
Pleistocene gravels
Some structure, steeper dips to E.
Topography
2 major hogback ridges Limestone Plateau
Race track
central area granite peaks
Radial drainage evidence of capture
Laccolithic mountains
Gravel fans

History
1 Dep. of marine strata
2 Uplift and erosion to low but not peneplained surface
3 Deposition of earlier Tertiary evidence of climate, streams could no longer carry material to sea
Age of Cypress Hills surface? Eocene coals, lignites
Causes of sucessive alternations, climate vs uplifts
Relation of terraces to glacials or interglacials
Problems of correlation
Relation to inwash-outwash of Nebraska
4 Ages of glaciation
Formation of Missouri River
Glacial stream diversions-Shonkin Sag. etc.

Cypress Hills-preglacial ???
Flaxville-Aftonian
No. 2- Sangamon Yarmouth
No. 3- Sangamon

92-117

Southern Rockies

General division of system into
Southern-Wyoming Basin- Middle-Northern

Southern Rocky Mts.
Definition-ranges between southernmost distinct folded mts
and the much lower Wyoming Basin

Boundaries
E= plains
N= lower area largely covered by Tertiary strata
W= Colorado Plateau, horizontal strata
S= pass along Santa Fe Rr dividing folded rocks from mesas

Geology
1 P re-Cambrian core, granite, gneiss, etc.
2 Paleozoic and Mesozoic strata, sedimentary, all folded
several firm sandstone formations through Cretaceous
3 Cenozoic- largely unconsolidated, alluvial formations and glacial drift
4 Igneous rocks both intrusive and volcanic, Tertiary
mainly in San Juan Mts.
Structure, each range an anticline Many faults
folded at end of Cretaceous

1954 Topography
Hogback foothills, Dakota, Fountain, etc. Some are gypsum ridges
Upland or peneplain- is there more than one surface? relation to Tertiary
Mountains above general upland
Gorges in edges of upland Names of several ranges
White R plateau
W Elk mts volcanoes + laccoliths

History Front Ranges
Upheaval at end of Cretaceous=Laramide Revolution
Erosion-problem: are uplands true peneplains or are they pediments?
1951 What is age relation? What is relation to alluvial deposits?
What is cause of several fillings and erosion intervals? Uplift?
Climatic change?
Erosion of Pliocene fill during Pleistocene; erosion of gorges canyon
Glaciation, why mainly on east sides
younger alluvial fans in Piedmont

117-132

San Juan Mts region See Prof. Paper 166

Definition= ranges W of San Luis Valley and S of Gunnison valley

Boundaries= see above

Geology*

pre-Cambrian granite, schist, greenstone, quartzite
Cambrian quartzite
Mississippian, Devonian limestone
Pennsylvania n, Permian sediments
Triassic-Jurassic red beds
Cretaceous Dakota ss and overlying shales etc.

Tertiary volcanics, rhyolite, andesite with interbedded gravels

Quaternary drifts and some volcanics

Topography-
Asidefrom the Needle Mts. which are like eastern ranges except more rugged= high dissected plateau of volcanics

Relief 2000-4000 feet
Heavily glaciated
Extensive recent landslides

History
late or post-Cretaceous folding
Prolonged erosion to surface of low relief-peneplain vs pediment
Cover of Telluride conglomerate demonstrates latter Exhumed pene. in
3 stages of vulcanism separated by erosion intervals Needle Mts.
Erosion to subdued surface with many residuals-peneplain vs pediment
Gravel cover of lower slopes demonstrates latter
Erosion a nd gla ciations. 3 stages known separated by erosion intervals
Landslides and rock streams of present

Parks
Definition= treeless low areas
North-Middle-South-San Luis Valley

Geology-pre-C ambrian to Quaternary or Recent
South Park older rocks
North and Middle, Tertiary fill in syncline
San Luis Quaternary and Recent alluvium and fans, dunes
Volcanics
Topography
Drainage to outside through canyons-Middle to W. San Luis to Rio Grande
Erosional topog in north including Rabbits Ears Range of volcanics
San Luis = alluvial surface

1 33-149

Wyoming Basin

Definition= area between higher ranges to N and S where folded rocks are in large part concealed under Tertiary

Boundaries wholly topographic, two openings to Great Plains and to Colorado Plateau are crossed by distinct uplifts

Geology

Pre-Cambrian, granite, etc.

Paleozoic, Mesozoic sediments. Note red beds of Triassic, Jurassic Mesa Verde and Dakota sss of Cretaceous Mississippian or Penn. ls

Tert iary- non-marine, clay and sandstone, youngest = Bishop conglomerate
local volcanics - Leucite Hills Elk Head Mts

pre-Tertiary is folded and axes trend toward NW

Topography

A basin which might in s ome ways be considered an embayment of Great Plains

More disturbed than most of Plains.

Erosional topography. Not all basins are structural, some are eroded anticlines

Drainage disregards uplifts to very large extent.

Important uplifts: Rock Springs anticline eroded into Baxter Basin
Axial Basin

Structural basins Great Divide on red beds
Shoshone

Low escarpments on firmer rocks Many wind hollows including Big Hollow near Laramie

Hogbacks near uplifts

Badlands on clays

Part of area has interior drainage due to aridity
alkalie lakes, soapy water

History

Laramide folding

Erosion and concurrent filling of depressed areas ending in Bishop conglomerate-pedimentation of adjacent mountains Fill led to superposition of drainage over lower uplifts

defer problem of Green River which flows across high mountains.

post Bishop erosion in stages correp ponding to glaciations of adjacent mountains

Middle Rockies 150-165

Definition: a ranges between Wyoming Basin and volcanic plateau of Y N.P.

B oundaries- E= Great Plains include the Big Horn Basin
N= Yellowstone River valley N of Park, volcanic plateau included
W= Columiba Plateau lavas and enclosed basins of Basin and Range
Problem: should we exclude the N-S ranges from Tetons S with Great Basin even if drianed to sea and free of alluvial fill in valleys?
S= lower ground of Wyoming Basin

Geology
Pre-Cambrian granitic cores of ranges
Folded sediments. Mississippian limestone important-phosphate rock
Tertiary land deposits including lignitic rocks- slightly disturbed - up to 9000'
extensive volcanics and intrusives
Pleistocne glacial drift

Topography
Major ranges such as Big Horns, Wind R. Gros Ventre, Unita= anticlinal uplifts
Tetons and many of the Wyoming-Idaho ranges= fault blocks
Upland volcanic plateaus, Absorakas, Yellowstone (latter less eroded)
Basins= synclinal areas, Big Horn, Jackson Hole, etc.
Uplifts much like southern ranges with glaciated residual peaks
Subsummit peneplain or pediments - remnant plane? - some T. on lower ranges
Canyons, foot hills, flatirons anticlinal valleys
Plateau topography, flat summits, mesas, canyons - live water effects, capture of Y.R.
Basin topography, flats, terraces, pediments, alluvial fans,
capture of Greybull R by a smaller stream with less gradient
becuase carrying finer debris
capture of some rivers crossing Big Horns? - Pryor gap - Shoshone diverted by Big Horn
Tatman level 1190= Cypress =preglacial
Polecat-Mesa, 625, 450= Flaxville = Aftonian
Roberts 200= No. 2 = Yarmouth
Emblem-Powell, 110-80= No. 2
Red Lodge-Cody 20= No. 3=Sangamon

1952 1945

History Big Horn Basin, G. S. A. 48: 813-894
Basins formed by Laramide revolution mts. too low to catch rain
Change to aridity by late Eocene due to mountain uplift
Fill led to superposition of streams -formation of subsummit pediments
No mid-Tertiary low level of mts. possible because of climate, sediments
Change to erosion, climatic change or uplift
Conflict of paleontological evidence with that of southern Plains
possibly fill completed earlier and erosion began sooner in N.
development of pediments, weathering vs lateral planation
relation of terraces to pluvials associated with glaciation to N.

Middle Rockies, cont. 166-182

Wasatch range
Evidence of faulting on west side tri. facets
Tetons
Uintas
Geology-pre-Cambrian quartzite
Topography. Hogbacks - underlain mus. qtz.
gorge of Green R. - Canyon of Ladore
Browns Park -
Glacial cirques,

History
Laramide folding
Tertiary filling and pedimentation In Uintas Gilbert Peak and Bear Mt. pediments. problem of age called peneplains in older reports
Green River problem - older students called antecedent, objection.
Superposition on fans, objection - ~~Capture objection~~
Capture aided by Tertiary faulting - tilting of pediments - objection
2 later interglacial pediments See Prof. Paper 185, p. 163.
History of Wasatch see G. S. A. 55: 819-894
1 Laramide folding and thrusting mts still low
2 Erosion
3 Deposition of Eocene Wasatch conglomerates etc. - change to arid
4 Gentle folding late Eocene
5 Erosion initiated major top. features including cross valleys
6 Vulcanism, tuff, Oligocene (Is tuff older than Herd Mt surface?)
7 Gentle folding
8 Erosion of Herd Mt. Surface, possibly ~~not~~ pediments, 1000' relief
9 (Miocene) mts were high - no true peneplain (slope to 16°)
10 Erosion of Weber valley pedimented surface, Pliocene - and erosion in E (date climate?)
11 Basin-Range faulting to 3000 ft. only slightly increased relief, tilted valleys, made hanging valleys
12 Erosion and burial of lower parts of pre-faulting surface Salt L. formation
13 Lake Bonneville + glaciation - in E. erosion of terraces - date?
14 Recent faulting, erosion
Correlation with Uintas fair but not with Idaho. because of doubt of relation of upland to Tertiary

Teton problem
last favors a fault line scarp (resurrected fault scarp)

3 30 Friday

Northern Rocky Mountains 183-197

Definition=ranges and mountain groups north of Y. N. P.

Boundaries E= Plains mts. include Little Belt, Castle, Crazy
N, stop at 49th parallel
W= Okanoga n R and Columiba lava platea u exclude mts. W. of Snake R
S= lava plateau of Y. N. P. and valley of Yellostone R

Geology
Pre-Cambrian
Archean crystalline, granite, schist, gneiss, qz.
Algonkian-Belt series to 60,000 ft, shale, 2 limestones, some ss
Paleozoic
sedimentary rocks, all folded Madison-ls (Miss.)
Permian volcanics phosphate rock
Mesozoic
Jurassic-Triassic, sediments, siltstone, ss, etc. folded
Jurassic intrusive granite
Cretaceous, shale, ss, folded
Great Unconformity
Cenozoic Tertiary continental sediments with volcanic ash, intrusives, lava flows, only slightly disturbed
Pleistocene drift and stream deposits

Topography
Uplifts from folding: Columbia, Bitterroot, Lost River
Little and Big Belt -Gallatin-Madison-Jefferson-Lewis and Clark, etc
due to intrusion:
mountains of Idaho batholyth -Castle-Crazy
narrow valley Poverty Flat
Basins, mainly contain Tertiary and Pleistonce deposits
Idaho, South Prairie, Lemhi, Rocky Mt. Trench, Purcell Trench,
Selkirk valley, Deer Lodge, Townsend

E

197-211

Bitterroot Range. evidence of faulting, normal or thrust, border of bathylith

Mountains of Canadian border
trenches
structure
glacial erosion features
Lewis and Clark ranges. thrust fault, age of Daly's Rocky Mts.

Rocky Mt. Trench 800 m long= Flathead, Bitterroot

Purcell Mts.

Purcell Trench intersects Rocky Mt. 200 M. N.

Selkirk Mts.

Selkirk Valley = Columiba valley

Columiba Mts = Okanogan Highlands

Okanogan Trench or Valley

Problem of Rocky Mt. Front in Saypo quad. Mont.

History of Rockies
Atwood and Atwood, G. S. A. 49: 957-980

Applies to southern and Middle Rockies

Mountain growth between Mesozoic and Cenozoic - Laramide Revolution

Eocene-mild climate but mountains glaciated, later a subdued surface, the Flattop pediment peneplain was formed now preserved under volcanics of San Juan and Absarokas (question- are these not pediments?)

Renewal of mountain growth accompanied by vulcanism of San Juan, Absarokas, Spanish Peaks, Y. N. P. etc.

Mountains high again and early fans were eroded. Basins filled with Oligocene, Miocene, Pliocene sediments (volcanics of Columbia Plateau)

Denudation of the mountains at same time as valley filling leading to Rocky Mountain or South Park level, peneplains and pediments including those of Uintas and San Juans

Uplift and erosion by superimposed streams=Canyon cycle

Formation of lower or Pleistocene pediments-glaciation in several stages separated by erosion intervals

Postglacial canyon cutting

will this apply to Northern Rockies?

here we have to say volcanics of Col. Plat middle and late T

211-224 and summary of Northern Rockies

Peneplain problem-"first catch the rabbit"

Evidence for
- Summits blend in distance as viewed from high points
- Poverty flat near Challis on Paleozoic sedimentary rocks is 25 m^2
- Some of the divides are nearly level although narrow
- Smooth subdued surfaces extend or slope under some of the Tertiary deposits and possibly the lavas of Columbia Plateau

Evidence against
- Stream valleys do not seem to be adjusted to structure as they should have been after peneplaination
- Instrumental measurments show that skyline is far from level
- Petrologists conclude that the subequal elevations of Idaho mountains are roughly at the original top of the batholith
- Since erosion seems to proceed faster above timberline than below this should bring about subequality of divides
- Isostatic balance may possibly prevent the occurence of mountains much above a certain heigth although in Cascades there are such
- Even distribution of drainage lines and development of similar slopes of stability on both sides of divides should cause subequal summit elevations
- The surfaces which extend below the Tertiary are in many places clearly ;pediments because they are covered with gravel; could Poverty Flat be a remnant of a local pediment formed long ago? If it is the significance is changed and it would not demonstrate a regional peneplain

If the existance of a peneplain (or other subdued surface) be accepted then what is its age in respect to the Tertiary sediments below this level?

For Eocene age
- Tertiary is all post Eocene
- Tertiary deposits found only below upland
- Upland is apparently undeformed
- Tertiary rests on subdued surfaces
- Miocene lavas enter valleys below the upland

For Pliocne age
- Tertiary may readily have been below base level
- Tertiary beds are locally disturbed more than upland appears to be
- Southern Rockies are known to have been mainly buried by Pliocene fans
- Not all the lavas are Miocene, some are much younger
- Valleys containg Tertiary are not erosional but structural
- Mountains could not supply the sediments in the valleys and still keep remnants of peneplain.
- Nature of Tertiary demonstrates both high mountains and aridity
- Change from Eocene erosion to Oligocne-Miocene dep. might be lavas, earth movement, or change to aridity

Pleistocene-evidence of more than one age of drift
- evidence of terraces No. 1= Flaxville? pediments of interglacial age
- Lake Missoula

Fenneman 225-237

Columbia Plateau

Definition - a basalt plateau, varying degrees of dissection

Boundaries- topographic except on south where leave out Basin Ranges so far as possible; includes mts. W. of Snake River

Sections: list them but defer discussion in detail-explain reasons for such marked differences
- Snake R. Plain= young lava plain
- Blue Mts.= outlier of Northern Rockies
- Payette= mainly lake deposits
- Walla Walla= eroded plateau on older flows
- Harney = arid section without the mts. of Basin and Range

Geology (data mainly from Flint)
- Dunes and later loess
- Touchet lake beds + alluvial terraces
- Scabland glacial outwash deposits
- Glacial drift-Wisconsin age + Quaternary flows Qv
- Palouse loess and Ringold lake beds
- Younger flows of Snake River Plain= QPv (geol. map of U. S.)
- Columbia River basalts PMv
- Sediments interbedded with flows-Ellensburg, Latah, John Day etc, mainly lake and stream deposits which date the flows Mc +Ec +Oc
- Eocene flows Ev lighter color than later flows
- Cretaceous sediments, K, small areas
- Jurassic and Triassic sediments + Jurassic intrusive
- Carboniferous sediments and flows

Manner of eruption-fissures vs low cones around vents
1953 fluidity of lavas
Local deformation of flows and sediments

Topography-
features due to hard and soft beds in flows and interbedded sediments- effect of columnar jointing in flows - loess covered areas, ~~[illegible]~~ scablands, cones of fa~~[illegible]~~ lakes, terraces
1951 anticlinal ridges in flows
canyons - falls
Outlying mountains, part volcanic, others of pre-flow rocks

History, general, details of sections later.
(1) Old erosion surface beneath Miocene flows. Its nature
(2) Eruptions. obstruction of drainage . Intervals between eruptions
probable sinking of surface beneath flows-cause
Nature of original surface of flows and sediments
Effect on drainage- why edge of flows where lavas cooled in water was weak- why streams were largely forced to edge of flows. Examples
1952 Why many streams disregard present slope of upland
Effect of folding of flows on stream courses

~~Class roll: Colbert, Colman, Finnegan, Frey, Fulkearth, Prucha~~

238-251

Snake River Plain
Definition= area of little dissected young basalt flows in valley of Snake R.

Boundaries: N, S, E. against higher land but omit valleys indenting uplands
W. arbitrary in appearance but is edge of young lavas

Geology: Metamorphic and igneous of mountains See W. S. P. 774
Older lavas, light colored Miocene
Younger basalts with associated lake deposits, mud flows, tuff
Pliocene and Pleistocene
Glacial drift, local
Dune sand, alluvium

Topography
Lava plain locally very rough
Cones, craters of the Moon. Spatter cones, ash cones(cinder cones),
lava domes, fissures, cinder crags, caves. Hells Half Acre, Wapi lava field
Underground loss of water, vanishing streams, lakes
Canyons and falls, springs, American Falls, Twin Falls etc. Cause
Buttes of older lavas

Payette section
Definition= area dominantly lake beds W of long. 115W

Boundary= Mts. north and NW including Blue Mts.
Basin Ranges to S. and SW
Interior drainage W

Geology
Eocene volcanics. Jurassic intrusive of Owhee Mts.
Miocene continental=lake beds
Younger basalts
Alluvial and terrace deposits

Topography
Valley of Snake much wider than above and terraced
mesas, many capped by lava
Owyhee Mts. = a linear ridge of basin-range type with granite core.
older lavas uplifted near mts. and eroded

Blue Mt. Section
Definition= large outlier of Northern Rockies plus an uplifted lava area

Boundary fixed largely by topography. Separated from Nor. Rockies by Snake
Canyon

Geology
Carboniferous etc, metamorphic sediments and lavas
Jurassic-Triassic same
Jurassic granite
Eocene lavas up to Pleistocene flows disturbed
Miocene and Pleistocene continental deposits

Topography
High enough for timber. Truly mountainous-Canyon of Snake, why little known
glaciation

251-264

Walla Walla section
Definition-what is left of Columbia Plateau N of Blue Mts. Harney secs.

Geology
Flows, Miocene to Pliocene on pre-lava basement Locally folded
Lake sediments and ash within basalt flows
Ringold sand, gravel, clay, silt, early Pleistocene
Palouse loess
Scabland sediments plus glacial drift(Wisconsin)
Touchet lake silts of same age as Scabland
Dunes and later loess

Topography
Palouse Hills loess belt, steep slopes but no soil erosion
Island buttes of older rock
Scabland bars
Coulees, dry falls
Western plateaus, dune areas, ridges

SCABLAND PROBLEM
Facts: 1 Scablands are due to erosion by glacial meltwaters on slope of ~~15 to 29 ft/m 13 ft/m~~ 20 ft/m Hobbs, no
2 Have a great vertical extent and appear to have been formed all at once (Allison, no)
3 Lower Columbia Valley carried lake waters flooded to about 1100 elev.
4 Gravel bars have beds which dip into tributary valleys
5 start at border of glaciation

Theories: Bretz, a super flood of unknown origin
for: bars are constructional, to 300 ft high, water deep
ponding in Columbia due simply to great volume
great width of falls, some places several at same level
gravel occurs on edge of Grand Coulee
1954 sidehill canyons, great horizontal extent of scabland
scabland at entrance to Yakima Valley means reversed flow
hanging tributary valleys, plucked basins in rock
Yakima valley filled with present river in 4½ days
here 49 depos. Flint
sediments too fine for a super-flood 13 ft/m
bars are erosional remnants of fill preserved because in mouths of tributaries upper limit of scabland not consistent.
destruction of Lake Lewis changed deposition to erosion (diversion divides)
slope of 20 ft/m with superimposed streams

GSA 1953 | 1952

$\sqrt{20} = 4.45$

$\sqrt{13}$ 3.6

D^2 varies with slope for material under size

Allison
holds that bars are really constructional L. Lewis not caus
relation of coarse stream dep to lake sediments shows different age;
suggests ice jams in Columbia R which grew upstream
finds evidence of lake and sidehill scabland below Wallula gateway
formation presumably progressive
objects to simultaneous erosion of so large an area.

Hobbs collapsed large glacier terminal

COULEE problem. sidehill valley

Lupher. GSA. 55: 1431-1462, 1944 ~~supports Allison~~ - 2 ages of fill
Allison J.G. 49: 54-73, 1941, GSA 44: 675-722, 1933 - ice jams
Flint GSA 49: 461-524, 1938

264-273

Yakima district.
anticlinal ridges- ash deposits left only in valleys but folded with lavas
smooth sides of ridges truncating structure
steeams flow in entrenched meanders

alternative explanations
Early folding
peneplain with superposition of streams
later folding of ridges
erosion of entrenced meanders

or Folding which caused only temporary ponding followed by entrenched meanders of essentially antecedent streams. Some case of diversion now being studied. Evidence of pebbles.
formation of pediments on flanks of ridges.

Comparison-pediments more in line with climate east of Cascades, also a simpler view

Deschutes district. ash mounds, origin??

Harney Section
Alluvial cover rather thin unlike typical basin country
Lakes due to lava flows

History, entire province

1 Older folded mountains like northern Rockies, deeply eroded but not peneplained
2 Early light colored lavas with associated lake and stream deposits
Eocene to Miocene
3 Later basaltic lavas, Miocene to Recent + assocated sediments
4 Diversion of streams to borders of flows with entrenchment-folding
5 Settling of center of basin and folding at time of Cascades
6 Glaciation-formation of loess-scabland and assocated lakes -dry falls, Grand Coulee lasted as long as Ontonagon ice dam, later than scablands
7 Postglacial abandonment of Grand Coulee but one gorge above was kept.
Later dunes and loess

294-306

Meteor Crater problem.

Facts:

Crater 570' deep 3950' across rim of much broken limestone
Holes drilled in bottom through recent silt into pulverized sandstone
below that only solid bed rock No sign of volcanic rock

Origin

Volcanic explosion steam or gas. Heat powder of explosives.
Time rate of change. Comparison in calories per gram
Steam about 600, dynamite 1100? Hydogren $3.4_5 \times 10^4$
Atomic bomb 2×10^{10} Impact of meteorite 5×10^5
black powder about 730

or volcanic origin

near San Francisco volcanic field
somewhat like basin of Zuni Salt Lake whih contains
2 cinder cones and a lava flow 1 m across 150' deep
may be due to salt solution J. G. 13: 85-194
According to Roberts lies on a line of minor folding

For meteoric origin

considerable meteoric material found in rim
extreme fracturing of rim rock
pulverization
like features of moon. Solar parabolic velocity = 26.5 m/sec
earth has velc. about 19 m/sec. sum= about 45 m/sec. diff.
about 8 m/sec
Energy at 40 m/sec = 300 + x equal mass of nitroglycerine
Siberian meteorite devastated circle of 25 m radius
Claimed that several meoric fragments penetrated in drill
hole on S rim at 1376
Heat enough to vaporize a meteorite

High Plateaus of Utah

Should begin with Vermillion Cliffs

Geology and topography, 3 major cliffs, Vermillion, White, Pink
minor Chocolate and on Cretaceous sandstones
faults lava caps Bryce Canyon, Cedar Breaks in Eocene
Zion Nat. Park

Uninta Basin

Area N of Book cliffs

Geology and topography

Cretaceous and Tertiary
Taviputs plateaus
Book cliffs = Mesa Verde Roan cliffs higher = Eocene border

274-294 cont

Structure
rocks mainly hori zontal
monoclines dip E
local domes, laccoliths
faults, generally down to W.

Topography
Flatish uplands part lava capped
Dissected to varying degree by canyons
Broken by scarps
Erosional with outliers, spurs due to firmer rocks, ss mainly along faults, generally simpler
1951
Mountains
Local dome uplift Zuni
Laccoliths-Henry
1953 Volcanic Mt. Taylor
Volcanic necks

Sections-Grand Canyon, older rocks plus volcanics
High Plateaus to 11000 elevev. Younger rocks plus volcanics
Uinta Basin-structural, cliffed
Canyon lands, most dissected
Navajo- less dissected, very arid
Datil- largely volcanics
1952 1952

Grand Canyon section
Definition- area of older sediments and volcanics of San Francisco region

Boundaries
Province boundary on W and S
E arbitrary line in E Arizona
NE Little Colorado R and Echo cliffs
N= foot of high Plateaus

Geology
pre-Cambrian through Kaibab ls plus volcancs
Monoclines and prominent faults area of highest uplift of strata

Topography
Grand Canyon-problem of Tonto and Esplinade benches Origin?
Plateau levels with scarps rise to E. Kaibab at Canyon station
San Francisco volcanic plateau-cones, flows
Crater Mound, problem of origin
Eastern monocline causing break in canyon at Lees Ferry

274-294 Colorado Plateau

Definition= area of previalingly horizontal sedimentary rocks and lavas
P lateau or plateaus?
Climate? elative elevation? Pentonel me 5000-11000

Boundaries
E and N-mountains
S erosional escarpment above lower ground, locally obscured by lavas
W escarpment along faults above lower Basin-Range country

Geology
P leistocene- glacial drift on highest plateaus, alluvium, dunes, etc.
younger lavas(basalts)

Tertiary
Bridger-lake dep.
Green R. oil shale
Wasatch-limestone, calc. ss, etc=Pink liffs
Flows and intrusions

Unconformity
Cretaceous
Laramie ss , yellow-gray cliffs 250-400
Lewis shale 500-1000
Mesaverde ss , yellow-coal-Book Cliffs 300-1000
Mancos shale, ss badlands, hogbacks 2200
Dakota ss , white-hogbacks to 100
McElmo shale 197-565
Jurassic
maroon ss, sh, cliffs 973-1430
gyp zone, scarp 100-450
Navajo ss, white WHITE CLIFFS 1260-1400
Todolito ss , sh, maroon 125-215
Wingate ss VERMILLION CLIFFS 250-400
Triassic
Chinle s h, ls, etc. 185-200
Shinarump ss, gray, yellow, bench 10-125
Moenkopi sh, ss, chocolate buttes 304-480

Permian
Kaibab ls bench 400-600
Coconino ss s, white cliff 250-350
Hermit sh 267-332
Supai, ss, white, red, Esplinade 1250-1400

Mississippian
edwall ls(blue) cliff 600-700

Middle Cambrian
Muave ls cliff 450-475
Bright Angel sh 25-375
Tapeats ss Tonto Platform to 285
Unconformity

Algonkian
Unkar ss, qz, sh, ls tilted to 4780
Archean
Vishnu schist cliff ----

THE PRE-CAMBRIAN of the GRAND CANYON

Introduction - The Grand Canyon of the Colorado River is the only area in the world where such a complete and exposed section of the Pre-Cambrian Algonkian rocks are found. These excellent exposures offer the geologist a classic means by which he can determine the stratigraphic succession and position of the Algonkian rocks.

History of the Area - Major J.W. Powell was the first person to record these rocks. They were noticed by him during his explorations of the Colorado River and its tributaries. In his report of 1875 he stated that hard vitreous sandstones of many colors overlie the granites and are separated by the large nonconformity from the overlying Carboniferous sediments. A thickness of about 10,000 was estimated by Powell for these sandstones. Below these sedimentary rocks are crystalline schists which Powell refers to as granites.

The Geographic Position of these Rocks - The portion of the Grand Canyon in which the Pre-Cambrian rocks exist is located in northern Arizona between 36^0 and 36^0 17' N latitude and 111^0 47' and 112^0 05' W longitude. Most of this in the valley portion of the canyon, between the mouth of Marble Canyon and apoint south of Vishnu's Temple, a little west of where the Colorado River changes its course from the south to the northwest. It is completely within the depths of the Grand Canyon, east and southeast and south of the Kaibab plateau.

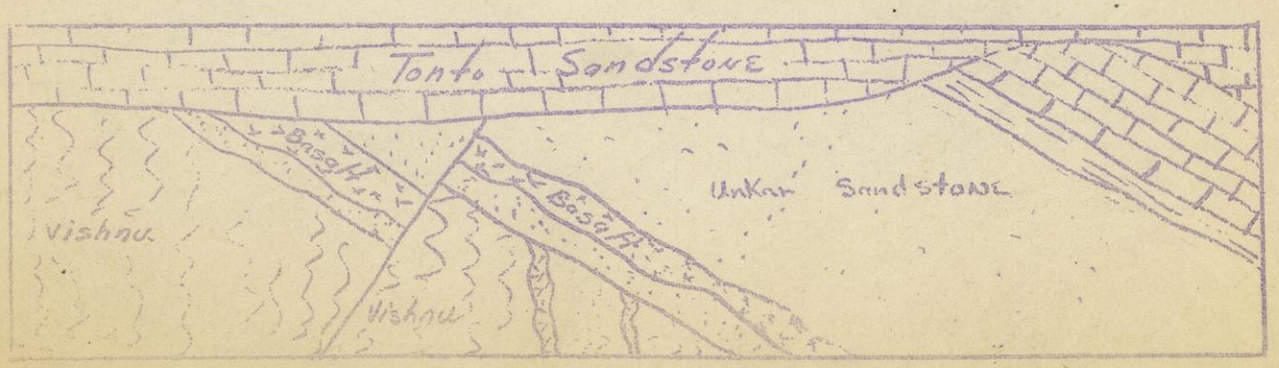
Nomenclature of the Grand Canyon - The name "Grand Canyon Group" was given by Major Powell to the rocks which lie below the Tonto sandstone and above the "Grand Canyon schists".

Charles D. Walcott modified Major Powell's classification, but generally followed the same system.

L.F. Noble and Charles Keyes renamed the Grand Canyon group of Powell maintaining only the Chuar series of Powell.

On the following pages, the stratigraphic section of Powell and Walcott, and that of Noble and Keyes will appear. Following each table will be the lithology as given by each of the original authors.

Below is a general picture of the Grand Canyon Group. (G.K. Gilbert)



Stratigraphy and Lithology - Powell and Walcott, with Walcott preparing the material as first related by Powell show the following section to be the Pre-Cambrian of the Grand Canyon.

CAMBRIAN. Tonto sandstone

Unconformity

ALGONKIAN Grand Canyon Group — Chuar; Unkar

Great Unconformity

ALGONKIAN (?) Vishnu

The following is this detailed lithology of the Chuar Section. This is beginning from the top at the base of the Cambrian.

Lithology	Thickness (Feet)
Sandstone, massive, reddish-brown, becoming shaly near the middle and passing down into reddish, sandy shale, and shale with few thin compact sandstone layers	200
Shale, black, thin layers, crumbling on exposure, with two 50-foot members of massive gray limestone on lower half	525
Limestone, hard, buff, with irregular oolitic cherty bands predominating in places	4
Shale, black, with few compact layers and thin, earthy limestone	33
Limestone, gray	8
Shale, black above, variegated below, showing light drab, pea-green, vermilion, chocolate, and buff colors, with few thin layers of sandstone	740
Limestone, concretionary, massive	10.- 25
Shale, reddish-brown on reddish-brown sandstone thinly bedded in its lower part	165
Shale, brown, sandy, passing down into chocolate and dark pure shale, alternating with brown and greenish, sandy shale; layer of oolitic iron ore near top	300
Shale, in part sandy with thin layers of limestone, one 4 feet thick near bottom conataining Stromatopora	325
Shale, chocolate-brown, dull and yellowish-green, sandy and clayey, with thin sandstone layers and 21 feet of limestone in thin layers near middle and base	625
Shale similar to above but with less sand and more clay and lime, 54 feet of limestone included	500
Shale, dark and slabby, gray limestone, with 5-foot bed of gray to buff, friable sandstone near base	22
Shale, black, with chocolate and greenish sandy layers and hard beds of sandstone, local thin gypsum deposits.	100
Shale, brown, andy, including three feet of compact, mottled buff limestone	18

Shale, black, brown, and chocolate above; chocolate, green, maroon, and drab below, and with layers of sandstone and sandy shales toward base	830
Sandstone, brown, in beds 8 to 18 inches, passing down into sandy and pure shale with layers of buff and chocolate sandstone, and drab shale passing down into ripple-marked sandy shale	110
Limestone, in part chocolate with irregular concretionary and bituminous layers near base	50
Shale, mostly pure and dark with one member of deep maroon; drab, yellowish green and dark shales with a dark chocolate member lying 100 feet of drab and dark greenish shale, with some sandy layers and thin sandstones; carries locally a 6-inch bed of limestone near base	450- 650
Average total	5120

The following section is the detailed lithology of the Unkar. This extends from the base of the Chuar to the top of the Vishnu.

Lithology	Thickness (Feet)
Limestone, massive gray to reddish (magnesian), passing down into limy sandstone	50- 150
Sandstone, light gray, yellowish-brown; purplish-brown and partly cross-bedded below	125
Sandstone and sandy shale, reddish-brown, ripple-marked	200
Basalt in 6 to 8 flows, 70 to 175 feet thick, separated by thin layers of sandstone	800
Sandstones, shaly, vermilion, rather fine-grained, ripple-marked and shrinkage cracked, with intercalated beds greenish-gray color, underlain by 700 feet of vermilion beds, mostly massive with sandy shale partings...	1730
Sandstone, chocolate colored, of which 800 feet are in a cliff of 5 massive members (slightly micaceous) separated by partings of shaly sandstone, chocolate above and greenish below	925
Sandstone, more or less shaly	125
Sandstone, friable and sandy, and micaceous shale.....	300
Sandstone with twisted and gnarled layers in top 15 feet; color gray with reddish spots; shaly in places	150
Sandstone, gray, hard, compact	90
Sandstone, massive compact, brown, buff, and purplish-brown (cliff)	1200
Sandstone, reddish-brown to vermilion, friable, shaly...	200
Sandstone, brick red, shaly.....	250
Sandstone, brown, friable, shaly, ripple marks and shrinkage cracks, with lower part more massive and fine conglomerate 10 feet at base.....	380
Limestone, light gray, with layers of shale	8
Sandstone, brown, with 2-foot bed of conglomerate	30
Limestone, reddish, cherty above; light gray and compact near base; 5-foot member of dark reddish-brown slate in middle	31
Basalt in one body	80
Limestone, light gray, compact, interbedded layers of chert or sandstone near base	26
Conglomerate, largely of pebbles of underlying pre-Unkar rocks on which it lies unconformably.....	30
Thickness of Unkar beds	6830

The formation of the previous pages were described by Walcott. L. F. Noble has made a detailed study of the Unkar strata near Shinumo Creek in Grand Canyon. The following are the:

FORMATIONS OF UNKAR GROUP IN SHINUMO QUADRANGLE	Feet
Dox sandstone: Micaceous shaly sandstones, red and vermilion above, gray green, purplish-green, and brown below; cross-bedded and ripple-marked, with shaly partings of green or gray color and some sandy layers; near base gnarled and twisted sandstone	2300
Shinumo quartzite: Alternating sandstones and quartzites, the sandstone mostly purple-brown, and quartzite white and hard, forming two principal cliffs, some sandstone layers gnarled and twisted	1564
Hakatai shale: Mostley red shale, upper part sandy, with 100 feet of blue shale below middle; some beds altered to jasper	580
Bass limestone: White limestone with blue shale intercalations in upper third, and of calcareous, red shales near lower part	335
Hotauta conglomerate, composed of local pebbles and arkosic, mostly reddish matrix, varying in hardness 1-	6
Total thickness.....	4785

By using previous works and by further detailed study L. F. Noble and Charles Keyes have compiled the following Pre-Cambrian Section of the Grand Canyon:

	Series	Formations	Thickness	Rocks
TACONIC		Interval		Unconformity
PROTOZOIC	Kwaguntan	Nunkoweap	200	Sandstones
		Walhalla	250	Shales
		Echo	100	Limestones
		Carbon Butte	1000	Shales
		Solitude	25	Limestones
		Oveja	175	Sandstones
		Interval		Unconformity
	Chuaran	Final	600	Shales
		Marble	15	Limestones
		Venus	625	Shales
		Oso	500	Sandstones
		Jupiter	1700	Shales
		Interval		Unconformity
		Gunther	150	Dolomites
		Chiquito	325	Sandstones
		Interval		Unconformity
	Cardenasan		800	Lavas
		Interval		Unconformity
	Grand Canyon	Dox	2300	Sandstones
		Shinumo	2000	Quartzites
		Hakatai	600	Shales
		Bass	300	Limestones
		Newberry	100	Lavas
		Hotauta	50	Conglomerates
		Interval		Unconformity
ARCHEOZOIC				Gneisses

The lithologies of the section of the previous page follows, proceeding from the base upwards.

The lithology of the Grand Canyon Series is detailed in the Shinumo Quadrangle by Noble.(Page 4)

Cardenasan: The Cardenasa lavas consist of eight flows which are about 800 feet thick. Eac is separated by a thin sandstone strata 1 - 15 feet thick. Marked erosional unconformities are found on the top and bottom of the lavas. The lavas are extrusive. The erosional unconformity is a specific datum-plane to which all above strata must be referred.

Chiquito: The Chiquito sandstones follow above the lavas. The lower beds are shallow water deposits with abundant ripple marked horizons. Massive sandstones are above, followed by shaly sandstones.

Gunther: The Gunther dolomite is a ledge forming formation which grades upward into dolomite from a calciferous sandstone at its base.

Jupiter: The Jupiter shales are above the dolomite. They are dark colored, often being black.

Oso: Above the Jupiter shales are the sandstones and shaly sandstones of the Oso formations.

Venus: The Venus temple is of about 600 feet of dark brown and green shales of the Venus formation.

Marble: The Marble limestone is only 15 feet thick but contains some signs of life (Stromatopora) This limestone also forms a ledge in the shales which surround it.

Final: The Final shales are brown, more or less sandy shales. Some thin limestones are found within these shales. The full thickness of these shales is not known because of an unconformity at their top.

Ovejo: A sandstone, bedded in the middle and shaley at the top and base.

Solitude: A massive, concretionary limestone forming a ledge projecting outward from the shales and shaley sandstone is the solitude limestone.

Carbon Butte: The Carbon Butte shales are black, forming the sides of a butte below a cap of sandstone.

Echo: The Echo limestone is the principal limestone in the Pre-Cambrian of the Grand Canyon. It consists of three ledges, separated by shales. Some Cryptozoan like fossils occur in the lowest sections.

Walhalla: This is a series of black shales about 200 feet thick.

Nunkoweap: These massive sandstones are the highest rocks exposed in the Pre-Cambrian section.

These lithologies conclude the sedimentary Pre-Cambrian roacks of the Grand Canyon. Above these are the post Pre-Cambrian sediments.

Below these sediments are the Pre-Cambrian crystalline schists. They are called Vishnu by all geologists who have worked in the Grand Canyon.

Vishnu Schists: The Vishnu schists and the other crystalline roaks below the Grand Canyon Pre-Cambrian sedimentary rocks are Archean in age.

Three main types of rocks are found in the Archean comples. All of these are schists.

1. Quartz schists that grade into mica schists
2. Quartz schists that grade into quartz-hornblende schists
3. Hornblende schists

Quartz diorite, granites and pegmatic dikes occur locally within the Archean complex.

Very little is known concerning these Archean rocks.

It is known that they have undergone metamorphism folding and faulting to a high extent in order to be as they are found. Because of the intensive reactions that have taken place within these rocks it is impossible to know anything relating to their original occurence.

THE STRUCTURE OF THE GRAND CANYON

Faults and some folding represent the structural geology of the Grand Canyon.

The West Kaibab fault is the predominant feature of the area.

Many small faults are found in the Un ar strata.

All of these faults are Pre-Cambrian in age.

Wheeler's fold is the only large fold in the Pre-Cambrian.

Other faults and folds occur in the region, but all are younger than Pre-Cambrian.

THE GEOLOGIC HISTORY OF THE GRAND CANYON

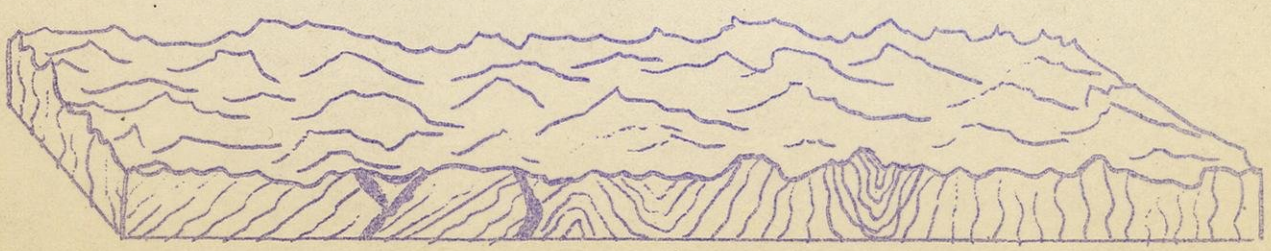
Four separate periods are evident in the Pre-Cambrian history of the Grand Canyon. In order of youngest to oldest, they are:

1. Post Algonkian erosion
2. Algonkian deposition
3. Pre-Algonkian erosian
4. Archean igneous activity.

The igneous and sedimentary stages have already been discussed. The other stages have caused the major unconformities in the Grand Canyon.

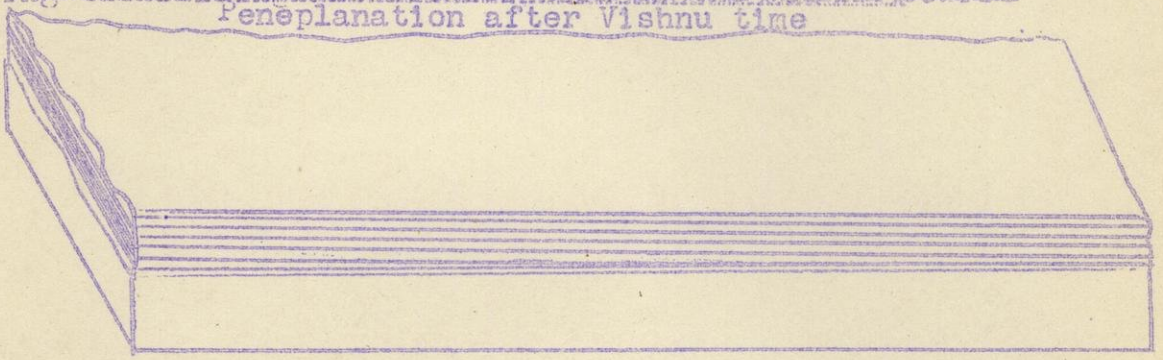
Hinds calls these stages the Ep-Archean and Ep-Algonkian. The unconformity between the Vishnu schist and the Algonkian sediments is the Ep-Arkean surface. The unconformity between the Algonkian sediments and the Paleozoic sediments is the Ep-Algonkean surface. During each stage active erosion and peneplanation took place. The maximum relief on each erosion surface is 50 feet.

Below is a diagramatic view of the stages of the Pre- Cambrian history of the Grand Canyon:



A. During the folding and metamorphism of the Vishnu schist.

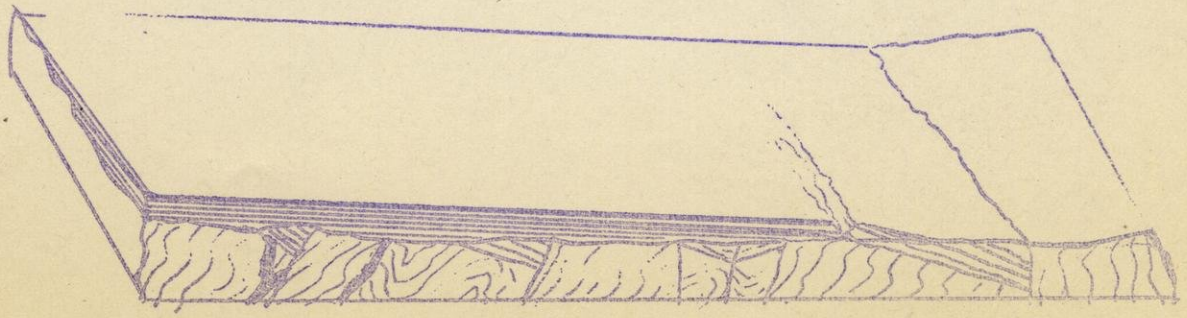
C. During the folding and metamorphism of the Vishnu schist
Peneplanation after Vishnu time



d. After deposition of the Grand Canyon (Proterozoic) system

D. After the Grand Canyon Disturbance had formed ranges of block mts.

E. Near peneplanation of the close of Proterozoic time.



CORRELATION and PROBLEMS

The Grand Canyon series, the Llano series of Texas and the Algonkian series of the Lake Superior region show similar lithologic series of strata, however a definite correlation cannot be made until a factor more reliable than lithology is obtained. It is probable that the Keweenawan series of Lake Superior and the Grand Canyon series represent the same time interval. This is the only correlation that can be made.

The interpretation of the complex erosional history of the Grand Canyon is the major problem of the Grand Canyon series.

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306-325

Canyon Lands
Definition
Boundaries = border of maximum dissection S side San Juan canyon N to Moan cliffs, W to higher plateaus

Topography entrenched meanders natural bridges in ss
Why so much dissected? Some broad valleys at E as Grand Junct, Col.
Mesa Verde- Great Sage Plain- Monument uplift with buttes of Triassic
1953 Laccoliths, Henry Mts etc. Navajo Mt.
Anticlines, Circle Cliffs, San Raphael Swell
See Prof. Paper 164 also Jour. Geol. 34: 29-57 on meanders
1958

Navajo Section
Definition= less dissected area E of Grand Canyon and S of Canyon Lands
Boundaries as above

Topography
Mesas, Cuestas, escarpments, canyons, washes, volcanic necks,
Black Mesa =Cretaceous outlier
Chuska Mts,= horizontal Eocene ss
San Juan Basin = syncline containg Tertiary
Painted Desert= Triassic red shales, petrified wood
See Prof. Paper 188

Datil Section
Definition-why discriminated??

Topography
Zuni uplift like Balack Hills escarpments Grand Canyon sequence
Zuni salt lake
Volcanoes-Mt. Taylor volcanic necks

History of Colorado Plateau

(1) Late Cretaceous-Eocene monoclines formed-Laramide Revolution

(2) Erosion interval part of Dutton's Great Denudation. Climate unknown

(3) Lake deposits of Eocene age deposited across beveled folds-some stream deposits

(4) Uplift possibly pre-Miocene-faulting down to W. Drainage superimosed

(5) Erosion interval, another part of the Great Denudation. not a peneplain

(6) Eruption of lavas, part basalts-Miocene? preserved level? spots pediments, not peneplains

(7) Second fault movement accompanied by eruptions of andesite and rhyolite in San Francisco Plateau Second eruptions

(8) Erosion interval of early Pleistocne leading to so-called Mohave peneplain Third part of the Great Denudation Meandering streams

(9) Pleistocne basalts erupted

(10) Pleistocne uplift and renewed faulting with continued eruptions some of them later than the Grand Canyon. Entrenched meanders formed. No trace of Colorado River in Great Basin until late Tertiary or early Pleistocne as shown by pebbles

(11) Glaciation of some of the higher plateaus Probably more water in rivers during glaciation of adjacent mountains.

(12) in recent years erosion is destroying flood plains and making them into terraces-cause???

See A. J. S. ~~235~~:239: 241-260 A. J. S. 174: 109-129
G. S. A. 56: 151-180, 107-150

AJS 244: 817-835 JG. 52: 361-387

Physiography April 22, 1940

Cannot meet labs but will have maps and directions on table.

If possible record last set and return. Another set due this week. Do not accept after Friday Another set ready for Jenkins in middle left drawer

BASIN AND RANGE PROVINCE

DEFINITION. region of isolated roughly parallel mt. ranges separated by detritus-filled basins, i. e. a region so arid that streams do not forward much debris to sea. Stress CLIMATE

BOUNDARIES

Highland of Colorado Plat to east-mainly fault scarp
Middle Rockies to NE. mainly a fault scarp
Edge of abundant ranges on north-gradational line
Foot of Cascade-Sierra range to west, in large part fault scarp
To SW exclude the higher and larger ranges of the coastal belt although structure and valley filling is continuous

SUBDIVISIONS

Great Basin-largely a great group of interior basins although some drainage to sea in northwest
Sonoran desert-region of large basins with few mts.
Salton trough-structural and top. depression bounded by mts. on NE
Mexican Highland-like the Sonoran district but higher and more mts.
Sacramento section-transitional to Colorado Plat on N. and Great Plains to E.
map on p. 10
Treat briefly and point out on maps Lobeck and geological

GEOLOGY

Deformed sedimentaries and intrusives older than Cretaceous. folds, faults. much igneous rock - volcanics plus some pre-Cambrian igneous
Valley fill-conglomerate, sandstone, volcanic-sedimentaries, lake deposits, salt, gypsum, clay, etc. Older parts cemented and considerably deformed, largely by tilting, drag along faults rather than by close folding
Age from Miocene to Recent. Faults in age down to Recent
Glacial drift on some of higher ranges Pleistocene lake basins - sediments
Volcanics, age to Recent some Tertiary intrusives

TOPOGRAPHY

Typical ranges 50-75 m. long, no great variation in width or height.
Stress abrupt sides, straight bases aside from local details.
Slopes cut by erosional valleys
Basins-half to 5/6th of area. Slopes up to 700 f.p.m. not easily seen in contrast with mts. alluvial fans with mud flows Centers of bolsons hold playas or salinas. Many of supposed fans are really pediments with shallow "gravel" on a smooth rock floor. Extent of these not always known. More abundant to south Dunes small and local. Salton sea and Nevada DESERT pavement
EVIDENCE of faults along mts. (a) recent scarps (b) faceted spurs (c) discordance of mt. borderwith internal structure (d) profiles of valleys of ranges (e) lines of springs (f) tilted peneplained (more likely pediments which had original slope) (g) displaced lavas

340-355

HISTORY

Physiographic history tied to that of sediments in valleys and to earth movements

Key lies in ORIGIN of BASINS.
Alternaties- (1) diastrophic (2) erosion by water with later blocking by fans (3) excavation by wind
(1) Geologic record proves (a) intermittent earth movement throughout Tertiary and Quaternary time (b) sedimentation by streams and in lakes in diastrophic basins under generally arid climate The relatively humid intervals were in Pleistocene, apparently coincident with continental glaciations. Start of Colorado River in present location during Pleistocene.(?) Dissection along Colorado gives sections of bolson deposits giving key to history. Recent faulting proved only where displacement of a land surface can be ~~proved~~ demonstrated
(2) Geologic record prohibits second hypothesis.
(3) Wind excavation a distinct possibility but most hesitate to endorse beaause of reputation of Keys, its chief advocate
Points for: (a) dust storms common (b) bottoms of some playas show wind dissection (c) wind basins common in other parts of west where favored by loose soil (d) old red loess came from deserts
Points against: (a) dunes not common (b) wind-worn mushroom pillars etc. etc. very rare. Old inscriptions in caves unfavorable (c) desert pavement unfavorable (d) not enough loess to east (e) dust soon returned from the mts. by next shower. (6) erosion by wind only down to water level

Much of the old controversy came because of lack of knoledge of basin sediments
" " " " pediments and mt. front
also early physiographers sought to introduce peneplains into a region of restless crust plus aridity. They also tried to put events into definite order rather than a complex sequence with much overlapping

GREAT BASIN
DEFINITION Includes 100 separate basins Basins of Pitt and Klamath drain to sea

BOUNDARIES see map

GEOLOGY see map

TOPOGRAPHY Block mts. of southern ~~xxxxx~~ Oregon= displaced lava, so recent faulting
Pleistocene lake basins near to higher ranges Evidence of beaches etc.
"Louderbacked" mts along foot of Sierra. Fault scarp of Wasatch

355-393

BASIN AND RANGE 3

Hand Sat report on Friday but not later

April 24, 1940

Review Great Basin

HISTORY Older folding and thrusting
Filling of basins-climate-how known
Pleistocene-humidity vs cooling
Evidence of standing water xxx vs alluvial fans
Two high levels long known in Bonneville and Lahontan (now thought may be four.) Evidence connecting the time as glacial.
Evidence of stillstands of level.
Overflow of Bonneville and erosion of outlet
Results of complete drying on amount of salt
1948 Keyes theory of diversion of xx Snake River into Bonneville. Weak point-too many other lakes
Postlake uplift of basin commonly ascribed to relief from load of water-weak point there
1950 was certainly movement in recent time at places where there was no lake! Not so easily demonstrated
Variation of level of Great Salt Lake in historic time-effect of irregation-Salt Lake cut-off
Search for potash-use of physiography in- ended by discoveries in red beds of New Mexico through oil exploration
1946

SONORAN DESERT
DEFINITIONLow altitude and few ranges-desert basins predominate-
Sonoran Gila Mohave

BOUNDARIES North-edge of ~~interior drainage~~ abutt mt ranges
east, edge of higher land and more abundant mts.
south, extends into Mexico
west, either province boundary or range of mts NW from Yuma

GEOLOGY Mainly valley fill near to mts. on rock pediments
Mts. largely granite and volcanics

1942 TOPOGRAPHY
Mts. ganerally without straight edges-much frayed
Undrained bolsons also filled basins with more or less through drainage.

HISTORY
Stages in development "Integration" of drainage
Fig. 133, p. 370
Development of pediments under rising base level of valley filling Arroyo Sheet floods(cause or effect)
Lateral swing of streams

W Branch Canal Creek

Physiography April 26

Problem of Colorado River

Passes through bolsons most of which have only a thin top layer which is horizontal Cuts through mt. ranges Boulder Dam in one of these not in Grand Canyon Comparison with Nile River in mud, volume etc.
History of Colorado as per Longwell and Blackwelder

(1) Older or pre-Miocene deformation
(2) Miocene faulting; change to arid basins Filling by lake and stream deposits plus volcanics Salt, gypsum, etc.
(3) more faulting and folding affecting the older bolson deposits
(4) Pliocene normal block faulting including the Grand Wash fault at ex edge of Colorado Plateau
(5) Basin filling, early Quaternary ending with a limestone formation
(6) Local faulting-formation of Colorado River in present location-superimposed across buried hard rock ranges Question/ did uplift of Rockies or coming of continental glaciers cause increased humidity? If so was there any Colorado in Tertiary time? And if there were where did it go? ? Compare with history of Great Plains. Get after the grads and majors on these points They should have read both these papers also one on origin of pediments
(7) Integration of Colorado River basins by the new through drainage and erosion of Grand Canyon (Canyon cycle)
(8) Gravel terraces or partial fillings may correspond to interglacial intervals rather than to glacial outwash so far from any ice Some faulting
(9) present day erosion into terraces and pediments

Longwell Howard in the Col. R.

SALTON BASIN

Definition Area around the subsea basin extension of Gulf of Calif.

Boundary Range of mts. NW. from Yuma. Other side the province boundary

Geology. Dam of Colorado R. sediments. Old beach line of Salton Sea. Accident of 1907. Dune areas. New all-American canal

History. Same as Sonoran Desert except for blocking of end of Gulf.

MEXICAAN HIGHLAND

Definition Half mt. half plain of which half bolson, rest with open drainage.

Boundary. Largely altitude next to Sonoran desert
Edge of Colorado Plateau to N. Apparently continuation of Grand Wash escarpment. Obscured by lavas Aubrey Cliffs Mogollon Platea.
(Have geol. maps of New Mexico and Arizona on board to discuss this
Sacramento faulted plateaus to east.

Geology. Bolsonfillings Gila conglomerate
Bed rocks largely volcanics but much older rock. Some important mining districts Glass Mts. of Texas= westermost Appalachians connecting in subsurface around the pre-Cambrian of central Texas to Ouachita Mtsi of eastern Oklahoma

Topography Basins which could drain to sea but rarely do
Tularosa basin alkali flat. relation of water table to possible depth of wind excavation gypsum dunes Springs form mounds by catching dust. Jornada del Muerton Plains of San Augustion.
They should be able to locate these on map

SACRAMENTO SECTION

~~Omit history for next time.~~ ~~Announce that discussion will be larger~~
Exam will cover work since ~~last~~ first one. ~~Room 110~~

396-409

Sierra-Cascade Province

Definition- range of mts. inside the great valleys and ~~separating~~ limiting Basin*Range and Co
Columbia Plateau ~~from~~

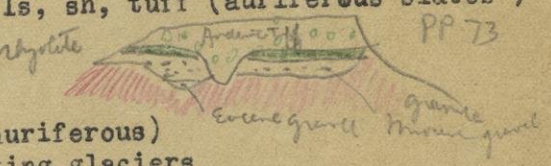
Boundaires S end = Tejon Pass
W topographic except in Oregon where = W limit of andesites
N international boundary
E topographic

Divisions
Sierras up to limit of continuous lavas ~~at~~ NB Feather R in California
Cascades north of that

Sierras
Definition= mountain range, massive, continuous for 400 m.+

Boundaries-see above

Geology
Paleozoic metamorphics
Jurassic-Triassic metamorphics, slate, ls, sh, tuff (auriferous slates)
Jurassic intrusive granite
Cretaceous marine (small area)
Eocene ss (in foothills) - some gravel
Miocene gravels covered with lavas (auriferous)
Glacial drift, outwash, etc. some existing glaciers



PP 73

Topography
1 Eastern face, fault scarps split toward N into main Sierra and Carson Ra
Ranges with L. Tahoe between
2 Three ranges in far noth, E to W. Diamond, Grizzly, Clermont
Diamond lines up with Carson to S
3 Subdued upland often miscalled a peneplain -relief to 3000 ft granite
4 High Sierra Peaks near headwaters of streams
Gold Belt on metamorphics much lower than area on granite
in south part some have distinguished broad valleys between
upland and canyons
4 Canyons of which only Yosemite and Hetch Hetchy are unusually
cliffed depth to 5000ft

409-430

History of Sierras
(1) Post Jurassic uplift and intrusions

(2) Late Cretaceous folding

(3) Erosion during Eocene or later to the "peneplain" or "broad valley" stage
stage 1 of Yosemite now preserved in Upper Y. falls relief, 3000 ft.

(4) Tilting to west caused deposition of auriferous gravels in late Eocene and Miocene
Some claim two ages of gravel(Prof. Paper 73)

(5) Eocene to late Miocene lavas, burying gravels, diverting streams
700'
(6) Tilting of fault block up on E causing erosion of stage 2 of Yosemite
or "mountain valley stage" Pliocene. Preserved in Indian and Illouette falls

(7) Pleistocene uplift in same way causing stage 3 of Yosemite or "canyon stage"
preserved in Bridal Veil

(8) Glaciation in several stages deepening and widening the canyons on shattered zones. Correlation with continental glaciation??

(9) Little Ice Age

Southern Cascades
Definition= area between metamorphics of Sierra and higher mts. to N.

Boundaries W side agains metamorphics of Klamath Mts., E is indefinite

Geology= lavas with some uplifted Tertiary on W.

Topography/ = principal mountains are volcanic, Mts Shasta, Lassen, etc. etc.
flows mainly andesite

Northern Cascades-why the order????
Definition= area of metamorphics like Sierra

Boundaries= E and W. top ographic, S= line of N.P. RR. or border of more flows

Geology= metamorphics and intrusives like Sierras and possibly connected.
some local young volcanic

Topography= rugged mts. which in distance resemble plateau dissected to maturity.
deep glaciated valleys, cirques, horns, L Chelan fiord, young volcanoes
Mt. Baker, Glacier Peak; granitic= Mt. Stuart

Eatons 94

430-441

Middle Cascades

Definition

Boundaries E. = edge of andesite
W= edge of valley or edge of lavas
N = N. P. rr.
S= line near Mt. Pitt

Column
Recent volcanics
Glacial drift
Miocene-Pliocene "Cascan" andesites
Miocene basalt (Col. R. Basalt)
Tertiary intrusives
Tertiary sediments, marine and cont.
Cretaceous marine
Jurassic intrusive
Carb. volcanics
Paleozoic sediments

Geology
Volcanics, mainly andesite, vary in age to Recent
Bury old lines of folding and uplift, some Tertiary in Col. valley
Topography some concealed basalts
Volcanic cones and flows, eroded volcanics-caldera of Crater Lake
Even skyline

History - Prothero
Folding involves as young as Miocene (Pliocene now established)

Peneplaination or "Methow surface." Type is the smooth sides of folds in basalt at Kelly Hollow near Yakima now called pediments
for= even skyline
Against= non-adjustment of streams
skyline is not level. Mature surface under basalts has been confused with post-volcanic erosion
Effect of porous mantle of volcanic ash locally retarding erosion on divide

Uplift(?) and erosion to present maturity

Glaciation and modern vulcanism

Special problems-
1952
Course of Columbia River across Cascades.
Is it antecedent or diverted by volcanics from an ancient course to S
Hodge considers present course too young for antecedent
Landslides in valley, Cascan flows undeformed

Origin of Crater Lake-explosion vs subsidence
Known ejecta of young age not enough to fill depression and make cone although they are in large amount
subsidence due to stopping of boiling over not all drainage.

Lowry & Baldwin GSA 63 - 1-24, 1952
1 Eruption of basalts with resultant or low terrane - includes limonite beds - & Miocene marine beds, probably valley where Col. R now is.
2 Later uplift to basalts - Col. R. then established near margin of basalts.
3 folding of Cascades - Twisidale fm deep in downfolded areas - some basic volcanism (early Pliocene)
4 Later Pliocene - Cascade volcanism contemp with Twisidale sed. sea level rose
5 Differential uplift - erosion of Col. R. gorge - most uplift near center 2500'+
6 sea level at -600 - Portland gravels - glacial erosion during since afterward
7 uplift to ± 400 ft to present condition contemp. with Seaslands

442-458

Pacific Border Province

Definition= ranges and associated valleys W of Cascade-Sierras and Basin-Range

Boundaries-foot of Cascades or border of lavas to E.
foot of Sierras-Tejon Pass , NE side of larger mountains omitting Salton ~~Sea in~~ to Gulf of California

Geology-
pre-Tertiary = "basement complex"
some of mountains same as Sierras (Klamath Mts)
~~mainly xx Tertiary xx~~ Jurassic intrusive, Carb. volcanics, metamorphics
Franciscan complex, also pre-Franciscan metamorphics
Cretaceous marine

Tertiary continental and marine, all folded, faulted
Pleistocene drift and stream deposits, some marine in Calif. + terraces
volcanics of Tertiary ~~and younger~~ age

Subdivisions
Olympic Mts.-Puget trough incl. Willamette valley- Wash-Oregon coast ranges-
Klamaths- Calironia Coast Ranges- Great Valley, Tehachapi- Los Angeles section-
~~Lower xx Sierra xx California~~ Lower California

Puget -Willamette trough
Definition= topography

Geology- glacial drift, mainly sand, very thick, much outwash
Eocene (coal-bearing)
volcanics, in part = Columbia River basalt

Topography
Drift-pitted outwash cut by valleys and in part drowned
inlets, canals, prairies, mounds, terraces, shells, moraines
Rock hills, in part basalt
alluvial fill

History involves at least two ages of drift - ice kept vallyes open. age??

Olympics
Definition

Why so little known

Geology-higher mts. = pre-Eocene igneous and metamorphic complex - unconformity
Tertiary sediments on margins Eocene lavas 2000-5000'
extensive volcanics Miocene sediments
Pliocene - Pleistocene diastrophism

Topography
Some high peaks, glaciated
General upland or inferred uplifted peneplain
valleys and lower terraces on Tertiary

458-471

Oregon Coast Ranges

Definition= range north of Klamath hard rocks

Boundaries= Coast on west
valley to east
hard rocks to S
Che halis R on N.

metamorphosed conglomerate, sandstone, siltstone, shale

Geology
All Tertiary sediments
Pleistocene-warping and gently folded sediments
marine terrace deposits (gold and chromite)
Pliocene= time of mountain making, few sediments
Miocene= time of folding, submarine eruptions, some sediments
Eocene= sediments and volcanics, folding, rests on pre-Tertiary complex
Folding branches out of Klamaths - in Washington trends to NW, So Olympics

Topography
Upland once called a peneplain, may be wave-cut terrace, in part.
Transverse valleys, double with entrenched meanders
Marine terraces to 1500 ft. - warped.
main terraces 150-170, 300-350, 500, 800-1000, 1500
all formed with a falling sea level
filled valleys, reexcavated during last uplift

Klamaths
Definition= area of old hard rocks much like Sierras

Boundaries, strictly geologic-lavas to E.

Geology relation to Blue Mts. to N. Cascades
Tertiary- clay, sand, gravel
Cretaceous folded conglom, ss, sh.
Jurassic-metamorphics and granitic intrustion some flows
pre-Jurassic metamorphics and basic intrusives, serpentine, greenstone
parts of structure unknown

Topography
Transverse drainage
Two story valleys, upland or "peneplain" on ridges - same as Sierras
marine terraces

2 harbors Coos Bay etc
+ one in Klamaths in channel marked
(Coast Range)

472-486

Valley of California
Definition-boundaries

Geology- Pleistocne and Recent alluvium on Tertiary
Best known in S. Part

Recent alluvial deposits, buff silt, , clay, arid climate 600 ft
Tulare formation with two distinct lake deposits in upper 600 ft
stream gravel-interglacial total thickness 500 to 3300 ft.
older lake deposits, glacial
Great unconformity = time of formation of Coast Range?
San Joaquin clays, Pliocene or Pleistocene, with some varved clays ascribed by some to earlier glaciations but of uncertain interpretation thickness 3300 ft
Etchigoin marine Pliocene

local uplift at Marysville Buttes, an eroded volcano

Topography
old alluvial fans of borders= redlands
Low plains or modern alluvial deposits
River lands or natural levees of present streams
Basins or areas inside natural levees
Island country or delta of rivers into Bay
San Joaquin has more east drainage so crowded to West
Tulare lake basin now dry most of time.

California Coast Ranges
Definition
Boundaries S = San Rafael mts. at border
N-= change to older hard rocks
E and W = topographic

Geology
Quaternary alluvium and marine sediments, folded and terrace
younger flows
Pliocene-Pleistocne continental and volcanic(tuff, flows, etc)
Tertiary marine including much ss, tuff
Cretaceous marine, ss, sh
Jurassic granite
Franciscan (Jurassic-Triassic) complex of sediments and volcanics, ss, chert, serpentine, schist
pre-Franciscan sediments, igneous, intrusives

Topography
parallel ranges ending against a coastal fault at NW.
straight, crests fairly even, few rolling uplands
marine terraces to 1500 (2300?) ft.
Willis has 3 types, uplifted blocks, tilted blocks, arched uplifts
many active faults shown by scarps, blocked drainage, shifted valleys, landslides. Possble confusion with normal erosion of resistant formations
change of climate to greater aridity filled lower parts of valleys and eroded heads
Streams consequent, subsequent, inherited from former surface, confusion of capture with antecedent streams

486-493

History of coastal ranges

Record very complex with many unconformities between folded formations
strata broken into fault blocks
no long quiet periods although possible maturity of erosion in Pliocene ??
Quaternary first marine deposition-then folding, then high elevation, submergence, then rise again with sea partly catching up

In Oregon Coast Range
dep. of early Pliocene, deformation, erosion, dep of later Pliocene
erosion up to middle Pleistocene= uplift of Coast Range
2 stages of valley cutting below modern sea level
dep. in earlier valleys-marine invasion and erosion forming terraces
erosion of second valleys
modern submergence or rise of sea level with alluvial fill

Smith gives for Oregon:

Eocene-unconformity-Oligocene- unconformity- Miocene-uplift and erosion with basalt eruption- Pliocene peneplain-uplift higher than now- submergence and formation of Pleistocne beaches-uplift- recent sub. or rise of sea level

Limestone - Limestone is used in the manufacture of sulphite cooking liquor to the extent of 440,000 tons annually. Of this total, we use 173,000 tons, the source of which is local.

Lime - The major percentage of lime is consumed in the sulphate and soda processes. An efficient lime recovery in these processes precludes a much greater usage. Some lime, essentially dolomitic, is used for the preparation of sulphite cooking acid. It is also a basic ingredient for producing calcium hypochlorite bleach liquor and in the bleaching process, and for the cooking of rags and straw.

Current annual usage is 500,000 tons, about twelve percent of the total production. About 50,000 tons are used in the Western industry.

Salt Cake - Salt cake, sodium sulphate, reduced to the sulphide, is the basic component of the sulphate pulping process. Its concentration is maintained at a predetermined level in the cooking liquor to produce the particular pulp desired in the mill. This chemical is derived from three sources: natural, synthetic, and by-product.

The sulphate process depends for its economic success entirely upon the efficiency of chemical recovery. Inasmuch as this percent recovery varies quite widely, we can only say that salt cake usage likewise varies over relatively wide limits. Normally, from approximately one hundred seventy-five to four hundred pounds per ton of finished pulp are required.

The industry current consumption, practically the entire production, is 650,000 tons. Pacific Coast usage of about 60,000 tons is mainly from natural deposits in California.

Soda Ash - Soda ash, sodium carbonate, is a source of alkali in preparation of the sulphate and soda cooking liquors. One purpose is to adjust to the final causticity, reducing the sulphidity to the desired percentage. In the soda process, soda ash is the essential chemical for liquor makeup.

A furthur, very important use is that it is the alkali used in the cooking of rosins for the preparation of rosin size. Soda ash, in conjunction with other alkalis, and miscellaneous materials, is used in the de-inking process for the reclaiming of waste papers.

Current consumption is about five percent of the total production at the rate of 150,000 tons annually, 10,000 tons of which are used on the Coast.

Caustic Soda - Caustic soda is what might be called a secondary pulping chemical. It is used in the preparation of purified cellulose for rayon pulps. Also, in the multi-stage bleaching of sulphate pulps it is finding wide application for removal of chlorinated products in the primary stages.

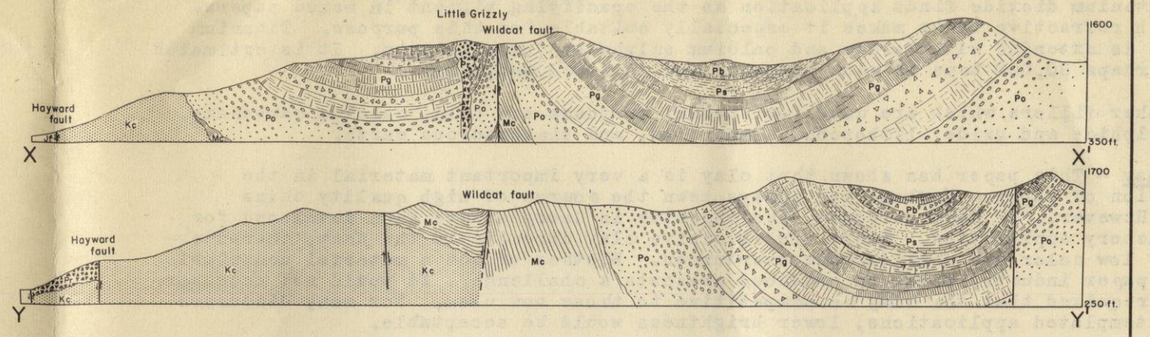
Annual consumption is about 110,000 tons, about six percent of the total. Based upon bleached pulp production, approximately 30,000 tons are required in this area.

Chlorine - In one form or another, chlorine finds application in most bleaching processes. This process, which we might term one of secondary cooking, accomplishes the final preparation of the pulp as a raw material for the paper mill. With the very rapid increase in production of bleached pulp, chlorine is very important in the industry. Approximately 250,000 tons or thirty percent of the total production is so used. The Pacific Coast requires 50,000 tons.

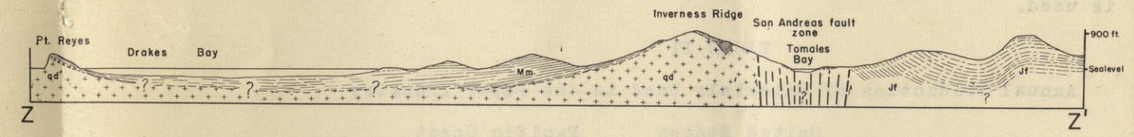
Fillers and Coating Materials - Many different pigments are used, both natural minerals and manufactured chemicals, to achieve the desired opacity, printability, color, smoothness and softness in the finished paper.

Clay is the most widely used pigment with its application being rapidly extended. At present around 600,000 tons, sixty percent of total production, are consumed annually. The Pacific Coast has not until very recently used an appreciable amount of this pigment.

BERKELEY HILLS AREA



POINT REYES – SAN ANDREAS AREA



AGE	FORMATION	SYMBOL	DESCRIPTION
RECENT		Qr	Sand dunes, marshes, alluvium, and man-made fills.
PLEISTOCENE		Qp	Poorly consolidated gravels, fossiliferous sands and oyster beds.
PLIOCENE	Merced	Pm	Gray to buff sandstone with foraminifera horizons.
PLIOCENE	Leona	Pl	Small isolated flows of rhyolite breccia
PLIOCENE	Bald Peak	Pb	Black to gray olivine basalt, vesicular and amygdaloidal in part.
PLIOCENE	Siesta	Ps	Fossiliferous lake deposits, shale, limestone and tuff.
PLIOCENE	Grizzly Peak	Pg	Basalt similar to Bald Peak, agglomerates, tuffs, and mud flows
PLIOCENE	Orinda	Po	Brown, green and red pebble sandstone and conglomerate of continental origin.
MIOCENE		Mu	Undifferentiated upper Miocene sedimentary rocks
MIOCENE	Monterey Cromwell	Mm Mc	Siliceous shale and well bedded gray to tan cherts. Basal conglomerate and sand
CRETACEOUS		Kc	Tan or buff shales and sandstone
JURASSIC	Franciscan	Jf	Undifferentiated shale, chert, and sandstone with some igneous and metamorphic rocks
(Franciscan divided by lithology; age relations not shown)		ss — ls	Gray to green sandstone and graywacke; ls, limestone
		ch	Well bedded red radiolarian cherts. Some buff to tan
		bg	Basalt porphyry showing pillow structure; gabbroic in part
		sp sc	Serpentine (sp) Silica-carbonate rock (sc)
PRE-JURASSIC ?	Bodega	gd	Quartz diorite of uncertain age
PALEOZOIC ?	Sur ?	pJ	Metamorphic series of marble, schist, and quartzite

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES DIVISION OF MINES
GENERALIZED GEOLOGIC MAP AND SECTIONS

BERKELEY HILLS – SAN ANDREAS RIFT ZONE

1949

0 1 2 3 4 5 10 MILES

GEOLOGY COMPILED FROM A.C. LAWSON, C.E. WEAVER, AND OTHERS

Titanium dioxide finds application as the opacifying pigment in waxed papers. Its high refractive index makes it especially suitable for this purpose. Titanium dioxide is extended with barium and calcium sulphates for some uses. It is estimated that perhaps 30,000 tons of such pigments are required annually.

Other fillers which are used for special purposes are talc, calcium carbonate, zinc sulphide and oxide, lithopone, blanc fixe, and diatomaceous earth.

Clay - This paper has shown that clay is a very important material in the production of paper. England has always been the source of high quality china clay. However, for most purposes, the deposits in Georgia have been developed for satisfactory application. There are extensive clay deposits in the West, characterized by low color and considerable overburden. Whether or not a material acceptable to the paper industry could be produced presents a challenge. It would not necessarily be required that the clay be competitive to those now used. For many discussed and contemplated applications, lower brightness would be acceptable.

If one is conversant with papermaking literature, he has periodically read of the production of alum from clay. This is a proven possibility, economics being the primary consideration. At present, relatively high grade bauxite from the South is used.

TABLE II

Annual Production of Materials Used in the Paper Industry

	United States Tons	Pacific Coast Tons	% of U.S. Tons
Pulp	10,605,000	1,754,000	17-1/2
Sulphate	4,597,000	414,000	9
Sulphite	2,476,000	966,000	39
Mechanical	1,812,000	312,000	17
Soda	466,000	21,000	4-1/2
Others	1,254,000	- - - -	-
Paper	19,180,000	1,565,000	7-1/2
Board	8,450,000	450,000	5

Chemicals	Used in U.S. Pulp & Paper Industry-Tons	Used in Pacific Coast Pulp & Paper Industry - Tons	
Sulphur	400,000	145,000	(imported)
Limestone	440,000	173,000	(local)
Lime	500,000	50,000	(local)
Salt Cake	650,000	60,000	(local)
Soda Ash	150,000	10,000	(local)
Caustic Soda	110,000	30,000	(local)
Chlorine	250,000	50,000	(local)
Alum	150,000	15,000	(local)
Clay	600,000	30,000	(imported)
Titanium pigments	30,000	-	(imported)
Talc	30,000	-	(local)
Sodium Silicate	400,000	-	(local)
Calcium Carbonate	75,000	-	(imported)
Sulphuric Acid	9,000	-	(local)
Asphalt	-	7,000	(local)
Sodium Aluminate	5,000	-	(imported)

493-510

Angeles Section

Definition= coast extension of Basin-Range geology

Boundaries
includes marine lowlands of coast and larger block mts.
excludes Salton Bain and granite block of Lower California

Geology

alluvial and marine unconsolidated sediments

Pliocene-Pleistocene marine to over 20000'

Oliocene-Eocene marine

Cretaceous marine
Franciscan
Granitic basement pre-Franciscan

Volcanics Tertiary

Structure- folded, extensive faulting
no marked difference from Coast Range to N San A Rift inside mts.

Topography
Lowlands on alluvium
anticlinal uplifts shown by radial drainage
mountains with some even uplands-fault borders in part

History
all strata including early Pleistocene folded, faulted with deposition in lower parts
Early surface cut by Perris surface
Galivan surface formed after complete burial of some mts. by Pliocene
Sulphur M surface of Ventura region is late maturity
area submerged to 1300 ft.
Uplift left 9 terraces differences on islands
Terraces warped, continued faulting, folding to present

Southern California section
Definition= block of Jurassic intrusive extending into U1 .

GeologyQuaternary terraces
Pliocene-Eocene sediments and volcanis
Cretaceous
Triassic volcanics
Jurassic intruded into older schists

Topography- block like Sierras but lower. Marine terraces
plateau broken into blocks by faults, some late Tertiary gravel now faulted
History-last deposits marine are Pliocene-early Quaternary a surface of old age with monadnocks-uplift and folding-marine terraces- uplift and erosion

GEOLOGY 1 30
PHYSIOGRAPHY OF WESTERN UNITED STATES

Final examination 11 June 54

Write on 10 only and please indicate which you left out. Leave postcard for grade

(1) Describe the origin of the features of Puget Sound including both the major and minor forms such as the shoreline.

(2) Describe not less than three lines of evidence which indicate that faulting and other earth movement is still in porgress on the Pacific coast.

(3) Compare tow theories of origin of the gorge of Columbia River through Cascades

(4) Give two arguments for and three against the importance of wind erosion in Basin and Range province

(5) Give three evidences of the ability of Colorado River to erode the Grand Canyon and ~~xxx~~ two alternative ideas some suggest for its origin.

(6) What three different types of mountains occur in Columbia Plateau giving and locating examples of each

(7) Show with diagram-corss section the relation of the upland surface of Southern Rockies to Colorado Piedmont and High Plains

(8) Compare three different hypotheses of crossing of Uninta Mountans by Green River.

(9) Give two possible explainations of the topography of mountans of central Idaho.

(10) Describe the terraces along the rivers of Missouri Plateau and two possible explanations of their cause.

(11) Explain with diagram the bearing of Boston Mountans of erosional history of Ozark Plateau giving at least two hypotheses

(12) Outline in roper order the evensts of history of topography of Ouachita Mountans

(13) Give in proper order the major steps in development of topography of Sierras in vicinity of Yosemite Valley

(14) Locte as definitely as possible and tell briefly ORIGIN of: (a) Break of the Plains, (b) Devils Tower, (c) White River Badlands, (d) Bitterroot Mountans, (e) Mt. Shasta, (f) Dominguiz Hill, (g) Henry Mountans, (h) Lewis Range, (i) St. Francis Mountans, (j) Olympic Mountains.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Twelve weeks examination 7 May, 1954

Write on four questions only and please show on cover which they are.

(1) Locate (province, section, state) and explain origin of briefly:
(a) Sacramento Section, (b) Mesa Verde, (c) Tonto Platform, (d) Vermilion Cliffs, (e) Wasatch Mts., (f) San Francisco Mt., (g) Grand Wash Cliffs, (h) Wind River Basin, (i) Bighorn Bas in, (j) Lake Missoula

(2) With regard to problem of origin of the b asins of Basin and Range Province state: (, a, b, c) three possible modes of origin, (d) why a contoversy arose over these, (e) significance of the deposits within the basins on this problem.

(3) With regard to the drainage of Colorado Plateau state: (a) time relation to monoclinal folds, (b) relation to deposits of Tertiary age, (c) time relation to faulting, (d) time relation to vulcanism, (e) age of present course into province to west.

(4) Outline in proper order 4 major stages of history of Columbia Plateau. (omit details of controversial portions)

(5) In regard to Crater Mound, Arizona: (a) describe, (b)(c) (d) state three major hypotheses which have been advanced for its origin, (e) state line of evidence which indicates a violent process rather than a slow one.

(6) Explain following facts briefly: (a) talus is scanty along many of the cliffs of Colorado Plateau, (b) Many of the canyons of Colorado Plateau display entrenched meanders, (c) (d) give two possible explanations of sloping uplands of Uinta Mountans, (e) most extinct lakes of Basin and Range P rovince have modern lakes in their basins.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Midsemester examination 5 April, 1954

Write on 4 questions only and please show on cover which they are.

(1) With respect to Grand Coulee: (a) locate, (b) describe briefly covering nature of sides, division into sections, slope, etc. (c) give commonly accepted theory of origin, and (e) state relation to the Scablands.

(2) With respect to Northern Rockies: (a) Describe briefly the topography contrasting with Southern and Middle Rockies (b.c) give two lines of evidence advanced to demonstate that the crests represent remnants of a former even surface, (d,e) give two important objections to above theory

(3) Locate as definitely as possible and give origin of: (a) Snake River Plain, (b) Baxter Basin, (c) Grand Canyon of Yellowstone River, (d) Thousand Springs, (e) Tetons, (f) Bighorn Basin, (g) Coteau du Missouri, (h) White River Plateau, (i) Wind River Basin, (j) Lake Missoula

(4) In respect to the Scablands of Washington state: (a, b) two facts agreeded on by the majority of those who have described the area, (c, d, e) three major theories with a brief explaination but without comparison of merits.

(5) (a, b) Give two alternative explainations of the origin of the smooth flanks of the basaltridges near Yakima, Washington
(c) Explain the greater prominence of glacial erosion features in Glacier National Park than farther south
(d) Explain levelness of Snake River Plain
(e) Explain why east face of Rocky Mountains is due to relatively recent erosion of an ancient uplift

(6) (a) Account for the disregard of mountain uplifts by the rivers of Wyoming Basin, (b) locate one apparent exception in this region, (c) account for the course of Columbia and Snake Rivers in the Columbia Plateau,
(d) account for the meanders of streams which cross the ridges near Yakima, Washington, (e) account for Royal Gorge of Arkansas River in Colorado.

(meanders)

GEOLOGY 1 30
P HYSIOGRAPHY OF WESTERN UNITED STATES

Six weeks examination March 8, 1954

Wr ite on 4 questions only and please idicate on cover which they are.

(1) State briefl y the location by province, section, state, etc. of: (a) High Plains (b) Loess Plains (c) Cypress Hills (d) Little Rocky Mts., (e) St Francois Mts., (f) Calla han Divide, (g) Edwards Plateau (h) Llano District, (i) Athens Plateau, (j) Magnet Cove

(2) With respect to Ouachita Mts. state briefly: (a) major types of rocks which make ridges, (b) (c) two inferences which might be drawn from "two story" topography giving diagram of same, (d) (e) two possible and probable origins for water gaps of major streams.

(3) With respect to problem of badland topography state: (a) origin of the term badlands, (b, c) two important areas thus far studied, (d) kind of material in which eroded, (e) cause of rapid erosion which is cutting into old subdued surfaces.

(4) With respect to the Southern Rockies state briefly: (a) geologic date of the major uplift, (b) evidence of more than one time when the mountains were of low relief, (c) relation of these times to conditions in Great Plains, (d) cause and distribution in general of hogback foothills, (e) effedt of glaciation on scenic features.

(5) In respect to the Ozarks s tate briefly: (a, b, c) name three different levels of uplands and their relation to geology, (d) (e) two possible ages of the upland surface found in Missouri.

GEOLOGY 130

PHYSIOGRAPHY OF WESTERN UNITED STATES

Final Examination June 11, 1953

Write on any 10 and please indicate which you left out. Please leave postcard for your grade.

(1) Locate as definitely as possible and tell origin of each briefly:
(a) Dominguiz Hill, (b) Olympic Mts., (c) St. Francis Mts.,
(d) Magnet Cove, (e) Chief Mt.

(2) Compare merits of two hypotheses of origin of Crater Lake.

(3) Explain briefly origin of Puget Sound.

(4) With respect to importance of wind erosion in semi-arid west state two arguments in favor and three against.

(5) List three different types of mountains which occur within Columbia Plateau.

(6) List three different types of mountains which occur within Colorado Plateau.

(7) Account for the drainage relations of Wyoming Basin and Bighorn Basin.

(8) Explain relations between the upland levels of Southern Rockies and the High Plains using diagram. Cite proof.

(9) Describe the terrace levels found in northern Great Plains giving two hypotheses of their origin.

(10) Compare two hypotheses of the crossing of Cascades by Columbia River.

(11) Describe geology and topography of Black Hills using diagram section.

(12) Give the evidences of the competency of Colorado River to erode the Grand Canyon opposing the popular idea that it is due to earth movement.

(13) Give two points for and three against the former existence of a peneplain in northern Cascade Mts.

(14) Take one of the photos--give its number; tell what event or phenomenon in western United States it illustrates; give its probable location.

9 copies
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GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Examination May 8, 1953

Write on 4 questions only and please indicate on cover which you left out.

(1) Locate as definitely as possible and tell origin briefly of:
(a) Henry Mountains, (b) Zuni Mountains, (c) Lake Lahontan,
(d) Espinade, (e) Death Valley, (f) Mesa Verde, (g) White Cliffs,
(h) Kaibab Plateau, (i) Hurricane Ledge, (j) Painted Desert

(2) Complete follwing statements giving in single sentence the best proof of each:
(a) Some of the lakes of Basin and Range are not as a salty as others which also have no outlet because---
(b) It may be incorrect to conclude that the formation of the Grand Canyon of the Colorado represents a separate cycle of erosion than does the erosion of the surrounding country because---
(c) A large portion of the erosion of Cretaceous and older rocks of the Colorado Plateau occurred in pre-Eocene time because--
(d) Entrenced meanders of San Juan River indicate---
(e) Most of the extinct lakes of Basin and Range province occur near to surviving lakes because--

(3) Give points for and against two alternative hypotheses of the relation of stream courses near Yakima, Wahsington to the age of deformation of underlying materials.

(4) List 5 evidences of occurrence of concealed faults along bases of mountains of Basin and Range porvince.

(5) Outline the problem of origin of Crater Mound, Arizona, considering three hypotheses with points for and against each.

(6) State the major hypotheses of origin of topography of Basin and Range province considering points for and against and the ~~basis~~ cause of the controversy.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Midsemester examination April 8, 1953

Write on any 4 questions only. Please indicate on cover which they are.

(1) (a) Distinguish between hogbacks and cuestas (b,c,d,e) explain 4 reasons why hogbacks occur only along certain portions of the Rocky Mountain Front.

(2) With regard to the problem of Green River through Uninta Mountains state (a,b,c) three major hypotheses, (d,e) most important reasons for rejection of two of them.

(3) With respect to the problem of origin of the Scablands of Columbia Plateau state: (a) facts about them generally agreed to, (b) their distribution, (c)(d)(e) three major hypotheses with brief explanation of each.

(4) Locate as definitely as possible and tell briefly the origin of:
(a) Yellowstone Lake, (b) Absoraka Range, (c) Grand Canyon of Yellowstone,
(d) Great Bend of Columbia River, (e) Townsend Valley, Montana,
(f) Moses Coulee, (g) Craters of the Moon, (h) American Falls,
(i) Owyhee Mountains, (j) Cypress Hills.

(5) Complete following sentences in reasonable length giving proof of each:
(a) No evidences of Tertiary fans has been found on west of Rocky Mountains because----
(b) (c) Two possible explanations of the smooth flanks of the basalt ridges near Yakima Wash. are----
(d) The mountains of northern Idaho were deeply eroded before the eruption of the Columbia River basalts because---
(e) The east face of the Teton Mts. is so scenic because---

(6) Explain two reasons why the scenery of Glacier National Park is more striking than that of Rocky Mountain National Park.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Six weeks examination March 9, 1953

Write on four questions only and please indicate on cover which they are.

(1) Locate as definitely as possible in regions studied this semester a good example of each: (a) hogback ridge due to novaculite, (b) escarpment due to erosion of alluvial fans, (c) granite monadnock, (d) entrenched meanders, (e) intermontane valley filled with alluvial deposits, (f) young volcanic cone, (g) two-story topography, (h) gorge due to superimposed stream, (i) volcanic neck.

(2) With respect to badlands state: (a,b) two major areas in Great Plains, (c) necessary material, (d) favorable type of climate, (e) relation to erosional history.

(3) Account for the course of Missouri River through Great Plains.

(4) Explain history of the present topography of Southern Rockies giving 5 major steps in proper order.

(5) Explain why the Great Plains are separated from Central Lowlands and compare merits of four different lines of division which have been suggested.

(6) State briefly the origin of (a) Gang Plank, (b) Nebraska sand hills, (c) terraces along Yellowstone River, (d) Big Snowy Mountains, (e) Boston Mountains.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Final examination June 12, 1952

Write on any 10 questions indicating on cover which you left out. Please avoid office or telephone calls before Monday noon.

(1) Give in proper order steps in history of topography of Sierras as demonstrated in Yosemite Valley

(2) Locate as definitely as possible and tell origin of: (a) Moses Coulee, (b) Bfeak of the Plains, (c) Lewis Range, (d) Red Hills, (e) Bitterbot Mts., (f) Novaculite Uplift, (g) Mt. Hood, (h) Magnet Cove, (i) Coteau des Prairie, (j) Death valley

(3) Using diagrams give steps in proper order of development of topography of San Juan Mts.

(4) Describe and account for topography of Puget Sound region.

(5) Explain origin and history of Salton Trough (Imperial Valley)

(6) Explain points for and against hypothesis of peneplaination in (a) Northern Cascades and (b) Oregon Coast Range.

(7) Describe the Los Angeles section in respect to geology, topography and history including what province it resembles.

(8) Compare two hypotheses of origin of Crater Lake

(9) Account for drainage pattern of Wyoming Basin except Green River.

(10) Give points for and against conclusion that cliffs of High Plateaus of Utah were formed in a different cycle than was the Grand Canyon.

(11) Compare four possible explanations of the fact that the Boston Mountains rise abruptly from the uplands to the north.

(12) Describe and locate examples of three different types of mountains which occur within Columbia Plateau.

(13) Outline in proper order of events the history of the topography of the Ouachita Mountains including cause of the drainage pattern

(14) Describe the Black Hills in respect to geology, major topographic features, and major events of history of the present topography.

GEOLOGY 130

P HYSIOGRAPHY OF WESTERN UNITED STATES

Examination May 9, 1952

Write on any 4 questions indicating on cover which they are. (4 only answered)

(1) Give essential basis of four hypotheses of origin of Scablands of Columbia Plateau. 3

(2) State at least 5 evidences of (a) concealed faults along bases of mountains of Basinx and Range Province and (b) two evidences of recent faulting.

(3) With respect to the drainage of Colorado Plateau state briefly evidence of its relation to (a) monoclinal folding, (b) Tertiary sediments, (c) faulting, (d) volcanism, (e) time of filling of basins of Basin and Range Province.

(4) Locate as definitely as possible and state origin or significance of: (a) Grand Was h Cliffs, (b) Wasatch Mts., (c) Esplinade, (d) Wind River Canyon, (e) Absoraka Mts., (f) Craters of the Moon, (g) Redwall Cliff, (h) White Cliffs, (i) Tularosa Basin, (j) Mesa Verde National Park

(5) Describe evidence for an significance in physiographic history of Lake B onneville

(6) Compare merits of three hypotheses of origin of enclosed basins of Basin and Range Province.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Apr 7, 52.

Midsemester Examination
Write on four questions and no more. Please show on cover when they are.

(1) With reference to the "Tertiary Basins" of Northern Rockies (a) describe them, (b) explain basis of controversy over their significance, (c) compare with similar features of Middle and Southern Rockies.

(2) With respect to the course of Green River through Uinta Mts. explain (a) three hypotheses, (b) points for each, and (c) points against each.

(3) Account for the Grand Coulee of Washington excluding the Scabland Problem except as it directly involved.

(4) Complete following ~~sentences~~ statements giving best single proof of each (no more counted than a single sentence of reasonable length each):
(a) Opinion is turning to the explanation of many sloping but smooth mountain uplands as pediments rather than as warped peneplains because---
(b) The history of the ridges near Yakima, Wash., is simplified by the modern interpretation of their smooth sides because--
(c) Superposition will explain course of Wind River because--
(d) The Gang Plank indicates that---
(e) Glacier National Park is more scenic than Rocky Mountain National Park, Col., because---

(5) Locate as definitely as possible and tell origin of: (a) Baxter Basin, (b) San Juan Mts., (c) yellowstone Plateau, (d) Spanish Peaks, (e) Lake Missoula, (f) Teton Range, (g) American Falls, (h) Thousand Springs, (i) Coteau du Missouri, (j) Big Horn Basin.

1 1

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

march 10, 52
March 10, 1952

Write on four questions and no more. Please show which you left out.

(1) Complete the following sentences giving briefly (limit a single sentence of reasonable length) best proof of each statement:
   (a) The Coastal Plain probably once buried the Ouachita Mountain because--
   (b) The Boston Mountains do not fit into the hypothesis of a fairly recent "Ozark peneplain" because--
   (c) The High Plains once extended farther north than now because---
   (d) The High Plains once extended farther east than now because---
   (e) The Edwards Plateau was uplifted above the Coastal Plain in fairly recent time because--

(2) Locate by province, state, section etc. (as specifically as possible) and give briefly origin of: (a) Gang Plank, (b) Pikes Peak, (c) Salem Plateau, (d) Missouri Coteau, (e) Callahan Divide, (f) St. Francis Mts., (g) Athens Plateau, (h) Comanche Plateau, (i) Hot Springs "peneplain", (j) Pine Ridge

(3) Describe in proper order not less than 5 major steps in combined history of Southern Rockies and central Great Plains.

(4) Account for formation of badlands and give two major localities in Great Plains.

(5) Give evidence for and discuss origin of "San Juan peneplain".

(6) Explain why Great Plains is separated from Central Lowland and discuss location of the dividing line.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Final examination June 6, 1951

Write on any 10 questions and please indicate which you omitted. In interest of speed of grading please avoid office or telephone calls before Saturday. Leave postcard for your grade either now or in mailbox.

(1) Compare two possible origins of the rolling upland of the Salem Platform involving each a different geologic age.
(2) (a) Describe and (b) account for Grand Coulee, Washington

(3) Explain two hypotheses of the present course of Columbia River across the Cascade Mountains.
(4) Account for the present course and geolgic age of Missouri River in Great Plains in regions studied this semester
(5) Locate as definitely as possible a good example each of: (a) vulcanism within historic time, (b) remnant of High Plains still extending to their source, (c) fault block mountain wholly of lava, (d) mesas capped by "natural brick", (e) bolsons now eroded by through stream.
(6) Explain origin and describe topography of Payette Section, Columbia Plateau.

(7) Explain in proper order with diagrams major steps in development of present topography of Colorado Front Range and Colorado Piedmont.
(8) Describe topography, structure and history of Angeles Section of Pacific Coast.

(9) Locate as definitely as possible and tell origin of: (a) Marysville Buttes, (b) Absoraka Range, (c) White Cliffs, (d) Craters of the Moon, (e) Henry Mts.
(10) Give evidence for and against the former presence of peneplains in both Sierra-Cascade Mts. and Pacific Coast Ranges.
(11) Outline the proofs you could present to prove that the Grand Canyon of the Colorado was really formed by the work of the present river.
(12) Descirbe the major topographic features (no details or local names required) of the Ouachita Mts. and explain history of the present topography.
(13) Account for (a) present course of Wind and Bighorn Rivers, (b) erosion of present course of Colorado River through Basin and Range Province.
(14) Account for the hanging valleys of Yosemite Valley, California.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Examination May 4, 1951

Write on 4 questions and no more. Please indicate which they are.

(1) Explain not less than 5 lines of evidence which indicate the presence of concealed faults along bottoms of many mountain ranges in Basin and Range Province.

(2) Enumerate in proper order with adequate explaination the major steps in history of topography of Colorado Plateau

(3) Expalin briefly not less than 2 points in favor of and 3 points against large-scale wind excavation of the basins of Basin and Range Province.

(4) Compare merits of two major hypotheses of origin of Meteor Crater, Arizona

(5) Complete following sentences giving best proof of each statement (no more than a single sentence of reasonable length considered):
   (a) The slight amount of talus below many of the cliffs of the High Plateaus of Utah is due to---
   (b) Entrenched meanders of Colorado Plateau indicate-----
   (c) Basin filling has gone on for a very long time in Basin and Range province because---
   (d) Vulcanism has been a long-continuing process in Colorado Plateau because---
   (e) Mature topography on the summit of a mountain range of Basin and Range Province indicates---

(6) Locate in provinces studied this semester and tell origin or nature of:
   (a) Hurricane escarpment, (b) Chuska Mts., (c) Lake Lahontan,
   (d) Uintah Mts., (e) "Great Denudation", (f) Mt. Trumbull,
   (g) Painted Desert, (h) Vermilion Cliffs, (i) Kaibab Plateau,
   (j) Axial Basin.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Midsemester examination April 2, 1951

Write on any 4 questions and no more. Please indicate on cover of bluebook which questions you answered.

(1) Locate as specifically as possible including province and section and state origin briefly
(a) Balcones Escarpment, (b) Llano District (central mineral district), (c) Ouachee Mountains, (d) Gros Ventre Mountains, (e) Craters of the Moon

(2) Locate in provinces studied thus far this semester a good example each of (a) sandstone hogbacks, (b) mountain front due to thrust fault, (c) result of burning out of lignite beds on topography, (d) gorge due to glacial diversion of river, (e) fault scarp (recent) of mountain range, (f) hills of loess, (g) extensive badlands, (h) lava plain, (i) effects of a recent igneous intrusion, (j) meandering valley.

(3) Compare merits of two major hypotheses of course of Green River across Uinta Mountains.

(4) With regard to three of the four theories of origin of the Scablands of Washington state (a) name of the originator, (b) basic idea of the hypothesis, (c) points for each, and (d) objection to each of the theories.

(5) Complete following sentences giving proof of each statement(no more than a single sentence of reasonable length will be considered:
(a) Observed subequality of summit levels of Northern Rockies may be due either to --- or ---. (please omit details)
(b) Sloping uplands of the Unita Mountains are now called pediments because----
(c) The High Plains once buried the entire eastern face of the Rocky Mountains because--
(d) The basin of the Colorado River of Central Texas is placed in the Great Plains because---
(e) No deposits comparable to those of the High Plains have been discovered on the west side of the Rocky Mountans because--

(6) Compare relative merits of two hypotheses of history of basalt ridges near Yakima, Washington

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

"Six weeks" examination. March 5, 1951

Write on any 4 questions and no more. Please indicate on cover of your bluebook which they are.

(1) List in proper order the major steps in history of development of topography of Ozark Plateau.

(2) Locate as specifically as possible and tell origin of the following: (a) South Park, (b) San Luis Valley, (c) Springfield Plateau, (d) Little Rocky Mountains, (e) Nebraska sandhill region, (f) Mesa de Maya, (g) Spanish Peaks, (h) Race Track, (i) Longs Peak, (j) Devils Tower.

(3) Discuss occurence and theories of origin of the terraces of Missouri Plateau.

(4) What evidences indicate manner of origin and time or times of formation of the Rocky Mountain upland.

(5) Complete following sentences giving best proof of each statement (no more than a single sentence of reasonable length considered):
(a) The Missouri River in the Great Plains is not in its preglacial location because--
(b) The Ouachita Mountains were much subdued before deposition of sediments of adjacent Coastal Plain because---
(c) The San Juan Mountans are more picturesque than the Front Range because---
(d) The High Plains once extended farther east than they now do because--
(e) The High plains must once have extended farther north than they now do because---

(6) Locate in areas thus far studied this semester a good example each of: (a) existing glacier, (b) hogbacks formed by erosion of novaculite, (c) glaciated alluvial fan surface, (d) laccolith, (e) "two story" mountain topography, (f) pediment terraces preserved by lava cover, (g) portion of Rocky Mountain front without hogbacks (h) little eroded volcanic cone, (i) plateau on coal-bearing sandstones, (j) ridges due to erosion of dikes.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Final examination June 6, 1950

Write on 10 questions only and please mark on cover which you left out. In the interest of speed in grading please do not ask for your grade either at office or by telephone but leave a postcard.

(1) Desribe and explain origin of the Grand Coulee, Washington.

(2) Discuss two possible interpretations of the rolling uplands of the Ozark Plateau.

(3) Complete following sentences giving proof of each in reasonable length:
(a) The High Plains once extended farther north than they now do-----
(b) Typical "Basin Ranges" are bounded by faults because---
(c) The line between Columbia plateau and Basin and Range is located by---
(d) Ridges due to resistant rock in the Ouachitas demonstrate that the dip is the same on both limbs of many folds because----
(e) The subdued topography on the crest of many Basin Ranges proves recenet faulting because--

(4) Compare merits of two possible explanations of Crater Mound, Arizona.

(5) Discuss points for and against theory that the enclosed basins of the Basin and Range Province are due to work of the wind.

(6) Older literature is full of reference to former peneplaination of the Northern Rockies. List evidences for and against this hypothesis.

(7) What two explanations have been advanced for the present course of Columbia River thrcugh Cascade Mountains? Explain each.

(8) Account for course of Missouri River across the Great Plains.

(9) Locate examples in Great Plains of (a) volcanic cone, (b) laccolith, (c) mesa capped by lava, (d) plateau capped by limestone, (e) terminal moraine of continental glacier.

(10) Account for origin and present topography of Snake River Plain.

(11) Outline with necessary diagrams in proper order the major steps in the development of present topography of Wyoming Basin and Middle Rockies.

(12) Illustrate with diagrams (a) the surface evidence of anticlines in the foothills of the Middle Rockies. (b) why hogback foothills are present along only part of the borders of the Southern Rockies.

(13) Compare topography, rock structure and history of Angeles Section of Pacific Coast and adjacent part of Basin and Range. Explain why a line of division is made and where.

(14) Locate and give origin of: (a) Marysville Buttes, (b) Hot Springs Plateau, (c) Absoraka Range, (d) San Francisco Plateau, (e) Boston Mountains, (f) Sacramento Section, (g) Great Divide Basin, (h) Lake Bonneville, (i) San Clemente Island (j) Bitterroot Mountans.

GEOLOGY 130

PHYSIOGRAPHY OF WESTERN UNITED STATES

May 5, 1950

Write on any 4 questions and no more. Please indicate which you left out. Grading may be delayed by field trips.

(1) Locate as definitely as possible and tell origin of or define: (a) Zuni Mountains, (b) Henry Mts., (c) Lake Bonneville, (d) Wasatch Mts., (e) "Great Denudation", (f) Mt. Taylor, (g) Painted Desert, (h) San Francisco Mt. (i) White Cliffs, (j) Pink Cliffs

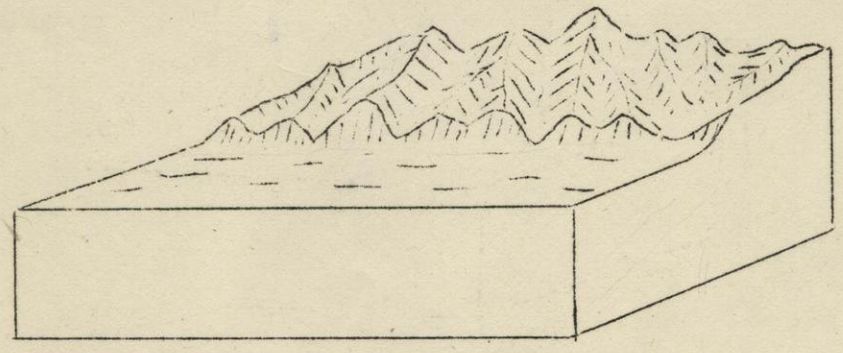
(2) Compare merits of several possible explanations of course of Green River through Unita Mountains.

(3) Explain and compare points for and against two hypotheses of drainage history in Yakima district, Washington.

(4) Complete following statements into a single sentence of reasonable length which expresses the proof of each:
(a) Faulting has gone on over a long period of time in Colorado Plateau because---
(b) Vulcanism has gone on over a long period of time in Basin and Range province because---
(c) Benches on sides of Grand Canyon of the Colorado indicate-----
(d) The fact that the same lava flow is present both at foot on and summit of the mountain range demonstrates that------
(e) Talus is scanty at bottoms of many of the cliffs of Colorado Plateau because---

(5) (a) Discuss problem of the age of Colorado River in Basin and Range province
(b) What facts has erosion by Colorado River in Basin and Range province disclosed which bear upon history of the topography?

(6) If you answer this question place your name on sheet, fold and enclose in your bluebook.
(a) Fill in a possible explantion of the geology and structure on edges.
(b) Give history demonstrated.



GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Midsemester examination April 3, 1950

Write on any four questions (note option in No. 4) and please indicate which ones they are on cover of your bluebook.

(1) Discuss and compare merits of at least two of the major hypotheses which have been advanced to explain the Scablands.

(2) In provinces studies thus far this semester locate as definitely as possible a good example each Of: (a) hogbacks with strata dipping toward the mountains, (b) mountains due to erosion of a granite intrusion (at time of mountain uplift), (c) buttes and mesas capped by natural slag, (d) gorge of an antecedent river, (e) gorge of a superimposed river, (f) gorge due to recession of falls, (g) gorge due to recession of a spring, (h) mountain front due to recent faulting, (i) mountains of eroded lava flows, (j) loess hills.

(3) Complete following statements giving best proof of each (no more than a single sentence of reasonable length will be counted):
(a) The mountains of southwest Idaho resemble a plateau because--
(b) The east face of the Bitterroot Mountains is so straight because--
(c) The Craters of the Moon may be older than they appear because--
(d) The mountains of Idaho were deeply eroded prior to the extrusion of of Columbia River basalts because---
(e) Glacier National Park has such steep-sided mountains because--

(4) Discuss BRIEFLY (a) definition, (b) boundaries, (c) general geology, (d) major topographic features of EITHER
(1) Middle Rocky Mountains or
(2) Payette section of Columbia Plateau

(5) Where (locate specifically as possible) is and what is origin of:
(a) Edwards Plateau, (b) Llano Estacado , (c) Blue Mountains,
(d) Moses Coulee, (e) Tertiary basins (general).

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

"Six weeks" examination March 6, 1950

Write on any 4 questions and no more. Please indicate on cover which they are.

(1) List in proper order the major steps down to present in development of the present topography of Great Plains and Southern Rockies.

(2) Where (be as specific as possible) is and what is origin of: (a) Devils Tower, (b) Pikes Peak, (c) Athens Plateau, (d) Spanish Peaks, (e) Fishers Peak, (f) Pine Ridge, (g) Highwood Mts., (h) St Francis Mts. (i) North Park, (j) Pine Ridge.

(3) Complete following sentences giving best proof of each statment (no more than one sentence of reasonable length considered):
(a) The High Plains were the product of a semi-arid climate because---
(b) Cirques are better developed in the San Juan Mountains than in the Front Range because---
(c) The present course of Missouri River originated during the Glacial Period because---
(d) The course of major streams in the Ouachita Mountains is now ascribed to superposition because---
(e) The upland level of the Ozark Plateau is commonly described as a dissected peneplain because---

(4) Account for the origin and distribution of the major areas of badlands in the Great Plains.

(5) Discuss the problem of origin of the partly gravel-covered sloping uplands and "mesas" of the Southern Rockies.

(6) Where in provinces thus far studied this semester could you find a good example of (locate as specifically as possible): (a) young volcanic cone, (b) terminal moraine of continental glacier, (c) hogback ridges formed by resistant layers in overturned folds, (d) subsequent valley on "red beds", (e) synclinal valley, (f) bed of glacial lake, (g) "two story" topography, (h) modern alluvial fans, (i) mountains due to laccolite, (j) mountain front without any hogbacks.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Final examination June 6, 1949.

Write on any 10 questions and no more. Please indicate which you left out. Please leave postcard for grade and avoid office or telephone calls.

(1) Contrast the merits of two different explanations of the origin of Crater Lake, Oregon.

(2) Explain in proper order the major events of the history of the topography of the Sierras. Use diagrams where needed.

(3) Contrast the merits and objections of three hypotheses of the origin of the Scablands of Washington.

(4) Explain the origin and present extent of the High Plains.

(5) Compare the topography of the Northern and Southern Rockies and account for the differences.

(6) Give physiographic significance and location of (a) Boston Mountains, (b) Springfield Plateau, (c) St. Francis Mountains, (d) Salem Plateau, (e) "shutins" of O zarks.

(7) (a) Using diagram explain effect on topography of overturned folds giving locality where displayed.
(b) State two major types of rock which cause ridges in Ouachita Mts.

(8) Using diagrams explain in proper order major steps in history of the topography of Southern Rockies.

(9) Account for origin and describe history of changes in Yellowstone Lake.

(10) Give observations which could be made in field to prove that the Grand Canyon of the Colorado is erosional and not constructional.

(11) Account for the course of Colorado River through Basin and Range Province giving evidence of its geological age.

(12) Give physiographic history and location of (a) Devils Tower, (b) Pine Ridge, (c) Black Hills, (d) Llano Estacado, (e) Little Rocky Mts.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES May 6, 1949

Write on any 4 questions and PLEASE INDICATE ON COVER OF BOOK which they are. Due to field trips there will be delay and grading these books.

(1) Locate as definitely as possible including province, section and state and tell origin or physiographic significance of:
(a) Circle Cliffs, (b) Navajo Mountain, (c) Chuska Mts., (d) Zuni Salt Lake, (e) Tularosa Basin, (f) Virgin River, (g) Hurricane Fault, (h) Salton Sea, (i) Moses Coulee, (j) Humboldt River.

(2) Describe the evidence and significane of Lake Bonneville.

(3) Compare relative merits of three hypothses of origin of the enclosed basins of Basin and Range Province.

(4) Explain evidences which demonstrate faulting along bases of the Basin Ranges including reason for scarcity of direct evidence.

(5) Complete following sentences(no more counted) giving best proof of each:
(a) Smooth sloping mountain summits are now interpreted as pediments because---
(b) The Scablands are admitted to be the products of erosion by glacial waters because---
(c) Long duration of aridity in the Basin and Range Province is demonstrated by ---
(d) The courses of many of the rivers of Columbia plateau is better explained by antecedence than by superposition because--
(e) Relatively recent uplift of the Colorado Plateau is shown by---

(6) Compare relative merits of hypothese of origin of Meteor Crater, Arizona (also known as Coon Butte).

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Midsemester examination April 4, 1949

Write on four questions and no more. Please indicate on cover of bluebook which you answered.

(1) Explain the difficulties of finding a satisfactory explanation of course of Green River across Uninta Mountains.

(2) Compare evidences for and against the explanation of the summit levels of Northern Rockies as a dissected peneplain.

(3) Account for the origin of Grand Coulee, Washington (not scabland problem).

(4) Where could you find a good example each in districts so far studied of: (a) very young volcanic cone, (b) hogbacks with dip slopes toward the mountains, (c) island of pre-volcanic rocks which projected through flows, (d) intermontain basin filled with Tertiary sediments, (e) anticlinal mountains, (f) mountains due to erosion of flows, (g) plain due to joining of many alluvial fans, (h) loess plains, (i) young basalt plain, (j) watergap of antecedent stream.

(5) Where and what is origin of: (a) Baxter Basin, (b) Big Horn Basin, (c) Absoraka Range, (d) Yellowstone Plateau, (e) Great Bend of Columbia R., (f) Gang Plank, (g) Teton Range, (h) Bitterroot Mts, (i) Blue Mts. (j) American Falls

(6) Complete following statments giving best proof of each (no more than a single sentence of reasonable length considered, more is a demerit):
(a) Modern opinion is turning to the explanation of many sloping mountain sides which are erosional as pediments rather than peneplains because--
(b) Southern Rocky Mountains once rose only a moderate heigth above adjacent plains because--
(c) The Northern Rocky Mountains may have had same post-Tertiary history as Southern Rocky Mts. because--
(d) (e) Two reasons for the steep and picturesque east face of Northern Rocky Mts. are ----

GEOLOGY 130
PHYSIOGRAPHY OF EASTERN UNITED STATES

"Six weeks" examination March 7, 1949

Write on four questions only and please indicate on bluebook which they are.

(1) Discuss origin of and relation of High Plains to Rocky Mountains including conditions found in Missouri Plateau.

(2) (a) Give the evidences which indicate that the topography of Ouachitas is result of more than one cycle of erosion.
(b) Outline major events of physiographic history under this view.

(3) Complete following sentences giving definite proof of each statement (NOT MORE than a single sentence of reasonable length considered):
(a) The position of the dunes along Arkansas River in Great Plains shows--
(b) Hogbacks are confined to certain portions of Rocky Mountan front beca use---
(c) The Badlands represent reinvinated erosion because ---
(d) The Ouachitas may once have been buried by sediments of Coastal Plain because--
(e) The upland of Ozark Plateau may be older than Pennsylvanian because--

(4) State as definitely as practicable the location of and give origin of: (a) Athens Plateau; (b) St. Francis Mts.; (c) Red Valley; (d) Missouri Coteau; (e) Edwards Plateau; (f) Mesa de Maya; (g) Pikes Peak, (h) Llano District; (i) Comanche Plateau, (j) Red Hills

(5) List in order the major events in physiographic history of San Juan Mts.

(6) Discuss problem of best location of east boundary of Great Plains.

GEOLOGY 130

PHYSIOGRAPHY OF WESTERN UNITED STATES

June 14, 1948

Final examination.

Write on 10 questions only and please mark which you left out. Please be brief and to the point. Leave postcard for your grade.

1. Compare merits of two explanations of history of Crater Lake, Oregon.

2. Account briefly for and locate by province, sections and state (s):
(a) Boston Mts., (b) Springfield Plateau, (c) St. Francis Mts.,
(d) Hot Springs Plateau, (e) Novaculite ridges.

3. Explain reasons for the controversy over the Basin-Range Problem and indicate probable solution.

4. Outline briefly the major events in the physiographic history of Sierras including Yosemite Valley.

5. What two interpretations may be offered for the smooth, sloping uplands found on many mountain summits of the west; compare implications of each.

6. Compare merits of two explanations of history of the Yakima district, Washington.

7. Account for the courses of major streams of Wyoming Basin (except Green River).

8. Describe the evidences of relatively recent crustal movement in Coast Ranges and state implication upon physiographic history.

9. What explanations may be offered for the known alternation of building up and erosion by streams of Great Plains.

10. Account for briefly and locate by province, section and state (s):
(a) Absoraka Mts., (b) Marysville Buttes, (c) San Francisco Mt.,
(d) Henry Mts., (e) Lake Bonneville.

11. List points for and against interpretation of summits of northern Cascades as a dissected peneplain.

12. Account for and locate by province, section, and state (s): (a) Ship Rock, (b) Race Track, (c) Missouri Coteau, (d) San Juan Mts.,
(e) Uinta Mts.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Examination May 7, 1948

Write on any 4 questions and plese indicate which one you left out.

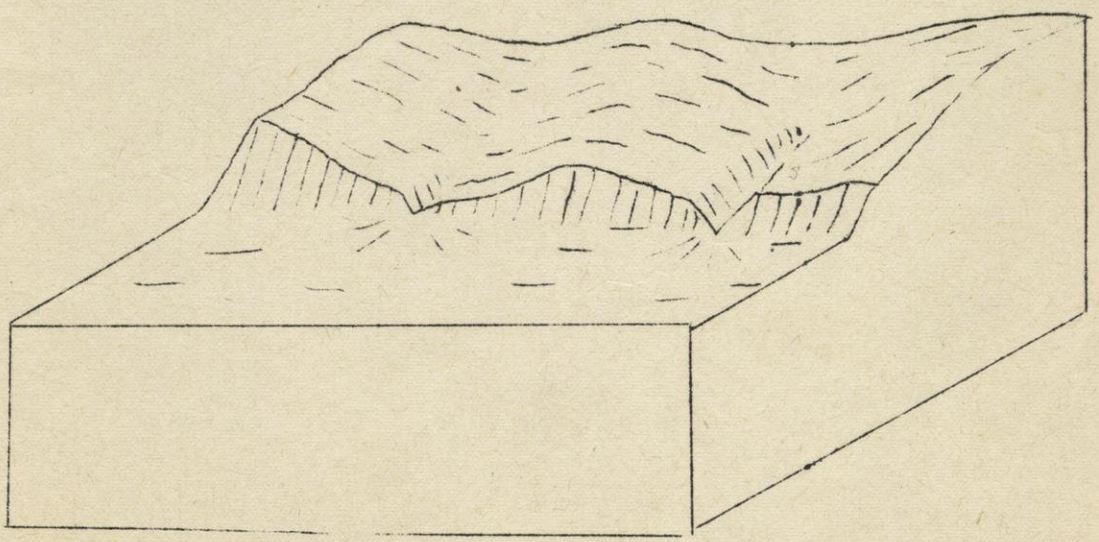
(1) List and compare merits of major points for and against the importance of wind in excavating the basins in Basin and Range Province.

(2) Where in western United States could you find a good example each of: (a) escarpment with trianglular facets; (b) eroded laccolithic mountain; (c) domed strata eroded into a basin; (d) basin separated from sea by delta; (e) erosion topography due to glacial meltwater; (f) extensive area where pediments occur; (g) canyon of stream superimposed by basin filling; (h) hills due to erosion of loess; (i) mesas of lake sediments capped by lava ; (j) mesas capped by ancient glacial drift.

(3) Complete following sentences giving best proof of each statement:
(a) Entrenched meanders of Colorado Plateau demonstrate--
(b) The shattering and fusing of the rocks at Meteor Mt., Arizona prove that--
(c) Saline or evaporite deposits of middle Tertiary age in lower parts of Basin and Range Province demonstrate--
(d) The fact that the cliffs on resistant formations are nearer together in the Grand Canyon than they are on south side of High Plateaus of Utah has been taken to mean--
(e) The relatively low salinity of some of the lakes of the Basin and Range Province indicates--

(4) Discuss briefly the problems raised by the course of Green River across the Uinta Mountains.

(5) What conclusion as to geologic history and structure may be drawn from the following diagram?



GEOLOGY 1 30
PHYSIOGRAPHY OF WESTERN UNITED STATES

Midsemester examination April 5, 1948

Write on 4 questions only and please indicate which you omitted.

(1) Compare merits of two hypotheses of physiographic history of northwestern part of Columbia Plateau.

(2) Compare points for and against the conclusion that Northern Rockies were once eroded to a peneplain.

(3) Discuss relative merits of at least two theories of origin of the Scablands of Columbia Plateau

(4) Locate in provinces thus far studied this semester a good example each of: (a) mountain front whith hogbacks which are formed by strata dipping toward t he mountains, (b) Mountains formed by erosion of batholith, (c) buttes capped by natural slag, (d) "horns" or sharp peaks due to glacial erosion, (e) recent spatter cones, (f) plain formed by recent alluvial fans, (g) gorge due to superimposed river, (h) valley due to recession of falls, (i) mesa capped by lava flow, (j) recent fault escarpment,

(5) Complete following sentences giving best proof of each statement (no more than a single sentence of reasonable length considered):
(a) The west face of the Wasatch Mountains is so straight because----
(b) Few streams cross Snake River Plain because--
(c) The smooth sides of the anticlinal ridge of Uinta Mountains are now termed pediments because--
(d) The Rocky Mountain Front is an erosional and not a direct result of earth movement because ---
(e) The northern Great Plains are more eroded than the central Great Plains because---

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Six weeks examination March 8, 1948

Write on four questions and no more. Majors in geology or geography must include at least one of the first two questions. Please indicate which questions you answered.

(1) Outline in proper order the major events of physiographic history of Great Plains and Southern Rockies indicating t he relations between them

(2) Compare the merits of two hypotheses of the age of the upland of the Ozark Plateau.

(3) Where (state province, state, etc) are and what is origin of:
(a) Devills Tower, (b) Colorado Piedmont, (c) North Park, (d) Gang Plank, (e) Highwood Mts., (f) Little Rocky Mts., (g) Pikes Peak, (h) South Park, (i) Goshen Hole, (j) Athens Plateau.

(4) Complete following sentences giving best pr oof of each statement (no more than a single sentence of reasonable length counted):
(a) The High Plains once extened frather east than they now do because--
(b) The position of t he Loess Plains with respect to the Sand Hills of Nebras ka prove that ---
(c) The present topography of the Pecos Section was formed during Pleistocene time because---
(d) The Sa n Juan Mountains are more picturesque than the easter n ranges of the Southern Rockies because--
(e) The Miss ouri Plateau once drained toward the northeast becaus e--

(5) Discuss briefly the geology, topography and physiographic history of the Ouachita Mountains.

(6) Discuss the problem of best location of east border of Great Plains.

(7) Explain the origin and distribution of badlands in Great Plains.

GEOLOGY 130

PHYSIOGRAPHY OF WESTERN UNITED STATES

Final Examination May 17, 1947

Write on 10 questions in all. Please mark on cover which you left out. Graduates and majors must include at least one of first two questions.

1. Compare merits of the theories of Allison, Bretz, and Flint on origin of the Scablands.

2. (a, b) Give two topographic evidences of anticlinal structure which are found in the Los Angeles district (c) What is topographic expression of anticlinal structure in foothills of Rocky Mts.? (d) What does Pine Ridge tell of the physiographic history of northern Great Plains? (e) Show with diagram the topographic expression of a resistant formation in an overturned fold.

3. Complete the following sentences
   (a) The Grand Canyon of the Colorado was formed in a different cycle of erosion than the escarpments of the High Plateaus of Utah because
   (b,c) This mountain range is bounded by a fault because - (two reasons)
   (d) The Colorado Plateau is differentiated from the Basin and Range Province because
   (e) The Henry Mts. are known to be -- because

4. Discuss two distinct theories of the origin of Crater Mount or Coon Butte, Arizona.

5. Account for and locate examples of (a) three kinds of mountains in Colorado Plateau and (b) two kinds of mountains within Columbia Plateau.

6. Outline in proper order essential steps (geological dates not required) in history of Sierras including Yosemite Valley.

7. Present the arguments you could advance to refute the idea that the Grand Canyon of the Colorado was made by local earth movements, say faulting.

8. Account for topography of the Puget Sound district.

9. Discuss briefly the geology, topography and physiographic history of California Coast Range. (Exclude Angeles and Lower California sections)

10. Locate as definitely as possible good examples in western U. S. of (a) triangular facets, (b) pediment, (c) antecedent stream crossing anticline, (d) recent faulting, (e) recent vulcanism within historic time, (f) wave-cut terrace on coast, (g) cirque, (h) area below sea level, (i) sandstone cliffs, (j) badlands.

vs. water

11. Discuss relative importance of wind erosion in western U. S. giving examples.

12. Discuss two theories of origin of Crater Lake, Oregon.

13. Outline with diagrams the history of the topography of the Southern Rockies as interpreted in text.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Examination April 16, 1947

Write on four questions only and please indicate which you answered.
Majors in geology or geography must include at least one of first two questions.

(1) Compare relative merits of three major hypotheses of origin of "Basin Ranges"

(2) Explain in proper order with diagrams the major steps in physiographic history of the Colorado Plateau.

(3) Complete following sentences giving best proof of each (NO MORE THAN a single sentence of reasonable length considered.)
(a) Colorado River did not occupy its present course through the Basin and Range province before Pleistocene time because---
(b) Many of the escarpments of the Colorado Plateau have very little talus because---
(c) Faulting has ontinued for a long time in Colorado Plateau and Basin and Range province because---
(d) Crater Mound appears to be the result of a "nigh power" explosive because--
(e) The climate of the Basin and Range province was once more humid than it now is because----

(4) Where in regions thus far studied coul you finad a good example of: (be as specific in location as possible):
(a) volcanic neck, (b) recent fault scarp, (c) uneroded laccolith, (d) antecedent stream, (e) pediment (f) playa, (g) young cinder cone, (h) cirques , (i) basin below sea level, (j) anticlinal valley

(5) Discuss location of the boundary between Basin and Range and Columbia Plateau province.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Midsemester examination March 19, 1947

Everyone is to write on four questions only. Majors in either geology or geography must include not less than two of first three questions. PLEASE INDICATE ON COVER OF BLUEBOOK WHICH YOU WROTE ON.

(1) Discuss hypotheses offered for the problem of the course of Green River through Uinta Mountains.

(2) Discuss different ideas on the relation of the Tertiary basins of Northern Rockies to the mountain summits or "peneplain".

(3) Describe and account for the Grand Coulee (do not include Scablands in general.)

(4) Explain why hogback foothills occur only along portions of the Rocky Mountains

(5) Complete following sentences giving best proof of each statement (no more than a single sentence of reasonable length will be considered):
(a) The east face of the Tetons is so straight and abrupt because---
(b) Scablands were made by glacial waters because---
(c) The Craters of the Moon appear younger than they probably are because--
(d) Yellowstone National Park is included in the ---Rockies rather than in the Columbia Plateau because---
(e) The mountains of central Idaho differ in topography from those of Colorado because---

(6) Compare relative merits of two different interpretations of physiographic history of Yakima District of Columbia Plateau.

(7) Where in regions studied this semester could you find a good example (locate as definitely as possible) of each of following:
(a) volcanic cone, (b) hogbacks due to thrust faults, (c) pediment, (d) island which projected above volcanic flows, (e) intermontane bas in enclosed by lava flows, (f) exhumed pre-Cambrian mountains, (g) anticlinal mountain range, (h) bed of glacial lake, (i) loess hills, (j) falls in horizontal lavas .

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Six weeks examination Feb. 19, 1947

Ever yone is to write o^n four questions only. Majors in either g^eology or geography must include not less than one of first two questions. Please mark on cover of your bluebook which questions you wrote on. Place your name on unued books and leave them for later exams.

(1) Discuss explanations of the relation of the uplands of the Southern Rockies to the surficial deposits of the High Plains to east.

(2) Compare two possible explana^tions of the two distinct summit levels found in Ouachita Mountains.

(3) Complete following sentences giv ing best proof of each statement: (no more than a single sentence will be counted)
(a) Cirques' are much more abundant on the east sides of the Southern Rockie^s because--
(b) The High Plains must once have extended farther north because---
(c) Smooth uplands of the San Juan Mountains are now recognized as pediments instead of peneplains because---
(d) The upland of the Sa^lem and Springfield plateaus may be an exhumed ancient peneplain because---
(e) ^he Edwards Plateau was once at about the same elevation as the Coastal Plain because--

(4) Where (be as definite as possible giving state, province, and section) could you find in areas studied this semester a good example each of: (a) s^and dunes, (b) volcanic neck, (c) mesa capped by gravel, (e) ridge of novaculite, (f) water gap, (g) butte capped by slag, (h) badlands, (i) entrenched meanders, (j) monadnock, (d) hogback

(5) Compare theories to explain present drainage of Ouachita Mountains.

(6) Define, bound, describe briefly geology and topography of EITHER (a) Raton Section OR (b) San Luis Valley.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Final examination May 18, 1946

Write on 10 questions; majors in geology or geography must include not less than two of first three questions. Please indicate which ones you wrote.

(1) Compare merits of five processes which might aid in producing the observed subequal summit levels of many western mountain ranges.

(2) (a,b) Give two topographic evidences of anticlinal structure which are found in the Los Angeles district (c) What is topographic expression of anticlinal structure in foothills of Rocky Mts.? (d) What does Pine Ridge tell of the physiographic history of northern Great Plains? (e) Show with diagram the topographic expression of a resistant formation in an overturned fold.

(3) Describe and account for the coulees of Columbia Platea (omit scablands).

(4) Present the arguments you could advance to refute the idea that the Grand Canyon of the Colorado was made by local earth movements, say faulting.

(5) Account for topography of the Puget Sound district.

(6) Explain two different possible histories of Teton Range, Wyoming.

(7) Discuss briefly the geology, topography and physiographic history of California Coast Range. (exclude Angeles and Lower California sections)

(8) Discuss possible explanations of course of Columiba River through both Columbia Plateau and Cascades.

(9) Locate as definitely as possible good examples in western U. S. of (a) trianglular facets, (b) pediment, (c) antecedent stream corssing anticline, (d) recent faulting, (e) recent vulcanism within historic time, (f) wave-cut terrace on coast, (g) cirque, (h) area below sea level, (i) sandstone cliffs, (j) badlands.

(10) Outline events in physiographic history of Sierras including Yosemite Valley. Use diagrams where they will help.

(11) Discuss relative importance of wind erosion in western U. S. giving examples

(12) Explain the essential differences between peneplains and pediments giving examples in western U. S.

(13) Complete following sentences giving proof of each: (a) The Rocky Mt. Front was once buried under stream deposits because--- (b) The High Plains once extended farther east because---- (c) Hogbacks are absent along east face of Rocky Mts in Glacier National Park because--- (d) Mountain glaciation makes mountains more scenic because--- (e) Edwards Plateau is included in Great Plains because---

(14) Discuss two theories of origin of Crater Lake, Oregon.

(15) Locate as definitely as possible and give physiographic significance of: (a) Mt. Rainier, (b) Llano district, Texas, (c) Zuni Mts. (d) Klamath Mts. (e) Yellowstone Lake, (f) Goshen Hole, (g) Callahan Divide, (h)Race Track (i) Missouri Coteau, (j) Golden Gate.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Examination April 17, 1946

Write on 4 questions only and please indicate on cover of book which ones you wrote on. Majors in geology or geography must include not less than one of first two questions.

(1) Compare the merits of three hypotheses of origin of the enclosed depressions of Basin and Range Province.

(2) Compare merits of two theories of origin of Crater Mound, Arizona.

(3) Discuss evidences which demonstrate climatic changes in Basin and Range Province during Tertiary and Quaternary time.

(4) Complete following sentences giving best single proof of each statement (no more than a single sentence of reasonable length considered):
(a) The Northern Rocky Mountains were deeply eroded before the Columbia River lavas were extruded because---
(b) Talus is scanty in much of the Colorado Plateau because---
(c) Interpretaion of the smooth sides of the anticlinal ridges as pediments simplifies the physiographic history or Yakima distrct because--
(d) Uplift of Colorado Plateau in relatively recent geologic time is indicated by--
(e) Colorado River was not in its present location in the Basin and Range Province before Pleistocene time because---

(5) Describe 5 evidences of concealed faults along bases of ranges of the Great Basin.

(6) List and explain major steps in physiographic history of Colorado Plateau from close of Cretaceous time to present.

(7) Locate as definitely as possible and give physiographic significance of:
(a) Henry Mts., (b) San Francisco Mt., (c) Chuska Mts.,
(d) Mesa Verde, (e) Kaibab Plateau, (f) Wasatch Mts.,
(g) Lake Lahontan, (h) Townsend Valley, (i) Poverty Flat,
(j) Great Divide Basin

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Midsemester examination March 20, 1946

Everyone is to write on four questions only. Majors in either geology or geography must include at least one of first two questions. PLEASE mark on cover of your book which questions you answered.

(1) Compare merits of three different hypotheses of rogin of the Scablands of Columbia Plateau.

(2) Discuss evidence for and against existance of one or more dissected peneplains in Northern Rockies.

(3) Account for courses of rivers of Wyoming Basin in relations to mountain uplifts including Uhinta Mts.

(4) List four distinct types of bed rocks and other underlying material found in Southern Rockies and describe topography found on each.

(5) Complete following sentences giveing best proof of each statement (no more than a single sentence of reasonable length considered):
(a) The Craters of the Moon may appear younger than they really are because---
(b) The summit uplands of Unita Mountains are now recognized as pediments instead of ------- ------ because---
(c) The upper portion of Grand Coulee is due to fall recession because---
(d) The presence of Boston Mountains is unfavorable to theory that Salem Plateau is an upraised and dissected peneplain of Tertiary age because---
(e) Snake River Plain is so level because---

(6) Give location as definitely as possible and state physiographic significane of (a) Big Horn Mts., (b) Idaho batholith, (c) Absoraka Mts., (d) Payette Section, (e) Mesa de Maya, (f) North Park, (g) Lewis Range, (h) American Falls, (i) Yellowstone Canyon, (j) Balcones escarpment.

(7) Outline briefly the essential steps in history of topography of Southern Rockies (Front Range only).

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Examination Feb. 22, 1946

Write on four questions only; majors in geology or geography must include at least one of first two questions. Please indicate which questions you left out.

(1) Discuss origin of the High Plains including possible reasons for their present extent; include relation to the uplands of Southern Rockies

(2) Discuss more than one explanation of the age relation of the uplands of Ozark Plateau in Missouri to the Boston Mountains. Diagram.

(3) Complete following sentences giving best proof of each statement (no more than a single sentence of reasonable length will be counted):
(a) The grass cover of the sand dunes of western Nebraska indicates--
(b) The Ouachita Mountains were peneplained before Lower Cretaceous time because--
(c) The "two story" topography of the Ouachita Mountains is commonly regarded as indicating--
(d) The San Juan Mountains are more scenic than the Front Range because-
(e) Inclined but smooth upland surfaces have been regarded as either (give two explantions but do not discuss merits)---

(4) Where and what are (make locations as specific as possible and give physiographic interpretation): (a) Devils Tower, (b) Little Rockies, (c) Longs Peak, (d) Baxter Basin, (e) San Luis Valley, (f) Cypress Hills, (g) St. Francois Mountains, (h) Springfield Plateau, (i) Athens Plateau, (j) Edwards Plateau

(5) Discuss factors which gave rise to Badlands in Great Plains including their distribution.

(6) (a) Explain effect of overturned folds on topography using diagram,
(b) explain why hogbacks occur only along portions of Rocky Mountain Front.

(7) Discuss reasons for locating the east border of Great Plains as given by Fenneman.

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Final examination May 18, 1945

Write on 10 questions in all. Majors in geography and geology must include at least two of first three questions, optional with others. Please indicate which questions you left out.

(1) Discuss merits of at leat five processes which might aid in producing the observed subequal summits of many mountain ranges.

(2) Discuss significance of the surface beneath the Pennsylvanian formations of Ozark Plateau in respect to present uplands including Boston Mts.

(3) (a) (b) What two topographic evidences indicate anticlinal structures in Los Angeles district? (c) What topographic expression indicates anticlines in foothills of Rocky Mts.? (d) What does Pine Ridge tell of former extent of High Plains, (e) What is topographic expression of an overturned fold containing a resistant formation?

(4) Account for and locate as definitely as possible: (a) Ouachita Mts, (b) Springfield Plateau, (c) St. Francis Mts., (d) Little Rocky Mts. (e) Raton mesas

(5) Account for and locate examples of (a) three kinds of mountains in Colorado Plateau and (b) two kinds of mountains within Columbia Plateau

(6) Outline in proper order essential steps (geological dates not required) in history of Sierras including Yosemite Valley.

(7) Complete following sentences giving best proof of each statement:
(a) The Edwards Plateau is included in Great Plains because--
(b) The Snake River Plain is so flat because-
(c) (d) Hogbacks do not occur at all points along the foot of the Rockies because (two reasons)-
(e) The Ouachita Mts were once buried by the Coastal Plain sediments because-

(8) Present proofs that the Grand Canyon of the Colorado was formed by the river.

(9) Discuss topography and physiographic history of Puget Sound district.

(10) Discuss effects of continental glaciation on topography of Great Plains both inside and outside the limit of drift.

(11) Where (be specific) in western U. S. could you find a good example of: (a) recently active volcano, (b) marine terrace, (c) loess plain, (d) drowned valley, (e) entrenched meander, (f) arete, (g) valley produced by recent faulting, (h) glacial lake bed, (i) kettle lake, (j) hanging valley not due to glacial erosion

(12) List physiographic evidences which demonstrate recent faulting in Basin and Range.

(13) Discuss the topography, scenery and physiographic history of Yellowstone Plateau

(14) Account for drainage in relation to rock structure in (a) Columbia Plateau, (b) Colorado Plateau

(15) Explain two different possible histories of origin of Teton Range, Wyoming

GEOLOGY 130
PHYSIOGRAPHY OF WESTERN UNITED STATES

Examination April 16, 1945

Write on four questions in all; majors in geology or geography must include at least one of first two questions. Please mark on cover of your bluebook which questions you wrote on.

(1) Compare relative merits of two major theories of the origin of the depression at Crater Mound, Arizona.

(2) Compare relative merits of three hypotheses of origin of the enclosed basins of the Basin and Range Province.

(3) Complete following sentences giving the best single proof of each statement:
(a) Vulcanism has occured over a long period of time in Colorado Plateau beca use---
(b) Faulting has occured in Basin and Range Province over a long period of time beca use---
(c) Benches on sides of Grand Canyon of the Colorado are due to differences in resistance of rock formations and not to uplifts because----- was not
(d) Colorado River was not in its present location below the Grand Canyon in middle Tertiary time because---
(e) Green River does not occupy the location which it had before the folding of Uinta Mts. Because---

(4) Where (be as specific as possible) and what (from standpoint of origin) are: (a) Sacremento Section, (b) Henry Mts., (c) Pink Cliffs, (d) Snake River Plain, (e) Painted Desert, (f) Marathon District, (g) Grand Canyon of the Y ellowstone, (h) Absoraka Mts., (i) Moses Coulee, (j) Baxter Basin

(5) Expalin the physiographic evidence of concealed faults along many Basin Ranges.

(6) Where (be as specific as possible) could you find in provinces studied this semester a good example each of:
(a) trianglular facets, (b) large area of sand dunes west of Great Plains, (c) dry falls, (d) playa, (e) pedimented mountain range, (f) young fault block mountain made of lava flows, (g) sandstone escarpment, (h) plateau of horizontal sedimentary rocks capped by lava west of Great Plains, (i) stream capture, (j) anticline in sedimentary rocks shown by hogbacks.

(7) Outline in proper order the essential steps in physiographic history of EITHER Colorado Platea or Columbia Plateau (one only)